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ORIGINAL RESEARCH

11-Year Trend of Mortality from Fatal Road Traffic Injuries in The Center of Iran; a Cross-sectional Study

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Abstract: **Introduction:** Road traffic injuries (RTIs) are one of the major health problems in developed and developing countries. In Iran, RTIs are the first leading cause of years of life lost (YLL). So, the present study investigated the 11-year trend of RTI- related mortalities in Iran. **Methods:** This study was a population-based cross-sectional study. All-cause deaths as well as RTI-related mortalities' data were collected from the Civil Registration Organization (CRO) and Legal medical organization (LMO) of Isfahan during 2011-2021. The mid-year population, number of deaths due to RTIs, the crude and age-standardized mortality (per 100,000) of RTIs, and the percentage of proportional mortality by sex and year of accident during the study period were calculated and reported. Also, trend analysis was done using join point regression program. **Results:** During the study period, 11,248 deaths occurred due to RTIs in Isfahan province. 8,894 cases were male (79.03%), the highest number of deaths in both male and female cases was reported in those aged 15-39 years. Among the males, trend of standardized mortality in 2011-2015 was decreasing (annual percentage changes = -6.76(CI 95%: -2.53, -15.03)), while in 2015-2021 it was increasing (annual percentage changes = 3.00 (CI 95%: 0.63, 9.87)). However, no significant trend was observed among females. **Conclusion:** The findings of the present study showed that the number and standardized mortality rate of RTIs decreased during the 11-year period. It seems that applying stricter policies, improving the quality of the roads of the province, improving the quality of cars, and increasing the number of hospital and pre-hospital medical facilities can play an effective role in reducing RTIs.

Keywords: Accidents, traffic; Mortality; Trends; Regression analysis

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1. Introduction

Road traffic injuries (RTIs) refer to unexpected and unforeseen events involving at least one motor vehicle. Fatal RTIs refer to the process whereby life is lost during an accident or within a maximum of 30 days after the crash. Deaths, injuries and disabilities resulting from RTIs are considered major concerns in public health (1). Today, RTIs are one of the major health problems in developed and developing countries (2-4). RTIs are complex events that result from human-related, environmental, and technical factors. Road design, the presence of warning signs, establishment and enforcement of driving laws and regulations, and the support of transportation structures are factors associated with the number and severity of RTIs(2).

The World Health Organization (WHO) has estimated that traffic accidents are accountable for more than 1.35 million deaths, over 10 million permanent disabilities, and 20-50 million injuries each year (5). More than 90% of RTI-related deaths occur in low- and middle-income countries, which include 60% of vehicles. In addition, in high-income countries, the probability of RTIs is higher among those with lower economic levels. RTI-related injuries and deaths are increasing day by day (4). According to the Global Burden of Disease (GBD), the number of deaths caused by RTIs did not significantly decrease in Iran (6). In Iran, some studies showed that the rate of mortality due to RTIs was 25.5 (7) and 30-39.5 per 100,000 (8), which is significantly higher than the global average (18.2 per 100,000 persons). In 2011, this rate was 24.3 per 100,000 persons in Isfahan province (5). In a recent study, the mortality rate due to road accidents in Iran was reported to be 18 per 100,000 persons (9). In Iran, RTIs are the second cause of death after cardiovascular diseases, and the first leading cause of Years of Life Lost (YLL) (10). According to the WHO reports, Iran has reached 21,631 deaths due to

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traffic accidents, which is equal to 6.50% of all-cause deaths (4). Also, the costs of RTIs has been calculated as 6.4% of the Gross Domestic Product (GDP) in Iran (11). In Iran, numerous studies have shown that more than half of the RTI victims are 15-44 years of age, who are the most active and productive part of the country's population (10, 12, 13). Considering the importance of RTIs and burden caused by them, it is necessary to provide a suitable information platform for their prevention and control by investigating and analyzing the current situation. Besides, Isfahan province due to its specific features, such as tourist attractions and being located on the highway of the country, which is one of the busiest routes of the country, has higher rates of RTIs (14). So the present study was aimed to investigate the 11-year trend of mortality and proportional mortality rate from the RTIs in Isfahan province between 2011 and 2021.

