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A decade of road traffic mortality in northeastern Iran: An epidemiological analysis from 2013 to 2023

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Abstract

Background: Road traffic injuries (RTIs) are a leading cause of mortality and disability worldwide, particularly in low- and middle-income countries (LMICs). In Iran, RTIs remain a significant public health challenge, especially in provinces such as Khorasan Razavi. Understanding the trends and patterns of RTI mortality is essential for developing effective public health strategies and interventions.

Objectives: The primary objective of this study was to analyze the temporal trends in road traffic-related mortality in Khorasan Razavi Province over an 11-year period (2013–2023) and identify demographic groups most at risk.

Methods: This descriptive-analytical cross-sectional study used mortality data from the Mashhad University of Medical Sciences registry, which records all RTI-related deaths. We calculated crude and age-specific mortality rates, analyzed the temporal trends, and computed Years of Potential Life Lost (YPLL) to estimate the societal impact of premature deaths.

Results: A total of 10,308 RTI-related deaths were recorded. The Cause-Specific Mortality Rate (CSMR) declined by 33.96%, from 27.31 per 100,000 in 2013 to 18.04 per 100,000 in 2023. Young adults (15–24 years) and the elderly (≥70 years) were the most vulnerable groups, with pedestrian fatalities remaining the leading cause of death. Additionally, bicycle and light vehicle-related fatalities saw a significant increase. The YPLL was highest among younger individuals, indicating the long-term societal cost of these deaths.

Conclusion: Although the overall mortality rate from road traffic accidents has decreased, RTIs continue to pose a significant public health issue in Khorasan Razavi Province. The findings highlight the need for targeted interventions for vulnerable groups, including youth, the elderly, and pedestrians, as well as improvements in infrastructure and road safety measures.

Keywords: Road traffic injuries, Mortality trends, Epidemiological surveillance, Iran, Khorasan Razavi, Years of Potential Life Lost.

Introduction

Road traffic injuries (RTIs) remain one of the leading causes of mortality worldwide and represent a significant public health challenge, particularly in low- and middle-income countries (LMICs). According to the World Health Organization,[1] approximately 1.3 million people die annually due to road traffic crashes, with an additional 20 to 50 million sustaining non-fatal injuries that frequently result in long-term disabilities and substantial socioeconomic burdens for individuals, families, and societies.[1,2] While many high-income countries have made significant progress in improving road safety, LMICs continue to bear a disproportionate share of the burden. Nearly 90% of global road traffic deaths occur in LMICs, despite these countries owning only about half of the world's vehicles.[3]

RTIs are not only a major cause of death but also contribute significantly to the years of potential life lost (YPLL), especially among younger age groups. Globally, traffic injuries are the leading cause of death among individuals aged 15–29 years, rendering youth a particularly high-risk group.[4] Males are disproportionately affected in both fatal and non-fatal crashes due to greater exposure to traffic, engagement in risky driving behaviors, and occupational factors.[1,5]

Human behavior is a critical determinant in the causation of road traffic crashes. Speeding, alcohol and substance use, non-use of seat belts or helmets, and

distracted driving are among the most well-documented risk factors.[6,7] However, environmental and vehicular factors -including road design, visibility, and vehicle safety- also substantially influence the occurrence and severity of traffic crashes.[8]

In Iran, road traffic crashes are consistently ranked among the top three causes of mortality and disability. Despite various national efforts to reduce this burden, RTIs remain a pressing concern. Notably, Khorasan Razavi Province, one of the most populous and economically active regions in northeastern Iran, has experienced a particularly high burden of fatal crashes. Khorasan Razavi Province is located in northeastern Iran and covers an area of approximately 118,851 square kilometers. The province has a population of over 6 million people with a mix of urban and rural populations. The provincial capital, Mashhad, is the second-largest city in Iran and serves as a major religious and commercial hub, hosting millions of pilgrims annually. The province is characterized by extensive road networks connecting major urban centers, rural areas, and international borders, which contributes to heavy traffic volume and complex traffic patterns. Its strategic location as a transit corridor between central Iran and neighboring countries, combined with diverse terrain including mountainous and desert regions, presents unique road safety challenges. Previous studies in Iran have demonstrated demographic and temporal patterns of traffic fatalities, identifying youth, older adults, and pedestrians as vulnerable groups.[9-11]

Evidence-based policymaking at the provincial level is hindered by the lack of updated, long-term epidemiological data that capture demographic, temporal, and cause-specific trends in RTI-related mortality.

