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ANALYZING THE IMPACT OF ROADSIDE FEATURES ON INJURY SEVERITY

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ABSTRACT
The design and implementation of a multimodal transportation system must address the issue of mobility and sustainability with the objective of making transportation safer, better, faster, and more reliable. Roadway safety hardware which has been provided as a countermeasure to reduce the severity of highway crashes may have a contributing effect to injury severities on the highway. This emphasizes the need to evaluate the effects of roadside features on injury severity along rural and urban roadways. The study examines the effectiveness of roadside hardware in twenty-four (24) counties in the State of Maryland using the vehicular crash data for the years 2016 to 2018. The relationship between accident occurrence and the traffic and control characteristics of roadway was investigated to develop a Multinomial Logit Model to identify the factors determining the severity of vehicle crashes in relation to roadside features. Findings showed that roadside features such as trees may increase the propensity of a fatal and serious injury relative to a property damage.

Keywords: Roadside Safety Hardware, Countermeasure, Multinomial Logit Model, Pedestrian-Vehicle Crashes.

1. INTRODUCTION
The purpose of transportation engineering is to plan and implement multimodal transportation systems that can address the problem of mobility and sustainability. Transportation researchers are finding new ways to reduce crashes on the highway, with the objective of making our transportation system safer, better, faster and more reliable. Roadway safety hard wares have been used as countermeasures to reduce crash severity on the highway; however, these roadway safety hard wares may also be contributing factors to fatal, incapacitating, or non-incapacitating roadway crashes. Roadway safety hardwares are used to prevent dangerous collisions involving roadway features such as trees, utility poles, steep slopes or cliffs (Holdridge et al., 2005). These roadway features are also major contributors to roadway crashes. It is therefore imperative to address the issue of crashes resulting from roadway features and hardwares by analyzing the impact of these roadway features and hardwares on crash severities; it is also imperative to investigate new ways to solve this problem. This study therefore, seek to analyze and model roadside related crashes and injury severities along rural and urban roadways in Maryland with the objective of investigating and identifying factors (in relation to roadside features) that can increase or decrease injury severity level.

Studies have shown that the number of fixed roadside objects and their offset have greatly influence the occurrence of roadside crashes. Vehicle collisions cost the United States billions of dollars each year and resulted in an estimated 34,080 fatalities in 2012. Roadside features are increasingly accounting for injury severities ranging from fatal, incapacitating (serious injury), and non-incapacitating (minor injury) to Property Damage Only (PDO) (Watson et al., 2014). Every year, hundreds of people are killed in Maryland in car accidents, while thousands more are hurt. Although Tens of thousands of additional car crashes only lead to property damage, these crashes can cause serious problems for the people involved. According to report, in 2016 Maryland saw 120,120 car accidents. In total, these crashes injured 50,864 and killed 522 people (Bedigian, 2020). Based on crash data downloaded from Maryland open data portal, from 2016 to 2018 a total of 237, 080 vehicular crashes were recorded of which 920 were fatal crashes, 70,204 were injury Crashes and 165,956 were property damage crashes. In the United States, crashes involving fixed roadside objects account for approximately 30% of the total number of traffic fatalities and 60% of crashes on the highway.

