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Construction and Implementation of a Crash Prediction Model on Two-Way Suburban Two-Lane Roads (Case Study: Qazvin-Avaj Road)

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ABSTRACT

Improving the level of road safety requires research that measures the effects of various variables on the frequency of accidents and takes practical measures to improve the level of road safety. In this study, first, the two inseparable axes of the Qazvin-Avaj suburban line were selected as a case study, and accident information was collected in the mentioned axis for the years 2010 to 2012. The number of accidents was selected as a dependent variable, and the variables of number of access roads and intersections, number of horizontal curves, and hourly traffic volume were selected as independent variables for modeling. The length of the day and night, depending on the spring and autumn hours, was divided into two parts, night and day, and a corresponding model was developed for each of them. In the end, the results were reported in such a way that the importance of effective variables in the day model is: number of access roads and intersections, hourly traffic volume, and then the number of horizontal arches. While for the night model, the variable number of horizontal arches had the most effect, followed by the number of access roads and intersections, and the least effective variable for the night model was the volume of hourly traffic.

Keywords: Accident prediction models, suburban roads, non-isolated two-lane roads.

1. INTRODUCTION

The rate of traffic accidents in relation to the number of trips, number of vehicles, and length of roads in developing countries, such as Iran, due to lack of sufficient and serious research over the past years is much higher than in countries that have sufficient attention and research in this area. Had [1-4]. Accidents affecting accidents are often divided into three categories: road, vehicle, and human [5-7]. Each of these categories can be the subject of discussion, but for road engineers, it will be more a matter of the road and the environment [8-10]. Road geometry, pavement condition, road environment, weather conditions, and traffic parameters are among the parameters of the road and environment subset [11]. Each of which can be divided into more subtle subgroups. In the following, studies are reviewed in order to select independent and affective variables on accidents. Knuiman examined the effect of the median width of four-lane roads on the crash rate using a negative binomial distribution. The results of this study show a decrease in the accident rate with increasing median width. In addition, the wider midpoints drastically reduce the rate of head-to-head off-road crashes between two-way cars, and as a result, the increase in width has a greater impact on severe crashes than crashes with only financial losses [12]. In 1998, Vogt and Bared developed a set of Poisson negative binomial regression models for predicting crash rates for suburban two-lane roads. Predictive variables include traffic volume, percentage of freight vehicles, shoulder and lane width, horizontal and vertical curves, roadside conditions, and route access density. These models are used to establish the base crash rate in crash prediction models [13]. The first crash prediction models for multi-lane roads were proposed by Pearsad in 1993, in which the relationship between crash statistics and traffic flow by daily average and hourly volume, the flow is described. The results show that the accident rate increases with the increase of traffic flow, which is explained by the average hourly volume of daily traffic flow [14]. Mahmoudabadi, in his model, for estimating the daily number of road accidents in Iran in 1987, has concluded that the number of types of accidents is inversely related to the traffic composition, which means that the higher the share of heavy vehicles, all injuries, and death and damage accidents will increase. Oh and Chang have found the relationship between crash rates and volume-to-capacity ratio (V / C) for various facilities on freeways. In the model proposed by Oh et al., Hourly rate and V / C rates for different sections of freeways such as main sections, tunnel sections, and toll sections have been calculated. They concluded that the relationship between V / C and the crash rate at all sections follows a u-shaped function [15]. In 2018, they developed an accident prediction model for freeway sections that was a function of traffic volume, the percentage of heavy vehicles, and weather conditions. They have stated that despite the length of the sections, the volume of traffic has a non-linear relationship with the occurrence of traffic accidents on freeways [16]. Thorton and Lyles have reported that higher speeds do not lead to more crashes. This study was performed by testing different speed limits, especially between 55 and 65 mph in Michigan [17]. An analysis by Lave shows that the main factor leading to accidents is not speeding alone. Rather, it is the difference between the speeds of vehicles moving in the same direction. This means that when cars are moving at the same speed, the traffic situation is safer, regardless of whether the speed is high or not, because the probability of