

**Prediction of trauma-specific death rates of pedestrians of Fars Province, Iran**

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**Abstract**

**Introduction:** Pedestrians are the most vulnerable group to accidents among road users. Due to the well-known concerns and complications of accidents involving pedestrians, the aim of this study was to identify the rate of such accidents for five-year period.

**Methods:** We analyzed all fatalities among pedestrians caused by traffic accidents during years of 2009-2013 in Fars Province in Iran. The study was a cross-sectional study in which logistic regression analysis was used to predict the death rate among pedestrians. Sensitivity analysis using the Monte Carlo method was used to increase the accuracy of the results. Then, we predicted the death rates for the years 2014-2018 predicted and compared the results with the actual data from the previous five-year period (2009-2013).

**Results:** During 2009-2013, 1723 out of 8689 (20.3%) of the people killed in traffic accidents were pedestrians. The death rate for male pedestrians in 2011 was estimated to be 10.86 per 100,000 (with an uncertainty interval of 95% giving a range of 9.85-12.05 per 100,000). Compared to the data for 2006, this represented a decrease of 20% (with a mean decrease of 4% per year). Based on these data, the death rate in 2018n was projected to be 8.08 per 100,000 (with an uncertainty interval of 95% giving a range of 7.26-8.87). Similar data and analysis for women indicated that the reduction in the rate of fatalities has been smaller than that for men in recent years, i.e., 2.2% versus 4%.

**Conclusion:** Although great progress has been made in reducing traffic accidents, to date, the death rate is still high among pedestrians. It is essential to continue to find ways to reduce traffic accidents and the pedestrians' deaths associated with them, especially among the elderly, who make up a disproportionate fraction of the deaths.

**Keywords:** modeling death rate, pedestrians, Fars Province

**1. Introduction**

According to a report from the World Health Organization (WHO) in 2010, traffic accidents are one of the main reasons for death throughout the world (1). At present, more than 140,000 people in the world are injured in traffic accidents every day, resulting in 3,000 deaths per day. If this trend continues, the number of people killed each day as a result of traffic accidents increase by more than 60% by 2020 (2). The worldwide death rate due to traffic accidents is 2.9 per 100,000, but this rate in Iran is 7.5 per 100,000, more than 2.5 times greater than the average for the world (3, 4). About 50% of total fatalities in road accidents occur among vulnerable road users. Inter alia, pedestrians suffer more severe injuries in traffic accidents than other road users.

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Over 270,000 pedestrians are killed on roads throughout the world every year, and, in some countries, more than 67% of these deaths are attributable directly to traffic accidents (5). Similarly, in Iran, traffic accidents involving pedestrians constitute the major portion of all of the accidents. The studies indicate that, in 2007, out of the total number of deaths due to traffic accidents (27,567), 6,258 of the people (22.7%) were pedestrians, and this percentage had increased to 28% by 2011 (1). Another study (between 2006 and 2010) showed that drivers had the highest rate of deaths in traffic accidents, but there also was a considerable number of pedestrians killed in those accidents (6).

Analysis on traffic accidents involving pedestrians is crucially important. However, few studies have been conducted in this field in Iran, and some of those have focused mainly on total deaths and ways to reduce the numbers of people who die in traffic accidents. This aim of this investigation was to describe some details related to traffic accidents that involved pedestrians by benefitting from one of the measurement tools in epidemiology science under title of rate. Likewise, prediction and trend determination models were used to estimate the death rate among pedestrians for the coming years. In statistics, this measure can be done by several methods, such as regression, auditing analysis (separation), time series, ranking, and others. There are several constraints in some of the classic techniques, including considering a default distribution such as a normal distribution for response variables, linearity of the offered relationship, the equality of error variances, and others. Thus, if the real data do not satisfy the given conditions in the model, they are not feasible and/or they may be accompanied by significant error (7, 8). Among these methods, the logistic regression techniques are assumed to be one of the most prevalent methods because they allow the estimation of variance trends (9-11).

