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Analysis of Crashes Involving First Responder Vehicles

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ANALYSIS OF CRASHES INVOLVING FIRST RESPONDER VEHICLES

By

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Abstract

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First responders face many hazards that put their lives at risk while on duty. A review of the National Law Enforcement Officers Memorial Fund statistics shows that 553 police officers died in the line-of-duty between 2008 and 2017 as a direct result of a traffic related incidents. Sadly, the nation's first responders are exposed to factors which make them uniquely vulnerable to traffic related injuries and deaths. The goal of this research is to investigate and analyze crashes involving first responder vehicles and struck-by crashes. This project concludes that approximately 1.2% of the crashes in the state of Florida involve a first responder vehicles The findings also highlight characteristics of interest to target for more research or revise traffic scene and management practices. Some of these highlighted characteristics include: sideswipes to emergency vehicles and dark settings with ambient lighting. The data found from this research should be implemented to protect the lives of emergency responders. Every bit of research that helps to discover safer techniques or situations can better lead to all responders going to home after their shift. These individuals are extremely thankful for focused efforts on helping the emergency responder community.

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Introduction

Highway safety is a significant challenge faced by society. The movement of millions of vehicles within a relatively small geographic area inevitably leads to vehicle conflicts. Over 35,000 deaths and 2.4 million injuries were attributed to motor vehicle crashes in the United States in 2015 (NHTSA, 2015). These numbers continue to rise. In 2017, there were 3,112 total traffic fatalities in Florida out of the 37,133 total United State fatalities (National, 2018). Highway crashes can have an immediate and significant impact on the mobility of individuals and goods traveling within the area. In the immediate aftermath of a crash, drivers in the vicinity must respond quickly to a dynamic and unpredictable environment. As vehicles approach the crash location, they tend to queue on the highway section. Furthermore, the crash scene itself is a distraction to drivers in both directions. This situation can increase the likelihood of yet another crash.

Crashes which occur as a result of an initial or primary crash are known as secondary crashes. Estimates suggest that nearly ten percent of freeway crashes can be classified as secondary (Goodall, 2017). A secondary is defined by a vehicle entering the scene of the primary incident, or vehicles colliding within the que upstream of the primary incident, or collisions within the queue in the opposite direction of the primary incident caused by driver distraction known as rubbernecking effect (Salum, 2019).These secondary crashes are exceptionally dangerous for the victims of the primary crash and the first responders dispatched to support them. Many organizations have missions and platforms encouraging the education of drivers and emergency personnel on the importance of the “move over” laws and protecting individuals working on the side of the road. Understanding why secondary crashes are occurring is the foundation to seeking a solution to this issue.

Secondary incidents lead to significant increase in traffic delays and reduced safety for a larger portion of the roadway. National, state, and local agencies are investing substantial amount of resources to identify and mitigate secondary crashes in order to reduce congestion, related fatalities, injuries, and property damages. Not much is currently known about how the characteristics of secondary crashes differ from those of primary crashes. A Transportation Research Board paper in 2008 stated, “Research on secondary crashes has been limited, mainly due to the poor quality of incident data and related traffic data that are necessary for secondary incident analysis” (Zhan, 2008). Other studies also state that although they have developed a modestly detailed framework of considering secondary crashes, their approaches are subject to underrepresentation or over representation of secondary crashes (Salum, 2019). Great data sets for this research are not easily available. This is due to the fact that secondary crashes are very challenging to track since detailed reports are hard to find and some crashes do not make it in the news. Understanding the factors that cause secondary crashes is the foundation to seeking a solution to mitigating this issue.

Secondary crashes are particularly dangerous for first responders attending to victims of the primary crash. Motor vehicle-related incidents, including single-vehicle, multi-vehicle, and officer struck-by-vehicle crashes are a leading cause of line-of-duty deaths for law enforcement officers in the United States. A struck-by crash refers to an incident where a worker or pedestrian is hit and injured by a vehicle. From 2009 to 2018, on average, at least one officer per week has been killed on our nation’s roads (CAUSES, 2019). Emergency medical service personnel, firefighter, and tow truck drivers are also at risk of secondary, struck-by vehicle crashes. Police, fire, ambulance, towing, and motorist assistance personnel fill a vital role in preserving the lives and safety of people during emergencies and incidents. These users and their vehicles often operate in ways that are different from other travelers, including methods in which roads were not intended or designed. Given the nature of their work and their interaction with routine traffic, issues can arise that impact both the safety and operational efficiency of the transportation systems, system users, and emergency responders. Responder groups form a unique class of transportation system users. Similar to other user groups like young and older drivers, responders have particular design, planning, operational, training, management, safety, and research needs that differ from the traveling public more broadly. Transportation system design and construction, including temporary modifications following incidents and during maintenance periods, directly and disproportionately influence the safety and efficiency of emergency response. Historically, this has been a lightly studied area within the greater context of transportation research.

Goals and Objectives

The goal of this research is to identify the factors leading to responder vehicle crashes and secondary struck-by vehicle crashes. This goal is accomplished through the completion of three objectives: 1) investigate crashes involving emergency responders vehicles in a representative state, 2) investigate struck-by crashes, and 3) find statistically significant characteristics of these types of crashes though the analysis of crash reports. The investigation then contrast crash contributing factors for responder vehicles, secondary crashes, and other (non-responder, non-secondary) highway crashes within the analysis region. Results of the analysis highlight statically significant characteristics that could be mitigated. Any solutions discovered can be implemented by practitioners in an effort to prevent on-duty fatalities of first responders in transportation related incidents.

Literature Review

Among first responders, it is common knowledge that driving and roadways are dangerous. There are written protocols to follow when driving to and parking at emergency scenes. For the development of this research, several areas of literature were reviewed including secondary incident reports, current studies, laws and regulation, and prevention. The relevance of these elements to this study are described in detail in the following literature review.

Secondary Incident Reports

In this section, five secondary incident were investigated by the National Institute for Occupational Safety and Health (NIOSH). Each paragraph gives a brief statement of how the firefighter died, as well as, what NIOSH determined were the contributing factors. After determining the contributing factors, NIOSH provides recommendations in hopes of decreasing the likelihood of a similar incident.

In 2007, a volunteer firefighter was struck by a passenger bus on an interstate highway while clearing the scene of a fire. The bus sideswiped a parked engine and struck the victim as he was placing rolled fire hose into the driver's side storage compartment. The victim was pronounced dead at the scene. The key contributing factor identified in this investigation was the bus driver's failure to slow down and move over while passing a highway emergency work zone. To minimize the risk of similar occurrences, the NIOSH report recommends fire departments should: (1) establish pre-incident plans regarding traffic control for emergency service incidents and pre-incident agreements with public safety agencies, traffic management organizations, and private sector responders. (2) Develop all-inclusive standard operating procedures for responding to highway incidents with specific guidance on positioning apparatus to protect emergency workers from oncoming traffic when entering or exiting parked vehicles, working pump panels, and retrieving or replacing equipment from apparatus storage areas. (3) Ensure that high visibility chevrons and reflective markings are applied to all apparatus to enhance conspicuity while parked at emergency scenes and during emergency response. (4) Ensure that standard operating procedures include guidance on establishing advance warning and transition areas, and consider the use of an upstream monitor for highway-related incidents. (5) Ensure that firefighters wear suitable high-visibility retro-reflective apparel while working non-fire emergency scenes near moving traffic. Another interesting prevention technique stated in this report suggested that commercial passenger bus manufacturers consider incorporating crash avoidance systems into design specifications for passenger buses (Lutz, 2009).

In 2010, a volunteer fire police captain was fatally injured when he was struck by a motor vehicle while positioned at a controlled intersection. The volunteer was sent to the scene to control traffic, he placed 5 lime green cones across the roadway and lit a flare. While his back was turned to oncoming traffic, a driver ran through and over the cones striking him. The following contributing factors were stated on the NIOSH report: there was no advance warning to motorists of the blocked-off roadway; the inconspicuousness of the victim; and the victim had his back to oncoming traffic. The report also gave key recommendations for future situations to reduce the risk of a secondary incident: (1) ensure that the placement of warning devices (portable signs, traffic cones, flares and portable changeable message signs) informs drivers of what to expect when approaching an incident scene; (2) ensure that personnel controlling traffic wear high visibility apparel and helmets; (3) ensure that standard operating guidelines include guidance on identifying and maintaining a safe location while working in or near moving traffic; (4) ensure that a personnel accountability system is in place and adhered to during emergency operations; (5) utilize state and local departments of transportation for additional resources; and, (6) consider participating in the establishment of local traffic incident management committees (Braddee, 2011).

In 2012, a fire officer was struck and killed at a motor vehicle crash scene. The primary incident damaged a natural gas meter causing a leak. A city police officer also responded to investigate the original crash. While waiting for the gas company to arrive, a van struck two firefighters and the police officer who were standing on the shoulder. The fire captain was killed upon impact. The police officer and other firefighter were seriously injured and were transported to metropolitan trauma center for treatment. The following contributing factors were stated in the NIOSH report: actions of the van driver; initial single vehicle crash involving damaged/leaking natural gas meter; inadequate protection of the highway/roadway work area; firefighters and police officer standing in close proximity to moving traffic; inadequate traffic management; and lack of procedures for controlling a damaged/leaking natural gas meter. The report also gave key recommendations for future situations to reduce the risk of a secondary incident: (1) Develop pre-incident plans regarding deployment to traffic incidents, scene safety, situational awareness, and traffic control for highway/roadway emergency work zones. (2) Develop and implement standard operating procedures for highway/roadway incidents including deployment protocols within the department's jurisdiction. (3) Ensure that all members receive training for conducting emergency operations at highway/roadway incidents. (4) Develop and implement standard operating procedures for response to incidents involving natural gas leaks. (5) Utilize the principles of the incident management system for effective command and control of highway/roadway incidents (Career, 2013).

In 2013, a volunteer firefighter was struck and killed on an interstate highway. The fire department was operating at the scene of a multiple vehicle crash when a fire department utility vehicle and Police vehicle were struck. Members of the fire department witnessed the oncoming car hauler enter the crash scene at a rate of speed that was excessive for road conditions. Witnesses yelled for everyone to get out of the way of the car hauler, but it was too late. The victim was struck by the car hauler and pushed onto the shoulder of the interstate. The victim died on scene. The following contributing factors were stated on the NIOSH firefighter fatality investigation report: Actions of the driver of the commercial car carrier, weather, grade of the interstate highway, inadequate protection of the highway/roadway work area, and inadequate traffic management. The report also gave key recommendations for future situations to reduce the risk of a secondary incident: (1) Develop pre-incident plans regarding deployment to traffic incidents, scene safety, situational awareness, and traffic control for highway/roadway emergency work zones; (2) Ensure that all members receive training for conducting emergency operations at highway/roadway incidents; (3) Ensure that a continuous scene size-up is conducted and risks are continuously assessed and managed throughout a highway/roadway incident; and (4) the Illinois State Fire Marshal’s Office should consider developing and implementing curriculum for the fire service on traffic incident management (Volunteer, 2014).

In 2013, volunteer fire chief lost his life after being struck by a vehicle on an interstate highway. The victim's department was dispatched to assist a neighboring fire department working a motor vehicle incident. The department was ordered to shut down both southbound travel lanes to allow for a helicopter to land. The victim responded to the scene in his personal vehicle and did not wear a high-visibility retro-reflective vest. The victim used his personal vehicle to block the southbound travel lanes and diverted traffic onto an off-ramp. A motorist, allegedly under the influence, drove around the victim's vehicle, striking and killing him. The following recommendations were given by the NIOSH suggesting fire departments: (1) ensure that emergency responders receive training and have adequate staffing, sufficient equipment, and appropriate procedures in place for responding to roadway emergency incidents. (2) Ensure that standard operating procedures/guidelines include guidance on identifying and maintaining a safe location while working in or near moving traffic. (3) Establish pre-incident plans and agreements regarding traffic control and incident management at roadway incidents with other fire departments, emergency medical services, law enforcement, local or state departments of highways, and private sector responders. (4) Ensure that apparatus equipped with high-visibility chevrons and reflective markings are used for blocking to enhance conspicuity and protection of emergency scenes while operating at highway incidents. (5) Ensure that all personnel working at highway incidents wear the appropriate personal protective clothing and equipment, to include high-visibility retro-reflective material (Wertman, 2014).

Current Studies

In a study posted in *Safety Science,* a group of individuals sampled traffic shock waves detected by the loop detectors in California to generate their results. Using multiple detectors, shock waves from each incident were calculated and updated along a freeway, and secondary incidents that occurred within the spatial-temporal boundaries of a primary accident were identified. Results show that secondary incidents account for 1.08% of California interstate freeway accidents. The study also stated, oftentimes secondary incidents are recorded without being specifically noted as secondary in the accident database. This can create difficulty in studying secondary incidents because it yields conservative values that are often lower than reality (Wang, 2016).

In a study posted by *Accident Analysis and Prevention,* a group of individuals used Bayesian complementary log-log model to identify significant variables in secondary incidents and develop a reliable secondary incident risk prediction model. The results indicated that the significant variables were average occupancy, incident severity, percent of lanes closed, incident type, incident clearance duration, incident impact duration, and incident occurrence time. The study stated that the limited knowledge on the nature of secondary incidents has largely impeded mitigation strategies, therefore, the results of this study have the potential to proactively prevent secondary incidents (Kitali, 2018).

