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Identifying the Contributing Factors to Nighttime Crashes at Freeway Mainline Segments in Florida

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Abstract

This study investigated the characteristics of the nighttime crashes at freeway mainline segments and the contributing factors to injury levels. The nighttime crash rate is 1.6 times more than daytime and the fatality rate is higher. In this study five injury levels, no injury, possible injury, non-incapacitating injury, capacitating injury, and fatal injury, were considered. Crash data (2005-2010) were collected for interstate highways in Florida. The no injury level was used as the baseline. Multinomial logit model (MNL) was selected to estimate the explanatory variables at 95% confidence. Contributing factors included driver-conditions, geometric-conditions, vehicle-conditions, crash-conditions, and environmental-conditions. This study concluded that safety equipment reduces crashes, alcohol, drugs and young drivers increase the likelihood of severe crashes.

Introduction

Driving during nighttime tends to be more risky than day time. The nighttime crash rate is 1.6 times of the daytime rate. Additionally, the fatality rate of nighttime crash is much higher than the day time's rate.

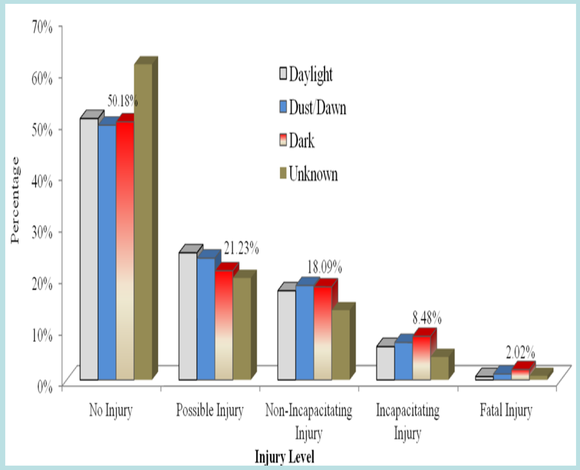

Figure 1 Percentage of Crash Injury Levels under Different Lighting Conditions from 2005 – 2010

The purpose of this study is to investigate the crash contributing factors to the injury outcomes and the characteristics of the night time crashes at freeway mainline segments. The findings from this study could help the engineers and researchers to further select the effective countermeasures and/or policies to effectively reduce the night time crashes, especially the injury severity levels.

Methods

MNL, was used in this study to estimate the crash injury outcomes by different explanatory variables.

(1)

$$\boldsymbol{Y}_{ik} = \alpha_k + \boldsymbol{\beta}_k \boldsymbol{X}_{ik} + \varepsilon_{ik},$$
$$i = 1, \ldots, n \;,\; k = 1, \ldots m,$$

(2)

$$P_i(k|\boldsymbol{\beta}) = \frac{\exp(\alpha_k + \boldsymbol{\beta}_k \boldsymbol{X}_{ik} + \varepsilon_{ik})}{\sum_{k=1}^{m} \exp(\alpha_m + \boldsymbol{\beta}_m \boldsymbol{X}_{im} + \varepsilon_{im})}$$

(3)

$$OR_{jk} = exp(\beta_{j_k}) \;, j_k = 1, \ldots, u_k$$

Data Collection

The six-year crash data were used in this study. 45,798 crashes were occurred at the freeways. Twenty-eight variables were initially selected and described in TABLE 1, included one categorical variable, twenty-one dummy variables and five continuous variables. Five injury level outcomes were coded from 1 to 5. The roadway condition, crash condition, driver information, and vehicle information were considered.

Type	Variable	Value	Description	Freeway	
				Count	Percent
Categorical	Injury Level	1	No Injury	20655	45.1%
		2	Possible Injury	11552	25.2%
		3	Non-Incapacitating Injury	8864	19.4%
		4	Incapacitating Injury	4055	8.9%
		5	Fatal Injury	672	1.5%
Dummy	Area	1	Rural	5009	10.9%
		0	Urban	40789	89.1%
	Alcohol_Drug	1	Alcohol or Drug Influenced	7297	15.9%
		0	No Alcohol or Drug Influenced	38501	84.1%
	Light	1	Street Light	28355	61.9%
		0	No Street Light	12434	27.1%
	Rain	1	If it was raining	6821	14.9%
		0	Otherwise	38977	85.1%
	Fog	1	If it was foggy	297	0.6%
		0	Otherwise	45501	99.4%
	Road_Wet	1	If crash was on the wet or slippery road	10689	23.3%
		0	Otherwise	35109	76.7%
	Divided	1	If the road is divided	39267	85.7%
		0	Otherwise	6531	14.3%
	Road_Defect	1	If the road has defect	3039	6.6%
		0	Otherwise	42759	93.4%
	Vision_Not_ Block	1	If vision is not blocked	43590	95.2%
		0	If vision is blocked	2208	4.8%
	Single_ Vehicle	1	Single Vehicle Crash	14149	30.9%
		0	Multi Vehicles Crash	31649	69.1%
	Rearend	1	If 1st harmful event is rear-end	14707	32.1%
		0	Otherwise	31091	67.9%
	HeadOn	1	If 1st harmful event is head-on	942	2.1%
		0	Otherwise	44856	97.9%
	Angle	1	If 1st harmful event is angle	5800	12.7%
		0	Otherwise	39998	87.3%
	LeftTurn	1	If 1st harmful event is left turn	1699	3.7%
		0	Otherwise	44099	96.3%
	RightTurn	1	If 1st harmful event is right turn	265	0.6%
		0	Otherwise	45533	99.4%
	SideSwipe	1	If 1st harmful event is sideswipe	4440	9.7%
		0	Otherwise	41358	90.3%
	Fixed_Object	1	If 1st harmful event is collision with fixed	10658	23.3%
		0	Otherwise	35140	76.7%
	Automobile	1	If crash involved in auto	33776	73.7%
		0	Otherwise	12022	26.3%
	Truck_Bus	1	If crash involved in truck or bus	11015	24.1%
		0	Otherwise	34783	75.9%
	Bike	1	If crash involved in bike	130	0.3%
		0	Otherwise	45668	99.7%
	No Safety Protection	1	If safety equipment is not used	3957	8.6%
		0	Otherwise	41841	91.4%
Continuous	Should_Width	Road Shoulder Width (ft)		0~98	
	AADT	Average Annual Daily Traffic in Thousand		4.50 ~328	
	Truck _Factor	Percent of heavy truck (%)		0~53	
	Post_Speed	Posted speed limit (mph)		45~70	
	Age	Driver age (year)		15~109	

