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The Potential of Ambulance Records for a Road Traffic Safety Agenda in Low-Income Cities

Studies from Karachi, Pakistan

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Contents

List of Publications

The thesis is based on following publications, wich will be referred to in the text by their Roman numerals:

I. Razzak JA, Luby SP, Laflamme L, Chotani H. Injuries among children in Karachi, Pakistan – What, where and how. Public Health 2004;118(2):114-120.

II. Razzak JA, Luby SP. Estimating deaths and injuries due to road traffic accidents in Karachi, Pakistan, through the capture-recapture method. International Journal of Epidemiology 1998;27(5):866-870.

III. Razzak JA, Laflamme L. Limitations of secondary datasets for the roadtraffic injury epidemiology: A study from Karachi, Pakistan. Prehospital Emergency Care 2005;9(3): 355-360.

IV. Razzak JA, Laflamme L. Temporal and spatial changes in road traffic injury in a low-income urban setting – An ambulance data based study from Karachi, Pakistan (submitted).

Abstract

Road traffic injuries (RTIs) are a major public health problem. Basic epidemiological data (person, place, time) and changes in them over time are fundamental in planning effective prevention programs. Such data are still difficult to find in low and middle income countries (LMICs). The overall aim of the thesis is to increase knowledge about the characteristics of RTI events and victims and their changes over time in an urban, low-income setting (Karachi, Pakistan). All studies forming the thesis are register-based and were conducted in Karachi (Pakistan). Data collections took place at two different points in time: in 1996-1997 (reference period 1993-95) for studies 1 and 2 and in 2003-2004 (reference period 2003) for studies 3 and 4. Common to all studies is the use of Edhi Ambulance Service (EAS) logbooks.

In study 1 the epidemiology of childhood RTIs was analysed. Study 2, assessed the magnitude of RTIs for all age groups. EAS logbook data were matched with traffic police data so as to compile incidence estimates of RTI mortality and morbidity using a two-sample capture-recapture design. Study 3 dealt with the accuracy (validity and quality) of EAS data. In Study 4 data from ambulance records were compared for two one-year periods (1995 and 2003) and significance of differences between years were measured using proportions of injuries.

For the period 1993-95, children aged 0-15 incurred 21% of the total number of RTIs recorded. One in six of the fatally injured children (15%) died either at the scene of the accident or during transportation to the hospital. Large vehicles (buses, minibuses and trucks) were involved in 54% of all cases. For the year 1994, police reported 544 deaths and 793 injuries while ambulance records noted 343 deaths and 2048 injuries due to road traffic crashes. It was estimated that at least 972 (CI=912, 1031) deaths and 18936 (CI=15507, 22342) injuries occurred during the study period. Traffic police records recorded only 56% of deaths and 4% of serious injuries, while the ambulance data counted only 35% of deaths and 11% of serious injuries. About ten years later, a total of 1,245 adult RTI victims were transported by the EAS during 2003, most of which were males (89.6%). Victims were, in rank order, pedestrians (24.9%), motorcyclists (20.9%), occupants of large public transport vehicles (minibuses, buses, coaches, coasters) (21.9%). There were missing entries

in EAS in about one in four cases (27%), the majority of which were the unique identifiers like name and age (67%). Data on other variables were reported in 95% or more cases. None of the medical examiners' reports or inpatient medical records contained a description of the injury event. The agreement rate for the variables available in the three datasets ranged from 61% to 100%. Comparing 1995 and 2003 showed a 41% lower number of RTIs in 2003 compared to 1995, with a 35% increase in the prehospital mortality. The road users most likely to be injured remained similar.

In sum, the burden of RTIs in Karachi is much larger than would be expected if only ambulance or police data alone were used to generate incidence rates. Males, pedestrians, motorcyclists and passengers of public transport vehicles constitute the majority of RTI victims. While many victims and events characteristics remain unchanged between the two periods, an augmentation in case mortality rates occurs. Further, while there are limitations to all three major sources of road traffic injury information in the city, ambulance data provide as accurate and more detailed information than either the medico legal reports or the hospital records.

These findings can serve as a basis for researchers and policy makers in identifying RTIs as a major public health problem in the city and for the planning of effective and focused interventions. They also provide a qualitative and quantitative assessment of the potential of ambulance data as an instrument for RTI surveillance.

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Key words: Road traffic injuries, pre-hospital care, vulnerable road users, time trends.

Introduction

Road traffic injuries (RTIs) are a major public health issue, especially in low and middle income countries (LMICs). A disproportionate number of these injuries are concentrated in urban areas, and effect young men and children from lower socio-economic classes. Lack of serious efforts towards prevention and treatment is responsible for an increase in the incidence of RTIs and their poor outcomes.

As an Emergency Medicine specialist, I deal with the consequences of RTIs every day. Trauma management is an expensive endeavour and many RTI victims in low income countries are only able to afford, at best, substandard care. In Pakistan, a low income country, road safety and its prerequisite data needs, take on additional imperatives: they represent the best means of managing RTIs and they must be affordable.

In 1995, when the studies forming this thesis were initiated, there was a general sense in Karachi that traffic injury fatalities were a common occurrence. No data were available in the published literature to plan an effective preventive strategy. In the interest of cost saving and sustainability, a decision was made not to set up a new injury surveillance system. Instead emphasis was placed on using existing data sources. When the traditional sources for RTI data were explored, it became evident that no adequate system existed. Hospitals did not have any data system at that time, police/traffic engineering bureau had only limited coverage and medico-legal records were difficult to access. Research on the emergency care system in the city identified ambulance services as a possible but unusual source of such data. The potential for an effective ambulance service in treating the victims as well as monitoring the safety situation through data collection in a low income country was unexplored and became the topic of this thesis.

Background

RTIs are one of the **major causes of preventable morbidity and mortality** through out the world.[1] [2] Globally, over 25% of all injuries are due to RTIs and results in approximately 1.2 million deaths and 50 million injuries.[3] Over half of these deaths affect young adults in the economically productive age group of 15-44 years. Children aged 5-14 years make the second largest group of victims. In this age group, RTIs are the second leading cause of death.[1] [3] According to the Burden of Disease Study of the WHO, RTIs will move from the 9th leading cause to the third leading cause of disability adjusted life years (DALYs) by the year 2020,[4] Besides the health consequences, RTIs also cause a significant **economic burden** on individuals and societies. It is estimated that one percent of the gross national products (GNP) in low-income countries, 1.5% in middle-income countries and 2% in high-income countries are lost to road crashes.[5] The lower estimates in LMICs likely reflect a lack of accurate data rather than actual lower costs.[6]

This background to the thesis has three constituent parts. Part I describes the burden of RTIs and reasons for income related disparities in RTI rates in LMICs. Part II focuses on the lack of reliable local data on RTIs in LMICs and explores various types of data with a special focus on data from ambulance. Part III centres on the data sources for RTIs as they existed in 1995 in Karachi Limitations of those data is presented, concluding with the need for an alternate data source like ambulance service.

Road Traffic Injuries in LMICs

During the past 25 years, the LMICs, have suffered an increase in the fatalities due to RTI, while the HICs have seen a decline. Today, 85% of all global road deaths, 90% of DALYs lost due to RTI and 96% of all road deaths among children occur in LMICs.[1] [4] According to estimates, RTIs account for 30-86% of all the trauma-related admissions to the hospitals in LMICs,[7]putting enormous burden on the resource poor health care systems in these countries.[8] [9]

Besides a higher burden, the patterns and characteristics of RTIs are also very different in LMICs. Greater exposure of pedestrians

and non-motorized vehicles to the motorized traffic, mixed land-use, unregulated public transport and poor trauma care are some of the important determinants of this difference.[10] It is estimated that 60-80% of all traffic fatalities in LMICs are pedestrians, bicyclists and motorcyclists; a much higher figure than the reported 30-40% in most HICs (Table 1).[11] Similarly, unlike HIC where private cars are the most frequent vehicle involved in road crashes, buses and trucks are the most frequent striking vehicle in LMICs.[7] Table 1 present the percent distribution of various types of road users in multiple low, middle and high income countries.

Table 1 Activity of Road Users (in percent) at the time of death
(Reproduced with some modifications from Mohan, 1992)[11]

City, Nation (year)	Pedestrians	Bicyclists	Motorized 2-wheelers	Motorized 4-wheelers	Others
Delhi, India (1994)	42	14	27	12	5
Thailand (1987)	47	6	36	12	-
Bandung, Indonesia (1990)	33	7	42	15	3
Colombo, Sri Lanka (1991)	38	8	34	14	6
Malaysia (1994)	15	6	57	19	3
Japan (1992)	27	10	20	42	1
The Netherlands (1990)	10	22	12	55	-
Norway (1990)	16	5	12	64	3
Australia (1990)	18	4	11	65	2
USA (1995)	13	2	5	79	1

The direct economic cost of RTIs in low income countries, estimated to be US$65 billion, is more than the total annual developmental assistance received by these countries.[12] Indirect costs are likely to be much higher as more than two thirds of road traffic deaths are of individuals in an economically productive age group.[12] This was quantified in a recent study from Bangladesh and India where the earning members from lower socio-economic class families were most likely to be involved in RTIs. In these families, the victims contributed, on an average about half of the total household income. About two thirds of families reported a decrease in the household income and a similar proportion reported an actual decrease in food consumption after a road crash death in the household.[13]

RTIs in Urban Areas of LMICs

Of the world's total population, almost half live in cities. It is predicted that growth in urban population will be responsible for almost all of the expected population increase in the next 25 years[14] Because of the greater exposure to traffic in their daily lives, urban dwellers are more vulnerable to suffering RTIs. The World Bank estimated that half of all road crash deaths and two-thirds of all RTIs in LMICs occur in urban settings.[15]According to the European Transport Safety Council, "the greatest everyday danger to people using towns and cities comes from the use of motor vehicles."[16]

Urban areas in LMIC have higher population and vehicular densities. They are also more likely to have residential, industrial and commercial activities happening concurrently in the same geographical location. As a consequence, pedestrians and non-motorized vehicles come into greater contact with large commercial and public transport vehicles.[17] These factors are likely to be more common in LMICs[18] The following paragraphs highlight features particular to the road safety in urban areas.