Objectives

Given these gaps, the present study aims to conduct a comprehensive 11-year epidemiological analysis (2013-2023) of traffic accident mortality in Khorasan Razavi Province using official mortality registry data. By identifying demographic risk groups, temporal patterns, and cause-specific mortality trends, our findings can inform targeted, multi-sectoral interventions to reduce RTI-related deaths and their societal impact.

Methods

Study design and setting

This descriptive-analytical cross-sectional study analyzed all registered road traffic-related deaths in Khorasan Razavi Province, northeastern Iran, over an 11-year period from 2013 to 2023 (1392–1402 in the Iranian calendar). Khorasan Razavi is one of the most populous provinces in Iran, with a mix of urban and rural populations and major transit routes connecting neighboring provinces and international borders.

Data sources

Mortality data were obtained from the official mortality registry of Mashhad University of Medical Sciences (MUMS), which is integrated into the national system for registration and classification of causes of death. Deaths due to road traffic accidents were identified using ICD-10 codes V01–V99 (pedestrian, pedal cycle, motorcycle, motor vehicle, and other transport-related accidents). The registry integrates data from forensic medicine, hospital records, and death certificates, ensuring high completeness and accuracy.

Data quality and completeness

As the mortality data were obtained from a validated secondary source, the registry software is designed to prevent incomplete or missing entries for essential variables (age, sex, cause of death, and date of death). Therefore, no cases were excluded due to missing or incomplete information.

Variables collected

Demographic variables included age, sex, nationality, and place of residence (urban/rural). Accident-related variables included year of occurrence, type of road user (pedestrian, cyclist, motorcyclist, motor vehicle occupant, heavy vehicle occupant, public transport passenger), and ICD-10 cause-of-death category.

Population data

Mid-year population estimates stratified by age group and sex were obtained from the Statistical Center of Iran for each study year and used as denominators for rate calculations.

Outcome measures

Crude Mortality Rate (CMR) - total RTI deaths per 100,000 population per year.

Age-Specific Mortality Rate (ASMR) - number of RTI deaths within each age group per 100,000 persons in that age group per year.

Proportional Mortality Rate (PMR) - proportion of RTI deaths among all deaths in a given year (%).

Cause-Specific Mortality Rate (CSMR) - mortality rates by type of road user or crash mechanism per 100,000 population per year.

Years of Potential Life Lost (YPLL) - calculated using the WHO standard formula:

$$YPLL = \sum (L - a) \times d$$

where L is the standard life expectancy at birth (70 years,

as recommended for LMIC mortality analyses), a is the age at death (in years), and d is the number of deaths in that age group. Deaths occurring at ≥70 years contributed zero to YPLL. YPLL was calculated overall and separately for males and females, expressed per 100,000 population.

Statistical analysis

Descriptive statistics (frequencies, percentages, means, and standard deviations) summarized the demographic and accident-related characteristics of decedents. Annual mortality rates (CMR, ASMR, PMR, and CSMR) and YPLL were calculated and presented in tables and trend graphs.

Temporal trends were assessed using the Chi-square test for trend for categorical variables and the Cochran–Armitage test where appropriate. Differences in mortality patterns by sex, age group, and cause of accident were analyzed using Chi-square (χ^2) tests or Fisher's exact test when cell counts were <5. All statistical analyses were performed using SPSS version 18.0. A two-tailed p-value <0.05 was considered statistically significant.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki.

