



Burden of Disease Caused by Road Traffic Accidents in the City of Mashhad

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Abstract

Background: Mashhad is the second-largest Iranian megacity with a population of roughly 3 million and receiving around 25 million tourists a year, wherein road traffic accidents (RTAs) have become the leading cause of death and injuries.

Objectives: The main purpose of this study was to calculate the burden of disease caused by RTAs in the city of Mashhad.

Methods: In this applied research using a descriptive cross-sectional method, data associated with RTAs in the city of Mashhad in March 2016 - March 2017 were collected based on a complete enumeration of RTA-induced fatalities and disabilities from the Organization for Cemetery Management (Ferdows Organization) affiliated to Mashhad Municipality and the database of the Ministry of Health of Iran (MOH). Following verification, the years of life lost (YLL), the number of years lost due to disability (YLD), and the disability-adjusted life years (DALYs) were measured through the method proposed by the World Health Organization (WHO).

Results: The total number of RTA deaths was 677 cases (men = 494 (73%) and women = 183 (27%)) and the number of DALYs was 29155 years (men = 21219/3 (72/8%) and women = 7935/1 (27/2%)). Of the total DALYs, 96% of them were associated with YLL, and 4% were related to YLD.

Conclusions: Mortality data are recorded with relatively high accuracy in Iran. Given low YLD in DALYs in comparison with the findings of similar studies in developed countries, there are possible defects in data quality, in particular in terms of non-fatal accidents and injuries. These findings can be thus exploited for optimal allocation of resources in Razavi Khorasan Province and across Iran.

Keywords: Burden of Disease, Disability Adjusted Life Years (DALYs), Roads Traffic Accidents

1. Background

Injuries caused by road traffic accidents (RTAs) account for the leading cause of death among people aged 15 - 29 years in the world, which can impose costs equivalent to 3% of the gross domestic product (GDP) in each country (1). According to the third global status report on road safety, low- and middle-income nations are extremely vulnerable, and mortality rates in these areas are twice higher than those reported in high-income countries in a way that 90% of deaths induced by RTAs worldwide occur in these regions (2).

To date, numerous studies have been conducted in developing countries to investigate the trends in mortality from RTAs and their associated factors as well as how to record the relevant data (3, 4). For example, in the city of Karachi, Pakistan, in 1994, 544 deaths and 793 injuries

caused by RTAs had been recorded (3). The mortality rate in Nepal between 2001 and 2002 had also grown from 4 to 7 per 100,000 of the population in 2011 - 2012 (5). About 18% of total hospital beds in Bangladesh had been allocated to RTA victims with an average length of stay of 7.5 days (6). Analysis of the trends in RTA deaths also revealed that they were rising in developing countries despite the predicted decline of 30% in developed nations (7).

In Iran, RTAs occur frequently and they are regarded as the second leading cause of death after cardiovascular diseases (CVDs). Also, the mortality rate of RTAs is 31 per 100,000 persons which is more than the global average as well as the values reported in the Eastern Mediterranean region (8, 9). Additionally, RTAs are the second cause of years of life lost (YLL) due to premature mortality after CVDs (10). Moreover, it leads to high disability-adjusted life

years (DALYs) among the 21 causes (11).

DALYs are summary measures of population health (SMPH) that combine information on mortality and non-fatal health outcomes. Summaries used to determine the current status of the burden of disease (BOD).

In this respect, DALYs, as an agreed index has been used in almost all similar studies on BOD following the recommendations and support of the World Bank and the World Health Organization (WHO) (12, 13).

The basic requirements for exercising SMPH to measure health status, diseases, injuries, and deaths in countries and around the world have emerged from the fact that as populations are undergoing demographic, epidemiological, and health transition stages, other mortality indices cannot properly represent the health status of communities. Therefore, non-fatal outcomes of diseases, as well as the relative increase in non-communicable diseases (NCDs) and events in comparison with infectious ones, have not been appropriately illustrated and quantitatively summarized (14).

