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RESEARCH ARTICLE

Identifying Significant Variables Influencing Overtaking Maneuvers on Two-lane, Two-way Rural Roads in Iran

Ali Tavakoli Kashani[1], Ehsan Ayazi[1*], Mahdi Sokouni Ravasani[1]

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Abstract

The main purpose of this study is examining effective and significant variables on overtaking maneuvers on two-lane, two-way rural roads in Iran. In this study, overtaking maneuver type as the response variable was considered in four levels: "normal overtaking (accelerative overtaking)", "aborted overtaking" maneuver, "lane sharing" and "cutting in (precipitous return to the driving lane)". The data were gathered using field data collection method, that is, an expert –a transportation engineer- accompanied by patrolling police interviewed 514 drivers on two-lane, two-way rural roads in two provinces of Zanjan and East Azerbaijan in the northwest of Iran. To identify the influence of each variable on the overtaking type, Pearson's chi-square test with the significance level of 0.05 was used and then to consider the influence of each significant variable on each level of the response variable, a multivariate logistic regression model was employed.

Keywords

two-lane rural roads, dangerous overtaking, chi-squared test, multinomial logistic regression model

[1] Department of Civil Engineering, Iran University of Science and Technology, Tehran, Iran

[*] Corresponding author, e-mail: ayaziehsan@civileng.iust.ac.ir

1 Introduction

According to the studies in Iran, 70 % of accidents occur on rural roads. The analysis of rural accidents shows that 50 to 60 % of these accidents happen on two-lane, two-way roads which constitute about 82 % of all roads in the country (Mohaymany et al., 2010). In these roads, because traffic flow in two directions is not separated, overtaking maneuver is performed using the opposite lane. If these maneuvers occur in no-passing or dangerous zones, they may lead to severe accidents and increase injuries and fatalities (Coufal and Semela, 2016). Therefore, overtaking maneuver is one of the most dangerous maneuvers on two-lane, two-way rural roads and the accident severity resulting from this type of maneuver is significantly higher than that of other accident types (Bar-Gera, 2011; Maghrour Zefreh and Török, 2016).

The overtaking maneuver on two-lane, two-way rural roads is a difficult maneuver that requires complicated decisions (Farah et al., 2008). Previous studies showed that overtaking maneuver on two-lane, two-way rural roads may lead to fatal accidents (Subotić et al., 2016). Because in this type of maneuver, unsafe lane change, low vision while overtaking, wrong decision to return to the lane or unexpected vehicle on the opposite lane may result in severe accidents (Papakostopoulos et al., 2015; Farah, 2011; Mar and Lin, 2005; Schubert et al., 2010). According to previous studies in Iran, around 70 % of rural traffic accidents occur due to driver's carelessness and risky behaviors as well as overtaking and speeding (Banakar and Fard, 2012).

Although performing overtaking maneuvers on two-lane, two-way roads is one of the most dangerous and most common maneuvers on these roads and lead to an increase in traffic accidents, specially head-on and fatal accidents, a few studies were conducted on effective variables in these maneuvers.

In a study on two-lane, two-way roads in England, Wilson and Best (1982) considered overtaking maneuvers using field data collection method. The data included 400 overtaking maneuvers on class A two-lane, two-way roads in England. The analysis of the data showed that while there was not enough gap for completing overtaking maneuver, "lane sharing" and "cutting in" maneuvers increased. In addition, when there was not enough gap for overtaking, only “flying overtaking (non-pause overtaking)” had less lane sharing than other types of overtaking (Best, 1982).

In a study by Matthews et al. (1998) on drivers’ behavior when driving, by filling questionnaire and using driving simulator, it was found that the frequency and risk of overtaking maneuvers for young and relatively aggressive drivers were more than those for other drivers (Matthews et al., 1998).

In 2005, Hegeman et al. considered maneuvers on two-lane, two-way roads using an instrumented vehicle. In their study, by observing vehicles overtaking through the instrumented vehicle, they found that there was no significant difference between duration of performing “normal overtaking”, “piggy backing overtaking”, “flying overtaking” and “2+ (two plus overtaking)” (Hegeman et al., 2005).