Results

From 2013 to 2023, Khorasan Razavi Province recorded 10,308 road traffic-related deaths. Annual deaths decreased from 1,380 in 2013 to 963 in 2023, with the Cause-Specific Mortality Rate (CSMR) declining from 27.31 per 100,000 population to 18.04 per 100,000, a 33.96% reduction. The mean CMR for traffic accidents was 14.18 per 100,000, with a mean proportional mortality rate (PMR) of 2.96% for accidental deaths and a mean crude death rate (CDR) for all causes of 4.93 per 1,000 population. The population increased from 5,052,797 in 2013 to 5,337,773 in 2023, while total deaths from all causes ranged from 27,816 to 44,769, with CDR peaks in 2020 (6.06 per 1,000) and 2021 (6.52 per 1,000) [Table-1]. As illustrated in Figure-1, both the absolute number of traffic accident deaths and the mortality rate per 100,000 population showed a consistent declining trend over the study period, with notable fluctuations in 2015 and a sharp decline from 2018 onwards.
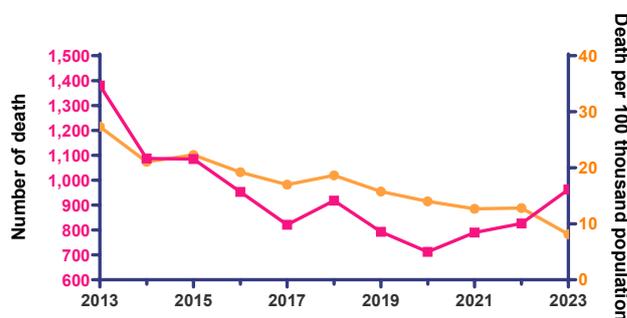

Figure-1. Temporal trends of number of deaths and mortality rate per 100,000 population from traffic accidents (2013–2023) [Note: The figure shows two trend lines - a solid line representing the absolute number of deaths (left y-axis) and a dashed line representing the mortality rate per 100,000 population (right y-axis). The solid line uses circular markers (●) for death numbers, while square markers (■) are used for mortality rates.]

Table-1. Mortality statistics (2013-2023)

Year	Total population	All deaths	Number of deaths due to accident	Crude death rate (per 1,000)	Proportional mortality rate (%)	Cause-specific mortality rate (per 100,000)
2013	5,052,797	27,816	1,380	5.51	4.96	27.31
2014	5,157,784	28,361	1,087	5.50	3.83	21.07
2015	4,864,499	29,103	1,085	5.98	3.73	22.30
2016	4,960,830	29,313	953	5.91	3.25	19.21
2017	4,835,845	31,754	821	6.57	2.59	16.98
2018	4,920,302	30,273	918	6.15	3.03	18.66
2019	5,027,668	31,722	793	6.31	2.50	15.77
2020	5,085,290	41,047	712	8.07	1.73	14.00
2021	5,132,208	44,769	790	8.72	1.76	15.39
2022	5,132,208	32,933	726	6.42	2.20	14.15
2023	5,337,773	32,455	963	6.08	2.97	18.04

As shown in Table-2, The 15–24 age group had the highest number of deaths annually, with 112 deaths in the 15–19 age group and 116 in the 20–24 age group in 2023. Deaths among children <5 years decreased from 67 in 2013 to 34 in 2023. The total number of deaths across all age groups declined from 1,380 in 2013 to 963 in 2023.

Table-2. Number of deaths by age groups during 2013-2023

Age Group						Year						
Years	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Under 5	67	67	61	52	43	43	46	26	27	20	34	486
5-9	34	34	30	35	29	21	22	20	19	15	26	285
10-14	30	28	16	16	23	31	23	16	22	25	18	248
15-19	88	79	65	75	67	68	56	59	78	106	112	853
20-24	118	95	106	71	65	88	73	67	84	102	116	985
25-29	149	86	89	82	87	82	54	54	61	61	69	874
30-34	92	81	92	64	68	80	69	57	67	66	65	801
35-39	73	72	69	66	47	52	63	61	60	64	63	690
40-44	77	65	70	65	46	52	50	48	69	58	70	670
45-49	75	44	50	48	35	59	53	46	47	56	58	571
50-54	79	73	70	48	43	49	56	40	39	43	53	593
55-59	102	51	57	63	60	72	51	46	38	32	47	619
60-64	63	59	55	62	48	60	47	42	49	43	70	598
65-69	63	52	45	38	39	42	29	38	43	39	54	482
70-74	76	67	67	58	29	25	31	24	25	31	39	472
75-79	85	63	40	40	38	45	25	29	37	22	36	460
80-85	14	11	21	9	4	8	5	6	2	2	3	85
85+	109	71	103	70	54	49	45	39	25	43	33	641
Total	1,380	1,087	1,085	953	821	918	793	712	790	826	963	10308