The city of Mashhad, as a metropolitan area with a population of approximately 3 million, is receiving about 25 million tourists per year (15, 16). However, there has been no comprehensive study about BOD caused by RTAs in this megacity so far.

2. Objectives

Given the need for policymakers to gain a better understanding of the current status, the present study aims to calculate RTA-induced BOD induced in this city.

3. Methods

This applied research with a descriptive cross-sectional design was performed using the method proposed by the WHO for the Global Burden of Disease (GBD) Study. Data associated with RTAs in the city of Mashhad in March 2016 - March 2017 were collected, and the study was conducted in 2018 - 2019. Data related to mortality and non-fatal injuries caused by RTAs in the city of Mashhad in which the victims had been referred to (16 teaching and non-teaching hospitals affiliated to Mashhad University of Medical Sciences including Mehr, Kamyab, Hasheminejad, Taleghani, Farabi, Imam Reza, Shariati, Ghaem, Aria, Artesh, Imam Hussein, Bint Al-Huda, Pasteur, Samen, Javad, and Khatam Al-Anbia) were examined through a survey.

The mortality data were also collected from three sources, including the deputy of health affiliated with Mashhad University of Medical Sciences, Iranian Legal Medicine Organization, and the Organization for Cemetery Management (Ferdows Organization) as a sub-division

affiliated with Mashhad Municipality for the management of cemeteries, funerals and burial ceremonies, registration of deaths, and other related affairs (17).

Moreover, further examinations indicated that the accuracy and the completeness of the data obtained from the Ferdows Organization were better than those from other sources. To make the maximum use of the data, information from other sources, and data contained in the hospital information system (HIS) was additionally utilized to complete and verify this data. The main research instrument was a researcher-made form (as a guide to data collection), the face validity of which was reviewed and approved by experts.

Data related to non-fatal injuries were also retrieved from Medcare as an RTA victim system affiliated to the Ministry of Health (MOH) and HIS. Considering that Medcare data are the basis for cost reimbursement by RTA patients to hospitals, it was selected as the main source. The most important shortcoming in the data in this system is that the victims' age is not available. To deal with this problem, 600 medical records in hospitals were reviewed, and data were compared with HIS reports and then verified. Patients with the ICD-10 injury diagnostic codes in the HIS were entered into the study. Patients were excluded from the study with a null diagnosis.

3.1. Calculation of DALYs

Based on the GBD 2015, the number of DALYs was calculated using the following formula:

$$DALY = YLL + YLD \quad (1)$$

In this formula, YLL refers to the years of life lost due to premature mortality. The YLL metric essentially corresponds to the number of deaths multiplied by the standard life expectancy at the age at which death occurs that can be calculated using social preferences, including age weighting and discounting. In this regard, age weights are used to differentiate the value of different ages and give more value to younger ages, and discounting rates are employed to convert future values into present ones. In this study, the YLL was calculated based on the standard life table released by the WHO.

Years lost due to disability (YLD) is also calculated by multiplying the number of new cases of injuries by the average duration of the case until remission or death and severity of disability. In the GBD study, a disability weight (DW) has been further defined for any non-fatal outcome between zero and one in which zero means complete health and one denotes death, expressed as a DW, indicating what part of a time period a non-fatal outcome should be considered lost (18).

To classify injuries as well as their related DWs, the weights suggested by the Institute for Health Metrics and Evaluation (IHME) in 2015 were used (19). To shed light on the duration of short-term outcomes of diseases, the GBD 2013 appendix as the last document on the duration of disability was employed (18). In this appendix, duration of disability had been reported by “day”, but in the present study, days were converted into a proportion of a “year”.

It should be noted that some injuries, including traumatic brain injury (particularly a concussion), traumatic brain injuries (TBI), superficial injuries, and internal organ damage, can have certain conditions. These types of injuries had been included in some studies based on the GBD, but they did not exist in others. The TBI has been recently added, and it has DW but not the duration of disability (DOD) in GBD 2016. A review of such injuries has demonstrated that they have been taken into account among moderate brain injuries. Therefore, in the present study, DW in GBD 2016 and DOD of moderate TBI were employed to determine BOD.

