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The Burden of Road Traffic Injuries in Iran and 15 Surrounding Countries: 1990–2016

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Abstract

Background: The Global Burden of Disease (GBD) Study provides estimates of deaths, years of life lost (YLL), years of life lived with disability (YLD), and disability-adjusted life years (DALYs) due to 249 causes of death, 315 diseases and injuries, and 79 behavioral, environmental, occupational, and metabolic risk factors in 195 countries, territories, and regions by sex and 20 age categories in 195 countries and regions since 1990. In this study, we aimed to present the burden of road traffic injuries (RTIs) in Iran and 15 surrounding countries in 1990–2016.

Methods: The standard Cause of Death Ensemble modeling (CODEm) is used to estimate deaths due to all causes of injury by age, sex, country and year. A range of 27 causes is used for estimating non-fatal health outcomes based on inpatient and outpatient datasets using DisMod-MR 2.0. Disability-adjusted life years (DALYs) estimate quantify the total burden of years lost due to premature death or disability and was computed by summing the fatal burden and non-fatal burden associated with a cause (i.e., YLL+YLD).

Results: In 2016, age-standardized transport injuries in Iran accounted for 35.6 (UI: 29.64–43.44) deaths per 100000 compared to 60.8 (UI: 51.04–72.49) in 1990. Transport injury became the fourth leading cause of death in Iran in 2016, up from the 5th leading cause of death in 1990. The burden of RTIs was mainly caused by motor vehicles and motorcycles and mostly affected the economically productive age groups (15–49), males and children, especially those at school age. Afghanistan with 59.14 deaths (52.09–66.8) and UAE with 53.71 deaths (36.59–72.77) had the largest transport injury death rates per 100000. From 1990 to 2016, Iran had -2.06 annual percent change in transport death rates. The lowest annual percent change is reported for Turkmenistan at -3.43. While Pakistan, UAE and Qatar had the highest annual percent change in transport injury. Across all countries, the observed-to-expected ratios for transport injury death rates varied considerably in 2016.The UAE had the largest age-standardized ratios of observed-to-expected rate (2.93), followed by Oman (2.39), Saudi Arabia (2.23), Afghanistan (2.04) and Iran (1.95).

Conclusions: RTIs continue to be a public health burden in Iran and its neighboring countries, even though, there is evidence for decline in RTIs across all countries except Pakistan. The most frequent sub-causes of death and injury are the motor vehicle, motorcycle, and pedestrian injuries. The most vulnerable road users are children and young adults.

Keywords: Accidents, traffic; Cost of illness; Iran; Middle East; Multiple trauma

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Introduction

In 2015, 1.5 million people worldwide died from transport injuries.[1] Globally, road injuries were the ninth leading cause of premature death in 2005 and became the eighth leading cause of death in 2015. It is projected that road injuries will be the forth leading cause of global disease burden in the year 2030.[1-4]

The burden of road traffic injuries (RTIs) is even more evident in the Eastern Mediterranean Region (EMR) and North Africa. In the midst of epidemiological transfer, these countries continually struggle to reduce the rate of mortality and disability associated with RTIs. As measured by disability-adjusted life years (DALYs) since 1990, RTIs have also had severe effects in Iran and in neighboring Arab countries including Bahrain, Saudi Arabia, Kuwait, Oman, Qatar, and the United Arab Emirates. This toll is unusually high in the male populatio[5,6] and burden the governments of these countries with considerable human, social and economic costs.[7] In Saudi Arabia, Afghanistan, and Bahrain, RTIs represent the majority of admissions to trauma centers.[8-10]

Multiple factors have been associated with Iran's and its surrounding countries' high RTI fatality and injury rates. These include the lack of a strong traffic safety culture,[11-13] inadequate traffic laws and vehicle safety features, an upsurge in the number of registered vehicles,[14] infrastructure flaws such as relatively few safe routes for walking and cycling,[15] poor pre-hospital trauma care and the lack of a systematic approach in coordinating RTIs,[16] as well as risky driving behaviors including the inconsistent use of seatbelts, helmets, and child restraints, and alcohol use.[15,17-21]

During the past 15 years, various evidence-based interventions have developed to protect road users against RTIs. These include mandatory seatbelt use for drivers of cars[22,23] and helmet use for motorcycle drivers and riders, car restraints for children, laws mandating different driving operation on different roads, traffic and weather conditions, traffic calming strategies, and TV and radio educational programs.[24-28]

A reliable and accurate evaluation of RTI trends can reveal to what extent planned interventions have been successful and guide the country's future strategies for better outcomes. In addition, these will provide valuable information for governments in prioritizing the allocation of resources to prevent and mitigate RTIs. In this paper, we aim to present trends of RTIs, years of life lost (YLLs), years of life lived with disability (YLDs), and (DALYs) by age, sex, and mode of transport in Iran from 1990 to 2016. We compare this data with data from the 15 countries surrounding Iran, using estimates from the Global Burden of Diseases, Injuries, and Risk Factors study 2016 (GBD 2016). Our findings will leverage comparative data and knowledge to help develop and enhance preventative policies and management of RTIs.

