Title: Estimation of the Burden of Road Traffic Accidents in Mazandaran Province Using YLL Index in 2023

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Abstract

Background: Road traffic accidents (RTAs) impose a substantial health and economic burden globally, particularly in low- and middle-income countries. Given the recent resurgence of RTA-related mortality in Iran, accurate local-level monitoring is essential for effective health policy. This study aimed to estimate the burden of RTA-related premature mortality in Mazandaran province using the Years of Life Lost (YLL) index in 2023.

Methods: This population-based, retrospective cross-sectional study utilized mortality data from the Mazandaran Forensic Medicine Organization and the Mazandaran University of Medical Sciences registries. YLL was calculated by multiplying the number of deaths at each age by the standard life expectancy at that age, based on GBD methodology, without age-weighting or time discounting. Data were stratified by age and gender to identify high-risk populations.

Results: A total of 506 fatal RTAs were recorded, with a mean victim age of 43.2 years. Males accounted for 83.4% of fatalities, yielding a 5:1 male-to-female ratio. The total YLL burden was 22,050 years, corresponding to a standardized rate of 668 per 100,000 population. The 15–29 age group contributed the largest share of the burden (36.9%), while the male-specific YLL rate (1,114 per 100,000) was five times higher than the female rate.

Conclusion: RTAs in Mazandaran represent a critical crisis, disproportionately affecting young males. The substantial loss of human capital in productive age groups necessitates an immediate shift toward evidence-based preventive interventions, specifically prioritizing the physical segregation of motorcycle lanes and stricter enforcement of safety regulations to mitigate this preventable public health burden.

Keywords: Accidents, Traffic, Premature Mortality, Years of Potential Life Lost, Public Health, Epidemiology

Introduction

Road traffic accidents are recognized as one of the most important public health challenges in the world and account for a significant share of mortality and disability in low- and middle-income countries (1). Regional systematic reviews show that the burden of these accidents in the Eastern Mediterranean and South Asian region is higher than in many developed regions and the trend remains worrying (2, 3) Studies conducted in developing countries such as India, Ethiopia and Kenya also indicate a gradual increase in human and economic losses caused by road accidents (4-6)

In Iran, traffic accidents are also considered one of the most important causes of premature death and disability, and despite some improvements in recent decades, they have still imposed a significant burden on the health system (7). The national survey of the burden of transport injuries has shown that the pattern of incidence and consequences of these accidents is heterogeneous in different provinces of the country, with some provinces experiencing a higher burden (8). Comparative provincial studies have also reported significant differences in the incidence of injuries between provinces, indicating the role of environmental, demographic and infrastructure factors (9). On the other hand, the analysis of the years of useful life lost in Iran shows that road accidents have a higher share in the loss of years of life in some provinces, including the heavily trafficked northern provinces (10).

To assess the consequences of these accidents, the Years of Life Lost (YLL) index is used to quantify the burden of premature mortality caused by road traffic accidents. This indicator measures the number of potential years of life lost due to deaths occurring before the expected lifespan and enables comparison of premature mortality burden across geographical areas and time periods. Because many road traffic accident victims die during their productive years, YLL provides an important measure of the impact of traffic-related premature deaths and supports evidence-based prioritization of prevention strategies.

Several factors contribute to the severity and occurrence of accidents, including individual characteristics, road conditions, vehicle, and social environment (12). Reviews have also pointed to the role of road pavement condition, speed, alcohol or drug use, and human error in increasing risk (13, 14). A similar pattern of risk factors has been reported in West Asia countries, including Saudi Arabia, indicating the multidimensional nature of this phenomenon (15).

Given the recent resurgence of traffic accident mortality in Iran, the need for accurate monitoring of the burden of disease at local levels is increasingly felt (16). Mazandaran province has been reported as a higher-risk area in national studies due to tourist traffic, road congestion, and climatic characteristics, and its specific study can provide valuable information for policymaking (8). Therefore, estimating the burden of traffic accidents using the YLL index in this province can help identify prevention priorities, allocate resources, and design targeted interventions (7). Therefore, the present study was conducted with the aim of estimating the burden of traffic accidents in Mazandaran province in 2023 based on the YLL index to provide a comprehensive picture of the consequences of death and disability caused by accidents and to provide a basis for health policy making.

Materials and Methods

Study Design and Setting

This cross-sectional, population-based study was conducted retrospectively using data from Mazandaran Province, Iran, for the calendar year 2023. Mazandaran Province, located in northern Iran along the Caspian Sea, serves as a major transit corridor and tourist destination, with a population of approximately 3.3 million. The province's challenging mountainous terrain and high seasonal tourism volumes create elevated RTA risk conditions.

Data Sources

Mortality Data:

Comprehensive mortality data for RTA-related total deaths were obtained from the Mazandaran Forensic Medicine Organization website and accident regidtry data of Mazandaran University of Medical Sciences.