an accident will be lower [18]. Yerpez and Fernandez (1986) analyzed irregular radius arcs and found that a 50% reduction in arc radius over 30 m increased the number of accidents [19]. In the case of spiral arches, Kansel (1998) argues that these arches reduce the accident rate on high-standard roads by 8 to 25 percent but found no reason to reduce road accidents to the standard design standard [19]. In a model developed by Mayora and Rnhio in 2003 for two-lane roads in the Spanish suburbs, the effect of accesses was calculated as the density of access points (access points per kilometer), resulting in an increase in the accident rate as the access density increased [20]. Previous research on the analysis of the number of accidents has relied more on statistical models such as linear regression models, Poisson regression model, and negative binomial models, and in these models, the relationships between accidents and traffic passing geometric characteristics and environmental factors have been investigated [21, 22]. In some of these studies, linear multivariate regression models have been used to predict the number of accidents, and it has been assumed that the number of accidents or accident rates of a linear function of various traffic environmental characteristics such as flow, climate, geometric design, driving status [23, 24]. However, in linear regression, it is assumed that the number of accidents follows the normal distribution. However, this assumption is not true for accidents [25] because it cannot express the random nature and discontinuity of road accidents. Also, according to this assumption, linear regression cannot be used for the non-negative nature of accidents [26] because, in some cases, the number of accidents Estimates a negative number. Therefore, the relationship between variables and accidents cannot be assumed to be linear [27]. To overcome this unrealistic assumption, the Poisson regression model used in the Poisson regression model assumes that the accidents follow a Poisson distribution with the expected values [28]. For example, Washington et al. in 2010 examined the relationship between the geometric characteristics of roads and truck crashes in the state of Virginia using Poisson regression [29]. Using the Poisson model, Miyaho et al. in 1992 investigated the empirical relationship between the number of truck crashes and the geometric characteristics of roads on intercity suburban roads in North Carolina [30]. Yuva and Lee (2001) used the Poisson regression model to predict the number of traffic accidents and concluded that the Poisson model is preferable to the linear regression model. They also concluded that the Poisson model is used in homogeneous situations, and when the data Accidents are not very scattered, that's right. Another statistical model used in the analysis of traffic accidents is the negative binomial model. Among these researches, the following can be mentioned [31]. Famui and Singh (2006) and Hall (2000) have established a relationship between accidents and geometric characteristics of roads using a negative binomial model [32]. In this regard, Miyaho has studied the performance of Poisson regression and negative binomial regression models and concluded that if the scatter between data is high, the negative binomial model should be used. Abdul Ati et al. Have concluded that most accident information is scattered and have preferred the negative two-sentence model to the Poisson model to model accidents. Due to the advantages and disadvantages of different models, in this study, statistical models have been used due to their high efficiency in predicting accidents [33, 34].

2. METHODOLOGY

According to the studies conducted so far, none of the research conducted in the field of accident prediction modelling in our country had developed separate models for day and night. Another weakness of previous research is the lack of explicit reference to the way the model was developed with the research database. Also, in most of the models developed to predict the number of accidents, the road segmentation method is not used, and they are mostly modelled by seasons or months of the year, and it is believed that this is possible because for each independent variable used in modelling. We should have at least ten items, and the number of seasons and months of the year should not exceed 12, and yet there can be no more than one independent variable in the model; it is far from common sense. In some cases, other models developed to predict the number of accidents in other countries have divided the study axis into pieces with different lengths, and unfortunately, include the length of the piece as an independent variable in the developed model and unfavourable conclusions about the length of the piece and impact. It is based on the number of accidents; Unaware that it is clear that the longer the piece, the greater the number of accidents. And the fact that a smaller number of accidents have occurred in a longer section can be due to other factors such as the length of the straight section or a lower frequency of arches, access roads, intersections, and other factors. One of the ways to eliminate this gross mistake is to divide the path into pieces of equal lengths, which in this research axis have been segmented in this way.