Materials and Methods

GBD provides estimates of deaths, YLL, YLD, and DALYs due to 249 causes of death, 315 diseases and injuries, 79 behavioral, environmental, occupational, and metabolic risk factors in 195 countries, territories, and regions by sex and 23 age categories in 195 countries and regions since 1990.[1,4,29-31]

Fatal Injuries

Input data for Estimating Mortality From Injuries

Vital registration data (sourced from civil registration and vital statistics systems), verbal autopsy data, mortality surveillance, censuses, surveys, and police record data were used to estimate injury mortality in the 2016 GBD. Police and crime reports are unique data sources for determining death from traffic injury and interpersonal violence. They were collected from published studies, national agencies, and institutional surveys, such as the United Nations Crime Trends Survey and the World Health Organization (WHO) Global Status Report on Road Safety Survey. For countries with vital registration data, police records were referenced only if the recorded number of road injury and interpersonal violence deaths exceeded that from vital registration.[1,4]

Data points that met the following outlier criteria were excluded: (1) were implausibly high or low relative to global or regional patterns, (2) conflicted substantially with established age or temporal patterns, or (3) conflicted significantly with other data sources conducted at the same locations, or locations with similar characteristics.[1,4]

Overview of Modeling Strategy

GBD 2016, the standard Cause of Death Ensemble modeling (CODEm) was used to estimate deaths due to all causes of injury by age, sex, country and year, excluding "Exposure to forces of nature" and "Collective violence and legal intervention." These fall under the aggregate cause of "Forces of nature, war, and legal intervention." Fatal discontinuity for five injury causes was also modeled in CODEm. These included "Motor vehicle road injuries," "Other transport injuries," "Fire, heat, and hot substances," "Poisonings," and "Other exposure to mechanical forces." Final fatal discontinuity estimates for these causes were merged with CODEm results post-CodCorrect to produce final cause-of-death results. CodCorrect uses a simple algorithm to scale specific deaths from all causes for each group, sex, year, and locations to ensure that the sum equals total all-cause mortality.[1,4]

GBD Injury Codes and Categories

As a standard diagnostic tool for epidemiology, International Classification of Diseases (ICD) codes and categories were used to classify injuries. In the GBD study, injury incidence and death are categorized through ICD-9 codes E000-E999, and ICD-10 chapters V to Y. Deaths and cases of alcohol poisoning and drug overdoses are classified under drug and alcohol use disorders (see Injury Cause List). The 2015 and 2016 GBD disease and injury study describes how injury causes were organized into 27 mutually exclusive, and collectively exhaustive, external cause-of-injury categories.[29] For GBD 2016, "self-harm" was grouped into "self-harm by firearm", and "self-harm by other specified means."

Preparation of Data

The preparation of cause of death data includes age splitting, age-sex splitting, smoothing, and outlier detection all of which are described in detail by Naghavi et al[4] and Lozano et al.[32] The concept of "garbage codes" and the redistribution of these codes was proposed in the GBD of 1990.[33] Garbage codes should not be identified as specific underlying causes of death, but have been entered as such on death certificates. A classic example is "Exposure to unspecified factor" (X59 in ICD-10 and E887 in ICD-9), and all undetermined intent codes (Y10-Y34 in ICD-10 and E980-E988 in ICD-9). Other examples of garbage codes in injuries are the coding of an injury death to intermediate codes like septicemia or peritonitis, or as an ill-defined and unknown cause of mortality (R99). Approximately 2% of total deaths in countries with vital registration data are attributed to these three injury garbage code categories.[32]

Splitting Into Sublevel Causes

In countries with non-detailed ICD code data, cause-of-injury categories were proportionally split into sublevel cause-of-injury categories. The sublevel cause-of-injury causes were created in the CodCorrect process. For GBD 2015 and 2016, the proportions were based on the Matzopoulos.[34]

Nonfatal Injuries

Case Definition for Non-fatal Health Outcome

The 2015 and 2016 GBD identifies 27 causes for non-fatal health outcomes, with transport injuries, falls, drowning, self-harm, interpersonal violence, and animal contact included in the estimation process. Each of these causes can include multiple modelable entities, which vary by cause. Injury incidence is defined using ICD-9 codes E000-E999 and ICD-10 Chapters V to Y. For non-fatal estimation, chapters S and T in ICD-10 and codes 800-999 in ICD9 are used to estimate morbidity.[29]

Input Data

To estimate morbidity from injuries, the GBD injury team used data from hospital and emergency department records, and surveys to produce years lost to disability (YLDs) by country, year, sex, age, external cause-of-injury, and nature of injury category. Similar data points that met outlier criteria were excluded.

Modeling Strategy

Two categories of injury severity were modeled separately for estimating injury incidence. Injuries that were severe enough to warrant "in-patient health care," and injuries requiring outpatient health care or emergency department visits, but not hospitalization, assumed that such care and facilities were available.

