COMPUTATIONAL RESEARCH PROGRESS IN APPLIED SCIENCE & ENGINEERING (CRPASE)

CRPASE: TRANSACTIONS OF CIVIL AND ENVIRONMENTAL ENGINEERING

Journal homepage: http://www.crpase.com

CRPASE: Transactions of Civil and Environmental Engineering 8 (1) Article ID: 2255, 1–4, March 2022 ISSN 2423-4591

Research Article

Investigation of the Factors Affecting Pedestrian Accidents in Urban Roundabouts

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Keywords

Roundabout,
Pedestrian,
Accidents,
Friedman test,
Factor analysis.

Abstract

Urban roundabouts are always implemented in order to represent the urban environment and traffic calming in cities. But with the increase in traffic flow rates as a result of the development of cities, they have sometimes lost their function. On the other hand, in many cases during off-peak hours, due to poor geometric designs of the roundabouts, drivers tend to exceed the speed limit, which in turn increases the number of pedestrian accidents in these roundabouts. Rasht, one of the most populous cities in northern Iran, has more than 20 roundabouts, and on the other hand, the number of pedestrian accidents in this city is very high. Therefore, in this study, using accident data from 2018 to 2021, the factors affecting pedestrian accidents in the urban roundabouts of Rasht city were investigated. The results of accident analysis using the Friedman test showed that the variables of accident reason, pedestrian gender, and driver age had the highest rank in the occurrence of pedestrian accidents in urban roundabouts. In addition, according to the factor analysis, the variables of lighting condition, road surface condition, and weather condition were under the first factor in pedestrian accidents in urban roundabouts. Therefore, human and environmental factors had the most significant impact on the occurrence of pedestrian accidents in Rasht urban roundabouts.

1. Introduction

Accidents are one of the most significant disadvantages of the transportation system, especially in urban environments, which endanger various groups such as pedestrians, vehicle drivers, cyclists, and motorcyclists [1]. Among these, pedestrians constitute the widest number of deaths and injuries in traffic accidents, which various factors such as the geometry of roads, the type of crossings, the clothing of pedestrians as well as the color of their clothes, and environmental factors can be of the most important variables affecting the severity of accidents. In addition, many pedestrian accidents occur at conflicting spots, including roundabouts and signalized and unsignalized intersections [2, 3]. Poor geometry design, lack of up-to-date infrastructure, and improper placement of pedestrian crossings can play a significant role in the occurrence of pedestrian accidents in urban roundabouts. Rasht, one of the most populous cities in northern Iran, with more than 20 roundabouts and significant statistics of pedestrian accidents, should be considered in accident-related studies. Therefore, after exploring various research, the factors affecting pedestrian accidents in the urban roundabouts of Rasht city are examined in this study.

In recent years, various studies have been carried out on factors affecting traffic accidents. Ghaffar et al. attempted to assess the burden of road traffic injuries (RTIs) in Pakistan. Results showed that most accidents occurred from 12 to 18. The incidence of RTI was the highest at the age of 16 to 45, and RTI in males was about three times greater than in

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Received: 14 December 2021; Revised: 13 January 2022; Accepted: 12 Februarry 2022
https://doi.org/10.52547/crpase.8.1.2255

Academic Editor: **Vahid Najafi Moghadam Gilani**

Please cite this article as: H. Hariri Asli, Investigation of the Factors Affecting Pedestrian Accidents in Urban Roundabouts, Computational Research Progress in Applied Science & Engineering, CRPASE: Transactions of Civil and Environmental Engineering 8 (2022) 1–4, Article ID: 2255.