Similar to the Bayesian study, Xu, Liu, Yang, and Wang developed a secondary incident risk prediction model on freeways using real-time traffic flow data. The results showed that real-time traffic variables significantly affect the likelihood of secondary incidents. The study states that risk of a secondary incident are affected by the primary crash characteristics, environmental conditions and geometric characteristics. The significant variables were traffic volume, average speed, standard deviation of detector occupancy, and volume difference between adjacent lanes. The results of this study, also, have the potential to proactively prevent secondary incident on freeways (Xu, 2016).

A Secondary Crash Identification Algorithm was developed to identify secondary incidents on roadways in a study performed by Sarker, Naimi, Mishra, Golias, and Freeze. The study also stated that secondary incident occurrences are non-recurrent in nature and lead to significant increase in traffic delay and reduced safety. National, state, and local agencies are investing substantial amount of resources to identify and mitigate secondary crashes in order to reduce congestion, related fatalities, injuries, and property damages. The methodological framework and processes proposed in the following study can be used by agencies for secondary incident identification (Sarker, 2015).

Another study used traffic shock waves to detect the possibility of a secondary incident. Results show that the shock waves created by primary accidents create a higher risk of a secondary incident occurrences than the effects of traffic volume. The possibility of a secondary incident increases during the durations of primary incident clearing. Unsafe speed and weather are other factors contributing to secondary incidents happening. The study states it is strongly suggested that when emergency responders arrive at the scene of an incident, they should not suddenly block, decrease, or unblock the traffic flow, but instead manage traffic in a smooth and controlled manner (Junhua, 2016).

A paper written in *Accident Analysis and Prevention,* investigates the strengths and weakness of different approaches and studies for secondary incident research. This paper focuses on the following aspects: static/dynamic approaches to identify secondary incidents, models to analyze secondary incident risk, and deployable countermeasures to prevent secondary incidents. The paper further explains some approaches: fuse data from multiple sources for secondary incident identification, use advanced learning algorithms for real-time secondary incident analysis, and deploy connected vehicles for secondary incidents prevention in future research (Yang, 2018).

One study, researched academic databases for articles published featuring interventions to reduce or prevent emergency service vehicle incidents. The study also conducted interviews with firefighters serving major metropolitan areas for additional prevention techniques. The results of the study presented that most articles focused on vehicle engineering interventions (38%), followed by policy and administration interventions (26%), environmental engineering interventions (19%) and education or training (17%). Firefighters reported implementing new policy (49%) and training interventions (29%). Enhanced drivers' training and risk management programs were associated with 19–50% and 19–58% reductions in emergency service vehicle incidents, respectively. The study stated that based on the available data, training and risk management approaches are effective solutions for prevention of emergency service vehicle incidents (Bui, 2018).

The understanding is that most secondary crashes studies consider both emergency responder vehicle crashes and struck-by crashes. Struck-by crashes can be much harder to identify if not documented properly, yet a study conducted in Wisconsin focuses on these types of crashes. In a study done by Yu, Bill, Chitturi and Noyce an in depth analysis of Wisconsin on-duty struck-by crashes was conducted to identify characteristics and contributing factors. These researchers pointed out the characteristics that were the highest and most prevalent among emergency response on-duty struck-by crashes. In their findings they determined that police officers are predominantly hit, a large proportion of struck-by crashes occur on rural interstate highways, the key driver contributing factor is speeding, winter months with ice on the roads and adverse roadway and weather conditions are an environmental factor, majority of these crashes are occurring while assisting traffic crashes (Yu, 2013).

Arizona Department of Transportation published a paper prepared by Rensel, Rafferty, and Yorks. This study focused on secondary crashes in Arizona and Traffic Incident Management. They determined that finding and calculating a crash modification factor for Traffic Incident Management would help identify cost effectiveness and the need for continuing and improving these strategies (Rensel, 2018).

A California report focused on officer-involved incidents. This study looked at 10 years of California data, and found that in 35,840 officer involved vehicle collisions, 39 officers were killed. The study also analyzed frequency of injuries, demographic characteristics of officers, agency size to collision ratios, day of the week, time of day, weather, road conditions, injury severity by officer type, and seatbelt use. Officers on motorcycles and seatbelt use seems to be a concern in this report. The study states the estimated financial impact of hundreds of millions of dollars highlight the importance of law enforcement and the community paying attention to this issue (Wolfe, 2016).

Laws and Regulation

The importance of roadside safety expands into government, in 2017 New York State's "Move Over Law" was expanded to protect volunteer emergency responders. The law requires drivers to move over when a parked or stopped vehicle displays blue or green lights. The original law applied to vehicles displaying red or white lights, as well as, amber lights. New York State's Ambrose-Searles "Move Over Act" is named in honor of two law-enforcement officers who were struck and killed while assisting roadside emergencies (Barclay, 2016).

Emergency responders on the side of the road are at risk of being struck. A broadcast from The Canadian Broadcasting Corporation encourages listeners to move over for police officers and attempts to education listeners about the 'move over' law. The broadcast focuses on one specific story of Officer Pyrah who was struck while stopped on the shoulder of a highway. Lucky, Officer Pyrah survived, in the broadcast he gives an account of his 2010 incident and comments on the move over law. In most Canadian Provinces and most of the United States, drivers are required by law to slow down and allow a one lane buffer when a marked vehicle is on the shoulder of a highway. Yet, Sgt. Kerry Schmidt states, "People will be flying by and we'll go out and stop them and they'll have no idea they were required by law to move over." There seems to be a misconnection in driver education, over 2,250 drivers have been charged and fined, this is an increase from 2000 drivers the year before. Officers believe the numbers would be way higher if they had a second officer stopping people who do not follow the 'move over' law, while the other officer does their job on the roadside. "Just give us a lane," Officer Pyrah tells drivers. "We just want to go home at the end of the day to see our families" (OPP, 2016).

Ensuring emergency responders return home safely is one of the major goals of the NIOSH. One of the Fatality Assessment and Control Evaluation Reports from the

NIOSH encourages governing authorities to consider enacting, or enhance existing, 'Slow Down, Move Over' legislation to include provisions that will help protect emergency responders who are working near moving traffic at highway emergency work zones. They also encourage governing authorities to consider adopting 'intelligent transportation systems' and incorporate 'slow down, move over' verbiage into crash warning messages that are broadcast on the national intelligent transportation systems (Lutz, 2009).

Governing systems of fire departments have also established safety requirements. For example, annual refresher training is now a requirement in the most recent edition of National Fire Protection Association (NFPA) 1500 (2018) – Standard on Fire Department Occupational Safety, Health, and Wellness Programs. Chapter 9 of the new edition of NFPA 1500 now has a separate chapter about “Traffic Incident Management” that all fire departments should be working to achieve (Sullivan, 2018 Critical).

Prevention

Jack Sullivan, a strong advocate for responder injury/fatality prevention and the Director of Training for the Emergency Responder Safety Institute, created a document outlining: the strategies and tactics for roadway incidents, safe positioning for emergency vehicles and rigs, size-up reports (as in scanning the scene for hazards and other important information), proper emergency light display, how to set up temporary traffic controls, paying attention to personnel safety, and roadway incident hazards and safety procedures training (Sullivan, 2015).

Sullivan also categorizes “D” drivers as drivers who are drowsy, drugged, drunk, distracted, disgruntled or disrespectful near emergency scenes. “D” drivers make jobs along roadways extremely hazardous and dangerous. Ways to mitigate hazards from “D” driver's is to increase awareness training, create and use standard operating guidelines, develop an environment where all agencies at the scene are on the same page (Law Enforcement, Fire, EMS, DOT, Towing & Recovery and Safety Service Patrols), conduct and attend annual training, and encourage and provide public education (Sullivan, 2018 Highway).

In another document by Sullivan, he discusses the importance and provides recommendations on the mitigating factors above. “D” drivers cause secondary incidents almost on a daily basis. It is critical that emergency teams prepare and respond with a defensive plan to protect personnel, the victims of the primary incident and motorists operating around the roadway incident. Sullivan lists and explains significant actions fire departments should take to prevent secondary crashes, and line of duty injuries or fatalities at emergency scenes. The first, strongly encourages fire departments to send all personnel through Roadway Incident Safety training and provide annual refresher training on local and multi-discipline traffic incident management policies and procedures. Sullivan also states all new members should be trained on the hazards of roadway incidents. There are a couple different types of instructor-led courses, as well as, online training available. The second, overviews how to receive traffic incident management training. The third, states that fire department and fire police should have procedures in place on how to properly setup blocking and temporary traffic controls at incident scenes to warn oncoming traffic of an incident ahead and prevent secondary incidents. The fourth, covers proper personal protective gear, specifically, hi-viz gear. The last action addressed in this document is proper display of emergency warning lights and any traffic control arrow devices on fire apparatus (Sullivan, 2018 Critical).

Sullivan created a full document detailing types of emergency vehicle blocking techniques for different incidents scenes. Sullivan clearly describes each preventative blocking technique and provides visual examples of each for better understanding. The document also includes which way the wheels should be turned and where cones and flares should be placed (Sullivan, 2016).

One study researched the possibility of using Changeable Message Signs (CMS) to provide motorists with real-time traffic information, yet little is known about their effectiveness. A paper written for Transportation Research Board 90th Annual Meeting, investigates if CMS reduce the number of secondary incidents. The report showed mild evidence that CMS reduce secondary incidents. The results show CMS influence area extends approximately 22 miles downstream from placement. Investments in CMS to provide information to motorists many be beneficial, although inter-vehicle communication may soon offer an alternative to CMS (Kopitch, 2011).

Similar to CMS, another study developed a control strategy of variable speed limits to reduce the risks of secondary collisions during inclement weather. Variable speed limit strategies propose to adjust the speed limits according to the current traffic and weather conditions to avoid secondary incidents. The results show that the variable speed limit strategy effectively reduces the risks of secondary incidents in various weather types (Li, 2014).

In another article by Sullivan published in Fire Engineering magazine, he discusses the many hazards emergency responders are at risk of at highway operations. The main idea focuses on “D” drivers, those who normally have a “me first” attitude towards driving. Sullivan states that the government is positive autonomous vehicle will solve this problem of deaths and injuries. The problem with this thinking is what is supposed to be done between now and when autonomous vehicles are established on the roads. Society cannot sit back and wait; therefore, Sullivan delineates what efforts need to be made to train and protect firefighters and EMTs responding to roadway emergencies. These key efforts involve: develop standard operating procedures/guidelines, emergency vehicle positioning, traffic control devices, LED lighting, personnel visibility, apparatus safety at the scene, and enforcing yielding to emergency vehicles (Sullivan, 2018).

The summer 2018 edition of Fire Rescue Academy magazine was centered around how to prevent injury and death on the road. Inside, Jack Sullivan, Robert Rielage, Rommie Duckworth, and Robert Avsec each lead a topic in their own article within the magazine. Sullivan advocates going back to the basics. Sullivan addresses the importance of knowing the basics of each of the following and how they are essential increasing safety on the roadside: hazard awareness; the three Cs, communication, collaboration and cooperation, setting up a safe work area, and personal protective equipment. Next, Rielage discusses how the responsibility of safely driving an emergency vehicle is just as important to the wellbeing of firefighters as any of these other initiatives. Rielage speaks about how to properly train drivers, ensure continuous apparatus operation training and evaluation, and being aware of driver reaction while driving to a scene even at pre-emptive traffic system intersections. Following this article, Duckworth reminds emergency responders that fire operations attract attention, so be aware that this makes every driver on the road a distracted driver when they are near the incident area. Duckworth also asks emergency responder to keep in mind time, distance and shielding. Minimizing the time that apparatus and firefighters operate in or around active roadways, minimizes the risk that individuals and vehicles will be struck. Use signaling devices like signs, cones, an arrow board, barricades, flares to increase the distance the drivers become aware of the incident. This gives drivers more time to react and adjust to the new traffic pattern. Finally, use emergency vehicles to shield the area properly. The last article by Avsec, commends fire apparatus safety innovations and improvements. Some of these improvements being electronic stability control that decreases vehicle rollover, evolutions in seat belt and airbag technology, stronger cabs that can withstand impacts, collision avoidance systems, and optics and screen displays that remove or reduce blind spots (Sullivan & Bashoor, 2018).

Summary of Findings

A review of the literature has shown that currently there is no way to gather complete and effective data. There are implications with reporting and documentation of these types of crashes because it is hard to catalog and receive accurate data for secondary crashes. The four elements of secondary incident reports, current studies, laws and regulation, and prevention were researched in order to gain a better understanding of the secondary incidents involving emergency responders. The studies done in Arizona, California, and Wisconsin are closely related to this study. This research closes the gap by considering another state (Florida) and going the extra step to determine the significance of some of the predominate characteristics between these types of crashes and the general population by looking at z-score and p values. The research presented in this paper seeks to build upon the prior knowledge and expand the scientific understanding of the statically significant characteristics that are associated with first responder vehicle and struck-by crashes.

