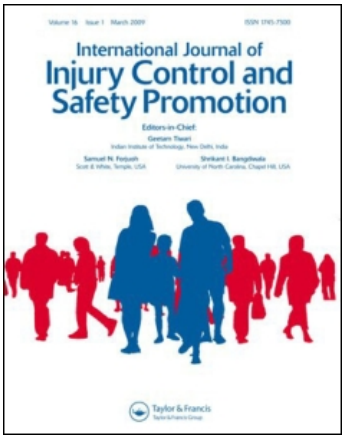

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Incidence of road injuries in Mexico: country report

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Incidence of road injuries in Mexico: country report

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We used data from various sources to triangulate to a national snapshot of the incidence of fatal and non-fatal road traffic injuries in Mexico in 2005. Data sources used include national death registration data, national hospital discharge data and a nationally representative health survey. We estimate that in 2005, 19,389 people died due to injuries and nearly one million were injured in road traffic crashes. While deaths in high-income countries are declining, this is not the case in Mexico. Young adult males are the demographic at the highest risk in non-fatal crashes, but the elderly have the highest road death rates primarily due to pedestrian crashes. Pedestrians alone comprise nearly half (48%) of all deaths. Cars pose a substantial threat to occupants (38% of deaths and 39% of hospital admissions) and to other road users.

Keywords: road traffic injuries; surveillance; Mexico; less developed countries

Introduction

Road traffic injuries (RTIs) cause significant global mortality and morbidity, with 85% of all deaths and 90% of disability-adjusted life years lost occurring in developing countries (Murray & Lopez, 1996; Nantulya & Reich, 2002). The 2004 World Report on Road Traffic Injury Prevention, jointly issued by the World Health Organization and the World Bank, highlighted the fact that unsafe roads pose a serious threat to global public health (World Health Organization (WHO), 2004). The Report emphasised the need for injury surveillance systems capable of generating reliable data for describing the public health burden of RTIs, 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. Thus, we developed a methodology that uses all existing information sources within a country to triangulate to a national snapshot of RTI metrics (Bhalla, Naghavi, Shahraz, Bartels, & Murray, 2009a) and have demonstrated to quantify national road injuries in Iran (Bhalla, Shahraz, Bartels, & Abraham, 2009b; Naghavi et al., 2009).

While various past studies have studied RTIs in Mexico, (Hijar, Chu, & Kraus, 2000; Hijar, Vazquez-Vela, & Arreola-Risa, 2003) we are not aware of any study that has characterised the national burden of road injuries. Thus, in this article, we estimate national road fatalities and non-fatal injury incidence in Mexico and disaggregate the incidence by age, sex, external cause, nature of injury and type of institutional medical care.

Methods

We have described the detailed methodology for generating a national road injury snapshot in an earlier article in this journal (Bhalla et al., 2009b). The method assembles data from multiple sources including death registers, hospital records and health surveys into national estimates. This requires filling information gaps, mapping from varying case definitions, deriving population-based incidence estimates from sources that may not track denominator populations and reapportioning cases assigned to poorly specified causes.

Data sources

Figure 1 illustrates our general strategy for estimating the national burden of road injuries in Mexico from various existing data sources. Note that we develop the national snapshot using information from four domains: deaths, hospitalised care (inpatient admissions

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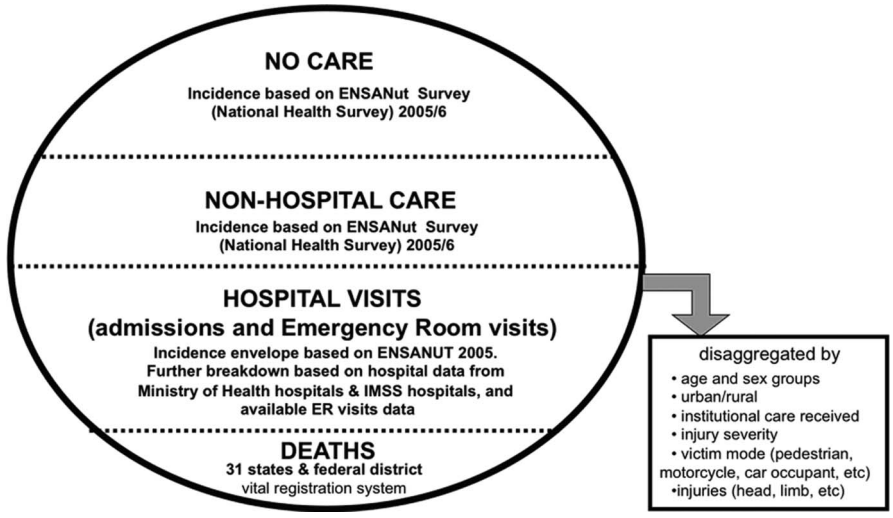

Figure 1. Developing a national snapshot of road injuries in Mexico from available data sources.

and emergency room visits), outpatient clinics and deaths.

