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Epidemiology and Outcome Determinants of Pedestrian Injuries in a Level I Trauma Center in Southern Iran; A Cross-Sectional Study

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ABSTRACT

Objective: To epidemiologically assess the accidents and incidents in the injured pedestrians referred to Shahid Rajaee Hospital, Shiraz in order to provide basic preventive strategies and reduce injuries and fatalities caused by traffic accidents in pedestrians.
Methods: This cross-sectional study was conducted on 5840 injured pedestrians referred to Shahid Rajaee Hospital, Shiraz from 2009 to 2014. The baseline characteristic including the demographic and clinical information, the mechanism of injury, injury severity score (ISS) and outcome determinants. We also recorded the outcome measures and the mortality. Multivariate logistic regression analysis was performed to investigate the factors related to mortality rate and Length of Stay (LOS) in hospital.
Results: In our study, the history of 5840 injured pedestrians was analyzed. The mean age of the patients was 41.3219.21± years. Multivariate logistic regression indicated that mortality increased with age. Moreover, the odds of mortality was more in patients with Injury Severity Score (ISS) between 16 and 24 [OR: 12.94, 95% CI (3.78-32.66), p=0.001] and injuries in the head and neck [OR: 7.92, 95% CI (4.18-14.99), p=0.020]. LOS in hospital was also higher in patients with ISS>25 [OR: 16.65, 95%CI (10.68-25.96), p=0.001].
Conclusion: Pedestrians have always been one of the most vulnerable road users. Our study indicated that the adverse consequences and mortalities in pedestrians increased with age. Hence, approaches are required to improve primary prevention programs and reduce deaths and injuries due to this major public health problem.

Keywords: Epidemiology, Injuries, Pedestrains, Southern Iran.

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Introduction

Road traffic injury is of a great national public health concern. Road crashes is responsible for approximately 1.2 million death and 20 to 50 million sustain non-fatal injuries globally each (nearly 3 500 people every day) [1-3]. According to the recent study, 22% of road traffic deaths concern pedestrians, but the percentage varies greatly between continents: 39% in Africa, 26% in Europe, 22% in the Americas, but 13% in South-East Asia [4]. Among different countries with high rate of rode accidents, Iran is the highest. As, pedestrians death in Tehran and Alborz provinces were 46.5 and 40.5 respectively. However, South Khorasan province with 8.6% of pedestrians death was the lowest [5]. The highest pedestrians death proportion occurred in Pedestrians, as one of the most vulnerable road users, have a very high proportion of fatalities related to road accidents in the world [6]. Nowadays, traffic accidents are the 9th cause of mortality [7] and are expected to be the fifth leading cause of mortality in the world by 2030 [8] and the fourth cause of Years of Life Lost (YLL) [9, 10].

In Iran, traffic accidents, with the annual incidence rate of 32 cases per thousands of people, are the second cause of mortality after cardiovascular diseases, the first cause of YLL due to premature death, and the most common cause of injury. Iranian pedestrians have the largest number of injuries (39.8%) among all the road users [11, 12]. The number of injuries to pedestrians and their mortality rate is dramatically increasing in developing countries compared to develop ones [13]. Additionally, pedestrians' accidents comprise 18% of road fatalities (22 thousands annually) in high-income countries and 45% of road fatalities (200 thousands per year) in low-income ones [14]. It is possibly due to large population of pedestrians, poor road infrastructure in developing countries and poor lighting, mixed traffic and large influx of cars [15]. Factors related to the patient including demographic characteristic (sex, gender and age), accident location, pedestrian action and the vehicle affects affect the victims' outcomes [5, 16, 17]. Since Iran is one of the developing countries where the number of vehicles is rising rapidly, mortality and injuries caused by traffic accidents are very high. Factors related to the patient such as, the road, Therefore, the present study aims to epidemiologically assess the accidents and incidents in the injured pedestrians referred to Shahid Rajaee Hospital, Shiraz in order to provide basic preventive strategies and reduce injuries and fatalities caused by traffic accidents in pedestrians.