2. Methods

2.1. Study design and setting

This population-based cross-sectional study investigated the information of all-cause deaths and deaths due to RTIs between 2011 and 2021 by age group, sex, year, and city of residence in Isfahan province via census method. The mid-year population, number of deaths due to RTIs, the crude and age-standardized mortality (per 100,000) of RTIs, and the percentage of proportional mortality by sex and year of accident during the study period were calculated and reported. Also, trend analysis was done using Joinpoint regression program. Isfahan province is located in the center of Iran and according to the latest population census conducted in 2016, it has 24 cities with 5,120,850 population. In Iran, the Civil Registration Organization (CRO), the Ministry of Health and Medical Education (MOHME), the Statistical Centre of Iran (SCI), and the Legal Medicine Organization (LMO) are the primary sources of information for deaths. About 15 to 20 percent of deaths are unnatural or suspicious, requiring an LMO certificate, and burial permission must be issued by a legal medical doctor. One of the most significant causes of these deaths is due to RTIs (in any form and with any time interval). For our study, we obtained data on all-cause mortality from Isfahan's CRO using the census method, while information on deaths resulting from RTIs was collected from Isfahan's LMO. In Iran, it is mandatory for all suspicious deaths to be evaluated and approved by the LMO Centre before a death certificate can be issued. Based on the 10th edition of the International Classification of Diseases, codes V01-V79 were classified as RTI deaths.

This study was approved by the Research Ethics Committee of Isfahan University of Medical Sciences (Ethics code: IR.MUI.RESEARCH.REC.1400.462).

2.2. Participants

The inclusion criterion was all deaths from all causes that occurred in each calendar year, not the date of registration; all deaths that occur during a road traffic crash or within 30 days after the accident due to road traffic injuries (defined by WHO); and living in Isfahan province.

Death of unknown age group, deaths that occurred before 2011 but was registered after that, and death for people who lived out of the Isfahan province were the exclusion criteria.

2.3. Data gathering

The website of the Statistical Center of Iran(SCI), was applied for 2011 and 2016 population and housing census data was used to obtain demographic information by sex and age groups (15, 16). Following separation of the age groups in a specific format, introduced by WHO, which is known as the epidemiology life table, population data was entered using ECXEL 2016 software. Considering that only 2011 and 2016 census data were available, to estimate the population in the other years of the study, Population Analysis Spreadsheets (PAS) software, based on the West model (Coale - Demeny) (17), was used.

The data provided by the CRO of Isfahan Province included all-cause deaths categorized by age group, sex, city of living, year of death, and year of death registration. Those with year of death from 2011 to 2021 were included using census method. The LMO of Isfahan Province was the source for obtaining the deaths caused by RTIs, based on ICD-10 V01-V79 codes, and all cases were included using census method.

2.4. Statistical analyses

Descriptive analyses were expressed as number and percentage, then crude and standardized mortality and annual proportional mortality rates were calculated for eighteen age groups (under 1 ,1-4, 5-9, 10-14, ..., 80) based on life table age grouping proposed by WHO. When we encountered missing values for the sex variable, they were amended based on the victims' first names. If the person's first name was not registered, relative frequency of males and females in the data set was used to correct missing values. Considering that mortality rates are affected by age structure, direct standardization method based on International Network for the Demographic Evaluation of Populations and Their Health (INDEPTH) of 2013 standard population (18) was used to control the effect of age.

We used joinpoint regression in order to calculate the trend of RTI-related mortalities during the study period. This model is one of the regression analysis methods, in which the independent variable is partitioned into intervals and a separate line segment is fit to each interval and the borders between the intervals are called joinpoints. To identify the best-fitting points, we relied upon the Bayesian Information Criterion (BIC) method and significant change in the linear slope of the trend. We began by performing this analysis starting with a minimum of zero, which represented a straight line. Due to the limited number of observed points (0-11 point 1 joinpoint proposed), we set the maximum number of joinpoints for statistical testing to one in this study.

We estimated their Bayesian Information Criterion (BIC) as: BIC(k) =ln(SSE(K))/n+2(K+1)ln(n)/n , where SSE is the sum of squared errors of the k-joinpoint regression model, n is the number of observations and 2(k+1) is the number of parameters in the model.