In another study by Shbeeb (2005) in Jordan, the data for overtaking maneuvers were obtained through field observations. It was shown that risky and incomplete overtaking maneuvers on straight and flat roads occurred more than those on curvy roads. Furthermore, risky overtaking maneuvers in plain areas were more frequent than those in mountainous areas (Shbeeb and Hamamdeh, 2005).

In 2009, Farah et al. developed a model to predict risky behaviors for overtaking on two-lane, two-way rural roads using a driving simulator. They observed that male drivers returned to the driving lane faster than female drivers when driving and, therefore, more time to collision was recorded for males than females. In addition, they found that when there was low traffic volume, there was more time for an overtaking maneuver and, consequently, drivers performed safer overtaking maneuvers. Furthermore, they showed that on roads with appropriate geometric design, compared to poorly designed roads, drivers kept more gap with the approaching vehicle on the opposite lane when overtaking and the frequency of risky overtaking decreased (Farah et al., 2009).

In another study in 2011, Farah et al. considered the effect of age and gender on driver’s overtaking maneuver on two-lane, two-way roads using a driving simulator. In their study, a total of 100 drivers were analyzed and they found that there was significant difference between the number of overtaking maneuvers for male and females. Overtaking maneuvers were much more frequent for male drivers than for female drivers. There was not a significant difference between the number of overtaking maneuvers for young and old drivers. In addition, they observed that female drivers compared to male drivers, and old drivers compared to young drivers, had longer overtaking time durations. Furthermore, they showed that more overtaking maneuvers occurred on roads with good geometric design compared to poor geometric design (Farah, 2011).

In 2013, Llorca et al. studied about the effect of age and gender on overtaking maneuver on two-lane, two-way roads. They used an instrumented vehicle equipped with a camera and a laser to drive on the road and collected data on overtaking maneuvers. A total of 214 overtaking maneuvers were observed. Data analysis showed that there was a significant difference between age and gender groups of drivers in overtaking maneuver. Young male drivers had aggressive and risky behavior as well as shorter overtaking maneuver (1 second shorter) compared to other groups (Llorca et al., 2013).

The major purpose of this study is to identify significant factors in performing “cutting in” overtaking maneuvers compared to other overtaking maneuvers on two-lane, two-way rural roads and to identify the effectiveness of each variable on overtaking maneuvers using field-gathered data. As stated in literature review, overtaking maneuvers in two-lane, two-way rural roads are categorized into normal overtaking, lane sharing, cutting in, flying overtaking, piggy backing, aborted overtaking and 2+ overtaking Which former studies have evaluated each one separately. In this study overtaking maneuvers are categorized in 4 categories contains “normal overtaking”, “aborted overtaking”, “lane sharing” and “cutting in” and then modelled, because firstly, these four categories were observed more than the other maneuvers during surveying and secondly, are included in overtaking maneuvers used in former studies.

Although nowadays driving simulator method is mostly applied to consider drivers’ behavior, this method is unable to consider the real risk that affects driver’s behavior. Because in a driving simulator, the driver does not perceive any risk. In fact, the driver is assured that there is no threatening hazard when driving in a simulated environment. As a result, the driver’s behavior in a simulated environment is much different from that in a real situation (Bella, 2011). Therefore, in some studies, gathering data in the field was preferred (Shbeeb and Hamamdeh, 2005; Harwood et al., 2010; Carlson et al., 2006; Llorca and Garcia, 2011).

2 Methodology

Field data collection method was used to gather the data and to conduct this study. An expert –a transportation engineer- was accompanied by police and patrolled on rural roads of Zanjan and East Azerbaijan provinces. The expert interviewed drivers performing overtaking maneuver and recorded correspondent information. It should be noted that the police was camouflaged when the drivers were overtaking and the police had no influence on the drivers’ behavior.

