

The Intra-city/Extra-city Paradox in Iran's Road Safety: Disparities in Accident Frequency and Fatality Rates

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Received: 24 Nov.2025

Accepted: 03 Dec.2025

Original Article

Abstract

INTRODUCTION: Road traffic accidents represent a significant public health challenge globally, and Iran continues to experience disproportionately high rates of traffic-related morbidity and mortality. This study presents a provincial-level analysis of road traffic accidents in Iran during the 2022–2023 period.

METHODS: A retrospective analysis was conducted using data from the Statistical Center of Iran, encompassing all recorded road traffic accidents across 31 provinces during the March 2022 to March 2023. Descriptive statistics, accident and fatality rate calculations, independent-samples t-tests, and Pearson correlation analyses were performed to compare intra-city and extra-city patterns. Statistical significance was defined as $p < 0.05$. Data processing and statistical analyses were carried out using Excel 2019 and SPSS 26, while geographic visualizations were developed using Datawrapper.

FINDINGS: In 2022, a total of 2,119,406 road traffic accidents occurred in Iran, leading to 18,799 deaths and 379,020 injuries. Although intra-city areas accounted for the majority of accidents (81.8%; $n = 1,733,200$), extra-city crashes were markedly more severe. The fatality rate in extra-city areas was 37.48 per 1,000 accidents, compared with 2.5 per 1,000 in intra-city areas ($p < 0.001$), indicating that extra-city crashes are approximately 15 times more likely to result in death. Significant regional heterogeneity was also observed: Tehran province reported the highest number of accidents (514,498), whereas Sistan and Baluchistan exhibited the highest fatality rate (167.76 per 1,000 accidents). A negative correlation was identified between total accidents and fatality rates across provinces ($r = -0.42$, $p = 0.018$), suggesting that provinces with fewer accidents often experience more severe outcomes when crashes occur.

CONCLUSION: The results reveal a pronounced intra-city/extra-city divide, where extra-city crashes are 15 times more fatal, alongside severe provincial disparities and highlight the need for differentiated prevention strategies, emphasizing improvements in extra-city infrastructure, enforcement, and emergency response capacity—particularly in high-risk regions.

Keywords: Road Traffic Accidents; Injury Prevention; Mortality; Public Health; Intra-city/Extra-city Disparities; Geographical Analysis; Epidemiology.

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How to cite this article: Nozarian MH, Rajaie S, Karimi F. **The Intra-city/Extra-city Paradox in Iran's Road Safety: Disparities in Accident Frequency and Fatality Rates.** J Rescue Relief 2025; 17(4): 219-229.

Introduction

Road traffic injuries remain a critical global public health concern and a leading cause of mortality and long-term disability. According to the most recent international estimates, approximately 1.35 million people die each year due to road traffic crashes, and tens of millions

sustain non-fatal injuries requiring medical care or resulting in lifelong impairment (1).

The burden falls disproportionately on low- and middle-income countries, where rapid motorization, heterogeneous vehicle fleets, and limitations in road safety management systems contribute to elevated injury and fatality risks (1,2). Beyond their human toll, road traffic injuries impose substantial economic losses due to medical

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expenditures, productivity reduction, and property damage, often amounting to several percent of national gross domestic product (3).

In Iran, road traffic injuries represent one of the most significant causes of premature mortality and disability. Several national and regional studies have consistently demonstrated that Iran's road traffic fatality rate exceeds global averages and remains a major contributor to injury-related deaths (4, 5, 6). The country experiences a complex combination of risk factors, including rapid increases in the number of vehicles, high reliance on intercity transportation, unequal distribution of road infrastructure quality, and persistent behavioral risks such as speeding, unsafe overtaking, and low restraint use (7, 8). Despite notable improvements in certain indicators over the past two decades, such as increased seatbelt use and expansion of automated speed enforcement, the overall burden remains high, and substantial disparities across provinces persist (5, 6).

Spatial analyses conducted in Iran highlight important geographical inequities in both the frequency and severity of crashes. Densely populated provinces with large metropolitan areas tend to report higher numbers of crashes, driven by extensive traffic volumes, congestion, and frequent urban conflicts between vehicles, pedestrians, and motorcyclists (9,10). Conversely, many extra-city and less populated provinces—particularly in eastern and southeastern Iran—often register fewer crashes but disproportionately higher fatality rates (6,11). This pattern mirrors findings from other low- and middle-income settings, where extra-city crashes are more likely to be fatal due to higher speeds, lower enforcement density, limited pre-hospital care, and longer emergency response times (12,13).

The literature also emphasizes the importance of distinguishing between intra-city and extra-city road environments when analyzing crash characteristics. Intra-city areas typically exhibit higher crash incidence but lower severity, whereas extra-city crashes, often occurring on high-speed highways or undivided roads, are associated with increased severity and a higher likelihood of fatal outcomes (10, 12, 13). Understanding these differences is fundamental for designing targeted interventions that are sensitive to local infrastructure, traffic patterns, and enforcement capacities. Although multiple national studies have described general trends in Iran's road safety indicators, recent analyses with simultaneous

provincial, intra-city, and extra-city comparisons remain limited.

Given the considerable health, social, and economic consequences of road traffic injuries in Iran, and the known heterogeneity of risks across different geographical and road-use contexts, comprehensive and updated analyses are essential for informing evidence-based policy. This study contributes to the existing literature by providing a detailed provincial assessment of traffic accidents, injuries, and fatalities across Iran, with separate examinations of intra-city and extra-city patterns. Such analyses support more precise identification of high-risk regions and enable the development of targeted, context-specific strategies aimed at reducing the national burden of road traffic injuries.