We estimated the incidence of fatal road injuries using the following national death registration datasets: (1) unit record death registration data, 1979–2005, containing external cause of death for injuries coded using the Tenth Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10), collected by the Ministry of Health; (2) unit record multiple causes of death data, 2001–2005, from the Sistema Estadístico, Epidemiológico de las Defunciones (SEED) registry maintained by the Ministry of Health, containing nature of injury and external cause coded using ICD-10 and (3) age-, sex- and external cause of death-tabulations, 1955–2005, from the WHO Mortality Database data (WHO Mortality Database, 2008). We present results derived from the WHO Mortality Database because it is the most complete death data source. Although the primary variables of interest for our analysis were age, sex, and external cause, the unit record data also contained variables for location of residence, education, marital status, occupation, insurance, medical care before death and death certifying agency.

The incidence of non-fatal road injuries was estimated from hospital administrative data and national health surveys. Hospital data sources included: (1) Subsistema Automatizado de Egresos Hospitalarios (SAEH), which is a hospital discharge database for all Ministry of Health Hospitals that includes unit record data for external cause and nature of injury coded to ICD-10, for 2005 ($N_{\text{total injury cases}} = 145{,}908$, $N_{\text{RTI cases}} = 29{,}416$); (2) Instituto Mexicano de Seguro Social (IMSS), which is a hospital discharge database similar to SAEH but for Mexican Institute of Social Security hospitals that does not include external cause, for 2005 ($N_{\text{total injury cases}} = 193{,}422$, $N_{\text{RTI cases}}$ not available because no external cause collected) and (3) unit record emergency room dataset for 2005 from Ministry of Health hospitals, which includes nature of injury and external cause aggregated at occupant and pedestrian, was also analysed ($N_{\text{total injury cases}} = 497{,}558$, $N_{\text{RTI cases}} = 42{,}778$).

We analysed two recent national health surveys: (1) Encuesta Nacional de Salud y Nutrición (ENSANut) ($N = 94{,}302$), and (2), 2003 World Health Survey ($N = 38{,}618$) (Olaiz-Fernández et al., 2006; World Health Survey, 2008). The results are presented from ENSANut only because of larger sample size and the fact that WHS does not contain data for individuals younger than 18 years. ENSANut is a national, state and urban/rural representative health and nutrition survey conducted in 2005 by the National Institute of Public Health. Sampling was probabilistic, multistage and cluster stratified (Olaiz-Fernández et al., 2006). We analysed responses to two consecutive questions to determine road injury incidence: (1) 'Did you suffer any damage to your health as a result of an accident in the past 12 months'? (Response categories: 'yes', 'no', 'no response' and 'I don't know'); (2) 'What type of accident did you have?' (Response categories: 'motor vehicle crash', 'run over by vehicle', 'other transport accidents'). We analysed the following question to disaggregate these results by type of medical care: 'What type of medical care/treatment did you receive'? We grouped response categories as 'hospital care (inpatient and emergency room)', 'non-hospital care' and 'no care' (Groupings: hospital care = clinica, sanatorio u hospital; non-hospital care = medico, consultorio, psicologo, terapeuta, remedios caseros,

automedicación, curandero(a) y/o yerbero(a), huesero (a) o sobador(a), and encargado(a) de la comunidad; no care = nada o nadi).

The population for 2005 with age, sex, and residence (urban/rural) was obtained from the National Institute of Public Health.

Analysis

We aimed to estimate incidence by age, sex, external cause, and residence (urban/rural), and type of institutional medical care (hospital inpatient, outpatient), wherever possible (Bhalla et al., 2009b). Hospital inpatient and outpatient datasets were further disaggregated by nature of injury.