Urban Population Size and RTIs: Evidence for the role of population size and the incidence of road traffic crashes is not convincing. A World Bank study from six developing countries showed a lack of a clear relationship between the urbanization levels and the contribution to the proportions of RTIs.[19] Two of the three countries with the lowest urbanization levels (Ethiopia and Zimbabwe) reported the highest proportion of urban road crashes. On the other hand, Botswana, with almost 50% urbanization, reported the lowest share of urban RTIs.

Vulnerable Road Users: Road users most at risk in traffic, such as pedestrians, cyclists and public transport passengers are often called vulnerable road users.1 In LMICs these road users are the victims of RTIs in 50-80% of cases, especially in urban areas.[20]

Mixed Traffic: Cities in LMICs are characterized by a mix of non-motorized and motorized modes.[21] In Thailand, Malaysia, Indonesia and Taiwan, motorized two and three-wheelers make up more than 50% of all motor vehicles. In Indian cities, non-motorized vehicles constitute 30-70% of all vehicles.[17] This results in a much different patterns of vehicular involvement in urban areas of

LMICs than in HICs. For example, the higher share of buses and trucks and two wheelers is much higher in LMIC cities.[1 20]
Urban Land-Use and Transportation: Cities in LMIC have a mixed pattern of land use, partly because large numbers of people need to walk between their places of residence and their places of work. No clear-cut concentric zones of different activities exist. Commercial developments and high-concentration housing are found in the core as well as the vicinity of the city. These unplanned land use patterns result in greater exposure of pedestrians and other vulnerable road users to large commercial vehicles, increasing the risk of crashes.[22]

Reasons for High Burden of RTIs in LMICs

Though the data presented thus far illustrates clearly the public health importance of RTIs,, health policy planners in many LMICs continue to remain focused only on communicable diseases. This translates into lack of research and development funding for the prevention of RTIs. Table 2 provides comparison between the global investment for some communicable diseases and RTIs.[23] Injury experts blame lack of accurate local data for this poor response.[1] Local data, needed to define the magnitude, identify high risk groups, describe weaknesses in road safety systems and test interventions for control of RTIs are non-existent in many low income countries. A recent International Conference on Road Traffic Injuries and Health Equity identified accurate data collection as "a critical step towards improving road safety conditions in every country represented at the conference."[24]

Table 2 Estimated global research and development funding for selected topics
(Reproduced with permission from WHO)

Disease or Injury	US$ (millions)	1990 DALYs ranking	2020 DALYs ranking
HIV/AIDS	919-985	2	10
Malaria	60	8	-
Diarrheal Diseases	32	4	9
Road Traffic Injuries	24-33	9	3
Tuberculosis	19-33	--	--

In sum, RTIs in LMICs are a growing public health problem. Vulnerable populations from urban areas of these countries are especially at higher risk of RTI related death or disability. The lack of reliable local data is one of the fundamental reasons for the low recognition and limited investment in this issue. The next part presents the various data sources for RTIs in LMICs and their limitations.

Data Sources for RTIs

Overall Scenario in LMICs

Various sources have been used to describe RTIs in different settings. These sources include vital registration, police, hospitals, newspapers, and medico-legal coroner's data. Each data source has strengths and weaknesses which more or less pronounced depending upon the setting where they are used. A detailed discussion on these data sources is available from standard texts.[25] In the text below, a general description of these data sources is given followed by limitations of each. One data source, the ambulance service, is presented in greater depth other sources have limited information is available on this subject.

Vital Registration

Vital registration is often the most comprehensive source of information on deaths occurring in a population. These data are used to make future predictions and formulate policies.[4] However, reporting death to government's vital registration is inconsistent. For example, in some countries it is legal to cremate or bury the dead without filing a report.[26] Similarly, a recent review of death information in the vital registration system in 115 countries was carried out. The review identified several issues, including incomplete information, poor quality information on cause of death and the limited coverage of the population. The study found that only 23 members states of WHO had "high quality death registration data".[27] Of the 11 countries in South East Asia, only 4 had usable data available on the cause of death while the rest of the 7 had no data. A study conducted in Chennai India showed that forty-one percent of death certificates had "unspecified medical condition" recorded as a cause-of-death. After verbal autopsy, the "Unspecified" category was reduced by about two thirds.[28]

Traffic Police

The police are often involved in the investigation of road traffic crash. The data obtained from police reports is a common way to describe the epidemiology of RTIs.[29] [30]Police records are often used for the analysis of trends as police in most countries had been recording road crashes for the longest. However, the data from police are generally limited to age, sex, location and time of injury and outcome at the scene of injury.[26]

There are other limitations as well. Not all crashes and injuries are reported to the police[31] [32] especially in LMICs.[11] Underreporting rates as high as 50% were reported from Bangalore, India.[33] Ghaffar et al. in a study from Islamabad, Pakistan found only 60% of fatalities reported by the local newspapers in the police records.[34] Crashes are not brought to police's attention often because of the hassles involved when dealing with police and for those who do come in contact with police, many are not recorded as people would rather pay a small bribe then risk getting involved with court cases.[35] Poor documentation of specific injuries and their severity also occur. This is thought to be due to poor training in assessing the severity of injuries beyond injured vs. dead.[26] A third limitation is related to the focus of police investigations i.e. to determine the person at fault. Public health perspective on the cause of crash is often not captured. Putting blame for the crash is the focus instead of revealing engineering/environmental factors. Dandona et al from Hyderabad, India found that over a 1 year period, the cause of death for all road crashes was recorded as "negligence of driver".[29]

Hospital Based Data

Medical records are vitally important in describing epidemiology of diseases within populations and have been used extensively to describe RTIs[36] [37] [38] [39]Several types of health care records can be obtained including hospital inpatient records, trauma registries, outpatient medical records, emergency medical services records and post acute care/rehabilitation information.[40] Besides the nature, severity and outcome of injuries, hospital records have been used to estimates the cost of treatment of injuries. Literature shows that capture of injuries by hospital based data is better than patients were found in the police records.[60] Similarly only about

60% of all hospitalized victims were in the police records in New Zealand.[41]The difference widens as one also includes patients discharged from the emergency departments.[42]

Hospital data do have several limitations including selection bias based on certain geographic, economic and clinical criteria. Victims with minor injuries may choose not to come to the hospital, thus only the most severe forms of injuries will be seen in the hospital and therefore available for researchers. Even for severe injuries, not everyone has an equal access to hospitals. Depending upon the nature of payment for services, some private hospitals may only see car passengers while a state run relatively low cost hospitals may see disproportionate number of pedestrians and two wheelers.

Ambulance Based Data

It is thought that ambulance personnel are in an ideal situation to actively partake in RTI control efforts as they are widely distributed among the population and reflect the composition of the community. They also enjoy high credibility and status in the community.[43] Activities where ambulance and pre-hospital care system were thought to have a role included: 1- risk assessment and intervention for individual and facilities, 2- injury data collection and 3- public education and advocacy. RTI data collection by ambulance personnel is the focus of this thesis.

In more established pre-hospital care system systems, researchers and policy-makers have suggested that pre-hospital care systems can expand their role in injury control by supporting and promoting the collection and utilization of injury data.[44] For example, the Institute of Medicine in the United States reports that EMS injury prevention efforts have "the potential to be the most effective EMS intervention."[45] Similarly, the National Highway Traffic Safety Administration in the USA has recently published a report on the future agenda for EMS education. The report identified training in injury prevention as one of the main emphasis for the future of EMS education. [46]

There are few actual examples in the literature on the use of ambulance data for injury surveillance and epidemiology. Bulk of these examples is from the US. The main focus of these studies is to describe the characteristics of injuries and crashes rather than to estimate incidence. In Arkansas, USA pre-hospital data was used to study paediatric injuries from all-terrain vehicles.[47] Similarly, in Daytona, USA, it was used to describe the injuries among motor-cyclists. EMS data has been used for other injuries as well. The same source of data was used to describe the epidemiology of falls,[48] drowning[49] and suicide.[50]

While these studies provide important information, their accuracy compared to other and more commonly used sources of data was rarely verified. One study looked at the quality of violent injury data obtained through pre-hospital system and found significant errors and omission[51] lack of organizational support, complexity of data elements, methods of data collection and knowledge and attitudes of ambulance personnel were some of the proposed reasons for high error rate. No data on accuracy of pre-hospital care in LMIC was available in the literature.

In summary, limitations exist for each of the commonly used data systems for RTIs. These limitations are more pronounced in LMICs. In this context, the ambulance data could be useful however; their potential remains unexplored in systems where pre-hospital care system is rudimentary.

