Road Traffic Injuries in Mexico

Harvard University Initiative for Global Health

Road Traffic Injury Metrics Group

Website: http://www.globalhealth.harvard.edu (click on Research => Road Traffic Injuries)

16th August 2008

Authors:

Kavi Bhalla[1]
Saeid Shahraz[1]
David Bartels[1]
Rafael Lozano[2,3]
Christopher Murray[2]

[1] Harvard University Initiative for Global Health, Cambridge, MA, USA
[2] Institute for Health Metrics and Evaluation, University of Washington, Seattle, WA, USA
[3] Ministry of Health, Mexico City, Mexico

This analysis was supported by grant funding from the World Bank Global Road Safety Facility.

Acknowledgements

We are grateful to the Mexican Ministry of Health (Secretaría de Salud), particularly the Vice Ministry of Innovation and Quality, and the General Direction of Health Information (GDHI) for providing access to the datasets used in this analysis of road traffic injuries in Mexico. This analysis would not have been possible without the extensive efforts of the GDHI in the careful design and implementation of these data collection activities. We are also grateful to the World Bank Global Road Safety Facility for providing the grant funding that enabled our analysis.

Table of Contents

Executive Summary

This report on Mexico is the second comprehensive assessment of road traffic injuries metrics at the country level produced by the Harvard University Initiative for Global Health Road Traffic Injury Metrics Project for the World Bank Global Road Safety Facility. The 2004 World Report on Road Traffic Injuries emphasized the need for reliable injury surveillance systems capable of generating reliable data for describing the public health burden of road traffic injuries, evaluating the impact of safety policies, and benchmarking achievements. However, most developing countries are unlikely to develop the capacity and infrastructure for such surveillance for several decades. Thus, this project intends to provide an interim solution that uses all existing information sources to triangulate to a national snapshot of road traffic injury metrics.

To produce this comprehensive country assessment of road traffic injuries in Mexico in 2005 we analyzed data from three data sources. Incidence of deaths from road traffic injuries were estimated based on the Mexican vital registration system and the incidence of non-fatal road traffic crashes, classified by the type of institutional medical care they received, were estimated based on the 2005 ENSANUT health survey. Two large hospital discharge registries (Ministry of Health and the Instituto Mexicano de Seguro Social) were analyzed for describing the nature of injuries sustained by crash victims.

The key findings of this report are summarized as follows:

- Road traffic deaths are a leading health concern for Mexico. 19,402 people died in Mexico in road traffic crashes in the year 2005, amounting to 18 deaths per 100,000 people and making road traffic deaths the fifth leading cause of death.
- The situation is not improving. Annual road traffic deaths have shown no signs of declining in the last three decades.
- In addition to deaths, road traffic crashes result in a large number of non-fatal injuries - over one million people are injured annually.
- Young adult males are the demographic at the highest risk in non-fatal crashes, but the elderly have the highest road traffic death rates, largely due to pedestrian crashes.
- There is an urgent need to provide safe infrastructure for vulnerable road users. Pedestrians alone comprise nearly half (48%) of all road traffic deaths
- There is a need to control the threat posed by cars. Not only are car occupants at high risk (38% of deaths, 39% hospital inpatient admissions), but cars pose a substantial threat to other road users. Cars were involved in three-fourths of all deaths either as impacting vehicles or as single vehicle crashes.
- Providing adequate rural medical care should be a leading priority. Although rate of road traffic crashes is higher in urban areas, indicating a hazardous urban travel environment, the rate of survival in crashes is substantially lower in rural areas, suggesting severe shortcomings in adequate medical care in rural areas.

The government of Mexico needs to act immediately to implement the recommendations of the 2004 World Report to stop the needless loss of life on Mexican roads.

Chapter 1

Background and Methodology

Project Background

The 2004 World Report on Road Traffic Injury Prevention, jointly issued by the World Health Organization and the World Bank, highlighted the concern that unsafe roads pose a serious threat to global public health. The report emphasized the need for injury surveillance systems capable of generating reliable data for describing the public health burden of road traffic injuries, evaluating the impact of safety policies, and benchmarking achievements. While such monitoring systems are common in high income countries, most low and middle income countries are unlikely to have such capacity for several decades. In the interim, the Harvard University Initiative for Global Health has partnered with the World Bank Global Road Safety Facility to build a knowledge management system that uses all existing information sources to triangulate to a national snapshot of road traffic injury metrics.

As part of this project, we will perform 18 country assessments of road traffic injuries over the next two years. This draft report of road traffic injuries in Mexico is our second report. The first report on "Road Traffic Injuries in Iran" is available at our website (http://www.globalhealth.harvard.edu; click on *Research* => *Road Traffic Injuries*). We are committed to keeping this project open-source and collaborative in nature. All readers are encouraged to provide feedback to help improve methods, incorporate other sources of information, and suggest more effective methods of communication of these results.*

Layout of report

The remainder of this chapter introduces the country of Mexico and the context in which road traffic injuries occur. This is followed by a description of the methods and analytic tools used to estimate road traffic injuries and deaths. Chapter 2 compares the magnitude of the problem of road traffic injuries in Mexico with other countries and with other health problems in Mexico. Chapter 3 describes the epidemiology of fatal road traffic injuries, focusing in particular on the age and sex profile, victim types (pedestrian, car occupants, etc), impacting vehicle, place of residence (urban or rural), and the timing of crashes. Chapter 4 focuses on non-fatal road traffic crashes, the nature of injuries sustained, the type of care received (inpatient, outpatient, care at home, or none), and the public health burden of road traffic injuries measured in disability adjusted life years lost. Finally, Chapter 6 summarizes our key conclusions and recommendations.

* Feedback may be sent to kavi_bhalla@harvard.edu , Phone:1.617.496.6903

Country background

Geography and Political Organization:

The United States of Mexico (henceforth Mexico) is located in the Latin America and Caribbean region of the World Bank. Mexico is the 14th largest country in the world and is bounded by the United States to the north, the Pacific Ocean to the west, Guatemala, Belize, and the Caribbean Sea to the south, and the Gulf of Mexico to the east. Total land area is 1,972,550 square kilometers.[1] Mexican topography is characterized by two north-south mountain ranges, the Sierra Madre Oriental in the east and the Sierra Madre Occidental in the west, the Sierra Nevada (Trans-Mexican Volcanic Belt), which runs east to west at the country center, and the Sierra Madre del Sur, which runs along the southwestern coast. The area between the Sierra Madre ranges is known as the *altiplano* (high plain), and is divided into the Mesa del Norte, with an average elevation of 1,100m, and the Mesa Central, with an average elevation of 2000m. Climatically, Mexico is divided into temperate and sub-tropical/tropical zones, which vary geographically based on altitude and rainfall, and ecosystems range from desert to tropical forest. Several major population centers, including Mexico City, are located in the "cool" zone, which exists above 1800m.[2] Mexico is a federal constitutional republic composed of 31 states and one federal district, the capital Mexico City. The 31 states are divided into municipalities (*municipios*), which are the smallest official political entity and are governed by a municipal president.

Demographics and Health:

According to recent population estimates, the 2007 population of Mexico was approximately 110 million, of which 76.5% live in urban areas.[3,4] The age structure is composed of 30.1% 0-14 years, 64% 15-64 years, and 5.9% 65 and more years.[3] Life expectancy at birth in 2007 for the total population was 76.2 years (73.7 for males and 78.6 for females). In 2007, the crude birth rate was 19.3 births per 1000 population, and crude death rate was 4.8 deaths per 1000 population.[4] Mexico is undergoing a period of epidemiological transition, during which the population continues to grow (1.15% growth rate estimated in 2007) as the epidemiological profile begins to exhibit mortality patterns similar to developed countries.[3] These patterns include reduction of overall mortality, infant and maternal mortality, and communicable disease mortality, and increased incidence of risk factors, such as obesity, and non-communicable disease.[5] Historical health structure and income inequities continue to persist and poorer states remain concentrated in the country's southern regions, where there is the highest disease prevalence and mortality from preventable causes. The 2005 human development index is 0.829, which places Mexico in the "high development" category.[6]

Economy:

Mexico has a free market mixed economy, which ranks Mexico in the World Bank Upper Middle Income category.[7] In 2006, Mexico's GDP was 1,201,838 million international dollars in purchasing power parity, ranking it 12th in the world.[8] Per capita income is one quarter that of the USA, and major income inequity exists.[9] The economy is a mix of agriculture and industry. Major industries include food, beverages, chemicals, petroleum, mining, clothing, motor vehicles, and tourism. In general, industry has become more dominated by the private sector, as exemplified by the restructuring and development of private railroads and toll roads in the past two decades.[10] Agricultural products include corn, wheat, soy, rice, beans, cotton, coffee, and fruit. Since the NAFTA agreement in 1994, trade with the United States and Canada has tripled, composing a substantial portion of the 90% of Mexican trade that falls under free trade agreements.[10]

Transport Sector:

The transport sector is of strategic importance to Mexico, due to its position between North and Central/South Americas and the importance of NAFTA-related freight transport in the Mexican economy. Mexico's increased integration into North American economic affairs will continue to boost the importance of freight transport.[11] In addition, transport-related industry, including car assembly and manufacturing of vehicle parts are vital to the Mexican economy.[12] The total road network in Mexico extends for 235,670km, and the paved road network extends for 116,751km (6,144km of expressway).[12] Some of this road infrastructure was constructed with World Bank loans from 1982-1997, as part of transport development and privatization of toll roads and railroads.[13] Increasing vehicle ownership, due to development of a domestic automobile industry and reduced prices of passenger vehicles, has placed stress on existing road infrastructure.[14,15] Additionally, increased vehicle ownership has contributed to negative traffic-related issues, such as traffic congestion, air pollution, and road traffic injuries.[16] These consequences disproportionately affect the urban poor, who have greater exposure risk to vehicle traffic.[15] Of note, 76.3% of the total Mexican population lives in urban areas.[17]

In this report, we focus our attention on quantifying the magnitude of the road safety problem in Mexico. This report emphasizes the magnitude of the health burden and provides a systematic analysis of the epidemiology of road traffic injuries.

Documentation of methods

Overview

This comprehensive country assessment of road traffic injury metrics contains best estimates of national level road traffic deaths, severe and minor injuries differentiated by age, gender, location (urban and rural), victim type (e.g. pedestrian, car occupant, etc), and vehicle type (e.g. car, motorcycle, etc). This report relies primarily on health sector data because road traffic death police statistics in most developing countries, including Mexico, are widely recognized to be incomplete.

Our general strategy is to develop a national estimate from various data sources that capture different aspects of the problem. In the current analysis of Mexico, data was sourced from vital registration, hospital registries, and health surveys. These datasets were processed to account for variables containing ill-defined causes and unknowns, and the results were extrapolated to the national level.

Data Sources

The following data sources were used to estimate the incidence and burden of road traffic injuries in Mexico. Unless otherwise stated, all analyses are for the year 2005.

Deaths: The following sources of death registration data were used to estimate the incidence of deaths. Note: sources within the Mexican registration system are listed separately because they provide different levels of detail for this analysis.

- Ministry of Health death registration data 1979-2005, unit record data: Contains only external causes for injuries.
- Multiple causes of death data: SEED, 2001-2005: Ministry of Health death certificate registry, unit record data. The data set included external causes as well as nature of injuries coded using ICD-10 categories.
- WHO Mortality Database: 1955-2005, Age-sex tabulations. During this period, Mexico transitioned from ICD-7 through ICD-10 reporting. Note that ICD-9 reporting available in this dataset uses the Basic Tabulation List.

In addition to causes of death, the unit record data also included many other victim variables, such as age, sex, location of residence, education, marital status, occupation, insurance, medical care before death, and the death certifying agency.

Detailed analysis of the Mexican injury mortality data, coding issues, and implications for handling unspecified causes are described in a separate internal report that can be provided on request.

Hospitalizations: The following sources of information about hospitalizations were analyzed.

- All Ministry of Health hospitals discharge records for 2005, unit record data. The data set contains information about both external causes as well as nature of injuries.
- Instituto Mexicano de Seguro Social (IMSS) hospitals discharge records for 2005, unit record data. Although IMSS hospital discharge records contain information about the nature of injuries, they do not record external cause codes.

Outpatient Visits: Emergency room data for 2005, unit record data. This dataset includes external causes (aggregated at the level of road traffic crashes resulting in occupant and pedestrian injuries) and nature of injuries sustained.

Health Survey: Two recent national health surveys, Encuesta Nacional de Salud y Nutrición (ENSANUT)-2005, and the 2003 World Health Survey (WHS). The results from these two surveys were compared. A summary comparison of the results from the two surveys is provided in Appendix 1. A detailed comparison report is available on request. Ensanut 2005 is used in the national estimates reported here because it provides a direct breakdown of care received for road traffic crashes. (See Appendix 1 for a comparison.)

Building a National Injury Snapshot

As illustrated in Figure 1.1, the process of generating a national snapshot of road traffic injuries has four broad aspects: deaths, hospitalizations, emergency room visits, and events that did not receive any institutional care. The national snapshot includes estimation of cases by external causes, the distribution of injuries, particularly for non-fatal cases that receive (or should receive) medical care, and the distribution of various other variables (including age, sex, timing of events, location of events, etc.).

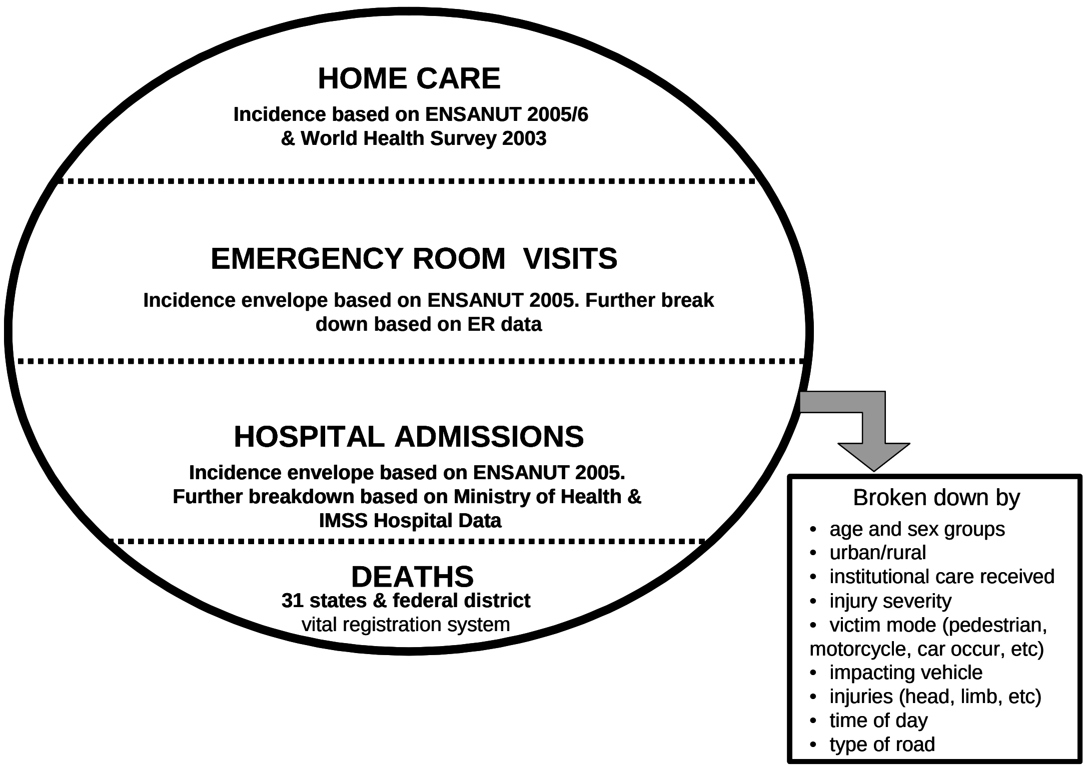


Figure 1.1: Developing a national snapshot of road traffic injuries in Mexico from all available data sources. Although we strive to estimate the breakdown of all data sources by the categories shown, at present this is not always possible.

The incidence of deaths is best captured by analysis of death registration system data, which in Mexico captures nearly all deaths (100% complete and 96% coverage in 2001).[18] Multiple causes of death data is used to characterize the pattern of injuries for fatal cases.

Incidence of hospitalizations and outpatient visits can be determined from hospital discharge datasets if these cover all medical facilities, or the coverage can be characterized, as a function of age, sex, and cause of hospital visit, so that incidence can be extrapolated after adjusting for biases. Although MOH and IMSS hospitals are expected to account for approximately 80% of all hospital facilities, a definitive estimate of coverage is not available. As a result, we used the health survey ENSANUT, which included questions about type of care received for road traffic crashes, to estimate the net incidence of hospitalizations and outpatient visits. However, road traffic crashes, especially those that result in use of medical facilities, are rare events in ENSANUT and further characterization of the distribution of hospitalizations and outpatient care was not possible using survey results. Thus, we used the MOH and IMSS hospitalization datasets and the ER dataset to disaggregate results by age, sex, external cause, time of crash, and location of crash. The MOH hospitalization dataset allowed further disaggregation of hospital admissions by nature of injuries. Similarly, the ER dataset was used for disaggregation of outpatient visits by nature of injuries.

Finally, the incidence of road traffic injuries that do not receive any institutional care was derived from the health survey ENSANUT.

Definitions Used

A common set of definitions used in the analysis of all countries analyzed in this project is available in a separate internal report available from our website.[19]. Key definitions from this report and adaptations needed for the Mexican dataset are described below:

- Ages are grouped into 11 categories (< 1, 1-4, 5-14, 15-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84, and 85+ years) following the current revision of the Global Burden of Disease Study.
- Location (urban/rural). Our review of the literature did not reveal a consistent definition for urban and rural areas. Definitions vary by country and also evolve in time. Thus, for instance, the United Nations Statistics Division provides population estimates for urban and rural areas but does not use the same definition in all countries.[20] Instead, they document the varying country specific definitions. We have adopted the definition of urban areas used by the UNSD for Mexico in their 2005 Demographic Yearbook: "Localities of 2,500 or more inhabitants."[20] It should also be noted that throughout this report location refers to location of residence, which may have an urban/rural classification different from the location of the injury event.
- Groupings of External Causes: The death registration datasets and the hospital discharge datasets were classified using ICD coding. The ICD-10 definitions for external cause groupings are shown in Table 1.1. ICD-9 data was also analyzed to estimate the time history of road traffic deaths. The GBD 2002 definitions for ICD-9 codes are used (RTI: E810-819, E826-829, E929.0).[21]
- Groupings of Nature of Injury Categories: The nature of injury ICD code groupings are shown in Table 1.2. HIGH Injury Code (Inj_code) mapping from ICD-10 code in the hospital dataset was based on the primary body region afflicted by the injury. These regions include: head, neck, thorax, abdomen, lower extremities, upper extremities, and other. These regions were assigned to match the injury body regions specified in the emergency room (ER) dataset. The ER dataset, however, also includes "vertebral column" injuries as a separate body region. This category was not included in the hospital mapping due to the difficulty of parsing vertebral column injuries from neck, thorax, and abdomen injuries. Unspecified ICD codes were mapped as "Unspecified" and dropped from analysis. Injuries that do not correspond to a wound or burn in a specific body region (e.g. poisonings, T36-T50) were mapped as "non_Body_Region" and dropped from analysis. ICD codes that correspond to multiple injury regions (e.g. T00.1) were mapped as "2_Body region Body region," where "2" indicates a multiple injury to two body regions and "Body region"

corresponds to the body regions of injury. For example, 2_Head Neck indicates an injury to the head and an injury to the neck. In analysis, individuals with multiple region injuries were considered as multiple people with all variables constant except for injury body region.

