Original Article

Comparison of Risk Factors for Pedestrian Fatality in Urban and Suburban Traffic Accidents

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Abstract

Background: The burden of traffic accidents on pedestrians is very high in Iran. Since the pattern of injury is different in urban and suburban accidents, this study was conducted to identify the risk factors associated with pedestrian mortality in urban and suburban traffic accidents in Tehran and Alborz Provinces. **Materials and Methods:** The data of all traffic accidents related to pedestrians in Tehran and Alborz Provinces were investigated from two databases of traffic police and forensic medicine. The effects of demographic variables (age and gender) and pedestrian position, time, accident location, and vehicle type on the outcome of pedestrian death were investigated. Multiple logistic regression was used to analyze the data. The significance level was considered <0.05 and statistical analyses were performed using STATA version 12. **Results:** From a total of 10742 pedestrians, 6804 males (63.3%) and 3938 females (36.7%) were studied in traffic accidents. In urban accidents, the effects of pedestrian age such as 35–64 years and >65 years compared to 15–24 years (odds ratio [OR]: 2.04, confidence interval [CI]: 1.26–3.3), (OR: 4.8, CI: 2.9–7.9), male gender (OR: 2.26, CI: 1.6–3.1), lighting condition at night compared to day (OR: 1.6, CI: 1.2–2.1), two-way not divided road versus one-way road (OR: 1.6, CI: 1.12–2.3), the status of day after holidays compared to normal days (OR: 1.53, CI: 1.09–2.14), type of vehicle such as heavy or semi-heavy and conventional or pickup versus motorcycles or bicycles (OR: 5.4, CI: 3.1–8.9) and (OR: 1.8, CI: 1.2–2.7) and pedestrian position at crossing the road from an unauthorized route compared to crossing the road from the authorized route (OR: 1.94, CI: 1.4–2.6) were significant on the fatality. Whereas in suburban accidents, there was a statistically significant correlation with pedestrian fatality only in two-way divided road compared to one-way (OR: 0.2, CI: 0.05–0.77). **Conclusion:** The present study showed that risk factors for pedestrian mortality are different in urban and suburban traffic accidents. It is necessary to take appropriate measures in urban and suburban areas to reduce the severity of injuries in pedestrians.

Keywords: Comparison, pedestrian, risk factors, traffic accidents

Introduction

Traffic accidents are considered among the most common causes of mortality and physical disabilities worldwide, causing more than 1.24 million deaths, 10 million disabilities, and about 50 million injuries.[1-6] Pedestrians are the most vulnerable group in traffic accidents, accounting for more than 22% (about 270,000 pedestrians) of deaths.[7] In addition to 270,000 mortalities, millions of pedestrians are injured as a result of traffic accidents, which ultimately many of these injured suffer from permanent disabilities.[8-10] In general, more

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than a third of all deaths and disabilities associated with traffic accidents in the world have been reported due to accidents between vehicles and pedestrians.[9]

In Iran, traffic accident fatality is very high in pedestrians, so pedestrian safety is one of the most important problems in the health system.[11] According to the forensic medicine organization in 2012, about 23% (4371) of traffic accident fatality are associated with pedestrians. The proportion of pedestrian fatality in traffic accidents was not the same in different provinces so that the highest proportion of pedestrian fatality occurred in the provinces of Tehran (46.5%) and Alborz (40.5%), and the lowest ratio was in South Khorasan Province (8.6%). On average, four people are killed daily in Tehran due to traffic accidents, two of them are pedestrians.[12]

Traffic accidents associated with pedestrians are due to the complex impact of multiple risk factors including personal characteristics (e.g., age and gender), environmental factors (e.g., lighting conditions, and weather conditions), and accident and vehicle conditions (e.g., vehicle type).[13-17] So as to plan properly the prevention and implementation of effective interventions for the protection of pedestrians, it is essential to understand the nature of the risk factors for pedestrians, in terms of accident's location (urban and suburban) and the type of collision (e.g., car with pedestrians and motorcycle with pedestrians) in traffic accidents. Therefore, considering the high odds ratio (OR) of pedestrian fatalities in traffic accidents, especially in the provinces of Tehran and Alborz, as well as insufficient information about the underlying factors, the main causes and other predictors of traffic accidents such as the location of the accident and the type of collision, the present study aimed at determining the factors related to the death of pedestrians in terms of the accident's location and the type of collision in Tehran and Alborz provinces.