Data Sources in 1995 in Karachi and the Need for Ambulance Data

In 1995 when the studies forming this thesis were conceived researchers concerned with injuries explored all the available data sources in Karachi. Police department referred the research group to the Traffic Engineering Bureau (TEB). The TEB, at that time was a division under the local government and was responsible for compiling police data on RTIs and investigating each crash to ascertain the underlying cause and provide solutions to prevent them in future.

The TEB shared with us police records which were available in the form of a 1-2 page daily report with 6-10 lines describing each crash during the past 24 hour period. Each crash narrative described the event in one paragraph and usually did not follow any format for the presentation of the data. The TEB was expected to carry out an in-depth investigation of the crash using an extensive data collection tool. Once investigations are completed, the data was entered into a computer program and was later used to generate an Annual Report. Original data from the TEB investigations was not available however the annual reports and the daily report from police were made available to the researchers. The annual report from 1994-1995 for e.g. showed only 544 injuries and 793 deaths due to road crashes, a number thought to be significantly lower than the actual burden of RTI in Karachi.

Medico-legal (ML) records were explored by visiting the trauma centers. The ML records were in the form of hand written reports, and did not have a mechanism of data entry or analysis. The access to the data also varied by hospital. Some centers made the data available right away while others refused on one ground or the other.

Data from the health care system was even more difficult to obtain. Emergency Departments did not keep any records with them. If patient was discharged, they took all the records with them. On the other hand, if patient was admitted, emergency assessment and treatment information went with the patient medical record to the wards. For the inpatients, no system of medical record keeping existed at that time. Building a new system of data collection, storage and analysis for RTI either in the emergency department or inpatient units was thought to be too expensive, cumbersome and unsustainable.

Vital statistics was considered but not pursued because of quality and the coverage issues. Data on deaths due specifically to RTIs was not available as all injuries were lumped together. There was also a concern that by focusing only on deaths, a large component of the burden of injuries in the form of non-fatal injuries will be missed.

Thus none of the traditionally used and existing data sources provided the basic level of information on RTIs in Karachi. Other avenues were explored including data obtained from ambulance services.

Ambulance System Data for Road Traffic Injuries in Karachi

A study was carried out in the mid 1990s to describe the pre-hospital trauma care in Karachi.[52]The study identified strengths and weaknesses of the pre-hospital trauma care by studying seven largest ambulance service providers in the city. Only one of them was found to provide emergency services to the victims of RTIs. The same service was found to have city wide coverage through peripheral ambulance centres spread through out the city. The review of their data system revealed that each victims transported by the service is logged into an "emergency log book". The log book contained information on the date, time and place of the crash, the name, gender and age of the victim, the activity of the victims at the time of crash, a brief description of the crash event, the hospital that the patient was transported to and the outcome in terms of the dead versus alive. This detail of information was not available to the research group from any other source of injury data. Though the main purpose of the ambulance service for the data collection was to keep a check on their drivers and ensure proper use of ambulances, potential for its use in describing RTIs existed. Review of literature (1966-1995) showed no peer reviewed publication from LMIC utilizing ambulance data to describe RTI.

Summary

RTIs in LMICs are a public health priority requiring urgent steps for their prevention. These steps must be guided by local data as the epidemiology and pattern of injury in LMIC urban setting is different compared to the HICs. Karachi in 1995 had little or no reliable local data. The city needed to define the magnitude of the RTIs as well as identify risk groups. Available sources of data in the city were either difficult to access or had limited information. Thus ambulance data was identified as a possible source.

Aims and Study Objectives

The overall aim of the thesis is to increase knowledge about the characteristics of RTI events and victims and their changes over time in an urban, low-income setting (Karachi, Pakistan).

The four specific objectives of the thesis are:

1. To describe the share and specific characteristics of RTIs in childhood injuries;

2. To measure the burden of RTIs in terms of hospitalisation and mortality;

3. To ascertain the accuracy of ambulance data on road traffic injuries compared with police and medico legal data;

4. To determine if the patterns of road traffic injuries are changing over time.

Materials and Methods

All studies forming the thesis are cross-sectional and based on data collected from registers of various kinds (described below). Data were collected from two different time periods; 1996-1997 (register data from 1993-95) for studies 1, 2 and 4 and in 2003-2004 (register data from 2003) for studies 3 and 4. Common to all studies is the use of Edhi Ambulance Service (EAS) logbooks.

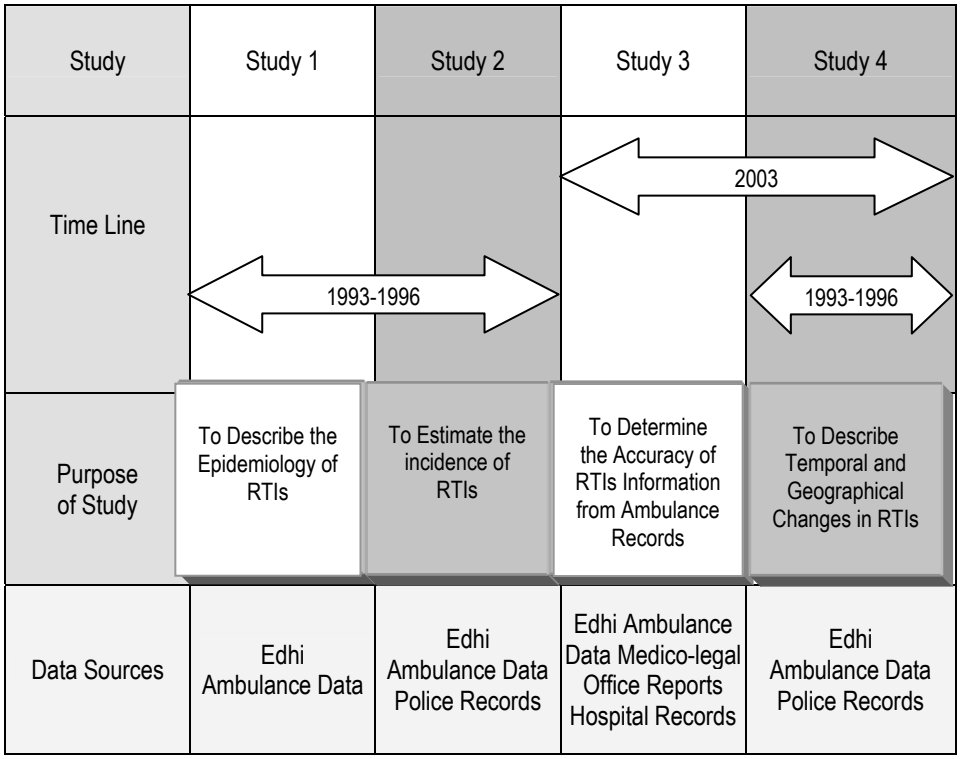


Figure 1. The studies forming the thesis.

Setting – Karachi

The setting of these studies was the city of Karachi. It is the largest city in Pakistan, and the hub of economic activity. It has an estimated population of 10 million and accounts for approximately 10% of the total population and 30% of the urban population of Pakistan. Internationally it ranks 13th among the world's most populous cities.[53] Forty three percent of the city's population is under the age of 15 years.

Like many cities in low-income countries, Karachi is characterized by extremely rapid growth in population and in motorization (with poor supporting infrastructure). The road length increased from 245 km in 1994 to 362 kilometers in 2003 (47.7%), while the number of motor vehicles increased from 859,459 in 1995 to 1,135,448 in 2003 (32.1%). (Table 3) (Transport and Communications Department, City District Government of Karachi, 2004).

Table 3. Trend in population, vehicles number and the length of road during the study period.

	Population (in millions)	Vehicles (in millions)	Road Length (km)
1995	8.465	0.88	245
2000	10.032	1.006	
2003	11.819	1.135	362

At the time of initial studies, 1993-1996, Karachi was administratively divided into 4 districts and 46 neighborhoods. During the study period, a new administrative arrangement was implemented. Among other changes, the city was divided into 19 "Towns", 18 controlled by the city government and one controlled by the cantonment authorities. The city's map with these administrative towns is shown in Figure 2.

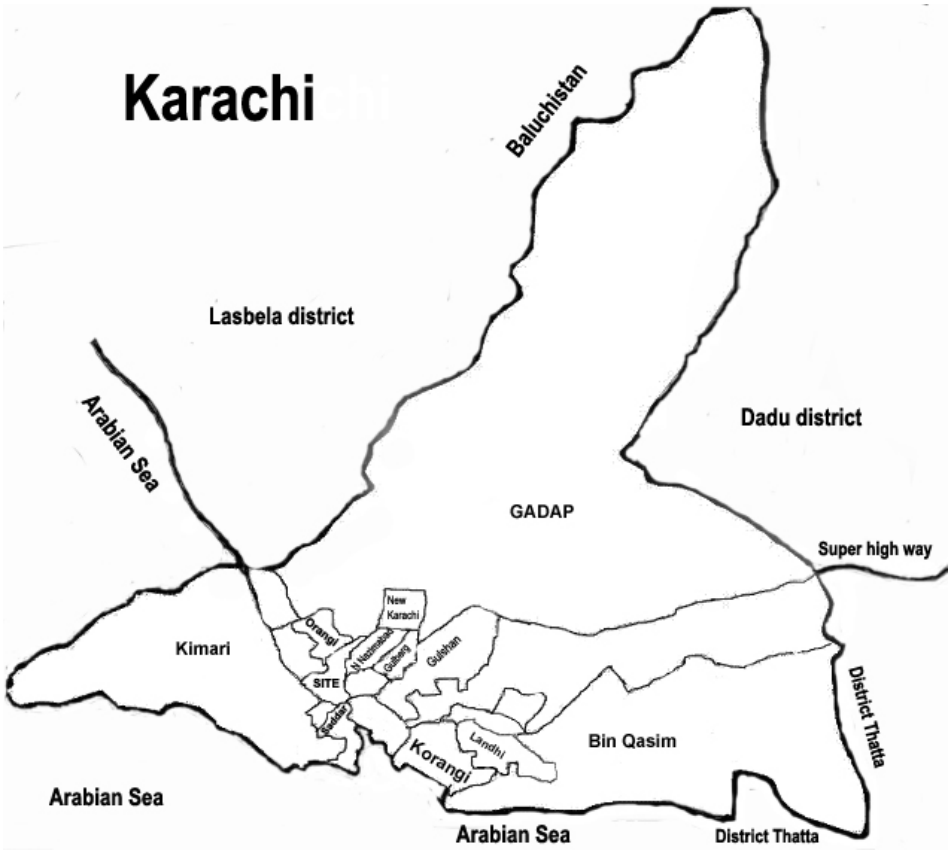


Figure 2. Current administrative map of Karachi.