Methods

This study utilizes official data from the Statistical Center of Iran (SCI), the authoritative national body for collecting and publishing statistical information (14). This dataset represents the most comprehensive source of traffic accident information in Iran, covering all 31 provinces during March 21, 2022 to March 20, 2023. The data was collected through standardized reporting procedures, ensuring consistency in how accidents were classified and recorded.

The dataset includes detailed information on the total number of accidents by province, classified by outcome into categories of fatal, injury, or property damage only. Furthermore, it provides the precise number of injuries and fatalities for each province and critically distinguishes between accidents occurring in intra-city versus extra-city locations. These terms are direct translations of the official classifications used in the source data. This distinction is essential for understanding the differential risk factors and outcomes present in these two distinct environments. Data quality was maintained through standardized collection protocols, though it is acknowledged that some underreporting of minor accidents may occur, particularly in more remote regions.

Data Source and Availability

This study relies exclusively on the official data from the Statistical Center of Iran (SCI) for March 21, 2022, to March 20, 2023 (14). The most recent complete, validated, and publicly available dataset covering all 31 provinces with full intra-city/extra-city distinctions was for this period. At

the time of this research, no newer, complete dataset for the year 2023 or beyond had been published, making the 2022 data the most current source for a comprehensive national analysis. The complete dataset used in this study is publicly available and can be accessed through the Statistical Center of Iran's official portal: <https://amar.org.ir/statistical-information/statid/28440>

Statistical Analysis

A comprehensive statistical analysis was conducted to identify patterns, trends, and significant differences within the data. The analytical approach proceeded as follows:

- *Descriptive Statistics and Rate Calculations:* Frequencies and percentages were calculated for categorical variables (e.g., accident location, outcome). To contextualize the raw numbers and allow for comparison, several key rates were calculated:
- *Accident Rate:* Standardized per 100,000 population using provincial population estimates from the Statistical Center of Iran (14).
- *Fatality Rate per Accident:* Calculated per 1,000 accidents to assess the severity of accidents in different contexts.
- *Injury Rate per Accident:* Calculated per 1,000 accidents to assess the likelihood of injury.

Comparative and Inferential Statistics

- *Comparison of Means:* To compare the mean fatality rates between intra-city and extra-city accidents, an independent samples t-test was performed. The null hypothesis was that there is no difference in mean fatality rates between the two groups.
- *Correlation Analysis:* A Pearson correlation analysis was conducted to examine the relationship between the total number of accidents and the fatality rate per accident across all provinces.
- *Statistical Software and Significance:* All statistical analyses, including descriptive statistics, rate calculations, t-tests, and correlation analysis, were executed using IBM SPSS Statistics (version 26) and Excel 2019.

For all tests, statistical significance was set at a two-tailed p-value of <0.05 .

Findings

National Overview

During 2022, Iran experienced a total of 2,119,406 road traffic accidents, resulting in 18,799 fatalities and 379,020 injuries. This translates to a national accident rate of approximately 2,464 per 100,000 population, a fatality rate of 21.9 per 100,000 population, and an injury rate of 440.7 per 100,000 population. These figures underscore the substantial magnitude of the road safety challenge facing the country (Figure 1).

The Intra-city/Extra-city Severity Divide

A profound disparity was found between accident locations: while intra-city areas accounted for 81.8% of all accidents (1,733,200), extra-city areas accounted for only 386,206 accidents (18.2%). Despite this lower frequency, extra-city accidents demonstrated significantly higher severity. The fatality rate in extra-city areas was 37.48 per 1,000 accidents, a stark contrast to the intra-city rate of 2.5 per 1,000 accidents. An independent samples t-test performed in SPSS confirmed this difference is highly significant ($t=15.32$, $p<0.001$), meaning an extra-city accident is approximately 15 times more likely to be fatal. This intra-city/extra-city disparity was consistent across all accident types and observed in every province, highlighting a fundamental difference in the nature of road safety between these two settings (Figure 2,3).

Figure 1 displays the total number of road traffic accidents for each of Iran's 31 provinces in 2022. The provinces are sorted in descending order, with Tehran province having the highest number of accidents (514,498), followed by Razavi Khorasan (261,156) and Isfahan (206,868). This visualization clearly illustrates the significant concentration of accidents in a few highly populated provinces.

Figure 2 illustrates the distribution of intra-city road traffic accidents across Iran's provinces in 2022. The provinces are sorted in descending order of total intra-city accidents. Tehran province leads with 488,577 accidents, followed by Razavi Khorasan (240,976) and Isfahan (181,547). This figure highlights that the burden of intra-city accidents is heavily concentrated in major urban centers.