Also, annual percentage changes (APC) and average annual percentage changes (AAPC) were applied to compare the decreasing or increasing trend of mortality rates. To estimate the APC and AAPC, the following regression model was used: APCi=exp(Bi)-1×100 And for AAPC=exp((WiBi)/(Wi)-1) ×100 where Bi is the slope coefficient for the ith segment with i indexing the segments in the desired range of years, and Wi is the length of each segment in the range of years.

The trend analysis was done using joinpoint regression program version 5.0.2 (Statistical Research and Applications Branch, National Cancer Institute). The data analysis was performed using SPSS 20.0 and Excel 2016 (A.S.U., Illinois, Chicago) software. A P- value less than 0.05 was considered statistically significant.

3. Results

The mid-year population, number of deaths due to RTIs, the crude and age-standardized mortality (per 100,000) of RTIs, and the percentage of proportional mortality by sex and year of accident during the study period (2011-2021), are shown in Table 1. During the study period, 11248 deaths due to RTIs had occurred in Isfahan province, of which 8894 cases were male (79.07%). The highest number of deaths in both males and females was observed in the age group of 15-39 years (845 females (35.90%) vs. 4196 males (47.17%)) (Table 2). The average standardized mortality rate due to RTIs in the study period was 28.36 in males and 7.91 in females per 100,000 persons (Table 1). 11-year average percentage of mortality from RTIs was higher in older age groups and was shown to increase with age. Therefore, the highest mortality percentage in all age groups was displayed in males over 80 years of age and females aged 75-79 years (Figure 1).

3.1. The trend of RTI-related mortality rate

The rate of RTI-related mortality was shown to decrease in males and females from 33.06 and 9.20 in 2011 to 29.78 and 6.55 per 100000 persons in 2021, respectively (Table 1 and Figure 2). However, this reduction was not statistically significant (male APC =-0.66, 95% CI=-3.89, 2.73 vs. female APC =-2.40, 95% CI=-5.15, 0.41). The results of joinpoint regression showed that, the trend of standardized mortality of RTIs in males had a joinpoint in 2015 and two segments (2011-2015 and 2015-2021) during 2011-2021. In the first segment (2011-2015), it was decreasing (APC = -6.76, 95% CI = -2.53, -15.03), while in the second segment (2015-2021) it indicated an increase in standardized mortality of RTIs (APC = 3.00, 95% CI = 0.63, 9.87) (Table 3 and Figure 2). However, trend of RTIs in females was stable.

3.2. Proportional mortality

The 11-year proportional mortality rate is shown in Table 1 and Figure 2. On average, 7.80% of all deaths in males and 2.84% in females occurred due to RTIs. The lowest RTI-related mortality rate was observed in the age group of 60 years and older, whereas the highest rate was observed in the age group of 15-39 years, and the peak rates was displayed in the age group of 15-19 years in males (38%) and 20-24 years in females (18%) (table 3 and Figure 3).

3.3. Proportional mortality trend

Proportional mortality decreased from 8.32% in 2011 to 6.53% in 2021 in males and from 3.2 %to 1.79% in females. In fact, although the percentage of annual changes (APC) of proportional mortality in both females and males decreased, it was not statistically significant (Male APC= -1.61, 95% CI = -3.71, 0.59 and Female APC= -4.20, 95% CI = -8.69, 0.52) (Table 2 and Figure 4). According to the joinpoint regression analysis, the trend of proportional mortality in females had a joinpoint in 2018 and two segments during 2011-2018 (first segment) and in 2018-2021(second segment), and proportional mortality was decreasing by 19.89% annually (APC = -19.89, 95% CI = -30.95, -12.16). The average annual percentage of change in females' proportional mortality due to RTIs was decreasing from 2011 to 2021, which was statistically significant (AAPC= -5.63, 95% CI=-7.80, -3.62) (Table 3 and Figure 4).