Materials and Methods

This cross-sectional study was conducted in Tehran and Alborz Provinces of Iran from March 21, 2013, to March 21, 2014. Traffic police collects all traffic accidents' data by specially designed forms called COM114 that include several variables. These data include variables related to the vehicles, passengers and occupants involved in an accident and also the road characteristics and environmental situations of the accident's location. On the other hand, the Legal Medicine Organization registers all fatalities caused by traffic accidents about 30 days after the accident in their data bank. In this study, we used the accidents recorded in the police database in which at least one pedestrian was involved. Considering the fact that the death event of some of the injured pedestrians may occur 30 days after the accident, we matched police and Legal Medicine Organization databases according to variables such as name, age, sex, date, and place of the accident to update the final status of injured pedestrians in the police database.[18] After matching records and removing duplicates, 10742 road accidents were included in the study. The demographic characteristics of pedestrians (pedestrian's sex and pedestrian's age), as well as accident data (season, and weekday in terms of holiday (before holiday, holidays, after holidays, and normal days)), environmental factors (lighting conditions (day, night, sunrise, or sunset), weather conditions (sunny, cloudy or foggy, and snowy or rainy), residential status of the accidents' location (residential area and nonresidential area), types of ways (highways and road), road types (two-way not divided, two-way divided, and one-way) and accident conditions (type of vehicle (conventional or pickup, heavy and semi-heavy, and motorcycle or bicycle) and pedestrian positions (crossing the road from the authorized route, and crossing the road from an unauthorized route) were investigated. The outcome in this study was death which was caused by traffic accidents and had occurred at the time of traffic accident or any time until 30 days after the accident.[18] Concerning the different nature of injury in urban and suburban accidents, the impact of related factors in these two regions was examined separately. Data were analyzed by univariate and multivariate methods. The logistic regression model was used to determine factors associated with the death of pedestrians. In the present study, the significance level was considered <0.05. All analyses were performed using STATA version 12 (college station, Texas 77845, USA).

Results

From a total of 93,788 traffic accidents, 10,742 cases (6804 males and 3938 females) were pedestrians. Among them, 10,059 were injured including 3771 females (37.5%) and 6288 males (62.5%), 469 were killed including 105 females (22.4%) and 364 males (77.6%) and the outcome of 214 people was unknown. The mean age of the urban pedestrians was 37.16 ± 0.2 years, and that of suburban pedestrians was 34.6 ± 0.96 years. Table 1 shows the frequency distribution of urban and suburban accidents according to some variables of the demographic and residential status of the accidents' location, type of vehicle, and pedestrian position. The majority of injuries and deaths are in the age group of 35–64 years. In terms of the type of vehicle, 72% of deaths in urban accidents and 84% of deaths in suburban accidents occurred by conventional or pick up vehicles. In terms of pedestrian position, 68% of the deaths in urban accidents and 53% of deaths in suburban accidents occurred in crossing the road from the authorized route [Table 1].

Table 2 shows the frequency distribution of urban and suburban accidents according to demographic variables including conditions of lighting, weather conditions, road type, season, weekday in terms of holiday, and classifications of the roads. In terms of condition of lighting, more than half of the deaths and injuries occurred in day and terms of weather conditions >90% of the deaths and injuries occurred in sunny weather. In terms of the road type, 68% of the deaths in urban accidents and 52% of deaths in suburban accidents occurred in the two-way divided roads.