2. LITERATURE REVIEW

Several literatures have analyzed crashes related to roadside features along state roads and corridors in the United States. Significant factors that affect crash severities involving roadside features through improved statistical efficiency along with disaggregate and multivariate analysis was done by Holdridge et al., 2005, their result shows that, roadside features such as the leading end of guard rails and bridge rails, trees and utility poles, increased the likelihood of a fatal injury. Their findings also state that the most frequently struck roadside features are trees and utility poles, while less frequently struck are guardrails, signs, mailboxes, and bridge ends. Roadside features with the highest percentage of fatal crashes were found to be culverts, trees, utility and light poles, bridges, rocks and earth embankments. Lee and Mannering (2002), analysed the impact of roadside features on run-off-road way accident frequency and injury severity using zero inflated count models and nested logistic models. Based on their analysis run-off-accident frequency will be reduced by reducing the distance between guardrails on the roadway and outside shoulder edge, reducing the number of isolated trees along the roadway, and increasing the distance between outside shoulder edge to light poles. Ewan et al., (2016), conducted a research on the impact of geometric and roadside features on crash occurrence and associated risks on low volume roads in Oregon. Their analysis show that roadways having lane width less than 12ft have a higher likelihood of crash occurrence compared to roads with the standard lane width of 12ft. Peng et al., 2012, investigated the impact of roadside features on road departure crashes. The evaluation was done on a 245-mile-long section of two-way lane roads in Texas. They used a negative binomial model for crash frequency and a multinomial logistic model for injury severity. Their analyses show that side slope condition, lateral clearance, shoulder width had significant effect on roadway departure crashes. According to Tung et al., (2008), roadside objects are the main contributing factors to motorcyclist fatalities. In 2005 there were over 25 000 fatalities as a result of a driver leaving their lane and either crashing with an oncoming vehicle, rolled over or hit an object located along the highway (FHWA, 2006).

Injury severity levels are usually ordered from the from the most critical (fatal injury) to the least critical (PDO under), as a result of this order, the ordered logistic models are best appropriate for modelling injury severity (Quddus et al. 2002, Kockelman and Kweon 2002, Khattak et al. 2002). However, for the independent variables to have a non-monotonic effect on the dependent variable, researchers have used multinomial logistic which is the opposite of ordered logistic (Wang and Abdel-Aty 2008, Tay et al. 2011). And according to Savolainen et al., (2011), multinomial logistic model is the most prominent model for modelling injury severity. This paper has therefore employed a multinomial logistic model to develop an injury severity model in relation to roadside features.

3. METHODOLOGY

Three injury severity levels were considered in this study: Fatal, Property damage and injury crash. Multinomial logistic was employed using SPSS statistical software to develop an injury severity model. The crash data was first downloaded from Maryland Open Data Portal. The data was then screened to remove duplicates and crashes with incomplete information. The data was then analyzed using SPSS statistical software. See figure 1 for methodology adopted.

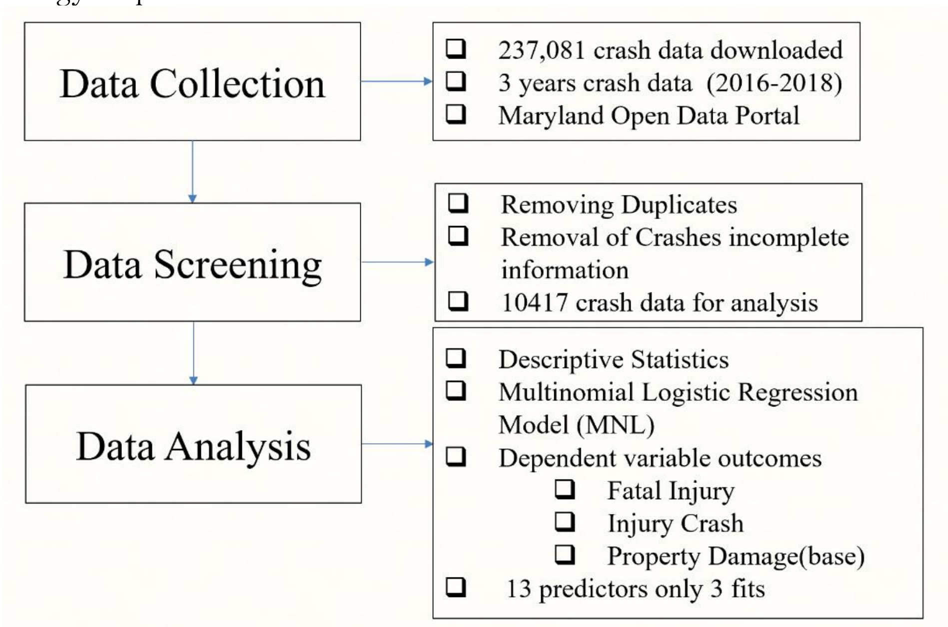

Figure 1. Research Methodology

3.1 Data

This paper utilized three years data from 2016-2018, extracted from Maryland Open Data Portal. A total of 237, 080 crashes were downloaded for 24 counties in the state of Maryland. Duplicate crashes were removed, and the data was screened for only roadside feature related crashes and other factors which are significant to affect injury severity. As a result of the screening only 10417 crash data were recovered. The crash data were downloaded with features such as number of lanes, type of terrain, date and time when the crash occurred, log mile, weather condition, manner of collision, light condition, manner of first collision, year of crash, and type of crash categorized as fatal, Property Damage, Injury crash.