4. Discussion

In this study, data on RTI-related death was collected from 24 cities for 11 years between 2011 and 2021, and the crude and standard mortality rates of RTIs were estimated. During the study period, a total of 11,248 persons died due to RTIs, of which 8,894 cases were male (79.07%) and 2,345 cases (20.93%) were female. This difference was observed in all study years (p value > 0.05), which was consistent with the results of a study conducted by Shahbazi and Makaran on the 11-year trend of RTI-related deaths in 2019, indicating that 80.1% of the victims of traffic accidents were male and 19.9% were female (19) Similar studies in Iran (20-22) and other countries (23, 24) have emphasized that the majority of RTI victims are male, and this is due to their higher levels of risky behavior, their greater subsequent exposure to work, as well as their social and cultural characteristics (2). In terms of age, most of the RTIs victims in both male (47.17%) and female (35.90%) cases were in the age group of 15-39 years. Similar results have been reported from the WHO, indicating that nearly 60% of deaths from RTIs occur between the ages of 15 and 44 years (25). However, higher RTI-related mortality percentage with age can be explained by the lower population of older age groups. Previous studies in Iran and other countries reported similar results; that is, members of a society in the active and productive age are more prone to death from RTIs (25-27).

Standardized mortality rate of RTIs was shown to decrease in males and females from 33.08 and 9.20 in 2011 to 29.78 and 6.55 in 2021 per 100000 persons, respectively. which was consistent with the study done by Erfanpoor et al. in 2023 on trend of mortality rate due to traffic accidents in Iran from 2006 to 2020. They showed that mortality rate had dropped from 39 in 2006 to 18.3 in 2020 (9). This reduction can be attributed to the cooperation between traffic police and MOHME. The most important traffic measures that play a significant role in the reduction of RTIs include mandatory use of seat belts, mandatory helmet use for motorcyclists, strengthening of traffic laws and regulation, and the production of mass education contents (all of these interventions started in 2005)(8, 28, 29). Also, the revision of the traffic laws after about 40 years from its initial introduction and the implementation of these laws and legislations from 2011 can be another reason. In addition, adding demerit points to the offender's driver's license and increasing the traffic fines since 2011 were other reasons for the reduction in traffic accidents (1). The actions of MOHME were increasing the number of ambulances, air ambulances, and motor ambulances, and reducing the average time emergency medical service takes to reach an accident scene (30-32).

In the proportional mortality, one joinpoint was found (year 2018) in females, and the APC of RTI mortality rate had significantly decreased from 2018 to 2021 (APC = -12.16, 95% CI: 30.95 -, 19.89). Also, the average percentage of annual changes in RTI-related proportional mortality of females decreased from 2011 to 2021, which was statistically significant (AAPC=-5.63, 95% CL= -7.80, -3.62) and can be explained by the emergence of the COVID-19 pandemic and the increase in overall mortality and the application of traffic restrictions for better control of COVID-19, which was consistent with the results of other studies (33-35). The overall death rate did not change much from 2011 to 2018, while from 2019 and especially 2020 to 2021, a high death rate was observed due to COVID-19 pandemic. Also, death from RTIs has remained constant or decreased in these years, so that the ratio of deaths from RTIs to total deaths (proportional mortality) was at the lowest level in 2020-2021(?) within the 11-year study period. This study showed that not only the increasing trend of these accidents had stopped, but also a downward trend was observed. Although a longer study is needed for a proper and more precise judgment, this reduction is probably due to the interventions carried out, such as changing the laws of driving violations, police actions, improving the traffic transportation infrastructure, and providing optimal health and treatment services, especially in the pre-hospital department. The efforts of the legislative officials to establish stricter laws regarding traffic violations are intensifying.

The punishments considered for lawbreakers and the increase of traffic fines were deterrents. Police actions in this direction include the implementation of regulations in the form of serious dealings with traffic offenders, making it mandatory to use safety helmets for motorcyclists and fasten seat belts for car passengers, establishing fixed and mobile police stations on highways and the country's roads and the shift in people's attitude and education using audio-visual tracts in the national media (8).

This study has several strengths. Firstly, the sample size is large, which increases the reliability of the findings. Secondly, the study covers a long period of time, allowing researchers to identify trends and patterns over time. Finally, the study draws on data from a highly credible source of information on deaths caused by RTIs (the LMO).

5. Limitations

Lack of access to death information for individuals who lived in Isfahan, but whose death certificates were issued outside of the province, particularly for those who died due to RTIs was a limitation of this study.

6. Conclusions

The findings of the present study showed that the number and the rate of standardized mortality of RTIs decreased during the 11-year period.

Also, the highest number of deaths was observed in the age group of 15-39 years. In order to continue the decreasing trend and prevent the increase of RTI-related death cases, it is necessary for decision makers and policy makers in the field of health to design and implement educational programs for vulnerable groups. It seems that applying stricter policies, improving the quality of the roads of the province, improving the quality of cars, and increasing the number of hospital and pre-hospital medical facilities can play an effective role in reducing RTIs.