Table-3 presents the age-specific mortality rates per 100,000 population. The 75–79 age group had the highest age-specific mortality rate (ASMR) in 2013 (147.42 per 100,000), declining to 22.22 per 100,000 in 2023. Elderly age groups consistently demonstrated the highest mortality rates throughout the study period, while younger age groups showed substantial reductions in ASMR over time.

Table-3. Age-specific mortality rate (per 100,000 population) during 2013-2023

Age Group						Year						
Years	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Under 5	13.83	13.27	12.39	10.21	8.88	7.81	8.34	4.84	6.53	5.19	2.71	8.55
5-9	9.72	9.29	8.51	9.81	8.68	5.83	4.46	4.88	3.61	2.74	1.53	6.28
10-14	7.28	6.54	3.94	4.98	6.56	8.46	5.92	3.89	5.37	5.82	1.26	5.46
15-19	20.03	1.71	15.85	18.93	19.88	20.19	16.43	16.88	20.57	26.75	9.55	16.98
20-24	21.54	14.47	20.89	12.13	17.13	20.76	21.26	19.85	20.20	24.17	11.35	18.52
25-29	21.32	14.79	16.14	14.63	17.27	17.19	11.98	12.82	11.25	11.68	6.49	14.14
30-34	19.96	17.24	20.20	13.24	12.65	14.76	12.67	10.52	9.14	9.39	4.67	13.13
35-39	20.54	19.56	19.18	17.42	10.91	11.54	13.16	12.16	8.27	8.44	3.83	13.18
40-44	25.53	21.00	23.59	21.14	14.72	16.39	14.26	12.80	12.21	9.49	4.92	16.00
45-49	30.58	17.44	20.91	19.18	13.36	22.07	19.24	16.35	12.11	13.29	5.60	17.28
50-54	35.76	32.23	33.60	22.73	20.55	23.22	25.34	17.45	12.19	12.74	6.50	22.03
55-59	62.40	30.22	36.16	38.35	32.35	38.43	26.88	24.00	15.01	11.70	7.23	29.34
60-64	58.83	53.46	53.38	55.32	35.19	42.36	31.47	27.24	23.01	17.93	12.47	37.33
65-69	72.42	59.88	58.48	50.24	44.84	44.52	28.17	36.13	38.17	24.37	12.85	42.73
70-74	110.37	94.86	102.93	89.26	42.88	37.46	46.86	38.85	32.72	33.71	14.59	58.59
75-79	147.42	109.99	78.69	82.87	80.23	92.96	47.35	55.09	61.35	34.99	22.22	74.83
80-84	61.33	46.54	1.003	42.61	14.59	26.63	15.01	2066	4.87	4.57	2.53	30.88
85+	22.510	300.42	21.271	331.45	196.97	163.14	135.11	119.85	105.44	164.14	45.19	181.77
Total	27.311	21.074	22.304	19.210	16.97	18.65	15.77	14.00	12.69	12.81	8.15	17.18

Table-4 shows the absolute number of deaths by type of traffic accident. Pedestrian accidents were the leading cause of death, with 368 deaths in 2015 and 277 in 2023. Bicycle-related deaths increased from 56 in 2013 to 224 in 2023. Light vehicle accident deaths rose from 65 in 2013 to 285 in 2023. Motorcycle accidents accounted for 5 deaths in 2023, and heavy vehicle accidents for 6 deaths. Miscellaneous accident deaths decreased from 971 in 2013 to 47 in 2023. The total annual deaths from all accident types decreased from 1,380 in 2013 to 963 in 2023.