Table 1 shows the number of cases coded to partially specified causes in the 2005 death registration data. These deaths were redistributed proportionately over the corresponding specified categories (as shown in Table 1) within age and sex groups. In particular, it should be noted that deaths attributed to the unspecified ICD-10 code X59 (accidental exposure to other and unspecified factors - exposure to unspecified factor) comprise 13.2% of all injury deaths.

We derived estimates of the incidence of non-fatal injuries by coupling the national health survey and the hospital discharge database as follows. The total incidence of RTIs was broken down by age, sex, residence (urban/rural), and the types of institutional medical care (hospital care, non-hospital medical care and no care) were estimated from the national health survey, ENSANut. Further breakdown of these by external cause (i.e. victim mode of transport) and nature of injuries (diagnoses) was done using fractions from the hospital databases. Thus, MOH and IMSS hospital data were together assumed to be a representative fraction of all hospital admissions in Mexico. As IMSS hospital data does not contain external cause, we used Bayesian inference to estimate the external cause from the injury diagnoses. (We have described this method in detail elsewhere (Bhalla, Shahraz, Naghavi, Lozano, & Murray, 2008)). Similarly, the external cause and nature of injuries recorded in the MOH emergency room data were assumed to be representative of national outpatient data for fractional breakdown of the survey-based envelope estimates.

Table 1. Distribution of deaths coded to partially specified causes in the Ministry of Health vital registration data for 2005.

	Cases (%[a])	Redistributed[b] over
Total (all-cause) deaths	485 376	
Total injury deaths	51,779 (100) (10.7% of all deaths)	
Unknown sex	38 (0.1)	Specified sex
Unknown age	678 (1.3)	Specified age
Unknown RTI (unspecified road user)	6,618 (12.4)	Specified RTI
Unknown transport injury (unspecified transport mode)	7 (0.0)	Specified transport
Unspecified accidents (X59)	6,867 (13.2)	Specified unintentional injuries
Unspecified injuries	1,160 (2.2)	Specified injuries

[a]% of all injury deaths.

[b]Redistribution is age- and sex-prorata (i.e. proportional redistribution over specified causes within age- and sex-aggregated categories).

Results

Table 2 shows the number of cases and rates of fatal and non-fatal road injuries disaggregated by age, sex and type of medical care. In 2005, nearly one million residents in Mexico were injured in road traffic crashes. Thus, approximately 1 of every 100 persons is involved in a RTI every year. Of these, 19,389 people were killed in road traffic crashes, amounting to an annual incidence rate (hereafter, referred to as 'rate') of 18 per 100,000 people. Over 0.7 million RTI victims received medical care at hospitals (as admissions or outpatients) and nearly 0.2 million cases did not receive any medical care.

Male fatality rates and non-fatal injury rates are higher than those of females in all age categories. The age-pattern of fatal rates differs from that for non-fatal injuries. While non-fatal injuries are highest among young adults and then generally decrease with increasing age, fatality rates increase with age and are highest among the elderly. This is true for both men and women.

Table 3 shows the ratio of inpatient cases per fatal case by sex and victim transport mode. For every fatal case, six cases are admitted to hospitals as inpatients. Pedestrians have the lowest number of inpatient hospital admissions relative to deaths suggesting a high case fatality rate. The highest ratio is for bicyclists (1 fatal case: 30.1 hospital admissions), who are nearly 10 times more likely to be admitted than pedestrians.

Figure 2 compares the distribution of deaths and hospital admissions by victim mode of transport. While car and pedestrians comprise the largest categories for both, pedestrians account for a much larger fraction of deaths (48%) and car occupants dominate hospital admissions (39%). Furthermore, whereas 86% of deaths are comprised of pedestrians

Table 2. Road injuries in Mexico in 2005 disaggregated by age, sex, and type of medical care received.