Data Sources

Four sources of data were used– 1) ambulance records, 2) police reports, 3) medico-legal office reports, and 4) hospital records. Whereas ambulance records were from a private non-governmental organization, the other three were from government run facilities. All four sources have separate mechanisms of collection, compilation and management of data. These data sources are more likely to record the more severe form of injuries.

Edhi Ambulance Service

Ambulance records constituted the main data source and were obtained from Edhi Ambulance Service (EAS). The Edhi Foundation is a private philanthropic institution well known for being the largest voluntary ambulance service in the world.[54] Earlier research has shown that the Edhi Ambulance Service (EAS) is the only ambulance service in Karachi with capacity to respond to RTIs and other emergencies.[55] Many other ambulance services exist but are primarily involved in either non-emergency transportation, usually transportation from hospital to hospital or hospital to home. At the time of the initial studies (1993-1996), the service operated 75 ambulances from 45 centers in the city. During the nine year study period, the ambulance service has consolidated its operation and has closed down a number of its peripheral ambulance centers (from 45 to 35) while maintaining the same number of ambulances (75 throughout the city).

The ambulances are staffed by drivers with no formal training in emergency trauma care or basic life support. Typically, the ambulances are equipped with a radio and a stretcher and, in some cases, an oxygen tank, a suction machine and a "first aid box" for wound dressing. Drivers of the ambulance maintain radio contact with the ambulance service control room; however, they have no communication with hospital staff and do not follow any treatment protocols.

Usually, a bystander at the scene of a RTI calls the ambulance service's dispatch center (also called the control room) by dialing a dedicated phone number. The dispatch center then instructs the ambulance center nearest to the site of crash to send an ambulance or ambulances using a two-way radio system. The driver arrives at the site of the crash, picks up the patient, and then transports him or her to the nearest trauma center. After reaching the hospital, the driver radios information pertaining to the crash and the victim to the control room, where the information is then entered into an emergency register (see Figure 3). The reported information includes the date, time and location of the crash; the name, age and gender of the victim; the vehicles involved; the setting of the crash; and the outcome and destination (usually a hospital) of the victim of crash.

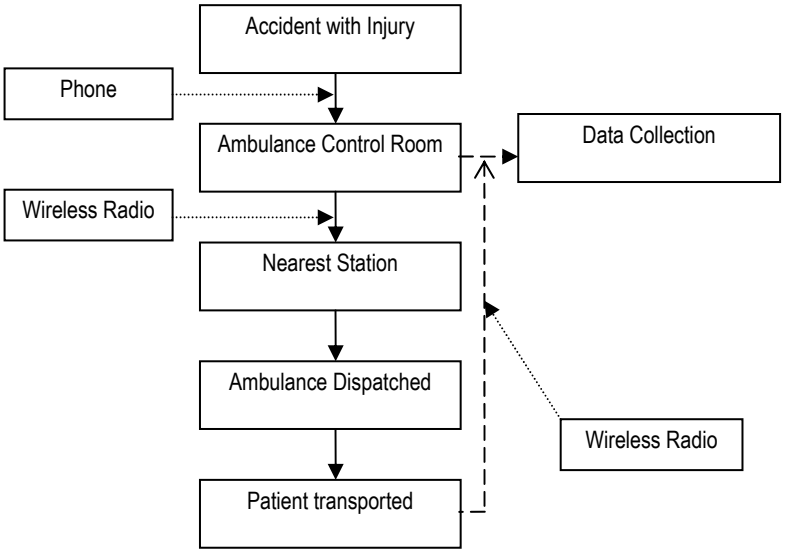


Figure 3. Information flow in the Edhi Ambulance Service.

Traffic Police Records

The traffic police in Karachi record information on road traffic crashes that they witness or investigate. The record is a brief description of the crash event and the vehicles and people involved. All records are compiled in a daily report and sent to the city government's Transport and Communication Department (formerly Traffic Engineering Bureau until 1999). The Transport and Communication Department is responsible for carrying out a detailed investigation of each crash. Upon completion of the investigation data are initially recorded on a performa and then entered into a computer program. The department produces a summary document of their investigations in the form of an annual "Accident Analysis Report". For this study, the individual case summaries submitted by the police department and the yearly accident analysis reports were obtained for the years 1994, 1995 and 2003.

Medico-Legal Reports

By Pakistani law all injury victims seen at medical facilities are evaluated by a medical examiner to facilitate any future legal proceedings in cases of road traffic injuries. The evaluation takes place in parallel with the management of the patient by emergency department staff. The medical examiners collect demographic and injury related information on each patient and enter them into a logbook. Similarly, all patients who are brought dead to the hospital are seen by a medical examiner. Information about them, including any findings from postmortem examination, is recorded in a separate "postmortem log".

Hospitals Records

Karachi has three major and six minor trauma centers. The major trauma centers are characterized by a higher level of care and the presence of medical examiners in emergency departments 24 hours a day. As mentioned above, the prevailing law requires all injuries to be registered at the medico-legal office. Thus a majority of trauma victims are brought either directly to one of these centers, or are transferred after initial trauma care is given at an outside facility.

In the emergency departments, patients are examined by a physician who documents the findings on a single sheet of paper. If the patient is discharged from the emergency department, the department's documentation sheet (along-with any x-rays, etc.) is taken away by the patient. Thus, no medical records are available for patients seen in and discharged from the emergency department. If the patient is admitted to hospital, the emergency-department document is placed in the patient's inpatient file and becomes part of medical records. Following discharge from hospital, the medical records of all injured patients are brought back to the Medico-legal Office and are stored for possible legal proceedings.

Study Design and Methods for Each Study

Study 1

The Share and Specific Characteristics of RTIs

Study Design
Study 1, which focuses on children aged 0-15 years, is based on a broader data collection encompassing all kinds of injuries and all age groups of injured people transported by the ambulance service. A portion of these data was presented as an independent paper describing road traffic injuries (with brief description of other types of injuries) among children. Data on road traffic injuries among adult was used again in paper 4.

Data Management
The EAS permitted the research group to analyze their data covering the time period from Oct, 1993 to Jan, 1996 (26 months in total). There was a gap of 5 weeks in the logs between Mar 25, 1994 and May 5, 1994 due to lost records. The data was obtained from the logbook of the ambulance service and was written in Urdu (national language of Pakistan). The log books were organized in eight columns (serial number, date/time, and location of the crash, description of the event, name, gender and age of the victim(s), hospital taken to, and outcome). Outcome was defined as dead or alive when the ambulance reached the hospital. It was not possible to tell if the death occurred at the scene of injury or during transportation. The event description generally contained information on the type of vehicle(s) involved, accompanied by a general description of the circumstances of the crash.

A system was developed to code free-text information using a codebook and followed the minimum dataset format of the World Health Organization with some local adaptations. For example, minibuses and motor rickshaws were included as they are common modes of transportation in Karachi. Minibuses have the capacity for 35 seated passengers (compared with buses which have the capacity for 52 seated passengers). Motor rickshaws are three-wheelers with the capacity for three people; the driver in the front seat and two passengers in the back seat. Using the same

system as the Karachi Development Authority, the city was divided into 41 neighborhoods for the purpose of this study.

Research assistants (RA) with prior training were used for data coding and entry. The Principal Investigator performed a quality check on a random sample of 10% of cases. The error rate was less than 1%.

Data Analysis
For study 1, descriptive uni-variate and bi-variate analyses were performed on the ambulance data for the period of 26 months. Confidence Intervals were calculated where appropriate. Data analysis was carried out using EpiInfo (version 6) and SPSS (version 9.05).

Study 2

The Burden of RTIs in Terms of Hospitalization and Mortality

Study Design
The capture-recapture method was used to estimate the total burden of road traffic injuries in Karachi. The capture-recapture method, which originated in biological sciences and fisheries, has been used in the recent years to study injuries. The method requires matching individuals from two or more independent sources of data. The total number of matched vs. non-matched cases in the two data sources are then used to calculate the total burden as well as a 95% confidence intervals around them.

Two data sources were used: EAS and traffic police data on all road traffic injuries during the year 1994 was obtained. Various criteria were developed for matching and a two sample capture-recapture method was applied to estimate the number of RTIs in the city.

Data Management
Ambulance data were obtained as described above.

