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Original Article

Epidemiological Characteristics of Road Accident Mortality and Identification of Hot Spots: Years of Life Lost in Fars Province, Iran

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Abstract

Background: We aimed to analyze the epidemiological characteristics of road accident mortality and identify high-risk areas, considering the years of life lost (YLL) in Fars Province, central Iran.

Methods: The present study was conducted cross-sectionally in 2019. We used Kernel Density and hot spot analysis to identify statistically significant clusters of road accidents. For the descriptive analysis, we utilized the chi-square test, considering a *P*-value of less than 0.05 as statistically significant. To calculate years of life lost, R 4.3.3 software and the "YLL" package were used.

Results: A total of 1,604 people died in road accidents, with the majority being male (1,304). The mean age of the subjects was 37.63±36.61 years. The axes with a greater concentration of accidents included Shiraz-Marvdasht-Abade towards Esfahan, Shiraz-Kazeroun towards Bushehr, and Kazeroun- Noorabad towards Yasouj. Head injury and multiple fractures were the most prevalent causes of death among both sexes. The number of deaths and YLL due to accidents was higher in men than in women, in all age groups. In men, the number of deaths and YLL were more between the ages of 15 and 34 years, while in women, the distribution of the number of deaths and YLL did not differ much until the age of 70 years.

Conclusion: There is significant accident hotspots along the Shiraz-Marvdasht-Abade towards Esfahan, Shiraz-Kazeroun towards Bushehr, and Kazeroun-Noorabad towards Yasouj routes. In addition, the highest number of YLL due to road accidents occurred among teenagers and young adults. Policymakers need to focus on targeted interventions in these high-risk areas and develop strategies aimed at reducing accidents, particularly among younger males, to enhance road safety and decrease mortality rates.

Keywords: Accidents; Traffic; Mortality; Disability-adjusted life years; Iran

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Introduction

Traffic accidents rank as the ninth-leading cause of death globally, resulting in approximately 1.19 million fatalities each year (1, 2). Road traffic accidents impose significant financial burdens on healthcare systems, involving extensive medical expenses, prolonged patient care, and economic productivity losses (3). Numbers and statistics related to deaths and injuries alone cannot show the true depth of the consequences of these incidents. Behind these numbers lie profound emotional impacts on victims, their families, and friends that cannot be quantified (4).

Young drivers frequently face heightened risk due to immature decision-making, insufficient driving skills, and risky behavioral patterns. Their tendency to engage in dangerous practices like excessive speed, rule violations, and substance-influenced driving significantly elevates their probability of traffic incidents. Also, statistical evidence indicates that an individual's gender significantly correlates with traffic incident probability and potential consequences (5). Additionally, weather conditions play a significant role in the frequency of accidents, with the risk of incidents notably increasing in snowy and icy conditions (6). One reason for the higher number of accidents in low and middle-income countries compared to developed countries is the inadequate road infrastructure (7, 8).

Years of Life Lost (YLL) is a measure used to assess the effect of early death on a community. It represents the combined years people would have lived if they had not died young. To determine YLL, one must multiply the number of deaths at each age by the average life expectancy for that age (1). In Iran, there are seventeen thousand deaths annually due to road accidents (7), and the total YLL from road accidents surpasses that from other causes of death. Following cardiovascular diseases, road accidents rank as the second leading cause of death and YLL in Iran. Statistics indicate that the mortality rate from traffic accidents (31 per 100,000 people) is significantly higher than the global average (1,8). In Iran, 28% of YLLs are attributed to accidents, making it the leading cause of YLL among all causes of death (9). To evaluate the impact of death caused by road accidents, one method is to measure the YLLs (10).

Identifying hot spots in road traffic accidents is crucial for enhancing road safety and implementing effective interventions. Hot spots can indicate underlying issues such as poor road design, inadequate signage, or hazardous conditions. By pinpointing these areas, authorities can allocate resources more effectively and prioritize safety improvements (11).