Starting with the 2015 GBD, the incidence for 27 cause-of-injury categories is modeled using DisMod-MR 2.0, which is a descriptive epidemiological meta-regression tool. DisMod-MR uses the integrative systems modeling approach to produce simultaneous estimates of disease incidence, prevalence, remission, and mortality. Covariates used in DisMod-MR came from hospital, emergency/outpatient departments, and survey datasets.[30] For GBD 2016, the DisMod-MR2.2 tool was used. No substantive changes in estimates were made from DisMod-MR 2.1, however, this made it possible to prove estimation for terminal age group of 95+ in addition to the new locations added for GBD 2016 cycle.[4]

YLLs are calculated by multiplying each death by the normative standard life expectancy and age of death (86 and 59 years, respectively) using the 2015 GBD standard life table.[1] YLDs are calculated by multiplying the number of prevalence cases of a certain health outcome by the disability weight (i.e. the general public's assessment of the severity of health loss associated with the cause) and assigned to this outcome.[29] A disability weight reflects the magnitude of the health loss associated with an outcome, and ranged between 0 (meaning full health) and 1 (equal to death). The DALYs estimate quantifies the total burden of years lost to premature death or disability, and is computed by summing the fatal burden and non-fatal burden associated with a cause (i.e., YLL+YLD). Other publications provide details for calculation of YLL and YLS estimates.[1,30]

In this report, RTIs comprise injuries involving motorized vehicles with four or more wheels, pedestrians, motorized vehicle with two wheels, pedal cycle vehicle, other road injuries, and other transport injuries. The study areas include Afghanistan, Armenia, Azerbaijan, Bahrain, Iran, Iraq, Kazakhstan, Kuwait, Oman, Pakistan, Qatar, Russia, Saudi Arabia, Turkey, Turkmenistan, and the United Arab Emirates. These countries encompass four regions of the Middle East, Central Asia, Eastern Europe and south Asia, and represent very diverse economic, cultural and social characteristics. They have different gross domestic products, socio-demographic profiles, health indicators, and health system capacities and coverage. However, each have faced similar health challenges at different times through war, unrest, and economic changes.

Role of the Funding Source

The funder of the 2016 GBD study had no role in the study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and has final responsibility for the decision to submit for publication.

Results

Iran: Mortality

In 2016, age standardized transport injuries in Iran accounted for 35.6 (UI: 29.64. -43.44) of deaths per 100 000, compared to 60.8 (UI: 51.04–72.49) of deaths in 1990 (see Supplementary data, Figure S1). Of the leading 21 level 2 causes of deaths, transport injuries descended from the fourth leading cause of death in 1990 to the fifth leading cause of death in 2016 (Figure 1). In the 15-49-year-old age group, transport injury ranked first among the top

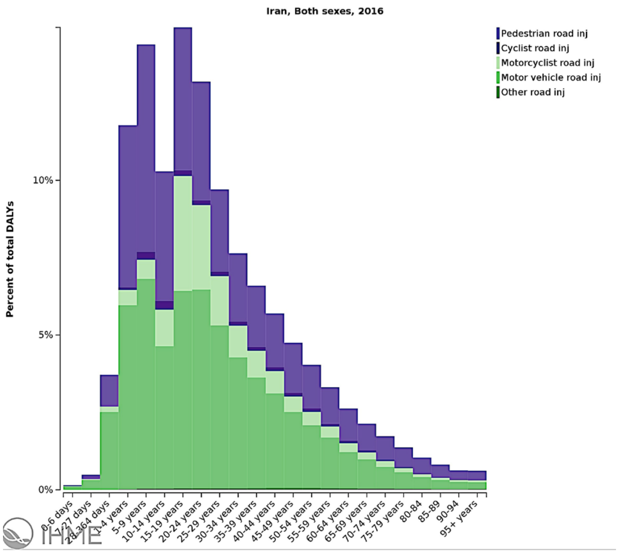

Figure 1. Percent of Total Death, Transport Injury Sub-causes, Both Sexes, 2016, Iran.

20 communicable, non-communicable, and injury causes of deaths, in 2016 (see Supplementary data, FigureS 2).

Table 1 depicts total numbers, age-standardized rates, the percent change of deaths, YLLs, YLDs and DALYs due to transport injury, RTI and different types of RTIs in both sexes between 1990 and 2016 in Iran. In 2016, in males, age-standardized death rates due to transport injuries were highest in motor vehicles (25.6), followed by pedestrian (19.85), and motorcyclist (6.28) per 100 000. These rates were much lower in females, as depicted in Table 1. During this period, death rate due to motor vehicle and pedestrian injuries (sub-cause of transport injury) in males decreased by 41.8% and 39.8%, respectively, and in females by 42.9%, and 44.3%, respectively. Similarly, the age-standardized death rates due to motorcycle road injuries decreased by 44.4% in males, for the same period. Furthermore, we observe a 15.2% decrease in death rates due to "other transports" in males, but 3.8% increase in females.

In 2016, age standardized RTIs in Iran accounted for 34.82 (UI: 28.97–42.3) of deaths per 100 000, compared to 59.87 (50.33–71.35) in 1990.