Table 1.1: External cause of death codes mapped to standardized HIGH-RTI external cause classification

ICD-3dgt	ICD-4dgt	HIGH- External Cause Grouping
V01-V04	V01-V04	RTI_Pedestrian
V05	V05	Tpt_non_RTI
V06, V09	V06, V09	RTI_Pedestrian
V10-V19	V10-V19	RTI_Bike
V20-V29	V20-V29	RTI_TwoWheeler
V30-V39	V30-V39	RTI_ThreeWheeler
V40-V49	V40-V49	RTI_Car
V50-V59	V50-V59	RTI_Van
V60-V69	V60-V69	RTI_Truck
V70-V79	V70-V79	RTI_Bus
	V80.6	Tpt_non_RTI
V80	V80.1–V80.5, V80.7-V80.9	RTI_AnimalRider
	V81.0-V81.1	RTI_Others
V81	V81.2-V81.9	Tpt_non_RTI
	V82.0-V82.1, V82.9	RTI_Others
V82	V82.2-V82.7	Tpt_non_RTI
	V83.0–V83.3	RTI_Others
V83	V83.4-V83.9	Tpt_non_RTI
	V84.0–V84.3	RTI_Others
V84	V84.4-V84.9	Agr_veh
	V85.0–V85.3	RTI_Others
V85	V85.4-V85.9	Tpt_non_RTI
	V86.0–V86.3	RTI_Others
V86	V86.4-V86.9	Tpt_non_RTI
V87-V88	V87-V88	RTI_Unk_nonPedBike
V89	V89	RTI_Unk
V90-V94	V90-V94	Tpt_non_RTI
V95-V97	V95-V97	Tpt_non_RTI
V98	V98	Tpt_non_RTI
V99	V99	Tpt_Unk
	Remainder of V	Tpt_non_RTI
W00-X57	W00-X57	Accident_non_Tpt
X58	X58	Accident_non_Tpt
X59		Accident_Unk
	X590-X593, X595-X598	Accident_non_Tpt
	X594, X599	Accident_Unk
X60-X84	X60-X84	Intentional_non_RTI
X85-Y02	X85-Y02	Intentional_non_RTI
Y03	Y03	Veh_assault
Y04-Y09	Y04-Y09	Intentional_non_RTI

Y10-Y31	Y10-Y31	Inj_non_Tpt
Y32	Y32	RTI_Unk
Y33	Y33	Inj_non_Tpt
Y34		Inj_Unk
	Y340-Y343, Y345-Y348	Inj_non_Tpt
	Y344, Y349	Inj_Unk
Y35-Y36	Y35-Y36	Inj_non_Tpt
Y40-Y84	Y40-Y84	Inj_non_Tpt
Y85	Y859	Tpt_Unk
	Y850	RTI_Unk
Y86	Y86	Accident_non_Tpt
Y87		Inj_Unk
	Y870	Intentional_non_RTI
	Y871	Intentional_non_RTI
	Y872	Inj_Unk
Y88	Y88	Inj_non_Tpt
Y89	Y89	Inj_non_Tpt

For mortality data coded using ICD 9: RTI=E810-E819, E826-E829; Unknown Accident= E928.9, E929.9; Unknown Injury = E980-E989.

Table 1.2: ICD-10 injury codes mapped to High Injury Code (body region)

ICD-3dgt	ICD-4dgt	HIGH Injury Code
S00-S09, T15-T18, T26, T28, T90	S00.0-S09.9, T15.0-T17.1, T18.0, T26.0-T26.9, T28.0, T28.5, T90.0-T90.9	Head
S10-S19, T17, T27-T28, T91	S10.0-S19.9, T17.2-T17.4, T27.0-T27.1, T27.4, T28.1, T28.6, T91.8-T91.9	Neck
S20-S29, T08-T09, T17-T18, T21, T27, T91, T95	S20.0-S29.9, T08.0-T09.9, T17.8, T18.1, T21.0-T21.9, T27.2, T91.1, T91.3-T91.4, T95.1	Thorax
S30-S39, T18-T19, T28, T91	S30.0-S39.9, T18.2-T18.5, T18.8-T19.0, T28.2-T28.4, T28.7-T28.8, T91.5	Abdomen
S40-S69, T10-T11, T22-T23, T92, T95	S40.0-S69.9, T10.0-T11.9, T22.0-T23.9, T92.0-T92.9, T95.2	Upper Extremity
S70-S99, T12-T13, T24-T25, T93, T95	S70.0-S99.9, T12.0-T13.9, T24.0-T25.9, T93.0-T93.9, T95.3	Lower Extremity
T00-T04, T20, T95	T00.0, T01.0, T02.0, T03.0, T04.0, T20.0-T20.9, T95.0	2_Head Neck
T27, T91	T27.5, T91.0	2_Neck Thorax
T02	T02.7	2_Thorax
T00-T04, T91	T00.1, T01.1, T02.1, T03.1, T04.1, T04.7, T91.2	2_Thorax Abdomen
T00-T05	T00.2, T01.2, T02.2, T02.4, T03.2, T04.2, T05.0-T05.2	2_Upper Extremity

T00-T05	T00.3, T01.3, T02.3, T02.5, T03.3, T04.3, T05.3-T05.5	2_Lower Extremity
T00-T05	T00.6, T01.6, T02.6, T03.4, T04.4, T05.6	2_Upper Extremity Lower Extremity
T06, T27-T29, T31-T32, T66-T71, T73-T75, T78, T94-96, T98	T06.0-T06.9, T27.6, T28.9, T29.0-T29.9, T31.0-T32.9, T66-T69.1, T69.8-T71, T73.0-T73.3, T73.8, T74.0-T74.3, T74.8-T75.9, T78.0-T78.4, T78.8-T78.9, T94.9, T95.4, T96.8, T98.0-T98.9	Other
T00-T05	T00.8, T01.8, T02.8, T03.8, T04.8, T05.8	2_Other
T07, T14, T17, T27, T30, T94-T95	T07.0-T07.9, T14.0-T14.9, T17.9, T27.3, T27.7, T30.0-T30.9, T94.1, T95.9	Unspecified
T00-T05	T00.9,T01.9, T02.9, T03.9, T04.9, T05.9	2_Unspecified
T33-T65, T79-T88, T96-T97	T33.0-T65.9, T79.0-T88.9, T96.0-T97.9	Non_Body Region

Analytical Methods

The key methodological issues in this analysis relate to the unspecified and ill-defined coding categories described in Table 1.1 and the need to estimate external causes from injuries information in the IMSS dataset.

Redistribution of unknowns and unspecified codes

Table 1.3 describes the distribution of cases assigned to different dump categories. As can be seen, a large number of cases are assigned to unspecified road traffic crashes (i.e. further classification of the external cause is not specified) and unspecified accidents, which correspond to the ICD-10 code *X59: Accidental exposure to other and unspecified factors – exposure to unspecified factor*. The development of analytical tools for dealing with these poorly-defined categories is ongoing. The default method for these categories is proportional distribution by age and sex categories. For example, consider the process applied to death registration data:

1. Produce age-sex tabulations of all causes of death categories. This includes categories for unspecified variables.
2. Within each cause of death category, proportionately redistribute unknown age and sex cases over the known age and sex cases. This redistribution is done separately for each age-sex category in which either age or sex is unknown. Thus, for instance, males of unknown age are redistributed over the categories of males of known ages. Although this requires several repeated redistribution updates of the known categories, the process is not sequence dependent because each update refers to the starting known age-sex distribution rather than an updated distribution.
3. Redistribute unknown and ill-defined causes of death over known causes:
    a. Redistribution is done proportionately within age-sex categories.
    b. Partly specified causes are redistributed over their respective cause groups in multiple stages. First, unspecified road traffic crashes are redistributed over

specified road traffic crashes. This is followed by redistribution of unspecified transport accidents over specified transport accidents. Next, unspecified accidents cases are redistributed over specified unintentional injuries. Finally, unspecified injuries are redistributed over all injuries.

c. The broader ill-defined categories, which would capture both injury and non-injury deaths, were not redistributed over the injury categories.

This procedure of proportional redistribution is used in the Global Burden of Disease Study.[22,23] However, the potential for substantial biases in unspecified categories that are not corrected by age-sex stratification exists. Thus, it is necessary to use the unit record vital registration dataset to develop multinomial regression models that predict the cause of death based on independent variables, such as age, sex, place of event, place of residence, education, and insurance type.[24] (See Appendix 2.) We conducted out-of-sample validation of the results by dividing the registered cases for which external causes were known into two parts, using one part to estimate the regression model, and the other to validate the model. The results showed only slight improvements in performance. Our general conclusion, for this study and future analysis in other countries, is that while multiple logistic regression analysis has the potential of correcting for many biases, in practice it does not provide much improvement over proportional redistribution within age-sex categories. It should be noted that neither method provides a satisfactory solution to handling cases assigned to the ICD-10 code X59. Our ongoing research in this area suggests that this code may contain a disproportionately larger number of falls. This needs to be investigated further.

Table 1.3: Unknowns and Ill-defined Cases in VR dataset

	Death records	**Redistributed Over**
Total VR records	**485,376**	**-**
Total injury deaths	51,779 (100%) (10.7% of all deaths)	Specified provinces
Unknown sex	38 (0.1%)	Specified sex
Unknown age	678 (1.3%)	Specified age
Unknown RTI	6,618 (12.4)%	Specified RTI
Unspecified transport	7 (0.0%)	Specified transport
Unspecified accidents (X59)	6,867 (13.2%)	Specified unintentional injuries
Unspecified injuries	1,160 (2.2%)	Specified injuries

Estimating external causes in hospitalizations from injury information

The IMSS hospital datasets did not contain any information about external causes. The absence of external causes is common in hospital discharge datasets, even in high income countries. However, estimating incidence by external causes is essential for designing effective prevention strategies. Thus, we developed a method for estimating the number of hospital admissions due to each external cause based on injury diagnosis.[25] (See Appendix 3.) The method starts with a prior probability distribution of external causes for each case (based on victim age and sex proportions) and uses Bayesian inference to update the probabilities based on the victim's injury diagnosis. We conducted method validation by constructing trial datasets using the MOH hospital discharge dataset, in which both external causes and nature of injuries are recorded. The method performed significantly better than age-sex proportional distribution, which would have been the default method for estimating external cause categories that have distinct underlying injuries. The method functioned well at identifying poisonings, drowning, and fire cases, but performed less well when distinguishing between falls and road traffic injuries, which are characterized by similar injury codes in our datasets. We have used this method for age, sex, and external cause breakdown of the incidence of hospitalizations for Mexico because it represents a significant improvement over past work.

Burden Calculations

The methods for estimating DALYs from health facility data has been described by the Global Burden of Disease (GBD) study.[22,23] Public health burden is measured using the Disability Adjusted Life Year (DALY), which expresses years of life lost due to premature death and years lived with a disability of specified severity and duration.[22,23] One DALY is one lost year of healthy life. DALYs can be calculated for road traffic injuries in a population by adding the numbers of life years lost (YLLs) in fatal crashes and the total years of healthy life lost due to disabilities (YLDs) for survivors of non-fatal crashes. Years of life lost (YLL) correspond to the number of deaths multiplied by the standard life expectancy at the age at which the death occurs after time discounting and age-weighting, which gives less weight to years lived at younger and older ages. Similarly, years lost to disability (YLD) are estimated by multiplying the number of incident non-fatal injuries with a disability weight for the injury and the average duration (in years) of the disability resulting from the event.

The GBD methods are currently undergoing revision as part of the GBD-2005 study. Since it is expected that the method for computing YLDs will undergo substantial revision, we have not computed these in the current study and only report raw incidence estimates for hospital inpatient and outpatient data. However, we expect that the method for computing YLLs is relatively stable (i.e. unlikely to change substantially) and these are reported here computed using GBD-2002 methodology.[22,23]

References

1. Mexico-Geography, https://www.cia.gov/library/publications/the-world-factbook/geos/mx.html, accessed 25 March 2008.
2. Mexico-Climate, http://www.britannica.com/eb/article-27377/Mexico, accessed 26 March 2008.
3. Mexico-Demographics, https://www.cia.gov/library/publications/the-world-factbook/geos/ mx.html, accessed 25 March 2008.
4. Health Situation in the Americas – Basic Health Indicators, http://www.paho.org/english/dd/ais/coredata.htm, accessed 26 March 2008.
5. WHO-Country Cooperation Strategy, http://www.who.int/countryfocus/cooperation_strategy/ ccsbrief_mex_en.pdf, accessed 25 March 2008.
6. http://hdrstats.undp.org/countries/data_sheets/cty_ds_MEX.html, accessed 26 March 2008.

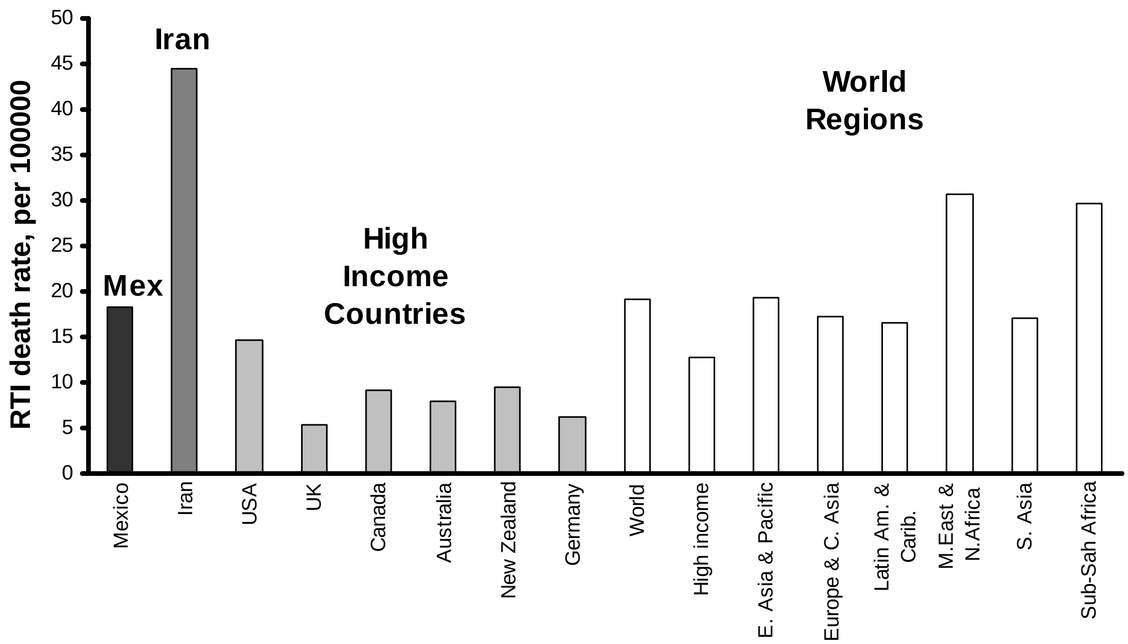
7. World Bank, http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,contentMDK:20421402~pagePK:64133150~piPK:64133175~theSitePK:239419,00.html#Upper_middle_income, accessed 28 March 2008
8. World Bank, http://siteresources.worldbank.org/DATASTATISTICS/Resources/GDP_PPP.pdf, accessed 26 March 2008.
9. Mexico-Economy, https://www.cia.gov/library/publications/the-world-factbook/geos/mx.html, accessed 25 March 2008.
10. World Bank, http://lnweb18.worldbank.org/oed/oeddoclib.nsf/DocUNIDViewForJavaSearch/ 12C776A78E010AD6852567F5005D71B4, 25 March 2008.
11. APEC, http://www.ieej.or.jp/aperc/2006pdf/Outlook2006/Whole_Report.pdf, accessed 26 March 2008
12. Mexico-Transport, https://www.cia.gov/library/publications/the-world-factbook/geos/mx.html, accessed 25 March 2008.
13. World Bank, http://lnweb18.worldbank.org/oed/oeddoclib.nsf/DocUNIDViewForJavaSearch/ 12C776A78E010AD6852567F5005D71B4, accessed 26 March 2008.
14. World Bank, http://www.worldbank.org/transport/urbtrans/cities_on_the_move.pdf, accessed 26 March 2008
15. WRI, http://earthtrends.wri.org/updates/node/135, accessed 26 March 2008.
16. UN. http://www.un.org/cyberschoolbus/habitat/profiles/mexico.asp, accessed 27 March 2008.
17. UNPD, http://esa.un.org/unup/p2k0data.asp, accessed 27 March 2008.
18. Mathers, C., et al., (2005), Counting the dead and what they died from: an assessment of the global status of cause of death data, Bulletin of the World Health Organization, 83(3), p.171-177.
19. Road traffic injuries – definitions, (Update Oct 2, 2007), Internal report, Harvard University Initiative for Global Health – Road Traffic Injury Metrics Project.
20. UN Demographic Yearbook 2005 (Table 6): http://unstats.un.org/UNSD/demographic/ products/dyb/dyb2005/notestab06.pdf.
21. Jamison, D.T., et al, eds., (2006), Disease Control Priorities in Developing Countries, 2nd ed., the World Bank and Oxford University Press, Washington, DC.
22. Murray, C.J.L., & Lopez, A.D, eds., (1996), The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020, Harvard School of Public Health, Boston, MA.
23. GBD2002 Global Burden of Disease (2002), World Health Organization. Available from http://www.who.int/healthinfo/bodestimates/en/. (Accessed on February 28 2008.)
24. Shahraz, S., et al. (2008), Redistributing ill-defined causes using regression models, Population Health Metrics, in prep.
25. Bhalla, K., et al. (2008), Estimating external causes for injury admissions in IMSS hospitals, Accident analysis and Prevention, accepted article.

Chapter 2

How big is the problem?