2.1 Statistical tests

The main purpose of this study is to identify significant factors in performing “cutting in” overtaking maneuvers compared to other overtaking maneuvers on two-lane, two-way rural roads and to consider the effectiveness of each variable on overtaking maneuver. To achieve this purpose, first, all independent variables are categorized and the Pearson’s chi-square test with p-value of 0.05 is used to identify significant variables. The Chi-square statistic is a non-parametric tool designed to analyze group differences when the dependent variable is measured at a nominal level. Like all non-parametric statistics, the Chi-square is robust with respect to the distribution of the data. Specifically, it does not require equality of variances among the study groups or homoscedasticity in the data. It permits evaluation of both dichotomous independent variables, and of multiple group studies. Unlike many other non-parametric and some parametric statistics, the calculations needed to compute the Chi-square provide considerable information about how each of the groups performed in the study. This richness of detail allows the researcher to understand the results and thus to derive more detailed information from this statistic than from many others.

Then, a multivariate logistic regression model is used to determine the relation between each independent variable and overtaking maneuver on two-lane, two-way rural roads.

2.2 The multivariate logistic regression model

The logistic regression model is usually used to categorize discrete variables. This model can be used to categorize binary response variables such as variables with 2 values or to categorize response variables with r classifications (r can be greater than 2). Since in this study, the response variable is nominal (not ordinal), the generalized logistic model is the most appropriate for analysis. These models consist of r-1 logit model for the response variable to compare each categorical level with a reference category.

In this study, "cutting in" overtaking maneuver is considered as the reference variable for comparison with other types of maneuvers. The logit model calculates the risk of "cutting in" overtaking maneuver in comparison with other types of maneuvers.

The type of maneuver which is denoted by Y is the response variable and geometric, environmental and human variables are predictor variables and are denoted by $X_{i1}, X_{i2}, X_{i3}, \ldots X_{ip}$, where i is the number of observation and p is the number of independent variables. It is assumed that $Y_i = (Y_i 1,\ Y_{i2},\ \ldots\ Y_{ir})^T$ has a multinomial distribution with index, $n_i = \sum_{j=1}^{r} Y_{ij}$ and parameter $(\Pi_{i1}, \Pi_{i2}, \ldots \Pi_{ir})^T$.

When classifications of 1, 2,…, r response variable are disordered, $\prod_i$ is related with independent variable through a set of r-1 reference classification of logit function. If j^* is considered as reference classification, the model is defined as follows:

$$\log\left(\frac{\Pi_{ij}}{\Pi_{ij*}}\right) = X_i^T \beta_j,\ \ j \neq j^* \qquad (1)$$

Where X_i^T = transpose of independent variable vector and β_j = coefficient vector for jth level of the response variable.

Since four classifications for response variable in this study have no specific order, three generalized logit models are defined from this analysis as j takes the values from 1 to 4. Because X_1 has length p, this model has $(r - 1) \times p$ parameters that can be arranged as a matrix.

In this model:

- Each classification can be selected as the reference classification. In this case, the value and interpretation of coefficients would be different.
- The kth element of β_j can be considered as a factor to increase the chance of response to be located in classification J versus classification j^*, when there is one unit increase in kth independent variable, and other independent variables remain constant.
- For the non-reference classification $j \neq j^*$, $\prod_i$ is defined using β as follows:

$$\Pi_{ij*} = \frac{1}{1 + \sum_{k \neq j*} \exp\left(X_i^T \beta_k\right)} \qquad (2)$$

- For the reference classification, $\prod_i$ is defined using β as follows (Bham et al., 2011):

$$\Pi_{ij*} = \frac{1}{1 + \sum_{k \neq j*} \exp\left(X_i^T \beta_k\right)} \qquad (3)$$

In this study, "cutting in" overtaking maneuver is considered as the reference classification. The multivariate logistic regression model is carried out using SPSS-21.

2.3 Data

The study area in this study consists of 5 rural roads including 13 sites in two provinces of Zanjan and East Azerbaijan in the northwest of Iran (Fig. 1):

Fig. 1 The location of the sites in the study area (www.iranpedia.ir)

The data used in this study were gathered using the field data collection method. The information includes site number, road type, shoulder width and shoulder type of sections (Table 1).