Tourist Population Considerations:

Given Mazandaran's significant tourism industry, both resident and non-resident RTA victims were included in the analysis to capture the complete burden on provincial healthcare systems and emergency services.

Variable Definitions

Years of Life Lost (YLL):

YLL were calculated as the number of deaths at each age multiplied by the standard life expectancy for that age, using Iranian national life expectancy tables of 77.65 years in 2023 (referenced from official World Bank sources and Iranian health statistics). The formula used was: YLL = Number of deaths × (Standard life expectancy – Age at death).

Data Collection and Statistical Analysis

RTA-related fatalities were identified via forensic and hospital records. Cases with incomplete demographic or clinical data (representing <5% of the total sample) were excluded to maintain data integrity; no imputation methods were employed.

Descriptive statistics were used to summarize demographic characteristics. Data were stratified by gender and standardized age groups (0–14, 15–29, 30–44, 45–59, and 60+ years) to identify high-risk populations. All analyses were conducted using Epi Info™ version 7.2.

The study protocol was approved by the Institutional Review Board of Mazandaran University of Medical Sciences, and all data processing adhered to established guidelines for the protection of human participants.

The project was found to be in accordance to the ethical principles and the national norms and standards for conducting Medical Research in Iran and approved by Research Ethics Committees of Education, Research and Technology Division of Iranian Red Crescent Society (Ethics code: IR.RCS.REC.1403.057, 2024-09-23)

Results

A total of 506 fatal road traffic accidents (RTAs) were recorded in Mazandaran province in 2023. The mean age of the victims was 43.2 ± 21.8 years (range: 1–94). (Table 1)

Table 1: Sociodemographic Characteristics of RTA Fatalities (Mazandaran, 2023)

Characteristic	**N (%) / Mean (SD)**
Total Fatalities	506 (100%)
Mean Age (SD)	43.2 (21.8)
Age Range (Min–Max)	1–94
Gender: Male	422 (83.4%)
Gender: Female	84 (16.6%)

Males constituted the majority of fatalities (n=422, 83.4%), resulting in a male-to-female ratio of 5:1. Regarding age distribution, the highest absolute frequency of deaths was observed in the ≥60 years age group (n=132, 26.1%), followed by the 15-29 years group (n=128, 25.3%).(Table 2)

Table 2: Distribution of Fatalities and YLL by Age Group

Age Group	**Fatalities (N)**	**Fatalities (%)**	**YLL (Absolute)**	**YLL Contribution (%)**
0–14	37	7.3	2,960	13.4
15–29	128	25.3	8,140	36.9
30–44	101	20.0	5,010	22.7
45–59	108	21.3	3,810	17.3
60+	132	26.1	2,130	9.7
Total	**506**	**100**	**22,050**	**100**

Based on the standard GBD methodology (YLL = N \times L), the total burden of premature mortality was estimated at 22,050 YLLs. (Table 3)

Table 3: Standardized YLL Indicators (Per Population)

Indicator	Value
Total YLL	22,050
YLL Rate per 1,000 population	6.68
YLL Rate per 100,000 population	668

The age-specific analysis revealed that the 15-29 years age group contributed most significantly to this burden, generating 8,140 YLLs (36.9% of the total). In contrast, the ≥60 years group, despite having the highest number of deaths, accounted for only 9.7% of the total YLL (2,130 years). Gender-disaggregated analysis showed that males bore the vast majority of the burden (18,380 YLLs, 83.3%) compared to females (3,670 YLLs, 16.7%). Assuming a provincial population of 3.3 million, the standardized YLL rate was 668 per 100,000 population. The male-specific rate (1,114 per 100,000) was approximately five times higher than the female rate (222 per 100,000), identifying young adult males as the most high-risk demographic for RTA-related premature mortality.(Table 4)

Table 4: Gender-Disaggregated YLL Burden

Gender	YLL (Absolute)	Proportion (%)	Rate per 100,000
Male	18,380	83.3	1,114
Female	3,670	16.7	222

Analytical Summary of Findings

- **Premature Mortality Burden:** The study calculated a total of 22,050 YLLs, indicating a significant loss of potential human capital within Mazandaran province.
- **The Age Paradox:** Although the elderly population (≥60 years) contributed the highest absolute number of deaths, the 15–29 age group accounted for the largest share of the YLL burden (36.9%), reflecting high vulnerability among young adults.
- **Gender Disparity:** A pronounced gender gap was observed, with males contributing 83.3% of the total YLL, resulting in a YLL rate approximately five times higher than that of females (1,114 vs. 222 per 100,000).
- **Standardized Burden:** The standardized YLL rate of 668 per 100,000 population positions Mazandaran as a high-risk region for traffic-related premature mortality, necessitating urgent evidence-based interventions.