Table-4. Number of deaths by type of traffic accident in Khorasan Razavi province (2013–2023)

Main Groups of Causes-of-Death	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Pedestrian accidents	264	215	368	262	248	296	276	257	247	223	277	2933
Motor vehicle accidents(cars, trucks)	4	5	19	13	18	13	13	6	16	5	11	123
Bicycle accidents	56	49	60	59	177	172	137	169	195	183	224	1481
Motorcycle accidents	1	4	5	4	1	7	9	15	13	6	5	70
Accidents involving cars and light vehicles	65	231	82	102	214	250	218	177	200	271	285	2095
Accidents involving heavy vehicles	5	9	2	2	6	14	9	6	12	9	6	80
Accidents involving public transport	2	4	1	1	11	5	9	8	13	7	13	74
Water-related accident	2	0	0	3	3	3	3	1	8	5	2	30
Accidents involving aircraft	10	25	8	16	43	34	7	28	58	83	93	405
Miscellaneous accidents	971	545	540	491	100	124	112	45	28	34	47	3037

The corresponding mortality rates per 100,000 population for each accident type are presented in Table-5. Pedestrian accidents maintained the highest cause-specific mortality rate (CSMR: 4.45 per 100,000 in 2023). Bicycle-related deaths showed a CSMR of 3.59 per 100,000 in 2023. Light vehicle accidents had a CSMR of 4.57 per 100,000 in 2023. Motorcycle accidents showed a CSMR of 0.08 per 100,000, and heavy vehicle accidents showed a CSMR of 0.09 per 100,000. Miscellaneous accident deaths decreased to a CSMR of 0.75 per 100,000 in 2023.

Table-5. Cause-specific mortality rate per 100,000 population by type of traffic accident in Khorasan Razavi province (2013–2023)

Main Groups of Causes-of-Death	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Average
Pedestrian accidents	5.22	4.16	7.56	5.38	4.99	6.12	5.60	5.11	4.85	3.58	4.45	5.18
Motor vehicle accidents (cars, trucks)	0.079	0.096	2.36	0.26	0.36	0.26	0.26	0.11	0.31	0.08	0.17	0.39
Bicycle accidents	1.10	0.95	7.45	1.21	3.56	3.55	2.78	3.36	3.83	2.94	3.59	3.12
Motorcycle accidents	0.019	0.077	0.62	0.08	0.02	0.14	0.18	0.29	0.25	0.09	0.08	0.17
Accidents involving cars and light vehicles	1.28	4.47	10.18	2.09	4.31	5.16	4.43	3.52	3.93	4.35	4.57	4.39
Accident involving heavy vehicles	0.098	0.17	0.24	0.04	0.12	0.28	0.18	0.11	0.23	0.14	0.09	0.15
Accidents involving public transport	0.039	0.077	0.12	0.02	0.22	0.10	0.18	0.15	0.25	0.11	0.20	0.13
Water-related accident	0.039	0	0	0.06	0.06	0.06	0.06	0.01	0.15	0.08	0.03	0.05
Accidents involving aircraft	0.19	0.48	0.99	0.32	0.86	0.70	0.14	0.55	1.14	1.36	1.49	0.75
Miscellaneous accidents	19.21	10.56	11.10	10.0	2.01	2.56	2.27	0.89	0.55	0.54	0.75	5.50

YPLL per 100,000 population ranged from 463 in 2020 to 880 in 2013. In 2023, YPLL was 516 per 100,000 overalls, with 821 per 100,000 for males and 206 per 100,000 for females [Table-6].

Table-6. Years of potential life lost (YPLL) per 100,000 population by sex in Khorasan Razavi Province (2013–2023)

Year	YPLL per 100,000	Male YPLL per 100,000	Female YPLL per 100,000
2013	880.81	1,354.00	401.14
2014	714.08	1,037.00	386.24
2015	746.61	1,150.00	333.76
2016	655.39	955.95	346.85
2017	606.14	974.42	256.61
2018	667.86	1,008.00	319.52
2019	577.84	894.58	255.11
2020	463.23	770.54	151.09
2021	527.28	850.01	199.96
2022	588.17	937.82	234.26
2023	681.72	1,088.00	271.43

Discussion

This 11-year epidemiological assessment of road traffic-related mortality in Khorasan Razavi Province revealed substantial reductions in both the absolute number of deaths and in crude mortality rates from 2013 to 2023. These findings align with national patterns observed in Iran, where mortality from road traffic accidents has generally declined over the past decade due to stricter traffic law enforcement, expansion of speed control measures, public awareness campaigns, and improvements in emergency medical services.[9,11] Comparable declines have been reported in other countries implementing multi-sectoral road safety interventions, including Poland and Brazil.[10,12] However, despite these improvements, the burden of RTIs in the province remains high, particularly among specific vulnerable groups.