Methodology

To achieve the research goal, a statistical analysis of prior emergency responder vehicle and struck-by vehicle crashes was conducted. Florida was selected as the study location because of the availability of data. The research task first required data gathering from the Florida's statewide crash database. This data was then processed to partition struck-by and responder vehicle crashes out of the general population. Then finally, hypothesis testing was conducted to identify the critical characteristics of interest regarding these crash types. The following sections of this chapter provide a detailed account of each task.

Gathering of data

There are several crash data systems with query functions that exist within the state of Florida. One of them being Signal Four Analytics. Signal Four Analytics is a statewide interactive, web-based geospatial crash analytical tool developed and maintained by the GeoPlan Center at University of Florida with support from the Florida Traffic Records Coordinating Committee (Common Crash). This system is accessible to Florida government agencies and their contractors or consultants. Therefore, this project has received access as a consultant for academic research.

With direct access to the system's database, Florida crash data was downloaded for further review. Signal Four Analytics has several custom queries by year for 2011 to 2018. Specifically, police, fire, ambulance vehicle and struck-by crashes from 2016 to 2018 were downloaded by entering the desired year and respective group into the Database/Report No. filter. For example:

- custom: db.ambulance_2016

- custom: db.fire_2017
- custom: db.police_2018
- custom: db. struckby_2016

Each custom query outputs crashes involving the corresponding emergency responds vehicle crashes. Next, for all crashes in Florida, general population, each month's data set had to be individually downloaded. This was done by using the calendar to select the corresponding dates for each month. The downloaded excel spreadsheets report characteristics of every reported crash including and not limited to: time and date of crash, location, type of crash, severity, and weather.

Data Partition

An in-depth analysis of the data gathered from 2016 to 2018 was conducted using excel with pivot tables and pie charts. Full analysis of data should reveal common features and patterns. After all the data was downloaded from the initial source, Signal Four Analytics, specific columns were sorted and organized for further analysis. Each months' totals had to be assemble into 3 years of data to yield total crashes for 2016 to 2018. An investigation of each years' and emergency responder group's total crashes, fatalities and other crash severities, crash type, potential yearly were conducted. Influenced crashes i.e. drug, alcohol, and distracted driving, as well as, weather and lighting were also studied in combination of all three years of data for the general public, ambulance, fire, police and struck-by crashes. This analysis yielded tables and pie charts that are shown in the results. The following is a list of all the characteristics of interest that were analyzed:

Crash Type:

- Angle
- Sideswipe, same direction
- Front to Front
- Front to Rear

Crash Severity:

- Fatalities
- Incapacitating Injuries
- Non-incapacitating Injuries
- Possible Injuries
- Property Damage Only

Influenced

- Alcohol Related
- Distraction Related
- Drug Related

Weather

- Clear
- Cloudy
- Fog, Smog, Smoke
- Other
- Rain
- Severe Crosswinds
- Sleet/Hail/Freezing Rain
- Blowing Sand, Soil, Dirt

Lighting

- Dark - Lighted
- Dark - Not Lighted
- Dark - Unknown Lighting
- Dawn
- Daylight
- Dusk
- Unknown
- Blank
- Other

During analysis of the three years combined, proportions of each characteristic of interest were determined and were used for testing significance in task 3.

Hypothesis test of significance

The next major task was completing a test of significance between the general population and each responder group for each crash characteristic of interest. This was done by using a z-score equation for proportions. The following Equation 1 is taken from the second edition of Statistical Methods for Rates and Proportions (Fleiss, 1981).

$$z' = \frac{|p_2 - p_1| - \frac{1}{2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}{\sqrt{\frac{p_1 q_1}{n_1} + \frac{p_2 q_2}{n_2}}} \qquad \textbf{(Equation 1)}$$

In this project the sample sizes (n) are large enough to not significantly affect the resulting Z-score; therefore, the resulting new equation used for this paper is Equation 2 shown below.

$$z' = \frac{p_2 - p_1}{\sqrt{\frac{p_1 q_1}{n_1} + \frac{p_2 q_2}{n_2}}} \qquad \textbf{(Equation 2)}$$

Each characteristic of interest, after converted into a proportion, was calculated into a z-score using Equation 2. The null hypothesis will be rejected at the 90% confidence level, or otherwise known as, 10% significance level. The necessary z critical value for the significance level is obtained from Table A.2. Critical values of the normal distribution from the second edition of Statistical Methods for Rates and Proportions (Fleiss, 1981). For a two-tailed test where the null is rejected at p value of less than 0.05, the critical value is a z-score of +/- 1.65. Since this is a Z-distribution using proportions, there are a few values the test needs to have: population size (n1), sample size (n2), proportion of population (p1), and proportion of sample (p2). First responder percentage and total number of crashes are known based on analysis in task 2, as well as, the percentage and total crashes for 2016-2018 general population. An example is shown below.

Step 1, determine the hypothesis.

- Hypothesis – The percentage of nighttime crashes with roadway lighting among ambulance involved crashes are significantly different than the percentage of nighttime crashes among non-responder crashes.
- Null Hypothesis - There is no difference in percentage between night crashes among the non-responder and night crashes among ambulance crashes.

Step 2, calculate z-score using equation 2 and known data.

Non-Responder involved Percentage for Dark-Lighted (p1) = 16.66%

Total Non-Responder involved crashes (n1) = 2147762

Ambulance Percentage for Dark-Lighted (p2) = 18.62%

Total Ambulance involved crashes (n2) = 2352

$$z' = \frac{0.1862 - 0.1666}{\sqrt{\frac{0.1666 * 0.8334}{2147762} + \frac{0.1862 * 0.8138}{2352}}}$$

$$z' = 2.44$$

Using the Z-table, or excel, z-scores can be converted into p values. In this example, a z-score of 2.44 would convert to a p value of 0.0073.

Step 3, make an observation. A z-score of 2.44 is greater than the critical value of Z = 1.65; Therefore, the test rejects the null hypothesis. It can be concluded that there is a difference in the percentage of nighttime crashes with roadway lights between ambulance vehicle crashes and the general population (non-responders); therefore, the research hypothesis is supported.

Each characteristic of interest's z-score and p-value are calculated using the same process as above and detailed in the following subsections.

Sample size

Sample sizes used in z-score analysis are the same for every characteristic of interest, but change slightly for each responder type. For any ambulance vehicle involved crashes the sample sizes used are:

- Total Non-Responder involved crashes (n1) = 2147762
- Total Ambulance involved crashes (n2) = 2352

For all fire vehicle involved crashes the sample sizes used are:

- Total Non-Responder involved crashes (n1) = 2147762
- Total Fire involved crashes (n2) = 2655

For police vehicle involved crashes the sample sizes used are:

- Total Non-Responder involved crashes (n1) = 2147762
- Total Police involved crashes (n2) = 21084

And the following analysis that show struck-by crashes the sample sizes used are:

- Total Non-Struck-by crashes (n1) = 2173658
- Total Struck-by crashes (n2) = 195

Sample sizes and proportions are summarized in *Table 1*.

Crash Severity

Crash severity was chosen as a characteristic of interest to show a need for this and further research. The hope is that even though numbers are "low" for fatality and injures the test of significance should show a significant difference in proportion of fatalities and injuries occurring among first responders.

Fatality

Ambulance Vehicle Involved

- Hypothesis: The percentage of fatal crashes among responding ambulances are significantly different than the percentage of fatal crashes in the general population.

- Null Hypothesis: There is no difference in percentage between fatal crashes among the general population and fatal crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Fatality Percentage (p1) = 0.39%
- Ambulance Fatality Percentage (p2) = 0.21%

Fire Vehicle Involved

- Hypothesis: The percentage of fatal crashes among firefighters are significantly different than the percentage of fatal crashes in the general population.

- Null Hypothesis: There is no difference in percentage between fatal crashes among the general population and fatal crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05

- Non-Responder Fatality Percentage (p1) = 0.39%
- Fire Fatality Percentage (p2) = 0.26%

Police Vehicle Involved

- Hypothesis: The percentage of fatal crashes among police officers are significantly different than the percentage of fatal crashes in the general population.

- Null Hypothesis: There is no difference in percentage between fatal crashes among the general population and fatal crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Fatality Percentage (p1) = 0.39%
- Police Fatality Percentage (p2) = 0.19%

Struck-by

- Hypothesis: The percentage of fatal crashes among first responders outside of their vehicle are significantly different than the percentage of fatal crashes in the general population.

- Null Hypothesis: There is no difference in percentage between fatal crashes among the general population and fatal crashes among first responders working the crash scene (outside of a vehicle).
- Two-sided
- level of significance: 10%, alpha = 0.05

- Non-Struck-by Fatality Percentage (p1) = 0.39%
- Struck-by Fatality Percentage (p2) = 2.05%

Incapacitating Injuries

Ambulance Vehicle Involved

- Hypothesis: The percentage of incapacitating injuries among responding ambulances are significantly different than the percentage of incapacitating injuries in the general population.

- Null Hypothesis: There is no difference in percentage between incapacitating injuries among the general population and incapacitating injuries among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Incapacitating Injuries Percentage (p1) = 2.62%
- Ambulance Incapacitating Injuries Percentage (p2) = 2.85%

Fire Vehicle Involved

- Hypothesis: The percentage of incapacitating injuries among firefighters are significantly different than the percentage of incapacitating injuries in the general population.

- Null Hypothesis: There is no difference in percentage between incapacitating injuries among the general population and incapacitating injuries among firefighters.
- Two-sided

- level of significance: 10%, alpha = 0.05
- Non-Responder Incapacitating Injuries Percentage (p1) = 2.62%
- Fire Incapacitating Injuries Percentage (p2) = 1.17%

Police Vehicle Involved

- Hypothesis: The percentage of incapacitating injuries among police officers are significantly different than the percentage of incapacitating injuries in the general population.

- Null Hypothesis: There is no difference in percentage between incapacitating injuries among the general population and incapacitating injuries among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Incapacitating Injuries Percentage (p1) = 2.62%
- Police Incapacitating Injuries Percentage (p2) = 2%

Struck-by

- Hypothesis: The percentage of incapacitating injuries among first responders outside of their vehicle are significantly different than the percentage of incapacitating injuries in the general population.

- Null Hypothesis: There is no difference in percentage between incapacitating injuries among the general population and incapacitating injuries among first responders working the crash scene (outside of a vehicle).

- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by Incapacitating Injuries Percentage (p1) = 2.61%
- Struck-by Incapacitating Injuries Percentage (p2) = 14.87%

Non-incapacitating Injuries

Ambulance Vehicle Involved

- Hypothesis: The percentage of non-incapacitating injuries among responding ambulances are significantly different than the percentage of non-incapacitating injuries in the general population.

- Null Hypothesis: There is no difference in percentage between non-incapacitating injuries among the general population and non-incapacitating injuries among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Non-Incapacitating Injuries Percentage (p1) = 9.07%
- Ambulance Non-Incapacitating Injuries Percentage (p2) = 9.35%

Fire Vehicle Involved

- Hypothesis: The percentage of non-incapacitating injuries among firefighters are significantly different than the percentage of non-incapacitating injuries in the general population.

- Null Hypothesis: There is no difference in percentage between non-incapacitating injuries among the general population and non-incapacitating injuries among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Non-Incapacitating Injuries Percentage (p1) = 9.07%
- Fire Non-Incapacitating Injuries Percentage (p2) = 5.12%

Police Vehicle Involved

- Hypothesis: The percentage of non-incapacitating injuries among police officers are significantly different than the percentage of non-incapacitating injuries in the general population.

- Null Hypothesis: There is no difference in percentage between non-incapacitating injuries among the general population and non-incapacitating injuries among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Non-Incapacitating Injuries Percentage (p1) = 9.07%
- Police Non-Incapacitating Injuries Percentage (p2) = 8.24%

Struck-by

- Hypothesis: The percentage of non-incapacitating injuries among first responders outside of their vehicle are significantly different than the percentage of non-incapacitating injuries in the general population.

- Null Hypothesis: There is no difference in percentage between non-incapacitating injuries among the general population and non-incapacitating injuries among first responders working the crash scene (outside of a vehicle).
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by Non-Incapacitating Injuries Percentage (p1) = 9.05%
- Struck-by Non-Incapacitating Injuries Percentage (p2) = 27.69%

Possible Injuries

Ambulance Vehicle Involved

- Hypothesis: The percentage of possible injuries among responding ambulances are significantly different than the percentage of possible injuries in the general population.

- Null Hypothesis: There is no difference in percentage between possible injuries among the general population and possible injuries among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Possible Injuries Percentage (p1) = 20.65%
- Ambulance Possible Injuries Percentage (p2) = 20.41%

Fire Vehicle Involved

- Hypothesis: The percentage of possible injuries among firefighters are significantly different than the percentage of possible injuries in the general population.

- Null Hypothesis: There is no difference in percentage between possible injuries among the general population and possible injuries among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Possible Injuries Percentage (p1) = 20.65%
- Fire Possible Injuries Percentage (p2) = 12.66%

Police Vehicle Involved

- Hypothesis: The percentage of possible injuries among police officers are significantly different than the percentage of possible injuries in the general population.

- Null Hypothesis: There is no difference in percentage between possible injuries among the general population and possible injuries among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Possible Injuries Percentage (p1) = 20.65%
- Police Possible Injuries Percentage (p2) = 14.65%

Struck-by

- Hypothesis: The percentage of possible injuries among first responders outside of their vehicle are significantly different than the percentage of possible injuries in the general population.

