



Analysis of Crashes Involving First Responder Vehicles

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SIGNAL FOUR ANALYTICS

Introduction

- An inherent danger comes with the duties of emergency response.
- First responders are exposed to factors which make them uniquely vulnerable to traffic related injuries and deaths.
- From 2009 to 2018, on average, at least one officer per week has been killed on our nation's roads [1].
- 19 firefighters & EMTs struck and killed in 2017 & 2018 [3].
- The goal of this research is to identify factors that lead to responder vehicle crashes and struck-by crashes.



Fire truck struck by car on I-4 in Hillsborough County, FL [2].

Methods

Gathering Data

- Signal Four Database (S4)
 - Florida statewide interactive, web-based geospatial crash analytical tool created and hosted by University of Florida, Geoplan Center
- Florida Crash Data from 2016 to 2018
- Custom queries from 2016 to 2018
 - Police Vehicle Involved
 - Fire Vehicle Involved
 - Ambulance Vehicle Involved
 - Struck-by Crashes

Data Partition

- Excel Analysis
 - Pivot Tables
 - Pie charts
 - Proportions
- Categories of Interest:
 - Crash Severity
 - Crash Type
 - Influence Related
 - Weather Conditions
 - Lighting Conditions



Signal Four Analytics. 2018 Police Vehicle crashes in Florida

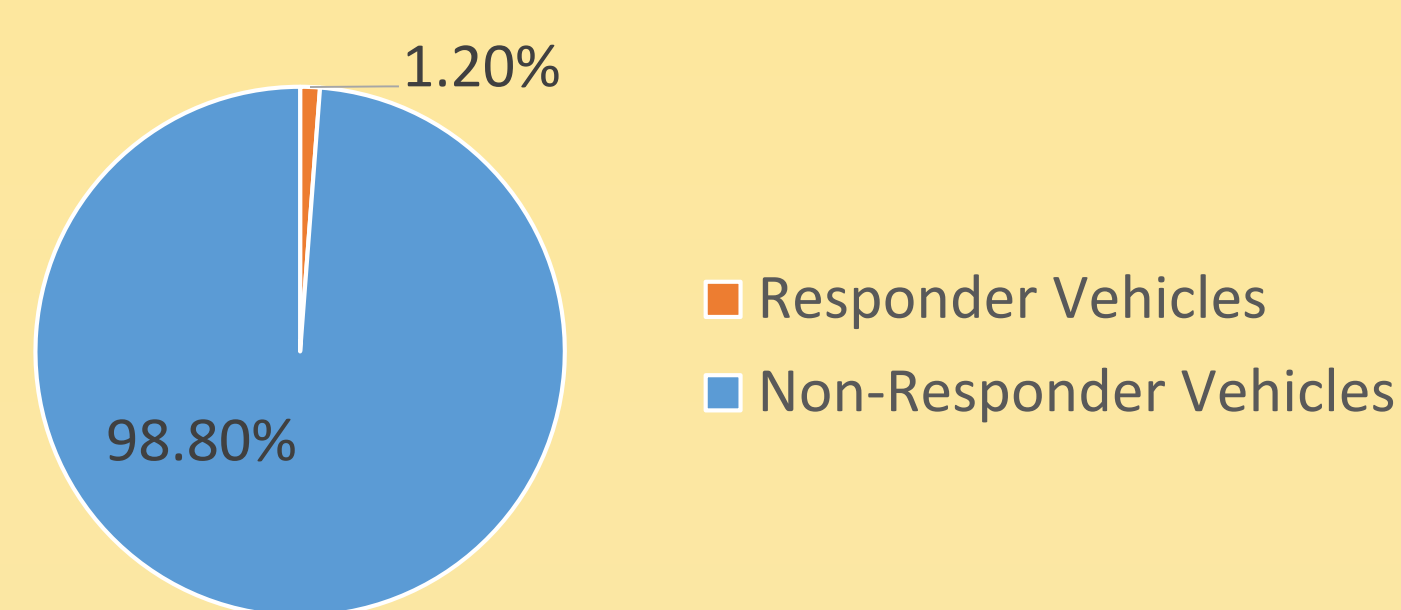
Significance Test

- Z-score
- Two-tailed test
- 10% significance level
- Z-critical = +/- 1.65

$$z' = \frac{p_2 - p_1}{\sqrt{\frac{p_1 q_1}{n_1} + \frac{p_2 q_2}{n_2}}}$$

Results

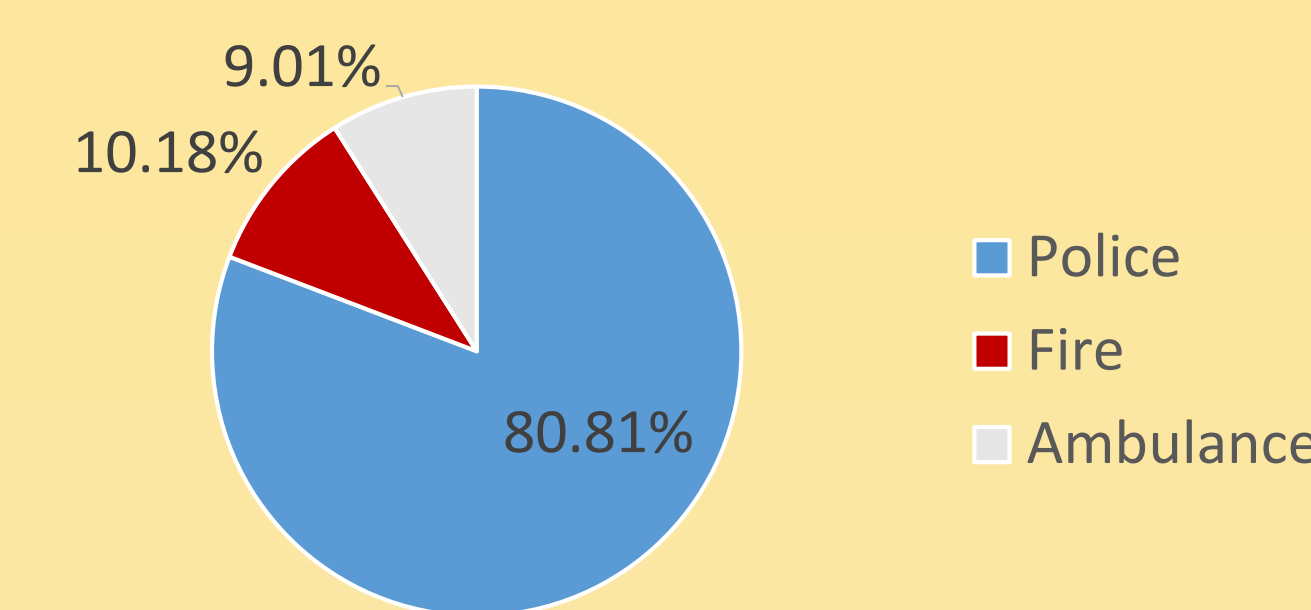
- 3 years of Crash Data: 2016 – 2018
- 2,173,853 crashes in the State of Florida
- For Tables 1 – 4, rows highlighted in red are significantly higher. These are targeted characteristics that may require future study to prevent these types of crashes.