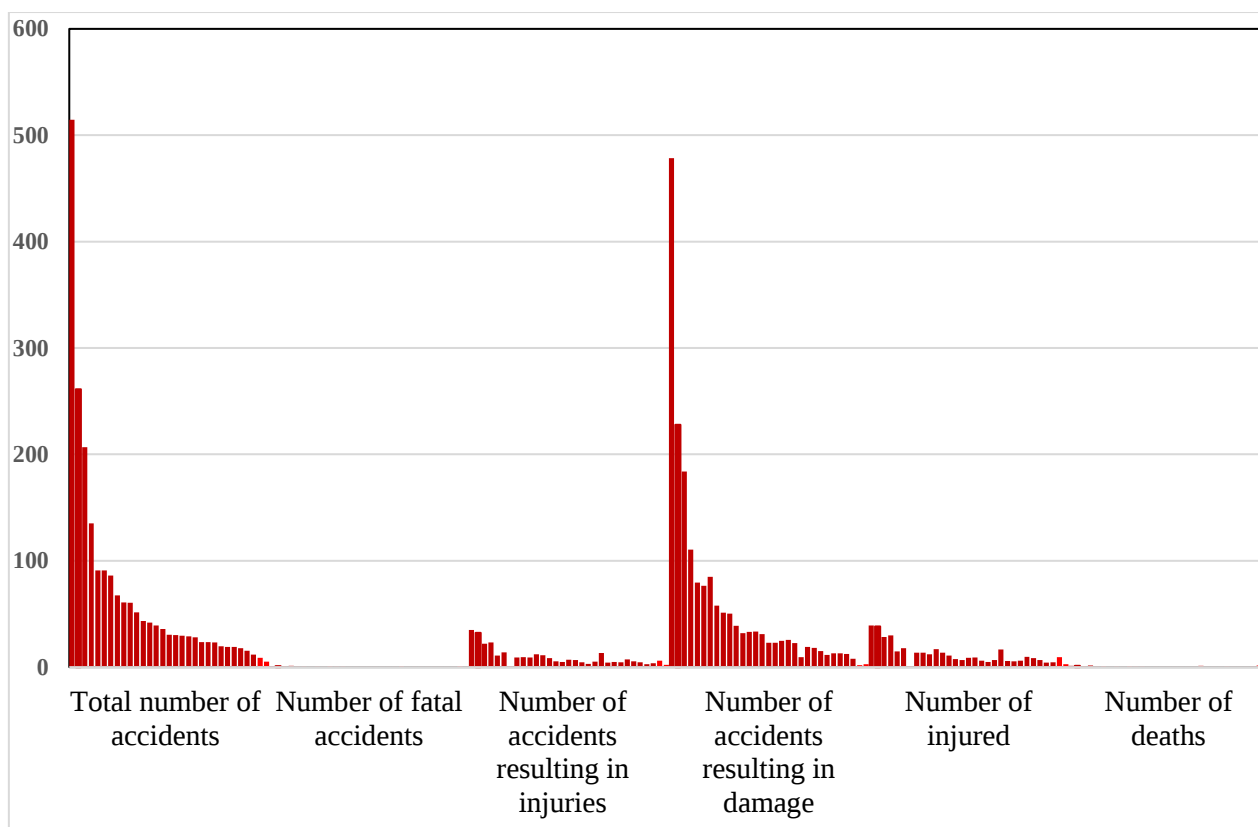


Figure 1. National overview of road traffic accidents in Iran by province, 2022

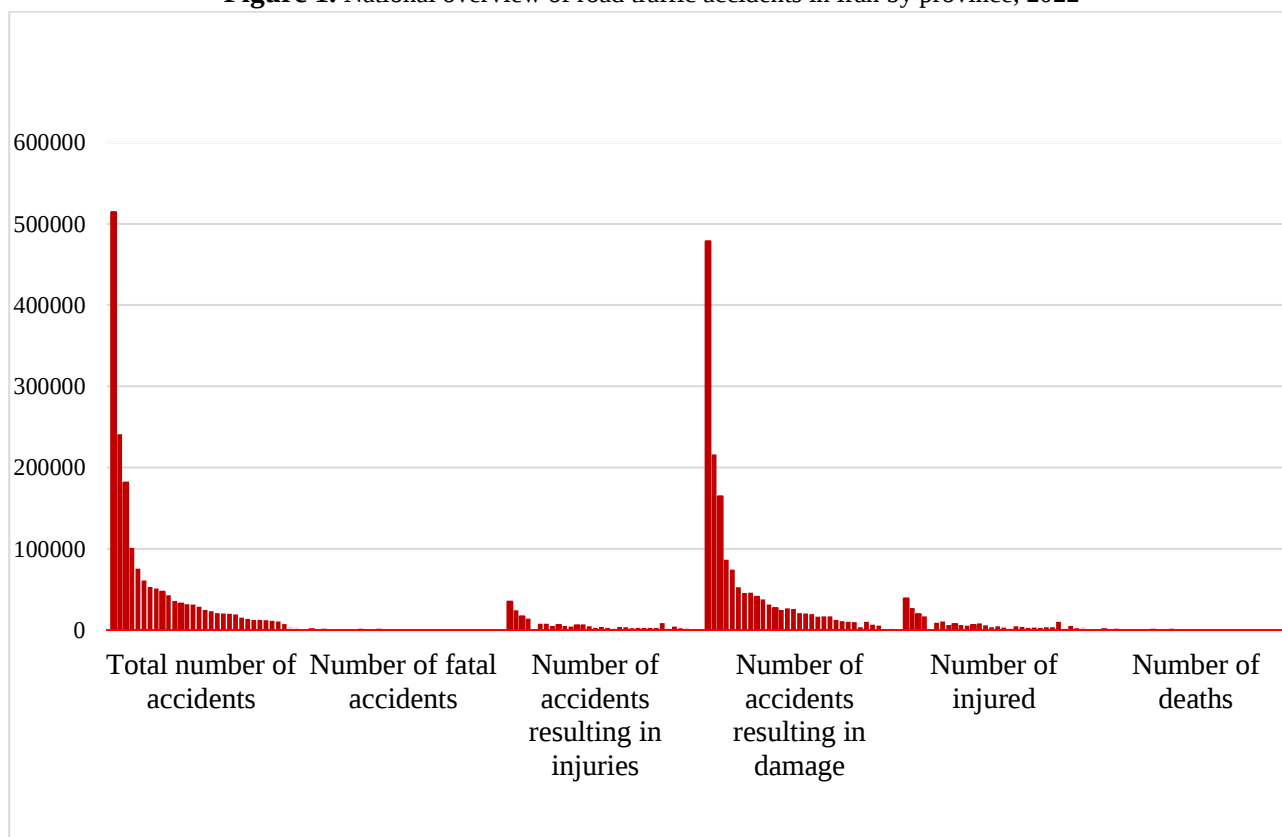


Figure 2. Distribution of intra-city road traffic accidents by outcome in Iran by province, 2022