Young adults aged 15–24 years consistently accounted for the highest number of deaths, which is consistent with both national and international literature identifying youth as a high-risk group.[4,10,13] Several factors contribute to this pattern, including limited driving experience, higher engagement in risky behaviors such as speeding or distracted driving, and greater daily exposure to road traffic due to education, employment, and social activities.[1,6,14] The persistently high YPLL in this group underscores the long-term societal and economic implications of these premature deaths. Similar age-specific burdens have been reported in Ethiopia, Brazil, and global analyses by WHO.[1,4,10]

While mortality among children under 10 years declined over the study period, possibly reflecting greater compliance with child restraint laws and improvements in urban safety measures,[11] elderly individuals (≥70 years) continued to show elevated age-specific mortality rates. This finding mirrors studies from Iran and other countries, where reduced physical resilience and increased frailty in older adults contribute to higher post-crash mortality.[4,12] Targeted infrastructure adaptations, such as better pedestrian crossings, improved lighting, and traffic calming near residential areas, could help reduce these risks.[15]

Pedestrians remained the most common victims of fatal RTIs in the province, a pattern consistent with prior studies in Iran, including earlier work in Khorasan Razavi,[15] and in LMICs generally.[1,3] Persistently high pedestrian mortality indicates ongoing infrastructure and enforcement challenges, such as inadequate crosswalk design, insufficient driver yielding, and poor nighttime visibility.[8] Notably, this study found a sharp and sustained increase in bicycle-related deaths, rising by nearly fourfold over the study period. This mirrors global trends where the popularity of cycling -often promoted for environmental and congestion-reduction benefits- has not been accompanied by parallel improvements in cyclist safety infrastructure, helmet use, or public awareness.[5,14] The increase in fatalities involving light vehicles also warrants further investigation, potentially reflecting higher vehicle ownership rates or changes in traffic patterns.

The observed decline in YPLL over time indicates progress in reducing premature mortality; however, the persistently high male-to-female YPLL ratio highlights ongoing gender disparities in exposure and risk behaviors.[5,6] The magnitude of YPLL in this study, though lower than some national-level estimates, is consistent with findings from other Iranian provinces when methodological differences (e.g., reference age, age standardization) are considered.[9,11]

Conclusions

Overall, these results reinforce the need for comprehensive, multi-sectoral interventions tailored to vulnerable groups. Such measures should include targeted behavioral programs for young drivers, expansion of safe cycling and pedestrian infrastructure, stricter enforcement of speed and helmet laws, and age-sensitive safety measures for elderly road users. Sustained progress will require coordinated actions among health, transportation, law enforcement, and urban planning sectors, along with continuous epidemiological monitoring to guide policy adjustments.

University of Medical Sciences for providing access to the mortality registry data used in this study.

Abbreviations

RTIs: Road Traffic Injuries; CMR: Crude Mortality Rate; ASMR: Age-Specific Mortality Rate; PMR: Proportional Mortality Rate; CSMR: Cause-Specific Mortality Rate; YPLL: Years of Potential Life Lost; ICD-10: International Classification of Diseases, 10th Edition; MUMS: Mashhad University of Medical Sciences.

Authors' contributions

All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

Availability of data and materials

The data used in this study are available from the corresponding author on request.

Ethics approval and consent to participate

The study was approved by the Ethics Committee of Mashhad University of Medical Sciences (Approval code: IR.MUMS.FHMPM.REC.1404.032). The dataset used in this study contained no names or personal identifiers; all records were fully anonymized prior to analysis to ensure participant confidentiality. All procedures performed in the study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments.

Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

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