In 2005, road traffic crashes resulted in 19,402 deaths in Mexico – over 50 people a day and two people per hour. This represents an annual death rate of 18.2 people killed per 100,000 residents of Mexico.

Figure 2.1 compares Mexican RTI death rates to other countries, regions, and the world. However, it should be noted that Mexican death rates are significantly in excess of those in high income countries, all of which have substantially higher motorization rates.



Sources: RTI death rates in Mexico and Iran based on our analysis of vital registration data; in high income countries based on IRTAD[1]; and, in World Regions based on GBD 2002.[2]

Figure 2.1: RTI death rate in Mexico compared with other countries and world regions.

Table 2.1 lists the leading causes of death in Mexico in the year 2004 based on the Mexican burden of disease study.[3] Note that our estimate of 19,402 road traffic deaths in Mexico agree well with the estimates of this burden of disease study. Road traffic crashes were the fifth leading cause of death in Mexico. Road traffic crashes resulted in 4.0% of all deaths in Mexico, almost twice the world average of 2.1%.

To place the annual RTI death toll in perspective, the 1985 Mexico City earthquake killed 9,000 people (official government statistics) attracting a dramatic emergency response and international attention, including visits from several heads of state (including Brazil, Venezuela, Spain and Peru). In comparison, the approximately 20,000 people road traffic deaths annually in Mexico receive little attention.

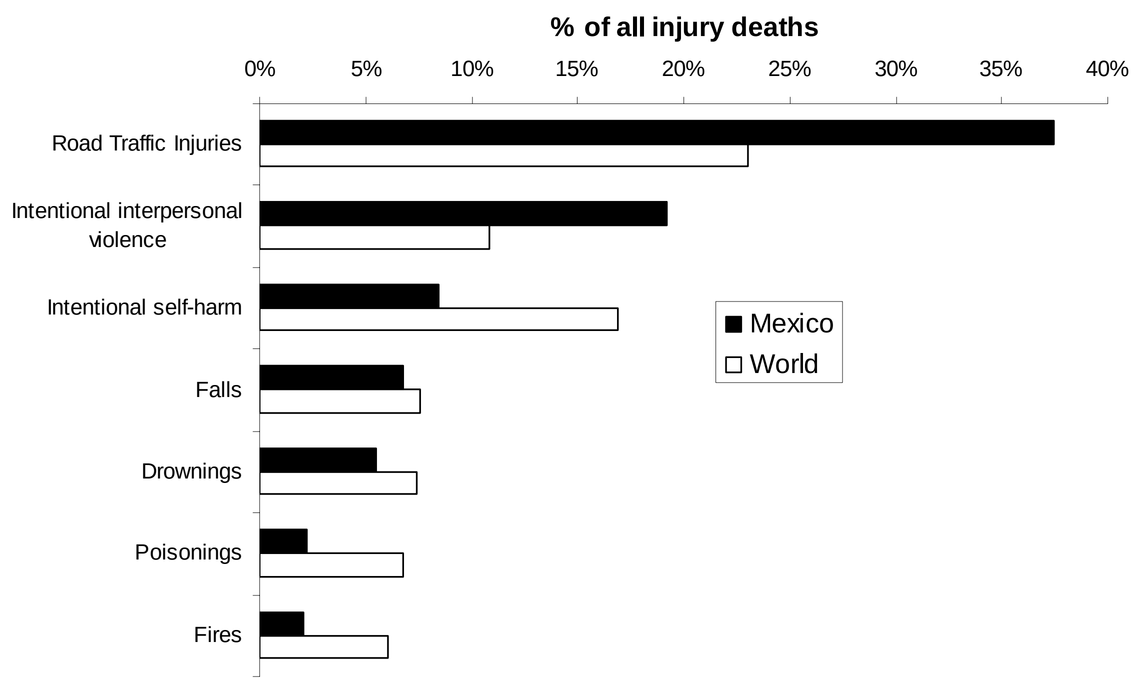
Table 2.1: Leading causes of death in Mexico in 2004

Rank	Cause of Death	# of deaths	% total deaths
	All causes	468,000	100 %
1	Ischemic heart disease	60840	13%
2	Diabetes mellitus	45396	10%
3	Cerebrovascular disease	28080	6%
4	Cirrhosis of the liver	25740	6%
5	Road traffic injuries	20592*	4%
6	Chronic obstructive pulmonary disease	18720	4%
7	Lower respiratory infections	18252	4%
8	Hypertensive heart disease	14976	3%
9	Birth asphyxia and birth trauma	14040	3%
10	Nephritis and nephrosis	12168	3%

Source: Mexico burden of disease study.[3]

*The estimate for 2005 based on our analysis in 19,402 road traffic injury deaths.

Figure 2.2 illustrates the profile of injury deaths in Mexico. Road traffic injuries are the leading cause of injury deaths in Mexico, accounting for 37% of all injury deaths. This is substantially in excess of the world average of 23%.



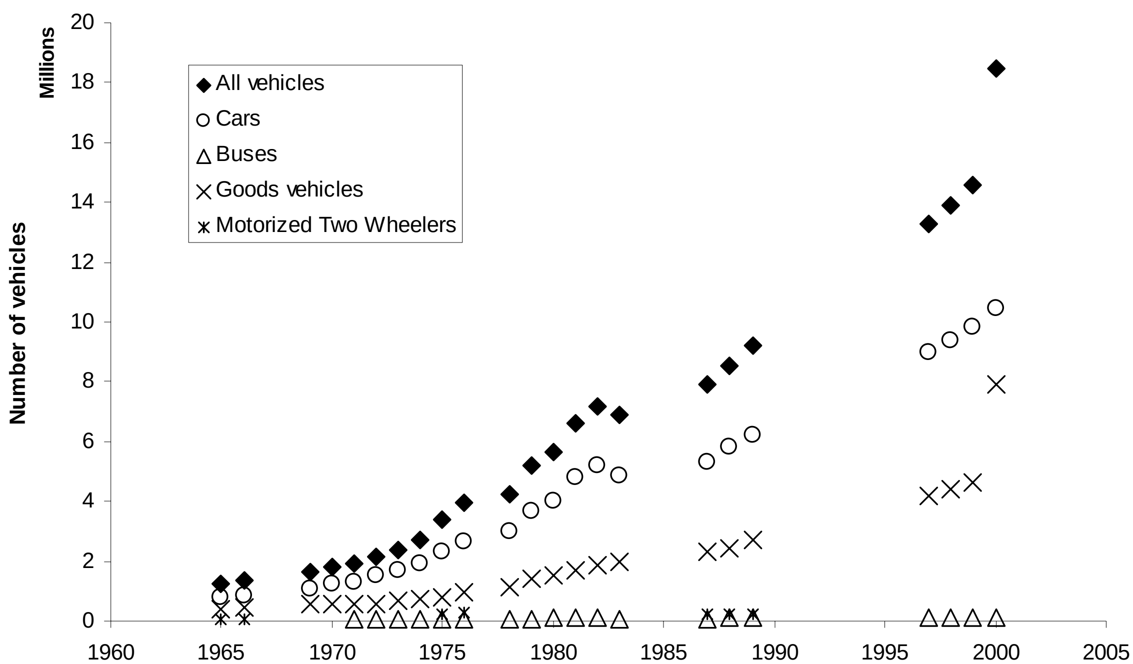
Source: Based on our analysis of the 2005 vital registration records as described in Chapter 1

Figure 2.2: Leading causes of injury death in Mexico

Time Trend

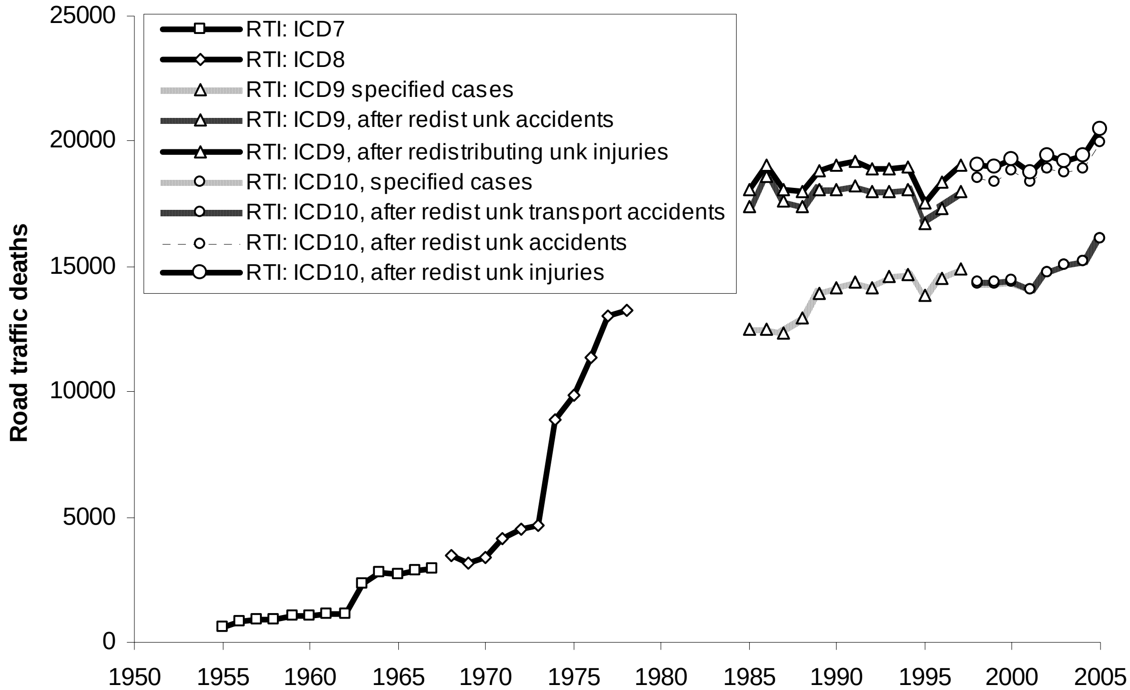
The 2004 World Report on Road Traffic Injury Prevention highlighted the growing gap in road safety between rich and poor countries.[4] Most OECD countries, including most of Western Europe, the US, Canada, Japan and Australia, have witnessed a remarkably similar history of road traffic injury death rates. Prior to 1970, death rates in most OECD countries were steadily rising. However, for the last three decades, these nations have seen declining death rates. On the other hand, road traffic injury death rates in the remainder of the world are rising partly due to the rapid growth in motor vehicle fleet resulting from economic development, as illustrated in Figure 2.3.

Figure 2.4 illustrates the history of road traffic deaths in Mexico. Road traffic deaths rose sharply in the 1960s and 1970s and have been relatively stable at close to 20,000 deaths annually since the early 1980s, showing a slight increase in recent years. It should be noted that some of the rapid rise in the late 1970s may be an artifact of increasing coverage during this period.[5]



Source: Vehicle registration statistics from International Road Federation.[6]

Figure 2.3: Growth of the vehicle fleet in Mexico



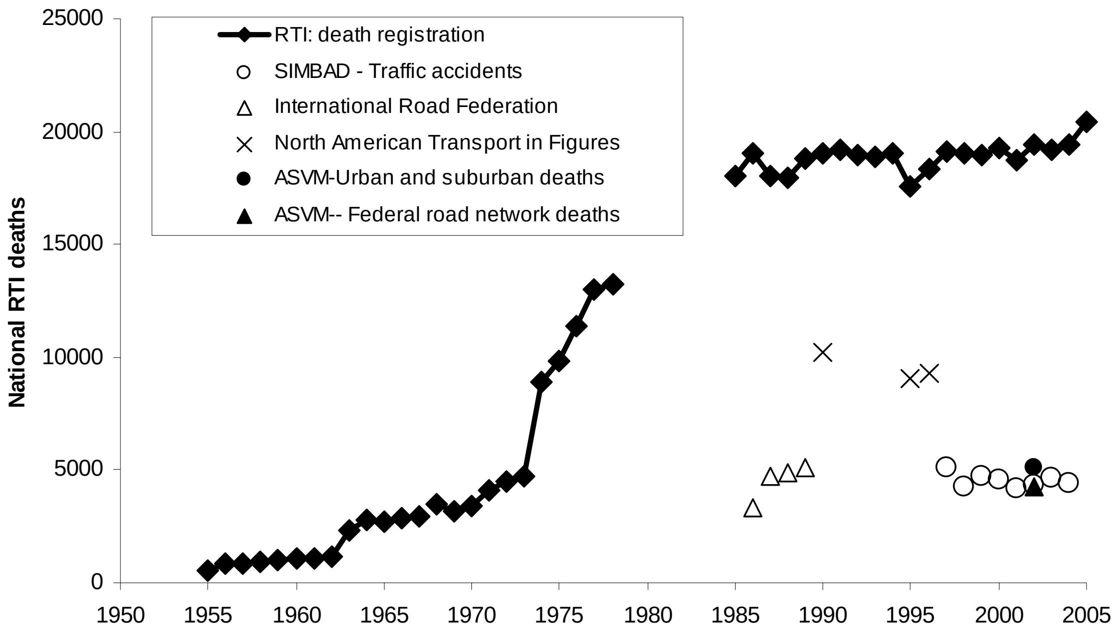
Source: Based on analysis of ICD7-10 coded death registration data. For deaths coded using ICD-9 and ICD-10, unspecified injuries were redistributed as described in Chapter 1. This was not possible for data coded using ICD7 and ICD8 because unspecified injuries were not reported separately in the WHO mortality database.

Figure 2.4: History of road traffic deaths in Mexico

Other estimates of road traffic deaths in Mexico

The two primary official sources of information about road traffic crashes in Mexico are the Ministries of Transport (Secretaria de Comunicacniones y Transportes) and Health (Secretaria de Salud). Our analysis of deaths has focused on health data because death registration data is more complete. Analysis shows that the estimates of deaths based on the two sources are substantially different.

Figure 2.5 illustrates road traffic deaths in Mexico based on our analysis compared with various published estimates. It should be noted that our analysis of the total death toll required various correction to account for deaths registered with unspecified and ill-defined causes (as shown in Figure 2.4). However, even the lowest, uncorrected estimate of road traffic deaths based on death registration exceeds the highest estimate from other sources by about 50%. Under-reporting by police is well acknowledged, but it is commonly assumed that deaths are more reliable captured. This is not the case in Mexico.



Sources:

- RTI death registration: Our analysis of vital registration data. Deaths coded to ill-specified causes redistributed as described in Chapter 1.
- International Road Federation: IRF compiles of official government estimates of transport indicators for all countries.
- SIMBAD database: Sistema Municipal de Base de Datos, INEGI: Fatal Traffic Accidents.[7]
- North American Transportation in Figures: based on data from Instituto Mexicano del Transporte and INEGI.[8]
- ASVM: Atlas de Seguridad Vial de Mexico (provided by Dr Luis Chias Becerril). Contains data on urban and suburban deaths (Accidentes de Tránsito Terrestre en Zonas Urbanas y Suburbanas) and deaths on the federal road network (Accidentes de Tránsito en la red federal de carreteras). These likely represent non-overlapping datasets that should be added for a national estimate of RTI deaths.[9]

Figure 2.5: Various estimates of RTI deaths in Mexico

References

1. International Road Traffic and Accident Database, Available from http://cemt.org/IRTAD/IRTADPublic/index.htm (Accessed on February 18 2008.)
2. GBD2002 Global Burden of Disease (2002), World Health Organization. Available from http://www.who.int/healthinfo/bodestimates/en/. (Accessed on February 18 2008.)
3. Stevens, G., et al., (2008) Characterizing the epidemiological transition in Mexico: National and Subnational Burden of Diseases, Injuries, and Risk Factors, 5(6): 900-910.
4. World Health Organization (WHO). (2004). World report on road traffic injury prevention, Geneva, Switzerland. International Road Federation, Available from www.irfnet.org (Accessed on February 18 2008.)
5. Braine T., (2006), Mexico's quest for a complete mortality data set. Bulletin of the World Health Organization;84(3):161-256.

6. International Road Federation (IRF). (2003). World Road Statistics. www.irfnet.org. (Accessed on February 18 2008.)
7. SIMBAD: Sistema Municipal de Base de Datos, http://sc.inegi.gob.mx/simbad/ (Accessed on May 19 2008.)
8. US Department of Transportation, Bureau of Transportation Statistics, US Department of Commerce, Census Bureau: Statistics Canada: Transport Canada, Instituto Mexicano del Transporte: Instituto Nacional de Estadistica, Geografia e Informatica: and Secretaria de Comunicaciones y Transportes, North American Transportation in Figures, BRS00-05, Washington, DC: 2000.
9. ASVM: Atlas de Seguridad Vial de Mexico (provided by Dr Luis Chias Becerril).

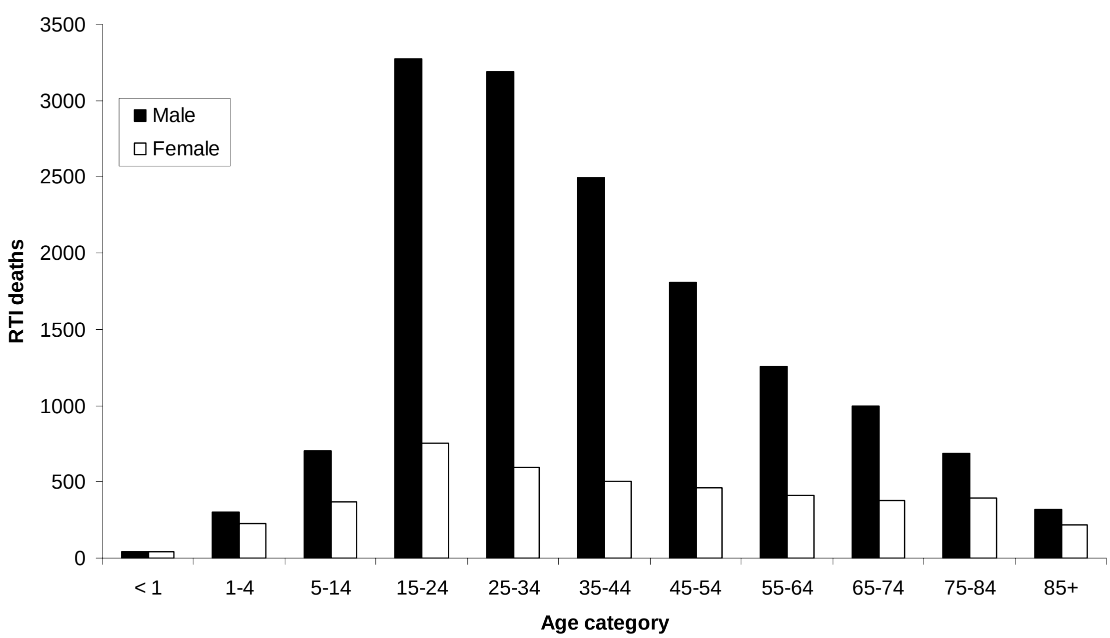
Chapter 3

Deaths from road traffic crashes: Who, When, Where?