Traffic police daily reports were a narration of the road traffic crash and contained information on numerous variables. The information did not follow any particular format. Information on date, time and place of crash, name and age of the victim, the vehicles involved, the setting and the outcome of the victims were extracted on a data collection sheet.

A corresponding injury event was then sought in the ambulance records and matched on seven variables. Definitions for matching were developed. The name of the victim in the ambulance service log was in Urdu, the national language of Pakistan, while police reported it in English. "Time" was considered matched if the recorded time from the two sources was within 1 hour of each other. Date, type of vehicle and registration number of vehicle were considered as matched if they were exactly the same in both the capture and recapture. Four separate criteria were developed to define matching. (Table 4)

Table 4. Matching criteria used for estimating road traffic injuries in Karachi using capture recapture method.

Standard/Criteria (in decreasing im-portant of severity)	Date	Time	Place	Name of Victim, Registration No, Vehicles, Outcome
A	Same	Same	Similar	All same
B	Same	Same	Similar	Any three of the above same
C	Same	Same	Similar	Any two of the above same
D	Same	Same	Similar	Any one of the above same

Data Analysis
An estimate of the total number of road traffic accident victims was made with the formula:

$$Estimation\ of\ n = \hat{n} = \frac{(c1 + 1)(c2 + 1)}{M + 1} - 1$$

Where c1 and c2 are the numbers of persons in the first and second capture respectively and m is the number of persons identified in both captures (matches). The following formulas[56] were used to calculate the variance and 95% confidence interval (CI) for the estimate of n:

$$Variance = \frac{(c_1 + 1)(c_2 + 1)(c_1 - m)(c_2 - m)}{(m + 1)^2 (m + 2)}$$

$$95\%\ CI = n \pm 1.9 \sqrt{Variance}$$

Study 3

The Accuracy of Ambulance Data on Road Traffic Injuries

Study Design
Study 3 comprises a retrospective review of three sources of data: a) Edhi Ambulance Service data, b) medical examiners' reports, and c) inpatient medical records. All adult victims of RTI transported by the ambulance service from January 1, 2003 to December 31, 2003 were included. Ambulance data for these cases were compared with the information available for the same patients in medical examiners' and inpatient medical records. Rates of agreement on individual variables were estimated.

Data Management
Ambulance data was obtained as described for study 1.

For medico-legal data, a list of variables and a code book for the possible information against each variable were developed. A data collection spread sheet was developed in Microsoft Excel. A research assistant and the PI collected the information on these spread sheet

and entered the data into MS Excel. The data was then converted into dbase for analysis using SPSS.

A data collection sheet and a code book similar to the medico-legal office data was developed for the hospital data as well. Hospital records were again in the descriptive format. Emergency department and admission notes of the physicians were used as the source of information. The data was collected and entered into to MS Excel spreadsheets and had analysis done in SPSS as described above.

Data Analysis

Ambulance data were examined for completeness of information, covering both missing records (empty cells) and missing variables, i.e. records where specific information was unknown or unavailable. Information from a sample of the ambulance data were compared with that from medical examiners' reports and inpatient medical records from the three major trauma centers. Statistical analysis was performed using the SPSS software package (version 9.05).

Study 4

Changes in the Patterns of Road Traffic Injuries Over Time.

Study Design

Study 4 consists of a retrospective case series of patients transported by EAS during two periods of one year each: Jan 1, 1995 to Dec 31, 1995 and Jan 1, 2003 to Dec 31, 2003. The changes observed between the two study years were compared. The changes over time in the ambulance data were contrasted with the findings from traffic police data.

Data Management

To assess whether there had been a change in injury and victim characteristics, data on all road traffic injuries were retrieved manually from the ambulance logs and the two reference years were compared.

For the geographical distribution, we used the main administrative unit of the city district called "town" (Sindh Local Government Ordinance, 2001). Location data in ambulance records for both years did not follow any standard format. Location descriptors ranged from name of the area to the name of a street/road to a nearby city landmark. The initial list of locations was in hundreds. These individual locations were identified on the detailed paper map obtained from the "Survey of Pakistan" and coded by towns.

Data Analysis

Uni-variate and bi-variate analysis was performed for time, month and day of the crash; age, gender and activity of the victim; the vehicle type involved; the outcome of the injury and the hospital that the patient was taken to. Individual variables in the two one-year periods were compared for all ages aggregated and for children and adults separately. P values and odds ratios with 95% confidence intervals were calculated.

To assess if the changes observed in the patterns were consistent between the ambulance and police registers, percentage of change in the victim and injury characteristics for the two registers were calculated. The following variables were compared: total number of RTIs, fatalities, vehicle types and activity of victims. Age and gender distributions and information about minibus passengers were not available for 2003 in the police data and therefore not compared.

Results

Study 1

The Share and Specific Characteristics of RTIs among Children

Share of road traffic injuries among all injuries among children
A total of 1,320 cases of injuries in children aged 15 years or less were identified during the study period, of which 81% were road traffic injuries (n=1,059), the most common cause.

Child victim characteristics
Male children registered four of five of those injuries (n=858; 81%) and the mean age of the injured children was 9.6 years (SD +/- 4.0). Among the victims, pedestrians and minibus passengers were most commonly involved (26% and 21%). Children were also injured as passengers of motorcycle (9%); bus (7%), car (6%), van (5%), truck (3%) or rickshaw (1%) and sometimes as bicycle riders (2%). In 179 (17%) of cases the identity of the involved vehicle was not know to the ambulance drivers.

Case fatality rate
Fourteen percent (n=145) of all road traffic injury victim children died after the injury, either at the scene of the accident or on the way to hospital. Pedestrian children had the highest mortality rate before getting to the hospital. (57%) Thus the case fatality rate (CFR) for a child pedestrian was about 3 times greater than that for all non-pedestrian children (CFR = 81 compared with 29; OR = 4.92, 95% CI 3.36–7.23).

Geographic characteristics
Pedestrian injuries (including fatal ones) were concentrated in certain areas of the city. Six of 42 locations accounted for more than 71% of all child pedestrian injuries.

Vehicle characteristics
A total of 1423 vehicles were involved in crashes that injured children. More than half of the vehicles were buses, minibuses or trucks with minibuses involved in 390 cases (27.4%), trucks/trawlers in 247 cases (17%). Buses (130; 9%) and motorcycles (141; 10%) constituted other significant groups.

Study 2

The Burden of RTIs in Terms of Hospitalizations and Mortality

Using the least strict standard for matching (when the time, date and place matched along with any one of the other four variables i.e. name of the victim, registration number of vehicle, type of vehicle and patient outcome matched), the study identified 220 cases that were present in both datasets. Capture recapture method estimated 972 deaths (95% CI= 912, 1031) and 18,936 injuries per year (95% CI=15,571, 24,415) implying that the serious injury rates from road traffic injuries in Karachi were at least 21 times higher than what is officially reported by the police at that time period (see Table 5).

Table 5. Deaths and injuries numbers by traffic police, ambulance service and estimates through capture recapture method.

	Deaths	Injuries
Traffic Police	544	793
Ambulance Service	343	2,048
Capture Recapture*	972	18,936

*Least restrict criteria used

Study 3

The Accuracy of Ambulance Data on Road Traffic Injuries

Completeness of information in ambulance data

The ambulance service transported a total of 1,006 road traffic injury victims to the three trauma centers in the city. Completeness of information was assessed by studying ten data pieces for each injured victim. Of the 10,060 data elements, a total of 546 entries (5.4%) were missing. All 546 entries were missing from 340 cases (27.3%). Two-thirds of the missing/unknown data concerned individual identifiers, i.e. name of the victim (38.4%), and age (29.1%). In more than 90% of cases there was complete information on vehicle type, activity of the injured, location, time, destination hospital, gender, and outcome.

Data availability from two commonly used sources of RTIs
Medical examiners' reports and inpatient medical records were obtained for the sample of 600 individuals transported by the ambulance service to the three major trauma centers (first 50 cases each month). Only 245 cases were present in the medical examiners' reports. Due to difficulty in locating inpatient medical records, even fewer had an inpatient medical record available for review (n=97).

Accuracy of ambulance data
Among cases present in either one or both of the medical examiners' reports and the inpatient medical records, a high level of agreement on individual variables was found. For example, in 98% of cases where AD showed a road traffic event as cause of injury, medical examiners recorded the same (241/245). Of the four unmatched cases in the two sets of records, two were identified as injuries secondary to "Burns", and two as due to "Assault" in the medical examiners' reports. The name matched in 232 out of 245 cases (89%), place – i.e. within the jurisdiction of the same police station – in 238 (95%), and time (+/- 3 hours) in 231 (89%). Outcome matched in all but seven cases (238 out of 245; 93%).

Whereas, only two of the medical examiners' reports contained a description of the injury event and circumstances, data of that kind were present in almost 90% of ambulance-based reports.

Inpatient medical records were also compared with the AD. None of the inpatient medical record showed place or time of injury. Information of interest in medical records closely matched the AD, and showed a strong level of agreement except for age of the injured.

Study 4

The Changes in Patterns of Road Traffic Injuries Over Time

Changes in RTI and Road User Characteristics
The total number of RTIs in the ambulance data is significantly lower in 2003 than in 1995 (2,692 in 1995 and 1,571 in 2003). Of these, respectively 585 (21.7%) and 328 (20.8%) were children (p=0.47). Males constituted the majority of victims, 86.8% and 87.4% respectively (p=0.6); and the average age of the victims, 29.0 years (±11 yrs) in 1995 and 28.8 (±11.3 yrs) in 2003, remains much similar (p=0.5).

