©2022 Published in 6th International Symposium on Natural Hazards and Disaster Management
21-23 October 2022 (ISHAD2022 Bursa - Turkey)
https://doi.org/10.33793/acperpro.XXXX

The effects of the hazard on road and road type on the motorcycle accident frequency

*1Kadir Berkhan Akalin
*1Department of Civil Engineering, Eskisehir Osmangazi University, Eskisehir, Turkey

Abstract:

Increasing motorcycle ownership, especially through its high flexibility and relatively cheap purchasing and operating costs compared to automobiles, increased the share of motorcyclists in traffic accidents. This situation has brought about the need to investigate the factors affecting motorcycle accidents and the prevention to reduce the severity and the number of accidents. In this study, relationships between accident frequency and carriageway hazard, road type, and surface condition were examined using the data set of motorcycle accidents that occurred in England. Vehicle load, object, animal, pedestrian, and previous accident on road were considered as carriageway hazards, one-way street, roundabout, slip road, single and dual carriageway were considered as road types, and wet and dry indicates the road surface conditions. Thus, accident frequencies were estimated using log-linear analysis, and the measures to be taken were discussed.

Key words: Motorcycle accident, carriageway hazards, traffic accident, log-linear analysis.

1. Introduction

Increasing capabilities and properties of motorcycles with developing technology (electric battery instead of gasoline, GPS tracking, increased range and improved comfort, etc.) and high flexibility in traffic encourage individuals to own a motorcycle. Along with all these opportunities, the fact that taxes, purchase and operating costs are more affordable than other motor vehicles increase the share of motorcycles in road traffic day by day. Considering the potential for increased motorcycle traffic to increase motorcycle accidents, the need for accident causality and prevention studies is obvious. For this purpose, when the literature is examined, it is seen that various studies have been carried out on motorcycle accidents.

In a study conducted in the USA in which the factors affecting the severity of motorcycle accidents were investigated with the multinomial logit model, environmental factors, road conditions, vehicle characteristics and driver characteristics were taken into account as factors affecting the five levels of accident severity (only property damage, potential injury, significant injury, disability injury and death) [1]. An ordered probit model was used to examine the factors affecting the severity of injury and the severity of damage caused by motorcycle accidents with a disaggregated data set collected in Singapore. According to the results, it was observed that the main factors causing more severe accidents are the engine capacity, collisions with objects and pedestrians [2]. In an accident analysis study conducted in the city of Calgary, it was determined that motorcycle accident severities are related to road type, speed, and alcohol use [3]. The study, using the latent class approach with

*Corresponding author: Address: Department of Civil Engineering, Eskisehir Osmangazi University, 26480, Eskisehir, Turkey. E-mail address: kbakalin@ogu.edu.tr, Phone: +902222393750 (Ex:3239)

motorcycle accident data collected in Iowa, shows a significant relationship between severity and factors such as fixed object, road type, riding without helmet, age, and alcohol or drug use [4].
In this study, carriageway hazards, surface conditions, and road type factors affecting the number of motorcycle accidents were investigated using the log-linear analysis. Frequencies were examined according to the best model result and the relationships between categorical variables were interpreted.

2. Materials and Method

Log-linear analysis was used to find the best model and to test the significance of the model within the scope of this paper. The log-linear analysis is used in statistics to examine the relationship between more than two categorical variables. The log-linear model expresses the logarithm of the frequency of each cell in the probability table as a linear combination of all possible interactions between the variables [5-7]. A typical log-linear model can be expressed as in Eq. 1.

$$\ln\left(F_{ijk}\right) = \mu + \lambda_i^X + \lambda_j^Y + \lambda_k^Z + \lambda_{ij}^{XY} + \lambda_{ik}^{XZ} + \lambda_{jk}^{YZ} + \lambda_{ijk}^{XYZ} \quad (1)$$

where;
F_{ijk} is the expected frequency with respect to the related cell,
X, Y, and Z are the variables,
i, j, and k are the number of categories of the related variables,
λ is the relative weight of each variable,
μ constant term.

In the analysis, 1025 accident data involving motorcycles in England between 2018-2021 were evaluated [8]. Here, the data obtained by filtering the motorcycle accidents including carriageway hazards are used. The crosstab for the dataset including carriageway hazard, surface condition, and road type variables is as given in Table 1.