Observed deaths for RTIs exceeded expected deaths by 0.003 (-2.38 vs. -2.08 per 100 000) (see Supplementary data, Figure S3). This ratio was nearly similar for males 0.003 (-2.34 vs. -2.02 deaths per 100 000) and females 0.001 (-2.39 vs. 2.25 deaths per 100 000) (see Supplementary, Figure S4). Of the leading 36 level 3 causes of death, age-standardized deaths due to RTIs ranked third in males versus ninth in females (see Supplementary data, Figure S5).

In 2016, the highest percentage of deaths was due to motor vehicle road injuries in the 20–24-year old group (19.1%; UI: 14.8%–24.0%). This was followed by pedestrian sub-cause in the 5–9-year-old group at 15.0% of total deaths (UI: 11.6%–18.6%). The highest motorcycling-related deaths occurred in the 15–19-year-old age group (9.24.1%; IU: 5.89% - 13.8%), followed by those 20–24 years old (7.47%; UI: 4.74%–13.4%) (see Supplementary data, Table S1) (Figure 1).

From 1990 to 2016, males who suffered motorcyclist and "other transport injuries" showed a 10.4% and 105.8% increase in deaths rates, respectively. Females who suffered "other transport injuries" showed a 65.1% increase in death rates. The percentage of change in other types of road injuries was negative (Table 1). In males and females, the highest reduction in death rates from 1990 to 2016 occurred in motorcycle sub-cause, 44.4 and 62.4, respectively (Table 1).

Years of Life Lost: Premature Death

In Iran, transport injuries claimed 1528.72 YLLs per 100 000 (UI: 1275.9–1852.3) in 2016 (see Supplementary data, Figure S6). RTTs moved from third leading cause of YLLs in 1990 to second in 2016 on the list of all causes (See Supplementary data, Figure S7). The rate of premature death from RTIs was higher in males (2295.4 per 100 000; UI: (1817.07–2872.7) than females (677.6 per 100 000; UI [538.5–856.5]). From 1990 to 2016, premature deaths due to RTIs changed in males and females from third to second and sixth to fifth, respectively (See Supplementary data, Figure S8).

In 2016, the rate of age-standardized YLL per 100 000 in males is the highest in motor vehicle injuries (1117.35 100 000; UI: 846.09–1443.9), followed by pedestrian injuries (791.3 per 100 000: UI: 588.72–1022.41) and motorcyclist injuries (317.9 per 100 000; UI: 223.2–524.2). In females, also, YLLs per 100 000 are highest in motor vehicle injuries (375.12: UI: 285.5–472.4) and pedestrian injuries (253.6; UI: 196.7–323.1) (Table 1).

From 1990 to 2016, "other road injuries" for males showed a 70.2% increase in YLLs, with a decrease for other causes. For females, all sub-causes of transport injuries were decreased. In males, the highest reduction in YLLs occurred in pedestrian injuries at 45.6% and in females in motorcyclist injury at 66.1%, (Table 1).

Years Lived With Disability

In 2016, transport injuries resulted in 210.2 YLDs per 100 000 in Iran (UI: (137.5–303.2) and ranked 10 out of a total of 21 level 2 causes of YLDs. This ranking has changed since 1990 from 12 to 10 (see Supplementary data, Figure S9). However, ranking of RTIs on the list of all causes of YLDs has remained the same from 1990 to 2016 (16th) (see Supplementary data, Figure S10). For male and female, RTIs, in 2016, resulted in 241.6 (UI: 157.72–347.34) and 111.6 (UI: 72.3–160.71) YLDs, per 100 000, respectively (see Supplementary data, Figure S11).

From 1990 to 2016, motorcycle and motor vehicles injuries for males showed a 14.9% and 8.55% decrease in YLDs, respectively. The highest reduction in YLDs occurred among male (17.5), and female (31.1%) pedestrians. Between 1990 and 2016, YLDs decreased among all transport injuries for females (Table 1).

The burden of disabilities resulting from different types of transport injuries started in the 5–10-year-old age group in both sexes and continued to increase across the entire

Table 1. Number, Age-Standardized and Percent Change of Burden of Transport Injuries and Sub-causes by Sex From 1990 to 2016, Iran