Table 1 The characteristics of the sites in the study area

Road type	Shoulder width (m)	Shoulder type	Road name	Site number
Curvy	2	Paved shoulder with different level from the road	Zanjan-Mianeh-Section 1	1
Straight and Flat	1.7	Paved shoulder with different level from the road	Zanjan-Mianeh-Section 2	2
Graded and Curvy	1.8	Paved shoulder on the same level as the road	Zanjan-Bijar-Section 1	3
Curvy	1.7	Paved shoulder on the same level as the road	Zanjan-Bijar-Section 2	4
Graded	1.5	Unpaved shoulder	Zanjan-Bijar-Section 3	5
Straight and Flat	1.7	Paved shoulder on the same level as the road	Zanjan-Abhar-Section 1	6
Graded	1.8	Paved shoulder on the same level as the road	Zanjan-Abhar-Section 2	7
Curvy	1.8	Paved shoulder with different level from the road	Zanjan-Abhar-Section 3	8
Graded and Curvy	1.85	Unpaved shoulder	Zanjan-Ahar-Section 1	9
Graded and Curvy	1.85	Unpaved shoulder	Zanjan-Ahar-Section 2	10
Graded	1.8	Paved shoulder with different level from the road	Zanjan-Ahar-Section 3	11
Graded and Curvy	1.3	Unpaved shoulder	Maraqeh-Hashtrood-Section 1	12
Straight and Flat	1.3	Paved shoulder on the same level as the road	Maraqeh-Hashtrood-Section 2	13

Environmental and geometric specifications of road including weather condition, road type, shoulder width and shoulder type were collected in the field and the characteristics of driver and passengers were gathered by filling a questionnaire. Totally, 514 overtaking maneuvers were observed, 202 maneuvers were “normal overtaking” (39.29 %), 134 maneuvers were “aborted overtaking” maneuver (26.07 %), 61 maneuvers were “lane sharing” (11.86 %), and 117 maneuvers were “cutting in” (22.78 %). So the overtaking maneuver was considered as response variable in 4 levels.

Then 11 geometric and non-geometric independent variables were analyzed that are shown in Table 2.

To consider the correlation of independent variables, Kendall non-parametric test (discrete variables) was applied. The results showed that all independent variables except “the number of passengers” and “front-seat passenger presence” (correlation coefficient=0.785) had correlation coefficients less than 0.5 and consequently, independent variables were not highly correlated. Therefore, “front-seat passenger presence” was not used for modeling. Table 2 shows predictor variables in terms of overtaking maneuver type. All independent variables were analyzed using SPSS-21. The information consists of weather condition, road type, shoulder width, shoulder type, number of passengers, front-seat passenger presence, expectation of camouflaged-police location, driver’s vision problem, driver’s education, driver’s age and frequency of getting ticket in the past year.

3 Results and Discussion

In this study, the effect of each independent variable on overtaking maneuvers on two-lane, two-way rural roads was considered using Pearson’s chi-square test (Table 3). The results showed that all variables had a significant relation with “overtaking type”. In order to fit the best logistic regression model, “weather condition”, “road type” and “shoulder width” were not entered to the model because of their low significance. A multivariate logistic regression model was developed on the mentioned data to identify the influence of significant variables on overtaking maneuvers on two-lane, two-way rural roads. The forward entry method was used for analysis. In this method, significant variable is entered the model one by one. Table 4 shows the results of the multivariate logistic regression.

Figure 2 shows the graph of the odds ratio for significant variables. This graph displays the effectiveness of each variable on overtaking maneuvers. The odds ratio more than 1 shows positive coefficient of variable in the model and shows that the related coefficient is effective in decrease of the probability of “cutting in” overtaking maneuver and odds ratio less than 1 shows negative coefficient of variable in the model and shows that the related coefficient is effective in increase of the probability of “cutting in” overtaking maneuver.

