EXAMINING FACTORS CONTRIBUTING TO MOTORCYCLE COLLISIONS WITH LEFT-TURNING VEHICLES AT URBAN INTERSECTION LOCATIONS

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Introduction

- Motorcycle crashes account for a significant proportion of traffic-related fatalities on U.S. roadways.
- Compared to motor vehicles, motorcycles traveling straight ahead are more susceptible to collisions with left-turning vehicles at intersections.

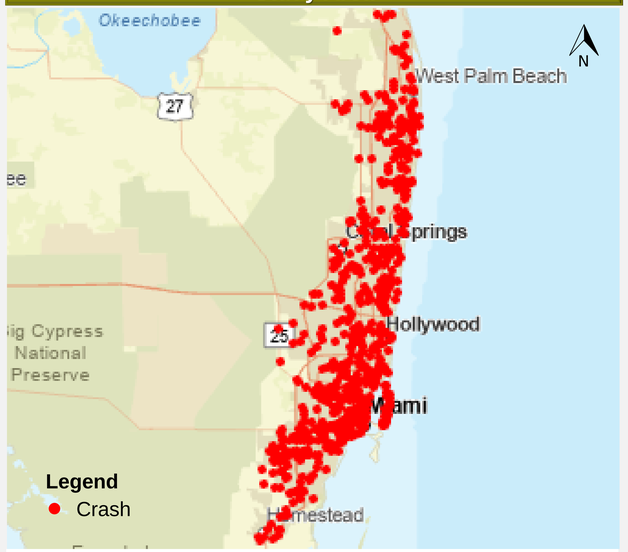
Study Objective

- Understand factors that may contribute to the disproportionate crash risk left-turning vehicles pose for motorcyclists.

Data

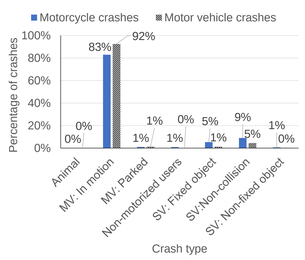
- Crash Analysis Reporting (CAR) database:
  - Repository of crash data for FDOT
  - Crash data from 2015 - 2017
  - 6,525 crashes involving motorcycles
  - 832 motorcycle crashes occurred on freeways
  - 5,159 motorcycle crashes occurred on surface roads

Study Area

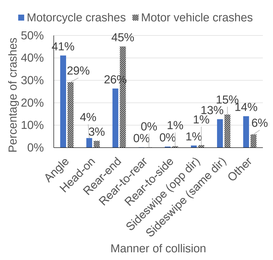


Motorcycle-motor vehicle (MC-MV) crashes in South Florida

Data Processing



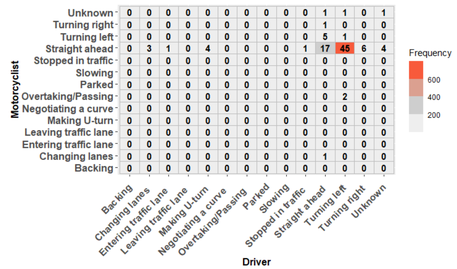
Type of crashes on surface roads



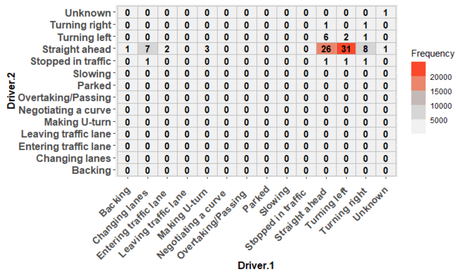
Manner of collision in multi-vehicle crashes

Data Processing

Matrix of movements of parties involved in angle crashes involving a motor vehicle in motion with motorcycles



Matrix of movements of parties involved in angle crashes involving a motor vehicle in motion with other motor vehicles