TABLE1.Selected Explanatory Variables

Results

Five injury outcomes were used and the baseline category is no injury. Twenty-three variables out of twenty-eight are significant for most of the injury outcomes.

Chance of Fatality				Severe Injury Outcome	
Alcohol or Drug influenced	**No Street Lights**	**No Safety Equipment Used**	**Single Vehicle Crash**	**Head-on, Angle, Left-Turn**	**Right-Turn and Sideswipe**
3.77 times greater	**1.43 times greater**	**8 times greater**	**1.4 times greater**	**2-18 times greater**	**0.001-0.9 times**

Model Fit Statistics

Observations	45798	Test	Chi-Square	Pr > χ^2
AIC	113780.3	Likelihood Ratio	5585.886	<.0001

Model Analysis

Parameter	Possible Injury			Non-Incapacitating Injury			Incapacitating Injury			Fatal Injury		
	Coef.	Std. Error	Pr > χ^2	Coef.	Std. Error	Pr > χ^2	Coef.	Std. Error	Pr > χ^2	Coef.	Std. Error	Pr > χ^2
Intercept	0.00	0.19	0.98	0.83	0.18	<.0001	-0.69	0.22	0.00	-4.42	0.50	<.0001
Area	-	-	-	-	-	-	0.27	0.06	<.0001	0.21	0.13	0.11
Should_Width	-	-	-	-	-	-	0.03	0.01	0.00	0.09	0.02	<.0001
AADT	0.002	0.000	<.0001	-	-	-	-	-	-	0.002	0.001	0.024
Truck _Factor	-	-	-	-	-	-	-	-	-	0.02	0.01	0.03
Post_Speed	-	-	-	0.01	0.00	<.0001	0.03	0.00	<.0001	0.03	0.01	<.0001
Alcohol_Drug	-0.17	0.03	<.0001	0.11	0.04	0.00	0.11	0.05	0.02	1.33	0.09	<.0001
Lighting	-	-	-	-	-	-	-0.15	0.05	0.00	-0.39	0.11	0.00
Rain	-	-	-	-0.28	0.06	<.0001	-0.19	0.08	0.02	-	-	-
Road_Wet	0.09	0.04	0.02	-	-	-	-0.18	0.07	0.01	-	-	-
Divided	0.08	0.04	0.02	0.11	0.04	0.01	-	-	-	0.82	0.19	<.0001
Vision_Block	-0.12	0.06	0.04	-0.22	0.07	0.00	-	-	-	-	-	-
Single_Vehicle	0.40	0.07	<.0001	0.61	0.07	<.0001	0.60	0.08	<.0001	0.37	0.16	0.02
RearEnd	0.66	0.05	<.0001	0.24	0.05	<.0001	-	-	-	-	-	-
HeadOn	0.72	0.09	<.0001	0.77	0.10	<.0001	0.95	0.13	<.0001	1.17	0.25	<.0001
Angle	0.51	0.06	<.0001	0.63	0.06	<.0001	0.57	0.08	<.0001	-	-	-
LeftTurn	0.79	0.08	<.0001	0.96	0.08	<.0001	1.13	0.11	<.0001	-	-	-
RightTurn	-	-	-	-0.48	0.21	0.02	-0.83	0.37	0.03	-	-	-
SideSwipe	-0.28	0.06	<.0001	-0.59	0.07	<.0001	-0.89	0.10	<.0001	-2.01	0.27	<.0001
Fixed_Object	-0.23	0.06	<.0001	-0.41	0.05	<.0001	-0.47	0.06	<.0001	-0.63	0.13	<.0001
Automible	-1.05	0.16	<.0001	-2.46	0.13	<.0001	-3.13	0.14	<.0001	-3.57	0.19	<.0001
Truck_Bus	-1.23	0.16	<.0001	-2.64	0.14	<.0001	-3.17	0.14	<.0001	-3.42	0.20	<.0001
Bike	1.34	0.43	0.00	-	-	-	-	-	-	-	-	-
No Safety Protection	-0.13	0.05	0.01	0.40	0.05	<.0001	1.04	0.05	<.0001	2.09	0.09	<.0001
Age	-0.003	0.001	<.0001	-0.004	0.001	<.0001	-0.003	0.001	0.034	-	-	-

TABLE 2. Multinomial Logit Model Result

Conclusion

The MNL was developed to estimate the contributing factors, including driver conditions, geometric conditions, vehicle conditions, crash conditions, and environmental conditions, to different injury outcomes for night time crashes.

The method can be applied to other types of road conditions, ramps, intersections, major and minor arterials, etc. The findings from this study could help the engineers and researchers to further select the effective countermeasures or policies to potentially reduce the night time crashes, especially the injury severity levels.