Materials and Methods

Study Population

This cross-sectional study was conducted on 5840 injured pedestrians who referred to Shahid Rajaee Hospital, Shiraz and admitted to the triage and emergency department from 2009 to 2014. Shahid Rajaee Hospital, the main trauma center of Fars province, is the largest referral center for traumatic patients in southwest of Iran, which started to work in 2008. Inclusion criteria: all the injured pedestrians who referred to this center during the last 5 years were selected through census. The patients' information was extracted from the hospital information system by using a checklist containing variables, including age, sex, marital status, accident area, injured body region, Injury Severity Score (ISS), Length of Stay (LOS) in hospital, and history of nosocomial infections.

Study Protocol

Injury severity was assessed using the ISS [18, 19]. In doing so, an Abbreviated Injury Score (AIS) was assigned to each injury based on the six body regions (head, face, chest, abdomen, extremities, and pelvis). The highest AIS from the 3 most severely injured body regions were squared and summed to produce the ISS [8, 10]. Accordingly, the injury severity was categorized as 1-3, 4-8, 9-15, 16-24, and ≥25. LOS was the hospitalization period; i.e., the interval between admission and discharge/death date for each individual. In this study, LOS was categorized into two intervals; i.e., ≤2 and >2 days. Nosocomial infections were defined as the infections that were caught in the hospital and were potentially caused by organisms that are resistant to antibiotics. Individuals with a positive culture obtained from blood, respiratory secretions, urinary system, surgical incision site, or cerebrospinal fluid and those with LOS more than 48 hours were assumed to have a nosocomial infection.

Statistical Analysis

The data were initially entered into the EXCEL 2013 software and their accuracy was checked. If the data were not consistent, necessary corrections were performed by referring to the patients' medical records. Then, statistical analyses were performed using the SPSS statistical software, version 19. For descriptive analysis, mean and Standard Deviation (SD) were computed for quantitative variables and absolute and relative frequencies were calculated for categorical ones. For analytical analysis, chi-square test and multivariate logistic regression based on 5% level of significance were used to determine the relationship between the variables and outcome. All variables with $p<0.3$ in the univariate analysis were entered into the multivariate logistic regression model to control for confounding effects . According to the missing of some variables, the modelling was implemented using 2935 sample.

Normality was also checked using one sample Kolmogorov-Smirnov test for continuous variables. All the statistical evaluations were made assuming a two-sided test based on 5% level of significance.

Results

In our study, the history of 5840 injured pedestrians was analyzed. The descriptive characteristics of the injured pedestrians is presented in Table 1. Accordingly, the mean ± SD of the patients' age was 41.3219.21± years. Besides, mortality was higher in males than in females (3.2% vs. 2.5%). As a whole, there is 172 (2.9%) death among the study subjects.

Moreover, the number of deaths was higher in married patients (3.2%), above 55 years age groups (7.6%), patients with ISS = 16-24 (9.9%), patients with injuries in the head and neck (8.0%), and patients with history of hospitalization in ICU (72.4%).

LOS in hospital was less than two days in 3845 patients (67.4%) with history of hospitalization in ICU. Also, the LOS in hospital was less than 2 days in 1589 females (70.6%). However, it was more than 2 days in 620 patients (42.7%) above 55 years of age, 941 patients (61.2%) with extremity injuries, and 281 ones (64.6%) with ISS = 16-24.

The results of univariate logistic regression analysis for the factors associated with mortality and LOS in hospital in injured pedestrians is presented in Table 2. These results showed that age ($p \leq 0.001$), injured body region ($p \leq 0.001$), ISS ($p \leq 0.001$), and marital status ($p=0.005$) were significantly related to mortality. Furthermore, age ($p \leq 0.001$), injured body region ($p=0.009$), ISS ($p \leq 0.001$), and gender ($p \leq 0.001$) were associated with LOS in hospital.

The results of multiple logistic regression analysis for the factors associated with mortality and LOS in hospital is presented in Table 3. These results showed that age, injured body region, and ISS were significantly associated with both mortality and LOS in hospital.