To our knowledge, no study has been conducted to assess the geographic distribution and identification of hot spots related to road accident mortality in Fars Province. Furthermore, the epidemiological characteristics of road accident mortality examined in this study-including the type of accident, manner of collision, type of injury, and seasonal and temporal patterns of road accidents-have not been addressed in previous research conducted in Fars Province. Consequently, this study seeks to identify the epidemiological characteristics of road accident fatalities, to pinpoint hot spots and potential YLLs due to road accidents in Fars Province. The findings of this study address a significant knowledge gap and offer policymakers crucial information to guide targeted interventions and enhance road safety.

Materials and Methods

Study population

The current study was conducted cross-sectionally in 2019 in Fars Province, central Iran. The information of people who died due to road accidents was obtained from the Fars forensic medicine organization. Based on the collected data, the deceased's demographic information including age, sex, and injury (the person's status at the time of the accident and the principal cause of death) as well as the information related to the accident (time, location, type of vehicle, and mechanism) was collected. The conditions for withdrawing

from the study include that individuals who had died 30 days after the traumatic injury were excluded from the study because their deaths might have resulted from other causes. Those who had died in Fars Province and whose deaths were recorded in the Province's hospitals were excluded, as well.

Ethical Approval

The present study has the code of ethics IR.SUMS.REC.No.073 of Shiraz University of Medical Sciences.

Mortality rate

The mortality rate was obtained using the death registration system, which is completed by the Province's healthcare centers. In this system, deaths and their causes are collected by specific forms modified based on international standards using all resources such as hospitals, cemeteries, the Forensic Medicine Organization, and rural healthcare centers. We utilized the general mortality rate formula as follows: $\text{Mortality Rate} = \frac{\text{Number of Deaths}}{\text{Population Size}} \times 10^{n}$

Where: Number of deaths refers to the total deaths observed in a specified period. Population size is the total population at risk during that same period. n is an exponent that adjusts the result to a per-unit basis (multiplying by 10^5 gives deaths per 100,000 people).

Years of Life Lost (YLL)

YLLs for a specific cause are calculated by multiplying the number of deaths attributed to that cause by a loss function that determines the years lost based on the age at which the death occurs. The fundamental formula for YLLs for a particular reason (c), age (a), sex (s), and year (t) is expressed as follows: $YLL(c.s.a.t) = N(c.s.a.t) \times L(s.a)$, where N(c,s, a,t) represents the number of deaths from cause c for the specified age a and sex s in year t, and L(s, a) is a standard loss function that indicates the years of life lost for a death at age a for sex s. To calculate YLL, R 4.3.3 software and the "yll" package were used. The YLL rates were calculated by subtracting the age at which individuals died from the standard life expectancy for a specific age and gender group.

Statistical Analysis

The geographical distribution of road accidents in Fars Province was illustrated using ArcMap version 10.8. We utilized Geographic Information Systems (GIS) and spatial statistics to identify hot spots. The study will incorporate a mix of methods and techniques, including Kernel density estimation and hotspot analysis, to examine comprehensively the presence of accident clusters. The symbology of kernel density is employed to categorize the output data using the Natural Breaks method, resulting in nine classes. In addition, the Gi-Bin Hot Spot analysis was divided into seven categories. To assess the level of self-correlation among the road accidents and the likelihood of clustering, we applied Moran's overall test. Furthermore, we employed five classes and manual techniques to map and differentiate various regions. The Chi-square test was also conducted to examine the differences in death frequencies by gender. *P*-value≤0.05 was deemed statistically significant.

Results

In total, 1,604 people died due to road accidents. Among them, 81.3% were male, and the average age was 37.63 ± 36.61 years. Additionally, 58.04% of the participants were married, and over 69.14% had educational qualifications below a diploma. The ratio of deaths occurring on urban roads to those on intercity roads was 1:1.74, indicating a higher number of fatalities on intercity roads. The most common causes of death for both genders were head injuries (55.24%) and multiple fractures (30.42%) (Table 1).