		Male						Female					
		1990		2016		Percent Change		1990		2016		Percent Change	
		Number	Age Standardized	Number	Age Standardized	Number	Age Standardized	Number	Age Standardized	Number	Age Standardized	Number	Age Standardized
Transport injuries	Death	21285.13	91.75	20974.26	54.65	-1.46	-40.43	7886.11	28.8	5762.24	16.3	-26.93	-44
	YLL	1245480.17	4189.56	1004397.59	2353.34	-19.36	-43.83	527990.01	1494.31	278691.85	686.25	-47.22	-54.08
	YLD	56988.17	310.54	103724.08	278.07	82.01	-10.46	30509.18	168.07	51253.62	140.52	67.99	-16.39
	DALY	1302468.34	4500.11	1108121.67	2631.4	-14.92	-41.53	558499.2	1662.37	329945.47	826.77	-40.92	-50.27
Road injuries	Death	2098.16	90.12	20448.93	53.27	-2.2	-40.89	7829.02	28.59	5689.71	15.92	-27.33	-44.34
	YLL	1223212.23	4115.68	979766.73	2295.39	-19.9	-44.23	524044.26	1483.68	275237.4	677.6	-47.48	-54.33
	YLD	47911.42	267.99	89879.49	241.62	87.6	-9.84	23301.86	135.14	40131.95	111.6	72.23	-17.42
	DALY	1271123.65	4383.67	1069646.22	2537.01	-15.85	-42.13	547346.11	1618.83	315369.35	789.2	-42.38	-51.25
Motor vehicle	Death	10016.83	44.02	10062.78	25.61	0.46	-41.83	3944.91	14.94	3164.61	8.52	-19.78	-42.94
	YLL	575156.1	2002.84	483921.98	117.35	-15.86	-44.21	257178.99	763.51	155479.34	375.12	-39.54	-50.87
	YLD	19482.46	111.24	37427.23	101.72	92.11	-.8.55	10389.03	60.73	18858.74	52.76	81.53	-13.12
	DALY	594638.56	2114.07	521349.22	1219.07	-12.33	-42.34	267568.02	824.24	174338.08	427.89	-34.84	-48.09
Pedestrian	Death	7680.9	33.01	7174.72	19.85	-6.59	-39.86	3244.7	11.38	2131.09	6.34	-34.32	-44.33
	YLL	459650.92	1454.21	327956.98	791.35	-28.65	-45.58	223448.67	598.21	99401.47	253.65	-55.51	-57.6
	YLD	11434.91	63.99	19269.19	52.77	68.51	-17.54	6534.08	39.05	9290.85	26.9	42.19	-31.12
	DALY	471085.84	1518.2	347226.16	844.12	-26.29	-44.4	229982.75	637.26	108692.32	280.55	-52.74	-55.98
Motorcycle	Death	2754.45	11.31	2613.48	6.28	-5.12	-44.44	434.64	1.42	217.77	0.53	-49.9	-62.4
	YLL	160717.37	569.32	139054.53	317.89	-13.48	-44.16	30294.79	82.73	12060.61	28.06	-60.19	-66.08
	YLD	11249.52	62.96	20505.61	53.56	82.28	-14.87	2790.55	15.62	4782.09	12.66	71.37	-18.98
	DALY	171966.89	632.25	159560.14	371.46	-7.21	-41.25	33085.35	98.35	16842.7	40.72	-49.09	-58.6
Cyclist	Death	439.64	1.71	552.39	1.39	25.65	-18.23	197.86	0.72	165.52	0.41	-16.35	-42.81
	YLL	26716.26	86.24	26753.99	63.58	0.14	-26.28	12691.44	37.85	7764.82	19.47	-38.82	-48.56
	YLD	3867.03	19.51	8502.59	22.41	119.87	14.82	2288.8	12.09	4486.95	11.81	96.04	-2.33
	DALY	30583.29	105.76	35256.58	85.99	15.28	-18.69	14980.24	49.94	12251.77	31.27	-18.21	-37.37
Other road injuries	Death	16.34	0.076	45.56	0.14	178.81	77.86	6.91	0.028	10.73	0.028	55.23	-1.66
	YLL	971.58	3.07	2079.25	5.22	114.01	70.25	430.36	1.38	531.17	1.29	23.42	-7.15
	YLD	1877.49	10.32	4174.88	11.16	122.36	8.09	1299.39	7.66	2713.32	6.48	108.81	-2.3
	DALY	2849.08	13.39	6254.12	16.38	119.51	22.33	1729.75	9.04	3244.48	8.77	87.57	-3.04
Other transport injuries	Death	376.97	1.63	525.33	1.38	39.36	-15.25	57.09	0.2	72.53	0.21	27.04	3.8
	YLL	971.58	73.88	2079.25	57.94	114.01	-21.58	3945.76	10.62	3454.44	8.65	-12.45	-18.57
	YLD	9076.76	42.56	13844.59	36.45	52.53	-14.35	7207.33	32.92	11121.67	26.9	54.31	-31.12
	DALY	31344.7	116.44	38475.45	94.39	22.75	-18.94	11153.08	9.04	14576.11	8.77	30.69	-3.04

life span. This is especially true for YLDs related to motor vehicle and motorcyclist injuries (see Supplementary data, Figure S12).

Disability-Adjusted Life Years

In 2016, transport injuries accounted for 1738.2 DALYs per 100 000 in Iran (UI: 1463.3–2087.2) (see Supplementary data, Figure S13) and 1438.67.14 DALYs (UI: 1 205 668.51–1 739 198.92) (see Supplementary data, Figure S14). RTIs moved from the third leading cause of DALYs in 1990 to second in 2016 on the list of all causes (see Supplementary data, Figure S15). In the same year, RTIs ranked second in males and resulted in 2537.01 per 100 000 (UI: 2057.17–3166.04). DALYs for RTIs, up one ranks from1990 (see Supplementary data, Figure S16). In females, RTIs ranked sixth out of all causes, in 1990, and 10th in 2016, which resulted in 789.2 (UI: 640.83–962.19) DALYs per 100 000 (see Supplementary data, Figure S17).