Fars Province is one of Iranian provinces with a lot of fatalities caused by traffic accidents (12). Since to date no modeling has been used to predict fatalities among pedestrians due to traffic accidents in Fars Province, which are a major public health issue in this Province, the aim of this study was to determine how the death rates among pedestrians due to traffic accidents vary with time. This was done based on modeling by logistic regression with respect to the existing data in Fars Province. The findings of this study may provide support for changes in the Province's policies and may provide data that can be used to support regulatory changes as part of the intervention required to reduce the death rates of pedestrians due to traffic accidents.

## 2. Material and Methods

The present study was conducted as a cross-sectional study in Fars Province (the largest Province in southeast Iran). In this study, we used forensic techniques to analyze all of the recorded fatalities caused by traffic accidents among pedestrians from 2009 through 2013. Based on Iranian law, autopsies are required for all people killed in traffic accidents to determine the cause of death. Then, all of the information is sent to the main center of the Province. Thus, we were able to use in this study all of the data for pedestrians killed in traffic accidents based on gender and age groups (under age 5, 5-14, 15-49, 50-69, and older than age 69) were utilized in this study. Logistic regression is deemed as one of the most prevalent models used for classification and prediction; it is used in epidemiological studies for data analysis and may be employed in modeling of observations (9, 13). We are utilized this model to predict fatality trend in pedestrians at Fars province. The mortality rate of pedestrians was predicted by converting the logistic model to linear form. A typical model of logistic regression is of the form:  $\text{Log}(P/(1-P)) = b_0 + b_1 X_1 + b_2 X_2 + \dots + b_k X_k$ , where  $\text{Log } P$  is the natural logarithm of the probability of the event of interest,  $b_0, b_1, b_2, \dots, b_k$  are the parameters of the model, and  $X_1, X_2, \dots, X_k$  are the explanatory variables (9).

Because logistic regression uses the maximum likelihood rather than the method of least squares, we used the predicted probability formula of the logistic regression model, i.e.,  $(P = e^{(b_0 + b_1 X_1 + b_2 X_2 + \dots + b_k X_k)} / (1 + e^{(b_0 + b_1 X_1 + b_2 X_2 + \dots + b_k X_k)}))$  to predict the death rate among pedestrians based separately on gender and age groups (14, 15). In this formula,  $P$  is the probability of a pedestrian's death; the symbol  $e$  is the exponential constant, the value of which is approximately 2.718;  $X_1, X_2, \dots, X_k$  are the independent variables (such as gender and age groups); and  $b_0, b_1, b_2, \dots, b_k$  are the coefficients of the logistic regression model for independent variables.

The sensitivity analysis was done using the Monte Carlo technique to increase the accuracy and precision of the estimated values. The uncertainty levels (percentiles 97.5 and 2.5, which were the results of Monte Carlo) were used instead of the 95% confidence interval. SPSS version 18 (SPSS, Inc., Chicago, Illinois, USA), Microsoft Excel, and Stata software were used to implement the steps in the analysis.

### 3. Results

#### 3.1. General findings

According to information recorded at the Shiraz Forensic Medicine Center, 8,689 people were killed due to traffic accidents in Fars Province between 2009 and 2013. Of those deaths, 1,753 (20.3%) were pedestrians. The information about the pedestrians who were killed is shown according demographic specifications in Table 1.

**Table 1.** Specifications of the pedestrians killed in traffic accidents based on age group and gender for the years 2009-2013

Gender	Age (yr.)	Death: n (%)				
		2009	2010	2011	2012	2013
Male	≤ 4	15 (5)	12 (5.2)	19 (8.7)	12 (5.1)	13 (4.9)
	5- 14	23 (7.7)	21 (9.2)	22 (10)	12 (5.1)	30 (11.2)
	15- 49	109 (36.3)	70 (30.6)	71 (32.4)	84 (35.6)	89 (33.3)
	50- 69	70 (23.3)	52 (22.7)	40 (18.3)	61 (25.8)	65 (24.3)
	≥ 70	83 (27.7)	74 (32.3)	67 (30.6)	67 (28.4)	70 (26.2)
	Total	300 (100)	229 (100)	219 (100)	236 (100)	267 (100)
Female	≤ 4	7 (6.9)	9 (8)	4 (3.7)	9 (9.9)	2 (2.4)
	5- 14	19 (18.6)	15 (13.3)	11 (10.2)	9 (9.9)	10 (11.9)
	15- 49	21 (20.6)	32 (28.3)	24 (22.2)	19 (20.9)	21 (25)
	50- 69	29 (28.4)	33 (29.2)	38 (35.2)	26 (28.6)	34 (40.5)
	≥ 70	26 (25.5)	24 (21.2)	31 (28.7)	28 (30.8)	17 (20.2)
	Total	102 (100)	113 (100)	108 (100)	91 (100)	84 (100)