Table 1: Characteristics of the studied subjects based on gender in Fars Province

Variables	n (%)			
	Male	**Female**	**Total**	***P*-value***
Age (yr-mean ± SD)	37.73 ± 19.99	37.19 ± 22.75	37.63 ± 36.61	0.340
Marital status				
Single	570(43.71)	103(34.33)	673(41.96)	0.001*
Married	734(56.29)	197(65.67)	931(58.04)	
Education				
Diploma	1127(88.73)	256(85.33)	1413(88.09)	0.290
Academic	147(11.27)	44(14.67)	191(11.91)	
Place of accident				
Intercity roads	828(63.50)	198(66)	1026(63.97)	<0.001*
Urban	476(36.50)	102(34)	578(36.03)	
Type of accident				
Car	620(47.55)	194(64.67)	814(50.75)	<0.001*
Motorcycle	451(34.59)	21(7.00)	472(29.43)	
Pedestrian	214(16.41)	85(28.33)	299(18.64)	
Bike	19(1.46)	0(0.00)	19(1.18)	
Situation accident				
Driver	923(70.78)	123(41)	1046(65.21)	<0.001*
Passenger	381(29.22)	177(59)	558(34.79)	
How to crash				
Accident of two vehicles together	675(51.76)	100(33.33)	775(48.32)	<0.001*
Accident to the vehicle	227(17.41)	83(27.67)	310(19.33)	
Vehicle crashes into object or animals	81(6.21)	25(8.33)	106(6.61)	
Overturn	304(23.31)	92(30.67)	396(24.69)	
Fall	17(1.30)	0(0.00)	17(1.06)	
Type of injury				
Head and neck	758(58.13)	128(42.67)	886(55.24)	<0.001*
Multiple fractures	409(31.37)	79(26.33)	488(30.42)	
Chest and abdomen	123(9.43)	70(23.33)	193(12.03)	
Others	14(1.07)	23(7.67)	37(2.31)	
* Chi-squared test, p-value<0.05				

Road accident mortality in the winter (blue) was lower than in other seasons, in other seasons the number was almost the same, but in the summer season (red) the number was a slight percentage higher. Road accident mortality increased slightly during the week, with the highest number of deaths occurring on Friday, which is a holiday. Even though 21.9% of the days of the year were

holidays, 22% of the accidents occurred on holidays. The lowest number of deaths occurred between midnight and 5 am, and the highest number of deaths occurred between 2 pm and 8 pm (Fig. 1).