- Null Hypothesis: There is no difference in percentage between possible injuries among the general population and possible injuries among first responders working the crash scene (outside of a vehicle).
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by Possible Injuries Percentage (p1) = 20.58%
- Struck-by Possible Injuries Percentage (p2) = 42.56%

Property Damage Only

Ambulance Vehicle Involved

- Hypothesis: The percentage of property damage only crashes among responding ambulances are significantly different than the percentage of property damage only crashes in the general population.

- Null Hypothesis: There is no difference in percentage between property damage only crashes among the general population and property damage only crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Property Damage Only Percentage (p1) = 67.26%

- Ambulance Property Damage Only Percentage (p2) = 67.18%

Fire Vehicle Involved

- Hypothesis: The percentage of property damage only crashes among firefighters are significantly different than the percentage of property damage only crashes in the general population.

- Null Hypothesis: There is no difference in percentage between property damage only crashes among the general population and property damage only crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Property Damage Only Percentage (p1) = 67.26%
- Fire Property Damage Only Percentage (p2) = 80.79%

Police Vehicle Involved

- Hypothesis: The percentage of property damage only crashes among police officers are significantly different than the percentage of property damage only crashes in the general population.

- Null Hypothesis: There is no difference in percentage between property damage only crashes among the general population and property damage only crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Property Damage Only Percentage (p1) = 67.26%

- Police Property Damage Only Percentage (p2) = 74.91%

Struck-by

- Hypothesis: The percentage of property damage only crashes among first responders outside of their vehicle are significantly different than the percentage of property damage only crashes in the general population.

- Null Hypothesis: There is no difference in percentage between property damage only crashes among the general population and property damage only crashes among first responders working the crash scene (outside of a vehicle).
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by Property Damage Only Percentage (p1) = 67.36%
- Struck-by Property Damage Only Percentage (p2) = 12.82%

Crash Type

Crash type is important because it can help identify where and why first responders are involved in crashes. Not all crash types were tested in this project. The top four from task 2, angle, sideswipe, head-on and rear-end, were chosen for analysis.

Angle

Ambulance Vehicle Involved

- Hypothesis: The percentage of angle crashes among responding ambulances are significantly different than the percentage of angle crashes in the general population.

- Null Hypothesis: There is no difference in percentage between angle crashes among the general population and angle crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Angle Percentage (p1) = 22.27%
- Ambulance Angle Percentage (p2) = 22.92%

Fire Vehicle Involved

- Hypothesis: The percentage of angle crashes among firefighters are significantly different than the percentage of angle crashes in the general population.

- Null Hypothesis: There is no difference in percentage between angle crashes among the general population and angle crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Angle Percentage (p1) = 22.27%
- Fire Angle Percentage (p2) = 25.46%

Police Vehicle Involved

- Hypothesis: The percentage of angle crashes among police officers are significantly different than the percentage of angle crashes in the general population.

- Null Hypothesis: There is no difference in percentage between angle crashes among the general population and angle crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Angle Percentage (p1) = 22.27%
- Police Angle Percentage (p2) = 21.21%

Sideswipe, same direction

Ambulance Vehicle Involved

- Hypothesis: The percentage of sideswipe crashes among responding ambulances are significantly different than the percentage of sideswipe crashes in the general population.

- Null Hypothesis: There is no difference in percentage between sideswipe crashes among the general population and sideswipe crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Sideswipe Percentage (p1) = 11.79%
- Ambulance Sideswipe Percentage (p2) = 24.83%

Fire Vehicle Involved

- Hypothesis: The percentage of sideswipe crashes among firefighters are significantly different than the percentage of sideswipe crashes in the general population.

- Null Hypothesis: There is no difference in percentage between sideswipe crashes among the general population and sideswipe crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Sideswipe Percentage (p1) = 11.79%
- Fire Sideswipe Percentage (p2) = 20.38%

Police Vehicle Involved

- Hypothesis: The percentage of sideswipe crashes among police officers are significantly different than the percentage of sideswipe crashes in the general population.

- Null Hypothesis: There is no difference in percentage between sideswipe crashes among the general population and sideswipe crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Sideswipe Percentage (p1) = 11.79%
- Police Sideswipe Percentage (p2) = 10.32%

Front to Front

Ambulance Vehicle Involved

- Hypothesis: The percentage of head-on collisions among responding ambulances are significantly different than the percentage of head-on collisions in the general population.

- Null Hypothesis: There is no difference in percentage between head-on collisions among the general population and head-on collisions among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Front to Front Percentage (p1) = 2.69%
- Ambulance Front to Front Percentage (p2) = 1.91%

Fire Vehicle Involved

- Hypothesis: The percentage of head-on collisions among firefighters are significantly different than the percentage of head-on collisions in the general population.

- Null Hypothesis: There is no difference in percentage between head-on collisions among the general population and head-on collisions among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Front to Front Percentage (p1) = 2.69%
- Fire Front to Front Percentage (p2) = 1.85%

Police Vehicle Involved

- Hypothesis: The percentage of head-on collisions among police officers are significantly different than the percentage of head-on collisions in the general population.

- Null Hypothesis: There is no difference in percentage between head-on collisions among the general population and head-on collisions among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Front to Front Percentage (p1) = 2.69%
- Police Front to Front Percentage (p2) = 2.72%

Front to Rear

Ambulance Vehicle Involved

- Hypothesis: The percentage of rear-end collisions among responding ambulances are significantly different than the percentage of rear-end collisions in the general population.

- Null Hypothesis: There is no difference in percentage between rear-end collisions among the general population and rear-end collisions among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Front to Rear Percentage (p1) = 36.71%

- Ambulance Front to Rear Percentage (p2) = 21.56%

Fire Vehicle Involved

- Hypothesis: The percentage of rear-end collisions among firefighters are significantly different than the percentage of rear-end collisions in the general population.

- Null Hypothesis: There is no difference in percentage between rear-end collisions among the general population and rear-end collisions among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Front to Rear Percentage (p1) = 36.71%
- Fire Front to Rear Percentage (p2) = 17.44%

Police Vehicle Involved

- Hypothesis: The percentage of rear-end collisions among police officers are significantly different than the percentage of rear-end collisions in the general population.

- Null Hypothesis: There is no difference in percentage between rear-end collisions among the general population and rear-end collisions among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Front to Rear Percentage (p1) = 36.71%

- Police Front to Rear Percentage (p2) = 31.87%

Influenced

Stakeholders, like Jack Sullivan, are concerned with "D" drivers and the fact that even though first responder normally follow protocol, first responders are still being affected by influenced drivers. Alcohol, distraction and drug were tested to see how statically significant these are in first responder involved and struck-by crashes.

Alcohol Related

Ambulance Vehicle Involved

- Hypothesis: The percentage of alcohol related crashes among responding ambulances are significantly different than the percentage of alcohol related crashes in the general population.

- Null Hypothesis: There is no difference in percentage between alcohol related crashes among the general population and alcohol related crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Alcohol Percentage (p1) = 2.01%
- Ambulance involved Alcohol Percentage (p2) = 1.06%

Fire Vehicle Involved

- Hypothesis: The percentage of alcohol related crashes among firefighters are significantly different than the percentage of alcohol related crashes in the general population.

- Null Hypothesis: There is no difference in percentage between alcohol related crashes among the general population and alcohol related crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Alcohol Percentage (p1) = 2.01%
- Fire involved Alcohol Percentage (p2) = 1.51%

Police Vehicle Involved

- Hypothesis: The percentage of alcohol related crashes among police officers are significantly different than the percentage of alcohol related crashes in the general population.

- Null Hypothesis: There is no difference in percentage between alcohol related crashes among the general population and alcohol related crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Alcohol Percentage (p1) = 2.01%
- Police involved Alcohol Percentage (p2) = 3.61%

Struck-by

- Hypothesis: The percentage of alcohol related crashes among first responders outside of their vehicle are significantly different than the percentage of alcohol related crashes in the general population.

- Null Hypothesis: There is no difference in percentage between alcohol related crashes among the general population and alcohol related crashes among first responders working the crash scene (outside of a vehicle).
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by Alcohol Percentage (p1) = 6.06%
- Struck-by Alcohol Related Percentage (p2) = 10.77%

Distraction Related

Ambulance Vehicle Involved

- Hypothesis: The percentage of distraction related crashes among responding ambulances are significantly different than the percentage of distraction related crashes in the general population.

- Null Hypothesis: There is no difference in percentage between distraction related crashes among the general population and distraction related crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Distraction Percentage (p1) = 12.77%
- Ambulance involved Distraction Percentage (p2) = 11.9%

Fire Vehicle Involved

- Hypothesis: The percentage of distraction related crashes among firefighters are significantly different than the percentage of distraction related crashes in the general population.

- Null Hypothesis: There is no difference in percentage between distraction related crashes among the general population and distraction related crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Distraction Percentage (p1) = 12.77%
- Fire involved Distraction Percentage (p2) = 9.15%

Police Vehicle Involved

- Hypothesis: The percentage of distraction related crashes among police officers are significantly different than the percentage of distraction related crashes in the general population.

- Null Hypothesis: There is no difference in percentage between distraction related crashes among the general population and distraction related crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Distraction Percentage (p1) = 12.77%
- Police involved Distraction Percentage (p2) = 16.60%

Struck-by

- Hypothesis: The percentage of distraction related crashes among first responders outside of their vehicle are significantly different than the percentage of distraction related crashes in the general population.

- Null Hypothesis: There is no difference in percentage between distraction related crashes among the general population and distraction related crashes among first responders working the crash scene (outside of a vehicle).
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by Distraction Percentage (p1) = 38.41%
- Struck-by Distraction Related Percentage (p2) = 14.87%

Drug Related

Ambulance Vehicle Involved

- Hypothesis: The percentage of drug related crashes among responding ambulances are significantly different than the percentage of drug related crashes in the general population.

- Null Hypothesis: There is no difference in percentage between drug related crashes among the general population and drug related crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05

- Non-Responder Drug Percentage (p1) = 0.53%
- Ambulance involved Drug Percentage (p2) = 0.47%

Fire Vehicle Involved

- Hypothesis: The percentage of drug related crashes among firefighters are significantly different than the percentage of drug related crashes in the general population.

- Null Hypothesis: There is no difference in percentage between drug related crashes among the general population and drug related crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Drug Percentage (p1) = 0.53%
- Fire involved Drug Percentage (p2) = 0.23%

Police Vehicle Involved

- Hypothesis: The percentage of drug related crashes among police officers are significantly different than the percentage of drug related crashes in the general population.

- Null Hypothesis: There is no difference in percentage between drug related crashes among the general population and drug related crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05

- Non-Responder Drug Percentage (p1) = 0.53%
- Police involved Drug Percentage (p2) = 1%

Struck-by

- Hypothesis: The percentage of drug related crashes among first responders outside of their vehicle are significantly different than the percentage of drug related crashes in the general population.

- Null Hypothesis: There is no difference in percentage between drug related crashes among the general population and drug related crashes among first responders working the crash scene (outside of a vehicle).
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by Drug Percentage (p1) = 1.6%
- Struck-by Drug Related Percentage (p2) = 2.05%

Weather Conditions

This project tested weather conditions because these are helpful in identifying what type of conditions first responders should be more cautious. Most individuals may think that only in inclement weather they should be on high alert, but it also seems like clear days can have a significant difference in crash proportions.

Clear

Ambulance Vehicle Involved

- Hypothesis: The percentage of clear weather condition during crashes among responding ambulances are significantly different than the percentage of clear weather condition during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between clear weather condition during crashes among the general population and clear weather condition during crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Clear Conditions Percentage (p1) = 79.53%
- Ambulance involving Clear Conditions Percentage (p2) = 79.97%

Fire Vehicle Involved

- Hypothesis: The percentage of clear weather condition during crashes among firefighters are significantly different than the percentage of clear weather condition during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between clear weather condition during crashes among the general population and clear weather condition during crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Clear Conditions Percentage (p1) = 79.53%
- Fire involving Clear Conditions Percentage (p2) = 80.3%

Police Vehicle Involved

- Hypothesis: The percentage of clear weather condition during crashes among police officers are significantly different than the percentage of clear weather condition during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between clear weather condition during crashes among the general population and clear weather condition during crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Clear Conditions Percentage (p1) = 79.53%
- Police involving Clear Conditions Percentage (p2) = 78.3%

Struck-by

- Hypothesis: The percentage of clear weather condition during crashes among first responders outside of their vehicle are significantly different than the percentage of clear weather condition during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between clear weather condition during crashes among the general population and clear weather condition during among first responders working the crash scene (outside of a vehicle).
- Two-sided
- level of significance: 10%, alpha = 0.05

- Non-Struck-by with Clear Conditions Percentage (p1) = 79.52%
- Struck-by with Clear Conditions Percentage (p2) = 76.41%

Cloudy

Ambulance Vehicle Involved

- Hypothesis: The percentage of cloudy weather condition during crashes among responding ambulances are significantly different than the percentage of cloudy weather condition during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between cloudy weather condition during crashes among the general population and cloudy weather condition during crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Cloudy Conditions Percentage (p1) = 13.88%
- Ambulance involving Cloudy Conditions Percentage (p2) = 12.8%

Fire Vehicle Involved

- Hypothesis: The percentage of cloudy weather condition during crashes among firefighters are significantly different than the percentage of cloudy weather condition during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between cloudy weather condition during crashes among the general population and cloudy weather condition during crashes among firefighters.

- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Cloudy Conditions Percentage (p1) = 13.88%
- Fire involving Cloudy Conditions Percentage (p2) = 12.88%

Police Vehicle Involved

- Hypothesis: The percentage of cloudy weather condition during crashes among police officers are significantly different than the percentage of cloudy weather condition during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between cloudy weather condition during crashes among the general population and cloudy weather condition during crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Cloudy Conditions Percentage (p1) = 13.88%
- Police involving Cloudy Conditions Percentage (p2) = 13.94%

Struck-by

- Hypothesis: The percentage of cloudy weather condition during crashes among first responders outside of their vehicle are significantly different than the percentage of cloudy weather condition during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between cloudy weather condition during crashes among the general population and cloudy weather condition during among first responders working the crash scene (outside of a vehicle).

- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by with Cloudy Conditions Percentage (p1) = 13.87%
- Struck-by with Cloudy Conditions Percentage (p2) = 13.85%

Fog, Smog, Smoke

Ambulance Vehicle Involved

- Hypothesis: The percentage of foggy, smoggy, and/or smoky weather conditions during crashes among responding ambulances are significantly different than the percentage of foggy, smoggy, and/or smoky weather conditions during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between foggy, smoggy, and/or smoky weather conditions during crashes among the general population and foggy, smoggy, and/or smoky weather conditions during crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Fog, Smog, Smoke Percentage (p1) = 0.3%
- Ambulance involving Fog, Smog, Smoke Percentage (p2) = 0.09%

Fire Vehicle Involved

- Hypothesis: The percentage of foggy, smoggy, and/or smoky weather conditions during crashes among firefighters are significantly different than the percentage of foggy, smoggy, and/or smoky weather conditions during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between foggy, smoggy, and/or smoky weather conditions during crashes among the general population and foggy, smoggy, and/or smoky weather conditions during crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Fog, Smog, Smoke Percentage (p1) = 0.3%
- Fire involving Fog, Smog, Smoke Percentage (p2) = 0.45%

Police Vehicle Involved

- Hypothesis: The percentage of foggy, smoggy, and/or smoky weather conditions during crashes among police officers are significantly different than the percentage of foggy, smoggy, and/or smoky weather conditions during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between foggy, smoggy, and/or smoky weather conditions during crashes among the general population and foggy, smoggy, and/or smoky weather conditions during crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Fog, Smog, Smoke Conditions Percentage (p1) = 0.3%

- Police involving Fog, Smog, Smoke Conditions Percentage (p2) = 0.46%

Struck-by

- Hypothesis: The percentage of foggy, smoggy, and/or smoky weather conditions during crashes among first responders outside of their vehicle are significantly different than the percentage of foggy, smoggy, and/or smoky weather conditions during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between foggy, smoggy, and/or smoky weather conditions during crashes among the general population and foggy, smoggy, and/or smoky weather conditions during among first responders working the crash scene (outside of a vehicle).
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by with Fog, Smog, Smoke Percentage (p1) = 0.3%
- Struck-by with Fog, Smog, Smoke Percentage (p2) = 0.51%

Other

Ambulance Vehicle Involved

- Hypothesis: The percentage of unknown weather conditions during crashes among responding ambulances are significantly different than the percentage of unknown weather conditions during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between unknown weather conditions during crashes among the general population and unknown weather conditions during crashes among responding ambulances.

- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Other Percentage (p1) = 0.63%
- Ambulance Other Percentage (p2) = 0.17%

Fire Vehicle Involved

- Hypothesis: The percentage of unknown weather conditions during crashes among firefighters are significantly different than the percentage of unknown weather conditions during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between unknown weather conditions during crashes among the general population and unknown weather conditions during crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Other Percentage (p1) = 0.63%
- Fire Other Percentage (p2) = 0.26%

Police Vehicle Involved

- Hypothesis: The percentage of unknown weather conditions during crashes among police officers are significantly different than the percentage of unknown weather conditions during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between unknown weather conditions during crashes among the general population and unknown weather conditions during crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Other Percentage (p1) = 0.63%
- Police Other Percentage (p2) = 0.44%

Struck-by

- Hypothesis: The percentage of unknown weather conditions during crashes among first responders outside of their vehicle are significantly different than the percentage of unknown weather conditions during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between unknown weather conditions during crashes among the general population and unknown weather conditions during among first responders working the crash scene (outside of a vehicle).
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by Other Percentage (p1) = 0.63%
- Struck-by Other Percentage (p2) = 2.56%

Rain

Ambulance Vehicle Involved

- Hypothesis: The percentage of rainy weather conditions during crashes among responding ambulances are significantly different than the percentage of rainy weather conditions during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between rainy weather conditions during crashes among the general population and rainy weather conditions during crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Rainy Conditions Percentage (p1) = 7.82%
- Ambulance involving Rainy Conditions Percentage (p2) = 6.89%

Fire Vehicle Involved

- Hypothesis: The percentage of rainy weather conditions during crashes among firefighters are significantly different than the percentage of rainy weather conditions during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between rainy weather conditions during crashes among the general population and rainy weather conditions during crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Rainy Conditions Percentage (p1) = 7.82%

- Fire involving Rainy Conditions Percentage (p2) = 6.03%

Police Vehicle Involved

- Hypothesis: The percentage of rainy weather conditions during crashes among police officers are significantly different than the percentage of rainy weather conditions during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between rainy weather conditions during crashes among the general population and rainy weather conditions during crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Rainy Conditions Percentage (p1) = 7.82%
- Police involving Rainy Conditions Percentage (p2) = 6.73%

Struck-by

- Hypothesis: The percentage of rainy weather conditions during crashes among first responders outside of their vehicle are significantly different than the percentage of rainy weather conditions during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between rainy weather conditions during crashes among the general population and rainy weather conditions during among first responders working the crash scene (outside of a vehicle).
- Two-sided

- level of significance: 10%, alpha = 0.05
- Non-Struck-by with Rainy Conditions Percentage (p1) = 7.81%
- Struck-by with Rainy Conditions Percentage (p2) = 6.15%

Severe Crosswinds

Ambulance Vehicle Involved

- Hypothesis: The percentage of severe crosswinds during crashes among responding ambulances are significantly different than the percentage of severe crosswinds during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between severe crosswinds during crashes among the general population and severe crosswinds during crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Severe Crosswinds Percentage (p2) = 0.01%
- Ambulance involving Severe Crosswinds Percentage (p1) = 0.04%

Fire Vehicle Involved

- Hypothesis: The percentage of severe crosswinds during crashes among firefighters are significantly different than the percentage of severe crosswinds during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between severe crosswinds during crashes among the general population and severe crosswinds during crashes among firefighters.

- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Severe Crosswinds Percentage (p1) = 0.01%
- Fire involving Severe Crosswinds Percentage (p2) = 0.04%

Police Vehicle Involved

- Hypothesis: The percentage of severe crosswinds during crashes among police officers are significantly different than the percentage of severe crosswinds during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between severe crosswinds during crashes among the general population and severe crosswinds during crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Severe Crosswinds Percentage (p1) = 0.01%
- Police involving Severe Crosswinds Percentage (p2) = 0.07%

Struck-by

- Hypothesis: The percentage of severe crosswinds during crashes among first responders outside of their vehicle are significantly different than the percentage of severe crosswinds during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between severe crosswinds during crashes among the general population and severe crosswinds during among first responders working the crash scene (outside of a vehicle).

- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by with Severe Crosswinds Percentage (p1) = 0.01%
- Struck-by with Severe Crosswinds Percentage (p2) = 0.51%

Sleet/Hail/Freezing Rain

Police Vehicle Involved

- Hypothesis: The percentage of sleet/hail/freezing rain conditions during crashes among police officers are significantly different than the percentage of sleet/hail/freezing rain weather conditions during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between sleet/hail/freezing rain weather conditions during crashes among the general population and sleet/hail/freezing rain weather conditions during crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Sleet/Hail/Freezing Rain Percentage (p1) = 0.01%
- Police involving Sleet/Hail/Freezing Rain Percentage (p2) = 0.005%

Blowing Sand, Soil, Dirt
Police Vehicle Involved

- Hypothesis: The percentage of crashes involving blowing sand, soil, and/or dirt among police officers are significantly different than the percentage of crashes involving blowing sand, soil, and/or dirt in the general population.

- Null Hypothesis: There is no difference in percentage between crashes involving blowing sand, soil, and/or dirt among the general population and crashes involving blowing sand, soil, and/or dirt among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Blowing Sand, Soil, Dirt Percentage (p1) = 0.003%
- Police involving Blowing Sand, Soil, Dirt Percentage (p2) = 0.005%

Lighting Conditions

Lighting Conditions are similar to weather conditions because these are also helpful in identifying what type of conditions first responders should be more cautious. Most individuals may think that dark conditions would be more dangerous, but it also seems like daytime can have a significant difference in crash proportions since high volumes of people travel during the day. It is important to note that these lighting conditions are the conditions of the roadway not if or what type of lighting first responders are using.

Dark – Lighted
Ambulance Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during dark/nighttime with artificial roadway lighting among responding ambulances are significantly different than the percentage of dark with artificial lighting during crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dark/nighttime with artificial roadway lighting among the general population and dark conditions with artificial lighting during crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Dark – Lighted Percentage (p1) = 16.66%
- Ambulance Dark – Lighted Percentage (p2) = 18.62%

Fire Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during dark/nighttime with artificial roadway lighting among firefighters are significantly different than the percentage of dark conditions with artificial lighting in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dark/nighttime with artificial roadway lighting among the general population and dark conditions with artificial lighting among firefighters.
- Two-sided

- level of significance: 10%, alpha = 0.05
- Non-Responder Dark – Lighted Percentage (p1) = 16.66%
- Fire Dark – Lighted Percentage (p2) = 16.16%

Police Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during dark/nighttime with artificial roadway lighting among police officers are significantly different than the percentage of dark conditions with artificial lighting in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dark/nighttime with artificial lighting among the general population and dark conditions with artificial lighting among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Dark – Lighted Percentage (p1) = 16.66%
- Police Dark – Lighted Percentage (p2) = 24.12%

Struck-by

- Hypothesis: The percentage of crashes that occurred during dark/nighttime with artificial roadway lighting among first responders outside of their vehicle are significantly different than the percentage of dark conditions with artificial lighting crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dark/nighttime with artificial roadway lighting among the general population and dark conditions with artificial lighting crashes among first responders working the crash scene (outside of a vehicle).
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by Dark – Lighted Percentage (p1) = 16.73%
- Struck-by Dark – Lighted Percentage (p2) = 24.62%

Dark - Not Lighted

Ambulance Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during dark/nighttime without roadway lighting among responding ambulances are significantly different than the percentage of nighttime conditions crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dark/nighttime without roadway lighting among the general population and nighttime conditions crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Dark – Not Lighted Percentage (p1) = 4.99%
- Ambulance Dark – Not Lighted Percentage (p2) = 3.91%

Fire Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during dark/nighttime without roadway lighting among firefighters are significantly different than the percentage of nighttime condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dark/nighttime without roadway lighting among the general population and nighttime condition crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Dark – Not Lighted Percentage (p1) = 4.99%
- Fire Dark – Not Lighted Percentage (p2) = 3.58%

Police Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during dark/nighttime without roadway lighting among police officers are significantly different than the percentage of nighttime condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dark/nighttime without roadway lighting among the general population and nighttime condition crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05

- Non-Responder Dark – Not Lighted Percentage (p1) = 4.99%
- Police Dark – Not Lighted Percentage (p2) = 8.13%

Struck-by

- Hypothesis: The percentage of crashes that occurred during dark/nighttime without roadway lighting among first responders outside of their vehicle are significantly different than the percentage of nighttime condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dark/nighttime without roadway lighting among the general population and nighttime condition crashes among first responders working the crash scene (outside of a vehicle).
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by Dark – Not Lighted Percentage (p1) = 5.02%
- Struck-by Dark – Not Lighted Percentage (p2) = 12.31%

Dark - Unknown Lighting

Ambulance Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during dark/nighttime with unknown roadway lighting among responding ambulances are significantly different than the percentage of nighttime conditions with unknown roadway lighting crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dark/nighttime with unknown roadway lighting among the general population and nighttime conditions with unknown roadway lighting crashes among responding ambulances.

- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Dark – Unknown Lighted Percentage (p1) = 0.22%
- Ambulance Dark – Unknown Lighted Percentage (p2) = 0.17%

Fire Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during dark/nighttime with unknown roadway lighting among firefighters are significantly different than the percentage of nighttime condition with unknown roadway lighting crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dark/nighttime with unknown roadway lighting among the general population and nighttime condition with unknown roadway lighting crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Dark – Unknown Lighted Percentage (p1) = 0.22%
- Fire Dark – Unknown Lighted Percentage (p2) = 0.23%

Police Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during dark/nighttime with unknown roadway lighting among police officers are significantly different than the percentage of nighttime condition with unknown roadway lighting crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dark/nighttime with unknown roadway lighting among the general population and nighttime condition with unknown roadway lighting crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Dark – Unknown Lighted Percentage (p1) = 0.22%
- Police Dark – Unknown Lighted Percentage (p2) = 0.21%

Struck-by

- Hypothesis: The percentage of crashes that occurred during dark/nighttime with unknown roadway lighting among first responders outside of their vehicle are significantly different than the percentage of nighttime condition with unknown roadway lighting crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dark/nighttime with unknown roadway lighting among the general population and nighttime conditions with unknown roadway lighting crashes among first responders working the crash scene (outside of a vehicle).
- Two-sided

- level of significance: 10%, alpha = 0.05
- Non-Struck-by Dark – Unknown Lighted Percentage (p1) = 0.22%
- Struck-by Dark – Unknown Lighted Percentage (p2) = 0.51%

Dawn

Ambulance Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during dawn conditions among responding ambulances are significantly different than the percentage of dawn condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dawn conditions among the general population and dawn condition crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Dawn Percentage (p1) = 1.55%
- Ambulance Dawn Percentage (p2) = 1.11%

Fire Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during dawn conditions among firefighters are significantly different than the percentage of dawn condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dawn conditions among the general population and dawn condition crashes among firefighters.

- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Dawn Percentage (p1) = 1.55%
- Fire Dawn Percentage (p2) = 1.21%

Police Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during dawn conditions among police officers are significantly different than the percentage of dawn condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dawn conditions among the general population and dawn condition crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Dawn Percentage (p1) = 1.55%
- Police Dawn Percentage (p2) = 1.5%

Struck-by

- Hypothesis: The percentage of crashes that occurred during dawn conditions among first responders outside of their vehicle are significantly different than the percentage of dawn condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dawn conditions among the general population and dawn condition crashes among first responders working the crash scene (outside of a vehicle).

- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by Dawn Percentage (p1) = 1.54%
- Struck-by Dawn Percentage (p2) = 1.54%

Daylight

Ambulance Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during daylight conditions among responding ambulances are significantly different than the percentage of daylight condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during daylight conditions among the general population and daylight condition crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Daylight Percentage (p1) = 75.01%
- Ambulance Daylight Percentage (p2) = 73.34%

Fire Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during daylight conditions among firefighters are significantly different than the percentage of daylight condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during daylight conditions among the general population and daylight condition crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Daylight Percentage (p1) = 75.01%
- Fire Daylight Percentage (p2) = 76.53%

Police Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during daylight conditions among police officers are significantly different than the percentage of daylight condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during daylight conditions among the general population and daylight condition crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Daylight Percentage (p1) = 75.01%
- Police Daylight Percentage (p2) = 62.82%

Struck-by

- Hypothesis: The percentage of crashes that occurred during daylight conditions among first responders outside of their vehicle are significantly different than the percentage of daylight condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during daylight conditions among the general population and daylight condition crashes among first responders working the crash scene (outside of a vehicle).
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by Daylight Percentage (p1) = 74.9%
- Struck-by Daylight Percentage (p2) = 56.41%

Dusk

Ambulance Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during dusk conditions among responding ambulances are significantly different than the percentage of dusk condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dusk conditions among the general population and dusk condition crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Dusk Percentage (p1) = 2.92%
- Ambulance Dusk Percentage (p2) = 2.72%

Fire Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during dusk conditions among firefighters are significantly different than the percentage of dusk condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dusk conditions among the general population and dusk condition crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Dusk Percentage (p1) = 2.92%
- Fire Dusk Percentage (p2) = 1.92%

Police Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during dusk conditions among police officers are significantly different than the percentage of dusk condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dusk conditions among the general population and dusk condition crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Dusk Percentage (p1) = 2.92%
- Police Dusk Percentage (p2) = 2.57%

Struck-by

- Hypothesis: The percentage of crashes that occurred during dusk conditions among first responders outside of their vehicle are significantly different than the percentage of dusk condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during dusk conditions among the general population and dusk condition crashes among first responders working the crash scene (outside of a vehicle).
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by Dusk Percentage (p1) = 2.91%
- Struck-by Dusk Percentage (p2) = 2.56%

Unknown

Ambulance Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during unknown lighting conditions among responding ambulances are significantly different than the percentage of unknown lighting condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during unknown lighting conditions among the general population and unknown lighting condition crashes among responding ambulances.

- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Unknown Percentage (p1) = 0.78%
- Ambulance Unknown Percentage (p2) = 0.09%

Fire Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during unknown lighting conditions among firefighters are significantly different than the percentage of unknown lighting condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during unknown lighting conditions among the general population and unknown lighting condition crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Unknown Percentage (p1) = 0.78%
- Fire Unknown Percentage (p2) = 0.26%

Police Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during unknown lighting conditions among police officers are significantly different than the percentage of unknown lighting condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during unknown lighting conditions among the general population and unknown lighting condition crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Unknown Percentage (p1) = 0.78%
- Police Unknown Percentage (p2) = 0.48%

Struck-by

- Hypothesis: The percentage of crashes that occurred during unknown lighting conditions among first responders outside of their vehicle are significantly different than the percentage of unknown lighting condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during unknown lighting conditions among the general population and unknown lighting condition crashes among first responders working the crash scene (outside of a vehicle).
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Struck-by Unknown Percentage (p1) = 0.78%
- Struck-by Unknown Percentage (p2) = 2.05%

Blank

Ambulance Vehicle Involved

- Hypothesis: The percentage of reports with lighting conditions not filled out among responding ambulances are significantly different than the percentage of unknown lighting condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between reports with lighting conditions not filled out among the general population and unknown lighting condition crashes among responding ambulances.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Blank Percentage (p1) = 0.88%
- Ambulance Blank Percentage (p2) = 0.04%

Fire Vehicle Involved

- Hypothesis: The percentage of reports with lighting conditions not filled out among firefighters are significantly different than the percentage of unknown lighting condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between reports with lighting conditions not filled out among the general population and unknown lighting condition crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Blank Percentage (p1) = 0.88%

- Fire Blank Percentage (p2) = 0.04%

Police Vehicle Involved

- Hypothesis: The percentage of reports with lighting conditions not filled out among police officers are significantly different than the percentage of unknown lighting condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between reports with lighting conditions not filled out among the general population and unknown lighting condition crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Blank Percentage (p1) = 0.88%
- Police Blank Percentage (p2) = 0.06%

Other

Fire Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during "other" lighting conditions among firefighters are significantly different than the percentage of "other" lighting condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during "other" lighting conditions among the general population and "other" lighting condition crashes among firefighters.
- Two-sided
- level of significance: 10%, alpha = 0.05

- Non-Responder Other Percentage (p1) = 0.06%
- Fire Other Percentage (p2) = 0.08%

Police Vehicle Involved

- Hypothesis: The percentage of crashes that occurred during "other" lighting conditions among police officers are significantly different than the percentage of "other" lighting condition crashes in the general population.

- Null Hypothesis: There is no difference in percentage between crashes that occurred during "other" lighting conditions among the general population and "other" lighting condition crashes among police officers.
- Two-sided
- level of significance: 10%, alpha = 0.05
- Non-Responder Other Percentage (p1) = 0.06%
- Police Other Percentage (p2) = 0.11%

Error! Reference source not found. provides a summary of the sample size and proportion of crashes attributed to each analysis factor. The factor analysis and z-scores are used to determine if the observed differences in these proportions are statistically significant between individual responder groups and non-responder crashes. The results discussion which characteristics are identified as critical players in emergency responder safety and why this could be happening.

Table 1: Summary Chart of Sample sizes and Proportions

	Non-Responder	Ambulance Vehicle	Fire Vehicle	Police Vehicle	Struck-by	Non-Struck-by
Sample Size	2,147,762	2,352	2,655	21,084	195	2,173,658
Fatalities	0.39%	0.21%	0.26%	0.19%	2.05%	0.39%
Incapacitating Injuries	2.62%	2.85%	1.17%	2.00%	14.87%	2.61%
Non-incapacitating Injuries	9.07%	9.35%	5.12%	8.24%	27.69%	9.05%
Possible Injuries	20.65%	20.41%	12.66%	14.65%	42.56%	20.58%
Property Damage Only	67.26%	67.18%	80.79%	74.91%	12.82%	67.36%
Angle	22.27%	22.92%	25.46%	21.21%		
Sideswipe, same direction	11.79%	24.83%	20.38%	10.32%		
Front to Front	2.69%	1.91%	1.85%	2.72%		
Front to Rear	36.71%	21.56%	17.44%	31.87%		
Alcohol Related	2.01%	1.06%	1.51%	3.61%	10.77%	6.06%
Distraction Related	12.77%	11.90%	9.15%	16.60%	14.87%	38.41%
Drug Related	0.53%	0.47%	0.23%	1.00%	2.05%	1.60%
Clear	79.53%	79.97%	80.30%	78.30%	76.41%	79.52%
Cloudy	13.88%	12.80%	12.88%	13.94%	13.85%	13.87%
Fog, Smog, Smoke	0.30%	0.09%	0.45%	0.46%	0.51%	0.30%
Other	0.63%	0.17%	0.26%	0.44%	2.56%	0.63%
Rain	7.82%	6.89%	6.03%	6.73%	6.15%	7.81%
Severe Crosswinds	0.01%	0.04%	0.04%	0.07%	0.51%	0.01%
Sleet/Hail/Freezing Rain	0.01%			0.005%		
Blowing Sand, Soil, Dirt	0.003%			0.005%		
Dark - Lighted	16.66%	18.62%	16.16%	24.12%	24.62%	16.73%
Dark - Not Lighted	4.99%	3.91%	3.58%	8.13%	12.31%	5.02%
Dark - Unknown Lighting	0.22%	0.17%	0.23%	0.21%	0.51%	0.22%
Dawn	1.55%	1.11%	1.21%	1.50%	1.54%	1.54%
Daylight	75.01%	73.34%	76.53%	62.82%	56.41%	74.90%
Dusk	2.92%	2.72%	1.92%	2.57%	2.56%	2.91%
Unknown	0.78%	0.09%	0.26%	0.48%	2.05%	0.78%
Blank	0.88%	0.04%	0.04%	0.06%		
Other	0.06%		0.08%	0.11%		

Results

The results are based on a review of 2,173,853 crashes in the State of Florida occurring between Jan. 1st, 2016 and Dec. 31st, 2018. To provide a context toward the overall scope of responder vehicle crashes, the results chapter begins with a general overview of the number crashes and fatalities found in the dataset,. The research results are then presented for responder vehicles by crash severity, crash type, influence factors, weather, and lighting condition. This is then followed with the analysis of struck-by vehicle crashes. The last step of the project shown in the results are the test of significance. This test is done for every characteristic of interest shown in the analysis of the data.

Total Crashes

In 2016, 2017, and 2018 the state of Florida reported respectively 712,251; 724,383; and 737,219 total crashes. Of those crashes, 8,559; 8,592; and 8,940 crashes involved first responders for their respective years. *Figures 1 through 6* display the percentage of responder vehicle crashes compared to the general population and the percentage of crashes by responder vehicle type.

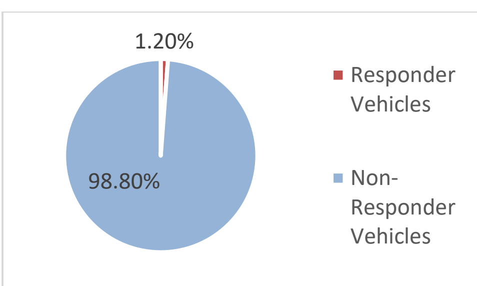

Figure 1: Percent of Total Crashes in 2016

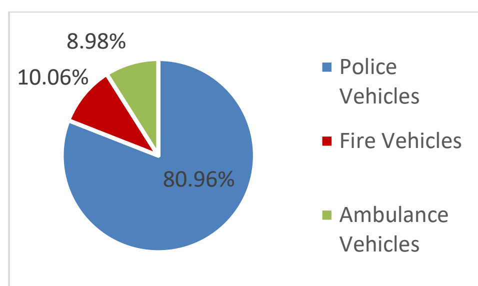

Figure 2: Percent of First Responder Crashes in 2016 by Vehicle Type

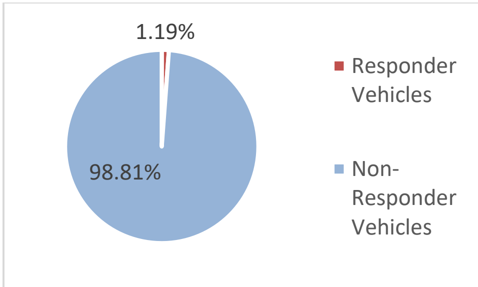

Figure 3: Percent of Total Crashes in 2017

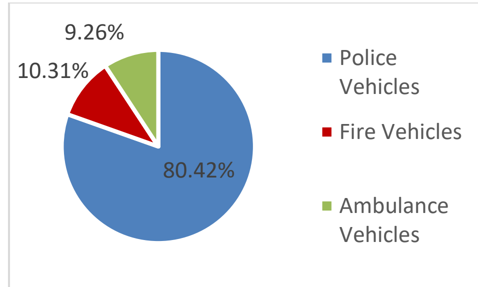

Figure 4: Percent of First Responder Crashes in 2017 by Vehicle Type

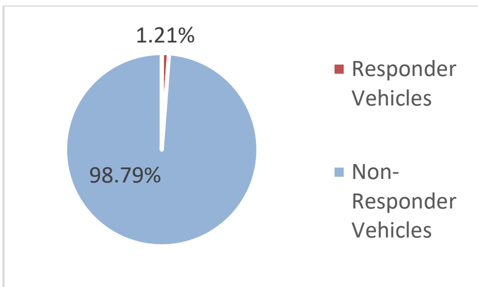

Figure 5: Percent of Total Crashes in 2018

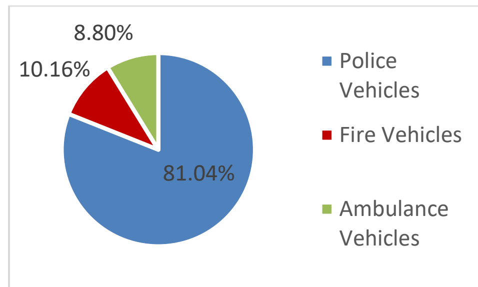

Figure 6: Percent of First Responder Crashes in 2018 by Vehicle Type

Figures 1, 3, and 5 show that approximately 1.2% of all vehicle crashes in the state of Florida involved a first responder vehicle. *Figures 2, 4, & 6* show that about 80 percent of crashes involved police vehicles. This suggest that police officers may be at a higher risk of injury when compared to other responder types. This could be because officers tend to spend longer hours in their vehicles, compared to other responder and/or because of behavioral factors of police drivers. Also, police are trained to use their vehicles in some situations to influence the movement of other vehicles (block access, close lanes, divert drivers, etc.), putting them at higher risk for collisions.