Descriptive Statistics

		MC-MV		MV-MV		Chi-square	
Variable	Category	Count	Perc.	Count	Perc.	χ2	P-value
Location and control for the left-turning driver	Signalized intersection	142	19%	12064	44%		
	Unsignalized intersection	208	28%	9958	37%	523.03	0.000
	Driveway/Alley Access	387	53%	5151	19%		
	Total	737	100%	27173	100%		
Weather	Clear	712	97%	25253	93%		
	Unclear	25	3%	1920	7%	14.33	0.000
	Total	737	100%	27173	100%		
Type of roadway left-turning driver is on	Divided	442	60%	15110	56%		
	Undivided	295	40%	12063	44%	0.032	0.857
	Total	737	100%	27173	100%		
Road class	Arterial	535	73%	20421	75%		
	Not arterial	202	27%	6752	25%	2.385	0.123
	Total	737	100%	27173	100%		
Time	Morning	61	8%	3678	14%		
	Mid-day	189	26%	8810	32%		
	Afternoon	156	21%	6270	23%		
	Early Evening	197	27%	4831	18%	71.51	0.000
	Late Evening	134	18%	3584	13%		
	Total	737	100%	27173	100%		
Sex of the operator of the vehicle going straight ahead	Male	696	94%	15690	58%		
	Female	41	6%	11483	42%	397.06	0.000
	Total	737	100%	27173	100%		
Sex of the operator of the left-turning vehicle.	Male	414	56%	14837	55%		
	Female	323	44%	12336	45%	0.647	0.421
	Total	737	100%	27173	100%		
Age of the operator of the vehicle going straight ahead	16-19	46	6%	1788	7%		
	20-25	228	31%	4472	16%		
	26-35	210	28%	6096	22%		
	36-45	103	14%	4712	17%		
	46-55	103	14%	4487	17%	182.87	0.000
	56-65	32	4%	3163	12%		
	66-75	14	2%	1571	6%		
	Over 75	1	0%	884	3%		
	Total	737	100%	27173	100%		
Age of the driver of the left-turning vehicle	16-19	44	6%	2142	8%		
	20-25	101	14%	4068	15%		
	26-35	146	20%	5220	19%		
	36-45	100	14%	4117	15%		
	46-55	116	16%	4086	15%	9.239	0.236
	56-65	94	13%	3179	12%		
	66-75	71	10%	2371	9%		
	Over 75	65	9%	1990	7%		
	Total	737	100%	27173	100%		

Methodology

- Resampling Techniques
  - Random under-sampling without replacement on the prevalent class (RUS)
  - Random over-sampling with a replacement on the minority class (ROS)
  - Synthetic Minority Oversampling Technique for Nominal and Continuous (SMOTE-NC)
  - Combined over- and under-sampling using SMOTE and Edited Nearest Neighbors (SMOTE-ENN)
- Logistic Regression

$$\pi_i = \frac{\exp(x_i^T \beta)}{1 + \exp(x_i^T \beta)}$$

$$\ell(\beta) = \sum_{i=1}^{n} \{y_i \log(\pi_i) + (1 - y_i) \log(1 - \pi_i)\}$$

- Model Selection

$$F - measure = 2 \times \frac{Precision \times Recall}{Precision + Recall}$$

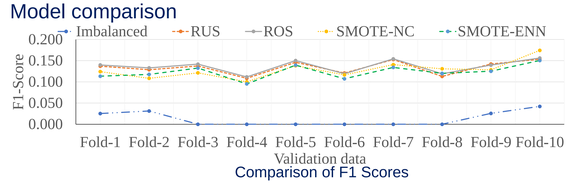
$$G - mean = \sqrt{Precision \times Recall}$$

- Bayesian Network Analysis

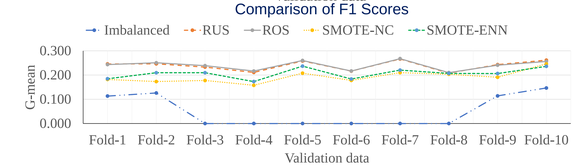
$$\mathrm{BDeu}(B,T) = \log(P(B)) + \sum_{i=1}^{n} \sum_{j=1}^{q_i} \left(log\left(\frac{\Gamma\left(\frac{N'}{q_i}\right)}{\Gamma\left(N_{ij} + \frac{N'}{q_i}\right)} \right) + \sum_{k=1}^{r_i} log\left(\frac{\Gamma\left(N_{ijk} + \frac{N'}{r_i q_i}\right)}{\Gamma\left(\frac{N'}{r_i q_i}\right)} \right) \right)$$