The road users represented in the injury data are similar for the two study years (see Table x). Pedestrians continue to account for the highest proportions in both years with 30% (n=806) of all victims in 1995 and 27% (n=424) of all victims in 2003. Motorcyclists and minibus passengers followed for both study years (13.2% in 1995 and 18.3% in 2003; 13.7% in 1995 and 15.8% in 2003 respectively).

Among the vehicles involved in road crashes, minibuses, trucks and motorcycles in both years topped the list. There was also a significant reduction in the involvement of buses from 7.6% to 4% (p<0.00; OR 0.51 CI 0.39-0.66), and an increase in the proportion of private cars, (involved in 8.1% of road traffic crash vehicles in 1995, and 15.7% in 2003 (p<0.00; OR 1.94 CI 1.67-2.25).

A significant increase in pre-hospital mortality is noted (13.6% to 19.2%) between the observation years (p<0.00; OR 1.78 CI 1.50-2.11). The significant differences observed for all ages aggregated, remain significant only among adults.

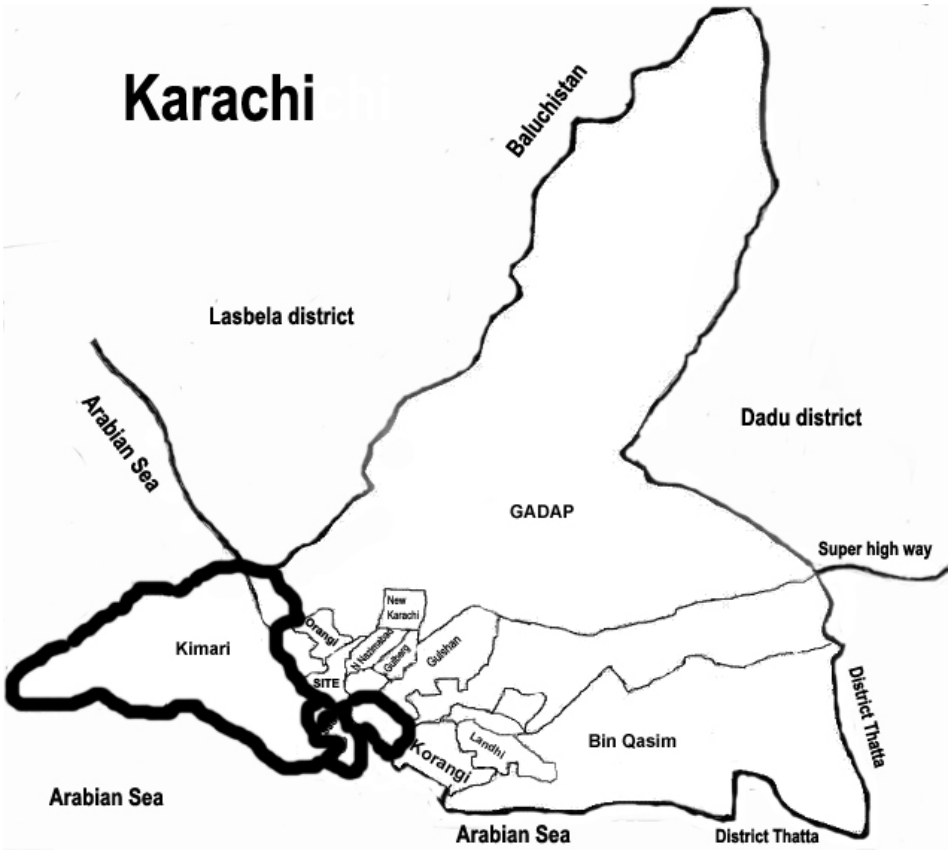
Table 6. Changes in road traffic injury victims and crash characteristics.

	No Significant Change	Significant Change
Average Age	X	
Gender Distribution	X	
Case Fatality		X
Vehicles Involved		
Minibuses	X	
Buses		X
Trucks	X	
Motorcycles		X
Private Cars		X
Victims		
Pedestrians	X	
Motorcyclists		X
Minibus Passengers	X	
Bus Passengers	X	
Pvt Car Passengers	X	

Changes in Spatial Distribution of RTI

The town with the highest proportion of RTI *(Gadap)* is the same for both years but many other towns show significant differences. (Figure 4) Differences in the case fatality ratio were assessed for towns with only 5 of the total 19 showing any decline. Of the 14 with an increase in case fatalities, only 3 were statistically significant. Further analysis by victim and injury characteristic did not reveal an identifiable reason for this change.

Figure 4. Towns with increase in the number of road traffic injuries between 1995 and 2003.



Unpublished Results on Adult Injuries

Information on adult injuries in Karachi, though not presented in a separate publication, can be found in papers 1, 3 and 4. In brief, during the 26 month study period from 1993-1995, 5654 injured adults were transported by the ambulance service and 83.4% of them were RTIs (n=4714). RTIs were followed by falls (3.9%, n=220), drowning (3.4%, n=190), and burns (2.6%, n=145). Interestingly, there were also 457 cases of "drug addicts" found dead on the streets, 244 others who were found dead with no known cause and an additional 213 who were found unconscious. Some of these cases could also be due to RTIs though no information to confirm that assertion was available to the drivers.

Summary of results

Burden and Characteristics of RTI: For the year 1994, police reported 544 deaths and 793 injuries while ambulance records noted 343 deaths and 2048 injuries due to road traffic crashes (study 2). The capture-recapture analysis estimated at least 972 (CI=912, 1031) deaths and 18936 (CI=15507, 22342) injuries during the study period. Thus the traffic police records counted only 56% of deaths and 4% of serious injuries, while the ambulance data counted only 35% of deaths and 11% of serious injuries. For the period 1993-95 it was observed that children aged 0-15 incurred 21% of the total number of RTIs recorded. Motor vehicle crashes (MVC) caused 80% of those injuries. One in six of the fatally injured children (15%) died either at the scene of the accident or during transportation to the hospital. Large vehicles (buses, minibuses and trucks) were involved in 54% of all cases. Comparing 1995 and 2003 (study 4) showed a 41% lower number of RTIs in 2003 compared to 1995 (1517 and 2692 respectively), with a 35% increase in the pre-hospital mortality (13.6% compared with 19.2%). The road users most likely to be injured in both instances were pedestrians, motorcyclists and minibus passengers. Whereas minibuses (24.7% and 23.5%), trucks (16.7% and 17.1%) and motorcycles (13.6% and 18.3%) remained frequently involved, the proportion of cars nearly doubled (8.1% to 15.7%). Some shifts in areas with higher proportion of RTI changed with some areas (towns) showing large increases in case fatality rate.

Data Quality: A total of 1,245 adult RTI victims were transported by the EAS during 2003 (study 3), most of which were males (89.6%). Victims were, in rank order, pedestrians (24.9%), motorcyclists (20.9%), occupants of large public transport vehicles (minibuses, buses, coaches, coasters) (21.9%), car occupants (7.6%), and occupants of large commercial vehicles (6.9%). Comparing ambulance data with the two other data sources (study 3) revealed that there were missing entries in EAS in about one in four cases (27%), the majority of which were the unique identifiers like name and age (67%). Data on other variables were reported in 95% or more cases. None of the medical examiners' reports or inpatient medical records contained a description of the injury event. The agreement rate for the variables available in the three datasets ranged from 61% to 100%.

Discussion

RTIs In Karachi – Victim and Crash Characteristics

RTIs were the most common cause of injuries among both children and adults in Karachi, a finding consistent with international estimates.[1 57 36 58] Depending upon the exposure to traffic, other injuries may be more common. It was observed in a hospital based study from Islamabad that falls were the most common cause of injuries among children and RTIs were a distant second.[59] This difference is likely due to Islamabad's large rural surroundings, a relatively smaller population and fewer vehicles. Agra, like Islamabad, is a relatively small city in India and reported falls as the leading cause of injuries among children[60] while a township in Johannesburg, South Africa had violence as the predominant cause of injury.[61]

Of all road users in Karachi, **pedestrians** were the most commonly injured group. Other studies from Pakistan show similar results[62 59 63] except the Pakistan National Injury Survey which showed vehicle occupants as the most likely road user involved in a crash (34%) followed by cyclists (24%), motorcyclists (21%) and pedestrians (12%).[64] The predominantly rural and suburban setting of this survey and the low number of crash victims in this study probably account for these differences. These variations reiterate the importance of local data for effective priority setting for interventions.

Internationally also, pedestrians are the most likely road user to be injured as seen in multiple studies from Asia[65 66 67] Africa[68 69] Latin America [70 71] and the Caribbean[30]. Many reasons are given for higher injury rates among pedestrians, including mixed road use, road designs with no space dedicated to pedestrians and traffic environment forcing risk taking behaviors. Mirza et al studied these high risk pedestrian behaviors in Karachi and reported that often pedestrians in Karachi crossed one lane at a time, or crossed as a group or ran across the road.[72] Other possible causes and interventions for pedestrian injuries are discussed elsewhere in this section.

Buses and minibuses constitute only 4% of all vehicles in the city and are the major part of the public transport system in Karachi. Despite their relatively low numbers, their involvement in RTIs is alarmingly high. Many other studies from LMICs including one from Karachi confirmed these findings.[62 73 74 75] Commenting on the reasons for the frequent involvement of public transport vehicles in RTIs, Nantulya and Reich held liable the current road traffic environment and the economic compulsion of the drivers. The authors suggest that poor wages force drivers to work long hours resulting in driver fatigue, sleep deprivation, overloading, and reckless driving.