Sex	Age (years)	Population (in 1000s)	Deaths		Hospital care		Non-hospital care		No care		Total non-fatal injuries	
			Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate
Both	0–4	10,544	598	6	No data	No data	No data	No data	No data	No data	No data	No data
	5–9	10,680	478	4	No data	No data	No data	No data	No data	No data	No data	No data
	10–14	10,844	595	5	67,474	622	8,940	82	24,883	229	101,296	934
	15–24	19,005	4,024	21	216,729	1,140	9,763	51	69,197	364	295,689	1,556
	25–44	31,238	10,518	34	272,358	872	10,252	33	69,308	222	351,918	1,127
	45–64	15,874	3,936	25	102,110	643	6,770	43	19,938	126	128,818	812
	65+	6,082	2,976	49	48,068	790	1,789	29	11,057	182	60,915	1,002
Male	0–4	5,366	336	6	No data	No data	No data	No data	No data	No data	No data	No data
	5–9	5,400	298	6	No data	No data	No data	No data	No data	No data	No data	No data
	10–14	5,437	403	7	40,984	754	7,258	134	17,806	327	66,048	1,215
	15–24	9,136	3,271	36	105,233	1,152	9,244	101	49,641	543	164,118	1,796
	25–44	15,083	8,955	59	166,889	1,106	8,068	53	52,177	346	227,133	1,506
	45–64	7,775	3,063	39	61,778	795	4,027	52	17,714	228	83,518	1,074
	65+	2,722	1,995	73	33,858	1,244	1,791	66	9,469	348	45,117	1,658
	Total	50,919	15,051	30	408,741	1,018	30,387	76	146,806	366	585,935	1,459
Female	0–4	5,178	261	5	No data	No data	No data	No data	No data	No data	No data	No data
	5–9	5,280	180	3	No data	No data	No data	No data	No data	No data	No data	No data
	10–14	5,407	192	4	26,104	483	1,532	28	6,790	126	34,426	637
	15–24	9,869	753	8	111,479	1,130	444	5	19,285	195	131,208	1,330
	25–44	16,156	1,563	10	111,034	687	2,672	17	20,071	124	133,777	828
	45–64	8,098	873	11	41,256	509	2,799	35	2,851	35	46,907	579
	65+	3,360	982	29	14,227	423	No cases	No cases	1,594	47	15,821	471
	Total	53,348	4,338	8	304,100	709	7,448	17	50,590	118	362,139	844
Total		104,267	19,389	19	712,841	858	37,835	46	197,397	238	948,073	1,142

Source: fatality based on national vital registration; all other care categories are based on ENSANut (national health survey).
Rate refers to annual incidence rate per 100,000 population.

Table 3. Ratio of hospital admissions (inpatient only) per fatal case by sex and victim mode.

Victim mode	Both	Male	Female
Pedestrian	3.5	3.3	4.0
Bicycle	30.1	25.2	123.5
Motorized Two Wheeler	8.8	8.0	15.8
Car	6.1	5.4	8.4
Van	8.4	6.7	18.1
Truck	3.8	4.2	2.9
Bus	9.9	9.9	9.8
Other	11.3	10.7	17.3
Total	5.9	5.5	7.3

Source: deaths based on death registration; hospital admissions based on hospital discharge data scaled to match total hospital admissions matched with those predicted by the ENSANut (national health survey).

and car occupants, only 67% of hospital admissions are comprised of pedestrians and car occupants. The discrepancy is largely due to increased motorised two-wheeler user and bicyclist cases in hospital admissions.

Figure 3 illustrates the trend of increasing total road traffic death rate with increasing age for all road traffic victims. This trend is driven by the increasing pedestrian death rate. Car occupant death rates are fairly constant across age groups and are much lower than pedestrians especially among older age groups.

Figure 4 illustrates the distribution of injuries by body region for hospital admissions. Head, upper extremity and lower extremity injuries are the most common for all victim modes of transport. However, the pattern of injuries differs by road users. While lower extremity injuries are most common among pedestrians and motorised two-wheeler riders, car occupants have more injuries to the head, neck, thorax and abdomen.

Discussion

Road injuries result in a substantial public health burden in Mexico. Figure 5 compares Mexico's 2005 RTI death rate with the death rates of various high-income countries, including the United States, world regions and Iran (Bhalla et al., 2009a; Global Burden of Disease, 2002; International Road Traffic and Accident Database, 2008). The death rate from road crashes in Mexico is higher than the regional average for the Latin American and Caribbean and is substantially higher than that of high-income countries, which have substantially higher motorisation rates.

Comparing our estimates of RTI deaths to those due to other causes estimated in the 2004 Mexican burden of disease study suggests that road deaths are the fifth leading cause of death in Mexico, accounting for 4% of all deaths – nearly two times the world average of 2.1% (Stevens et al., 2008). Road injuries are the leading cause of injury deaths in Mexico, comprising 37% of all injury deaths, substantially higher than the world average of 23%.