Table 3 shows the risk factors associated with pedestrian fatalities in urban and suburban traffic accidents. In urban accidents, the effects of pedestrian age such as 35–64 years

Table 1: The frequency distribution of urban and suburban accidents according to some demographic variables of residential status of the accident location, type of vehicle, and pedestrian's position

Variables	Status	Urban			*P*	Suburban			*P*
		Injury, *n* (%)	Fatality, *n* (%)	Total, *n* (%)		Injury, *n* (%)	Fatality, *n* (%)	Total, *n* (%)	
Age (years)	<15	1237 (12.5)	38 (9.3)	1275 (12.4)	<0.001	58 (15.5)	7 (11.8)	65 (15)	0.053
	15-24	1635 (16.5)	36 (8.7)	1671 (16.2)		65 (17)	5 (7.8)	70 (15.8)	
	25-34	2212 (22.4)	58 (14.2)	2270 (22.1)		82 (22)	8 (13.7)	90 (20.8)	
	35-64	3735 (37.7)	164 (40.4)	3899 (37.8)		147 (39)	33 (52.9)	180 (40.9)	
	>65	1076 (10.9)	111 (27.3)	1187 (11.5)		26 (6.5)	9 (13.7)	35 (7.5)	
Sex	Female	3727 (37.7)	93 (22.3)	3820 (37.1)	<0.001	97 (25.4)	12 (15.7)	109 (23.8)	0.081
	Male	6153 (62.3)	313 (77.7)	6466 (62.9)		284 (74.6)	63 (84.3)	347 (76.2)	
Residential status of the accident location	Residential area	7965 (85.9)	315 (82.2)	8280 (85.8)	0.044	156 (49.4)	17 (25.4)	173 (45.2)	<0.001
	Nonresidential area	1306 (14.1)	68 (17.8)	1374 (14.2)		160 (50.6)	50 (74.6)	210 (54.8)	
Type of vehicle	Conventional or pickup	6484 (73.2)	262 (72.4)	6746 (73.1)	<0.001	277 (80.3)	53 (84.1)	330 (80.9)	0.059
	Heavy and semi-heavy	539 (6.1)	57 (15.8)	596 (6.5)		33 (9.6)	9 (14.3)	42 (10.3)	
	Motorcycle or bicycle	1840 (20.8)	43 (11.9)	1883 (20.4)		35 (10.1)	1 (1.6)	36 (8.8)	
Pedestrian's position	Crossing the road from the authorized route	5608 (83.7)	187 (68)	5795 (83.1)	<0.001	173 (77.2)	26 (53.1)	199 (72.9)	0.001
	Crossing the road from an Unauthorized route	1090 (16.3)	88 (32)	1178 (16.9)		51 (22.8)	23 (46.9)	74 (27.1)	

Table 2: The frequency distribution of urban and suburban accidents according to variables of the condition of lighting, weather conditions, road type, season, weekday in terms of holiday and classification of roads

Variable	Status	Urban			*P*	Suburban			*P*
		Injury, *n* (%)	Fatality, *n* (%)	Total, *n* (%)		Injury, *n* (%)	Fatality, *n* (%)	Total, *n* (%)	
Condition of lighting	Day	6214 (67.4)	220 (57.7)	6434 (67)	<0.001	207 (65.9)	38 (56.7)	245 (64.3)	0.268
	Night	2629 (28.5)	151 (39.6)	2780 (29)		94 (29.9)	24 (35.8)	118 (31)	
	Sunrise or sunset	373 (4.1)	10 (2.6)	383 (4)		13 (4.1)	5 (7.5)	18 (4.7)	
Weather conditions	Sunny	8918 (96.8)	359 (94.2)	9277 (96.7)	<0.001	303 (96.8)	66 (98.5)	369 (97.1)	0.517
	Cloudy or foggy	137 (1.5)	12 (3.2)	149 (1.5)		4 (1.3)	1 (1.5)	5 (1.3)	
	Snowy or rainy	159 (1.7)	10 (2.6)	169 (1.8)		6 (1.9)	0 (0)	6 (1.6)	
Road type	Two-way not divided	2297 (24.9)	55 (14.4)	2352 (24.5)	<0.001	107 (34.3)	7 (10.5)	114 (30)	<0.001
	Two-way divided	4818 (52.3)	260 (68.2)	5078 (52.9)		127 (40.7)	35 (52.2)	162 (42.8)	
	One-way	2096 (22.8)	66 (17.3)	2162 (22.6)		78 (25)	25 (37.3)	103 (27.2)	
Season	Spring	2447 (26.3)	82 (21.3)	2529 (26.1)	0.034	77 (21.3)	13 (18.6)	90 (20.9)	0.328
	Summer	2420 (26)	90 (23.4)	2510 (25.9)		88 (24.4)	15 (21.4)	103 (23.9)	
	Autumn	2469 (26.5)	115 (30)	2584 (26.6)		95 (26.3)	26 (37.1)	121 (28.1)	
	Winter	1984 (21.3)	97 (25.3)	2081 (21.4)		101 (28)	16 (22.9)	117 (27.1)	
Week day in terms of holiday	Before holiday	1522 (16.3)	50 (13)	1572 (16.2)	0.013	69 (19.1)	14 (20)	83 (19.3)	0.735
	Holidays	1411 (15.1)	68 (17.7)	1479 (15.3)		69 (19.1)	15 (21.4)	84 (19.5)	
	After holidays	1661 (17.8)	88 (22.9)	1749 (18)		64 (17.7)	15 (21.4)	79 (18.3)	
	Normal days	4726 (50.7)	178 (46.4)	4904 (50.5)		159 (44)	26 (37.1)	185 (42.9)	
Classification of road	Highways	1141 (63.1)	121 (72.9)	1262 (64)	0.012	48 (17.2)	28 (41.8)	56 (17.2)	<0.001
	Road	666 (36.9)	45 (27.1)	711 (36)		231 (82.8)	39 (58.2)	270 (82.8)	