RTIs were found to be clustered in certain areas of Karachi. Similar **clustering of RTIs** has been reported widely.[1] In Mexico City for example 4 out of 16 regions of the city contribute to 57% of pedestrian deaths. Several determinants for the clustering have been described.[70] Some of the clusters are around black spots; a common term for areas with higher concentration of road traffic crashes. Analysis and treatments of these black spots, usually through engineering interventions is thought to an effective solution for prevention of RTIs[76] Similarly, in absence of proper land-use planning, residential, commercial and industrial activity evolve in a haphazard pattern. This produces heavy flows of traffic through residential areas thus increasing chances of a crash.[77 78] The social and economic class of the neighborhoods has also been implicated as independent determinant for RTIs. [79 80] In the United Kingdom for example, the pedestrian injury rates among children from areas with highest economic deprivation were 3 times higher than rates for children in the most affluent areas.[81] In Karachi too, the areas with highest number of RTIs were generally lower socio-economic areas and those closer to one of three main highways originating from the city.

Pre-hospital Deaths due to RTIs in Karachi

The majority of deaths due to RTIs worldwide occur in the pre-hospital phase. Many of these deaths are thought to be potentially preventable through improved pre-hospital care[82 83] This is extremely important in the context of Karachi where fatality rates are several times higher than in other places. As shown in studies 1 and 4, one

out of every six children and one out of every seven adult victim of road traffic crash died before reaching the hospital compared to the international figure of 1 death for every 50 injuries

Three possible explanations could be offered for the observed higher mortality.

1. **Pre-hospital factors** like delay in reaching the crash site and lack of even the most basic medical care during transportation are two important factors determining injury outcomes. [84 85] According to one study, the pre-hospital component of the total RTI mortality was higher in countries with poor post-crash care. Ghana (81%) one of the countries studied, had no formal pre-hospital care system and was found to have the highest pre-hospital mortality. It was followed by Mexico (72%) and USA (59%) with higher level of sophisticated of pre-hospital services.[86] While Edhi ambulance service has extensive network, the actual response time in case of RTI is not available. Estimates provided by the ambulance service staff range from 15 to 30 minutes depending upon the area. This response time is considerably higher than the response times of <5 minutes in many advanced pre-hospital systems. Another factor, as discussed in material and methods, is the lack of care during the ambulance transportation. No direct evidence exists for improvement in outcome secondary to medical care in the ambulance in urban settings like Karachi. In fact the emphasis in many HIC is on rapidly transporting victims to the hospital rather than wasting time in the field. In the last six months, the Edhi ambulance service has started training drivers in basic life support and the results of this intervention may help illuminate the impact on outcome.
2. The majority of victims in Karachi are pedestrians and drivers/passengers of two wheeled vehicles; the most unprotected of the road users. The most commonly involved vehicles are buses, minibuses and trucks which are powerful because of their mass, geometry and structural properties. A crash between a pedestrian and a truck will cause a much more severe injury even at a

relatively low speed.[87] It is thus plausible that **the severity of injuries** in Karachi is higher than in other places

3. **Selection bias** is also likely as patients requiring transport by an ambulance are known to have more severe forms of injuries compared to those who can walk or are able to sit up in another form of transport. A discussion on this aspect is included as part of the limitations of the thesis.

Changes Over Time — Victim and Crash Characteristics
Study 4 attempted to identify differences in the causes, locations and outcome of RTIs between the two observation years. Most of the victim and crash characteristics remained unchanged. Pedestrians, motorcyclists and passengers of buses and minibuses were still the most frequently injured group. Vehicles involved in the crash also remained similar. There were two very important differences. In 2003, ambulance service transported 41% less victims of RTIs and of those who were transported; the fatality rate was significantly high in 2003 then 9 years earlier.

The **reduction in the total number of RTIs** is an unexpected finding. During this time, the city grew rapidly adding 31% more people[53] and 32% more vehicles (Karachi City District Government, 2004). Unlike HIC, where reduction in RTIs is a well-documented contemporary phenomena[1] downward trends in LMICs have not yet been widely reported. Where such reductions were found, varied explanations like deterioration of the economic status of the country, (in Thailand)[67] to the artefacts of the data at hand (in Mozambique) were presented[69]. In Karachi, the main question is whether the change is real.

There has been a decrease in the numbers of ambulance centres in the city with an resultant change in the coverage and reach of the ambulance service between the two study periods. This could have caused a decline in the service's ability to provide prompt service and thus reduce the number of patients transported by them. Two methods were applied to confirm this hypothesis: first, the police data were assessed for a similar change. Data from traffic police also showed a decrease 15% in RTIs. Secondly towns with reduction in the number of ambulance centres were compared to those

without. However, before a final conclusion can be drawn more in-depth study including application of a capture-recapture method needs to be done.

Another significant difference was **an increase in the pre-hospital mortality** of RTI victims. Greater involvement of motorcyclists who are known to have higher mortality is one of the reasons. There is also evidence to point to the fact that ambulances may be transporting patients with a greater severity of injuries in 2003 compared to 1995. This is suggested by higher fatality rates among groups like pedestrians.

Data Sources for RTIs – Lessons Learned

Coverage: Prior to 1995 the incidence of RTIs in Karachi was based on figures from police. Around that time, use of ambulance data was also being investigated. There was a concern that both of these data sources underestimated the public health importance of the issue. Capture-recapture methodology, which is used to estimate true incidence using two or more imperfect and incomplete sources of data, was applied. Its successful use has been reported in demography, ecology, infectious diseases as well as in injury research[88 89 90 91 92 93 94 95 96 97]As estimate based on capture-recapture method showed, both police and ambulance service grossly underestimated RTI burden in the city (study 2). Police records counted 56% of the estimated deaths and 4% of serious injuries while the ambulance data counted 35% of deaths and 11% of serious injuries. These differences were based on the most conservative estimates from the capture-recapture analysis. Using more liberal matching criteria, capture-recapture analysis estimates of RTI are more than twice as high for injuries and more than 3 times as high for mortality.

The problem of underestimation by secondary data sources like police, hospital, emergency departments, and ambulance service is well documented in other settings. Tercero from Nicaragua reported that only 1 in 4 fatalities and 1 in 7 injuries were reported by the police.[98] Similarly, when Baracik and Fife matched the records of the patients presenting to the emergency department with police records, they found that only about half of all cases

presenting to the emergency department were present in police registers[99] In Australia, police reported 64% of all traffic injury admissions in a hospital[97] in one study and 50% of patients seen in the emergency department in another study.[42] Ambulance did a little worse than police in this study. Among children less than 15 years a study from California, USA found a police under-reporting rate of about 20% for pedestrians and 10% of bicyclists.[100]

The under-counting is not uniform. If affects some groups more than others. A study from la Reunion Island compared police data with a community based data and found better reporting of deaths (87%) compared to a significantly lower reporting of hospital admissions (37%).[95] In another study, drivers, and victims transported by ambulance service and those requiring admissions were more likely to be registered with the police. Children, lower socioeconomic groups, people from out of state were less likely to be registered in their study population.[99] Similarly, in another study, the reporting by police was found to be higher with increasing levels of injury severity and was substantially lower for casualties of certain ethnic groups.[97]

Comparing Karachi to other cities in the region provides interesting insights into the effects of difference in data definitions, collection methodology, coverage and accuracy. Review of the urban RTI data from the 3 out of 4 neighbouring countries (except Afghanistan) showed huge variability. The capital of India, New Delhi is a city similar to Karachi in population, area and road length. Police in New Delhi report 3-4 times as many deaths due to RTI than the police in Karachi.[20] Bombay, another Indian city with an even a greater population and vehicle numbers reported 1361 deaths; a figure two and a half times greater than reported the Karachi police and closer to the estimates of capture-recapture analysis.[20] Beijing, the largest city in China, reported 1502 fatalities in 1999.[101] On the other hand, the city of Tehran, with a population of 8 million, reported only 174 deaths in 2003 from a study based on six major hospitals in the city.[102] These variations under-score need for uniformity of data definitions and collection methods in order to facilitate comparison within and between regions.

Accuracy: Study 3 and to a lesser extent studies 1 and 4 provide an evaluation/assessment of the accuracy of ambulance data by comparing results from ambulance data with data from the hospital, police and the medico-legal services. Four observations emerge from these comparisons:

1. The Edhi ambulance services records had complete information on a majority of the variables studied. However, unique identifying information was missing from a quarter of cases. This is expected, as patients using ambulance are often are too sick to provide any information. In many cases, there is no time to collect information, as prompt transportation is the priority. Other more established EMS systems of US and Europe have reported similar limitations. A study done in Daytona, USA for example found[103] that data on speed, helmet use and alcohol use was often missing from the pre-hospital care data.
2. The second important conclusion is that the information contained in the ambulance data is as accurate as the hospital and medico-legal data. In this study, it was assumed that the hospital and medico legal data were themselves completely accurate; a fact which may not be true. However, since these two along with the police make the bulk of epidemiological literature on RTI worldwide, findings from this study should reassure researchers and policy makers who base their decisions on data from ambulance service.
3. The third important finding of the study was that in Karachi, access to the hospital records of trauma victims is difficult and unreliable mainly because of poor record keeping and filing system. Only 40% of hospital records were available despite repeated visits and access was worse for some hospitals than others. These variations reflect mainly lack of resources both financial and human. The results from 2003 also showed that the reasons identified in 1995 leading to the use of ambulance service data in the first place persisted in 2003.