2.1. CASE STUDY

According to the accident database in the mentioned years, 1042 accidents in this axis have been registered by the traffic police, and certainly, the number of accidents that occurred will be more than the number of recorded accidents. Factors such as car collisions with obstacles, guardrails, etc., deviation from the route, or the amount of damage below the amount of damage determined by insurance companies are factors that prevent the registration of accidents by the police. How many accidents are recorded by the traffic police is hidden from us. The accuracy of the recorded information is also the responsibility of the police. Finally, in this study, we examined the accidents recorded by the traffic police. It should be noted that the information of 80 km leading to Avaj was taken from the police database, Avaj - Qazvin road, and 15 km leading to Qazvin from the police database, Qazvin - Miyaneh road.

Table 1. Number of accidents registered by the traffic police in the years 2010 to 2012 on the Qazvin-Avaj route

Year	Total number of registered accidents	Injury accident	Number of injured	Fatal accident	Number of fatalities
2010	377	49	70	11	22
2011	335	68	99	14	19
2012	330	112	253	14	21

Examining the Table 1, it is clear that the number of injuries has always had an upward trend, and the severity of accidents has increased. It is also a little difficult to believe that the number of fatal accidents has not increased, given that the number of fatal accidents has increased significantly because safety and training measures in the field of accident safety have not been significant during these years. This could mean that the number of accidents has always increased, and the encouragement and punishment imposed on the road police staff to reduce the number of accidents and fatalities have led the police to provide a mechanism to reduce the number of accidents and fatalities. It should also be noted that in Iran, the traffic police record only those killed in accidents who died in accidents, while in most countries all injured in accidents who die while being transported to medical centers and injured who die within a month. They die after an accident, and those who died are considered in accidents. In cooperation with the General Directorate of Transportation and Terminals of East Azerbaijan Province, information on the traffic axis studied in the years during the study; was obtained. The mentioned information includes hourly traffic, percentage of heavy vehicles, the average speed of traffic flow, etc. Unfortunately, by referring to the General Department of Roads and Urban Development of the province and the subordinate departments of the city, it was not possible to access the executive-oriented plans studied. Therefore, some of the geometric characteristics of the route, information such as mileage, location of horizontal arches of the route, access roads, and intersections, as well as the use of roadside areas, were obtained through field research.

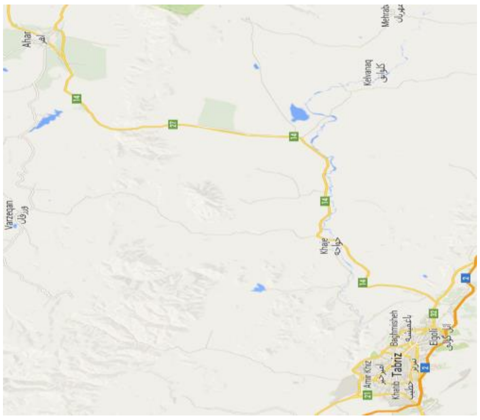

Figure 1. Map of the studied area extracted from Google Map

2.2. SEGMENTATION OF THE ROUTE

In order to segment the route, an attempt was made to divide the axis into homogeneous parts in order to allow more detailed research. Finally, for the accuracy of the work, the whole studied axis was divided into 31pieces equal to 3km. It should be noted that, if the pieces were defined with different sizes, the accident rate in the piece should be used to develop the model, and therefore, given that this research is based on the number of accidents, the pieces have equal lengths, were defined

2.3. SELECTION OF RESEARCH VARIABLES

First, the length of the day was divided into two parts of12 hours; this division was different based on spring and autumn hours to develop two separate models for research. Based on the information segmentation of arches, intersections, and access roads, the volume of traffic for the day and night hours was applied to the relevant components, and then all the information was entered into the SPS software (version21).