#### 3.2. Number of pedestrian fatalities

Figure 1 shows that, given the existing trend in the number of fatalities among female pedestrians, it is expected that, for the five forthcoming years, the maximum number of deaths in the age group of 15-49 will be 24 (With an uncertainty interval of 95%, the number would be in the range of 22-26). This was followed by the age groups of > 70 and 50-69. Also, with respect to the trend that has been observed in previous years for male pedestrians, it is expected that there will be 74 deaths in the age group of 50-69 (With an uncertainty interval of 95%, the number would be in the range of 67-81). These were followed by the age groups of > 70 and 15-49.

#### 3.3. The specific death rate among pedestrians per 100,000 population

The results indicated that the maximum fatality rates due to traffic accidents were among pedestrians of both genders in the age groups of > 70, 50-69, and < 5. It is expected that, with the existing trend during recent years, the death rate will decrease or remain uniform for all age groups of males and females (Figure 2).

The death rate for males in the 5-14 age group in 2013 was estimated to be about 10.32 (uncertainty level 95%:9.36-11.38) p100,000 p decreased by 47% (with mean annual decrease of 9.4% and taking into account population growth). The death rate of female pedestrians for the age group < 5 was estimated to be about 1.14 (uncertainty interval 95%: 1.02-1.25) p100,000 p had a decrease of 72% (with mean annual decrease of 14.8%) with the maximum decrease among other age groups during years 2009- 2013. Despite the predictions of decreased death rates for all age groups during 2013- 2018, an increasing trend is expected among females for the age groups of < 5 and 15-49 (Table 2). Overall, the death rate of pedestrians due to traffic accidents is expected to have a decreasing trend; however, by considering the existing trends, it is expected that the rate of reduction will be greater in males than in females (5% versus 2.2%) (Figure 3).