- For Tables 1 – 4, rows highlighted in blue are significantly lower. These are areas where common protective measures are probably doing a good job of preventing these types of crashes.



Percent of Vehicle Crashes

Table 1: Test of Significance for Ambulance Vehicle Involved

	Non-Responder	Ambulance Vehicle Involved	z-score	p-value
Sample Size	2,147,762	2,352		
Fatalities	0.39% (8,448)	0.21% (5)	-1.90	0.0286
Incapacitating Injuries	2.62% (56,310)	2.85% (67)	0.66	0.2543
Non-incapacitating Injuries	9.07% (194,802)	9.35% (220)	0.47	0.3183
Possible Injuries	20.65% (443,612)	20.41% (480)	-0.29	0.3835
Property Damage Only	67.26% (1,444,590)	67.18% (1,580)	-0.09	0.4657
Angle	22.27% (478,211)	22.92% (539)	0.75	0.2264
Sideswipe, same direction	11.79% (253,119)	24.83% (584)	14.64	0.0000
Front to Front	2.69% (57,716)	1.91% (45)	-2.74	0.0031
Front to Rear	36.71% (788,478)	21.56% (507)	-17.86	0.0000
Alcohol Related	2.01% (43,070)	1.06% (25)	-4.45	0.0000
Distraction Related	12.77% (274,316)	11.9% (280)	-1.30	0.0971
Drug Related	0.53% (11,367)	0.47% (11)	-0.44	0.3309
Clear	79.53% (1,708,161)	79.97% (1,881)	0.54	0.2961
Cloudy	13.88% (298,021)	12.8% (301)	-1.56	0.0589
Fog, Smog, Smoke	0.3% (6,387)	0.09% (2)	-3.53	0.0002
Other	0.63% (13,571)	0.17% (4)	-5.42	0.0000
Rain	7.82% (167,953)	6.89% (162)	-1.78	0.0372
Severe Crosswinds	0.01% (232)	0.04% (1)	0.75	0.2278
Dark - Lighted	16.66% (357,818)	18.62% (438)	2.44	0.0073
Dark - Not Lighted	4.99% (107,159)	3.91% (92)	-2.69	0.0035
Dark - Unknown Lighting	0.22% (4,671)	0.17% (4)	-0.56	0.2885
Dawn	1.55% (33,191)	1.11% (26)	-2.04	0.0207
Daylight	75.01% (1,611,092)	73.34% (1,725)	-1.83	0.0335
Dusk	2.92% (62,647)	2.72% (64)	-0.58	0.2799
Unknown	0.78% (16,823)	0.09% (2)	-11.56	0.0000
Blank	0.88% (18,855)	0.04% (1)	-19.44	0.0000