In both 1990 and 2016, the largest DALYs in males and females resulted from motor vehicle injuries (Table 1). This was followed by pedestrian and motorcycle injuries. From 1990 to 2016, DALYs for males decreased in all types of transport injuries except in "other road injuries," which increased by 22.3%. In males, the highest reduction in DALYs rate occurred in pedestrian injuries followed by motorcyclist road injury at 44.4% and 41.2%. In females the highest reduction occurred in motorcycle injuries followed by pedestrian injuries at 58.6% and 55.9%. (Table 1).

Transport Age Standardize Death Rates and DALYs in Iran and 15 Surrounding Countries

As depicted in Table 3 in 2016, Afghanistan had the largest transport injury death rates per 100 000 (59.1), followed by UAE (53.7), Oman (51.4), Saudi Arabia (37.5), and Iran (35.6). From 1990 to 2016, Iran had -2.06 annual percent change in transport deaths rates. The lowest annual

Table 2. Age Standardized Deaths Rates for Transport Injuries, Both Sexes, in Iran and Neighboring Countries, 1990–2016

	1990	1995	2000	2005	2010	2016	Annual % Change	O/E	SDI
Afghanistan	62.96	66.25	66.19	68.41	60.59	**59.14 (52.09 -66.8)**	**-0.24**	**2.04**	**0.28**
Armenia	19.69	15.9	12.32	10.92	9.9	8.78 (7.62- 10.15)	-3.11	0.46	0.75
Azerbaijan	18.18	20.65	9.73	9.8	8.99	8.51 (6.88 – 10.61)	-2.92	0.46	0.77
Bahrain	33.35	33.14	49.94	23.53	16.84	15.74 (12.68 – 19.86)	-0.02	0.77	0.74
Iran	**60.8**	**62**	**62.66**	**61.23**	**46.33**	**35.62 (29.64 -43.44)**	**-2.06**	**1.95**	**0.77**
Iraq	29.79	30.8	31.26	31.09	29.31	27.49 (21.11- 34.5)	-0.31	0.8	0.47
Kazakhstan	25.24	24.45	21.75	30.25	25.05	18.27 (14.86- 22.17)	-1.24	0.95	0.76
Kuwait	27.18	29.88	28.39	27.79	21.76	18.83 (13.81- 24.96)	-1.41	1.28	0.83
Oman	**83.74**	**76.59**	**66.58**	**60.59**	**57.22**	**51.45 (45.25- 57.63)**	**-1.87**	**2.39**	**0.72**
Pakistan	17.74	21.23	24.24	26.48	26.46	24.95 (19.53 – 34.31)	1.31	0.75	0.52
Qatar	31.7	29.79	45.16	49.99	35.47	33.38 (23.53- 46.68)	0.2	1.95	0.79
Russia	26.92	36.62	31.6	30.65	22.35	19.83 (14.05 – 26.97)	-1.18	1.34	0.83
Saudi Arabia	49.83	48.34	48.51	47.53	43.47	37.5 (33.27 -41.28)	-1.09	2.23	0.8
Turkey	19.09	19.67	16.11	13.45	11.02	11.63 (9.6-13.66)	-1.91	0.61	0.76
Turkmenistan	20.9	15.9	14.14	15.07	10.96	8.58 (7.76 -9.41)	-3.43	0.45	0.76
United Arab Emirates	**49.79**	**48.75**	**45.34**	**45.74**	**52.6**	**53.71 (36.59 – 72.77)**	**0.29**	**2.93**	**0.77**

Table 3. Age-Standardized DALYs Rate and Ratio of Observed vs. Expected (O/E), Per 100 000, Both Sexes, All Transport Injuries in Iran and its Neighboring Countries, 2016.

Location	DALYs	Lower Bound	Upper Bond	O/E
Afghanistan	2985.1	2646.6	3411.9	2.05
Armenia	530.43	453.7	619.46	0.5
Azerbaijan	518.97	428.86	633.92	0.5
Bahrain	619.2	515.7	757.3	0.60
Iran	1738.25	1463.33	2087.2	1.7
Iraq	1388.38	1084.58	1718.67	0.82
Kazakhstan	1078.87	897.45	1292.58	1.02
Kuwait	914.65	711.73	1165.44	1.05
Oman	2258.74	1973.84	2542.83	1.94
Pakistan	1295.87	1044.39	1697.91	0.79
Qatar	1621.05	1238.38	2144.94	1.67
Russia	1187.91	879.14	1544.87	1.37
Saudi Arabia	1583.74	1417.4	1752.53	1.66
Turkey	673.28	567.14	785.89	0.64
Turkmenistan	560.12	498.47	643.86	0.53
United Arab Emirates	2085.46	1488.11	2733.16	2.04

percent change is reported for Turkmenistan at -3.43. While Pakistan, UAE and Qatar had the highest annual percent change in transport injury (Table 2). Across all countries, the observed-to-expected ratios for transport injury death rates varied noticeably in 2016. The UAE had the largest age-standardized ratios of observed-to-expected rate (2.93), followed by Oman (2.39), Saudi Arabia (2.23), Afghanistan (2.04) and Iran (1.95) (Table 3).

