Identifying the Contributing Factors of Motorcycle Fatality Rates in the USA – An Exploratory National Data Analysis

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Introduction

❑ Motorcycle safety is a growing concern in the overall transportation safety and many states include motorcycle safety in the Emphasis Areas in the Strategic Highway Safety Plan (SHSP).

❑ Motorcycle fatality rate being fatalities per 100,000 registered motorcycles is considered one of the important indicators of this emphasis area.

Problem Statement

❑ The national data indicates that motorcycle fatalities per 100,000 registered motorcycles is **six times** higher than those of passenger cars per 100,000 registered cars over the years with alarming increase.

❑ Motorcycles made up 3 percent of all registered vehicles in the United States in 2015 and accounted for only 0.6 percent of all vehicle miles traveled.

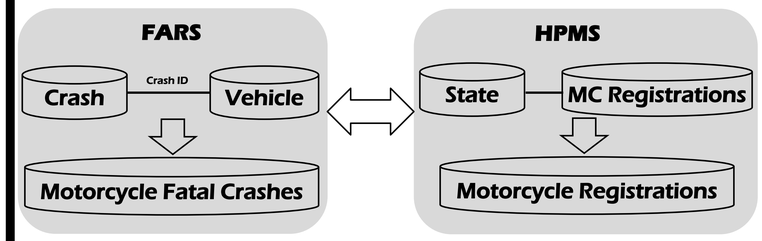
❑ Single- and multi-vehicle crash characteristics are different particularly for motorcycles.

Objective

❑ This main objective of this study is to identify the contributing factors related to motorcycle crashes with an emphasis for single- and multi-vehicle crash rates.

Data

Crash Data: FARS, Motorcycle Registration Data: HPMS



Analysis Period: 2011 - 2015

Figure 1: Dataset Processing for Model

Methodology

❑ Modeling steps initiates with continuous censored regression. Then, single- and multi-vehicles crashes involving motorcycles were modeled with bivariate framework..

$$Y_i^* = \beta X_i + \varepsilon_i, \quad i = 1,2, \ldots N$$

$$Y_i = Y_i^* \quad if \quad Y_i^* > 0 \qquad Y_i = 0 \quad if \quad Y_i^* \leq 0$$

where,

Y_i = fatalities per 100,000 registerted motorcycles

X_i = a vector of independent variables (e.g., human, driving history, crash types, temporal and spatial characteristics)

β_i = a vector of estimable parameters,

N = number of observation in the model

ε_i = normally and independently distributed error term with zero mean and constant variance σ^2.

$$Fatalities\ per\ 100,000\ registered\ motorcycles = \left[\frac{Fatalities}{Registered\ Motorcycles}\right] * 100,000$$

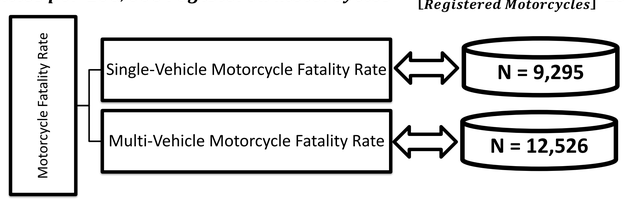


Figure 2: Modeling Framework

Empirical Results

Table 1: Empirical Model Results for Motorcycle Fatality Rates

Meaning of variables	Coefficient	t-stat	P-Value
Constant	0.425	15.121	0.0000
Temporal characteristics			
Time of day (1 if time between 4 PM to 7 PM, 0 otherwise)	0.043	3.16	0.0016
Month of year (1 if June, 0 otherwise)	0.059	3.123	0.0018
Month of year (1 if July, 0 otherwise)	0.046	2.464	0.0137
Month of year (1 if August, 0 otherwise)	0.070	3.806	0.0001
Spatial characteristics			
Traffic route type (1 if US route sign, 0 otherwise)	0.126	6.956	0.0000
Traffic route type (1 if Local municipal route sign, 0 otherwise)	0.068	3.943	0.0001
Crash location (1 if rural roads, 0 otherwise)	0.140	10.257	0.0000
Funtional class of roadway (1 if local urban road, 0 otherwise)	0.136	5.897	0.0000
Roadway alignment (1 if roadway curves to the left prior to critical crash, 0 otherwise)	-0.043	-2.411	0.0159
Crash types			
Vehicle involved in crashes (1 if single vehicle, 0 otherwise)	0.097	4.687	0.0000
Crash type (1 if manner of collision is angle, 0 otherwise)	0.073	4.46	0.0000
Final position of vehicle (1 if outside travel lane, 0 otherwise)	0.047	2.288	0.0222
Driving history			
Previous crash history (1 if 1 crash occurred last 3 year, 0 otherwise)	0.123	-6.134	0.0000
License suspension (1 if driver's license was not suspended, 0 otherwise)	0.066	3.953	0.0001
Moving violation (1 if one violation in last 5 year, 0 otherwise)	-0.158	-5.71	0.0000
Moving violation (1 if no violation in last 5 year, 0 otherwise)	-0.118	-4.857	0.0000
Speeding violation (1 if no speeding violation in last 5 year, 0 otherwise)	-0.060	-3.983	0.0001
Behavioral characteristics			
Alcohol content (if BAC is upto 80, 0 otherwise)	0.035	2.339	0.0193
Contributing factor to fatal crash (1 if speeding, 0 otherwise)	0.041	2.367	0.0179
Presence of passenger (1 if more than driver, 0 otherwise)	0.144	9.359	0.0000
Sigma	0.920	27.852	0.0000
Number of observations		22,929	
Log likelihood at zero, LL(0)		-30,414	
Log likelihood at convergence, LL(β)		-30,170	
Chi-square, χ2 = - 2*[LL(0) – LL(β)]		488	

The p-value is considered up to 0.02indicating at 98% confidence that coefficient estimates are significantly different from zero.

Empirical Results

Human	Spatial	Temporal	Crash Type
• Alcohol (0.08) • Occupants • Speeding • Moving violation (1 or no) • Speeding violation (no) • Suspended license (no) • Previous crash history (1)	• US Route • Local Municipal route • Rural roads • Urban local roads • Road alignment (curved to left)	• TOD (4 – 7 PM) • MOY (Jun – Aug)	• Single-vehicle • Run-off-road • Angle

Figure 4: Model Results for Motorcycle Fatality Rate (Full Model)

Human	Spatial	Temporal	Crash Type
• Alcohol (0.08) • Speeding • Helmet (no)	• Local Municipal route • Rural roads • Road alignment (curved to left) • Segments	• TOD (1 – 3 PM) • MOY (Aug)	• Run-off-road

Figure 4: Model Results for Single-vehicle Motorcycle Fatality Rate

Human	Spatial	Temporal	Crash Type
• Occupants • Speeding (No) • DWI (no) • Age (55+)	• Urban roads • 3-leg INTX • 4-leg INTX	• TOD (4 – 7 PM)	• Angle • Front to rear impact

Figure 5: Model Results for Multi-vehicle Motorcycle Fatality Rate

Conclusions

❑ The national data analysis clearly shows the spatial, temporal, crash type, driving history, and drivers' behavioral aspect highly affect Motorcycle fatality rates.

❑ The risk factors associated with motorcycle fatality rates vary by nature of single- and multi-vehicle crashes.

❑ A well-defined Motorcycle Strategic Safety Plan is critical considering 'Towards Zero Deaths' in the near future.

Future Directions

❑ Fatalities per 100M motorcycle VMT
❑ Rural vs Urban (bivariate)
❑ Age group (multivariate)

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