Percent of First Responder Crashes by Vehicle Type

Table 2: Test of Significance for Fire Vehicle Involved

	Non-Responder	Fire Vehicle Involved	z-score	p-value
Sample Size	2,147,762	2,655		
Fatalities	0.39% (8,448)	0.26% (7)	-1.30	0.0965
Incapacitating Injuries	2.62% (56,310)	1.17% (31)	-6.97	0.0000
Non-incapacitating Injuries	9.07% (194,802)	5.12% (136)	-9.22	0.0000
Possible Injuries	20.65% (443,612)	12.66% (336)	-12.37	0.0000
Property Damage Only	67.26% (1,444,590)	80.79% (2,145)	17.68	0.0000
Angle	22.27% (478,211)	25.46% (676)	3.78	0.0001
Sideswipe, same direction	11.79% (253,119)	20.38% (541)	10.98	0.0000
Front to Front	2.69% (57,716)	1.85% (49)	-3.22	0.0006
Front to Rear	36.71% (788,478)	17.44% (463)	-26.15	0.0000
Alcohol Related	2.01% (43,070)	1.51% (40)	-2.11	0.0175
Distraction Related	12.77% (274,316)	9.15% (243)	-6.46	0.0000
Drug Related	0.53% (11,367)	0.23% (6)	-3.29	0.0005
Clear	79.53% (1,708,161)	80.3% (2,132)	0.99	0.1597
Cloudy	13.88% (298,021)	12.88% (342)	-1.53	0.0632
Fog, Smog, Smoke	0.3% (6,387)	0.45% (12)	1.19	0.1176
Other	0.63% (13,571)	0.26% (7)	-3.69	0.0001
Rain	7.82% (167,953)	6.03% (160)	-3.88	0.0001
Severe Crosswinds	0.01% (232)	0.04% (1)	0.71	0.2379
Dark - Lighted	16.66% (357,818)	16.16% (429)	-0.70	0.2413
Dark - Not Lighted	4.99% (107,159)	3.58% (95)	-3.91	0.0000
Dark - Unknown Lighting	0.22% (4,671)	0.23% (6)	0.09	0.4632
Dawn	1.55% (33,191)	1.21% (32)	-1.60	0.0543
Daylight	75.01% (1,611,092)	76.53% (2,032)	1.85	0.0322
Dusk	2.92% (62,647)	1.92% (51)	-3.74	0.0001
Unknown	0.78% (16,823)	0.26% (7)	-5.21	0.0000
Blank	0.88% (18,855)	0.04% (1)	-22.00	0.0000
Other	0.06% (1,288)	0.08% (2)	0.29	0.3865