Fatal Crashes

2016 saw 3,203 fatal vehicle crashes in the state of Florida, including 13 first responders. 2017 saw 3,122 fatal and 24 responder fatal crashes, while 2018 experienced 2,176 crashes with 16 of those representing responder fatalities. *Figures 7 through 12* display the percentage of fatal crashes (number of fatal crashes divided by the total number of crashes) among first responders and the general public.

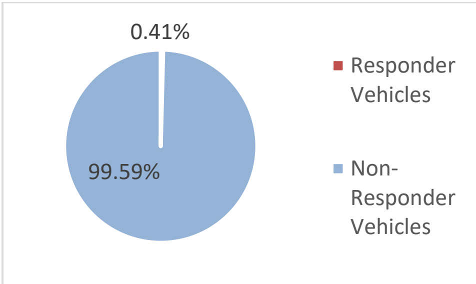

Figure 7: Percentage of fatal crashes in 2016

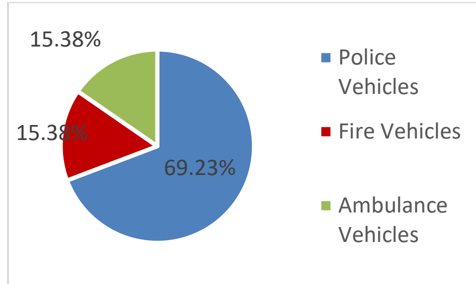

Figure 8: Percentage of fatal crashes among first responders in 2016

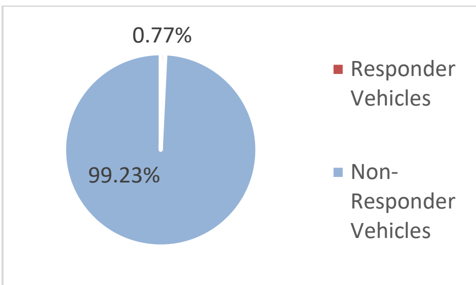

Figure 9: Percentage of fatal crashes in 2017

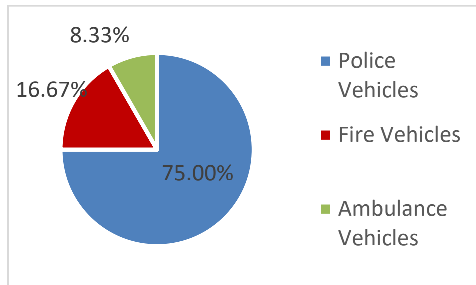

Figure 10: Percentage of fatal crashes among first responders in 2017

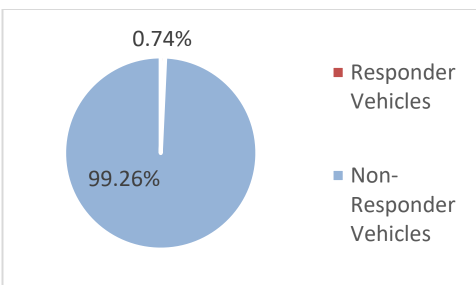

Figure 11: Percentage of fatal crashes in 2018

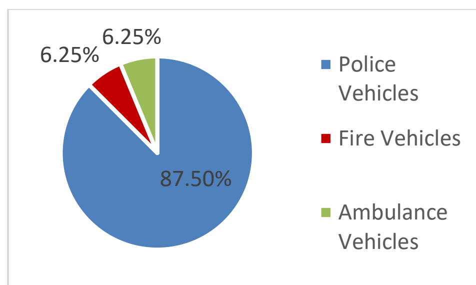

Figure 12: Percentage of fatal crashes among first responders in 2018

From 2016 to 2017 there was a 0.36 percent increase in the percentage of first responder fatalities. Among the individual responder groups, compared to 2016 and 2017, the pie charts show a reduction in ambulance and fire vehicle crash fatalities in 2018. Reviewing the actual numbers in *Table 2* there does not seem to be a significant change in the overall number of fatalities. Police vehicle crashes still see the largest proportion of fatal crashes.

Table 2: Frequency of Fatalities among First Responder Vehicle Type

	Frequency of Fatalities		
	2016	**2017**	**2018**
Ambulance	2	2	1
Fire	2	4	1
Police	9	18	14
Total	13	24	16

Crash Severity

For further analysis the levels of crash severity were plotted for 2016, 2017, and 2018 and shown in *Figures 13 - 24.*