This chapter describes the epidemiology of fatal road traffic crashes in Mexico, focusing in particular on the age, sex, location (urban/rural), and time of the crash. In addition, the characteristics of the mode of transport of the victim and the impacting vehicle are also described. This analysis is primarily based on an analysis of the 2005 death registration dataset using methods described in Chapter 1.

Age, sex and location (urban/rural)

Table 3.1 displays incidence counts and rates by age, sex and residence location (urban/rural) for the 19,402 deaths due to road traffic crashes in Mexico in 2005. Figure 3.1 illustrates the age and sex characteristics of these deaths. Road traffic crashes kill men in a much larger number (15,055 deaths) than women (4,347). Although this is also the case in most other countries, the ratio of male to female deaths (3.5) in Mexico is much higher than the world average of 2.68.[1] Male deaths exceed female deaths primarily due to gender disparities, which result in women traveling less than men and, thus, having lower risk exposure. In comparison, in the USA, where the disparity in exposure is smaller, the ratio of male to female deaths is lower (2.1 male deaths per female death).[2] Similarly, in Iran, where gender disparities are higher than that in Mexico (see gender-related national indices reported by the UNDP Human Development Reports), the ratio of male to female deaths is higher (4.4 deaths male deaths per female death).[3,4]



Source: Based on our analysis of the 2005 vital registration records as described in Chapter 1

Figure 3.1 RTI deaths in Mexico by age and sex groups

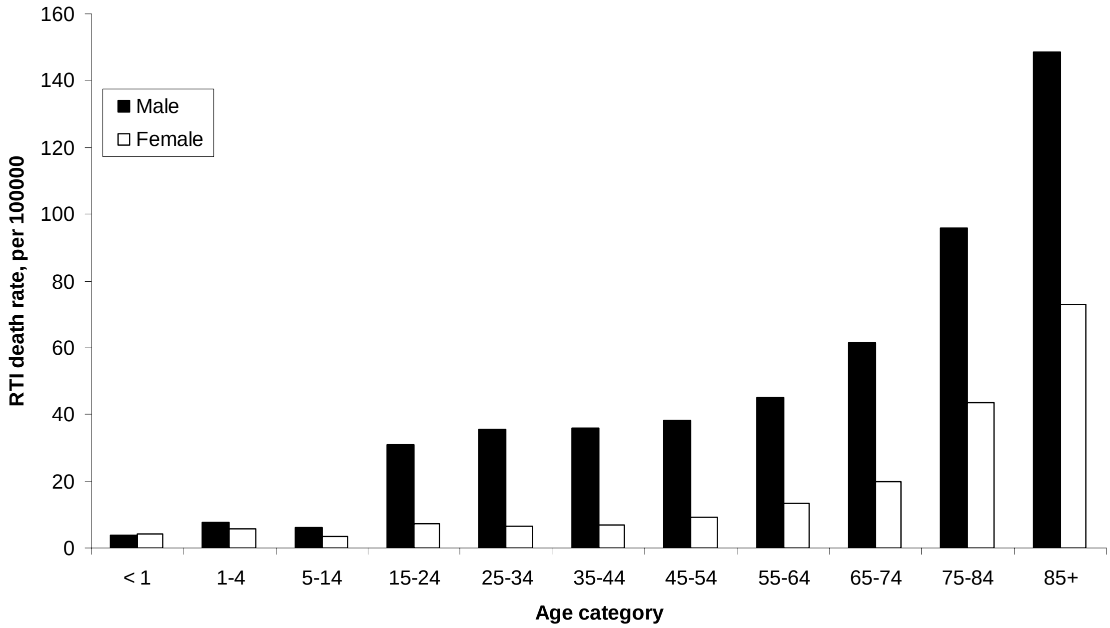
Road traffic death counts increase with age, peak in the age group of 15-24 years, and decline for older age groups. This is true for both men and women. The male-female differences in death counts are particularly pronounced among young adults. These differences are comparatively smaller among children (<15 years) and among the most elderly (>85 years), where disparities in traffic exposure are likely to be smaller.

The age pattern of road traffic deaths broadly resembles the population distribution of Mexico. However, the most populous age group in Mexico is 5-14 years, which suggests a sharp transition in road traffic death rates in the 15-24 years age group.

Table 3.1: Age, sex and location (urban/rural) characteristics of road traffic deaths in Mexico.

		Urban deaths		Rural deaths		Total deaths	
Sex	**Age**	**Cases**	**Rate**	**Cases**	**Rate**	**Cases**	**Rate**
both	< 1	63	4	16	3	79	4
	1-4	401	7	131	6	532	7
	5-14	762	5	311	5	1073	5
	15-24	3020	19	1004	21	4024	19
	25-34	2949	20	837	23	3785	21
	35-44	2352	21	644	23	2997	21
	45-54	1718	22	551	28	2269	23
	55-64	1257	28	410	29	1667	29
	65-74	1012	39	354	38	1365	39
	75-84	858	74	222	49	1080	67
	85+	416	118	115	75	531	105
male	< 1	31	4	8	3	40	4
	1-4	226	8	75	7	301	7
	5-14	482	6	219	7	701	6
	15-24	2398	29	873	36	3271	31
	25-34	2449	34	740	42	3189	35
	35-44	1934	35	561	41	2495	36
	45-54	1345	36	460	47	1804	38
	55-64	933	45	326	46	1259	45
	65-74	716	62	277	59	993	62
	75-84	533	109	152	68	685	96
	85+	247	176	70	98	317	148
	Total	11294	28	3761	30	15055	28
female	< 1	32	5	7	3	39	4
	1-4	175	6	55	5	230	6
	5-14	279	4	92	3	372	3
	15-24	622	8	131	5	753	7
	25-34	500	7	97	5	596	7
	35-44	418	7	83	6	501	7
	45-54	373	9	91	9	465	9
	55-64	324	14	84	12	408	13
	65-74	295	21	77	17	373	20
	75-84	325	48	70	30	395	43
	85+	170	80	44	55	214	73
	Total	3514	9	833	7	4347	8
Total		14808	18	4594	18	19402	18

Source: Based on our analysis of the 2005 vital registration records as described in Chapter 1.

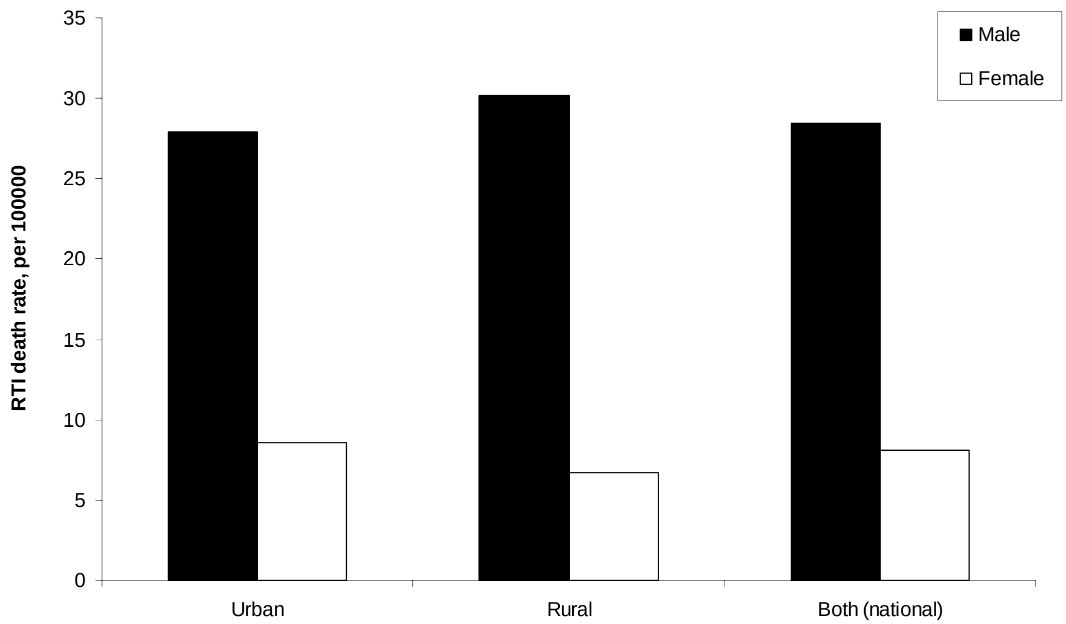


Source: Based on our analysis of the 2005 vital registration records as described in Chapter 1.

Figure 3.2: Road traffic death rates in Mexico by age and sex groups

Figure 3.2 illustrates road traffic death rates by age and sex groups. Death rates increase with age and are highest for the most elderly age groups. A similar age pattern exists in other countries as well. For instance, in the US as well as in Iran, the oldest age groups have the highest death rates.[2,4]

Figure 3.3 illustrates road traffic death rates by sex and location of residence (urban/rural). Death rates are marginally higher in rural areas for men and urban areas for women. Although the age breakdown in Table 3.1 suggests that the urban-rural risk differentials are higher for adult men in the age group 15-45 years, they are nevertheless not substantial.



Source: Based on our analysis of the 2005 vital registration records as described in Chapter 1.

Figure 3.3 Road traffic deaths rates in Mexico by sex and residence (urban/rural)

Victim's mode of transport

Table 3.2 and Figure 3.4 describe road traffic death rates by victim's mode of transport, location of residence (urban/rural) and sex. Pedestrians are the most common victims (9,213 deaths) accounting for nearly half (48%) of all road traffic crash victims. Car occupants rank second with 7,330 deaths (38%). Together these two modes account for 86% of all road traffic deaths.

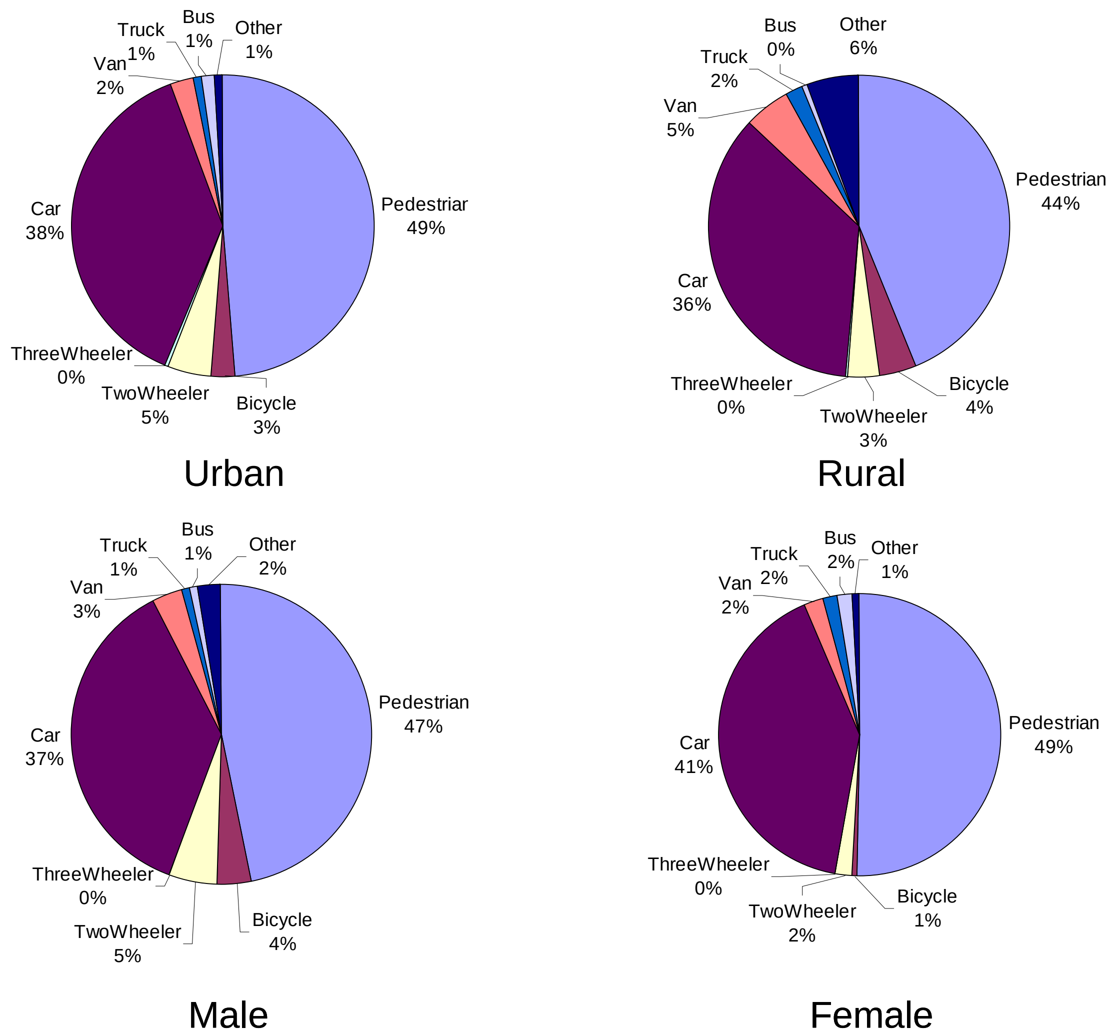
The transport mode breakdown of male and female deaths show expected patterns – motorized two-wheelers comprise a higher fraction of male deaths, while cars occupants comprise a higher share of female deaths. Unlike many other middle and lower income countries, motorized two-wheeler riders comprise only a small fraction of the total deaths in Mexico. This is likely because of the small number of motorized two-wheelers in the Mexican vehicle fleet.

The transport mode break down is similar for urban and rural areas. The key difference is that pedestrians are at a higher risk in urban areas than in rural areas. However, rural areas have a higher rate of deaths classified to the "others" category, which is primarily comprised of animal riders. Thus the overall percentage of vulnerable road users is similar.

Table 3.2: Victim's mode of transport by sex and location (urban/rural)

		Urban deaths		Rural deaths		Total deaths	
Sex	**Age**	**Cases**	**Rate**	**Cases**	**Rate**	**Cases**	**Rate**
both	Pedestrian	7192	9	2021	8	9213	9
	Bicycle	395	0	176	1	572	1
	MotorizedTwoWheeler	697	1	155	1	852	1
	MotorizedThreeWheeler	7	0	3	0	9	0
	Car	5695	7	1635	7	7330	7
	Van	365	0	238	1	604	1
	Truck	139	0	87	0	226	0
	Bus	174	0	21	0	195	0
	Others	144	0	257	1	401	0
male	Pedestrian	5411	13	1622	13	7033	13
	Bicycle	374	1	169	1	544	1
	MotorizedTwoWheeler	624	2	143	1	767	1
	MotorizedThreeWheeler	7	0	3	0	9	0
	Car	4244	10	1310	11	5554	10
	Van	300	1	212	2	512	1
	Truck	106	0	45	0	151	0
	Bus	104	0	12	0	116	0
	Others	124	0	244	2	368	1
	Total	11294	28	3761	30	15055	28
female	Pedestrian	1781	4	399	3	2180	4
	Bicycle	21	0	7	0	28	0
	MotorizedTwoWheeler	73	0	12	0	85	0
	MotorizedThreeWheeler	0	0	0	0	0	0
	Car	1451	4	325	3	1776	3
	Van	65	0	26	0	92	0
	Truck	33	0	42	0	74	0
	Bus	70	0	8	0	78	0
	Others	20	0	13	0	33	0
	Total	3514	9	833	7	4347	8
Total		14808	2	4594	2	19402	2

Source: Based on our analysis of the 2005 vital registration records as described in Chapter 1.

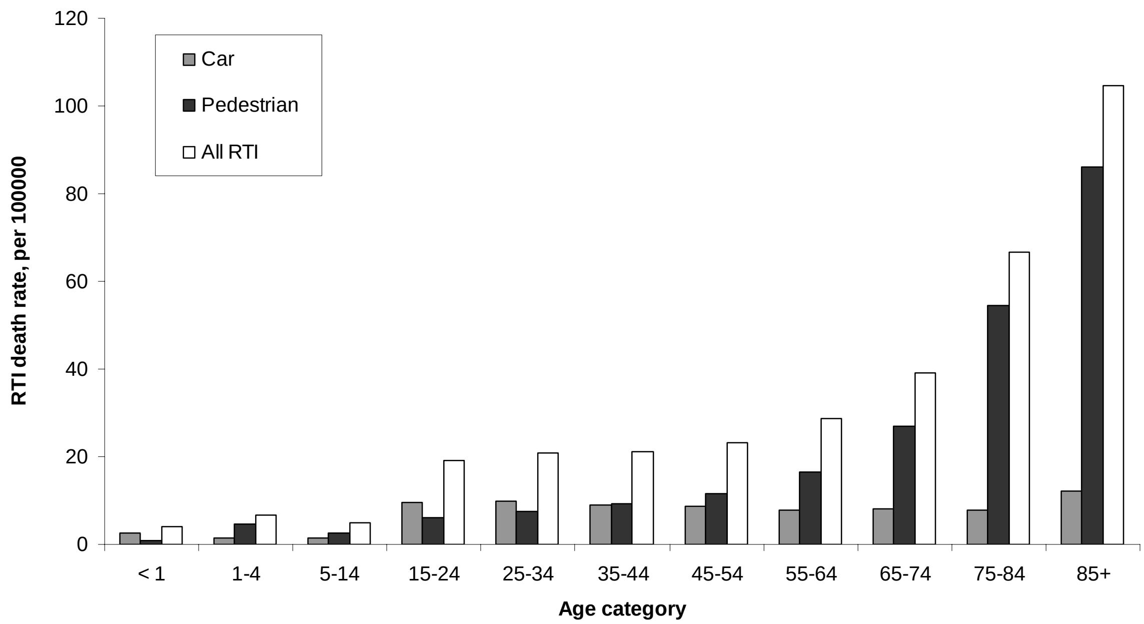


Source: Based on our analysis of the 2005 vital registration records as described in Chapter 1.

Figure 3.4 Victim's mode of transport for urban and rural residents

Figure 3.5 illustrates the age distribution of the two leading victim classes: car occupants and pedestrians. The rapid increase in total road traffic death rates (all RTI) with increasing age is driven largely by the rapid increase in death rates among pedestrians. Rates of car occupant deaths are much lower than pedestrians. Higher death rates among the elderly are likely in part due to frailty and the decreased ability of the human body to withstand mechanical forces with age. Since pedestrian crashes inflict more severe injuries than occupant crashes, the likelihood of death from these crashes is also higher.