and >65 years compared to 15–24 years (OR: 2.04, confidence interval [CI]: 1.26–3.3 and OR: 4.8, CI: 2.9-7.9), male gender (OR: 2.26, CI: 1.6–3.1), lighting condition at night compared to day (OR: 1.6, CI: 1.2–2.1), two-way not divided road versus one-way road (OR: 1.6, CI: 1.12-2.3), the status of day after holidays compared to normal days (OR: 1.53, CI: 1.09–2.14), type of vehicle such as heavy or semi-heavy and conventional or pickup versus motorcycles or bicycles (OR: 5.4, CI: 3.1–8.9 and OR: 1.8, CI: 1.2–2.7) and pedestrian position at crossing the road from an unauthorized route compared to crossing the road from an authorized route (OR: 1.94, CI: 1.4–2.6) were significant on the fatality. Whereas in suburban accidents, pedestrian fatality showed a statistically significant correlation only

with two-way divided road compared to one-way road (OR: 0.2, CI: 0.05–0.77) [Table 1].

Discussion

The results of this study showed that some risk factors in increasing the fatality of pedestrian in urban traffic accidents are not considered as risk factors in suburban accidents. They include pedestrian's age, pedestrian's sex, condition of lighting, weekday in terms of holidays, type of vehicle and pedestrian position. Furthermore, the results of this study showed that the only common risk factor in urban and suburban accidents is the road type. The risk of pedestrian fatalities in urban accidents was higher in two-way not divided than in one-way roads, while in suburban accidents the fatality risk was lower in two-way not divided and two-way divided roads than in one-way roads. Based on the results of this study, some of the increased risk factors for pedestrian deaths in urban areas and the suburban areas are not known as risk factors. However, regarding the content of Table 3 and the wide CI of suburban OR, the non-significant *P* value of correlations can be due to a small sample size.

Based on the results of this study, age is an effective and significant factor on the death of pedestrians in urban traffic accidents. Ameri and Karimnia showed in their study that Iranian elders are more likely to die in traffic accidents than other age groups.[1] This matter has also been observed in other studies.[14,19-21] Aging causes more severe injuries and as a result, an increased risk of fatality from traffic accidents in old pedestrians can be due to reducing the visibility of vehicles, senses and perception, reduced ability of walking, and low response to the risk.