Three different classifications have also been developed for brain injuries, including mild, moderate, and severe. Since it is not possible to split up and categorize the data in three modes, DW and DOD cases of moderate brain injury were used as the average severity of such injuries according to neurologists' opinions. To determine the DW of superficial injuries and contusions, the results in the study by Haagsma et al. (20) were additionally utilized, and the GBD 2013 was employed for the duration of onset (18). The reason for using different sources was to have access to the latest ones and increase the accuracy of the calculations. The summary of the sources used in this study is presented in Table 1.

Table 1. Types of Data and Sources Used in the Study

Row	Data Type	Source Used
1	Standard life expectancy	The WHO standard life expectancy table was used.
2	Titles of injuries and disabilities weights	The proposed disability weights of the Institute for Health Assessment and Evaluation (IHME) were used.
3	Duration of short-term Injuries	GBD 2013 appendixes used.
4	Duration and severity of brain injuries	The weight of disability and duration of moderate level of brain injury were used.
5	Concussion	Weight: Global Burden of Disease 2016 study, for the duration: Global Burden of Disease 2013 study was used.
6	Superficial injuries and contusions	Weight: study Hasma et al. for the duration: Global Burden of Disease 2013 study was used.

Data analysis was performed via descriptive statistics, including frequency, percentage, mean, and standard deviation using Microsoft Excel 2016.

4. Results

The total number of deaths from RTAs was 677 cases (men = 73% and women = 27%) with a mean and standard deviation of 40 and 22.77 years, respectively. The mortality rates of men and women experiencing RTAs were 33.2 and 12.2 per 100,000 of the population, respectively. The mortality rate in both genders was in a total of 22.6 per 100,000 of the population (Table 2).

The number of YLL based on the standard life table used by the WHO was 27,968 years (men = 72% and women = 28%). The maximum YLL in men (65%) was also related to the age group of 15 - 44 years, and that was 51% for women in the same age group. Considering both genders, the highest YLL value (62%) belonged to the age group of 15 - 44 years. Among the age groups of both genders, age groups of 15 - 19 and 25 - 29 years by 13% of the total YLL had been assigned with the highest BOD. The number of YLL due to premature mortality was 932.2 per 100,000 of the population.

The total number of people suffering from non-fatal injuries induced by RTAs in 2016 - 2017 was 25,712 (men = 70% and women = 30%). The mean age of men and women was 29.45 and 32.7 years, respectively. The mean age of the injured was also 30.44 years, with a standard deviation of 17.37 years. The highest number of injured was correspondingly observed in males (17%) in the age group of 26 - 30 years and females (13%) in the age group of 31 - 35 years. As well, the highest number of injured in both genders (15%) was reported in the age group of 26 - 30 years. Of the total number of individuals affected, 66% of them had suffered superficial injuries, and 33% had been affected with more severe injuries and were in need of being hospitalized (Table 3). Of the 36 injuries resulting in hospitalization in both genders; patella, tibia, and fibula fractures (24.62%), open wounds (15.57%), forearm fractures (8.42%), and shoulder and arm fractures (7.36%) were the most frequent ones. The frequency of these injuries was also similar in men and women separately. Besides, the bulk of YLD was related to long-term TBI (44%), spinal cord injury (15%), nerve damage (12%), femoral (long-term) shaft (10%), patella, tibia, and fibula fractures (4%), and third-grade burns (4%), respectively.