3. RESULTS AND DISCUSSION

In order to develop the model in question, first, a series of pre-tests and then a model had to be developed; it was also tested with third-year data from the developed model. These steps are discussed below.

3.1. INDEPENDENCE TEST OF INDEPENDENT VARIABLES

Chi-square test is used to examine the independence between independent variables in qualitative data, and correlation test is used in quantitative data.

Table 2. Correlation test

		Dastrasi	Gos	Htr	Htsh
Dastrasi	Pearson Correlation	1	-.090	.017	.019
	Sig. (2-tailed)		.630	.927	.919
	N	31	31	31	31
Gos	Pearson Correlation	-.090	1	-.258	-.257
	Sig. (2-tailed)	.630		.161	.163
	N	31	31	31	31
Htr	Pearson Correlation	.017	-.258	1	1.000
	Sig. (2-tailed)	.927	.161		.000
	N	31	31	31	31
Htsh	Pearson Correlation	.019	-.257	1.000**	1
	Sig. (2-tailed)	.919	.163	.000	
	N	31	31	31	31

Where in:

Variable number of access and intersection in the plot: Accessibility

Variable Number of horizontal arcs per piece: Gos

Average volume of hourly traffic per piece for the day model: Htr

Average variable hourly traffic volume per piece for night model: Htsh

Given that in Table 2 the values for sig are greater than 0.05, so there is no partial correlation between the independent variables, and the variables are independent of each other.

3.2. LINEAR TEST

In this study, before the regression test, the assumptions of this test should be examined first. One of the presuppositions of the regression test is to check the linearity of the independent variables.

Table 3. Coherence test (independence of variables) - for the day model

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions		
				(Constant)	Zscore(htr)	Zscore(gos)
1	1	1.279	1.000	.00	.32	.35
	2	1.000	1.131	1.00	.00	.00
	3	.989	1.137	.00	.10	.00
	4	.732	1.322	.00	.58	.64

Table (3) shows the eigenvalues and the status index, respectively. Eigenvalues close to zero indicate that the internal correlation of the predictions is high and small changes in the amount of data lead to large changes in the regression equation coefficients. Status indicators with a value of more than 15 indicate the probability of linearity between independent variables, and a value of more than 30 indicates a serious problem in using regression. It should also be noted that in this study, standard values of variables were used to reduce the maximum errors related to the alignment of variables. This means that first, the standard values of the variables (z-score) were calculated using SPSS software, and the analysis was performed with the standard values. The situation with the variables of the model of predicting the number of accidents at night is also described in Table (4).

Table 4. Coherence test (independence of variables) - for night model

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions		
				(Constant)	Zscore(htsh)	Zscore(gos)
1	1	1.278	1.000	.00	.32	.35
	2	1.000	1.131	1.00	.00	.00
	3	.988	1.137	.00	.10	.00
	4	.733	1.320	.00	.58	.64

The night model, like the day model, is in a good position in terms of alignment.

3.3. CHECKING THE NORMALITY OF ERRORS (ERROR SQUARES)

Another assumption of regression is that the errors have a normal distribution with a mean of zero [35]. Obviously, a regression cannot be used if this default is not established. For this purpose, the standard values of the errors should be calculated, and the data distribution diagram and their normal diagram should be drawn, and then a comparison should be made between the two diagrams. The results of the normal error test for the day and night model are in Figure (2) and Figure (3), respectively.