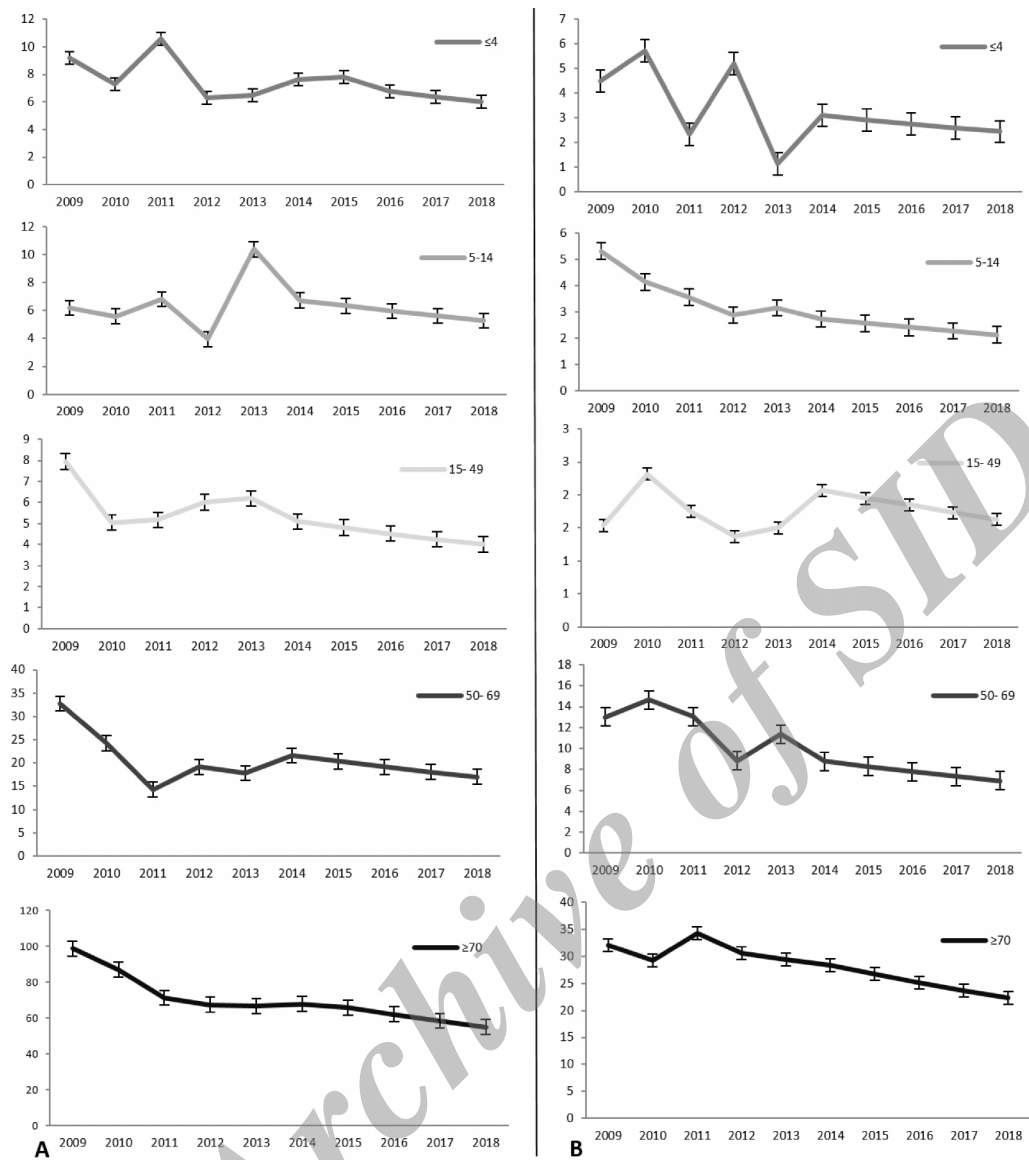


Figure 1. Trends of death rates of pedestrians based on gender: A) females; B) males