Road traffic death rates increase four fold between the age groups of 5-14 years and 15-24 years. This is most likely associated with the increased exposure among young adults in the 15-24 years age group. While death rates for both pedestrians and car occupants increase during this age transition, the effect is six times larger for car occupants.



Source: Based on our analysis of the 2005 vital registration records as described in Chapter 1.

Figure 3.5 Age distribution of pedestrian, motorcycle rider and car occupant deaths

Impacting Vehicle

Analysis of the victim's mode of transport is useful for identifying road users at high risk but does not provide insight into the threat posed by different vehicle types. This is better understood by analyzing the Who-hit-who matrix illustrated by Table 3.3. In this matrix, impacting vehicles are listed in columns and the victim's mode of transport is listed in rows. Single vehicle crashes (e.g. roll over, motorcycle falls, etc) are included as a column. The who-hit-who matrix illustrates that heavier vehicles (i.e. cars, trucks and buses) are more likely to be impacting vehicles in fatal crashes. This reflects the expectation that in a crash between two vehicles, the fatality is more likely to be in the lighter vehicle.

The who-hit-who matrix is useful for identifying vehicle-victim combinations that are at particular risk. Table 3 suggests that of all road traffic deaths in Mexico, 33% were pedestrians killed in crashes with cars, and 34% were car occupants killed in single vehicle crashes. The remaining impacting vehicle-victim combinations are a much smaller proportion. Single vehicle crashes are a substantial problem for car occupants with almost 80% of car occupant deaths occurring in single vehicle crashes.

Figure 3.6 compares the composition of road traffic deaths by impacting vehicle with victim's mode of transport. The impacting vehicle's proportions are obtained by applying single vehicle proportions to the corresponding vehicle's total (last row in Table 3.3). This is a new metric for evaluating the risks imposed by different vehicles. In order to properly account for the societal risks due to a particular vehicle type, it is necessary to determine the threat posed by this vehicle type to other road users. This risk should be evaluated in addition to analyzing risks by victim's mode of transport as is usually done.

Thus, for instance, while pedestrians comprise 48% of the victims, there were no deaths among vehicle occupants associated with striking a pedestrian. Pedestrians are never threats to other road users. On the other hand, cars were the impacting vehicle in 40% of fatal crashes, almost as often as car occupants were victims (42%). Taken together, the threat posed by cars to other road users and the threat posed by cars to their own occupants compose 74% of all road traffic deaths in Mexico.

Table 3.3: Who-hit-who matrix for fatal collisions

	Pedestrian	Bicycle	Motorized Two Wheeler	Car	Bus/Truck	Single vehicle	Total
Pedestrian	0%	1%	2%	33%	11%	0%	48%
Bicycle	0%	0%	0%	1%	0%	1%	3%
Motorized Two Wheeler	0%	0%	0%	2%	0%	2%	5%
Car	0%	0%	0%	3%	4%	34%	42%
Bus/Truck	0%	0%	0%	0%	1%	1%	2%
Total	0%	2%	2%	40%	17%	39%	100%
Total	0%	3%	4%	74%	19%	n.a.	

Notes: Numbers are percent of all RTI deaths. Last row includes the fraction of single vehicle cases in the corresponding vehicle's total. These results are estimated from 2178 cases in the 2005 Vital Registration datasets RTI deaths for which both impacting vehicle and victim's mode could be determined from the ICD-10 cause of death codes. The sample size is small (~ 11% of all RTI deaths) and may not be unbiased.

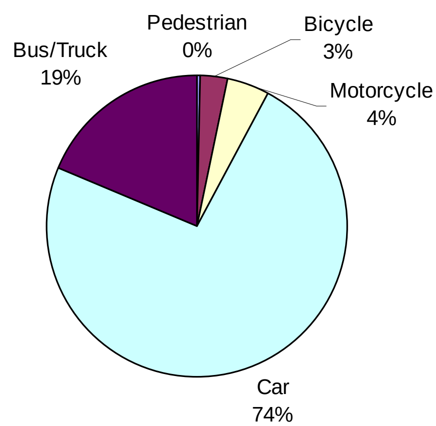


Figure 3.6 Road traffic deaths in Mexico by impacting vehicle
Notes: See notes for Table 3.3

Death rates by province

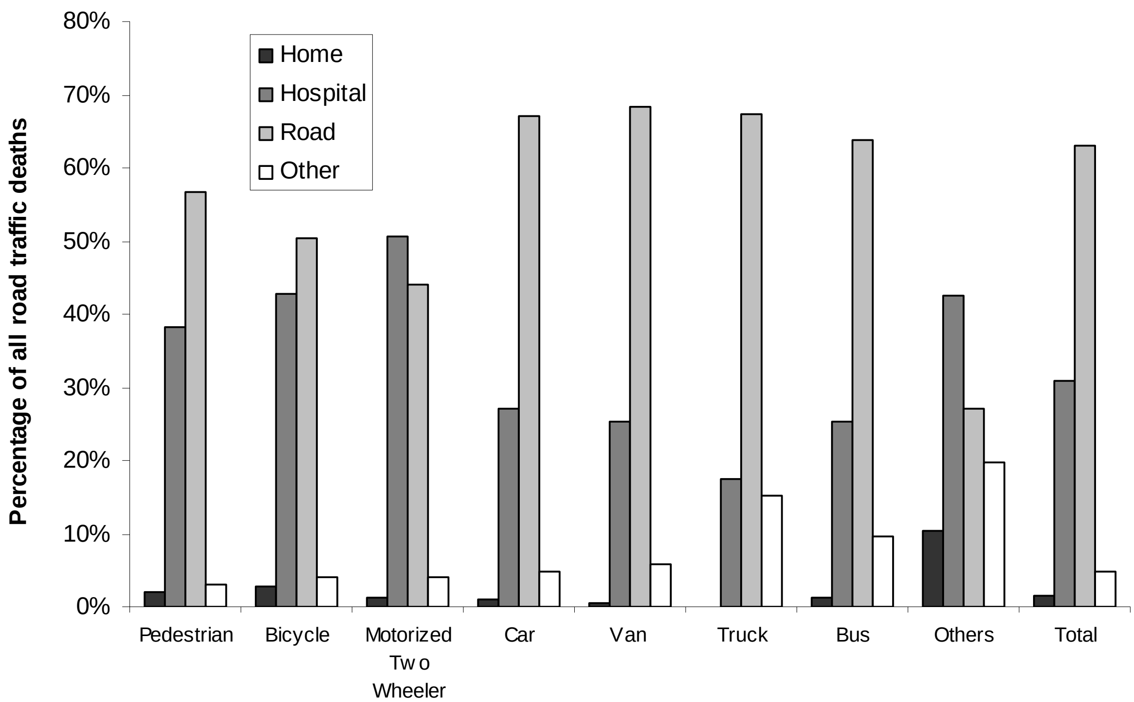
Figure 3.7 illustrates that road traffic death rates vary substantially by province. Although explaining the causes for province-level variations in death rates is beyond the scope of this report, such insight can be useful for designing effective policies.[5]

Notes: Shade of province reflects RTI death rate in province. Superimposed bars represent the proportion of pedestrians, motorcycle/bicycle, and occupants. Source: Based on our analysis of the 2005 vital registration records as described in Chapter 1.

Figure 3.7 Road traffic death rate in different provinces of Mexico

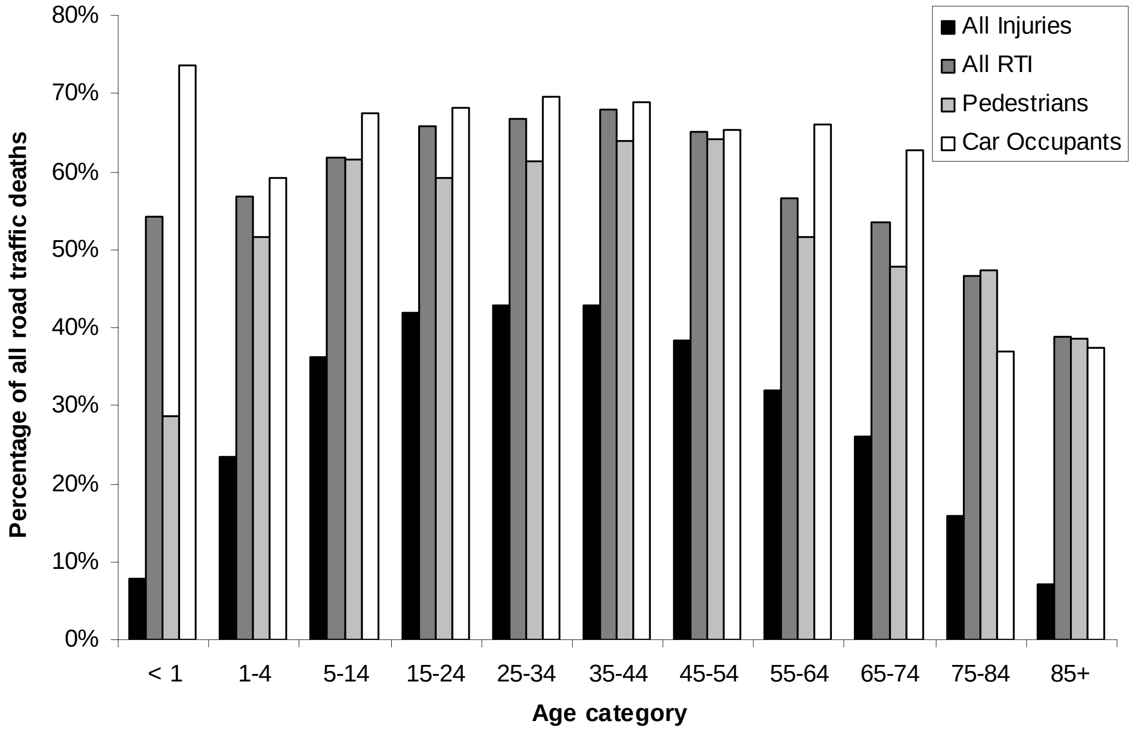
Location of death (hospital/on-scene)

Figures 3.8 and 3.9 illustrate the site of road traffic deaths by victim's mode of transport and age group. Whether a victim receives medical care depends on multiple factors, including the severity of injuries and the availability and access to medical care. Over all 63% of all deaths in Mexico occur on the crash site (road), a negligible number (1%) occur at home, and the rest (36%) occur in a hospital or other location. A high fraction of deaths at the crash site has also been documented by other studies.[6] Deaths among vulnerable road users (pedestrians, bicyclists, and motorized two wheelers) are more likely to occur in a hospital than deaths among vehicle occupants, which are more likely to be on the road. Figure 3.9 illustrates that deaths on the crash-site are more common among young adults than among children and the elderly.



Source: Based on our analysis of the 2005 vital registration records as described in Chapter 1

Figure 3.8 Site of road traffic deaths by victim's mode of transport



Source: Based on our analysis of the 2005 vital registration records as described in Chapter 1.

Figure 3.9 Site of road traffic deaths by age group

References

1. GBD2002 Global Burden of Disease (2002), World Health Organization. Available from http://www.who.int/healthinfo/bodestimates/en/. (Accessed on February 28 2008.)
2. Finkelstein, E.A., Corso, P.S., Miller, T.R., and Associates, (2006) The incidence and economic burden of injuries in the United States, Oxford University Press, New York.
3. United Nations Development Programme Human Development Reports, http://hdr.undp.org/en/statistics/.
4. Bhalla, K.B., Shahraz, S., Naghavi, M., Bartels, D., and Murray, C., 2008, Road traffic injuries in Iran, Harvard University Initiative for Global Health, available from: http://www.globalhealth.harvard.edu (click on Research => Road Traffic Injuries).
5. Province level analysis of road traffic injuries in Mexico, Internal Report, Harvard University Initiative for Global Health - Road Traffic Injury Metrics Project.
6. Arreola-Risa C, Mock CN, Padilla D, Cavazos L, Maier RV, Jurkovich GJ. Trauma Care Systems in Urban Latin America: The Priorities Should Be Prehospital and Emergency Room Management. The Journal of Trauma: Injury, Infection, and Critical Care 1995;39(3):457.

Chapter 4

Non-fatal crashes: institutional care, nature of injuries, and health burden

This chapter focuses on non-fatal road traffic crashes, the resulting injuries, injury severity, the institutional care provided, and the public health burden. The primary data sources for these results are the 2005 vital registration dataset for estimating deaths; the 2005 hospital registry datasets coupled with the 2005 health survey ENSANUT for estimating inpatient and outpatient visits; and the 2005 health survey ENSANUT for estimating injuries that received care at other locations or did not receive any care.

Classifying road traffic injuries by severity is technically challenging because of the difficulty in defining severity thresholds. In this chapter, we report road traffic crashes by type of care provided (inpatient or outpatient) but discourage the reader to consider these as a proxy for severity. Ideally, for our purposes, injury severity should measure the level of impairment and the loss of functional health due to the injury. Unfortunately, there exists little empirical research on the evolution of functional health following different types of injuries. Further research to develop tools for mapping injuries recorded in hospital records to disability is urgently needed. In this chapter, we have used existing burden of disease methodologies to compare non-fatal and fatal collisions.

Institutional Care

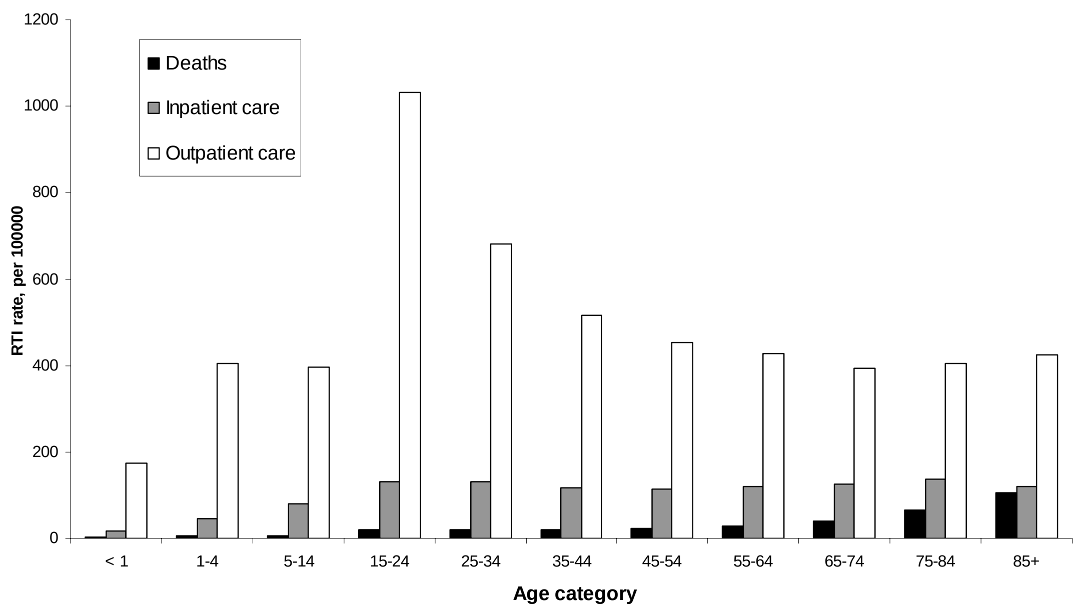
Over one million residents of Mexico were involved in road traffic crashes in the year 2005. In other words, close to one of every hundred people in Mexico are involved in a road traffic crash every year. This includes 0.25 million cases that did not receive institutional care. While it is possible that some of these crashes resulted in injuries that needed treatment, it is likely that, in the majority of these cases, injuries were too minor to warrant medical attention. If these cases are eliminated from the total, there were 0.76 million road traffic injuries (0.71% of population) in Mexico in 2005. An estimated 0.11 million road traffic crash victims were admitted to hospitals as inpatients and an additional 0.63 million individuals received outpatient care. For every death, there were 6 times as many hospital admissions and 32 times as many outpatient visits.

Table 4.1 and Figure 4.1 illustrate the age distribution of fatal and non-fatal cases that received institutional care. The hospital inpatient and outpatient visit rates have an age trend that is different from that of deaths. While the death rate increases steadily with age, the rate of injuries that received hospital care increases and peaks in the age group of 15-24 years and declines for higher ages. This pattern is likely due to two effects. First, young adults are more likely to be involved in road traffic crashes than the elderly. Second, among young adults, these crashes are less likely to be fatal because of their ability to withstand greater mechanical forces and recover more quickly. This is also evident from the ratio of hospital visits to deaths, which is much smaller among the elderly because of their frailty.