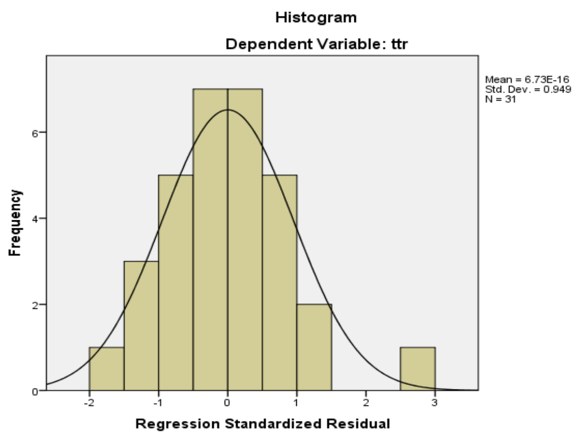

Figure 2. Normal error test for day model

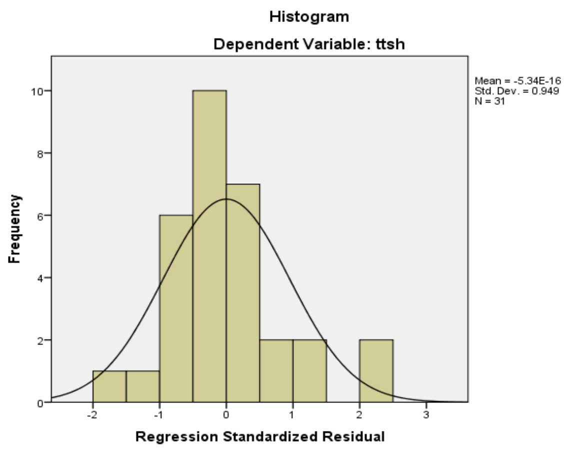

Figure 3. Normal error test for night model

Number of crashes for the day model: ttr Number of crashes for night model: ttsh By comparing the error frequency distribution diagram and the normal distribution diagram, it is observed that the error distribution is almost normal, and therefore, regression can be used.

3.4. DURBIN-WATSON TEST

Another assumption considered in regression is the independence of the errors (the difference between the actual values and the values predicted by the regression equation) from each other. The results of this test for both day and night models are shown in Tables (5) and (6), respectively.

Table 5. Durbin-Watson test for day model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.925a	.855	.839	2.01512	1.832

Table 6. Durbin-Watson test for night model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.830a	.689	.654	1.24896	2.011

Given that the value of the Durbin-Watson statistic for both models is between 1.5 and 2.5, the assumption of no correlation between the errors is not ruled out, and regression can be used.

3.5. EXAMINING HOW DATA IS DISTRIBUTED

The Kolmogorov-Smirnov (KS) test was used to examine the distribution of research data. For discrete quantitative variables in the Poisson distribution, the sig value must be greater than 0.5 for confirmation

Table 7. Kolmogorov-Smirnov test for discrete quantitative variables

		ttr	ttsh	tttr	tttsh	dastrasi
N		31	31	31	31	31
Poisson Parametera,b	Mean	16.7742	5.7742	8.2903	2.8710	1.4194
Most Extreme Differences	Absolute	.074	.064	.092	.090	.113
	Positive	.074	.064	.092	.067	.074
	Negative	-.051	-.063	-.060	-.090	-.113
Kolmogorov-Smirnov Z		.415	.358	.512	.502	.628
Asymp. Sig. (2-tailed)		.995	1.000	.956	.962	.825

		gos
N		31
Poisson Parametera,b	Mean	.6774
Most Extreme Differences	Absolute	.089
	Positive	.051
	Negative	-.089
Kolmogorov-Smirnov Z		.493
Asymp. Sig. (2-tailed)		.968

Given that the sig value is greater than 0.5, the assumption that it is Poisson is confirmed. Also, for continuous quantitative variables in the normal distribution, the sig value must be greater than 0.5 for confirmation.

Table 8. Kolmogorov-Smirnov test for continuous quantitative variables

		htr	htsh	thtr	Thtsh
N		31	31	31	31
Normal Parametersa,b	Mean	789.0000	488.3226	827.7742	512.4194
	Std. Deviation	92.88452	57.66882	97.15648	60.88173
Most Extreme Differences	Absolute	.134	.133	.152	.129
	Positive	.134	.133	.152	.129
	Negative	-.118	-.118	-.119	-.120
Kolmogorov-Smirnov Z		.744	.740	.847	.719
Asymp. Sig. (2-tailed)		.637	.643	.470	.679

Given that the sig value is greater than 0.5, the assumption of normality is confirmed.