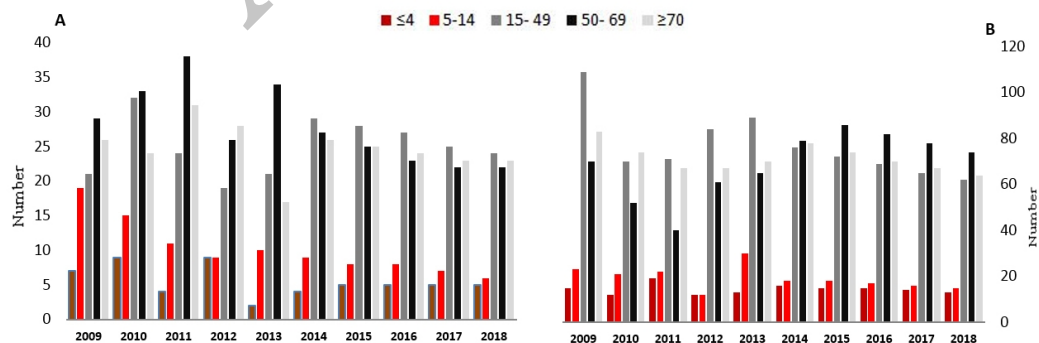
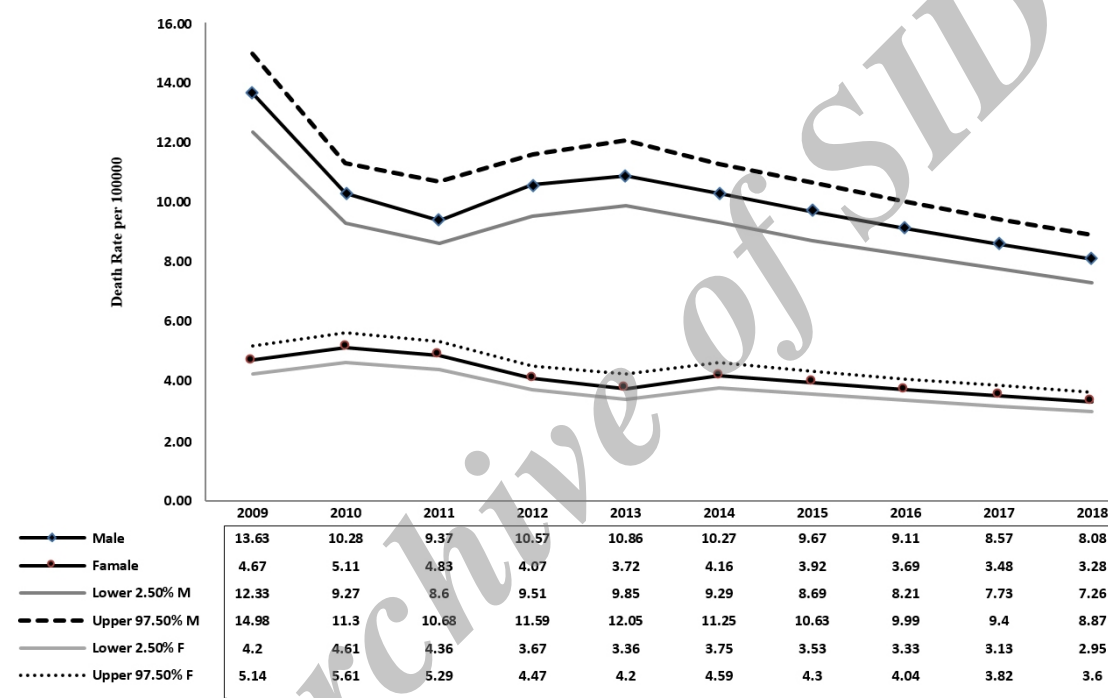


Figure 2. Trends of death rates among pedestrians based on gender: A) trend of death rate of males separately based on age group per 100,000 population; B) trend of death rate of females per 100,000 population

**Table 2.** Projected percentage increase in deaths based on gender and age groups for the years 2009-2018

Trend of death rate of pedestrians in traffic accidents by gender	Age groups (years)	Percentage increase during years 2009-2013	Percentage increase during years 2013- 2018
Trend of death rate of male pedestrians in traffic accidents (p100,000 p)	≤ 5	-30	-7
	5- 14	-47	-49
	15- 49	-22	-35
	50- 69	-46	-5
	≥ 70	-32	-18
Trend of death rate of female pedestrians in traffic accidents (p100,000 p)	≤ 5	-74	1.4 times
	5- 14	-40	-32
	15- 49	-2	+8
	50- 69	-12	-39
	≥ 70	-8	-24

**Figure 3.** Death rates in pedestrians based on gender with uncertainty level (UCL)

#### 4. Discussion

In developing countries, the rank of mortality due to traffic accidents was 8 per 100,000 in 2010, whereas it was 10 per 100,000 in 1990. In developed countries, the rank of mortality rate due to traffic accidents decreased from 17 in 1990 to 9 per 100,000 in 2010. Moradi et al.'s study showed an increasing trend of deaths and injuries from traffic accidents in Iran from 1993 to 2006. The deaths by these events were the highest during 2005-2006, at 28,000 per year. However, since 2007, there has been a continuous decrease in the annual number of deaths from traffic accidents (6, 16). Despite of the fact that pedestrians are not related to vehicles, they make up a notable percentage of the deaths from traffic accidents. During the years that were investigated in this study, pedestrians were estimated to account for about 20% of the fatalities in traffic accidents according to similar techniques used by the studies that were conducted (1, 5). With respect to importance of this issue, this research was the first investigation that has used modeling to predict the death rate among pedestrians due to traffic accidents in Fars Province.