To place this estimate into perspective, the 1985 Mexico City earthquake killed approximately 9000 people and attracted a dramatic emergency response, replete with international attention and visits from heads of state (Timeline: Latin American earthquakes since 1970, 2007). Similarly, drug violence in Mexico claimed over 6300 lives in 2008, and received substantial international attention and the deployment of army soldiers and federal police to combat the cartels (Mexico says troops cut drug deaths in border city, 2009). In comparison, the approximately 20,000 people killed by road crashes annually have received little attention.

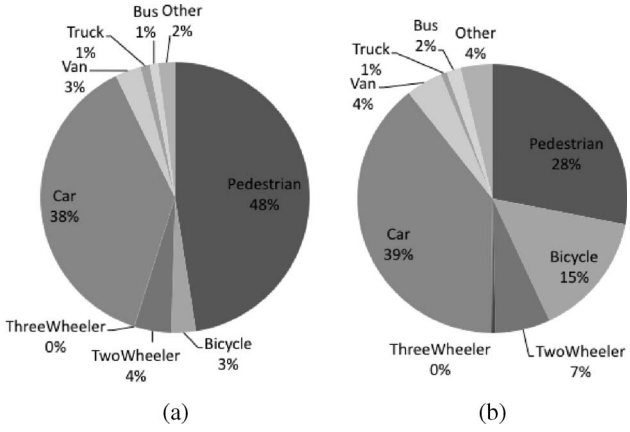

Figure 2. Distribution of deaths and hospital admissions by victim mode of transport (a) Deaths (b) Hospital admissions (19,389 cases) (114,607 cases). Sources: fatal cases based on vital registration; hospital admissions based on hospital discharge data.

Figure 6 illustrates that our estimate for fatal RTI incidence is substantially different than published figures (ASVM: Atlas de Seguridad Vial de Mexico; International Road Federation (IRF), 2003; SIMBAD: Sistema Municipal de Base de Datos, 2008; US Department of Transportation, 2000). Previously published estimates are largely dependent upon police reporting, which have been shown to substantially under-report non-fatal cases in most developing countries (Aeron-Thomas, 2000; Amoros, Martin, & Laumon, 2007; Elvik & Mysen, 1999). Additionally, it is apparent that road deaths in Mexico have remained steady for over two decades and show no sign of decline.

It should be noted that Figure 6 also shows the relative effect of the reapportioning deaths assigned to partially specified causes (e.g. unspecified transport injuries, unspecified accident, etc.) in the death registration as shown in Table 1. This reapportionment, which is in (age- and sex-specific) proportion to the fully specified causes, results in an increase in the number of road deaths by nearly 30%. This is a potential source of error because we have assumed that deaths coded to partially specified causes are not biased, i.e. the specified deaths are representative of the deaths coded to partially specified categories. Although this is a source of uncertainty in the estimates, it should be noted that even the unadjusted (completely specified) road injury cases from the death registration data substantially exceed estimates from other sources.

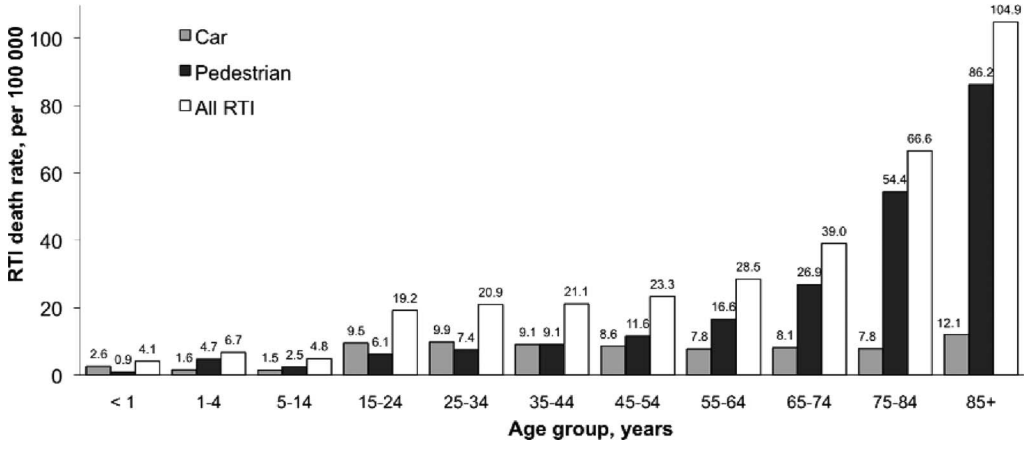

Figure 3. Death rate by age category and victim mode of transport. Source: vital registration data.