females [4]. Labinjo et al. conducted population-based research to examine the RTI epidemiology in Nigeria. Results indicated that motorcycle accidents accounted for 54.33% of RTI. Increased risk of injury was associated with males in the age of 18 to 44 [5]. Hu and Xiang investigated the properties of road accidents by quantitative analysis. Results showed that 92.68% and 5.42% of fatalities happened in straight and curved roads, respectively. Moreover, fatalities in the daytime were more serious than those in the night time and driving a motor vehicle was the significant reason of fatalities [6]. Zangooei Dovom et al. examined the distribution of fatal accidents in Iran. According to the result, the males had more casualties compared with the females and most accidents had a peak at 21 to 30 ages for both genders. Moreover, the male-to-female ratio was 3.41. They also indicated that the riskiest group was the male motorcyclist among all road users [7]. López et al. investigated the accident patterns and contributory factors. Results of the study showed that the highest accident rate occurred in the condition of good weather, daylight, regular working day, the age group of 28–60, summer season, male gender, and from 12 to 18 [8]. Zimmerman et al. aimed to survey all people living in households within 200 m of two low volume roads in Tanzania. Results showed that the majority of accidents contained motorcycles (71%) and the majority of victims were males (82%) with 27 mean age [9]. Lee and Jeong investigated the properties of road collisions in truck drivers. Results indicated that the accident rates were greater in the middle of the week. The accident rates in the daytime were greater (81.7%) than those in the night time. Accidents mostly occurred in clear/cloudy weather (76.2%). Most accidents happened on the straight roads (62.2%), followed by intersections (15.4%) and curved roads (9.4%) [10]. Casado-Sanz et al. considered various factors affecting road accidents. The results showed that driver's age 30–45 years old, male driver, the middle of the week, good weather condition, and daylight had the maximum percentage of accidents in Spain [11]. Hosseinian et al. in a study examined factors affecting the severity of pedestrian accidents in Iran. By investigating various variables such as clothing color, age, accident time, day, weather condition, education, pedestrian action, crossing facilities, crossing permit, job, road classification, and fault status, they indicated that clothing color had a significant influence on pedestrian accidents [12].

2. Methodology

In this section, first, the study area, the required data, and how to collect them are introduced. Then the types of statistical methods are described. The purpose of this study is to determine the ranking and discover the factors affecting pedestrian accidents in the urban roundabouts of Rasht city.

2.1. Study Area

The present study was conducted in Rasht city. This city is one of the metropolises of Iran and the capital of Guilan province. Rasht is also the largest and most populous city in northern Iran.

2.2. Data Collection

In order to conduct research on road safety improvements, accident information should be collected meticulously. The results of consecutive visits to the Rasht Traffic Police Statistic Center led to the collection of information on the 12-month accidents from 2018 to 2021. In total, the statistical population was 343 pedestrian accidents that occurred in Rasht city. The collected data includes the number of injured and dead pedestrians based on variables such as age, gender, type of accident, type of road, etc.

2.3. Statistical Analyses

A variety of statistical analysis methods, including the Kolmogorov-Smirnov test, Friedman test, and factor analysis, were used to examine pedestrian accidents in urban roundabouts of Rasht city.

3. Results

3.1. Kolmogorov-Smirnov Test

In order to select the appropriate test for exploring the dataset, the statistical distribution of the data should first be ensured. The Kolmogorov-Smirnov test was used to examine the normality of the distribution. Table (1) shows the results of this test for different variables. The results showed that the test was significant, and therefore, these variables did not have a normal distribution. Therefore, nonparametric tests should be used for inference.

3.2. Friedman Test

In the research, 12 independent variables were presented that the rank of each of these variables was examined by the Friedman test. This test can be applied to evaluate the rank equality of variable levels. Table 2 shows the statistical significance in which the statistical sample volume, chi-square statistic, degrees of freedom, and the level of significance (α) are represented. As shown in Table 2, a lower level of significance of α than 5% indicated that H0 was rejected, which shows that claiming the rank equal was not accepted. As a result, ratings were not uniform. In Table 3, the ranking status of the independent variables is presented, indicating the mean rating of each variable. The smaller the mean rating, the greater the importance of the variable.

Table 4 illustrates the results of factor analysis, indicating the KMO index and the Bartlett's test. According to Table 4, the KMO index value was more than 0.60, indicating that it was appropriate to use the factor analysis. Also, the significance level of the test statistic was less than 0.05, meaning that there was a significant correlation between the variables.

Table 5 indicates the eigenvalues and variance corresponding to each component. Whatever the eigenvalue of a component is higher, that component indicates more variance. In Table 5, initial eigenvalues, eigenvalues of non-rotating and post-rotating extraction components are presented. Results indicated that the components 1 to 6 had eigenvalues greater than 1. So, they remained in the analysis. Moreover, Table 6 also indicates the matrix of the remaining

components. The values in Table 6 illustrate the correlation of each variable with the relevant components.

Factor analysis was performed on 12 independent variables affecting pedestrian accidents in urban roundabouts of Rasht city, which identified six factors as the main factors. The analysis showed that the variables of lighting condition, road surface condition, and weather condition were under the first component. Also, accident time, accident season, and driver gender were under the second most influential components in accidents. Similarly, guilty vehicle, driver age, and pedestrian gender variables were under the third component, accident day was under the fourth component, accident reason was under the fifth component, and finally, pedestrian age was considered as the sixth most effective factor in pedestrian accidents in urban roundabouts of Rasht city.