This study shows the reduced growth of death rate caused by traffic accidents were among pedestrians at Fars province during years 2009- 2013. According to the conducted predictions, it will be still followed by a decremental trend by 2018. But it will differ from this trend in terms of this point that the speed of reducing this trend will be

lower than previous years, especially among females. Similar to our studies, Monfared et al., who conducted a study using a time series model, showed that the death rate caused by traffic accidents was predicted to decrease in Iran during the coming years (17). In another study that was conducted in the UK in 1996, a time series model and Poisson regression were used, and the results indicated that the death rate due to traffic accidents was reduced among children in 2005 (18). According to the results of this study, the maximum death rate among pedestrians due to traffic accidents will occur among the older pedestrians in the forthcoming years. The survey done by Gorgin et al. also showed that about 67% of the pedestrians killed in traffic accidents were older than 65, a mean age that was approximately 10 years younger than other predictions (19). This may be due to the problems that older people have in crossing roads expeditiously because of senility, moving more slowly, and various diseases. It was even shown in Korea that there is significant relationship among depression and traffic accidents (20). According to a report from the Forensic Medicine Organization, 50% of the deaths among people older than 50 are the result of accidents. This is probably due to their joint-skeletal problems, sedentary lifestyles, and slow reaction times. Older people cannot rescue themselves effectively after traffic accidents due to chronic diseases of osteoporosis and arthritis, which increases incidents of broken bones, hospitalization, as well as increased incidents of death for this group (21). Similarly, this study indicated that after older people, the children have the next highest risk, and their risk is reduced as they approach adulthood. Similar to our investigation, Kemp et al., in their study focused on epidemics of accidents involving children, found that traffic accidents have been identified as the most lethal accidents for children in Britain and Wales. The reason is that very young pedestrians are less aware of the hazards and risks associated with moving vehicles as well as their lack of familiarity with traffic rules and regulations (22). Another study conducted in Shiraz showed a similar finding (12). Thus, isolation of specific paths for very young pedestrians from vehicular traffic, parents' paying greater attention to the locations and movements of their children, and parents' training their children regarding the observance of rules for crossing roads can be effective measures for reducing the rate of deaths among very young pedestrians due to traffic accidents.

Pedestrians have very little protection against injuries when they are involved in a traffic accident, so their injuries are likely to be severe (19). The death rate is higher among male pedestrians than female pedestrians. This may be due to more males being in public places in the community and to females potentially observing traffic rules and regulations better than males. It is expected with the present trend of the death rate among female pedestrians in the age group of 15- 49 will increase in the future. This may be mainly due to the more prominent presence and transport of females at this age group in the community during recent years and the coming years. During recent years making efficient efforts by all of the relevant bodies especially police, several great strides have been taken in reducing such accidents. So, the aforesaid rate had been decreased from over 9 to 7 cases (p100,000 p). It is expected with the existing trend that we will achieve approximately 6 cases (p100,000 p) in forthcoming years. It should be noted that the death rate is still a very high figure among pedestrians in Fars Province, and it is far from the ideal point. Thus, scientific and research support is required to help reach this point. Given the wide range problems for pedestrians, inadequate research has been conducted to focus on how to reduce injuries to pedestrians in traffic accidents. The focus to date has been on the passengers inside the vehicles.

This study is the first to use a logistic regression analysis to predict the death of pedestrians in Fars Province, and, like other modeling methods, it has some limitations. The most important factor in all modeling methods is their dependence on accurate data. Thus, the authors tried to use data that were collected carefully and precisely. In addition, there are some variables involved in the death of pedestrians that, unfortunately, could not be included in this model due to lack of availability. In general, we used a new statistical technique to predict acceptable results and provide a context for further studies.

## **5. Conclusions**

This study predicted that the death rate of pedestrians in traffic accidents in Fars Province would during years 2009-2018. Although there will be a decreasing trend, the death rate of pedestrians in traffic accidents is still very high and is a far from the ideal point. Therefore, to reach this point, scientific research is required to develop and implement preventive strategies in various sectors. Also, we have to teach at-risk groups (especially children and older people) how to better protect themselves and provide facilities and structures of traffic safety for pedestrians.

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**Conflict of Interest:**

There is no conflict of interest to be declared.

**Authors' contributions:**

All authors contributed to this project and article equally. All authors read and approved the final manuscript.

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