Table 3: Test of Significance for Police Vehicle Involved

	Non-Responder	Police Vehicle Involved	z-score	p-value
Sample Size	2,147,762	21,084		
Fatalities	0.39% (8,448)	0.19% (41)	-6.49	0.0000
Incapacitating Injuries	2.62% (56,310)	2% (422)	-6.39	0.0000
Non-incapacitating Injuries	9.07% (194,802)	8.24% (1,737)	-4.37	0.0000
Possible Injuries	20.65% (443,612)	14.65% (3,089)	-24.50	0.0000
Property Damage Only	67.26% (1,444,590)	74.91% (15,795)	25.49	0.0000
Angle	22.27% (478,211)	21.21% (4,472)	-3.73	0.0001
Sideswipe, same direction	11.79% (253,119)	10.32% (2,175)	-6.98	0.0000
Front to Front	2.69% (57,716)	2.72% (574)	0.31	0.3774
Front to Rear	36.71% (788,478)	31.87% (6,720)	-15.00	0.0000
Alcohol Related	2.01% (43,070)	3.61% (762)	12.48	0.0000
Distraction Related	12.77% (274,316)	16.6% (3,499)	14.86	0.0000
Drug Related	0.53% (11,367)	1% (210)	6.81	0.0000
Clear	79.53% (1,708,161)	78.3% (16,508)	-4.33	0.0000
Cloudy	13.88% (298,021)	13.94% (2,939)	0.27	0.3954
Fog, Smog, Smoke	0.3% (6,387)	0.46% (96)	3.40	0.0003
Other	0.63% (13,571)	0.44% (93)	-4.15	0.0000
Rain	7.82% (167,953)	6.73% (1,420)	-6.25	0.0000
Severe Crosswinds	0.01% (232)	0.07% (14)	3.13	0.0009
Sleet/Hail/Freezing Rain	0.01% (128)	0% (1)	-0.26	0.3994
Blowing Sand, Soil, Dirt	0% (59)	0% (1)	0.42	0.3374
Dark - Lighted	16.66% (357,818)	24.12% (5,085)	25.22	0.0000
Dark - Not Lighted	4.99% (107,159)	8.13% (1,714)	16.63	0.0000
Dark - Unknown Lighting	0.22% (4,671)	0.21% (45)	-0.13	0.4495
Dawn	1.55% (33,191)	1.5% (317)	-0.50	0.3096
Daylight	75.01% (1,611,092)	62.82% (13,244)	-36.50	0.0000
Dusk	2.92% (62,647)	2.57% (542)	-3.16	0.0008
Unknown	0.78% (16,823)	0.48% (101)	-6.35	0.0000
Blank	0.88% (18,855)	0.06% (12)	-46.61	0.0000
Other	0.06% (1,288)	0.11% (24)	2.31	0.0104

