Expected years of life lost through road traffic injuries in Mexico

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Background: Road traffic injuries (RTIs) are a leading cause of premature mortality, mainly in low- and middle-income countries [1]. An increase in the related burden has been observed worldwide and pedestrians, cyclists, and two-wheeled motorcycle riders are the most vulnerable populations that contribute to the observed mortality [2,3]. In Mexico, the overall RTI mortality has decreased since 2009; however, an increase in fatal motorcycle mortality has been observed and RTIs are still a main cause of death [4–6].

Traditional mortality rates have been used to evaluate the RTI burden in Mexico, which fail to highlight the premature deaths [7]. In 2015, the country adopted the United Nations Sustainable Development Goal on health (SDG3) and its aim is a 40% reduction of premature deaths by the year 2030. RTIs are one of the targeted causes of premature death [8]. A cost-effectiveness approach is needed to reach the proposed objective and the estimation of standard expected years of life lost (YLL) may be feasible and beneficial.

The YLL measure was developed by the Global Burden of Disease (GBD) study and is a useful analytical tool, from an economic and health policy perspective, for measuring preventable loss of life. The disability-adjusted life year (DALY) is calculated as the sum of the YLL and YLD. This health measure incorporates strategies (i.e. time-based discounting) used in cost-effectiveness analyses. In addition, the age-standardized YLL (ASYLL) has been used to compare goals across populations [9] and is a valid measure for identifying demographic or regional subgroups (i.e. the states of a country) with the highest premature mortality rate [10].

To the best of our knowledge, there are no published studies evaluating regional premature mortality due to traffic accidents in Mexico. This approach may be useful to identify high risk subgroups where particular interventions focused on the prevention of premature loss of life may be beneficial. The aim of this study was to estimate the burden of RTIs through YLL and ASYLL in Mexican individuals of 15 years of age and older at death in 2014. In addition, sex, age, and region-related differences were evaluated.
Methods

The YLL for RTIs were calculated following the methods described by the GBD study [11]. First, sex and age-stratified (15–24, 25–34, 35–44, 45–64 and ≥65 years of age) mortality data were obtained from the National Institute of Statistics and Geography of Mexico [12]. The following underlying causes of death (International Classification of Diseases 10th revision, ICD-10) were included: V09.2, V09.3, V12–V14, V19.4–V19.9, V20–V28, V29.4–V29.9, V30–V39, V40–V49, V50–V59, V60–V69, V70–V79, V80.3–V80.5, V81.1, V82.1, V83.0–V83.4, V84.0–V86.4, V87.0–V87.8, V89.2, and V89.9. These events are clustered using code E49B (Mexican List of Causes of Death) for statistical purposes [13].

Second, the YLL measure was computed for males and females by multiplying the number of RTI deaths by the number of years of expected remaining life at the respective age interval according to the 2013 Tables of Life (Global Health Observatory) of Mexico [14]. The total population was obtained from the 2010 National Census of Population and Housing [15]. The average age of death, per age interval, was calculated using national data from the Statistical and Epidemiological Death Registration System [16]. The following parameters were fixed: discount rate ($\beta = 0.04$), adjustment constant for age-weights ($C = 0.1658$), and age-weighting modulation ($K = 0$). Templates (Microsoft® Excel®) from the GBD study were used to compute the YLL and the summary statistics were estimated using Stata® MP 13.0 (StataCorp LP). Finally, the ASYLL rates per 100,000 inhabitants were estimated using the World Standard Population (2000–2025).

The Local Health Research and Ethics Committee of the Mexican Institute of Social Security approved the present study.

Results

The number of RTI-associated deaths in 2014 was 11,944 in males and 2693 in females (Table 1), representing 2.5% of all deaths occurring in Mexico within the same period. The unadjusted mortality rates per 100,000 inhabitants were 31.7 in males (ranging from 18.4 to 66.0) and 19.0 in females (ranging from 4.2 to 12.1).

Table 2 shows the YLL by sex, age group, and state of residence. The YLL was higher in males in all age groups. The overall YLL in males was 274,451 and the highest age-adjusted rate (933 per 100,000 inhabitants) was observed in individuals from 25 to 34 years of age.