In 2016, for every 4 males who died of RTIs in Iran, 1 female died (3.3 to 1). Similarly, RTI death rates in neighboring countries affected more males than females. Armenia reported the highest male-to-female ratio (5.1 to 1) and Pakistan reported the lowest (2.1 to 1). In all countries, motor vehicle injuries were the major sub-cause of transport injuries (Figure 2).

Figure 3 visually depicts age-standardized DALY rates per 100 000 for both sexes in Iran and 15 surrounding countries for transport injuries. Iran had the highest rate in 2016 (1738.2) after Afghanistan (2985.1) and Oman (2258.7) and UAE (2085.5). The lowest DALY is reported for Azerbaijan (518.9). Azerbaijan and Turkmenistan respectively, have the lowest death and DALY rates due to transport injuries (Table 3). The highest ratios of observed-versus-expected age-standardized DALYs belong to the Afghanistan (2.05), followed by UAE (2.04), and Oman (1.94). Iran's ratio is 1.7 (Table 3).

Discussion

This is the most recent report of the burden of RTIs in Iran and its neighboring countries. Our findings show that RTIs are epidemic in these countries. In Iran, the burden is mainly caused by motor vehicles and motorcycle-related injuries and primarily affect the most economically productive age groups. The RTI burden is disproportionally borne by males and school-age children, findings that are supported by previous studies.[35]

From 1990 to 2016 pedestrians had a large reduction in the burden of RTIs (i.e., death, YLLs, YLDs and DALYs). This suggests, perhaps, that policies aimed at protecting and enhancing the safety of these vulnerable road users are having an effect.

Reporting on Iran's experience, and that of its neighboring

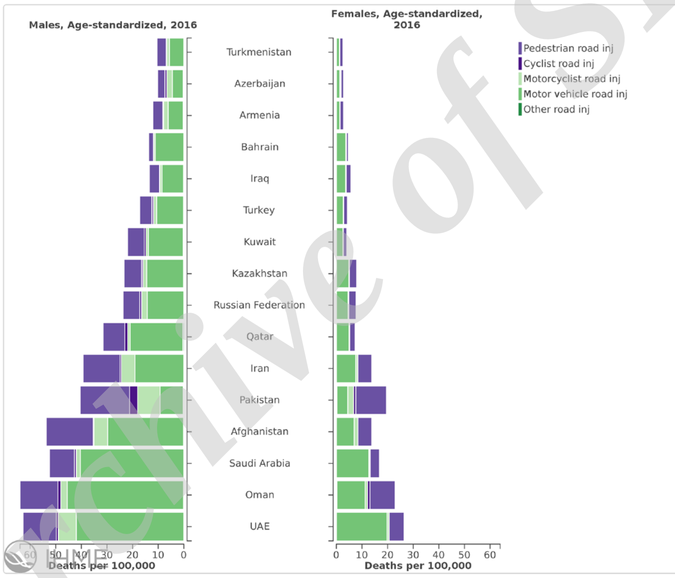

Figure 2. Age-Standardized, Death Rate, Male and Female, 2016, Iran and Surrounding Countries.

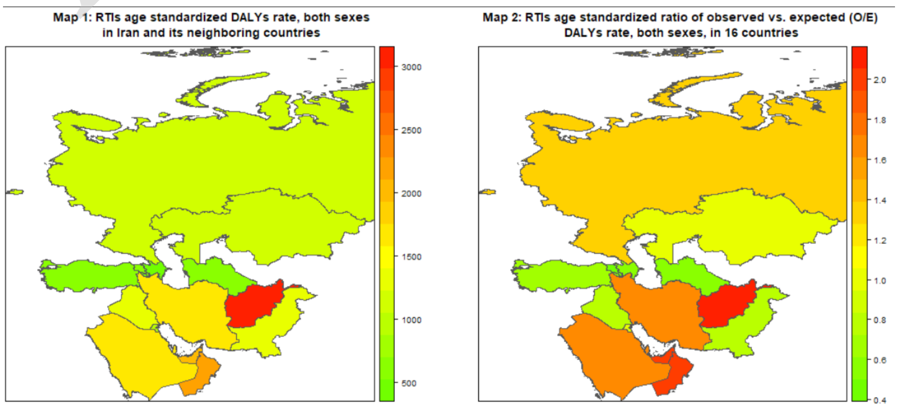

Figure 3. Age-Standardized, DALYs Rate and Ratio of Observed/Expected for Transport Injuries, Both Sexes, 2016, Iran and its Neighbouring Countries.

countries from 1990 to 2016 reveals several important points.[1] Firstly, in all countries, motor vehicle injury is the leading sub-cause of death. Secondly, males are disproportionally affected by RTI-related deaths and burdens compared to females. Thirdly, there is no discernable relationship between a country's Socio-Demographic Index (SDI) scores and RTI deaths. For example, with an SDI score of 0.77, Iran has been more successful in lowering its RTI O/E death ratio than Saudi Arabia, which enjoy SDIs of 0.8. Similar disconnects exist in other countries, suggesting RTI prevention and management go beyond socio-economic factors in countries even in the same general geographical region.