3.6. MULTIPLE REGRESSION

The step-by-step method was used to enter the data. In this method, independent variables are added to the regression model one by one, and if they do not play a significant role in the regression (due to the sig test of the linearity of the relationship of the variables) are removed from it. In regression, the significance of the whole regression must first be tested, which is done by the ANOVA table, which is shown in Table (9). Then, the significance of each of the coefficients of the independent variables should be examined, which is done using the coefficient table. The results of multiple regression for the day model are shown in Table (10).

Table 9. ANOVA table for day model

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	376.150	1	376.150	28.611	.000b
	Residual	381.269	29	13.147		
	Total	757.419	30			
2	Regression	519.524	2	259.762	30.574	.000c
	Residual	237.895	28	8.496		
	Total	757.419	30			
3	Regression	647.780	3	215.927	53.175	.000d
	Residual	109.639	27	4.061		
	Total	757.419	30			

Table 10. ANOVA table for night model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11.873	1.124		10.562	.000
	dastrasi	3.453	.646	.705	5.349	.000
2	(Constant)	-6.647	4.598		-1.446	.159
	dastrasi	3.416	.519	.697	6.582	.000
	htr	.024	.006	.435	4.108	.000
3	(Constant)	-13.813	3.425		-4.033	.000
	dastrasi	3.596	.360	.734	9.982	.000
	htr	.029	.004	.545	7.189	.000
	gos	3.293	.586	.428	5.620	.000

In the ANOVA table, the Regression row represents the amount of change in the dependent variable, which is explained by the independent variables. The Residual line also indicates the amount of change in the dependent variable, which is explained by other factors (random and random). Considering that in the ANOVA table, the sig values in all three stages are less than 0.5, so the significance of the whole regression model is confirmed. This means that there is a linear relationship between these variables. By examining the table of regression coefficients for the day, the following was obtained:

$$Y = -13.813 + 0.743x_1 + 0.545x_2 + 0.428x_3 \quad (1)$$

Where in:

- Number of accesses and intersections located in the section
- Hourly traffic volume (vehicle per hour)
- Number of horizontal arcs located in the piece
- Number of accidents that occurred in the plot (for one year)

And for the night model:

Table 11. ANOVA table for night model

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	40.933	1	40.933	12.563	.001b
	Residual	94.487	29	3.258		
	Total	135.419	30			
2	Regression	78.438	2	39.219	19.272	.000c
	Residual	56.981	28	2.035		
	Total	135.419	30			
3	Regression	93.302	3	31.101	19.938	.000d
	Residual	42.117	27	1.560		
	Total	135.419	30			

Table 12. Table of model coefficients for the night model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.157	.560		7.429	.000
	dastrasi	1.139	.321	.550	3.544	.001
2	(Constant)	2.852	.537		5.314	.000
	dastrasi	1.238	.255	.597	4.853	.000
	gos	1.720	.401	.528	4.293	.000
3	(Constant)	-3.513	2.115		-1.661	.108
	dastrasi	1.240	.223	.599	5.556	.000
	gos	2.007	.363	.617	5.530	.000
	htsh	.013	.004	.343	3.087	.005

$$Y = -3.513 + 0.599x_1 + 0.343x_2 + 0.617x_3 \qquad (2)$$

3.7. MULTIPLE REGRESSION TEST

For the day:

Table 13. ANOVA table for day model testing

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	189.037	1	189.037	36.706	.000b
	Residual	149.350	29	5.150		
	Total	338.387	30			
2	Regression	240.716	2	120.358	34.504	.000c
	Residual	97.671	28	3.488		
	Total	338.387	30			
3	Regression	277.410	3	92.470	40.945	.000d
	Residual	60.977	27	2.258		
	Total	338.387	30			