| State          | Males     |          | Females    |          | Overall   |          |
|----------------|-----------|----------|------------|----------|-----------|----------|
|                | n         | %        | Rate       | n         | %        | Rate     |
| Aguascalientes| 170 (5.9) | 44.2     | 44 (1.9)   | 10.4      | 214 (4.1) | 26.5     |
| Baja California| 250 (2.7) | 22.4     | 89 (1.5)   | 8.1       | 339 (2.2) | 15.3     |
| Baja California Sur | 91 (5.8) | 39.6     | 25 (2.4)   | 11.4      | 116 (4.4) | 25.8     |
| Campeche       | 100 (4.5) | 35.2     | 29 (1.7)   | 9.8       | 129 (3.3) | 22.3     |
| Coahuila       | 366 (4.3) | 38.9     | 92 (1.4)   | 9.5       | 458 (3.0) | 23.9     |
| Colima         | 90 (4.3)  | 39.4     | 16 (1.1)   | 6.8       | 106 (3.0) | 22.8     |
| Chihuahua      | 455 (3.8) | 30.5     | 83 (0.8)   | 5.2       | 538 (2.4) | 17.4     |
| Durango        | 364 (3.1) | 31.9     | 123 (1.4)  | 10.4      | 487 (2.4) | 21.0     |
| Guanajuato     | 642 (4.2) | 36.5     | 144 (1.2)  | 7.2       | 786 (2.9) | 21.0     |
| Guerrero       | 309 (3.4) | 29.0     | 89 (1.3)   | 7.5       | 398 (2.5) | 17.7     |
| Hidalgo        | 276 (3.8) | 31.6     | 85 (1.4)   | 8.7       | 361 (2.7) | 19.5     |
| Jalisco        | 875 (4.0) | 35.4     | 209 (0.8)  | 5.9       | 789 (1.4) | 11.7     |
| Mexico City    | 1557 (4.0)| 30.5    | 359 (1.1)  | 6.5       | 331 (4.0) | 29.9     |
| Michoacan      | 370 (2.8) | 26.1     | 89 (0.9)   | 5.6       | 459 (3.1) | 15.3     |
| Morelos        | 129 (2.4) | 21.6     | 40 (0.9)   | 6.0       | 169 (1.7) | 13.4     |
| Nayarit        | 146 (4.5) | 38.8     | 36 (1.5)   | 9.3       | 182 (3.2) | 23.9     |
| Nuevo León     | 400 (3.1) | 24.3     | 123 (1.2)  | 7.3       | 523 (2.2) | 15.7     |
| Oaxaca         | 354 (3.1) | 29.3     | 86 (0.9)   | 6.2       | 440 (2.1) | 17.0     |
| Puebla         | 541 (3.2) | 29.6     | 116 (0.8)  | 5.5       | 657 (2.1) | 16.7     |
| Querétaro      | 241 (5.2) | 39.9     | 56 (1.4)   | 8.4       | 297 (3.5) | 23.4     |
| Quintana Roo   | 131 (4.8) | 27.9     | 21 (1.1)   | 4.6       | 152 (3.3) | 16.4     |
| San Luis Potosi| 359 (4.7) | 42.2     | 83 (1.4)   | 9.0       | 442 (3.2) | 24.9     |
| Sinaloa        | 533 (6.3) | 55.0     | 98 (1.7)   | 9.8       | 631 (4.5) | 32.0     |
| Sonora         | 371 (4.1) | 39.6     | 92 (1.5)   | 9.8       | 463 (3.1) | 24.7     |
| Tabasco        | 494 (7.8) | 66.0     | 96 (2.0)   | 12.1      | 590 (5.3) | 38.2     |
| Tamaulipas     | 360 (3.9) | 34.6     | 123 (1.6)  | 10.6      | 506 (2.9) | 22.3     |
| Tlaxcala       | 127 (4.4) | 33.3     | 26 (1.0)   | 6.1       | 153 (2.8) | 19.0     |
| Veracruz       | 515 (2.0) | 20.1     | 121 (0.6)  | 4.2       | 636 (1.4) | 11.7     |
| Yucatan        | 214 (3.4) | 31.2     | 46 (0.9)   | 6.4       | 260 (2.3) | 18.5     |
| Zacatecas      | 246 (5.5) | 50.3     | 49 (1.3)   | 9.2       | 295 (3.6) | 28.9     |
| Overall        | 11,944 (3.6)| 31.7   | 2963 (1.1)| 7.3       | 14,907 (2.5) | 19.0     |

The absolute frequencies (n), proportions (%) from the total number of registered deaths, and unadjusted mortality rates per 100,000 inhabitants are presented. Data source: Main causes of mortality by place of residence, age and sex, 2014; National Institute of Statistics and Geography.
at death. The YLL in females was 58,470 and the highest rates were observed in young females (15–24 years of age, 158 YLL per 100,000 inhabitants).

In the estimation by region (Table 3), the overall YLL in males ranged from 88.7% (Quintana Roo) to 76.1% (Baja California). The national estimate was 82.4%. The
highest ASYLL rates per 100,000 inhabitants were registered in individuals from 25 to 34 years of age (526), followed by those from 15 to 24 years of age (459) and from 35 to 44 years of age (410). The overall ASYLL rate was 416 per 100,000 inhabitants and the highest state-stratified mortality rates were observed in Tabasco (851), Sinaloa (709), Durango (656), Zacatecas, (642) and Baja California Sur (570).

Discussion

Our findings suggest that the 2014 RTI burden in Mexico was 332,922 YLL and the mortality rate was higher for males (274,451 YLL, 82.4%). We identified sex, age, and region-related patterns that may be useful in designing and prioritizing intervention policies focused on the prevention of premature loss of life. The illness burden of RTIs in Mexico was previously estimated at the national level [1] and the regional (per state) burden was not evaluated. To the best of our knowledge, this is the first study evaluating regional differences in the burden using the YLL and ASYLL rates as health measures.