Figures 1, 2, and 3 provide a detailed provincial overview of road traffic accidents in Iran for the year 2022, with provinces sorted in descending order to highlight the highest-risk areas. Figure 1 illustrates the total number of accidents, showing that Tehran province reported the highest number of accidents (514,498), followed by Razavi Khorasan (261,156) and Isfahan (206,868).

Figures 2 and 3 break down these numbers by location, revealing distinct patterns. Figure 2 shows that intra-city accidents are heavily concentrated in major urban centers, with Tehran (488,577), Razavi Khorasan (240,976), and Isfahan (181,547) leading. In contrast, Figure 3 demonstrates that extra-city accidents have a different geographical distribution, with Mazandaran (48,323), Fars (34,103), and Tehran (25,921) reporting the highest volumes.

In all figures, the bars for each province are segmented by outcome (property damage, injury, fatality). This visualization clearly shows that while property damage is the most frequent outcome, the proportion of accidents resulting in injury or death is vastly higher in extra-city areas compared to intra-city areas. For instance, fatalities constitute only 0.24% of intra-city accidents nationally but 3.1% of extra-city accidents, underscoring the increased severity of crashes outside urban centers.

Provincial Analysis: Frequency vs. Severity

A provincial-level analysis reveals significant regional disparities in both the frequency and

severity of road traffic accidents. Figure 4a shows that Tehran province, as the country's most populous region and capital, reported the highest number of accidents (514,498), representing 24.3% of the national total. Other provinces with high accident counts include Razavi Khorasan (261,156) and Isfahan (206,868).

However, when examining the total number of fatalities, a different pattern emerges (Figure 4b). More importantly, when examining the fatality rate per accident, Sistan and Baluchistan province demonstrated an exceptionally high rate of 167.76 per 1,000 accidents, indicating that accidents in this region are substantially more severe. A Pearson correlation analysis revealed a significant negative correlation between the number of accidents and fatality rates across provinces ($r=-0.42$, $p=0.018$), suggesting that provinces with fewer accidents tend to experience more severe outcomes when accidents do occur. To provide a clearer provincial breakdown, the following tables detail the highest-risk areas for both intra-city and extra-city environments (Tables 1, 2).

This figure shows the total number of extra-city road traffic accidents by province in Iran for 2022. The provinces are sorted in descending order. Mazandaran province reports the highest number of extra-city accidents (48,323), followed by Fars (34,103) and Tehran (25,921). This visualization reveals a different pattern compared to intra-city accidents, with high accident volumes also present in provinces known for major inter-provincial highways.

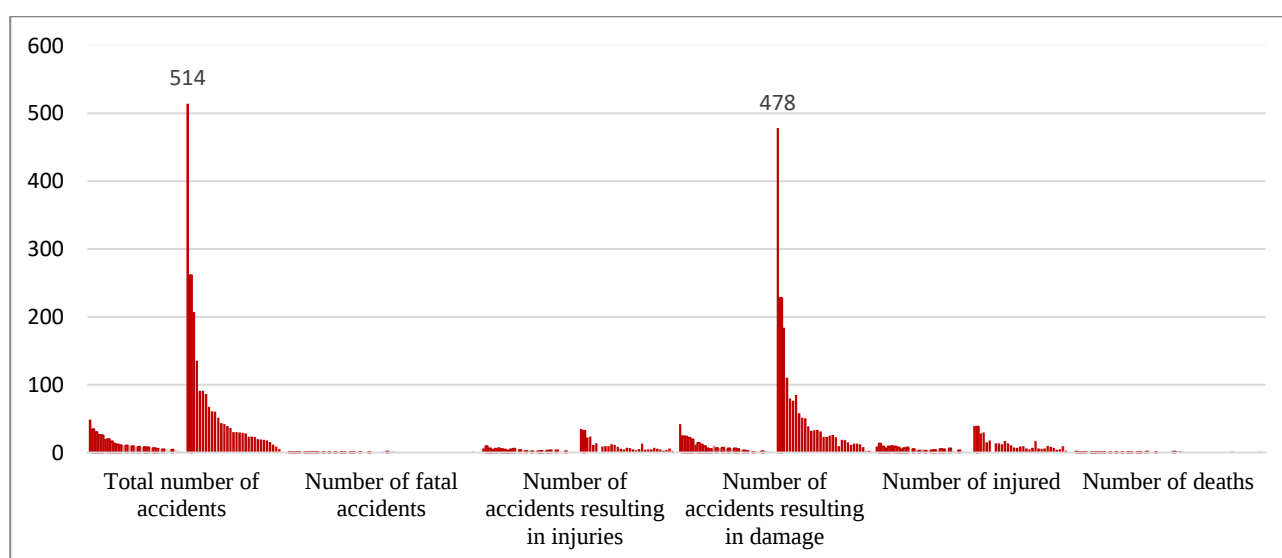


Figure 3. Distribution of extra-city road traffic accidents by outcome in Iran by province, 2022