Table 1. Kolmogorov-Smirnov test results

Number	Variables	Most extreme differences			Asymp. sig. (2-tailed)
		Absolute	Positive	Negative	
1	Accident time	0.192	0.181	-0.192	0.0
2	Accident day	0.217	0.217	-0.217	0.0
3	Accident season	0.228	0.228	-0.195	0.0
4	Road surface condition	0.492	0.492	-0.328	0.0
5	Lighting condition	0.389	0.389	-0.293	0.0
6	Accident reason	0.266	0.182	-0.266	0.0
7	Driver gender	0.538	0.538	-0.391	0.0
8	Driver age	0.279	0.279	-0.235	0.0
9	Pedestrian age	0.213	0.213	-0.177	0.0
10	Pedestrian gender	0.252	0.142	-0.252	0.0
11	Weather condition	0.487	0.487	-0.323	0.0
12	Guilty vehicle	0.448	0.448	-0.298	0.0

Table 2. The Friedman test results

Number of data	Chi-square	Degrees of freedom	Asymp. sig.
343	2784.688	11	0.0

Table 3. Mean rank in the Friedman test

Variables	Mean	Rank
Accident reason	10.53	1
Pedestrian gender	9.61	2
Driver age	8.92	3
Accident time	8.46	4
Accident season	8.33	5
Accident day	6.42	6
Pedestrian age	5.49	7
Lighting condition	4.56	8
Guilty vehicle	4.19	9
Weather condition	4.10	10
Road surface condition	3.66	11
Driver gender	3.22	12

Table 4. KMO & Bartlett's test

KMO measure of sampling adequacy	Bartlett's test of sphericity		
	Approximate. chi-square	Df	Sig.
0.750	1065.986	66	0.0

Table 5. Total variance explained

Components	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	2.297	19.143	19.143	2.297	19.143	19.143	2.297	19.143	19.143
2	1.729	14.409	33.552	1.729	14.409	33.552	1.729	14.409	33.552
3	1.380	11.500	45.052	1.380	11.500	45.052	1.380	11.500	45.052
4	1.134	9.447	54.498	1.134	9.447	54.498	1.134	9.447	54.498
5	1.122	9.349	63.847	1.122	9.349	63.847	1.122	9.349	63.847
6	1.028	8.570	72.417	1.028	8.570	72.417	1.028	8.570	72.417
7	.856	7.134	79.551				.856	7.134	79.551
8	.726	6.050	85.601				.726	6.050	85.601
9	.619	5.162	90.763				.619	5.162	90.763
10	.499	4.161	94.924				.499	4.161	94.924
11	.470	3.914	98.838				.470	3.914	98.838
12	.139	1.162	100.000				.139	1.162	100.000

Table 6. Component matrix

Variables	Components					
	1	2	3	4	5	6
Accident time	.439	-.466	.107	.109	-.318	-.362
Accident season	.307	.491	-.271	.360	.102	.167
Accident day	-.058	.090	.101	-.767	.283	.283
Road surface condition	.862	.192	-.221	-.051	.176	.026
Lighting condition	.560	-.344	.017	-.337	-.265	-.197
Guilty vehicle	-.185	.473	-.468	.079	-.304	-.338
Pedestrian age	-.142	.416	.215	.035	.421	-.485
Driver gender	-.046	-.509	-.297	.389	.351	.381
Driver age	.318	-.003	.677	.314	-.187	.254
Pedestrian gender	.181	.349	.619	.130	.218	-.094
Weather condition	.871	.196	-.197	-.069	.158	.059
Accident reason	-.042	.539	.051	-.086	-.573	.423

4. Conclusion

In this research, various methods were used to determine more accurately the variables affecting the severity of pedestrian accidents in Rasht urban roundabouts. Each method investigated the effective variables by its specific algorithm. By examining the statistics of pedestrian accidents using various statistical analyses, it was found based on the Friedman test, the most important factors affecting pedestrian accidents were accident reason, pedestrian gender, and driver age, indicating that the human factor was the most influential factor in the accidents. Moreover, according to the factor analysis, lighting condition, road surface condition, and weather condition as an environmental factor were under the first influential factor affecting pedestrian accidents of Rasht urban roundabouts. Therefore, the results showed that human and environmental factors had the greatest impact on the occurrence of pedestrian accidents in Rasht urban roundabouts. Thus, safety solutions should be presented according to the results to reduce pedestrian accidents and increase road safety.

Conflict of Interest Statement

The authors declare no conflict of interest.

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