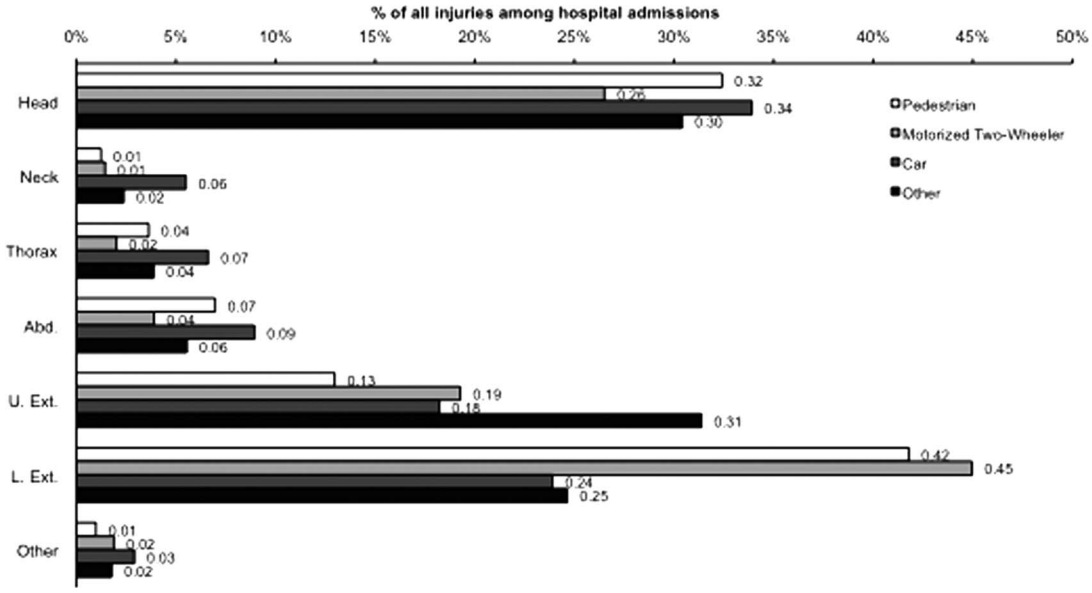

Figure 4. Distribution of injuries among inpatient cases for pedestrians, car occupants and all road users. Source: hospital discharge dataset (SAEH).

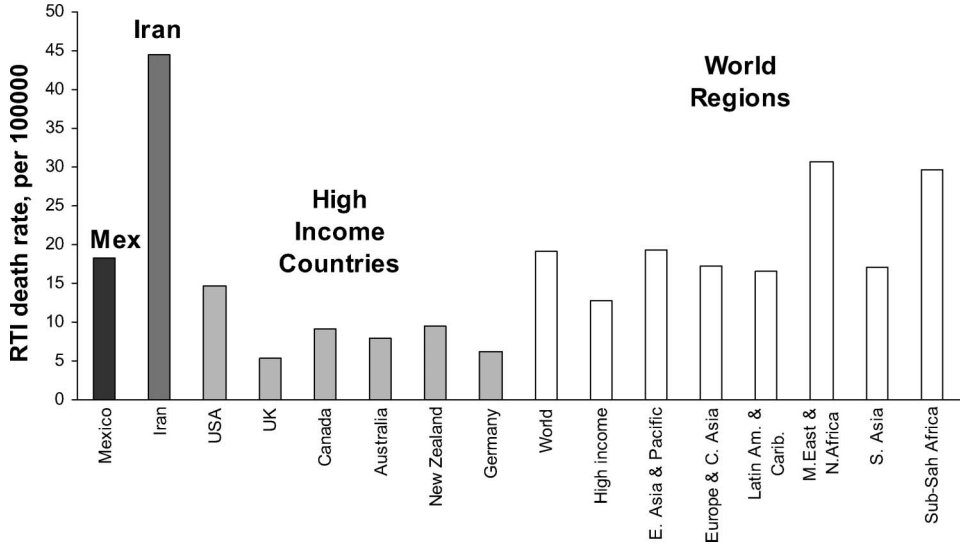

Figure 5. Road injury death rate in Mexico compared with other countries and world regions. Sources: Mexico and Iran based on our analysis of vital registration data (Bhalla et al., 2009a); high-income countries based on the International Road Traffic and Accident Database (IRTAD 2008); and, World regions based on the Global Burden of Disease (GBD 2002).