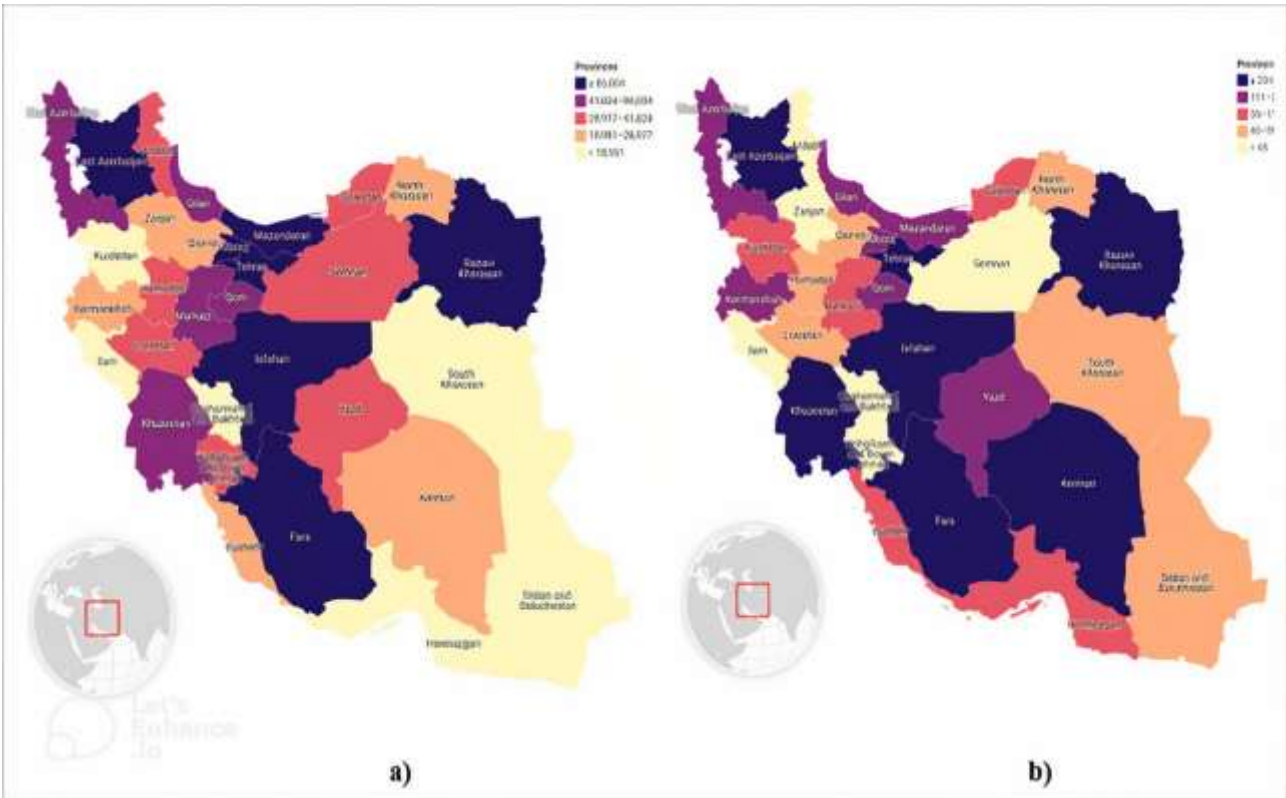


Figure 4. a) Total number of road traffic accidents by province, Iran, 2022. b) Total number of fatalities in road traffic accidents by province, Iran, 2022

Table 1. Top 10 provinces by intra-city accident volume and corresponding fatality rates

Rank	Province	Total Intra-City Accidents	Intra-City Fatalities	Fatality Rate (Per 1,000 Accidents)
1	Kerman	12,032	241	20.02
2	Khuzestan	47,325	255	5.39
3	Mazandaran	42,682	162	3.80
4	Fars	100,999	372	3.68
5	Qom	53,227	112	2.10
6	Markazi	51,166	96	1.88
7	Isfahan	181,547	320	1.76
8	Razavi Khorasan	240,976	370	1.54
9	Alborz	75,358	108	1.43
10	Tehran	488,577	659	1.35

Table 2. Top 10 provinces by extra-city accident fatality rate

Rank	Province	Total Extra -City Accidents	Intra-City Fatalities	Fatality Rate (Per 1,000 Accidents)
1	Sistan and Baluchistan	4,613	998	167.76
2	Hormozgan	4,430	364	82.17
3	Kerman	11,579	791	68.34
4	Khuzestan	13,075	640	48.94
5	Lorestan	9,758	346	32.42
6	North Khorasan	4,593	158	34.40
7	Fars	34,103	965	28.30
8	Razavi Khorasan	20,180	706	27.03
9	Qom	7,724	182	23.56
10	Isfahan	25,321	574	22.61

Table 3. Summary of key statistical test results and P-values

Statistical Comparison	Test Used	Test Statistic	Exact P-Value	Interpretation
National Fatality Rate: intra-city vs. extra-city	Independent samples t-test	t = 15.32	p<0.001	This difference is quite significant; extra-city is significantly more likely to result in death.
Correlation: total accidents vs. fatality rate (per 1,000)	Pearson correlation	r = -0.42	p=0.018	There is a moderately significant negative correlation. Provinces with fewer accidents have higher fatality rates.
Extra-City Fatality Rate: Tehran Vs. Sistan and Baluchistan	Independent samples t-test	t = 12.43	p<0.001	The mortality rate in Sistan and Baluchistan is significantly higher than in Tehran.