The decrease in rates of change in RTIs deaths between 1990 and 2016 across all countries, except UAE, Pakistan and Qatar, suggests that advocacy and action in prevention and management of RTIs are moving in the right direction. However, it is imperative to identify national measures that have contributed to the downward trend to formulate and initiate additional effective plans and policies. For example, Iran has addressed road congestion at the local level by assembling a surveillance system and road network in its capital of Tehran. Also, in order to accurately register RTIs fatalities, Iran has used the capture-recapture method in West Azerbaijan.[36]

Pakistan has introduced the Road Traffic Injuries Research Network (RTIRN) surveillance system in Karachi to capture RTIs.[12] The UAE has addressed improving drivers' training by establishing a new training center. Oman has a state-of-the-art vehicle registration and mechanical center.[37] Russia has addressed seatbelt and child restraint use and speeding by funding programs with similar aims.[38] Bahrain has reduced children/pedestrian casualties by increasing the number of traffic police near schools.[39] It is equally important to determine the extent to which these measures address road and vehicle safety, management of trauma care, road safety education and training, and result in stricter enforcement of traffic laws.[24,15,40,41] This calls for capacity building at the national and regional level to: (1) capture accurate RTI data, (2) monitor the human, social, and economic cost of road traffic crashes and injuries, (3) establish more efficient educational programs in Iran and its neighboring countries to improve road and traffic safety and decrease road injury burden through cultivating a safe driving culture, (4) evaluate the effectiveness of interventions, and (5) disseminate success stories in reducing the burden of RTIs. Also, the increase in the number of roads, cars, drivers, pedestrians, driving hours, distracted driving due to the use of mobile phones, increasing tourism, among other factors, call for multi-sectoral cooperation and political will at the national, regional, and global level. These entities must fund and support road safety education, professional development and training, research, and projects that promote a culture of road safety and reliable RTI data capture.[37] Although these tasks may seem daunting, they will enable and empower the next generation of road users to limit road traffic deaths and burden of injury.

Limitations in Data and Modeling

Despite the continuous burden of RTIs, the lack and limitations of vital registration data, incomplete reports, different and sometimes conflicting methods of data collection are common hindrances and prevalent in most of the countries in the current study.[42] Estimates were, therefore, calculated using models and covariates that rely on limited vital registration data, incomplete and different death records, available police and verbal autopsy data, and by borrowing strength over time and location using the large GBD mortality database. Therefore, where data was less available, estimates are less precise. Moreover, police data tends to underestimate the exact degree and details of deaths. Police data estimates were used in instances where reported deaths were higher than vital registration numbers. Efforts were made to capture all sources of uncertainty in the data.[29,43]

In conclusion, nearly two decades after the first UN resolution on road safety in March 2003, and the WHO endorsement that "Road Safety Is No Accident" in 2004,[37] thousands of RTI-related deaths, DALYs, YLL, and YLD are still reported in Iran and its neighboring countries. RTIs continue to be a public health burden. There is some evidence of decline in RTIs at the national level for each of the countries in our study except for Pakistan. The most vulnerable road users are children and young adults. The most frequent sub-causes are the motor vehicle, motorcycle, and pedestrian injuries. Furthermore, our findings support the value of ongoing efforts in each country to enhance the safety of all road users.

Global advocacy is needed to promote the completeness of vital registration data in Iran and its neighboring countries. At the regional level, Iran and its neighbors could consolidate their efforts for road safety capacity building, scale up effective preventive and management RTI measures, and establish and monitor a regional RTI registry to capture accurate pre-crash, crash, and post-crash data. Partnership with private sectors could facilitate innovative strategies to reduce the toll of RTIs.

Authors' Contribution

SBH took the lead in writing the manuscript in consultation with MN and AA. AS assisted with the calculations, technical details and drafting the manuscript. SD assisted with mapping GBD data. All the authors provided critical feedback and helped shape the analysis and the final version of the manuscript.

Conflict of Interest Disclosures

The authors of this manuscript do not have any conflicts of interest to disclose at the time of submission.

Ethical Statement

This manuscript reflects original work. It has not been published in whole or in part and is not under consideration elsewhere. All authors have read the manuscript and have agreed that the work is ready for submission and accept responsibility for its contents. The funding source played no role in the design of the study, the analysis and interpretation of data, and the writing of the paper. The study did not involve human participants and/or animals; therefore, no informed consent was needed.

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Supplementary Materials
Supplementary data contains Table S1 and Figures S1-S17.

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