Table 1. The Crosstab for the Dataset

Surface	Road Type	Carriageway Hazard					Total
		Animal in carriageway	Object on road	Pedestrian in carriageway	Previous accident	Vehicle load on road	
Dry	Dual carriageway	1.56%	5.95%	1.27%	1.07%	1.95%	11.80%
	One-way street	0.00%	1.07%	0.20%	0.10%	0.20%	1.56%
	Roundabout	0.10%	0.98%	0.20%	0.29%	0.59%	2.15%
	Single carriageway	12.59%	28.98%	4.78%	2.93%	6.54%	55.80%
	Slip road	0.10%	0.39%	0.00%	0.10%	0.10%	0.68%
Wet	Dual carriageway	0.29%	3.02%	0.29%	0.29%	1.07%	4.98%
	One-way street	0.00%	0.68%	0.49%	0.00%	0.10%	1.27%
	Roundabout	0.00%	0.49%	0.00%	0.20%	0.10%	0.78%
	Single carriageway	2.93%	12.29%	2.24%	0.98%	1.95%	20.39%
	Slip road	0.00%	0.49%	0.00%	0.10%	0.00%	0.59%
Total		17.56%	54.34%	9.46%	6.05%	12.59%	100.00%

Dual carriageway, one-way street, roundabout, single carriageway, and slip road as road type, animal in carriageway, object on road, pedestrian in carriageway, previous accident, and vehicle load on road as carriageway hazard, wet and dry as surface condition are categorical variables in the dataset.

3. Results

After trials with log-linear analysis, it was determined that the most suitable model is found to be as in Eq. 2, and the parameter estimations of the model are given in Table 2. Please note that analysis were made according to accident frequency but converted to percentages in crosstabs.

$$\ln(F) = Constant + CarriagewayHazard + Surface + RoadType + CarriagewayHazard * Surface + RoadType * Surface \quad (2)$$

Table 2. Parameter Estimations of the Log-Linear Model

	Estimatation	Std. Error	z-value	p	*
Constant	3.182	0.117	27.176	<0.001	*a*
Carriageway Hazard					
Object on road	0.958	0.097	9.870	<0.001	*a*
Pedestrian in carriageway	-0.801	0.148	-5.404	<0.001	*a*
Previous accident	-1.162	0.169	-6.877	<0.001	*a*
Vehicle load on road	-0.426	0.131	-3.247	0.001	*a*
Surface					
Wet	-1.413	0.245	-5.764	<0.001	*a*
Road Type					
One-way street	-2.023	0.266	-7.606	<0.001	*a*
Roundabout	-1.705	0.232	-7.355	<0.001	*a*
Single carriageway	1.553	0.100	15.524	<0.001	*a*
Slip road	-2.850	0.389	-7.331	<0.001	*a*
Carriageway Hazard:Surface					
Object on road:Wet	0.705	0.213	3.306	0.001	*a*
Pedestrian in carriageway:Wet	0.738	0.291	2.539	0.011	*a*
Previous accident:Wet	0.438	0.348	1.287	0.198	*c*
Vehicle load on road:Wet	0.426	0.279	1.527	0.127	*c*
Surface:Road Type					
Wet:One-way street	0.656	0.409	1.605	0.109	*c*
Wet:Roundabout	-0.148	0.445	-0.332	0.740	
Wet:Single carriageway	-0.143	0.185	-0.770	0.441	
Wet:Slip road	0.710	0.581	1.288	0.198	*c*

[*] Level of significance; [a] 95% confidence interval. [b] 90% confidence interval. [c] 80% confidence interval

Null deviance: 2665.43 on 49 degrees of freedom
Residual deviance: 58.17 on 32 degrees of freedom
AIC: 252.93

As can be seen from Table 2, there are relationships between accident frequency and carriageway hazard, road type, and surface condition. Carriageway hazard, road type, and surface condition were included as three main, carriageway hazard-surface and surface-road type were included as two-way components in the model. In order to examine the significance of the relationships, please refer to the confidence intervals for the estimated parameters.

Accident frequencies according to model estimation are given in Table 3. As can be observed here, motorcycle accidents occur most frequently when there is an object on the road in single carriageway. This is followed by the presence of animal and vehicle load in single carriageway in case the road surface is dry.