4.1. DALYs

The number of DALYs based on the standard life table released by the WHO was 29,155 years (men = 72.8% and

Table 2. The Frequency of Deaths Due to RTA in the City of Mashhad Based on Gender and Age Group

Age Group	Male	%	Per/100000	Female	%	Per/100000	Total	%
0 - 14	45	9.1	11.7	27	14.8	7.3	72	10.6
15 - 24	94	19.0	43.7	18	9.8	8.2	112	16.5
25 - 34	95	19.2	28.8	28	15.3	8.5	123	18.2
35 - 44	69	14.0	30.0	32	17.5	13.9	101	14.9
45 - 54	48	9.7	30.0	15	8.2	9.4	63	9.3
55 - 64	51	10.3	51.0	26	14.2	26.0	77	11.4
≥ 65	92	18.6	115.0	37	20.2	46.3	129	19.1
sum	494	100	33.2	183	100	12.3	677	100

Table 3. The Amount of YLD Based on Gender, Age Group and Type of Injury in the City of Mashhad

Gender/Age Group	Fractures			Amputation and Spinal Cord Injury			Brain Injuries			Others Injuries			Total	Per/100000	%
	No.	Per/100000	%	No.	Per/100000	%	No.	Per/100000	%	No.	Per/100000	%			
Male															
0 - 14	22	5/8	14.6	3	0.8	1.7	69	18.3	17.8	12	3.2	4.6	106.9	28.1	10.9
15 - 24	46	21.8	30.1	12	5.6	7	142	67.5	36.4	46	21.7	18.4	245	116.7	25
25 - 34	47	14.2	30.8	49	14.8	28.8	115	34.7	29.4	98	29.6	25.2	308	93.4	31.4
35 - 44	14	5.9	8.9	69	30	40.6	48	20.9	12.3	79	34.2	29.1	209	91	21.3
45 - 54	12	7.6	8	17	10.6	10	0	0.1	0.1	12	7.4	6.3	41	25.8	4.2
55 - 64	5	5.4	3.6	20	20	11.8	5	0.6	1.2	21	20.6	17.5	51	46.6	5.2
≥ 65	6	7.7	4.1	0	0	0	11	1.4	2.9	1	1	0.8	18.3	10.1	1.9
Sum	152	68.5	100	170	81.9	100	390	143.5	100	268	117.8	100	980.1	65	100
Female															
0 - 14	12	3.4	30.5	9	2.5	23.7	36	9.6	40.8	18	4.9	0.3	75.3	20.4	36.4
15 - 24	2	0.9	5	0	0	0	29	13.3	33.6	17	7.8	0.3	48.4	22	23.4
25 - 34	9	2.8	22.9	17	5	43.2	12	3.7	14	19	5.6	0.3	57	17.2	27.6
35 - 44	5	2.1	12	0	0	0	0	0	0	1	0.4	0	5.8	2.5	2.8
45 - 54	2	1.4	5.6	0	0	0	0	0.1	0.2	1	0.4	0	3.1	2	1.5
55 - 64	5	5.4	13.3	13	13	33.1	5	5.3	6.1	11	10.1	0.2	34	33.8	16.4
≥ 65	4	5.5	10.8	0	0	0	5	5.8	5.3	0	0.5	0	9.4	11.8	4.6
Sum	41	1.4	100	39	1.4	100	87	2.5	100	66	2	100	206.8	14	100

women = 27.2%). Of the total DALYs, 96% and 4% were assigned to YLL and YLD, respectively. The number of DALYs obtained based on the population of the city of Mashhad in 2016 - 2017 was 968 years per 100,000. The highest DALYs (62%) also belonged to the age group of 15 - 45 years, and the minimum value (3%) was for the age group of 70 years and older. The highest absolute value of DALYs (13%) was associated with the age groups of 15 - 20 and 25 - 30 years.

5. Discussion

The main purpose of this study was to calculate BOD caused by RTAs in the city of Mashhad in 2016 - 2017. These findings suggested that mortality rates of men and women due to RTAs were 32.93 and 12.3 per 100,000 population, respectively, and the given value in both genders was 22.6 per 100,000 population in total. The mortality rate from RTAs

in the present study in comparison with the value reported by the WHO published in 2015 was also two and a half times higher than the average in European countries but lower than that in African nations (21).

In addition, the results revealed that the number of DALYs was 29,155 years, of which 73% and 27% were for men and women, respectively. Of the total DALYs, 96% was assigned to YLL, and 4% was for YLD. According to the population in the city of Mashhad in 2016 - 2017, the DALYs were 9.7 per 1000 population. The maximum DALYs (62%) also belonged to the age group of 15-44 years, and the minimum value (3%) was allocated to the age group of 70 years and older.