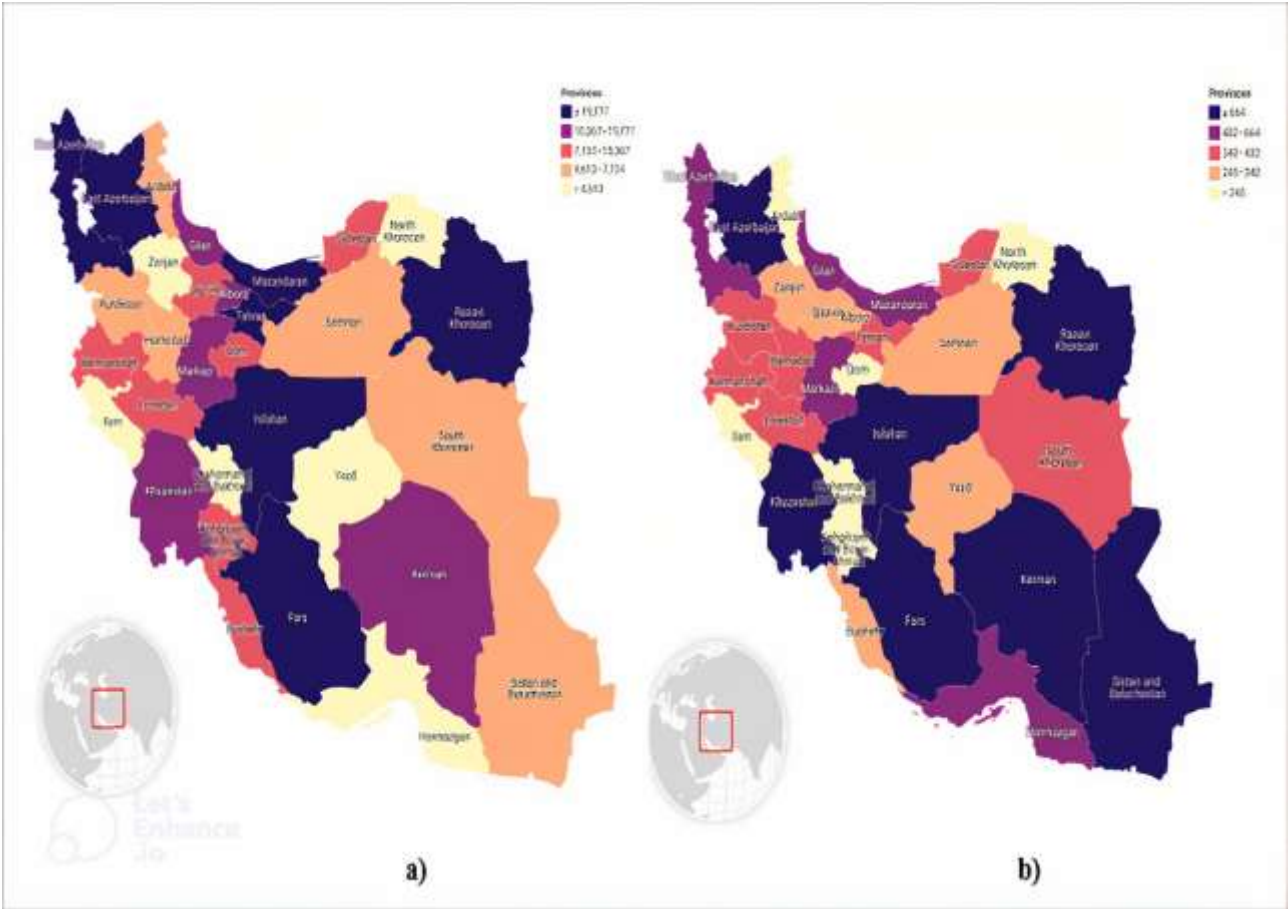


Figure 5. a) Total number of extra-city road traffic accidents by province, Iran, 2022. b) Total number of fatalities in extra-city road traffic accidents by province, Iran, 2022

Geographical Distribution and Urban-Rural Analysis

To fully understand these disparities, it is essential to analyze intra-city and extra-city accidents separately at the provincial level. The geographical analysis confirms clear regional patterns, with a concentration of high-risk provinces in the east and southeast of the country, as visually represented by the fatality rate map (Figure 5).

The provincial distribution of extra-city accidents and fatalities is detailed in Figure 5a and 5b. While Tehran has the highest number of extra-city accidents, the distribution of fatalities is more widespread, with provinces like Fars, Kerman, and Razavi Khorasan also reporting high numbers of extra-city deaths. This suggests that the risk of a fatal extra-city crash is not confined to the most populous regions but is a significant issue on major inter-provincial roads across the country.