3.2 Descriptive Statistics

After the downloaded data was screened a total of 10417 roadside related crashes were retained and used for analysis. Figure 2 shows the descriptive statistics for the variable lighting condition. From the result most of the crashes including fatal, injury and property damage crash occur in the dark with no lights. Descriptive statistics from Figure 3 show that majority of the fatal and injury crashes were caused by vehicle striking a tree along the cross section of the road. And majority of the injury crashes and property damage was caused by the vehicle striking a guardrail, Figure 4 shows that majority of the crashes occurred during clear weather that means during the daytime.

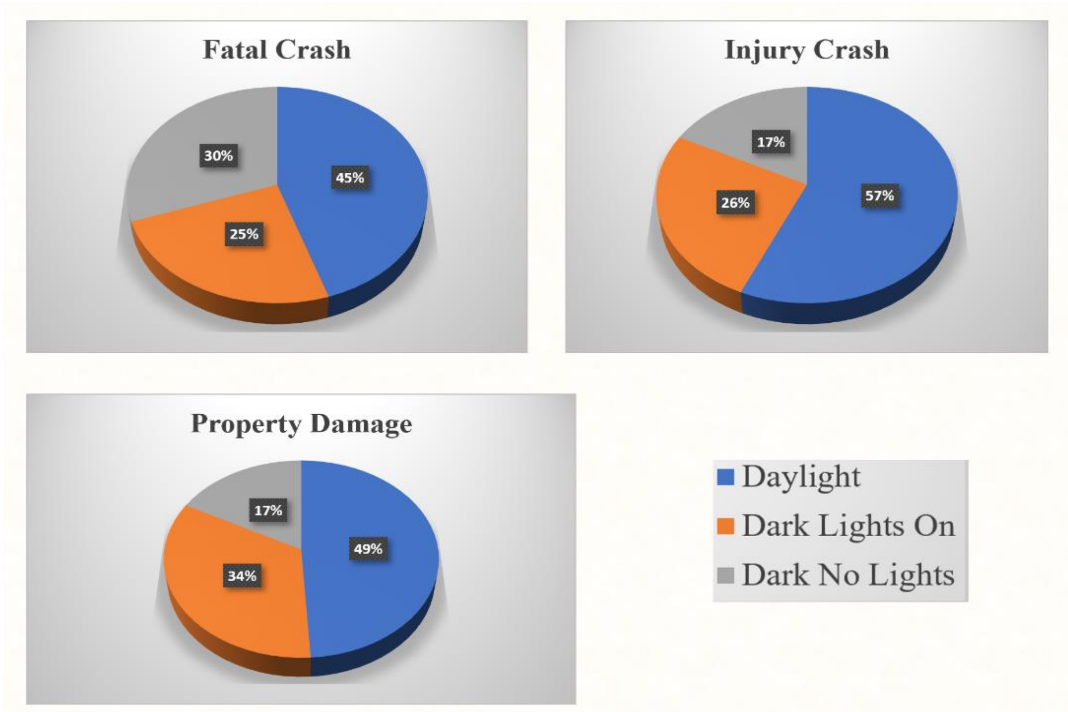

Figure 2. Descriptive Statistics for the Variable Lighting Condition

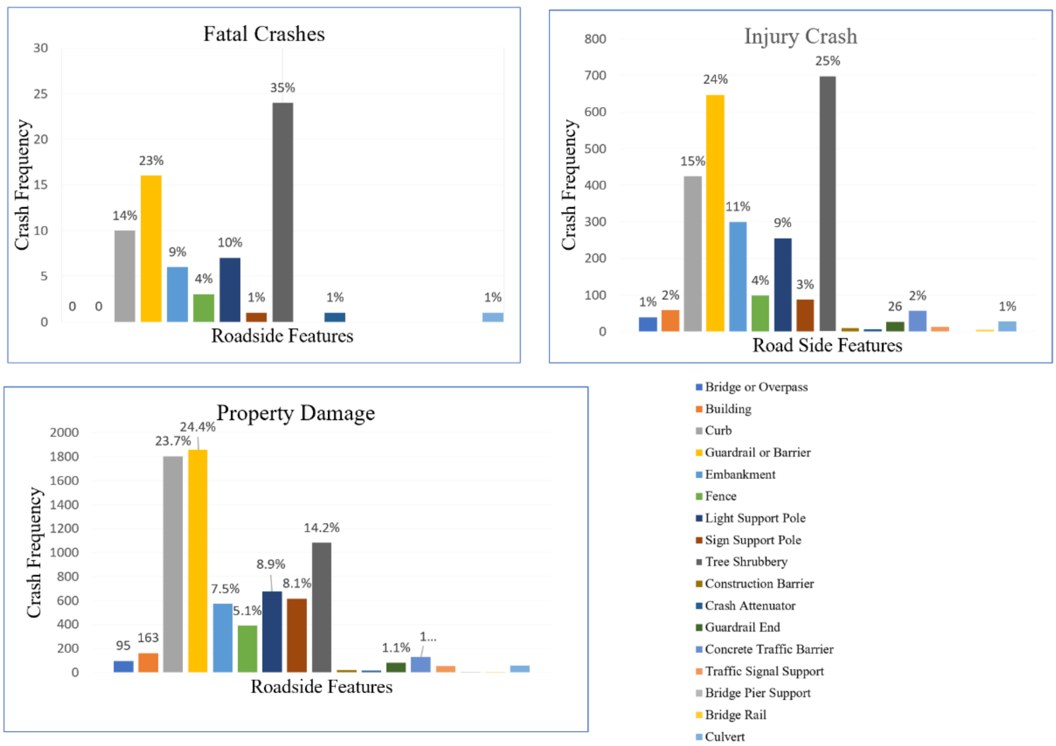

Figure 3. Descriptive Statistics for the Variable Roadside Features

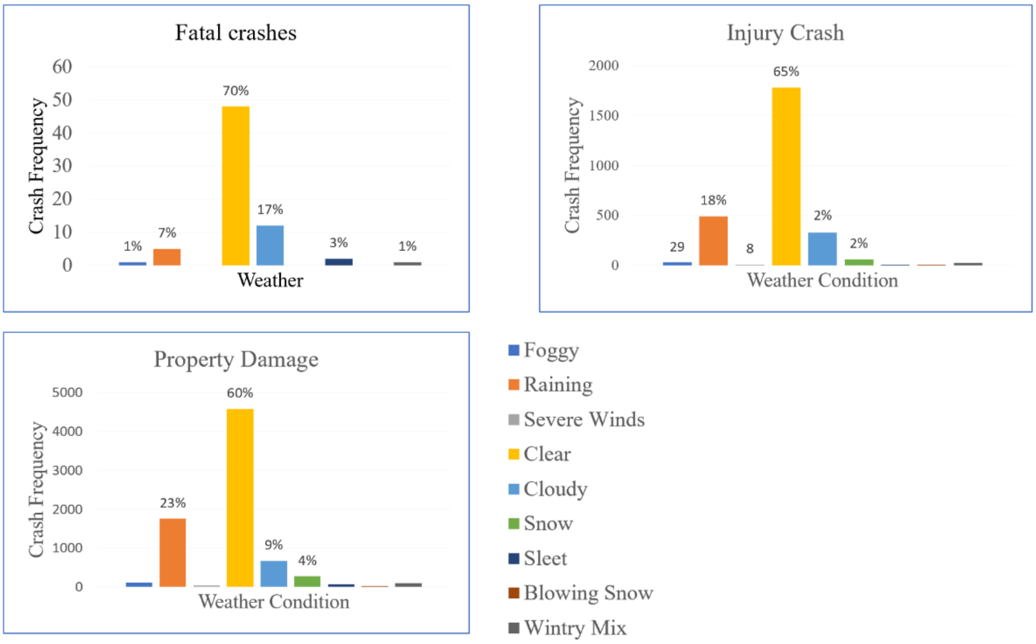

Figure 4. Descriptive Statistics for the Variable Weather Condition

4. INJURY SEVERITY MODEL RESULT DISCUSSION

The primary objective of this model is to estimate injury severity levels as a function of the explanatory variables such as roadside features and other significant factors that may affect injury severity level. The model developed is at a confidence