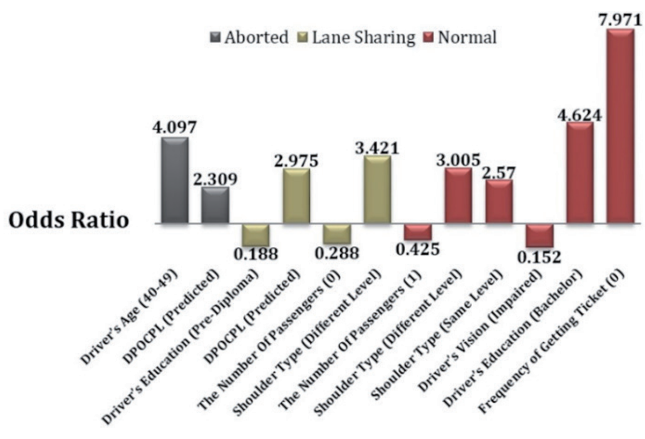

Fig. 2 Graph of the odds ratio for significant variables

Table 2 Predictor variables in terms of overtaking type

Variable	Category	Normal Overtaking	Aborted Overtaking	Lane Sharing	Cutting in	**Total**
Weather condition	Dry	120 (38.7 %)	81 (26.1 %)	28 (9.1 %)	81 (26.1 %)	**310**
	Rainy	82 (40.2 %)	53 (26 %)	33 (16.2 %)	36 (17.6 %)	**204**
	Total	**202**	**134**	**61**	**117**	**514**
The Number of Pssengers	0	59 (38.3 %)	30 (19.5 %)	30 (19.5 %)	35 (22.7 %)	**154**
	1	39 (33.3 %)	33 (28.2 %)	10 (8.6 %)	35 (29.9 %)	**117**
	2	43 (37.7 %)	39 (34.2 %)	11 (9.7 %)	21 (18.4 %)	**114**
	3>=	61 (47.3 %)	32 (24.8 %)	10 (7.8 %)	26 (20.1 %)	**129**
	Total	**202**	**134**	**61**	**117**	**514**
Front-seat Passengers	Presence	141 (39.6 %)	102 (28.7 %)	31 (8.7 %)	82 (23 %)	**356**
	Absence	61 (38.6 %)	32 (20.3 %)	30 (19 %)	35 (22.1 %)	**158**
	Total	**202**	**134**	**61**	**117**	**514**
Road Type	Straight and Flat	55 (33.1 %)	43 (25.9 %)	22 (13.3 %)	46 (27.7 %)	**166**
	Curvy	25 (37.3 %)	22 (32.8 %)	11 (16.4 %)	9 (13.5 %)	**67**
	Graded	65 (42.8 %)	45 (29.6 %)	18 (11.8 %)	24 (15.8 %)	**152**
	Curvy and Graded	57 (44.2 %)	24 (18.6 %)	10 (7.8 %)	38 (29.4 %)	**129**
	Total	**202**	**134**	**61**	**117**	**514**
Shoulder Width (m)	1.30–1.85	138 (40.1 %)	95 (27.6 %)	31 (9 %)	80 (23.3 %)	**344**
	1.85–2.00	64 (37.6 %)	39 (22.9 %)	30 (17.7 %)	37 (21.8 %)	**170**
	Total	**202**	**134**	**61**	**117**	**514**
Shoulder Type	Paved Shoulder (Different Level from Road)	99 (44.4 %)	65 (29.1 %)	20 (9 %)	39 (17.5 %)	**223**
	Paved Shoulder (the Same Level as Road)	66 (40 %)	45 (27.3 %)	22 (13.3 %)	32 (19.4 %)	**165**
	Unpaved shoulder	37 (29.4 %)	24 (19 %)	19 (15.1 %)	46 (36.5 %)	**126**
	Total	**202**	**134**	**61**	**117**	**514**
Driver’s Prediction of Camouflaged-Police Locations	Predicted	46 (37.7 %)	42 (34.4 %)	18 (14.8 %)	16 (13.1 %)	**122**
	Unpredicted	156 (39.8 %)	92 (23.4 %)	43 (11 %)	101 (25.8 %)	**392**
	Total	**202**	**134**	**61**	**117**	**514**
Driver’s Vision	Impaired	8 (14 %)	25 (43.9 %)	6 (10.5 %)	18 (31.6 %)	**57**
	Healthy	194 (42.5 %)	109 (23.8 %)	55 (12 %)	99 (21.7 %)	**457**
	Total	**202**	**134**	**61**	**117**	**514**
Driver’s Education	Pre-diploma	124 (39 %)	69 (21.7 %)	47 (14.8 %)	78 (24.5 %)	**318**
	Bachelor	66 (48.9 %)	35 (25.9 %)	8 (5.9 %)	26 (19.3 %)	**135**
	Master or Doctoral	12 (19.7 %)	30 (49.2 %)	6 (9.8 %)	13 (21.3 %)	**61**
	Total	**202**	**134**	**61**	**117**	**514**
Driver’s Age	20–29	46 (33.8 %)	37 (27.2 %)	18 (13.2 %)	35 (25.8 %)	**136**
	30–39	81 (42.2 %)	52 (27.1 %)	12 (6.3 %)	47 (24.4 %)	**192**
	40–49	37 (36.6 %)	25 (24.8 %)	23 (22.8 %)	16 (15.8 %)	**101**
	50>=	38 (44.7 %)	20 (23.5 %)	8 (9.4 %)	19 (22.4 %)	**85**
	Total	**202**	**134**	**61**	**117**	**514**
Frequency of Getting Ticket in the Past Year	0	68 (35.1 %)	53 (27.3 %)	27 (13.9 %)	46 (23.7 %)	**194**
	1	51 (39.8 %)	29 (22.7 %)	14 (10.9 %)	34 (26.6 %)	**128**
	2	43 (54.4 %)	12 (15.2 %)	8 (10.1 %)	16 (20.3 %)	**79**
	3	4 (12.1 %)	19 (57.6 %)	2 (6.1 %)	8 (24.2 %)	**33**
	4	14 (63.6 %)	5 (22.7 %)	0 (0 %)	3 (13.7 %)	**22**
	5+	22 (37.9 %)	16 (27.5 %)	10 (17.3 %)	10 (17.3 %)	**58**
	Total	**202**	**134**	**61**	**117**	**514**