Table 4.1: Annual road traffic crashes in Mexico classified by the care they received

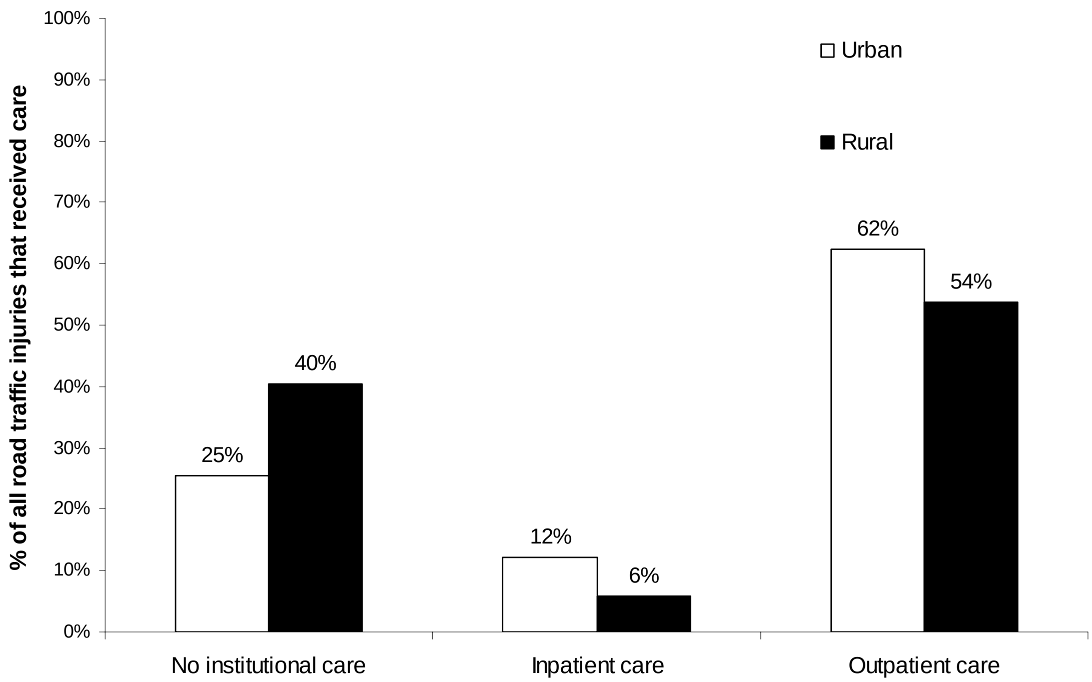
		Fatal		Inpatient		Outpatient		Other and no care		Total	
Sex	**Age**	**Cases**	**Rate**	**Cases**	**Rate**	**Cases**	**Rate**	**Cases**	**Rate**	**Cases**	**Rate**
both	< 1	79	4	329	17	3382	175	0	0	3790	196
	1-4	530	7	3524	45	32050	405	3247	41	39351	497
	5-14	1073	5	17440	79	87612	396	46343	209	152467	689
	15-24	4025	19	27756	132	216792	1033	84776	404	333350	1589
	25-34	3788	21	23874	132	123453	682	42157	233	193272	1068
	35-44	2997	21	16399	116	73182	515	40460	285	133039	937
	45-54	2270	23	11109	114	44106	453	12236	126	69721	716
	55-64	1668	29	7007	120	25040	429	12440	213	46155	790
	65-74	1369	39	4400	126	13720	392	5538	158	25026	715
	75-84	1080	67	2230	138	6574	405	5639	348	15523	957
	85+	529	105	609	120	2155	426	0	0	3293	651
male	< 1	40	4	196	20	2128	215	0	0	2364	239
	1-4	301	7	2192	54	19148	474	269	7	21910	542
	5-14	701	6	12274	109	53325	472	30458	270	96758	857
	15-24	3273	31	20607	195	141919	1341	64197	606	229995	2173
	25-34	3191	35	18052	201	82647	919	30734	342	134625	1496
	35-44	2496	36	11907	171	48143	690	29400	421	91946	1318
	45-54	1805	38	7964	169	28967	614	10066	213	48803	1034
	55-64	1260	45	4845	174	16366	588	9197	330	31668	1137
	65-74	995	62	2945	182	8647	535	4546	281	17132	1060
	75-84	686	96	1467	205	4091	573	5170	724	11414	1597
	85+	315	148	366	172	1473	694	0	0	2154	1014
	Total	15063	28	82816	156	406854	769	184036	348	688769	1301
female	< 1	39	4	133	14	1255	133	0	0	1427	151
	1-4	229	6	1332	34	12902	333	2979	77	17441	451
	5-14	372	3	5166	48	34286	316	15885	146	55709	514
	15-24	752	7	7150	69	74874	720	20580	198	103355	994
	25-34	597	7	5822	64	40805	449	11423	126	58647	645
	35-44	501	7	4492	62	25040	347	11060	153	41093	569
	45-54	465	9	3145	63	15138	302	2170	43	20917	417
	55-64	408	13	2161	71	8674	284	3244	106	14487	474
	65-74	374	20	1455	77	5073	269	992	53	7895	419
	75-84	394	43	763	84	2482	274	469	52	4109	453
	85+	214	73	243	83	682	232	0	0	1139	388
	Total	4346	8	31861	60	221211	413	68801	129	326219	609
Total		19409	18	114677	108	628065	590	252837	238	1014987	953

Sources: Deaths based on vital registration; Inpatient and outpatient based on hospital registry scaled to match estimates based on the health survey Ensanut; Other and no care based on Ensanut. See chapter 1 for details.



Sources: Deaths based on vital registration; Inpatient and outpatient based on hospital registry scaled to match estimates based on the health survey ENSANUT. See chapter 1 for details.

Figure 4.1: RTI incidence by age and institutional care



Sources: Based on analysis of the health survey ENSANUT.

Figure 4.2: Percentage of RTI cases that receive care by residence (urban/rural)

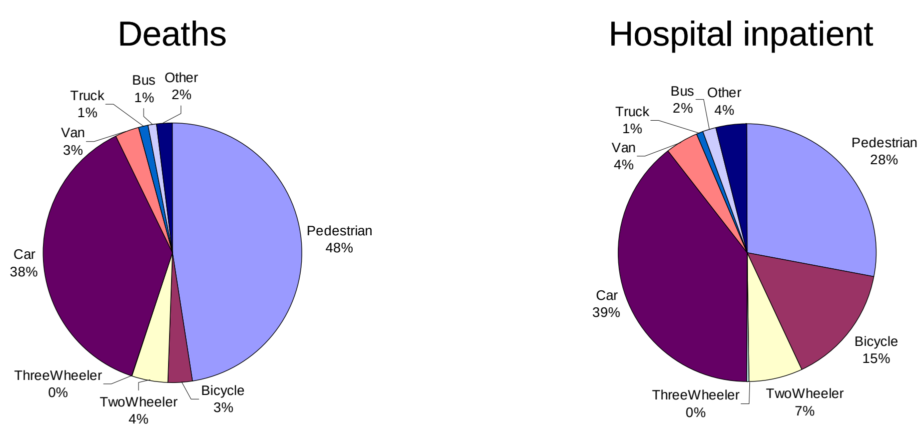
Figure 4.2 illustrates the percentage of cases that received care (as a total of all cases that received care, including inpatient, outpatient, and home care) by sex and location of residence (urban/rural). A substantially higher fraction of road traffic injuries receive no institutional medical care in rural areas. In urban areas, road traffic injury victims are twice as likely to be admitted to hospitals. The difference is smaller for outpatient care but is still considerable. It is possible that these differences reflect insufficient availability of medical facilities in rural areas combined with lower income among rural residents, reducing their ability to access available care.

Table 4.2 illustrates the ratio of inpatient care per fatality for different victim transport modes. This ratio is much higher for bicyclists and motorized two-wheeler riders than the average for all modes. As a result, these two categories of road users comprise a much larger fraction of hospital admissions than deaths. This is illustrated in Figure 4.3, which shows that while bicyclists account for only 3% of all deaths, they comprise 15% of all hospital inpatient admissions.

Table 4.2 Ratio of deaths to hospital inpatient admissions

Sex	Victim Mode	FATAL	INPATIENT
both	Pedestrian	1	3.5
	Bicycle	1	30.1
	Motorized Two Wheeler	1	8.8
	Car	1	6.1
	Van	1	8.4
	Truck	1	3.8
	Bus	1	9.9
	Other	1	11.3
	Total	1	5.9
male	Pedestrian	1	3.3
	Bicycle	1	25.2
	TwoWheeler	1	8.0
	Car	1	5.4
	Van	1	6.7
	Truck	1	4.2
	Bus	1	9.9
	Other	1	10.7
	Total	1	5.5
female	Pedestrian	1	4.0
	Bicycle	1	123.5
	TwoWheeler	1	15.8
	Car	1	8.4
	Van	1	18.1
	Truck	1	2.9
	Bus	1	9.8
	Other	1	17.3
	Total	1	7.3
Total		1	5.9

Sources: Deaths based on vital registration; Inpatient based on hospital registry scaled to match estimates based on the health survey ENSANUT. See chapter 1 for details.



Sources: Deaths based on vital registration; Inpatient based on hospital registry scaled to match estimates based on the health survey ENSANUT. See chapter 1 for details.

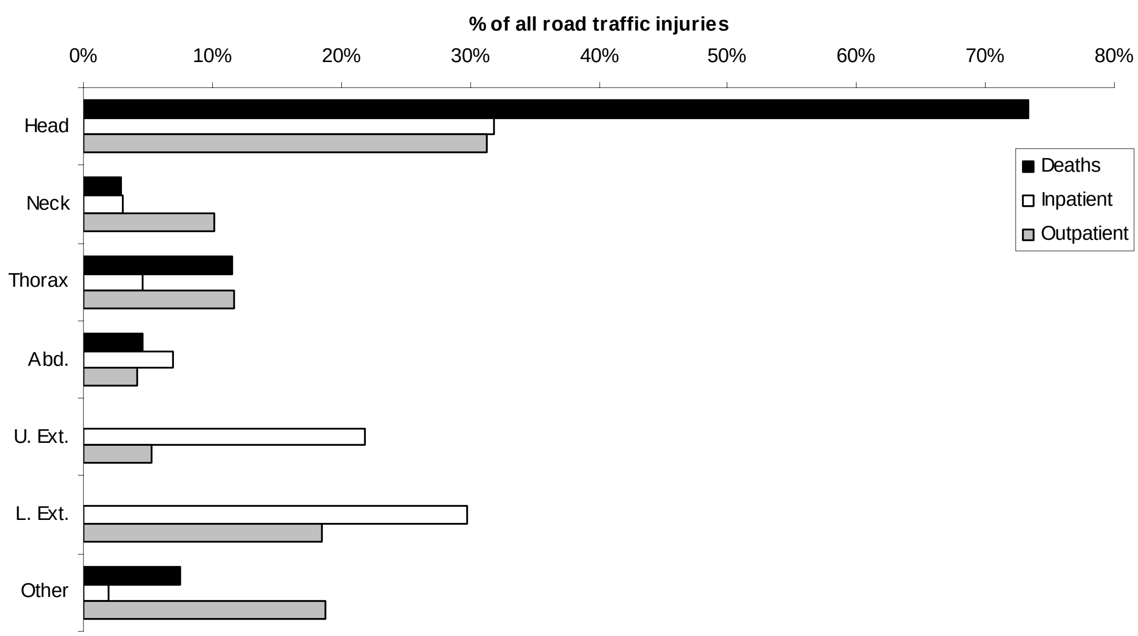
Figure 4.3 Victim transport mode distribution of deaths compared with hospital inpatient cases

Nature of Injuries

While so far in this report, "incidence" has referred to the number of individuals injured, injuries in Figures 4.4-4.7 refers to the total number of injuries sustained; i.e. if an individual suffered from two injuries in the same event, he/she would be counted twice.

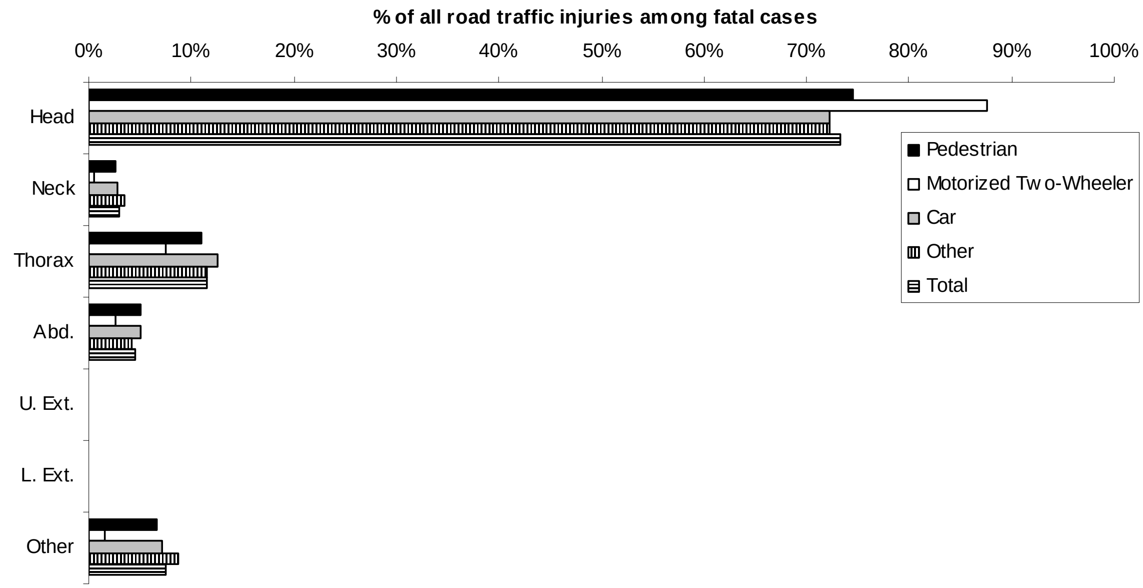
Figure 4.4 illustrates the distribution of body regions for fatal and outpatient/inpatient nonfatal injuries. Over 70% of all deaths involve head injuries, with thoracic injuries contributing another 11%. In comparison, hospital admissions cases involve fewer head injuries (approximately 30%), but much higher injuries to the extremities. Head, lower extremity, and upper extremity injuries account for over 80% of all injuries among victims admitted to hospital for inpatient care. Injuries among victims who received outpatient care are more evenly distributed across all body regions.

Figure 4.5-4.7 illustrates the distribution of injuries among fatal, inpatient and outpatient cases for the two leading victim categories: pedestrians and car occupants. The distribution of injuries among fatal cases is remarkably similar for pedestrians and car occupants. Among hospital admissions, pedestrians are much more likely to suffer from lower limb injuries than car occupants, while car occupants are more likely to suffer from thoracic, neck and upper extremity injuries. While pedestrians incur severe lower limb injuries from interactions with vehicle bumpers, car occupant injuries are usually caused by the interaction of the upper body with the steering wheel and dashboard.



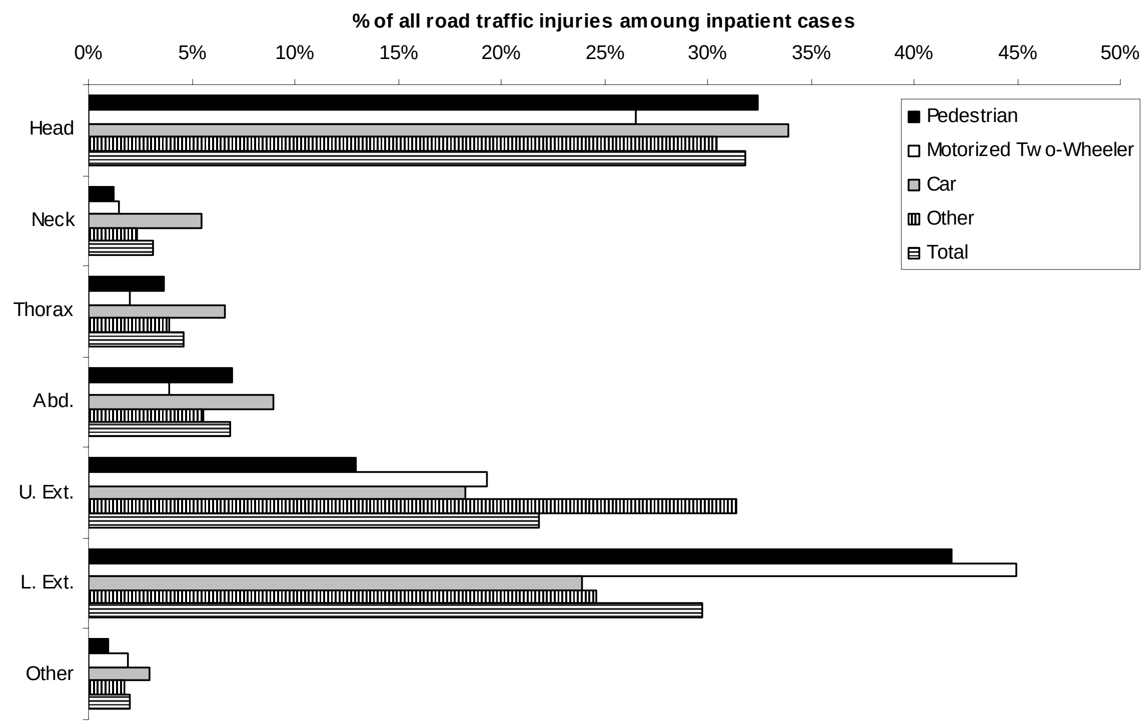
Source: Deaths based on death registration (multiple causes of death data); Inpatient based on MOH hospital discharge dataset; and Outpatient based on ER dataset.

Figure 4.4: Distribution of injuries among fatal, inpatient and outpatient cases



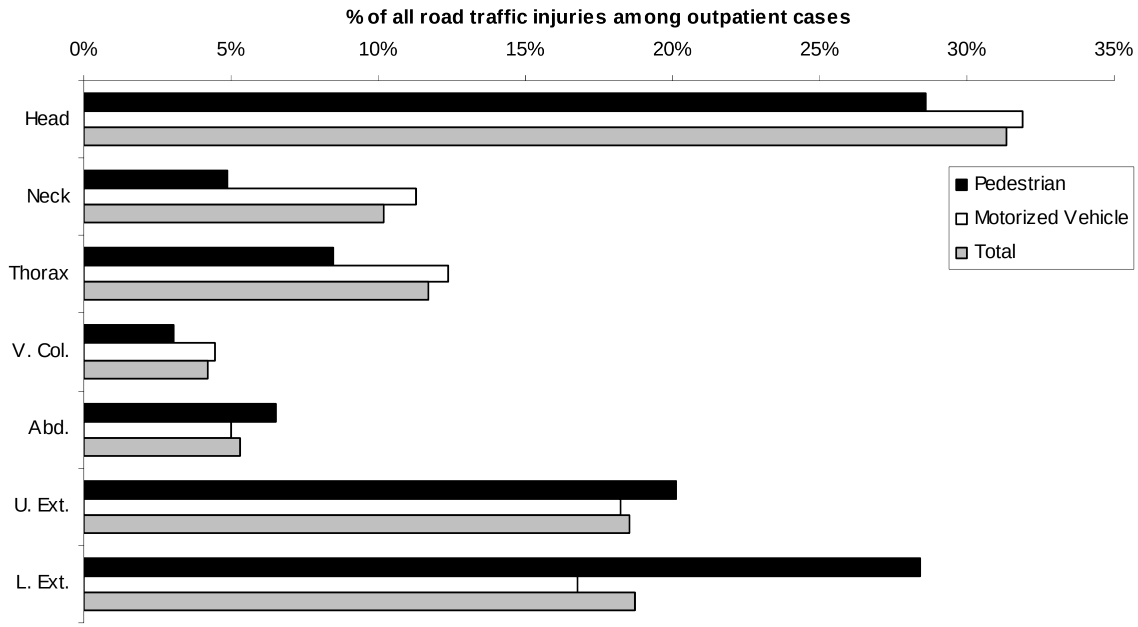
Source: Deaths based on death registration (multiple causes of death data)

Figure 4.5: Distribution of injuries for deaths among pedestrians, car occupants, and all road users



Source: Based on MOH hospital discharge dataset.

Figure 4.6: Distribution of injuries among inpatient cases for pedestrians, car occupants, and all road users



Source: Based on emergency room discharge data.

Figure 4.7: Distribution of injuries among outpatient cases for pedestrians, motorized vehicle occupants, and all road users

Public Health Burden

As discussed in Chapter 1, our description of public health burden relies upon Global Burden of Disease Study measures.[1,2] At the present stage, we have computed the burden from fatal cases in terms of the total years of life lost. However, we have not reported the burden associated with non-fatal injuries because the methods for computing YLDs for multiple injuries are currently being revised and are expected to change substantially.