interval of 95%. This means that variables with p-values greater than 0.05 (which is the standard reference P-value for a 95% confidence interval) are not significant variables affecting injury severity levels.

Variables with positive coefficient indicates that with the presence of the said variable there is a likelihood that the corresponding injury severity will increase in comparison to the base injury severity level (property damage). The reverse is the case for negative coefficient variables. According to the model developed, significant roadside features affecting injury severity levels are: Trees, sign support poles, traffic signal support and fence. Other factors found to significantly affect injury severity level are lighting and weather condition. When controlling for roadway features the model show that the variable standing tree have positive coefficients. This means that the presence of trees and embankments along the roadway increases the propensity of a fatal and serious injury relative to a property damage. This means that there is a high probability for a crash to be a fatal or serious injury when struck by a tree or an embankment along the road. The result also show that a cloudy weather may increase the propensity of a fatal or serious injury relative to a property damage. See table 1 for multinomial logistic result.

Table 1: Multinomial Logistic Result

Number of Observations			10417	
Log-Likelihood			923.730	
Chi-square			525.398	
P-Value			<.0001	
Base Case: Property Damage				
	Fatal Crash		Injury Crash	

Variables	Coefficient	P-Value	Coefficient	P-Value
Intercept	-3.776	.008	-1.420	<.0001
Roadside Features				
Bridge or Overpass	-14.239	.990	-.055	.858
Building	-14.228	.986	-.264	.348
Curb	-.877	.410	-.618	.010
Guardrail or Barrier	-.496	.635	-.222	.354
Embankment	-.375	.731	.167	.499
Fence	-.699	.549	-.584	.025
Light Support Pole	-.255	.815	-.146	.556
Sign Support Pole	-2.169	.128	-1.185	<.0001
Tree Shrubbery	.370	.720	.386	.100
Construction Barrier	-14.382	.995	-.061	.896
Crash Attenuator	1.173	.418	-.384	.468
Guardrail End	-14.052	.989	-.290	.376
Concrete Traffic Barrier	-13.991	.987	.042	.882
Traffic Signal Support	-14.377	.993	-.690	.084
Bridge Pier Support	-15.078		-14.954	.995
Bridge Rail	-14.369	.998	1.243	.166
Culvert	0^c		0^c	
Weather				
Foggy	-.256	.857	.145	.645
Raining	-1.202	.276	.210	.382
Severe Winds	-14.355	.994	-.180	.698
Clear	.099	.922	.582	.010
Cloudy	.643	.541	.755	.002
Snow	-13.971	.983	.000	.999
Sleet	1.067	.390	-.258	.524
Blowing Snow	-13.894	.995	.736	.100
Wintry Mix	0^c		0^c	
Lighting condition				
Daylight	-.460	.117	.260	<.0001
Dark Lights On	-.664	.050	-.083	.246
Dark No Lights	0^c		0^c	