Table 3 Chi-squared test for predictor variables

Variable	Pearson Chi-Square Value	Degree of Freedom	Significant Level
Weather condition	**9.25**	**1**	**0.026**
The Number of Passengers	20.16	4	0.003
Road Type	**20.99**	**3**	**0.013**
Shoulder Width (m)	**8.39**	**1**	**0.039**
Shoulder Type	24.92	2	0.000
Driver's Prediction of Camouflaged-Police Locations	12.05	1	0.007
Driver's Vision	20.48	1	0.000
Driver's Education	31.69	2	0.000
Driver's Age	21.46	3	0.006
Frequency of Getting Ticket in the Past Year	40.69	5	0.000

Table 4 Results of the multivariate logistic regression model

Variable	Category	Reference	Estimates	P-value	OR	95% lower limit	95% upper limit
			Lane sharing				
Intercept			-1.888	0.002			
Driver's Age	40–49	50>=	1.410	0.01	4.097	1.132	12.706
DPOCPL*	Predicted	Unpredicted	0.837	0.03	2.309	1.000	5.333
			Aborted Overtaking				
Intercept			1.245	0.008			
Driver's Education	Pre-diploma	Master or Doctoral	-1.671	0.001	0.188	0.073	0.487
DPOCPL	Predicted	Unpredicted	1.090	0.002	2.975	1.476	5.996
The Number of Passengers	0	3>=	-1.243	0.007	0.288	0.118	0.707
Shoulder Type	Different Level	Unpaved Shoulder	1.230	0.001	3.421	1.706	6.858
			Normal Overtaking				
Intercept			1.018	0.01			
The Number of Passengers	1	3>=	0.885-	0.015	0.425	0.210	0.859
Shoulder Type	Different Level	Unpaved Shoulder	1.1	0.001	3.005	1.611	5.605
Shoulder Type	Same Level	Unpaved Shoulder	0.944	0.004	2.570	1.344	4.912
Driver's Vision	Impaired	Healthy	0.885-	0.000	0.152	0.058	0.396
Driver's Education	Bachelor	Master or Doctoral	1.531	0.005	4.624	1.601	13.354
Frequency of Getting Ticket	0	5+	2.076	0.003	7.971	2.026	31.356