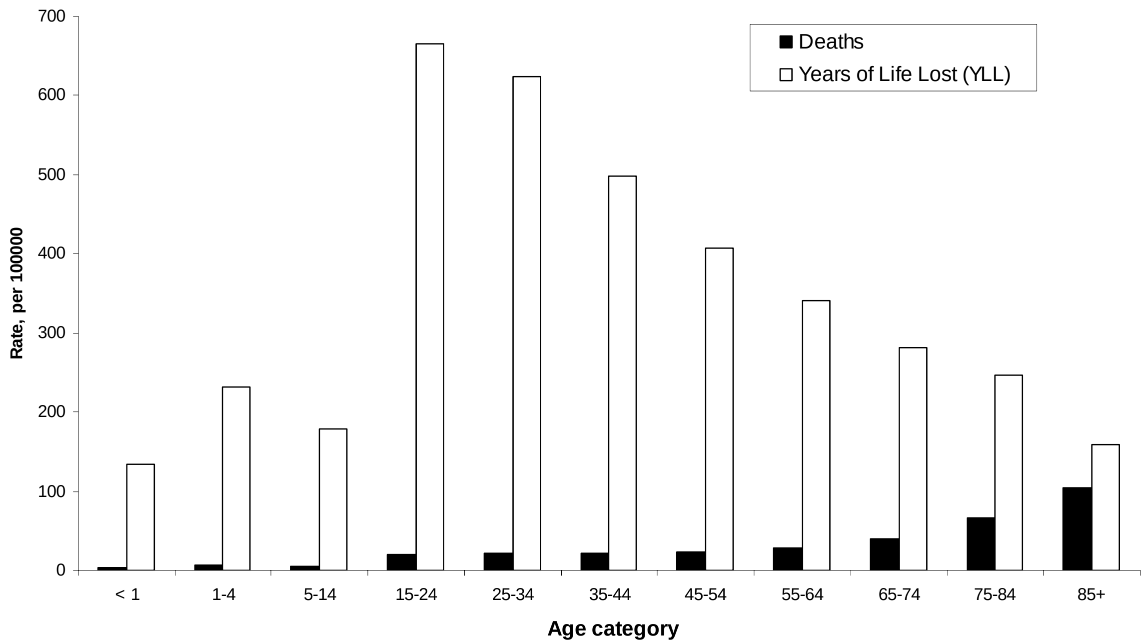
Table 4.3 and Figure 4.8 compare the age and sex distribution of deaths with total years of life lost. Computing years of life lost due to premature deaths gives greater weight to young lives. Thus, they have a trend that is considerably different from the death rate trend. While road traffic death rates increase with age, years of lives lost peak among the young adults, suggesting that young adults bear most of the public health burden of road traffic crashes.

Figure 4.9 illustrates the distribution of years of life lost by victim mode of transport. As with deaths, pedestrians and car occupants account for most (84%) of the life years lost to road traffic crashes.

Table 4.3: Years of Life Lost (YLL) by age and sex

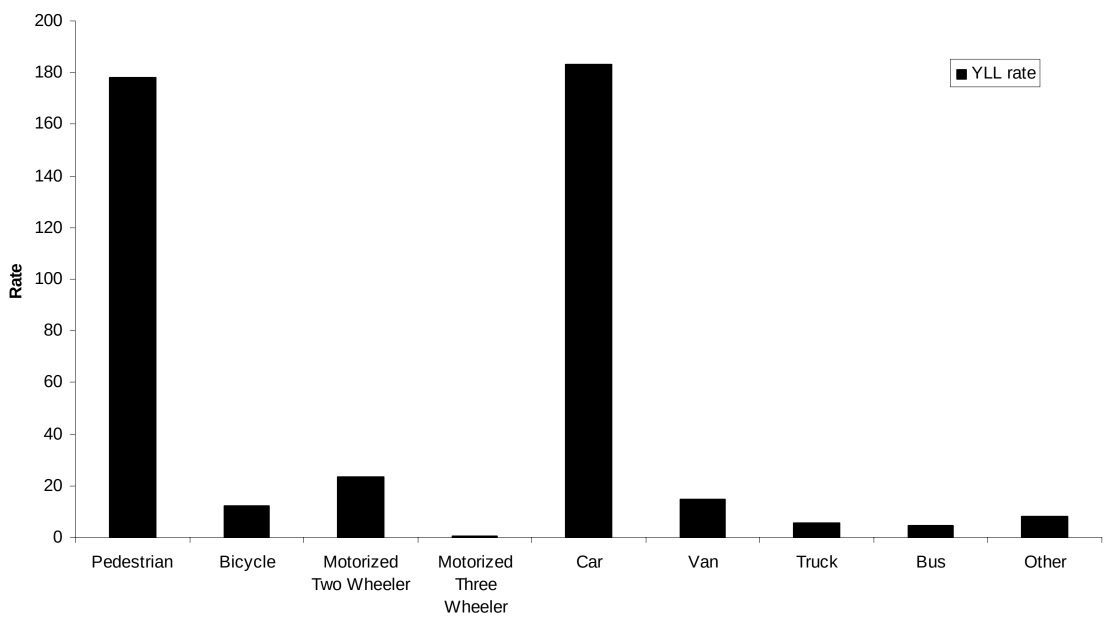
		Deaths		Years of Life Lost	
Sex	**Age**	**Cases**	**Rate**	**YLL**	**Rate**
both	< 1	79	4	2587	134
	1-4	530	7	18294	231
	5-14	1073	5	39502	178
	15-24	4025	19	139535	665
	25-34	3788	21	112954	624
	35-44	2997	21	70717	498
	45-54	2270	23	39629	407
	55-64	1668	29	19892	341
	65-74	1369	39	9844	281
	75-84	1080	67	3987	246
	85+	529	105	803	159
male	< 1	40	4	1293	131
	1-4	301	7	10358	256
	5-14	701	6	25746	228
	15-24	3273	31	113114	1068
	25-34	3191	35	94907	1055
	35-44	2496	36	58629	840
	45-54	1805	38	31358	664
	55-64	1260	45	14865	534
	65-74	995	62	6988	432
	75-84	686	96	2388	334
	85+	315	148	446	210
	Total	15063	28	360091	680
female	< 1	39	4	1295	137
	1-4	229	6	7936	205
	5-14	372	3	13755	127
	15-24	752	7	26421	254
	25-34	597	7	18047	198
	35-44	501	7	12088	167
	45-54	465	9	8271	165
	55-64	408	13	5027	164
	65-74	374	20	2856	152
	75-84	394	43	1599	176
	85+	214	73	357	122
	Total	4346	8	97654	182
Total		19409	18	457745	430

Source: Based on our analysis of the 2005 Mexican death registration data



Source: Based on our analysis of the 2005 Mexican death registration data

Figure 4.8 Public health burden of fatal road traffic crashes and non-fatal road traffic crashes that received institutional care by age

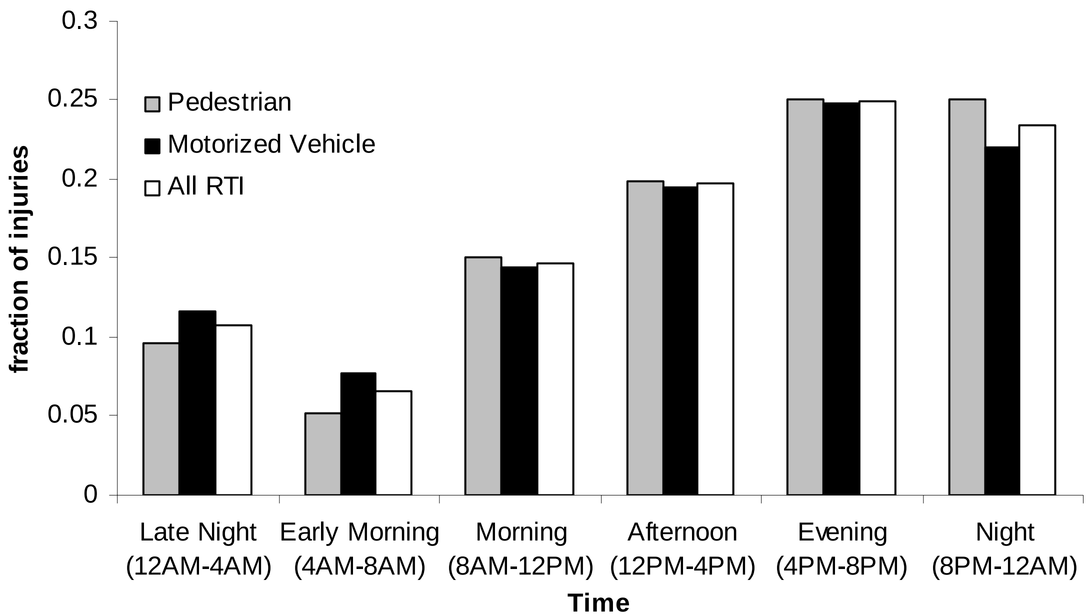


Source: Based on our analysis of the 2005 Mexican death registration data

Figure 4.9 Public health burden of fatal road traffic crashes and non-fatal road traffic crashes that received institutional care by victim's mode of transport

Timing of injuries

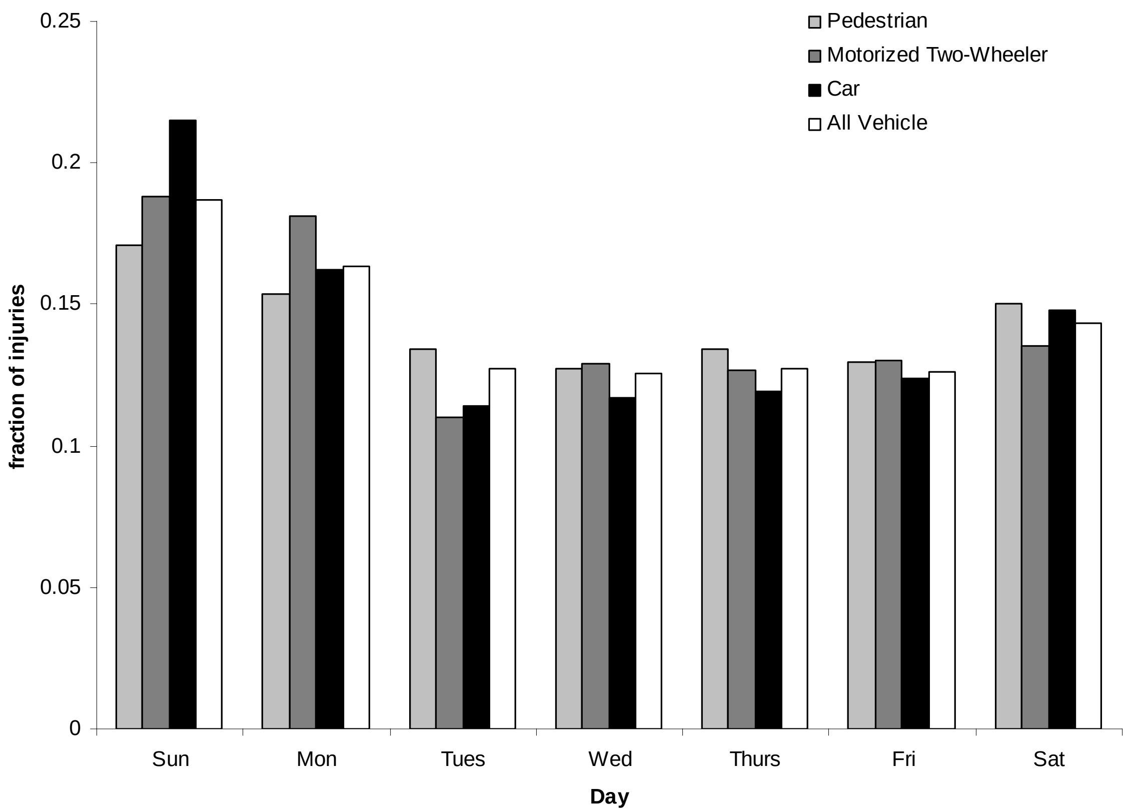
Figures 4.10- 4.12 illustrate the time distribution for injuries among pedestrians, motorized two-wheeler riders, car occupants, and overall road traffic deaths. Figure 4.10 illustrates the distribution by time of day. The differences between the victim types (pedestrians vs. occupants) are relatively small. More road traffic crashes requiring outpatient care (60%) occur during the heavier travel associated with day time (i.e. 8AM to 8PM). However, higher injury rates continue into the night period (8PM-12AM) even though travel during this period is less likely. This is probably because the decrease in exposure is compensated by the increased risks due to poor visibility and the possibility of driving under the influence.



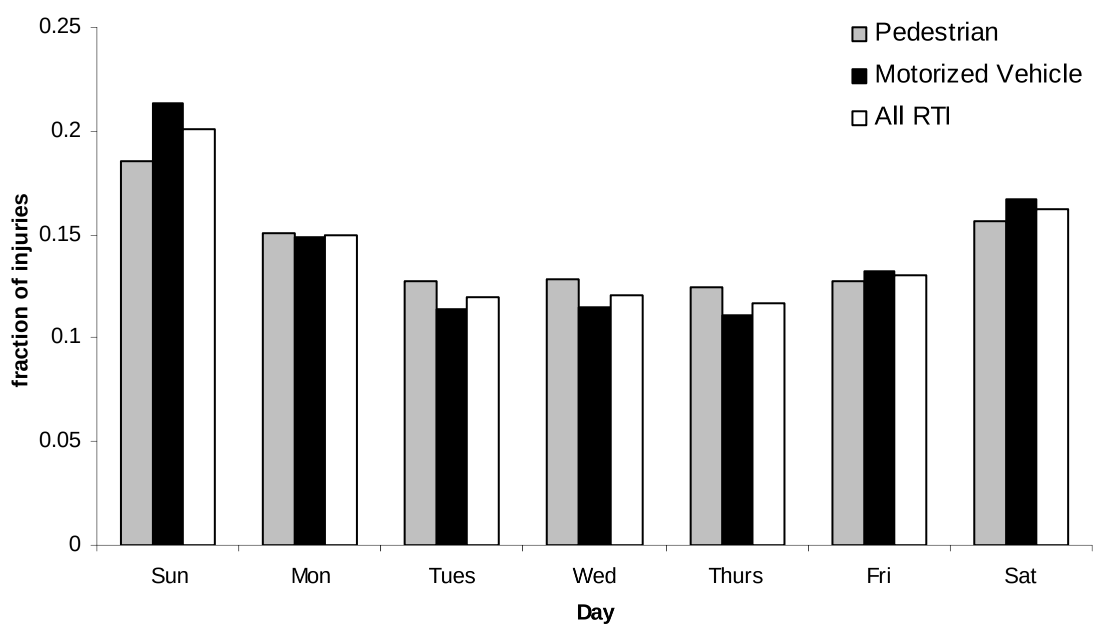
Source: Emergency Room visits. Time of day was not available for hospital admissions.

Figure 4.10 Distribution of RTI outpatient visits by time of day

Figure 4.11 illustrates the distribution of non-fatal road traffic crashes by day of week. Both hospital admissions and outpatient visits are highest on Sunday, which is the weekend holiday. A similar elevation of crash rates on the weekend holiday also occurs in other countries (for e.g. on Fridays in Iran).[3] Figure 4.12 illustrates the distribution of non-fatal road traffic crashes by month. Although the distribution of inpatient admissions does not show a distinct pattern, emergency room visits are slightly higher during the summer months.



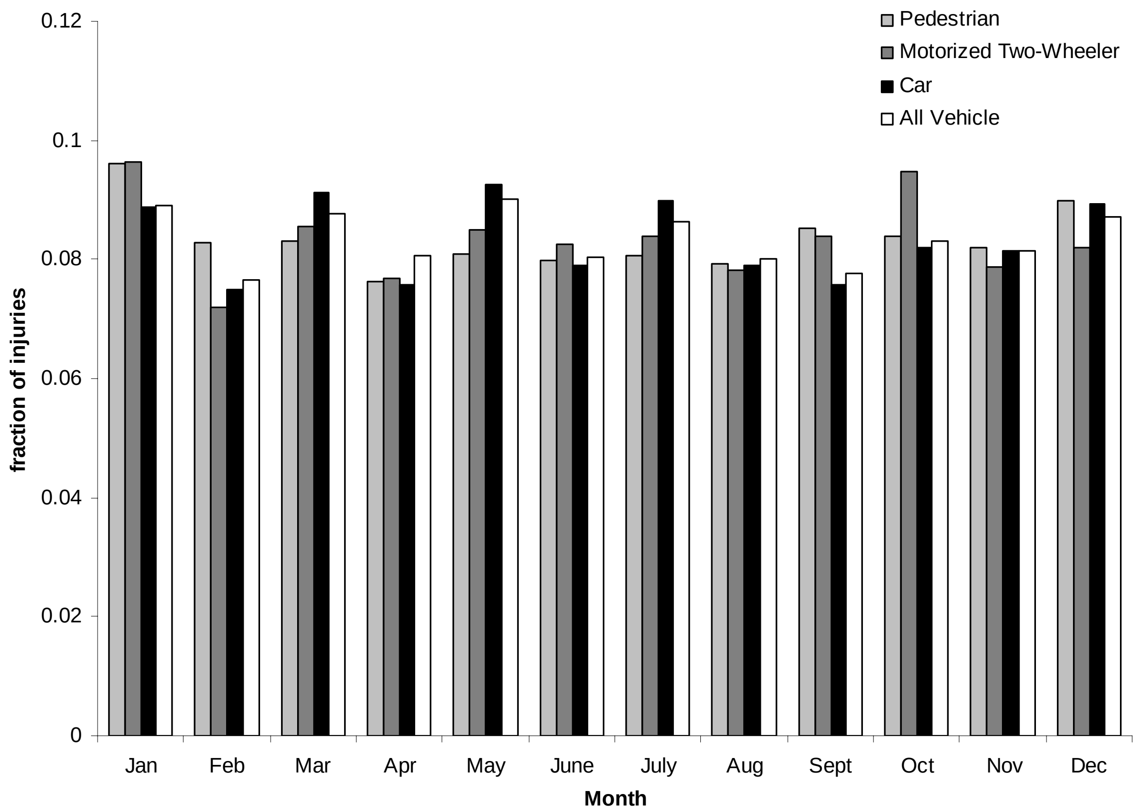
(a) Inpatient



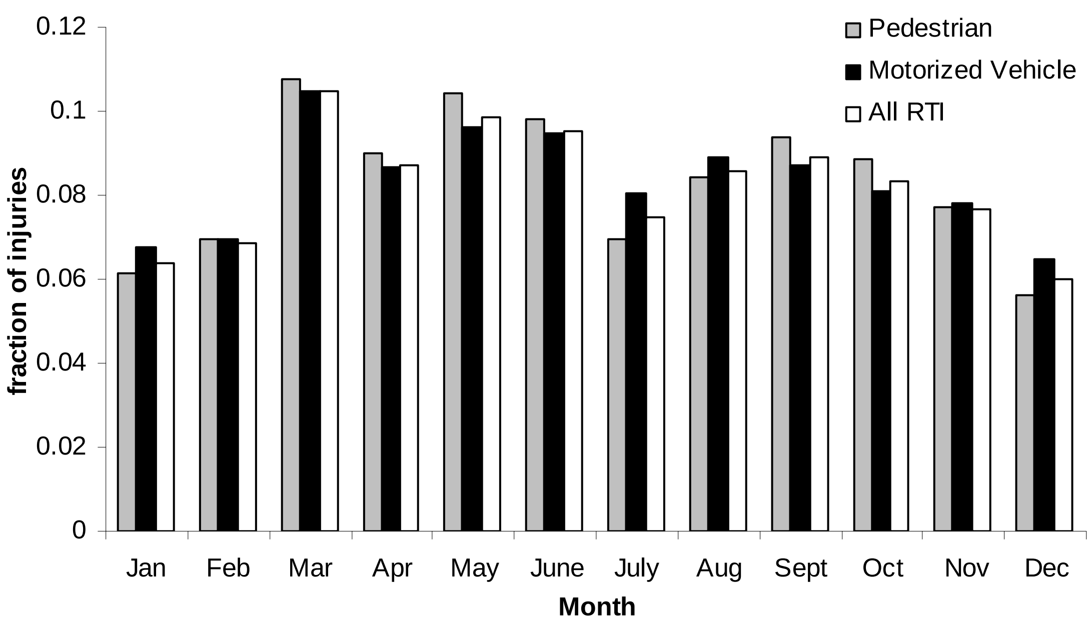
(b) Outpatient

Source: Inpatient based on MOH hospital discharge dataset; and Outpatient based on ER dataset.