5. CONCLUSION

This study has successfully used SPSS statistical software to model injury severity, utilizing crash data downloaded from Maryland Open Data Portal. The objective was to analyze the impact of roadside features on injury severity levels and investigate the impact of other explanatory factors affecting crash severity level on rural and urban roads in the State of Maryland. To achieve the research objectives this study utilized the Multinomial logistic model in SPSS to model injury severity. Based on the data analysis from this study, most of the crashes including fatal, injury and property damage crash occur in the dark with no lights. And majority of the fatal and injury crashes were caused by vehicle striking a tree along the cross section of the road. And majority of the injury crashes and property damage was caused by the vehicle striking a guardrail. Most of these crashes occurred during clear weather that means during the daytime. From the Multinomial Logistic model, significant roadside features affecting injury severity levels where found to be trees, sign support poles, traffic signal support and fence. Other factors found to significantly affect injury severity level are lighting and weather condition. The presence of trees along the roadway have been found to increase the propensity of a fatal and serious injury relative to a property damage. This means that there is a high probability for a crash to be a fatal or serious injury when struck by a tree along the roadway cross section. Cloudy weather may also increase the propensity of a fatal or serious injury relative to a property damage.

6. REFERENCES

Bedigian, B. (2020). What are the Car Crash Statistics in Maryland?

Ewan, L., Al-Kaisy, A., and Hossain, F. (2016). Safety effects of road geometry and roadside features on low-volume roads in Oregon. Transportation Research Record, 2580(2580), 47–55. https://doi.org/10.3141/2580-06

FHWA. (2006). Safety Compass: Highway Safety Solutions for Saving Lives. U.S. Department of Transportation. The Federal Highway Administration (FHWA).

Holdridge, J. M., Shankar, V. N., and Ulfarsson, G. F. (2005). The crash severity impacts of fixed roadside objects. Journal of Safety Research, 36(2), 139–147. https://doi.org/10.1016/j.jsr.2004.12.005

Khattak, A. J., Pawlovich, M. D., Souleyrette, R. R., and Hallmark, S. L. (2002). Factors related to more severe older driver traffic crash injuries. Journal of Transportation Engineering, 128(3), 243–249. https://doi.org/10.1061/(ASCE)0733-947X(2002)128:3(243)

Kockelman, K. M., and Kweon, Y. J. (2002). Driver injury severity: An application of ordered probit models. Accident Analysis and Prevention, 34(3), 313–321. https://doi.org/10.1016/S0001-4575(01)00028-8

Lee, J., and Mannering, F. (2002). Impact of roadside features on the frequency and severity of run-off-roadway accidents: An empirical analysis. Accident Analysis and Prevention, 34(2), 149–161. https://doi.org/10.1016/S0001-4575(01)00009-4

Peng, Y., Geedipally, S., and Lord, D. (2012). Effect of roadside features on single-vehicle roadway departure crashes on rural two-lane roads. Transportation Research Record, 2309, 21–29. https://doi.org/10.3141/2309-03

Quddus, M. A., Noland, R. B., and Chin, H. C. (2002). An analysis of motorcycle injury and vehicle damage severity using ordered probit models. Journal of Safety Research, 33(4), 445–462. https://doi.org/10.1016/S0022-4375(02)00051-8

Savolainen, P. T., Mannering, F. L., Lord, D., and Quddus, M. A. (2011). The statistical analysis of highway crash-injury severities: A review and assessment of methodological alternatives. Accident Analysis and Prevention, 43(5), 1666–1676. https://doi.org/10.1016/j.aap.2011.03.025

Tay, R., Choi, J., Kattan, L., and Khan, A. (2011). A multinomial logit model of pedestrian-vehicle crash severity. International Journal of Sustainable Transportation, 5(4), 233–249. https://doi.org/10.1080/15568318.2010.497547

Tung, S. H., Wong, S. V., Law, T. H., and Umar, R. S. R. (2008). Crashes with roadside objects along motorcycle lanes in Malaysia. International Journal of Crashworthiness, 13(2), 205–210. https://doi.org/10.1080/13588260701788534

Wang, X., and Abdel-Aty, M. (2008). Analysis of left-turn crash injury severity by conflicting pattern using partial proportional odds models. Accident Analysis and Prevention, 40(5), 1674–1682. https://doi.org/10.1016/j.aap.2008.06.001

Watson, D. C., Al-kaisy, A., and Anderson, N. D. (2014). Examining the effect of speed, roadside features, and roadway geometry on crash experience along a rural corridor. Journal of Modern Transportation, 22(2), 84–95. https://doi.org/10.1007/s40534-014-0040-4