7. Declarations

7.1. Acknowledgments

We thank the Civil Registry Organization and Legal Medicine Organization of Isfahan province for providing the data.

7.2. Conflict of interest

None.

7.3. Funding

This paper is part of a PhD dissertation in Health in Emergencies and Disasters, no funding was secured specifically for this study.

7.4. Authors' contribution

RM, MHY, MM and GA jointly planned the study. AE conducted the data collection on-site and organizations. MRM and MM planned and performed the statistical analyses. All authors contributed to the reporting of the study, MM collected and prepared the data and reviewed, MRM revised the manuscript, all authors approved the final manuscript as submitted and agree to be accountable, finally MRM submit-

ted the study

7.5. data availability

Data are available on reasonable request

7.6. Ethical approval

This study was approved by the Research Ethics Committee of Isfahan University of Medical Sciences and received the ethics code: ir.mui.research.rec.1400.462. All steps of the study were conducted in accordance with ethical principles.

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Table 1: Distribution of population and number of deaths by sex and year, crude and age-sex-standardized road traffic injury (RTI) mortality rate and proportional mortality (per100) in the study population

Year	Population (n)		Death (n)		RTI Mortality Rate (%)				Proportional mortality (%)	
					Participants		Field			
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
2011	2472023	2399685	913	241	36.93	10.04	33.08	9.2	8.32	3.20
2012	2496770	2423306	896	223	35.89	9.20	31.35	8.34	8.43	3.10
2013	2521582	2446999	801	221	31.77	9.03	27.64	8.46	7.68	3.18
2014	2546259	2470561	811	213	31.85	8.62	28.18	7.69	8.35	2.94
2015	2571070	2494251	719	205	27.97	8.22	24.11	7.51	7.37	3.03
2016	2595818	2517879	747	214	28.78	8.50	25.7	7.86	7.83	3.12
2017	2620629	2541570	742	218	28.31	8.58	25.8	8.3	7.98	3.22
2018	2645309	2565129	914	235	34.55	9.16	30.99	8.99	9.67	3.49
2019	2670122	2588819	765	230	28.65	8.88	26.78	7.85	7.77	3.01
2020	2694863	2612446	804	160	29.83	6.12	28.57	6.24	6.55	1.85
2021	2719677	2636139	782	194	28.75	7.36	29.78	6.55	6.56	1.79
TOTAL			8894	2354	31.21	8.52	28.36	7.91	7.80	2.84

Data are presented as number or percentage.

Table 2: Distribution of the 11-year road traffic injury-related mortality rate by age and sex in Isfahan province between 2011 and 2021

Age group (year)	Number of death due traffic accidents			
	Male (n)	Female (n)	Male n (%)	Female n (%)
<1	23	27	598 (6.72)	347 (14.47)
1-4	201	120		
5-9	195	121		
10-14	179	79		
15-19	815	105	4196 (47.17)	845 (35.90)
20-24	952	169		
25-29	897	172		
30-34	804	206		
35-39	728	193		
40-44	652	132	2238 (25.18)	569 (24.17)
45-49	456	151		
50-54	533	152		
55-59	507	134		
60-64	440	138	1862 (20.93)	593 (25.19)
65-69	392	139		
70-74	319	107		
75-79	283	100		
80	428	109		
Total	8894	2354	8894 (79.07)	2354 (20.93)

AUC: area under the receiver operating characteristic (ROC) curve.

Table 3: Annual age-sex adjusted rate of mortality from road traffic injuries and proportional mortality rate between 2011 and 2021

Mortality Rate	Sex Male (n)	APC trend 2011-2015 Female (n)	APC trend 2015-2021 Male n (%)	AAPC 2011-2021 Female n (%)
Adjusted	Male	-6.76 (-15.03,-2.53)*	3 (0.63, 9.87)*	-1.02 (-2.48, 0.63)
	Female	- 0.48 (-7.55, 20.10)	-8.34 (-24.41, 0.92)	-2.91 (-6.03, 0.81)
Proportional	Male	0.77 (-4.59, 21.85)	-8.95 (-24.94, 0.45)	-2.25 (-5.38, 1.55)
	Female	1.24 (-1.56, 5.39)	-19.89 (-30.95, -12.16)*	-5.63 (-7.80,-3.62)*

Data are presented with 95%confidence interval. APC: annual percentage change, AAPC: average annual percent change,
*: Indicates that the APC or AAPC is significantly different from zero at the alpha = 0.05 level.