Figure 4.11 Distribution of RTI hospital inpatient and outpatient visits by week day



(a) Inpatient



(b) Outpatient

Source: Inpatient based on MOH hospital discharge dataset; and Outpatient based on ER dataset.

Figure 4.12 Distribution of RTI hospital admissions and outpatient visits by month

References

1. Murray, C.J.L., & Lopez, A.D, eds. (1996). The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020, Harvard School of Public Health, Boston, MA.
2. GBD2002 Global Burden of Disease (2002), World Health Organization. Available from http://www.who.int/healthinfo/bodestimates/en/. (Accessed on February 28 2008.)
3. Bhalla, K.B., Shahraz, S., Naghavi, M., Bartels, D., and Murray, C., 2008, Road traffic injuries in Iran, Harvard University Initiative for Global Health, available from: http://www.globalhealth.harvard.edu (click on Research => Road Traffic Injuries).

Chapter 5

Conclusions and Recommendations

This report provides a comprehensive assessment of road traffic injuries at the national-level in Mexico. This chapter starts by summarizing the key findings. This is the second report in a series of country assessments that are being conducted. Thus, this chapter closes with a discussion of methodological issues and the implications for analysis of other countries.

Road Traffic Injuries in Mexico

Almost 20,000 people are killed in road traffic crashes annually in Mexico. This represents an annual death rate of 18 deaths per 100,000 people. Road traffic injuries are among the leading health problems in the country. They are the 5th leading cause of death in the country, accounting for 4% of all deaths (19,402 deaths).[1] In addition to deaths, road traffic crashes result in a large number of non-fatal injuries. Over one million people report being injured in a road traffic crash every year. Of these, over 700,000 people seek hospital care resulting in a significant burden on health institutions.

As in other countries, young adult males are at highest risk. The age group of 15-24 year old males dominates our tabulations of deaths, hospital admissions, outpatient visits, as well as injuries that do not receive any institutional medical care. Nevertheless, after normalizing for population, road traffic death rates are highest among the elderly, especially elderly pedestrians. This suggests the need for providing safe mobility options for the elderly.

Car occupants and pedestrians comprise the single largest road traffic victim categories, together accounting for 86% of all road traffic deaths and 67% of all hospital inpatient care for road traffic injuries. Pedestrians alone comprise nearly half (48%) of all road traffic deaths. Providing safe infrastructure for pedestrians should be a leading priority.

Not only are car occupants at a high risk (38% of deaths), cars pose a substantial threat to other road users. Our analysis found that cars were the impacting vehicle in 40% of all deaths. An additional 34% of all deaths were caused in single vehicle car crashes. Thus, cars are implicated in three-fourths of all road traffic deaths in Mexico. Controlling the threat posed by cars is fundamental to reducing the burden of road traffic deaths in Mexico.

Our report reveals large urban-rural differentials in road traffic injuries. The risk of road traffic crash involvement was much higher in urban areas, elucidating the need for safer urban transportation systems. However, death rates in urban and rural areas were similar, suggesting that the rate of road traffic crash survival is much lower in rural areas. In fact, the fraction of road traffic crashes that are admitted to hospitals in rural areas (6%) is half of the fraction in urban areas (12%). This indicates a failure of the Mexican health system to provide adequate medical care for rural residents.

While road traffic deaths may not be rapidly rising in Mexico as they are in many developing countries, the annual death toll has shown no signs of declining for over two decades. Almost all high income countries have witnessed declines in their national road traffic death rates since the 1970s. These declines have occurred in response to a significant and sustained policy effort. Mexico cannot afford to wait any further and should act immediately to implement the recommendations of the 2004 World Report on Road Traffic Injury Prevention.[2] In particular, the Mexican government needs to establish a national road safety agency with the necessary legislative authority and financial resources to implement a road safety strategy that provides safe mobility for all Mexicans.

Methodological Considerations and Limitations

The key methodological innovation in this project is the process of bringing together information from multiple sources to develop a comprehensive country assessment of fatal and non-fatal road traffic injuries. We have already demonstrated the feasibility of this approach in Iran.[3] In the current report, we use a variety of data sources, including the death registration system, hospital inpatient admissions from MOH and IMSS hospitals, outpatient visits from an ER discharge database, and WHS and ENSANUT health surveys that allow estimation of incidence of injuries by care received.

Our experience from the analysis of these two countries (Iran and Mexico) suggests that this process has several methodological issues that require the development of analytical tools. Typically, these methodological issues relate to managing data quality issues (e.g. unspecified categories), diagnostic tools for determining data quality, and methods for extrapolation in regions from which data may not be available. For the current study, we have worked on the development of two mathematical tools that help resolve these issues when unit record (micro) data is available. The first method is the use of multinomial logistic regression models to estimate external causes for cases assigned to unspecified and dump ICD codes. This method uses other variables in the Mexican death registration dataset to predict the causes for unspecified and dump cases. These additional variables include age, sex, education, occupation, marital status, urban/rural, and province of residence. We found from iteratively including additional variables that the exclusive use of age and sex resulted in the bulk of methodological improvement. This suggests that proportional redistribution using age and sex works well allowing us to use tabulated data with more confidence. The results and methods are currently being prepared for publication.[4]

The second method attempts to determine external cause for IMSS hospital admission data, which provides up to six nature of injury ICD-10 codes. This is a common problem in hospital discharge datasets even in high income countries. The databases do not track external causes, which are of primary interest to policymakers, largely because hospital discharge data are not usually intended for surveillance. Thus, a method is needed to estimate external causes from the distribution of injuries. We developed and validated a method that uses Bayesian inference. We start with a prior probability distribution of external causes for each case based on age and sex. We derived these distributions from the MOH hospital discharge dataset, which includes external cause and nature of injury codes. These prior probabilities are then updated based on injuries using the Bayes probability theorem. Our validation showed that the method is a substantial improvement over proportional age-sex distribution. The results and methods are described in detail in an upcoming journal publication.[5]

Estimating incidence from hospital datasets is another area of concern. In our analysis of Iran, the hospital datasets included a limited time registry of all hospital inpatient admissions and outpatient care for a selected set of provinces. This allowed us to generate incidence rates for these provinces which were extrapolated to national annual rates. In Mexico, this was not possible because we could not characterize the coverage of the hospital discharge dataset. Thus, we have relied on the results of the ENSANUT health survey which allowed estimation of incidence of road traffic injuries and the care they received.

However, several methodological issues remain and further work is needed. In particular, uncovering potential biases in unspecified ICD-10 codes and determining analytical methods to resolve these biases will be an ongoing concern for our project.

As we also reported in our analysis of Iran, these comprehensive assessments of road traffic injuries provide new insights.[3] Most past work in developing countries focuses almost exclusively on analysis of national road traffic deaths. However, we show that data on hospitalizations can uncover substantially different patterns. For instance, in Mexico we find that although bicyclists only account for 3% of all deaths, they comprise 15% of all hospital inpatient care. Similarly, in the analysis of Iran, we reported that although motorcycle riders ranked third (after car occupants and pedestrians) in deaths, they were the leading cause of hospitalizations, accounting for more than half of all inpatient care. In fact, in Iran we computed burden estimates (in disability adjusted life years lost) to show that motorcycle riders bore the largest public health burden because of the large number of non-fatal injuries. These results highlight the need for analyzing non-fatal injury data in national assessments of road traffic injuries.

This report also highlights the importance of focusing on health sector and vital registration data to estimate road traffic injuries. We find that other estimates of road traffic deaths (based primarily on police and crime reporting) substantially underestimate road traffic deaths, as was also the case in Iran. Both of these countries have already transitioned to relying upon death registration data for analysis. However, the implication for other developing countries, without high quality vital registration systems, is that police reports are underestimates and alternate methods for assessment are needed.

References

1. Stevens, G., et al., (2008) Characterizing the epidemiological transition in Mexico: National and Subnational Burden of Diseases, Injuries, and Risk Factors, 5(6): 900-910.

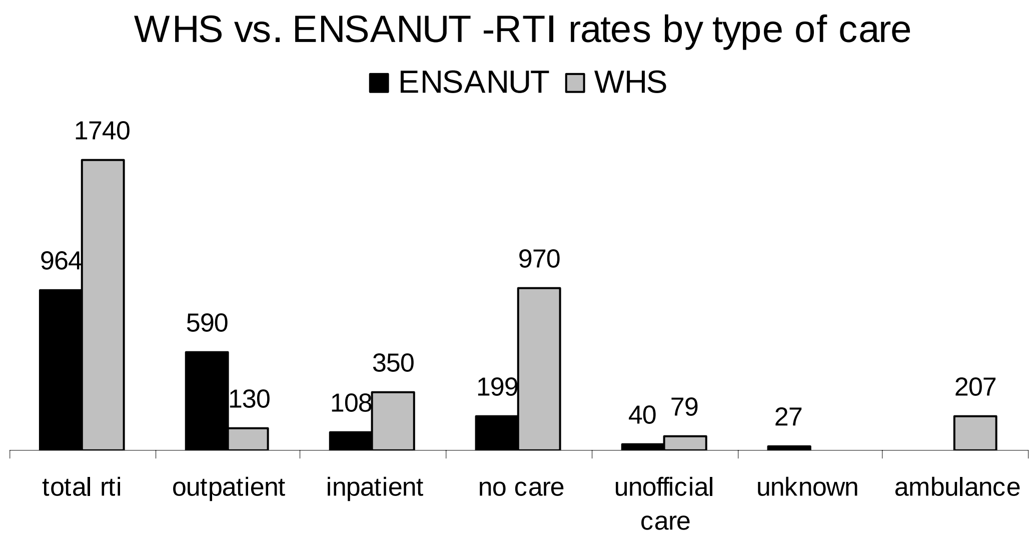
2. World Health Organization (WHO). (2004). World report on road traffic injury prevention, Geneva, Switzerland. International Road Federation, Available from www.irfnet.org (Accessed on February 18 2008.)
3. Bhalla, K.B., Shahraz, S., Naghavi, M., Bartels, D., and Murray, C., 2008, Road traffic injuries in Iran, Harvard University Initiative for Global Health, available from: http://www.globalhealth.harvard.edu (click on Research => Road Traffic Injuries).
4. Shahraz, S., et al. (2008), Redistributing ill-defined causes using regression models, Population Health Metrics, in prep.
5. Bhalla, K., et al. (2008), Estimating external causes for injury admissions in IMSS hospitals, Accident analysis and Prevention, accepted article.

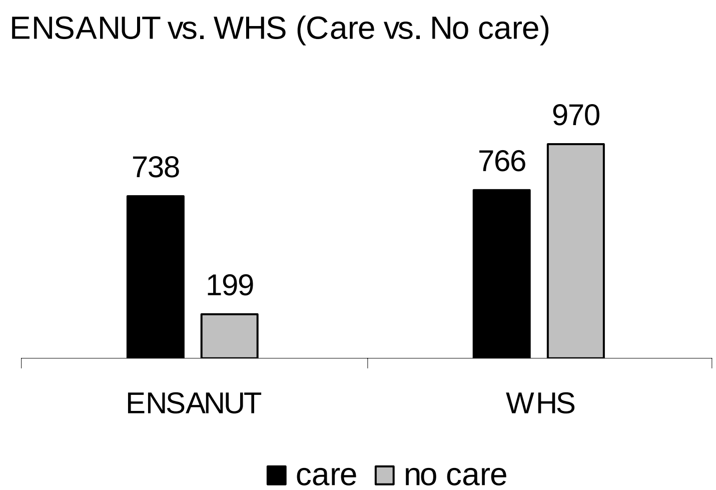
Appendix 1: Estimating Incidence of RTIs from Health Surveys (ENSANUT and WHS)

This appendix compares the results of ENSANUT 2005 and WHS 2003 for RTI rates in different subgroups of medical care. The detailed analysis is documented in a separate internal report that can be provided on request.

Survey Questions.

	ENSANUT 2005 (sample size :54068)	WHS (sample size: 37940)
RTI	1. Did you suffer any damage to your health as a result of an accident in the past 12 months? yes/no/no response/“I don’t know” 2. What type of accident did you have?” --Motor vehicle crash (*choque de o entre vehículos de transport*) -- Run over by vehicle (*atropellamiento)* -- Other transport accidents*(otros accidentes de transporte)*	In the past 12 months, have you been involved in a road traffic accident where you suffered from bodily injury? yes/no
INTERVENTION	What type of medical care/treatment did you relieve? 1) Inpatient care: “*clinica, sanatorio u hospital*” 2) Outpatient care: “*medico, consultorio*” plus “*psicologo, terapeuta*” plus “*otro personal de salud*” 3) Unofficial care: “*remedios caseros, automedicación*” plus “*curandero(a) y o yerbero(a)*” plus “*huesero(a) o sobador(a)*” plus “*encargado(a) de la comunidad*” 4) No care: “*nada o nadie”*.	1. Did you receive any medical care or treatment for your injuries? yes/no 2. Where did you first receive care? --On-site, ambulance --hospital --outpatient facility --private physician --traditional healer --other





Comparing results from WHS and ENSANUT analysis, it is evident that the RTI event rate for people who receive care is comparable across both the surveys (738 in ENSANUT vs. 766 in WHS). However, this is not the case for the "No care" group because of different question frames used by the two surveys.

The ENSANUT survey questions allow relatively clear identification of inpatient and outpatient care, which was not possible using WHS. ENSANUT is also a much larger survey with twice the number of observations.

Based on this comparison, ENSANUT results have been used in this study.

Appendix 2: Redistributing ill-defined causes using regression models

Article in preparation for submission to Population Health Metrics

Title: Improving the quality of injury statistics by using regression models to redistribute ill-defined events

Authors: Saeid Shahraz[1], Kavi Bhalla[1], David Bartels[1], Mohsen Naghavi[2], Rafael Lozano[2], Christopher J.L. Murray[2]
[1]Harvard University Initiative for Global Health, Cambridge, MA
[2]Institute for Health Metrics and Evaluation, Seattle, WA, USA
[3]Mexico Ministry of Health, Cuauhtemoc, DF, Mexico

Abstract

Background

Interpreting ill-defined/unknown cause of death in vital registration data is a major challenge for determining burden of injury. The conventional method consists of age/sex proportionate redistribution of ill-defined/unknown causes over known cause categories and ignores potential bias in the original data. If case-level data are available, additional victim information may help redistribute ill-defined/unknown cases and, thereby, provide less-biased redistributions. We test the validity of multinomial regression applied to estimate cause of death distribution for cases with ill-defined/unknown mortality codes.

Methods

We evaluate the performance of the multinomial regression model by application to test datasets from 2004 Mexican vital registration data. To predict cause of death, the regression method makes use of independent variables, such as sex, age, place of accident, place of residence, education, and insurance type. We apply age/sex proportionate redistribution to the same test datasets to compare the two methods.

Results

The multinomial regression model performs more accurately than age/sex proportionate redistribution.

Conclusions

When case-level data is available, regression models can use additional dataset covariates to redistribute ill-defined/unknown causes over known causes. However, when only data of tabulation-level detail are available, sex/age proportionate redistribution performs acceptably.

Appendix 3: Estimating external causes for injury admissions in IMSS hospitals

Article accepted for publication in Accident Analysis and Prevention

Title: Estimating the distribution of external causes in hospital data from injury diagnosis

Authors: Kavi Bhalla[a*], Saeid Shahraz[a], Mohsen Naghavi[b], Rafael Lozano[c], and Christopher Murray[b]

[a]Harvard University Initiative for Global Health, Cambridge, MA
[b]Institute for Health Metrics and Evaluation, Seattle, WA, USA
[c]Mexico Ministry of Health, Cuauhtemoc, DF, Mexico

Abstract

Hospital discharge datasets are a key source for estimating the incidence of non-fatal injuries. While hospital records usually document injury diagnosis (e.g. traumatic brain injury, femur fracture, etc) accurately, they often contain poor quality information on external causes (e.g. road traffic crashes, falls, fires, etc), if such data is recorded at all. However, estimating incidence by external causes is essential for designing effective prevention strategies. Thus, we developed a method for estimating the number of hospital admissions due to each external cause based on injury diagnosis. We start with a prior probability distribution of external causes for each case (based on victim age and sex) and use Bayesian inference to update the probabilities based on the victim's injury diagnoses. We validate the method on a trial dataset in which both external causes and injury diagnoses are known and demonstrate application to two problems: redistribution of cases classified to ill-defined external causes in one hospital data system; and, estimation of external causes in another hospital data system that only records nature of injuries. In comparison with age-sex proportional distribution (the method usually employed), we found the Bayesian method to be a significant improvement for generating estimates of incidence for many external causes (e.g. fires, drownings, poisonings). But the method, performed poorly in distinguishing between falls and road traffic injuries, both of which are characterized by similar injury codes in our datasets. While such stop gap methods can help derive additional information, hospitals need to incorporate accurate external cause coding in routine record keeping.