4. Another important finding was that the hospital and medico-legal records do not have information important for public health interventions. Description of the event of injury and the activity of the victim (pedestrian vs. motorcyclist for example) were universally missing; findings which are not unique to Pakistan. Similar results were reported by Mutasingwa and Aaro from Tanzania where records of four hospitals showed significant gaps in the information recorded.[104] Studies from non-injury literature also show similar problem with using hospital records. A study of inpatient pediatric care facilities in 13 districts of Kenya identified both missing and inconsistent information in the hospital records.[105]

Limitations

Selection Bias

Selection biases are distortions that result from procedures used to select subjects and from factors that influence study participation.106 In ambulance data, selection biases occur in two main forms: 1- bias towards selecting severe injuries[107] 2- bias in selecting certain people who have access to the ambulance service compared to those who do not. Poor road infrastructure in some areas and unavailability of phone and other communication system can hamper ambulance usage in certain neighbourhoods and by certain socio-economic class. Thus it is impossible to ensure provision of exact same level of access to the whole city by a given ambulance service. Similarly, not all patients with RTIs would be seen by police or would visit one of the three major trauma centres. Since not everyone in Karachi has equal access to the services from which these data are extracted, Karachi's total population cannot be used as a denominator, which causes difficulties in generalizing these findings as well as make it difficult to calculate accurate RTI rates.[108] [109]

The capture-recapture methodology was used to counter this bias. Even with the use of the capture-recapture method, only the more severe forms of injuries were captured and therefore even these estimates are probably the "tip of the iceberg". For the other three studies, no incidence data was presented.

A third type of selection bias could occur due to bias during reporting such that the system favours capturing of some cases more than others. This phenomenon has been described for the various data sources above; however, for Karachi reporting bias is a problem particularly with medico-legal data and police data[35] Such a bias is unlikely in case of the ambulance data.

Observation/Information Bias

Observation or information bias results from systematic differences in the way data on exposure or outcome are obtained from the various study groups.[110] A potential type of observation bias in the data at hand could originate from the misclassification of cases. In Karachi, no clear definition of RTI existed at the hospital or the ambulance service. There was a chance that misclassification could happen at the time of defining the cause of an injury as RTI. Data from study 3 showed a 1.6% rate of misclassifying another injury as RTI.

An additional information bias could occur while defining the outcome of an injury. According to the WHO, a road traffic fatality is defined as: "any person killed immediately or dying within 30 days as a result of an injury accident".[111] Of the four data sources used in this thesis, two (ambulance and hospitals) did not have any formal definition of death due to RTI. Thus ambulance and police may misclassify a person as alive when in fact they died after getting admitted to the hospital. The high fatality rate among ambulance transported patients may actually be even higher if a 30 day follow-up is done.

Lack of Trend Information

The study compares two year-points rather than analyzing trends. The extent to which these two years represent the RTIs in time in-between 1995 and 2003 is difficult to assess. While the change in RTIs is unlikely to be artefactual (as both ambulance and police data point to similar changes), it is still not known when during the period of 1995 and 2003, the decrease started. Also it is not know if this is a decrease is a long term event or just a one time outlier. In order to determine whether the differences observed are circumstantial or the reflection of a more profound change deserves investigation and this, in turn, calls for a more sophisticated design.

Missing Information

Unique identifiers were missing in about a quarter of all RTI cases in the ambulance data. Such information is not crucial in defining the high risk population groups. However, they become extremely important when attempts are made to link various data sources with the aim of consolidating the strengths of individual source. More unique identifier will be needed before meaningful linking of data is possible.

Thus strengths and the weaknesses of the studies in the thesis largely originate from the use the existing data sources in Karachi. Creating a new injury data system often seems more attractive because of greater control over data content, format, variables to be collected, population base, and the quality of the data. However, this approach suffers from extreme expense, length of time required to get a new system up and running, possible duplications of effort and technical and political complications. According to Christoffel and Gallagher:

> "Real world experience suggests that consolidating, evaluating, and improving existing, easily available sources of injury data should be the priority in an injury surveillance program. Using data already collected by another organization will be less complicated, less expensive, and less time consuming than undertaking your own data collection".[112]

Implications for Road Traffic Injury Control

RTIs are a Major Public Health Problem Requiring an Appropriate Policy Response in Karachi

Through a more accurate estimate of mortality and morbidity, studies from this thesis have helped define the public health importance of RTIs in Karachi. Political will, essential to any major policy shift, can be achieved only through increased awareness of the magnitude of the problem.[113] Efforts like this have resulted in government's keen interest in the area of road safety. The province of Sindh wherein Karachi is located declared year 2005 as the year of road safety. Also recently, the Governor of the province has established a high level advisory board to look into possible steps to make roads safer.

Prevention Activities Targeted to the Vulnerable Road Users

Identification of groups at higher risk for RTIs particular to a given region is critical in making appropriate preventive interventions.[113] In Karachi, preventive efforts have to be targeted to the pedestrians, motorcyclists and passengers of public transport vehicles and the system of public transport. Based on this information a number of preventive steps can be taken that do not require further research. These interventions include instituting traffic calming techniques especially in areas of mixed road use,[114] physically separating pedestrians from buses, minibuses and trucks; enforcing helmets laws; implementation of policy of keeping the doors of buses and minibuses closed except when at a stop, redefining the bus routing system to reduce the competition between drivers and tying compensation of drivers with the hours of driving rather than with the number of passenger transported.

Prevention Activities Targeted in Some Areas/Neighbourhoods

The studies in this thesis identify areas with higher rates of RTIs. Because of the limitations described above, confirmation of the geographical distribution may be carried out using other data sources. Once confirmed, more in-depth look at the most frequent areas of RTI can be taken in order to identify black spots. Treatment of black spot through engineering interventions can greatly reduce chances of RTIs in those places. [76]

Improvement in Pre-hospital Care

Studies from other low income countries have shown survival benefits with affordable, simpler pre-hospital care interventions in low-income country settings.[115,116] The finding of a high pre-hospital mortality among victims of RTIs in Karachi highlights the need for implementation of such interventions. Initial efforts could be targeted towards reducing response and transport times and instituting basic life saving measures. A pilot project could be started in areas like Gadap, which has consistently shown higher number of RTIs and deaths.

Implications for the Role of Ambulance Data in RTI Surveillance System

Often too much time and too many resources are spent on defining the burden of injuries leaving very little resources to actually do something about the problem. Thus cost of data collection from ambulance and other sources presented in this thesis are of prime importance from LMIC perspective. The cost of data collection, entry and primary analysis for the 26 month data (1993-1996) was less than US$:500. In 2003 when the data was collected for one year period, the cost was US$:150. Though this cost does not include the cost of space and computer usage, the overall cost would still be much smaller than any new system of data collection.

The results of this thesis support the idea that using existing sources of data can limit the cost and resources needed to draw the main lines of RTI characteristics and distribution. Given that the limitations of the data are well-understood, large amounts of useful information can be garnered from these sources in settings like Karachi.

Few cities in LMICs have a well developed pre-hospital care system, most don't have any formal system of pre-hospital transportation or care. But interest in this area is growing[115 117] and recently World Health Organization published guidelines for Pre-hospital Care of Trauma Victims.[118] The findings from this thesis would allow a developing pre-hospital care system to incorporate the data collection as one of the important functions of the system and focus on eliminating many of the limitation faced in Karachi and studied in this thesis.

The next step in Karachi would be to use the findings from these studies to establish an injury surveillance system. Such a surveillance system will require data from at least two sources one of which should be the ambulance data which is currently the only source of information on the event of injury. To obtain more accurate place of Karachi and proper follow-up, medico-legal records may be used as the other source. Establishing that link though possible would require improvements in the collection of unique identifiers as well computerizing the current data recording system. Preliminary work on computerizing the record at the ambulance service has

already started and all of the non-emergency transports by the ambulance service are being entered into a computerized database. Computerization of the medico-legal records will be a more difficult task requiring substantial investment by the government as well as attitude change.

Implications for Future Research

There is a dearth of good quality intervention research in LMICs. Urban areas are especially in need of best practices and practical solutions to prevent RTI.[119] Initially such research projects can target pedestrians, two wheelers, buses and minibuses, road engineering and pre-hospital care system.[113] Relationships built during the project with ambulance, police and medico-legal department can be very useful in such intervention trials.

Conclusions

In Karachi, males, pedestrians, motorcyclists and passengers of public transport vehicles constitute the majority of RTI victims in the two study periods. A large number of these injuries involve buses, minibuses and trucks. Also, while many victims and events characteristics remain unchanged between the two periods, there are some noteworthy changes, in particular a reduction in the total number of victims, an augmentation in case mortality rates and some changes in the geographic distribution of injuries. Changes are observable among adult victims but not among children.

In addition, it appears that the burden of RTIs is much larger than would be expected if only ambulance or police or the data alone were used to generate incidence rates.

Finally, from another point of view, while there are limitations to all the major sources of RTI information in the city, ambulance data provides as accurate and more detailed information then either the medico legal reports or the hospital records.

These findings can serve as a basis for researchers and policy makers in identifying RTIs as a major public health problem in the city and for the planning of effective and focused interventions. They also provide a qualitative and quantitative assessment of the potential of ambulance data as an instrument for RTI surveillance.

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