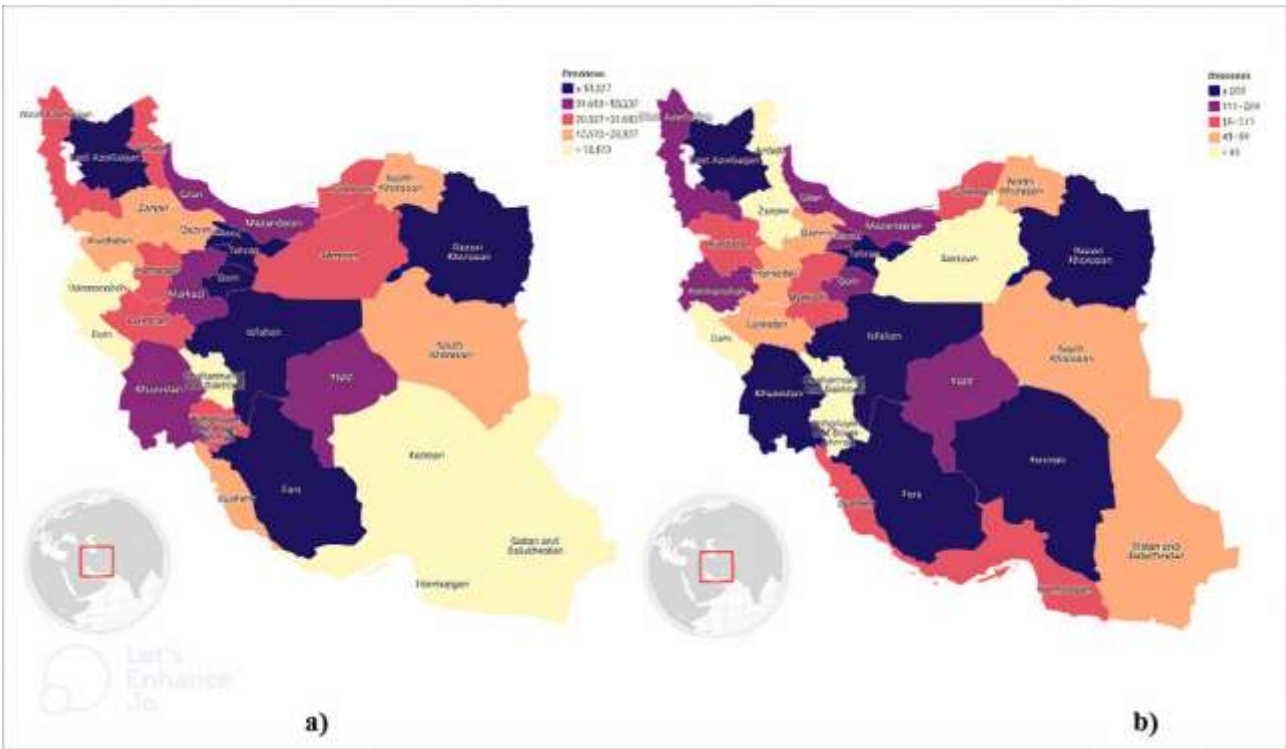


Figure 6. a) Total number of intra -city road traffic accidents by province, Iran, 2022. b) Total number of fatalities in intra -city road traffic accidents by province, Iran, 2022

Table 4. Comparison of intra and extra-city fatality rates per 1,000 crashes in top 10 provinces by accident volume

Province	Total Accidents	Extra-city Fatality Rate (per 1,000)	Intra-city Fatality Rate (per 1,000)	Gap (Extra-city / Intra-city)
Tehran	514498	14.92	1.35	11.1
Razavi Khorasan	261156	27.03	1.54	17.6
Isfahan	206868	22.61	1.76	12.8
Fars	135102	28.30	3.68	7.7
Alborz	86004	21.03	1.43	14.7
Mazandaran	91005	8.67	3.80	2.3
Kerman	23611	68.34	20.02	3.4
Khuzestan	60400	48.94	5.39	9.1
Qom	60951	23.56	0.48	49.1
Lorestan	30285	32.42	1.63	19.9

Conversely, the pattern for intra-city accidents is more predictable. Figures 6a and 6b show that the number of both intra-city accidents and fatalities is heavily concentrated in Iran's largest metropolitan areas. Tehran, Isfahan, and Razavi Khorasan lead in both categories, reinforcing the link between urban traffic volume, congestion, and the frequency of non-fatal crashes.

Comparative Fatality Rates in High-Volume Provinces

To further solidify the finding of a universal intra-city/extra-city divide, a comparative analysis was

performed for the top 10 provinces by total accident volume. As presented in Table 4, the fatality rate for extra-city accidents is drastically higher than for intra-city accidents in every single one of these provinces. The gap ranges from a 6-fold difference in Alborz to a staggering 49-fold difference in Qom. This analysis conclusively demonstrates that the heightened risk of fatality on extra-city roads is a systemic, nationwide issue in Iran, transcending regional variations in overall accident frequency.

Discussion and Conclusion

The findings of this study reveal a complex and challenging road safety landscape in Iran, characterized by a high overall accident burden and profound disparities in outcomes. The national accident rate of 2,464 per 100,000 population is substantially higher than global averages, reinforcing Iran's position as a country with a critical road safety problem. This high rate imposes significant economic costs, estimated to exceed 6% of GDP annually, representing a substantial burden on the nation's healthcare system and overall economy (17). While the majority of accidents result in property damage only, the fatality rate per 1,000 accidents (8.87) is alarmingly high compared to many developed nations, indicating that when accidents occur in Iran, they are more likely to have fatal consequences.

Perhaps the most striking finding is the profound disparity between intra-city and extra-city road safety outcomes. While intra-city areas experience a higher frequency of accidents, an extra-city accident is approximately 13 times more likely to be fatal. This severe intra-city/extra-city divide aligns with previous research (9, 11) and can be attributed to a confluence of factors. Higher vehicle speeds are common on extra-city roads, which often have higher speed limits and less enforcement (12). Furthermore, extra-city regions suffer from limited emergency medical services, characterized by longer response times and fewer specialized trauma centers, which critically reduces the chances of survival following a severe crash (12,15). The road infrastructure itself is often different, with extra-city roads typically having narrower lanes, fewer safety barriers, and less lighting. Finally, accidents in remote areas may not be discovered as quickly due to lower traffic volumes, further delaying emergency response.