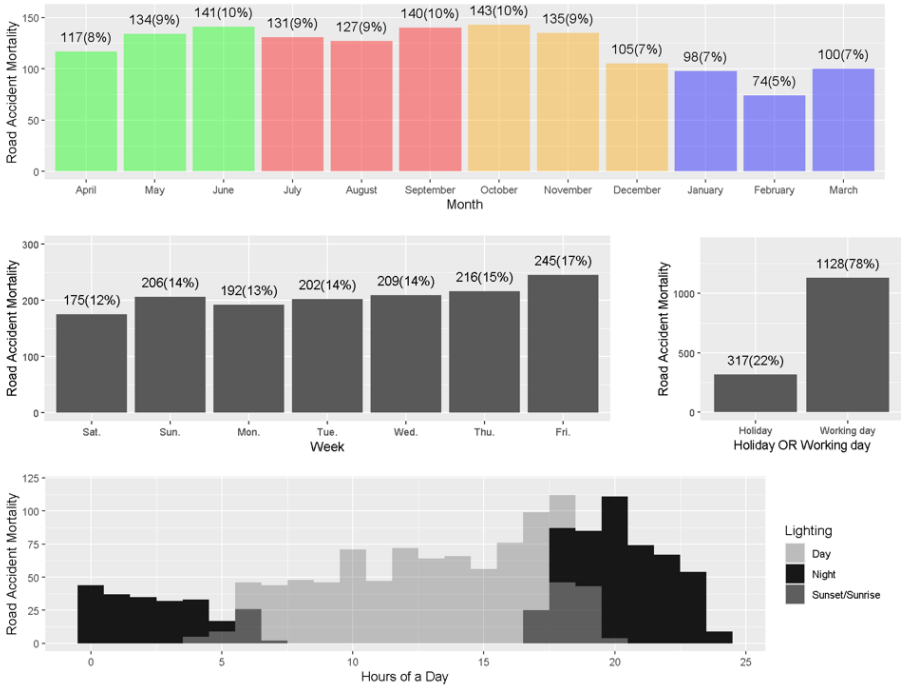

Fig. 1: Distribution of the number of deaths due to accidents by Season, Month, Week, and Hours of the day

The total number of deaths was 1,304 for men, 300 for women, and 1,604 overall. The years of life lost due to accidents amount to 62,991 for men, 14,936 for women, and 77,927. Fig. 2 illustrates the number of deaths and YLL from road traffic crashes in Fars Province by gender and age groups. In every age group, the number of deaths and YLL was higher in men than in women. Among men, the highest number of deaths and YLL occurred in the 15 to 34 year age range, while for women, the distribution remained relatively consistent until the age of 70.

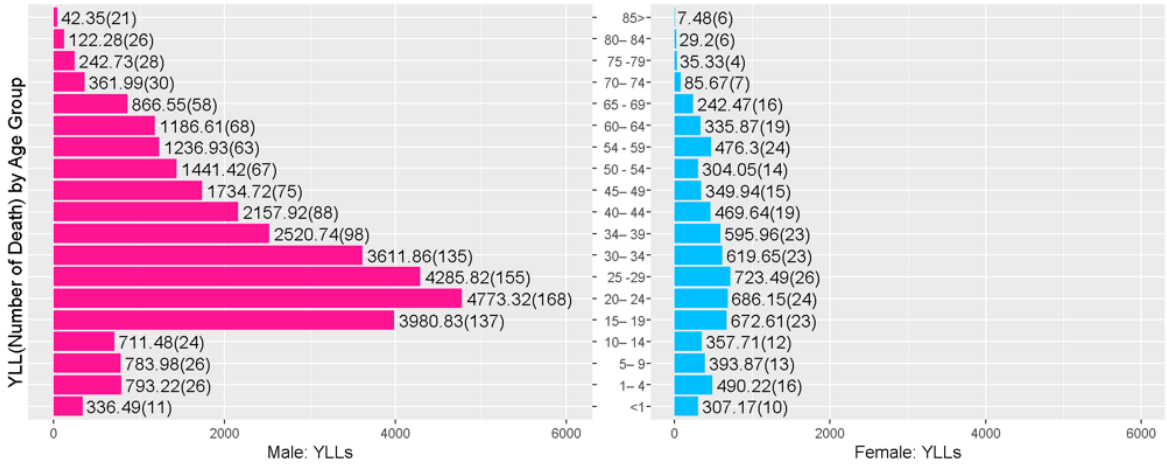

Fig. 2: The number of deaths and YLL due to road traffic crashes in Fars Province by gender in age groups

The majority of the deceased cases were related to Shiraz (33.16%), Kazeroun (7.73%), Marvdasht (6.42%), and Darab (5.42%) (Fig. 3). The kernel density analysis indicates that the most densely concentrated high-incident routes in Fars Province's main roads are as follows: Shiraz-Kazeroun towards Bushehr, Shiraz-Jahrom-Darab towards Bandar Abbas, Shiraz-Marvdasht-Abade towards Esfahan, and Shiraz-Noorabad towards Yasouj, as shown in Fig. 4.