Besides, a similar study had been conducted in this field in the Netherlands by Polinder et al. (22), reporting that RTAs had led to 76,400 DALYs annually. The DALYs were also equal to 4.7 per 100000 population, and 64% of

Table 4. The Amount of YLL, YLD, and DALY Based on Gender and Age Group in the City of Mashhad

Age Group	YLL			YLD			DALY		
	No.	Per/100000	%	No.	Per/100000	%	No.	Per/100000	%
Male									
0 - 14	3347	880.7	16.5	106.9	28.1	10.9	3453.4	908.8	16.3
15 - 24	5681	2705.4	28.1	245.0	116.7	25.0	5926.4	2822.1	27.9
25 - 34	4836	1465.3	23.9	308.0	93.4	31.4	5143.5	1558.6	24.2
35 - 44	2851	1239.6	14.1	209.0	91.0	21.3	3060.0	1330.5	14.4
45 - 54	1493	933.3	7.4	41.0	25.8	4.2	1534.2	958.9	7.2
55 - 64	1126	1125.9	5.6	51.0	46.6	5.2	1176.9	1176.9	5.5
≥ 65	906	1132.8	4.5	18.3	10.1	1.9	924.6	1155.7	4.4
Sum	20240	1354.7	100	980.1	65.0	100	21219.9	1419.7	100
Female									
0 - 14	2060	556.6	26.6	75.3	20.4	36.4	2134.8	577.0	26.9
15 - 24	1140	518.2	14.8	48.4	22.0	23.4	1188.5	540.2	15.0
25 - 34	1487	450.5	19.2	57.0	17.2	27.6	1543.8	467.8	19.5
35 - 44	1388	603.6	18.0	5.8	2.5	2.8	1394.1	606.1	17.6
45 - 54	521	325.7	6.7	3.1	2.0	1.5	524.2	327.6	6.6
55 - 64	651	651	8.4	34.0	33.8	16.4	684.7	684.7	8.6
≥ 65	482	602.3	6.2	9.4	11.8	4.6	491.3	614.1	6.2
Sum	7728	529.7	100	206.8	14.0	100	7935.1	529.0	100

them were non-fatal injuries (48500 YLD vs. 27900 YLL). In all age groups except that for the age group over 65 years, DALYs in men were higher than women. The ratio of DALYs to 100,000 population in the present study was also about twice of that in the Netherlands based on the survey by Polinder et al. According to the sub-groups of DALYs, this ratio for YLL was equal to 5.4, and that was 0.11 for YLD. One of the most important reasons for this difference was that in the study by Polinder et al., the ratio of long-term to short-term injuries was first calculated and separated; therefore, the contribution of YLD was more than YLL; which was not consistent with the findings of the present study.

The findings of studies conducted in Iran on DALYs per 100,000 population represented values of 12 in Yazd province and 26 in Kermanshah province (23, 24). The rate of DALYs in Yazd province was 24% more than that in the city of Mashhad, which might be due to differences in type and number of injuries reported, such that injuries with higher BOD such as spinal cord injury had been observed more than those in the present study. Moreover, the rate of DALYs in Kermanshah province was by 72% higher than that in the city of Mashhad which could be due to the number of people who had lost their lives that was 72% higher than that in the present study (24) as well as the difference

between the time of the studies and use of various methods to estimate DALYs (i.e., use of GBD 2010 that could provide higher life expectancy for premature mortality).

In the study by Naghavi et al. in 2007 in Iran, the BOD of RTAs had obtained the highest DALYs per 100,000 population (1,963 years/100,000) (25). Comparing the rate of DALYs in both studies, it was concluded that the rate of DALYs had been halved for about 14 years over time. The time difference between both studies at high rates of DALYs had also been observed in previous years, and several studies had reported a descending trend in the number of deaths from RTAs in recent years (26-29).