The regional disparities identified in this study are equally concerning. The exceptionally high fatality rate per accident in Sistan and Baluchistan province (167.76 per 1,000 accidents) points to specific, localized challenges. These likely include limited healthcare infrastructure, with fewer medical facilities and specialized trauma centers; challenging terrain and road conditions, including mountainous areas and desert landscapes; longer distances to medical facilities due to the province's large area and dispersed population; and potentially a higher proportion of motorcycles, which are globally associated with higher fatality rates in accidents (16). Socioeconomic factors may

also play a role, as lower provincial indicators can influence vehicle maintenance standards, road quality, and access to healthcare (17).

High-traffic, urbanized provinces like Tehran experience more accidents, but these may be of lower severity due to factors like lower average speeds, better emergency response infrastructure, and more advanced medical facilities. In contrast, less populated provinces may have fewer accidents, but when they occur, they are more likely to be fatal due to the aforementioned extra-city risk factors. This decoupling of accident frequency and severity has important implications for policy, suggesting that strategies to reduce the number of accidents may not automatically reduce fatalities (18).

These findings have significant implications for road safety policy in Iran. A one-size-fits-all approach is unlikely to be effective. Instead, targeted interventions tailored to the specific challenges of extra-city areas and high-risk provinces are urgently needed. For extra-city regions, this should include improving road infrastructure through widening roads, adding safety barriers, and improving lighting. Enhancing emergency medical services is paramount, potentially involving establishing more trauma centers in remote areas, improving ambulance response times, and implementing helicopter emergency medical services in regions with challenging terrain. Targeted enforcement of traffic laws, especially speed limits, through increased patrols and speed camera usage is also critical (19,20).

For high-risk provinces like Sistan and Baluchistan, interventions must be even more specific and culturally adapted. This could involve improving the overall healthcare network, addressing unique road safety challenges posed by local geography, and implementing public education campaigns tailored to local contexts and vehicle usage patterns. Furthermore, improving vehicle safety standards nationwide, through stricter inspection requirements and incentives for newer vehicles, could contribute to reducing the severity of accidents across the country.

This study is not without limitations. The data relies on reported accidents, and it is likely that minor accidents, particularly in remote areas, are underrepresented. The dataset also lacks detailed information on accident causes, vehicle types, or driver demographics, which would provide valuable insights for developing more targeted

interventions. Future research should aim to incorporate more granular data to better understand the causal pathways leading to accidents and fatalities. Longitudinal studies examining the impact of specific policy changes over time would also provide invaluable evidence for refining road safety strategies.

This comprehensive analysis of Iran's road traffic accidents in 2022 reveals a deeply fractured safety landscape, defined by critical, evidence-based challenges that render a single, nationwide strategy ineffective. The results are unambiguous: while 81.8% of accidents occur in intra-city areas, an extra-city accident is approximately 15 times more likely to be fatal (37.48 vs. 2.5 fatalities per 1,000 accidents, $p < 0.001$). Furthermore, the risk is not uniform across the country; while Tehran faces the highest volume of accidents, provinces like Sistan and Baluchistan face a catastrophic severity, with a fatality rate of 167.76 per 1,000 accidents—nearly 19 times the national average. A significant negative correlation ($r = -0.42$, $p = 0.018$) confirms that high-frequency and high-severity are distinct problems requiring different solutions.

This statistical divide translates into three distinct, on-the-ground challenges that demand targeted interventions. The core issue is the exponentially higher danger of crashes on extra-city roads, a peril driven by high vehicle speeds, inadequate infrastructure, and critically, delayed emergency medical response. This problem is compounded in high-risk provinces like Sistan and Baluchistan, Kerman, and Hormozgan, where difficult terrain, vast sparsely populated areas, and limited access to trauma centers create a uniquely severe environment. Concurrently, urban centers like Tehran and Isfahan face a challenge of scale, where the sheer volume of accidents, though less likely to be fatal individually, creates a significant burden of injuries and economic losses. To effectively address this crisis, policymakers must adopt a multi-pronged strategy: prioritizing infrastructure and speed enforcement on extra-city roads, establishing regional trauma centers and tailored education in high-risk provinces, and investing in public transport and smart traffic management in urban centers. Only through this comprehensive, evidence-based approach can Iran hope to reduce its disproportionate burden of road traffic deaths and injuries.

Compliance with Ethical Guidelines

Ethical approval and informed consent were not required for this study, as it relied on publicly

available, anonymized secondary data from the Statistical Center of Iran. The dataset contained no personally identifiable information.

Funding/Support

The authors received no specific funding for this work.

Author's Contributions

In this article, Fereshte Karimi, as the corresponding author, was responsible for project management, writing, reviewing, and editing the research; and the first author, Mohammad Hussein Nozarian, was responsible for conceptualization, methodology, formal analysis, data collection, and writing the first draft. Also, Soheila Rajaei was responsible for research, sources, data collection, writing, reviewing, and editing.

Conflict of Interests

The authors declare no conflict of interest.

Acknowledgments

The authors would like to thank the anonymous reviewers for their insightful comments and valuable suggestions that greatly improved the quality of this manuscript. It is worth noting that for the production of geographic visualizations, the Datawrapper platform was used due to its capabilities to create clear, interactive, and publication-quality maps for effective communication of spatial inequalities.

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