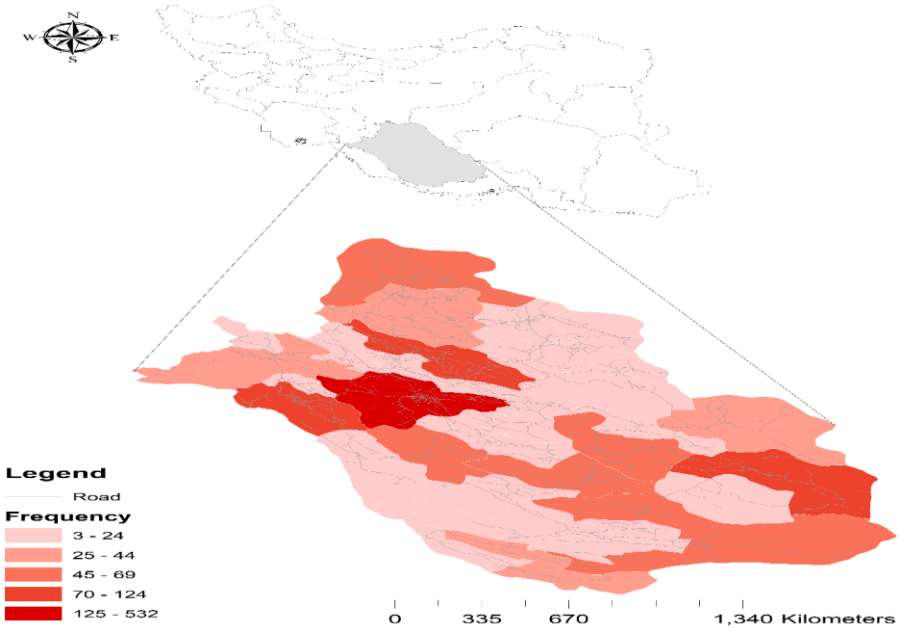

Fig. 3: Geographical distribution of mortality related to road traffic crashes in Fars Province

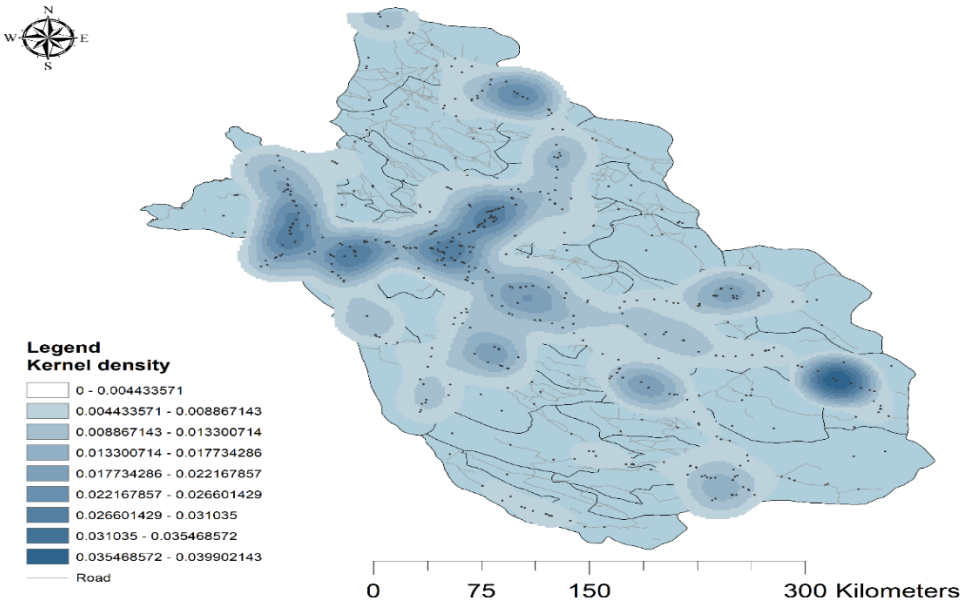

Fig. 4: Kernel density analysis for identifying high-concentration areas of road accident mortality in Fars Province

The Gi-Bin Hot Spot analysis shows areas with a higher density of accidents are primarily located along the main roads in Fars Province, particularly on the following routes: Shiraz-Marvdasht-Abade towards Esfahan, Shiraz-Kazeroun towards Bushehr, and Kazeroun-Noorabad towards Yasouj (Fig. 5).