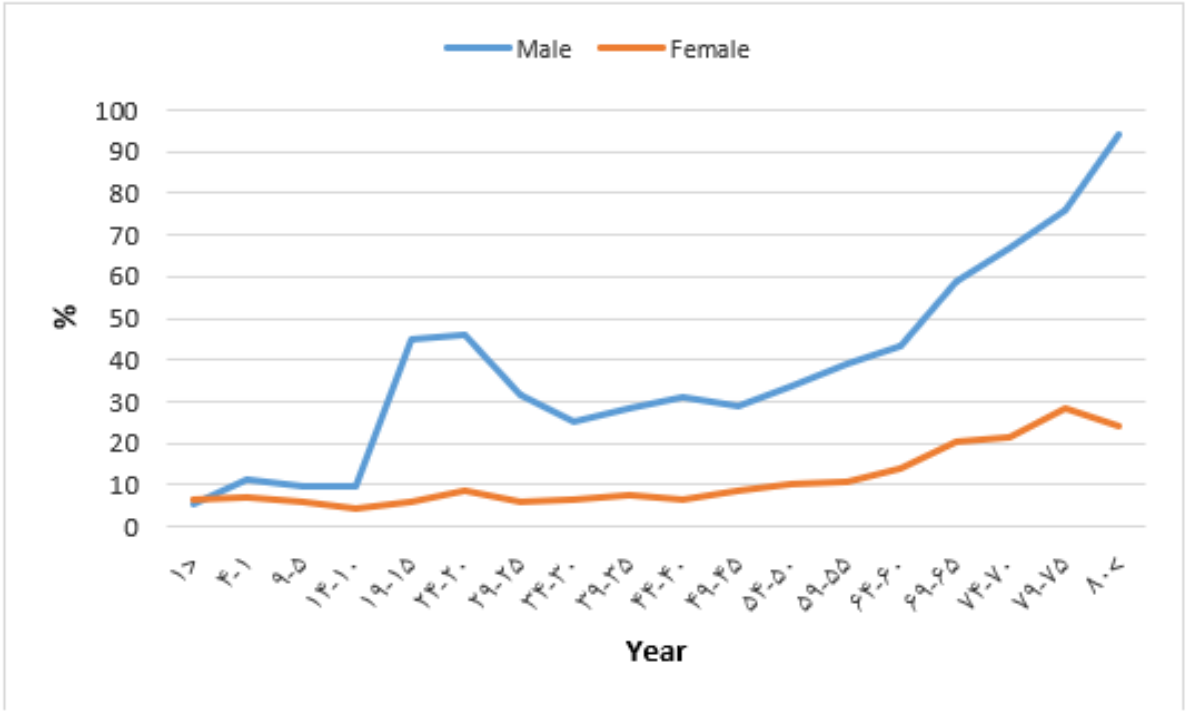

Figure 1: The 11-year average standardized road traffic injury-related mortality rate by age and sex in Isfahan province between 2011 and 2021.