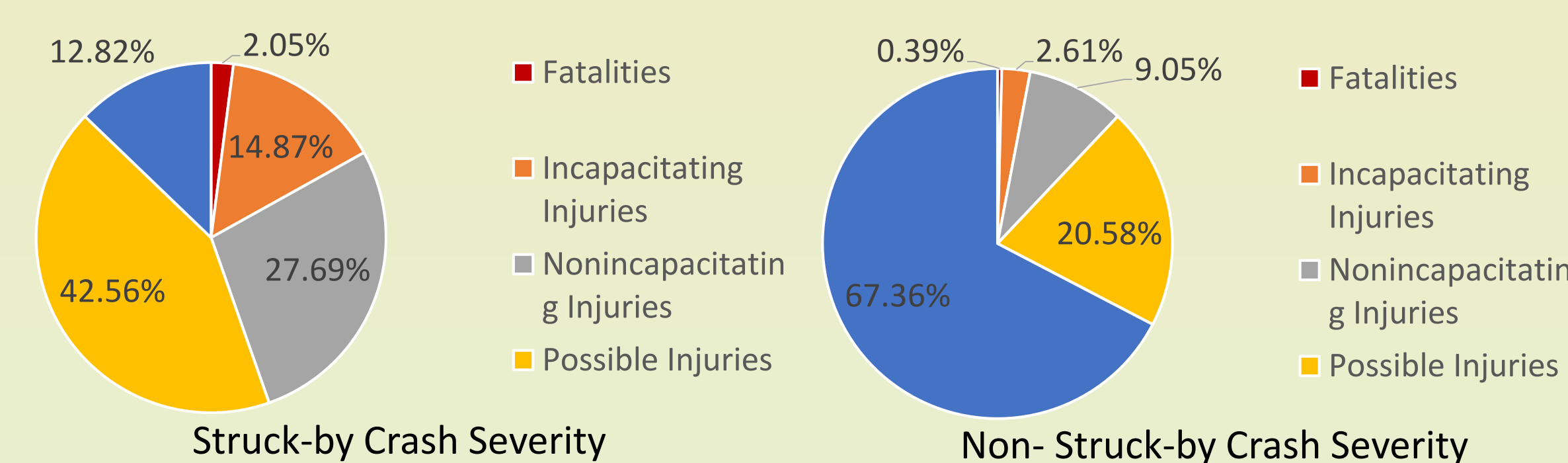


Table 4: Test of Significance for Struck-by Crashes

	Non-Struck-by	Struck-by	z-score	p-value
Sample Size	2,173,658	195		
Fatalities	0.39% (8,497)	2.05% (4)	1.64	0.0509
Incapacitating Injuries	2.61% (56,801)	14.87% (29)	4.81	0.0000
Non-incapacitating Injuries	9.05% (196,814)	27.69% (54)	5.82	0.0000
Possible Injuries	20.58% (447,434)	42.56% (83)	6.21	0.0000
Property Damage Only	67.36% (1,464,112)	12.82% (25)	-22.78	0.0000
Alcohol Related	6.06% (131,670)	10.77% (21)	2.12	0.0169
Distraction Related	38.41% (834,985)	14.87% (29)	-9.24	0.0000
Drug Related	1.6% (34,778)	2.05% (4)	0.45	0.3283
Clear	79.52% (1,728,533)	76.41% (149)	-1.02	0.1531
Cloudy	13.87% (301,576)	13.85% (27)	-0.01	0.4955
Fog, Smog, Smoke	0.3% (6,496)	0.51% (1)	0.42	0.3379
Other	0.63% (13,675)	2.56% (4,992)	1.71	0.0439
Rain	7.81% (169,683)	6.15% (12)	-0.96	0.1685
Severe Crosswinds	0.01% (247)	0.51% (1)	0.98	0.1635
Dark - Lighted	16.73% (363,722)	24.62% (48)	2.56	0.0053
Dark - Not Lighted	5.02% (109,036)	12.31% (24)	3.10	0.0010
Dark - Unknown Lighting	0.22% (4,725)	0.51% (1)	0.58	0.2818
Dawn	1.54% (33,563)	1.54% (3)	-0.006	0.4975
Daylight	74.9% (1,627,983)	56.41% (110)	-5.21	0.0000
Dusk	2.91% (63,299)	2.56% (5)	-0.31	0.3793
Unknown	0.78% (16,929)	2.05% (4)	1.25	0.1050

Main Findings

- First responder vehicles were involved in 1.21% of crashes from January 2016 – December 2018
- Struck-by injuries and fatalities are statistically higher than Non-Struck-by crashes
- Target Characteristics of Interest:
 - Fire Vehicle Involved Crashes have a significantly larger percentage of Angle Crashes. This could be due to the way firefighters are trained to park their engines at an angle to protect crash scenes.
 - Ambulance & Fire Vehicle Crashes suffer a relatively higher proportion of Sideswipe Crashes. This may suggest that these larger vehicles struggle to maneuver in confined spaces and when passing slower moving vehicles, or it could suggest that these vehicles are being sideswiped while parked at a scene.
 - Crashes influenced by alcohol, drugs, and distraction were more likely to occur in Police Vehicle Involved and Struck-by crashes. It should be noted that the distracted driving results are likely skewed by underreporting.
 - Dark conditions with the presence of lighting was more likely to increase the occurrence of crashes for Ambulance Vehicles. Few Ambulance crashes occur during dark hours when lighting is not present. This could suggest that the artificial lighting of the roadway reduces the contrast between the lights of the ambulance and the environment. More research on vehicle lighting is currently being conducted by other groups. Vehicle lighting studies would also help identify why fire vehicles were involved in more crashes during daylight hours. Similar to the finding regarding ambulance crashes, ambient lighting may obscure the emergency lights of the responder vehicle.
 - Police Vehicle Involved and Stuck-by crashes were more prevalent during dark hours.

Future Directions

In continuation of this project, the future expected results should help identify crash rates for first responders on Florida roadways. Potential recommendations discovered through this research should be used to protect the lives of first responders. Future steps in this research will involve crash frequency modeling, mitigation implementation, and education for the emergency responder community.

References

- CAUSES OF LAW ENFORCEMENT DEATHS OVER THE PAST DECADE (2009-2018). (2019, March 29). In *The National Law Enforcement Officers Memorial Fund*. Retrieved from <https://nleomf.org/facts-figures/causes-of-law-enforcement-deaths>
- Knight, K. (2018, July 21). Car collides with Hillsborough fire truck, sparking traffic delay on I-4 at Branch Forbes Road. In *abc Action News*.
- Running The Roads. (2018, October). *Emergency Responder Safety Institute*.

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