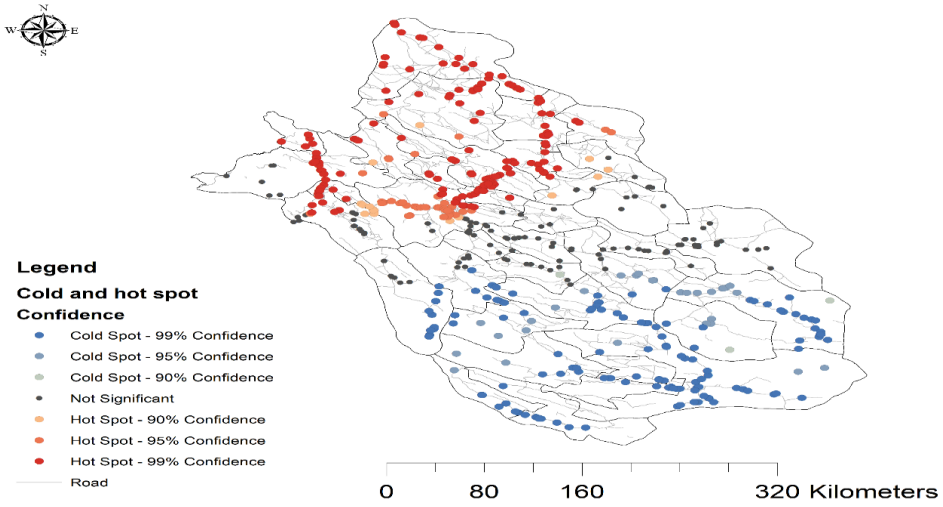

Fig. 5: Hot Spot analysis for road accident mortality points of Fars Province

The spatial autocorrelations measured by the Global Moran's I index for road accident mortality locations were found to be positive and statistically significant (I = 0.99, *P*<0.001), indicating a strong spatial dependence among road accidents. Similarly, these findings suggest a significant clustering of mortality rates in Fars Province, rather than a random or uniform distribution (Fig. 6).

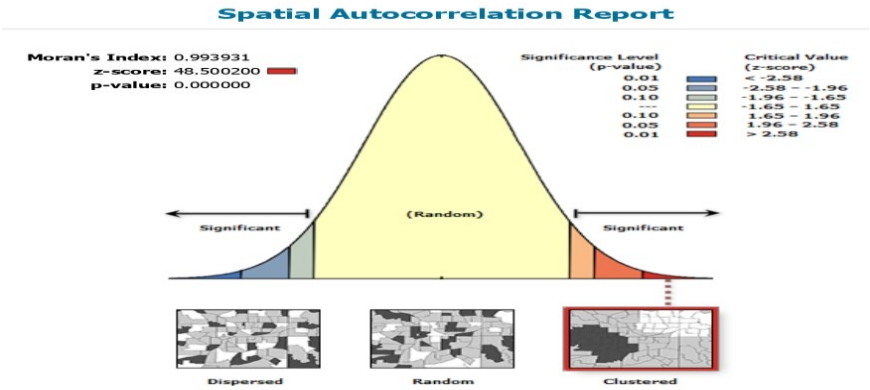

Fig. 6: Spatial autocorrelation of road accident mortality based on the Global Moran's I Index in Fars Province

Discussion

The incidence of deaths caused by road accidents among males was considerably greater than that among females. Additionally, the average age of the deceased suggests that many fatalities occur during individuals' prime working years. This trend negatively affects productivity and economic growth. The routes with a higher frequency of accidents included Shiraz-Marvdasht-Abade towards Esfahan, Shiraz-Kazeroun towards Bushehr, and Kazeroun-Noorabad towards Yasouj. The main causes of death identified in the study were primarily head injuries and multiple fractures. The overall rate of YLL due to road accidents was a significant concern and was particularly elevated among adolescents and young adults.