Table 3. Accident Frequencies According to Model Estimation

Surface	Road Type	Carriageway Hazard					Total
		Animal in carriageway	Object on road	Pedestrian in carriageway	Previous accident	Vehicle load on road	
Dry	Dual carriageway	2.35%	6.13%	1.06%	0.13%	1.54%	11.20%
	One-way street	0.31%	0.81%	0.14%	0.74%	0.20%	2.20%
	Roundabout	0.43%	1.11%	0.19%	0.10%	0.28%	2.11%
	Single carriageway	11.11%	28.95%	4.99%	3.48%	7.26%	55.79%
	Slip road	0.14%	0.36%	0.06%	0.04%	0.09%	0.69%
Wet	Dual carriageway	0.57%	3.02%	0.54%	0.28%	0.57%	4.98%
	One-way street	0.15%	0.77%	0.14%	0.07%	0.15%	1.27%
	Roundabout	0.09%	0.47%	0.08%	1.14%	0.09%	1.88%
	Single carriageway	2.34%	12.36%	2.20%	0.03%	2.34%	19.28%
	Slip road	0.07%	0.36%	0.06%	0.04%	0.07%	0.60%
Total		17.56%	54.33%	9.47%	6.05%	12.59%	100.00%

Conclusions

In this research, the effects of carriageway hazards, road types, and surface conditions on motorcycle accident frequency were investigated using log-linear analysis. According to the model estimation results, it was seen that there were significant relationships between the categorical variables and the frequency of motorcycle accidents.

Considering the frequency of accidents according to the model estimation, it is seen that motorcycle accidents are more likely to occur on the dry surface than on wet surface conditions. The main reason for this might be that fewer motorcycle trips are made and motorcyclists ride more carefully in rainy weather. Regardless of whether the road surface is wet or dry, it is predicted that the most frequent accident will occur because of an object on road in single carriageway. Other frequent accidents are followed by the presence of animals and vehicle load on road in single carriageway. The fact that most accidents happen on a single lane road, in case of an object on the undivided road, reflexively crossing to the opposite lane or overtaking without control, insufficient braking distance due to high speed in case of an oncoming vehicle, and unused reflectors for previous accidents can be counted as reasons. In the light of these results, a sustainable measure might be developed to avoid objects on the road by ensuring that traffic officers and local officials are immediately aware of the problem by utilizing artificial intelligence and image processing systems for surveillance cameras.

For further studies, the factors affecting the frequency and severity of motorcycle accidents can be investigated by developing accident causality models that consider more independent variables with a disaggregated data set.

Acknowledgements

I very much appreciate the U.K. Department for Transport for openly shared road safety data and contributions to academic studies. I also wish to thank the open source R Project and R Studio contributors and package developers for providing a free software environment for statistical computing and graphics.

References

[1] Shankar V, Mannering F. An exploratory multinomial logit analysis of single-vehicle motorcycle accident severity. Journal of safety research; 1996;27(3):183-194.

[2] Quddus MA, Noland RB, Chin HC. An analysis of motorcycle injury and vehicle damage severity using ordered probit models. Journal of Safety research; 2002;33(4):445-462.

[3] Rifaat SM, Tay R, De Barros A. Severity of motorcycle crashes in Calgary. Accident Analysis & Prevention; 2012;49:44-49.

[4] Shaheed MS, Gkritza K. A latent class analysis of single-vehicle motorcycle crash severity outcomes. Analytic Methods in Accident Research; 2014;2:30-38.

[5] Akalın KB, Karacasu M, Ergül B, Altın Yavuz A. Examination of Traffic Accidents in Antalya by Log-Linear Analysis. 3rd International Conference on Civil and Environmental Engineering; 2018.

[6] Christensen R. Logistic Regression, Logit Models, and Logistic Discrimination. Log-Linear Models and Logistic Regression; 1997;116-177.

[7] Howell DC. Statistical methods for psychology. Cengage Learning; 2012.

[8] U.K. Department for Transport. Road Safety Datasets. https://www.gov.uk/government/collections/road-accidents-and-safety-statistics#road-safety-data. Last accessed: 01.07.2022.