Of the nearly one million people who were injured in road crashes in 2005, 0.2 million did not receive any medical care. While some of these cases are undoubtedly relatively minor injuries not requiring institutional medical care, it is likely that several cases required medical treatment but did not receive it due to disparities in access to care. Thus, in 2005 there were at least 0.75 million people, representing over 0.7% of the population, injured in road crashes severe enough to warrant some form of medical care.

Males are much more likely to be killed or injured than females in Mexico. This trend is fairly consistent across countries and is likely associated with gender disparities that result in decreased female travel, and differences in risk taking

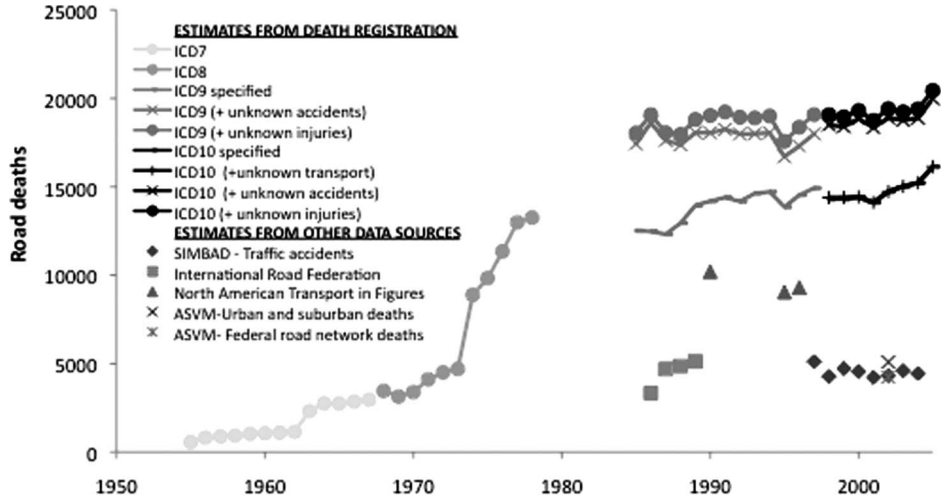

Figure 6. Time series of road traffic deaths in Mexico from various sources. Sources: vital registration, Sistema Municipal de Base de Datos (SIMBAD 2008), International Road Federation (IRF), North American Transportation in Figures, and Atlas de Seguridad Vial Mexico (ASVM 2004).

behaviour. The rate of non-fatal injury generally peaks from ages 15 to 34 for both males and females, whereas the elderly have the highest death rates for both sexes. This difference is likely due to a lower threshold for biomechanical damage in elderly persons than children and young adults. A similar pattern is seen in other countries, including the United States (Finkelstein, Corso, Miller, 2006).

The vast majority of deaths are composed of car occupants and pedestrians, whereas inpatient cases also include a substantial proportion (22%) of motorised two-wheeler users and bicyclists. This is an intriguing pattern and is likely an outcome of younger people being more likely than the elderly to use motorised two-wheelers and bicycles. The pattern of injuries observed among hospitalised cases is consistent with mechanisms of injury. Pedestrians sustain high levels of lower extremity injury due to forceful contact with vehicle bumpers and high levels of head injuries due to impact with vehicle windshields or the ground. Car occupants or drivers have a higher proportion of neck and thorax injuries, which are likely caused by upper body interaction with the steering wheel and dashboard.

Conclusion

This analysis uses analytical methods that incorporate various data sources (vital registration, hospital data, health surveys) to triangulate to national road injury estimates. We show that RTIs are a leading cause of death and impose a substantial public health burden in Mexico. The government of Mexico needs to act immediately to implement the recommendations of the 2004 World Report (World Health Organization (WHO), 2004) to stop the needless loss of life on Mexican roads.

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