* DPOCPL: Driver's Prediction of Camouflaged-Police Locations

3.1 Lane sharing

Driver's Age (40-49): This variable represents drivers aged 40 to 49. Its coefficient is positive. It shows that for drivers in this group, the probability of performing "lane sharing" is 4 times greater than performing "cutting in" (OR=4.097). In fact, it can be seen that for older drivers, the probability of performing "cutting in" is less than young drivers. The probable reason for that might be more caution, less risk taking and more driving experience compared to younger drivers (Matthews et al., 1998, Llorca et al., 2013).

Driver's Prediction of camouflaged-police locations (Predicted): This variable represents the expectation of camouflaged-police locations because of observing police in the previous travels. In fact, because some drivers have seen traffic police in a specific area, they expect the presence of police in the area. Its coefficient is positive and shows that drivers perform less "cutting in" overtaking maneuver while they expect police locations. If a driver be aware of police location, "lane sharing" probability is about 2.3 times greater than "cutting in" overtaking maneuver (OR=2.3). This finding is reasonable because drivers in the presence of police are careful to avoid getting fined and their risky overtaking maneuvers (cutting in) are less.

3.2 Aborted overtaking maneuver

Driver's education (Pre-Diploma): This variable represents drivers with high school degree or lower than that. Its coefficient is negative. It shows that for Pre-Diploma drivers, the probability of performing "cutting in" overtaking maneuver is about 5.3 times greater than "aborted overtaking" maneuver (OR=1/0.188=5.3). It seems that people with lower educational level, perform more risky overtaking maneuver than other drivers. It implies that, this group of drivers do more risky behaviors and do not recognize overtaking sight distance correctly.

Driver's Prediction of camouflaged-police locations (Predicted): The coefficient of this variable is positive. The result shows that expectation of camouflaged-police locations causes the probability of "aborted overtaking" maneuver to be about 3 times greater than that of "cutting in" (OR=2.97). Drivers who intend to perform overtaking maneuver, cancel their maneuver at expected police locations.

The number of passengers (0): This variable indicates that there is no passenger in the vehicle. Its coefficient is negative. The results show that while driver is alone in the car, the probability of performing "cutting in" overtaking maneuver is about 3.5 times greater than that of performing "aborted overtaking" maneuver (OR=1/0.288=3.47). It can be inferred that in the presence of passenger, driver's caution increases. In other words, passengers control driving quality and warn driver when needed.

Shoulder type (Paved shoulder with different level from the road): This variable represents paved shoulder with different level from the road and has a positive coefficient. It shows that on roads with paved shoulder with different level, the probability of "aborted overtaking" maneuver is about 3.5 times greater than that of "cutting in" maneuver (OR=3.42). It can be seen that on roads having paved shoulder with different level from the road, the drivers of vehicles being overtaken and on the opposite lane, are able to have more lateral movement compare to unpaved shoulders and this can help drivers to overtake safely.

3.3 Normal overtaking

The number of passengers (1): It shows the presence of one passenger as well as the driver. Its coefficient is negative. But it has a smaller value compared to the situation of passenger absence. The result shows that an increase in the number of passengers, corresponds with an increase in the probability of performing "normal overtaking" in comparison with "cutting in" maneuver. Alone drivers seem to drive more carelessly because they have no controller in the vehicle.

Shoulder type (Paved shoulder with different level from the road or with same level as the road): Both coefficients are positive. It shows that on the roads with paved shoulder compared to unpaved shoulder, the probability of performing "normal overtaking" is respectively about 3 and 2.5 times greater than "cutting in" maneuver. As we explained before, on roads having paved shoulder compared to the roads having unpaved shoulder, the drivers of vehicles being overtaken and on the opposite lane, are able to have more lateral movement compare to unpaved shoulders and this can help drivers to overtake safely.