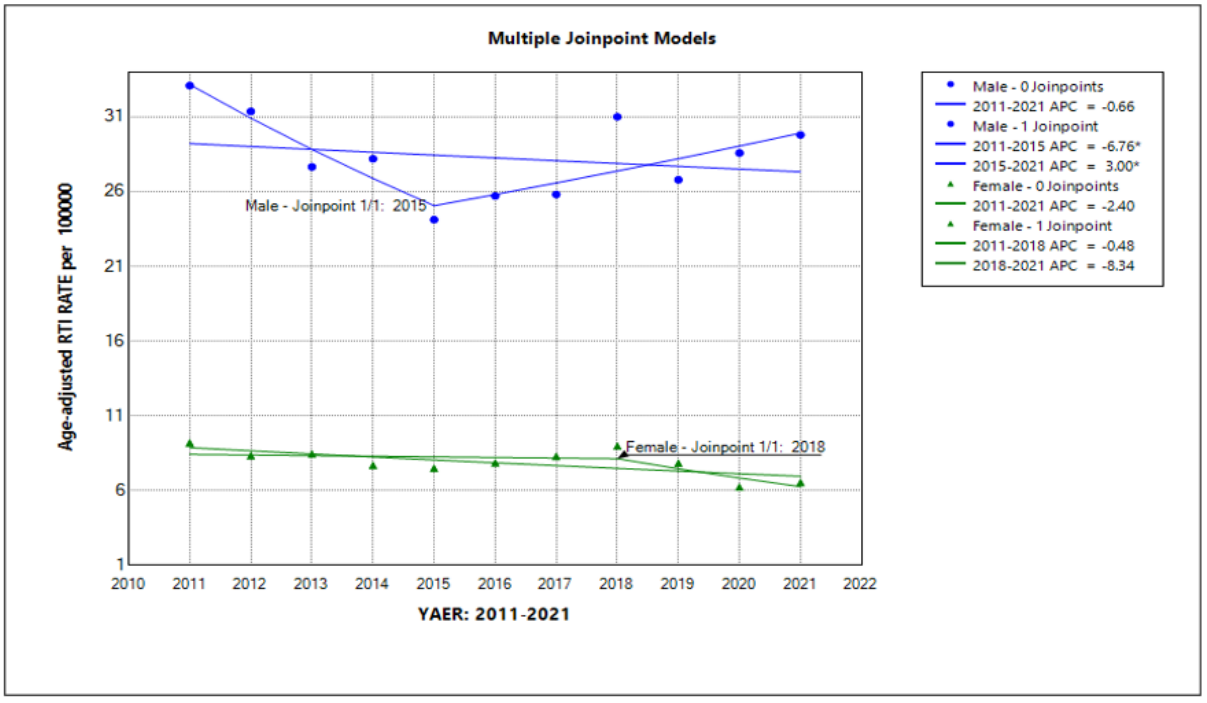

Figure 2: The trend (smooth line) and joinpoint (broken line) in age-sex standardized (INDEPTH population, per 100,000 persons) road traffic injury (RTI)-related mortality rates by sex in Isfahan province between 2011 and 2021. *: indicates that the Annual percent change (APC) is significantly different from zero at the alpha=0.05 level.