Table 14. Table of model coefficients for daily model testing

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.816	.704		6.845	.000
	dastrasi	2.448	.404	.747	6.059	.000
2	(Constant)	-6.333	2.954		-2.144	.041
	dastrasi	2.423	.333	.740	7.284	.000
	thtr	.014	.004	.391	3.849	.001
3	(Constant)	-10.145	2.558		-3.966	.000
	dastrasi	2.518	.269	.769	9.372	.000
	thtr	.017	.003	.478	5.653	.000
	gos	1.760	.437	.342	4.031	.000

$$Y = -10.145 + 0.769x_1 + 0.478x_2 + 0.342x_3 \qquad (3)$$

For Night:

Table 15. ANOVA table for night model testing

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20.899	1	20.899	11.526	.002b
	Residual	52.585	29	1.813		
	Total	73.484	30			
2	Regression	32.014	2	16.007	10.808	.000c
	Residual	41.470	28	1.481		
	Total	73.484	30			
3	Regression	46.791	3	15.597	15.777	.000d
	Residual	26.692	27	.989		
	Total	73.484	30			

Table 16. Table of model coefficients for night model testing

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	**Std. Error**	**Beta**		
1	(Constant)	1.716	.417		4.110	.000
	dastrasi	.814	.240	.533	3.395	.002
2	(Constant)	-3.391	1.902		-1.783	.085
	dastrasi	.801	.217	.525	3.698	.001
	thtsh	.010	.004	.389	2.739	.011
3	(Constant)	-5.802	1.674		-3.465	.002
	dastrasi	.862	.178	.564	4.847	.000
	thtsh	.013	.003	.508	4.233	.000
	gos	1.117	.289	.576	3.866	.001

$$Y = -5.802 + 0.564x_1 + 0.508x_2 + 0.576x_3 \qquad (4)$$

According to the developed model for day and night in the day model (Equation 1), the number of accesses and intersections located in the section, hourly traffic volume, and then the number of arches located in the section is important, respectively. While in the model developed for the night (Equation 2), the variable of the number of horizontal arches located in the section is more important than the number of accesses and intersections located in the section and the volume of hourly traffic. Also, by comparing Equation (1) with Equation (3) and Equation (2) with (4), which are the tests of the developed models for day and night, respectively, the order of importance of the variables did not differ, which indicates the approval of the developed models. Their adaptation is to reality.

4. CONCLUSION

In this research, statistical methods have been used for modeling by constructing a separate regression model for day and night with the data of 2010 to 2012 and validation of the developed models with the data of 2010, which showed the compatibility of the developed models with reality. The models developed for day and night were as follows:

:Day

$$Y = -13.813 + 0.743x_1 + 0.545x_2 + 0.428x_3$$

:Night

$$Y = -3.513 + 0.599x_1 + 0.343x_2 + 0.617x_3$$

•The variable of the number of access roads and intersections located in the sections in the model developed for the day have the greatest impact on the number of accidents; While in the model developed for the night, this variable has the most impact on the number of accidents after the variable of the number of horizontal arcs located in pieces. For every 10 percent increase in the number of accesses and intersections in the day model, the number of accidents increases by 22.2 percent, while for the same increase in the night model, the number of accidents increases by only 4.9 percent.

•The hourly traffic volume variable occurred after the variable number of access roads and intersections located in the sections in the model developed for the day, the most influential variable on the number of accidents; While this variable occurred in the model developed for the last night and the least influential variable on the number of accidents. For every 10% increase in hourly traffic volume in the day model, the number of accidents increases by 16.3%, while for the same amount in the night model, the number of accidents increases by only 2.8%.

•The variable of the number of horizontal arcs located in pieces in the model developed for the day is the least effective and the last variable affecting the number of accidents that occurred; while in the model developed for the night, this variable has the greatest impact on the number of accidents. For every 10% increase in the number of horizontal arcs in the day model, the number of accidents increases by 12.8%, while for the same increase in the night model, the number of accidents increases by 5.1%.

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CONFLICT OF INTEREST

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