Discussion

This study quantifies a substantial premature mortality burden from road traffic accidents (RTAs) in Mazandaran Province, yielding 22,050 Years of Life Lost (YLL) and a standardized rate of 668 per 100,000 population in 2023. These findings reveal a persistent public health crisis that severely undermines regional human capital and sustainable development, demanding an urgent, multispectral emergency response. The observed YLL

rate far exceeds the global age-standardized road injury YLL rate of 446.5 per 100,000 reported by the Global Burden of Disease Study 2021, signaling a disproportionate local risk that cannot be explained by population structure alone (17). Given Mazandaran's role as a major transit corridor and tourism hub, intense seasonal traffic surges likely overwhelm both road infrastructure and trauma care capacity, amplifying mortality (8). Consequently, these findings should trigger a re-evaluation of provincial road safety governance as a health emergency priority.

A pivotal epidemiological insight is the "age paradox": while individuals aged ≥60 years accounted for the highest absolute number of deaths (26.1%), the 15–29 age group contributed the largest share of total YLL (36.9%). This highlights a catastrophic loss of life among economically productive young adults, a trend consistent with national burden studies and recent meta-analyses (7). The pronounced 5:1 male-to-female YLL ratio further mirrors Iranian national patterns, reflecting differential behavioral exposures such as elevated motorcycle ridership among young males (9). This gender-age interaction identifies young male riders as the primary risk group, for whom targeted enforcement and environmental modifications could yield the greatest survival gains. The standardized burden of 668 per 100,000 positions Mazandaran among the highest-risk provinces in Iran, corroborating recent warnings of a resurgence in RTA mortality and underscoring the failure of current passive safety strategies (16).

This analysis is subject to limitations. Reliance on forensic and hospital registries may lead to under-ascertainment of non-hospital deaths, and the exclusion of cases with incomplete records (<5%) introduces potential selection bias, although its impact is likely minor. Moreover, data from Babul University of Medical Sciences were unavailable, so the true provincial YLL is almost certainly higher than reported. Importantly, the study did not estimate Years Lived with Disability (YLD), meaning the full disability-adjusted life year (DALY) toll of RTAs—incorporating long-term physical and psychological sequelae—remains unmeasured, reinforcing that the total health loss is substantially greater than the mortality-only YLL estimate (11). The use of national life expectancy without age-weighting aligns with current GBD methodology, facilitating international comparisons but limiting the capture of within-province sociodemographic heterogeneity. Strengths include complete enumeration of medically certified RTA deaths and the application of a standardized YLL metric that permits direct benchmarking against global and national figures.

Study Limitations

The principal limitations of this study stem from its reliance on secondary registry data. Potential documentation gaps and the absence of data from Babol University of Medical Sciences likely yield an underestimate of the true provincial burden. Furthermore, the exclusive focus on fatal outcomes omits the substantial disability component of RTA-related DALYs, limiting a full picture of population health impact. Nevertheless, the extensive coverage of the Mazandaran University of Medical Sciences registries ensures robust internal validity for sub-provincial targeting of interventions.

Conclusion

This study establishes a baseline YLL rate of 668 per 100,000 for RTAs in Mazandaran and unequivocally identifies young male motorcyclists as the demographic in greatest need of urgent, evidence-based intervention. The catastrophic loss of life within the 15–29 age bracket represents a direct threat to the province's economic productivity and long-term development. To avert further preventable mortality, provincial emergency and transport authorities must transition from reactive surveillance to proactive structural measures, most critically the physical segregation of motorcycle lanes in high-incidence corridors—an intervention supported by meta-analytic evidence of significant crash reduction coupled with intensified enforcement of helmet and speed regulations (18). Embedding such strategies within a multispectral road safety emergency plan is essential to safeguard Mazandaran's human capital and to reverse the recent alarming upward trajectory of traffic-related premature death.

Ethical Considerations

This study received approval from the Research Ethics Committee of the Iranian Red Crescent Society, Deputy of Education, Research and Technology (Ethics Code: IR.RCS.REC.1403.057). All data were anonymized prior to analysis, and informed consent requirements were waived for retrospective mortality data collection in accordance with institutional guidelines. The research was conducted in full compliance with the ethical standards outlined in the Declaration of Helsinki.

Consent for Publication

Not applicable.

Availability of Data and Materials

All data generated and analyzed during this study are included in this published article. Additional datasets used during the current study are available from the corresponding author upon reasonable request, subject to ethical approval and data sharing agreements.

Competing Interests

The authors declare no conflicts of interest related to this study.

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Author Contributions

RH conceived and designed the study, led the development of the research methodology, and supervised data analysis. PK, TD, and HB supervised data collection procedures and

contributed to analytical methodology. FG and MJM interpreted results and contributed to manuscript preparation. All authors participated in drafting and critically revising the manuscript for important intellectual content and approved the final version for submission.

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