Mortality

The odds of mortality was approximately 8 times greater in the patients with head and neck injuries in comparison to those who suffered from injuries in extremities [OR: 7.92; 95% CI (4.18-14.99), $p=0.020$] and approximately 13 times greater in the patients with ISS=16-24 compared to those with ISS = 1-3 [OR: 12.94; 95% CI (3.78-32.66), $p \leq 0.001$]. Moreover, the odds of death increased with age [OR: 1.40, 95% CI (1.03-1.50), $p \leq 0.001$].

Length of Stay in Hospital

The odds of LOS in hospital >2 days was 1.25 times greater in males than in females [OR: 1.25; 95% CI (1.05-1.49), $p=0.012$], 0.67 times greater in the patients with head and neck injuries compared to those suffering from injuries in extremities [OR: 0.67; 95% CI (0.51-0.87), $p=0.004$], and 16.65 times greater in the patients with ISS > 25 in comparison to those with ISS=1-3 [OR: 16.65; 95% CI (10.68-25.96), $p \leq 0.001$]. Moreover, the odds of LOS in hospital

Table 1. Description of the socio-demographic factors of pedestrian accidents in Fars province, Iran.

	Mortality			LOS	
	Total (n=5840) n (%)	**Non-survived (n=172)**	**Survived (n=5668)**	**<2 (days) (n=3872)**	**>2 (days) (n=1968)**
Gender (n=5840)					
Female	2252 (38.6)	57 (2.5)	2195 (97.5)	1589 (70.6)	663 (29.4)
Male	3588 (61.4)	115 (3.2)	3473 (96.8)	2283 (63.6)	1305 (22.3)
Age (year) (n=5840)					
<35	2806 (48.0)	33 (1.2)	2773 (98.2)	2015 (71.8)	791 (28.2)
35-55	1583 (27.1)	29 (1.8)	1554 (26.6)	1026 (64.8)	557 (35.2)
55>	1451 (24.8)	110 (7.6)	1341 (23.0)	831 (57.3)	620 (42.7)
Martial status (n=5840)					
Single	983 (16.8)	15 (1.5)	968 (98.5)	639 (65.0)	344 (35.0)
Married	4857 (83.2)	157 (3.2)	4700 (96.8)	3233 (66.6)	1624 (33.4)
Injured body region (n=2935)					
Head and neck	842 (28.7)	67 (8.0)	775 (92.0)	373 (44.3)	469 (55.7)
Face and chest	243 (8.3)	11 (4.5)	232 (95.5)	122 (50.2)	121 (49.8)
Abdomen	313 (10.7)	12 (3.8)	301 (96.2)	129 (41.2)	184 (58.8)
Extremities	1537 (52.4)	24 (1.6)	1513 (98.4)	596 (38.8)	941 (61.2)
Injury severity score (n=3375)					
1-3	600 (17.8)	7 (1.2)	593 (98.8)	481 (80.2)	119 (19.8)
4-8	669 (19.8)	9 (1.3)	660 (98.7)	374 (55.9)	295 (44.1)
9-15	1448 (42.9)	54 (3.7)	1394 (96.3)	526 (36.3)	922 (63.7)
16-24	435 (12.9)	43 (9.9)	392 (90.1)	154 (35.4)	281 (64.6)
≥25	223 (6.6)	11 (4.9)	212 (95.1)	87 (39.0)	136 (61.0)
ICU admission(5840)					
Yes	134 (2.3)	97 (72.4)	37 (27.6)	3845 (67.4)	1861 (32.6)
No	5706 (97.7)	75 (1.3)	5631 (98.7)	27 (20.1)	107 (79.9)
LOS (days) (n=5840)**					
<2	5836 (99.9)	169 (2.9)	5667 (97.1)	-	-
>2	4 (0.1)	3 (75.0)	1 (25.0)	-	-

Table 2. Crude Odds Ratio (OR) estimating the factors associated with mortality and LOS in hospital in pedestrian accidents.