In other similar studies conducted in countries such as Brazil and China, the rate was 1,176 and 1,076 years per 100,000 population, respectively (30, 31). The findings by Ladeira et al. in Brazil had correspondingly demonstrated that Brazil was the second-largest country in terms of BOD caused by RTAs among South American nations since most of these countries had BOD values between 610 and 700 per 100,000 population, which were below the rate reported in the present study (32). The mortality rate in the present study was also quite similar to that reported by Wang et al. (31). Furthermore, this study suggested that the rate of DALYs in China per 100,000 population was 11% more than that in the present study, which could be attributed to the

time difference in both studies.

The findings of the present study additionally revealed that the ratio of YLD to YLL was 0.04, which could be due to low quality and unstable recording of injury data in the city of Mashhad, making BOD of non-fatal injuries lower than estimated. This ratio also showed unexpected and significant differences in other studies. In the Netherlands, this ratio was equal to 1.7 and for Belgium (in the cities of Flanders and Brussels), Serbia, and six low-income countries (i.e. Uzbekistan, Nigeria, Morocco, Cambodia, Sri Lanka, and Bolivia), it was 1.02, 0.76, and 0.29, respectively (22, 33, 34). The low ratio of YLD to YLL in the present study, generally referred to the quality of the data recorded, especially for disability (11). Health management information systems (HMIS) for recording disability and injury data of RTAs in developing countries were both scarce and diagnostic codes in a significant portion of the data were general, leading to lower weight allocation to them (18, 30, 35). However, the data on death rates were largely validated once a guideline for death registration entitled Manual on Recording and Classifying Causes of Death was issued in Iran by the MOH since 2004 (36), which is currently almost being fully implemented. To obtain an estimate of disability data for the city of Mashhad with a simple simulation assuming the accuracy of the recorded mortality data and 0.29 for the ratio of YLD to YLL, the DALYs would be 36,078, 24% more than the initial value. In this situation, the ratio of DALYs per 100,000 population in the present study would be 12.02, which was about two and a half times higher than the value reported in the study by Polinder et al. in the Netherlands.

The findings of the present study could be fully generalized to relevant policies in the city of Mashhad and have implications for domestic comparisons with regard to the same level of quality of data collection in all provinces. Comparing the results of the present study with those in other cities and foreign countries, the issue of data quality, especially in the field of recording cases of non-fatal injuries, needs to be taken into consideration.

The present study also had limitations such as completing age for victims, lack of medical diagnosis code as well as incompatibility of medical diagnosis code with the length of hospital stay, demanding the use of different data registration systems. In the field of mortality data, those obtained from the Organization for Cemetery Management (Ferdows Organization) affiliated to Mashhad Municipality were more complete than ones from other sources, although they lacked codes for physiological causes of death. It could be acknowledged that the data were more complete compared with other mortality data sources, so ensuring the absolute completeness of the data needed a separate study.

Owing to the lack of a comprehensive RTA information system in Iran and the problem of data collection, developing and establishing a comprehensive data registration system for RTAs that can be analyzed point-by-point is thus assumed as one of the recommendations of this study for relevant policymaking. It is also suggested that the causes of accidents in young people and ways to reduce them be investigated in future studies.

5.1. Conclusion

As improvement in the quality of life is the ultimate and common goal among individuals, families, and policymakers, a direct decline in DALYs can significantly enhance it. Considering RTAs, the findings of the present study show that 62% of the total DALYs are related to the age group of 15 - 44 years, which is three times more in males than females. The application of the present study is to carry out evidence-based planning and policymaking to reduce the RTAs. Analyzing RTA data and targeting activities towards RTA mitigation can, therefore, augment the effectiveness of such activities and ultimately influence the quality of life of individuals and households.

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Footnotes

Authors' Contribution: Study concept and design: M. Y., and A. M. Analysis and interpretation of data: A. T., and M. V. Drafting of the manuscript: A. M., H. E. and M.Y. Statistical analysis: A. M., M.V., and A.M.

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