Table 3: Determination of factors related to pedestrian fatalities in urban and suburban traffic accidents in Tehran and Alborz Provinces

Variable	Status	Urban		Suburban	
		Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Sex	Female	-	-	-	-
	Male	2 (1.2-2.6)***	2.26 (1.6-3.1)***	1.83 (0.92-3.6)	1.89 (0.63-5.6)
Age (years)	<15	1.4 (0.85-2.3)	1.6 (0.85-3.07)	1.65 (.43-6.18)	2.06 (0.28-15)
	15-24	-	-	-	-
	25-34	1.2 (0.76-1.9)	1.09 (0.62-1.9)	1.35 (.37-4.8)	1.4 (0.27-7.3)
	35-64	2.03 (1.36-3)***	2.04 (1.26-3.3)**	2.94 (0.98-8.8)	3.1 (0.78-12.2)
	>65	4.75 (3.1-7.2)***	4.8 (2.9-7.9)***	4.6 (1.2-17.3)*	5.3 (0.9-31.6)
Lighting condition	Day	-	-		-
	Night	1.62 (1.31-2)***	1.6 (1.2-2.1)***	1.4 (0.79-2.4)	-
	Sunrise or sunset	0.75 (0.4-1.43)	0.64 (0.28-1.5)	2.1 (0.7-6.2)	-
Weather conditions	Sunny		-		-
	Cloudy or foggy	2.17 (1.19-3.96)*	2.11 (0.97-4.5)	1.15 (1.12-10.4)	-
	Snowy or rainy	1.56 (0.81-3)	1.6 (0.69-3.7)	Empty	-
Residential status of the accident location	Residential area	-	-	-	-
	Nonresidential area	1.31 (1.006-1.7)*	1.1 (0.75-1.6)	-	-
Type of vehicle	Conventional or Pickup	1.73 (1.25-2.4)***	1.8 (1.2-2.7)**	6.7 (0.9-50)	1.9 (0.23-16.4)
	Heavy and semi-heavy	4.5 (3-6.8)***	5.4 (3.1-8.9)***	9.5 (1.14-79.5)*	4 (0.37-45)
	Motorcycle or bicycle	-	-	-	-
Pedestrian position	Crossing the road from the authorized route	-	-	-	-
	Crossing the road from an Unauthorized route	2.42 (1.86-3.14)***	1.94 (1.4-2.6)***	3 (1.6-5.7)***	1.68 (0.62-4.6)
Road type	Two-way not divided	1.71 (1.3-2.25)***	1.6 (1.12-2.3)**	0.85 (0.48-1.5)	0.55 (0.22-1.4)
	Two-way divided	0.76 (0.53-1.1)	0.85 (0.53-1.4)	0.2 (0.08-0.49)***	0.2 (0.05-0.77)*
	One-way	-	-	-	-
Season	Spring	0.68 (0.5-0.92)*	0.83 (0.55-1.26)	1.06 (0.48-2.3)	-
	Summer	0.76 (0.57-1.02)	0.87 (0.59-1.29)	1.07 (0.5-2.3)	-
	Autumn	0.95 (0.72-1.25)	1.11 (0.78-1.58)	1.72 (0.87-3.4)	-
	Winter	-	-	-	-
Week day in terms of holiday	Before holiday	0.87 (0.63-1.2)	1.01 (0.68-1.5)	1.24 (0.61-2.5)	-
	Holidays	1.28 (0.96-1.7)	1.18 (0.79-1.76)	1.33 (0.66-2.66)	-
	After holidays	1.4 (1.1-1.82)*	1.53 (1.09-2.14)*	1.43 (0.71-2.88)	
	Normal days	-	-	-	-
Type of ways	Highways	-	-	3.4 (1.9-6.1)**	0.92 (0.35-2.77)
	Road	-	-	-	-

***<0.001, **<0.01, *<0.05. CI: Confidence interval, OR: Odds ratio

According to the results of this study, in urban accidents, the OR of pedestrian fatalities was higher when crossing the roadway from an unauthorized route than crossing an authorized route. In line with the present study, the results of Sze *et al.* showed that the risk of pedestrian fatality is higher when crossing the road or junction and walking along footpath compared to other positions.[17] In the study of Kiya and Soori, 19.1% of dead pedestrians traveled on unauthorized routes.[21] Pedestrians would rather cross from unauthorized routes and accept the risk of accidents due to inappropriate and inadequate facilities of the roads. The proper control of traffic and the creation of physical barriers, such as plants and concrete edges, will influence the decision of passersby to cross authorized routes of the street routes.[18] In addition, one of the key factors in people's decision on using road facilities, such as bridges, is that the bridges ought to be built on their ways. Therefore, the proper positioning of bridges in the usual pedestrian movement, the use of bridges for all people, and the importance of these bridges in terms of increasing the safety of the public, encourage pedestrians to use these bridges.[18] Furthermore, to increase the use of pedestrians, the escalator seems to be a good solution.[22]