	Mortality		LOS	
	OR (95% CI)	P-value	OR (95% CI)	*p*-value
Age (years)	1.40 (1.04-1.50)	0.001[b]	1.10 (1.01-1.20)	0.001[b]
Gender				
Female	Reference	Reference	Reference	Reference
Male	1.27 (0.92-1.75)	0.139	1.37 (1.22-1.53)	0.001[b]
Marital status				
Single	Reference	Reference	Reference	Reference
Married	2.15 (1.26-3.67)	0.005[a]	0.93 (0.80-1.07)	0.346
Injured body region				
Extremities	Reference	Reference	Reference	Reference
Head and neck	5.45 (3.39-8.57)	0.001[b]	0.79 (0.67-0.94)	0.009[a]
Face and chest	2.98 (1.44-6.18)	0.003[a]	0.62 (0.47-0.82)	0.001[b]
Abdomen	2.51 (1.24-5.08)	0.010[a]	0.90 (0.70-1.15)	0.421
Injury severity score				
1-3	Reference	Reference	Reference	Reference
4-8	1.15 (0.42-3.12)	0.776	3.18 (2.47-4.10)	0.001[b]
9-15	3.28 (1.48-7.25)	0.003[a]	7.08 (5.64-8.89)	0.001[b]
16-24	9.29 (4.13-20.86)	0.001[b]	7.37 (5.56-9.76)	0.001[b]
≥25	4.39 (1.68-11.48)	0.003[a]	6.31 (4.51-8.83)	0.001[b]
LOS in hospital (days)				
≤2	Reference	Reference	Reference	Reference
>2	2.69 (1.97-3.65)	0.001[b]	-	-

[a]Statistically significant at the 5% level; [b]statistically significant at the 1% level.

Table 3. Adjusted Odds Ratio (OR) estimating the factors associated with mortality and LOS in hospital in pedestrian accidents

	Mortality n=2935		LOS n=2935	
	OR (95%CI)	*p*-value	OR (95%CI)	*p*-value
Age (years)	1.40 (1.03-1.50)	0.001[b]	1.10 (1.00-1.20)	0.019[a]
Gender				
Female	Reference	Reference	Reference	Reference
Male	-	-	1.25 (1.05-1.49)	0.012[a]
Injury severity score				
1-3	Reference	Reference	Reference	Reference
4-8	4.38 (1.26-15.22)	0.020[a]	3.66 (2.71-4.95)	0.001[b]
9-15	11.11 (4.41-37.91)	0.001[b]	8.71 (6.57-11.56)	0.001[b]
16-24	12.94 (3.78-32.66)	0.001[b]	15.22 (10.64-21.76)	0.001[b]
≥25	5.09 (1.48-17.49)	0.010[a]	16.65 (10.68-25.96)	0.001[b]
Injured body region				
Extremities	Reference	Reference	Reference	Reference
Head and neck	7.92 (4.18-14.99)	0.020[a]	0.67 (0.51-0.87)	0.004[a]
Face and chest	5.79 (2.65-12.63)	0.001[b]	1.57 (1.12-2.19)	0.008[a]
Abdomen	2.28 (1.10-4.70)	0.025[a]	0.87 (0.67-1.13)	0.009[a]

[a]Statistically significant at the 5% level; [b]statistically significant at the 1% level.

increased with age [OR: 1.10; 95% CI (1.00-1.20), *p*=0.019].

Discussion

Despite the widespread knowledge about pedestrian injuries in developed countries, there are many evidences in developing countries that indicate lack of compliance to implement this knowledge for control of pedestrian injuries and lack of sufficient research in this field.

The present study assessed the epidemiological characteristics of the injured pedestrians in Fars province over the last 5 years. The data were collected from Rajaee trauma center, Shiraz, Iran. Based on the results, the fatalities caused by traffic accidents were similar in males and females (3.2% vs. 2.5%), which is consistent with the results of the study by Bumbasirevic and colleagues [20]. Additionally, the 55-year age group had higher mortality (7.6%) compared to other age groups. Moreover, most of the hospitalized cases were the elderly pedestrians (> 55 years) , which is consistent with the results of other studies [21-25].