This study identified age and gender as factors associated with road accidents, indicating that men and individuals of working age face a higher risk of mortality, consistent with findings from other research (12, 13). The death of individuals in their working years can have significant economic consequences. Their exit from the workforce can lead to decreased productivity, affecting the economy (14). Additionally, road accidents raise public health concerns (15) and frequently result in significant expenses for both survivors and their families, including medical expenses and rehabilitation services. Road traffic injuries are projected to cost the global economy around $1.8 trillion from 2015 to 2030. This figure highlights a significant impact on productivity and economic growth (4).

Individuals from lower socioeconomic backgrounds face a higher risk of fatal accidents, as studies indicate that mortality rates are concentrated among deprived groups. This risk is particularly pronounced among those driving vehicles with lower safety standards (16). Additionally, lower levels of education are associated with a higher risk of accidents and fatalities. This correlation exists because education often serves as a proxy for socioeconomic status (17).

Our research indicates that most fatalities from road accidents occur on main roadways. This finding aligns with the outcomes of other studies (18, 19). Major roadways typically permit higher speeds. Elevated speeds are associated with an increased likelihood of fatal accidents. For example, a 1% rise in average speed may result in a 4% rise in the risk of fatal accidents (2). The combination of increased traffic volume, higher speeds, diverse road users, infrastructure issues, environmental factors, and driver behavior all contribute to the elevated mortality rates from road accidents in regions adjacent to primary roadways.

Our findings indicated that head injuries and multiple fractures were the primary factors contributing to mortality, consistent with other research (20, 21). Numerous fractures, especially those affecting the pelvis and chest, can result in considerable blood loss and shock, which greatly heightens the risk of mortality (19). Furthermore, the coexistence of head injuries and multiple fractures can complicate medical treatment. For example, individuals with significant head trauma may need mechanical ventilation, which increases the likelihood of mortality (22). Effective prevention strategies focusing on public awareness campaigns are essential to mitigate these risks and reduce fatalities associated with road accidents. For instance, billboards featuring damaged vehicles, have been shown to effectively reduce speed and raise awareness of road safety risks (23). Additionally, delivering messages aimed at young male drivers can effectively address their specific driving habits and promote safer practices.

In our study, the total rate of YLL resulting from road accidents was a major issue, especially pronounced among teenagers and young adults, according to the findings of Azarbakhsh et al (1). Risky behaviors commonly observed in teenagers and young adults lead to increased accident rates. Actions like speeding, driving under the influence of alcohol or drugs, and not wearing seatbelts are more frequently seen in this demographic. Such behaviors greatly elevate the chances of serious injuries and fatalities in the case of an accident (24). The YLL metric highlights the considerable impact of road traffic injuries on adolescents and young adults. This suggests that they not only face a higher risk of fatality from such accidents, but

their deaths happen at a stage in life where they could have lived many additional years.

Limitations

This study faced some limitations. Firstly, it focused solely on fatalities, overlooking non-fatal injuries and their related characteristics. Secondly, being a cross-sectional study, it offers only a snapshot at a particular moment, which restricts the ability to analyze trends over time. These limitations indicate that, although the study offers important insights into road traffic accidents in Fars Province, additional research is necessary to fill these gaps and improve our understanding of this public health concern.

Conclusion

The elevated rate of YLL due to road accidents among adolescents and young adults underscores a critical public health issue. Given the frequency of fatalities on major roads and the identification of accident hot spots, it is essential to improve safety measures in these high-risk areas. Addressing this requires targeted interventions focusing on education about safe driving practices, enforcement of traffic laws, and improved road safety measures designed to protect this vulnerable demographic.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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