The disparities between the sexes observed in our study are a common global finding and sex-related stereotypes about risk-taking and risk perception while driving have an influence on this phenomenon [17,18]. In urban areas of Mexico, male automobile drivers are more likely to be involved in alcohol-impaired driving and less likely to use seatbelts [19,20]. A higher RTI-related mortality among males has also been described in developed countries, mainly in younger individuals [21].

Nearly 75% of analyzed deaths occurred in individuals ≤44 years of age and the highest ASYLL rate (526 per 100,000 inhabitants) was observed in adults from 25 to 34 years of age. The 25–34 year age group is more likely to be employed, compared with individuals 24 years of age and younger [22], thus increasing the economic burden. Heterogeneous state-specific ASYLL rates were found. The highest rate was observed in Tabasco (southeastern region of Mexico), where 5.3% of all deaths registered in 2014 were due to RTIs. This is double the number of the national estimate (2.5%) within the same period. Interestingly, the motorization rate of Tabasco is lower than the average rate (273.1 vs. 310.3 per 100,000 inhabitants, respectively), but the number of accidents occurring on federal highways (17.6%) and the total number of deaths involving motorcycle riders (36.5%) were higher than the national estimates (5.4% and 12.4%, respectively). These events may have determined the scenario observed.
The overall ASYLL rates were low in wealthy (i.e. Nuevo León) and highly motorized (i.e. Mexico City) states, perhaps due to the quality of emergency care provided and the exposure of populations particularly vulnerable to traffic [23]. Within-country disparities in RTI burden have been described in other populations [21,24,25]. This fact may be secondary to multiple risk exposures, including infrastructural characteristics, health care facilities and alcohol drinking prevalence [25].

The conceptual framework of traffic injuries is complex. They result from the interaction of road users, vehicles, and infrastructure [26]. The published data regarding interventions to reduce the related burden in low- and middle-income countries is limited [27]. The World Report on RTI prevention highlights the need for an integrated effort focusing on improved information systems, response capacity strengthening, and reduced exposure to modifiable risk factors plus the availability of resources for targeting them [17].

Several risks factors associated with increased RTI risk and death have been documented in the Mexican population. These factors include those influencing the occurrence of the crash (speeding, alcohol consumption, and hand-held mobile phones) and injury severity (non-use of crash helmets by two-wheeled vehicle users and non-use of retention devices, such as seat belts and child safety seats) [28–30].

Most of the cost-effectiveness strategies to reduce the RTI burden in low- and middle-income countries are linked to legislative interventions [27]. The current Mexican road legislation is permissive and poorly applied [31]. An integrated juridical effort is needed that includes the regulation of alcohol-impaired driving, prohibition of talking on hand-held phones while driving, verification of the use of retention devices by drivers and occupants, and high penalties for offenders. Susceptible populations must be included [32].

The population mobility patterns have changed and a constant growth in motorcycle users has been observed since 2002 [33]. A simultaneous increase in fatal motorcycle injuries has been documented [6]. In addition, also in Mexico, high mortality rates secondary to intentional injuries (i.e. homicide and suicide) are observed [34].

The potential limitations of our study must be cited. First of all, despite the fact that official mortality data were used to compute the YLL and ASYLL rates, the burden of disease may be underestimated, given that approximately 30% of fatal RTIs are misclassified [35]. Second, data to estimate the RTI-associated YLD are not systematically collected in Mexico and therefore we were unable to compute the DALY. However, the YLL and ASYLL rates are valid stand-alone indicators for quantifying premature mortality due to specific events [36–38]. Third, a clustered analysis was performed and no specific populations involved in those injuries were identified. Governmental data indicate that the highest number of victims of fatal RTIs in 2013 were pedestrians (51.5%), followed by occupants of four-wheeled automobiles (34.4%), motorcycle riders (12.3%), and bicyclists (1.8%) [39].

Conclusions

Our findings provide quantitative evidence of the burden of RTIs in Mexico. These are preventable events and efforts to reduce the associated economic and social burden must be made. Sex, age, and region-related patterns were highlighted in our study and they may be useful in improving the impact of public policies focused on the prevention of premature loss of life secondary to traffic injuries.

Acknowledgments

None.

Author contributions

EMZ designed the study and performed data collection and analysis; wrote the manuscript. OMC and ALR designed the study, analyzed data and wrote the manuscript. BTH analyzed data and wrote the manuscript. JGE wrote the manuscript. AMG wrote the manuscript. MH wrote the manuscript. RASP wrote the manuscript.

Disclosure statement

No potential conflict of interest was reported by the authors.

Ethics and consent

The Local Health Research and Ethics Committee of the Mexican Institute of Social Security approved the present study. The informed consent was waived due to the particular design of this study.

Funding information

None.

Paper context

The road traffic injuries-related mortality in Mexico has been evaluated using traditional rates that fail to highlight the premature deaths. The years of life lost due to these injuries during 2014 were estimated in this study and sex, age, and region-related differences were evaluated. The obtained estimators may useful to improve the impact of public policies focused on the prevention of these events.
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