The results of this study showed that there was a statistically significant relationship between the lighting condition and pedestrian fatalities in urban accidents. The OR of pedestrians' death at night was higher than that on the day. Shadmani *et al*. showed that driving at sunrise is one of the most important variables affecting traffic accident fatalities in both urban and suburban areas.[5] In the study of Vorko-Jović *et al*., the risk of death at night, sunrise, and sunset was 2.29 times higher than that on the day.[23] Furthermore, Kiya and Soori found that at 15–18 and 18–21 o'clock, the highest traffic accidents occurred for pedestrians.[21] The high risk of death of pedestrians at night can be due to insufficient lighting in the roads, lack of lights in vehicles, fatigue, and drowsiness of drivers, and as a result, delayed seeing of pedestrian, and high-speed collision of the vehicle with pedestrians. The state of the control of traffic police should also be considered as a possible factor.

In the present study, there was a statistically significant relationship between the type of vehicle and pedestrian death in urban road accidents. The risk of death in the case of collision of heavy and semi-heavy-duty vehicles and conventional or pickup with pedestrians was higher than the risk of death related to motorcycles or bicycles. This relationship was also observed in Zhang *et al*. in China.[8] Furthermore, a study by Desapriya *et al*. in 2010 showed that the risk of death in collision of trucks with pedestrian was 55% higher than conventional vehicles ($P < 0.001$).[24] The heavyweight and volume of heavy vehicles compared with motorcycle and bicycle can be a reason for the increased rate of pedestrian fatalities. A study by Ballesteros *et al*. in 2004 on pedestrian injuries and vehicle type in Maryland indicated that vehicle heavyweight and speed were associated with an increase in pedestrian's death and injuries.[13]

In the present study, there was a statistically significant relationship between days of the week in terms of holidays and the death of pedestrians in urban accidents. Therefore, the OR of fatality on the days after the holiday was higher than the normal days of the week. However, the results of some studies indicate that there is no statistically significant relationship between weekdays and the severity of pedestrian's injuries.[17] However, several studies have shown this relationship. The results of Khorshidi *et al*. showed that the frequency of all types of accidents on days before the long holidays is higher than the other days.[10] in the study of Sadeghian *et al*., there was a statistically significant difference in the frequency of injuries caused by traffic accidents in different days of the week.[25] The results of Mabunda *et al*. showed that the highest frequency of pedestrian's fatality occurred in the early days of the week.[26] As various studies have shown, with increasing pedestrian traffic, the frequency of traffic accidents in pedestrians is significantly increased.[27,28] In the present study, the increased risk of death after holidays can be due to increased traffic load on the passageways and the increasing population at risk as a result of increased volumes of traffic vehicles as well as more pedestrian traffic for purchasing, school openings, educational and public institutions. In this direction, the results of the study by Moradi *et al*. indicated that the least incidence of pedestrian-related traffic accidents in Tehran occurred during the various months of April, due to the decrease of traffic in passageways and the number of passersby, the closure of schools until mid-month and reduced student traffic in the first half of the April due to Nowruz holiday.[29]

Conclusion

The findings of this study show that mortality risk factors for pedestrians are different in urban and suburban traffic accidents. Therefore, so as to reduce traffic accident fatality, it is necessary to take appropriate measures in the urban and suburban areas.

The strength of this study was to use the two most important national sources of traffic accidents (traffic police and forensic medicine) to obtain more accurate data on deaths. The limitations of this study include the inability to access certain factors, such as vehicle speed and alcohol consumption, which may be effective on the consequences of accidents, and most importantly the lack of access to the population at risk.

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Conflicts of interest

There are no conflicts of interest.

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