Results

- Model comparison



Comparison of F1 Scores



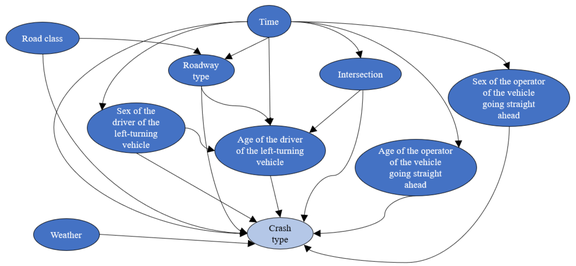
Comparison of G-mean scores

- Scenarios for crash-type prediction inference

Location	Roadway type	Time	Age of the driver of vehicle turning left	Age of the operator of vehicle going straight ahead	MC-MV	MV-MV
Proportion distribution					0.500	0.500
Driveway/Alley access	Divided	Late Evening	56-65	20-25	0.851	0.149
Driveway/Alley access	Divided	Early Evening	46-55	26-35	0.851	0.149
Driveway/Alley access	Divided	Early Evening	56-65	26-35	0.825	0.175
Driveway/Alley access	Divided	Early Evening	56-65	20-25	0.824	0.176
Driveway/Alley access	Divided	Late Evening	46-55	20-25	0.824	0.176
Driveway/Alley access	Divided	Late Evening	26-35	26-35	0.823	0.177
Driveway/Alley access	Undivided	Early Evening	20-25	20-25	0.816	0.184
Driveway/Alley access	Undivided	Early Evening	26-35	20-25	0.816	0.189

Results

Variable	Category	Coef.	OR	Std. Error	Z value	P-value
Location	Signalized intersection					
	Unsignalized intersection	**0.661**	**1.94**	**0.113**	**5.858**	**0.000**
	Driveway/Alley Access	**2.021**	**7.55**	**0.104**	**19.419**	**0.000**
Weather	Clear					
	Unclear	**-0.822**	**0.44**	**0.209**	**-3.930**	**0.000**
Type of roadway straight ahead driver is on	Divided					
	Undivided	**-0.392**	**0.68**	**0.082**	**-4.804**	**0.000**
Road class	Arterial					
	Not arterial	**0.228**	**1.26**	**0.089**	**2.554**	**0.011**
Time	Mid-day					
	Morning	-0.123	0.884	0.153	-0.801	0.423
	Afternoon	0.138	1.148	0.113	1.222	0.222
	Early Evening	**0.682**	**1.979**	**0.109**	**6.281**	**0.000**
	Late Evening	**0.606**	**1.834**	**0.123**	**4.932**	**0.000**
Sex of the operator of the vehicle going straight ahead	Male[b]					
	Female	**-2.567**	**0.08**	**0.162**	**-15.833**	**0.000**
Sex of the driver of the left-turning vehicle	Male					
	Female	0.015	1.02	0.079	0.196	0.844
Age of the operator of the vehicle going straight ahead	20-25					
	16-19	**-0.755**	**0.47**	**0.169**	**-4.456**	**0.000**
	26-35	**-0.452**	**0.64**	**0.102**	**-4.429**	**0.000**
	36-45	**-0.910**	**0.40**	**0.125**	**-7.290**	**0.000**
	46-55	**-0.882**	**0.41**	**0.125**	**-7.062**	**0.000**
	56-65	**-1.706**	**0.18**	**0.194**	**-8.812**	**0.000**
	66-75	**-1.850**	**0.16**	**0.281**	**-6.593**	**0.000**
	Over 75	**-3.796**	**0.02**	**1.005**	**-3.777**	**0.000**
Age of the driver of the left-turning vehicle.	20-25					
	16-19	-0.158	0.85	0.189	-0.837	0.403
	26-35	0.139	1.15	0.136	1.025	0.305
	36-45	0.014	1.01	0.148	0.093	0.926
	46-55	0.209	1.23	0.143	1.460	0.144
	56-65	0.174	1.19	0.151	1.148	0.251
	66-75	0.252	1.29	0.164	1.535	0.125
	Over 75	**0.436**	**1.55**	**0.170**	**2.566**	**0.010**
Constant		-3.7222		0.199	-18.670	0.000



Optimal Bayesian Network structure

Conclusions and Recommendations

- While motorcyclists are only about 94% more likely to be involved in a collision with a left-turning vehicle than a motorist at an unsignalized intersection they are nearly eight times as likely to be involved in these collisions at driveways and alleys
- MC-MV collisions are disproportionately likely to involve a motorist over the age of 75 attempting to turn left in front of an oncoming motorcyclist during the nighttime period, a result of difficulty in judging the speed and position of the oncoming motorcycle
- Persons over the age 25 are less likely than younger cohorts to be the operator of the motorcycle going straight ahead.

Acknowledgement

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