The findings of the present study showed that age, ISS, and injured body region were associated

with mortality in both crude and adjusted analyses. Accordingly, mortality increased with age, which is consistent with the results of other studies [12, 26]. According to the study by Harruff and colleagues [21]. elderly pedestrians, due to aging and less mobility, are not able to cross the street at the right time. Also, the elderly's poor understanding causes delay in feeling threatened; therefore, they are less likely to be able to leave for the safe position. Underlying diseases and other aging processes can be the other causes of increased risk of injury in the elderly pedestrians [21, 27-32]. On the other hand, the reduction of the brain mass and the adhesive layer around the skull, despite the relatively low clinical signs, increases the risk of subdural hemorrhage, which could increase mortality in the elderly [33-35].

ISS was also associated with mortality, such a way that higher ISS was accompanied with higher mortality, which is consistent with the results of other studies [6, 36, 37]. According to the study performed by Salehi and colleagues [38] , although higher ISS is usually associated with more fatalities, it should be noted that mortality may be associated with other factors, such as age and existence of underlying diseases like heart disease. Notably, in the study of prognosis and mortality of multiple trauma patients with ISS, similar ISS cannot exactly represent similar prognosis.

Furthermore, mortality was higher in the patients with head and neck injuries compared with those suffering from injuries in their extremities, which is consistent with the results of other studies [26, 39]. Injured pedestrians usually suffer from multiple injuries in different body parts. During a crash, the force transmission to the pedestrian typically includes three phase impacts, namely vehicular bumper impact, vehicular hood and windscreen impact, and ground impact. Lower extremities are the most affected body region in the vehicular bumper impact phase [31, 35, 40]. Besides, head and body injuries mostly occur due to bumping into the vehicle's windshield. Severe injuries in these regions also occur due to collision [34].

The study findings showed that LOS in hospital increased with age, which is in agreement with the results of the previous studies [41-44]. In this study, adverse consequences increased with age, which can be caused by more physical weakness, decreased physiological reserve, and reduced ability to improve the performance in older pedestrians. Also, reduction of perception, sensation, and cognitive ability to response to risks could increase the severity of injury in the elderly pedestrians [45, 46].

In the current study, LOS in hospital was higher in males than in females. According to the study performed by Schoenberg and colleagues [47], females are at a greater risk of death compared to males. Besides, the majority of women lost their lives in the early hours before getting to the hospital; thus, their average LOS in hospital was lower.

Furthermore, ISS and injured body region were associated with LOS in hospital. Accordingly, LOS in hospital was higher in the patients with lower extremity injuries and in those with higher ISS, which is consistent with the results of various studies [33, 48]. In fact, injuries to the head, followed by brain damage and intracranial hemorrhage, causes immediate death thus reducing the LOS in hospital.

Since pedestrians are one of the most vulnerable road users undergoing the greatest burden of injuries among the groups using roads, it is essential to develop security programs to reduce this burden in pedestrians. These programs include general education of pedestrians regarding inappropriate behaviors, such as talking, inattention, and distraction while crossing the roads [13, 49], as well as educating drivers regarding road safety and speed reduction, which eventually decreases mortality caused by accidents in pedestrians. Also, engineering interventions in roads design, such as pedestrian lanes, road barriers, pedestrian bridges, pedestrian crossing signs, and improved road lighting in high-risk areas, can reduce injuries and deaths in pedestrians.

One of the major limitations of the present study was misclassification of some studied variables, including injury severity and injured body region, which could have affected the determination of two major outcomes; i.e., mortality and length of hospital stay. Thus, the accuracy of the final analyses of these variables was not verified.

In conclusion, accidents are a major problem in Fars province. Besides, deaths caused by traffic accidents impose a great economic burden on the society. Pedestrians are one of the most vulnerable groups at risk of road accidents. The results of the present study showed that increase in age and ISS was accompanied with increase in adverse consequences and deaths among pedestrians. Hence, approaches are required to improve primary prevention programs and reduce deaths and injuries due to this major public health problem.

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