Driver's vision (Impaired): This variable's coefficient is negative. The results show that for drivers wearing glasses, the probability of performing cutting in overtaking maneuver is about 6.6 times greater than that of "normal overtaking" (OR=1/0.152=6.6). It seems that drivers wearing glasses have problems in recognizing speed and distance of vehicle on the opposite lane and perform more risky overtaking maneuvers compared to the drivers with healthy vision.

Driver's education (Bachelor): Its coefficient is positive. The results show that the probability of performing "normal overtaking" for drivers with university degree is about 4.6 times greater than that of performing "cutting in" maneuver. with an increase in drivers' education, the ability of understanding speed and distance of vehicle on the opposite lane increases, overtaking risk reduces, respect for law increases and eventually the probability of performing "cutting in" overtaking maneuver reduces.

Frequency of getting ticket in the past year (0): This variable shows the drivers who have not received ticket by police in the past year. Its coefficient is positive. The result shows that for drivers who have not received ticket in the past year, the probability of performing "normal overtaking" is about 8 times greater than "cutting in" maneuver. Drivers who have not received ticket in the last year are probably law-abiding drivers. Therefore, they do not perform risky overtaking.

4 Conclusion and Recommendations

This study was conducted using field data collection method by an expert-a transportation engineer- accompanied by traffic police and by filling questionnaires on drivers who performed overtaking maneuver, in totally 13 sites on 5 two-lane, two-way rural roads in Zanjan and East Azerbaijan provinces. In this study, the relations between performing overtaking maneuvers and geometric, driver and passengers variables were examined. Geometric data were gathered in the field and other variables about driver and passengers were collected by stopping drivers who perform overtaking maneuver and filling questionnaire.

Totally 514 overtaking maneuvers including "normal overtaking", "aborted overtaking" maneuver, "lane sharing" and "cutting in" were recorded. At first, significant variables were determined by Pearson's chi-square test and then were entered in a multivariate logistic regression model. The results of the model showed that for 40 to 49 years old drivers, the probability of performing "lane sharing" maneuver was about 4 times greater than that of "cutting in" overtaking maneuver. Furthermore, drivers who were aware of police locations had less probability of performing "cutting in" overtaking maneuver than that of performing "lane sharing" and "aborted overtaking" maneuver. Thus, the presence of traffic police on rural roads should be in a way that drivers always feel the presence of them. The use of police surveillances camera in appropriate distances on the road can give this feeling to drivers and decrease risky overtaking maneuvers. For drivers with low educational levels, the probability of performing risky maneuver of "cutting in" was about 5.3 times greater than "aborted overtaking" maneuver.

On the other hand, for drivers with university degree, the probability of performing "normal overtaking" was about 4.6 times greater than that of "cutting in" overtaking maneuver. It seems that training of low-educated people when obtaining driver's license, enable drivers not to perform risky overtaking maneuvers and to respect traffic rules. In addition, it was shown that generally drivers performed more risky overtaking maneuvers of "cutting in" when there is no passenger. This probability in the absence of passengers in "aborted overtaking" maneuver and for one passenger in "normal overtaking" was 3.47 and 2.35 respectively. Passengers can control and reduce unsafe driving behaviors. The results of the model also indicated that on roads with paved shoulders, the probability of performing "cutting in" was less than "normal overtaking" and "aborted overtaking" maneuver in comparison with roads with unpaved shoulders. Using paved shoulders as well as providing more space for overtaking maneuver, can reduce collision risk by increasing lateral movement possibility for overtaking vehicles.

This study showed that the probability of performing "cutting in" for drivers wearing glasses was about 6.6 times greater than that of "normal overtaking" maneuver. Finally, it was found that the probability of performing "normal overtaking" for drivers who did not receive ticket by police in the past year was about 8 times greater than that of "cutting in" overtaking maneuver. Encouraging programs such as insurance discounts, free technical inspections, or free park cards for drivers with no tickets or applying negative scores on driver's license after receiving each ticket, is suggested to motivate drivers to drive more carefully.

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