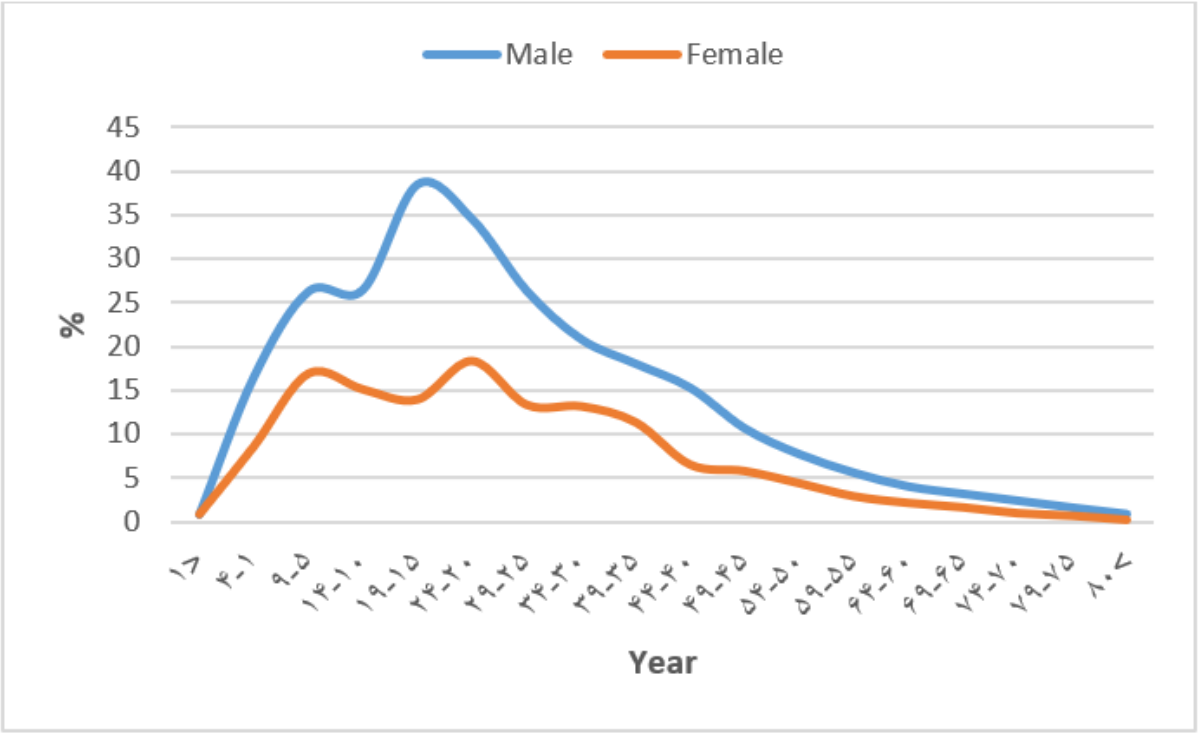

Figure 3: The 11-year average proportional road traffic injury-related mortality rate by age and sex in Isfahan province between 2011 and 2021.

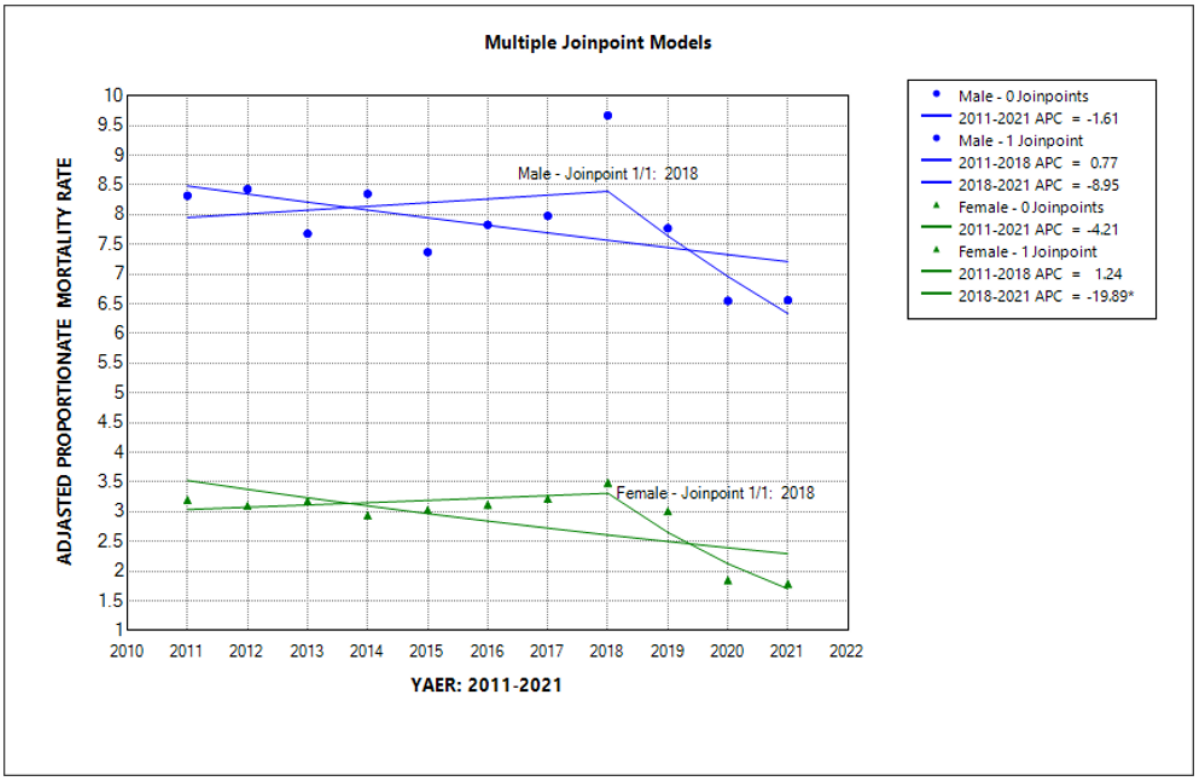

Figure 4: The trend (smooth line) and join point (broken line) of age-sex standardized (INDEPTH population, per 100,000 persons) proportional road traffic injury-related mortality rates by sex in Isfahan province between 2011 and 2021. *: indicates that the Annual percent change(APC) is significantly different from zero at the alpha=0.05 level.