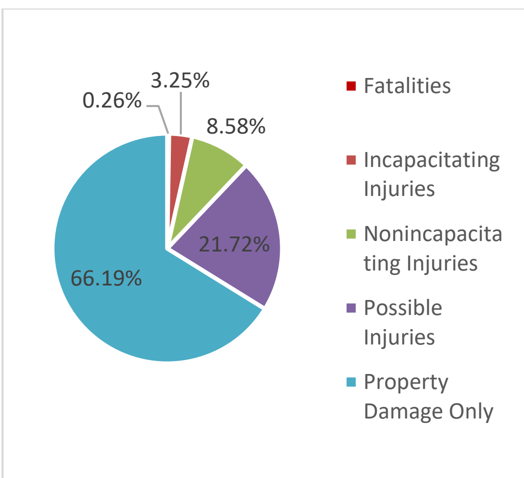

Figure 13: 2016 Ambulance Vehicle Crash Severity

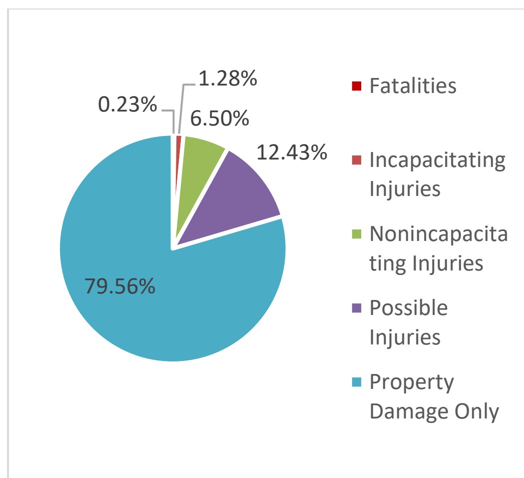

Figure 14: 2016 Fire Vehicle Crash Severity

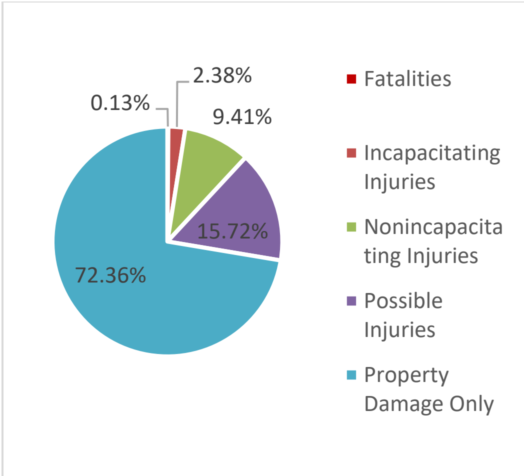

Figure 15: 2016 Police Vehicle Crash Severity

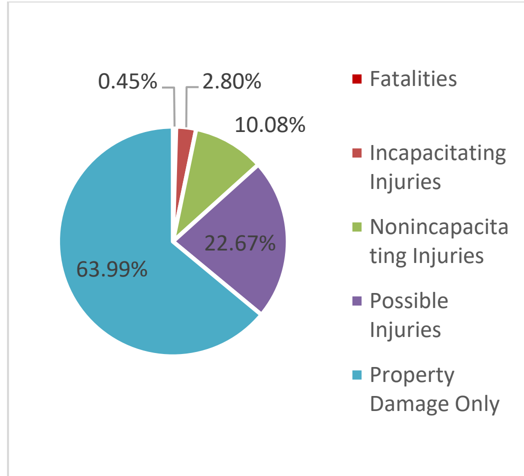

Figure 16: 2016 Non-Responder Vehicle Crash Severity

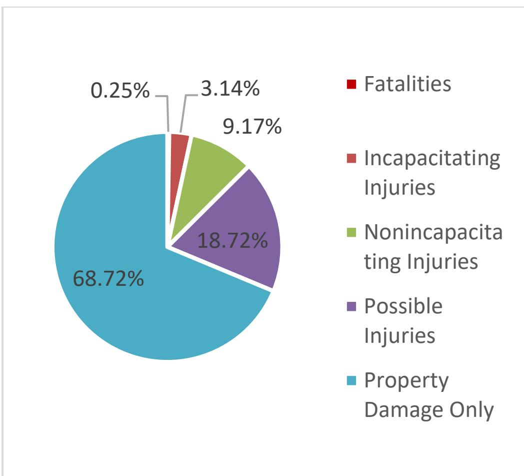

Figure 17: 2017 Ambulance Vehicle Crash Severity

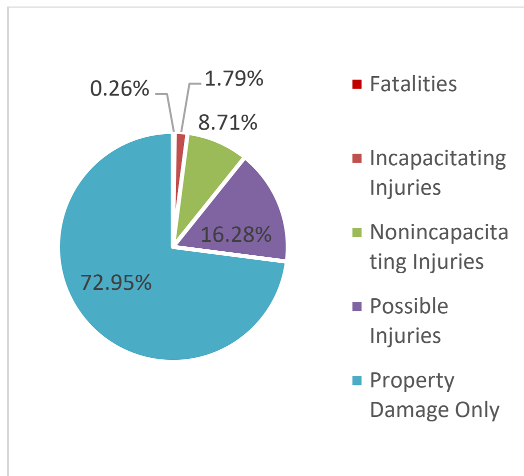

Figure 19: 2017 Police Vehicle Crash Severity

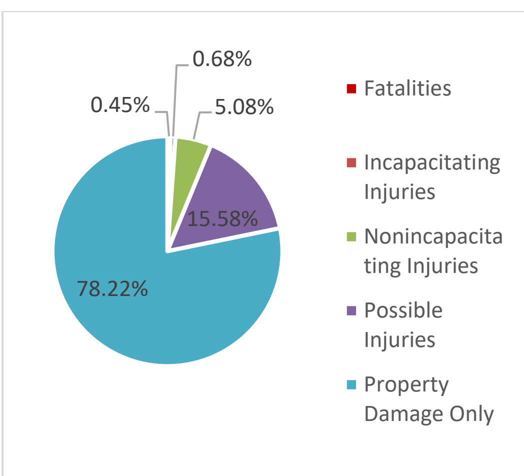

Figure 18: 2017 Fire Vehicle Crash Severity

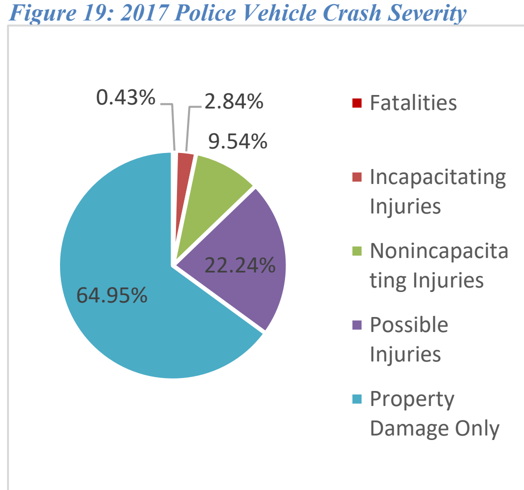

Figure 20: 2017 Non-Responder Vehicle Crash Severity

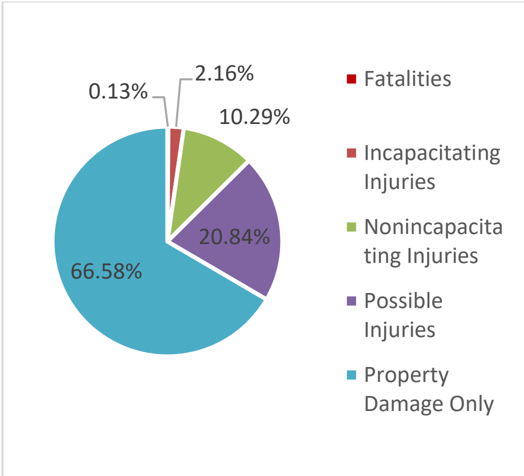

Figure 21: 2018 Ambulance Vehicle Crash Severity

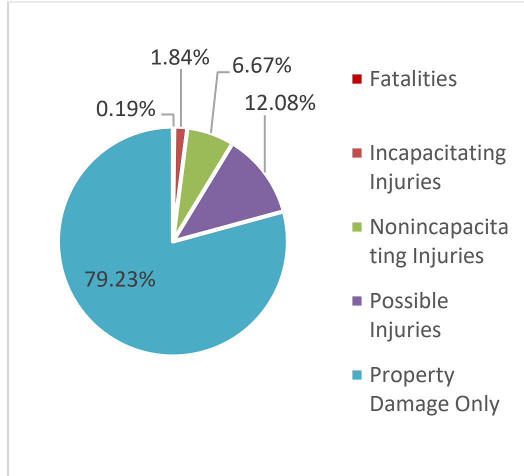

Figure 23: 2018 Police Vehicle Crash Severity

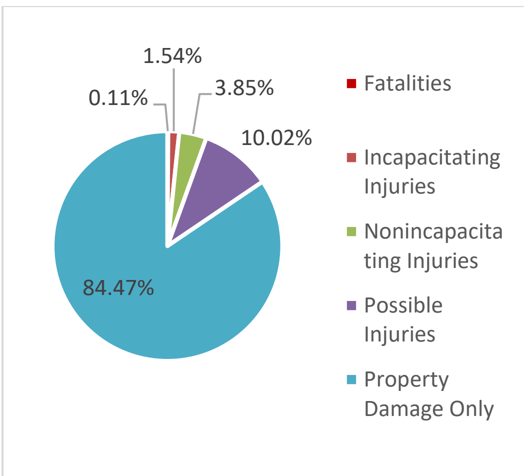

Figure 22: 2018 Fire Vehicle Crash Severity

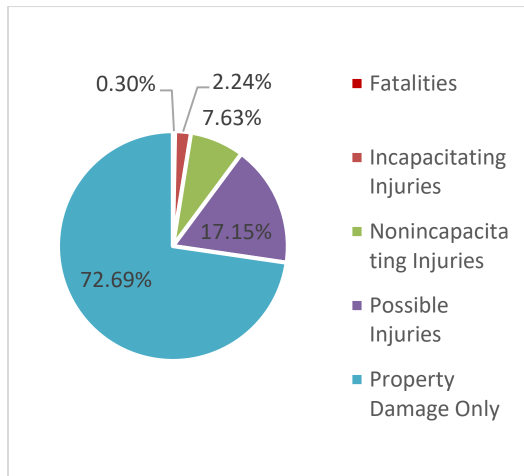

Figure 24: 2018 Non-Responder Vehicle Crash Severity

These percentages for police vehicle crash severity are very similar to the report from California (Wolfe, 2016). This data is displayed in appendix B, Table I. This supports the validity of the data, and that these states are seeing similar rates of fatalities and injuries among first responders. In 2016 and 2017 ambulance vehicle crashes have the highest percentage of all level of injury compared to fire and police vehicles, but not the general population. In 2018, ambulance vehicle crashes saw highest percentage of all level of injury among all groups. Another noticeable change in the data is fatality percentages for fire and police vehicle involved crashes doubled in both groups from 2016 to 2017. This can also be seen in *Table 2*.

Crash Types

None of the previous studies found during the literature review process investigated crash types. From this analysis there is a common trend within each responder group. The top three crash type among all groups are angle, front to rear (rear-end), and sideswipe traveling in the same direction. Police vehicle involved crashes seem to follow a similar pattern to the general public, where angle tend to be approximately 22 percent, front to rear approximately 33 to 36 percent, and sideswipes same direction are about 11 percent. Ambulance seem to have higher sideswipes. Top three percentages range from 23-26, 23-25, and 24-27 respectively for angle, front to rear, and same direction sideswipe crashes. Fire Vehicle crashes have a 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. Fire vehicle's top three percentages were 25-32 percent for angle crashes, 18-20 percent for front to rear (rear-end) crashes, and approximately 22 percent for sideswipe same direction crashes. Crash types for 2016, 2017, and 2018 are shown in *Figures 27 – 38* in Appendix A.

Potential Liability

When police officers in the state of Florida submit a crash report, the officer has to assess the damage to the vehicles involved in the crash. While these estimates are a best guest, they can provide at least some insight into the financial impact of vehicle repair. These estimates are provided as totals, i.e. for a two-car collision, where one of the vehicles is a responder vehicle, the estimate include the damage to both vehicles. These damages are considered potential liability to the state. The true liability is not known until the crash has been adjudicated. For example, the state of Florida was potentially liable for close to $44 million vehicle repair in 2018. However, this is based in estimates provided by the police officer at the scene and does not account for which driver was a fault. Tables 2 through 4 display the potential liability cost for 2016, 2017, and 2018, by responder vehicle type. The estimates suggest that while police vehicles make up the vast majority of responder vehicle crash, they represent the lowest estimated vehicle damage cost. This is likely because police vehicles are modified personal vehicles. Therefore, the vehicles are less expensive and do not require specialized parts or labor. Whereas, ambulances and fire apparatus are significantly more expensive and need specialized knowledge for their repair and maintenance.

Table 3: Potential Liability to the state of Florida in 2016

Vehicle	Potential Liability	
Police Vehicles	$	3,079,334.00
Fire Vehicles	$	3,664,949.00
Ambulance Vehicles	$	23,191,706.00
All First Responders	$	29,935,989.00

Table 4: Potential Liability to the state of Florida in 2017

Vehicle	Potential Liability	
Police Vehicles	$	3,111,872.00
Fire Vehicles	$	3,532,429.00
Ambulance Vehicles	$	24,659,113.00
All First Responders	$	31,303,414.00

Table 5: Potential Liability to the state of Florida in 2018

Vehicle	Potential Liability	
Police Vehicles	$	3,200,255.00

Fire Vehicles	$	3,667,027.00
Ambulance Vehicles	$	37,739,176.00
All First Responders	$	44,606,458.00

Influenced Crashes

After the crash data was analyzed by year for the above characteristics, the three years of data were combined for the rest of the analysis. *Table 6* revels the percent of crashes that were related to influenced drivers, this includes alcohol, distraction and drugs.

Table 6: Percent of crashes that were influenced from January 2016 to December 2018

	Percentages			
	Non-Responder	Ambulance	Fire	Police
Alcohol	2.01%	1.06%	1.51%	3.61%
Distraction	12.77%	11.90%	9.15%	16.60%
Drug	0.53%	0.47%	0.23%	1.00%
Total Influenced	15.31%	13.44%	10.89%	21.21%

Of all the first responders, police have the highest portion of influenced crashes even compared to the non-responder, general population, crashes. This could be due to the fact that police are pursing or pulling over these types of drivers and are generally operating during the same times and in the same locations as drunk and drugged drivers.

Weather Conditions

In a review of more characteristic of interest, weather does not seem to have a significant difference in which types of weather are associated with types of first responder involved crashes verses non-response crashes. This can be seen in *Table 7*.

Table 7: Weather Condition Percentages from January 2016 to December 2018

Weather Conditions	Non-Response	Ambulance	Fire	Police
Clear	79.53%	79.97%	80.30%	78.30%

Cloudy	13.88%	12.80%	12.88%	13.94%
Fog, Smog, Smoke	0.30%	0.09%	0.45%	0.46%
Other	0.63%	0.21%	0.30%	0.50%
Rain	7.82%	6.89%	6.03%	6.73%
Severe Crosswinds	0.01%	0.04%	0.04%	0.07%
Sleet/Hail/Freezing Rain	0.006%			0.005%
Blowing Sand, Soil, Dirt	0.003%			0.005%

The above percentages for police vehicle involved crashes are very similar to the report from California (Wolfe, 2016). This can be seen in Appendix B. The only extreme difference in that two studies that that Florida has double the percent of rainy condition crashes. California and Florida have very different levels of rain fall. Excluding rain, this comparison study supports the validity of the data, and that these states are seeing similar rates of weather conditions among first responders.

Lighting Conditions

Next lighting conditions show slight changes that could be significant among police involved crashes in dark setting with both lighted and not lighted conditions.

Table 8: Lighting Condition Percentages from January 2016 to December 2018

Lighting	Non-Response	Ambulance	Fire	Police
Dark - Lighted	16.66%	18.62%	16.16%	24.12%
Dark - Not Lighted	4.99%	3.91%	3.58%	8.13%
Dark - Unknown Lighting	0.22%	0.17%	0.23%	0.21%
Dawn	1.55%	1.11%	1.21%	1.50%
Daylight	75.01%	73.34%	76.53%	62.82%
Dusk	2.92%	2.72%	1.92%	2.57%
Unknown	0.78%	0.09%	0.26%	0.48%
Blank	0.88%	0.04%	0.04%	0.06%
Other	0.06%		0.08%	0.11%

Similar to weather, the percentages for lighting types shown for police vehicle involved crashes are very similar to the report from California (Wolfe, 2016). *Table 8* can be compared to their Table V shown in Appendix B. This supports the validity of the data, and that these states are seeing similar rates of lighting conditions among first responders.

Test of Significance for First Responder Vehicle Crashes

In the last step of analysis, a z distribution test for significance explain in the methodology was conducted to determine which characteristics of interest are significantly different for certain responder groups. The results for each of the responder groups are presented in the following sections.

Ambulance Vehicle

Table 9 provides the z-score significance test results ambulance vehicle crashes. The table is partitioned into sections for crash severity, crash type, influence factors, weather, and time of day. The first column defines the parameter being compared. The second column provides the proportion and number of crashes attributed to each parameter for non-responder crashes. The third column provides the proportion of crashes and number for ambulances crashes. While the fourth and fifth columns compare the two populations by providing the z-score and p-values, respectively. Factors determined to be significant at a value of 0.05 are shaded in gray.

Table 9: Test of Significance results for Ambulance Vehicle Crashes

	Non-Responder	Ambulance Vehicle Involved		
Sample Size	2,147,762	2,352	z-score	p-value
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)	-0.00	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
Sleet/Hail/Freezing Rain	0.01% (128)	0% (0)		
Blowing Sand, Soil, Dirt	0% (59)	0% (0)		
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% (1725)	-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
Other	0.06% (1,288)	0% (0)		

The analysis suggest that ambulance crashes resulted in significantly fewer fatalities. One reason for this could be the larger size of the ambulance. Another explanation could be that when an ambulance is involved in a crash, there are already trained medics on scene. After arriving to the scene, ambulance drivers typically park at the far end of the crash site behind the protection angled fire trucks and law enforcement vehicles. This way ambulance can safety load victims into their vehicles. Ambulance crashes were also shown to have a higher proportion of sideswipe crashes and lower proportion of rear-end and head-on crashes. This may suggest that ambulances are sideswiped while attending the scene of a roadway crash. This could also suggest that ambulance drivers, while maneuvering between traffic in route to a call, are sideswiping slower moving vehicles. The result found that ambulances are significantly less likely to be involved in a collision with a drunk driver. In a review of the time of day results, ambulance involved crashes are significantly higher during dark hours with lighting. Interesting, 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. Weather does not appear to have any significant impact on ambulance crashes. The significance for weather factors provided in the table are based on only six observations.

Fire Vehicles

Table 10 provides the test of significance results for fire vehicle crashes. The table layout is identical to the previous table. Fire vehicles crashes were shown to have significantly fewer injuries and more property damage only crashes, when compared to non-responder vehicles. Again, this is like due to the vehicle's larger size. Fire vehicles were also subject to significantly more angle and sideswipe crashes and fewer rear-end and head-on collision. This likely because fire vehicles tend to move within traffic similar to ambulances and would therefore be more likely to sideswipe slower moving vehicles. Fire vehicles are also placed in blocking position to protect responders working on or near the roadway. This position could result in more angle and/or sideswipe crashes. Fire vehicles were shown to experience fewer crashes with drunk, drugged, and distracted drivers. Fire vehicles were also less likely to crash during rainy conditions. There was a significant decrease in the proportion of fire crashes that occurred at dark without light, dusk, and dawn. Conversely, more crashes appeared to have occurred during daylight hours. Similar to the finding regarding ambulance crashes, ambient lighting may obscure the emergency lights of the responder vehicle.

Table 10: Test of Significance results for Fire Vehicle Crashes

	Non-Responder	Fire Vehicle Involved		
Sample Size	2,147,762	2,655	z-score	p-value
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)	-12.38	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
Sleet/Hail/Freezing Rain	0.01% (128)	0% (0)		
Blowing Sand, Soil, Dirt	0% (59)	0% (0)		
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)	-1.61	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

Police Vehicles

Table 11 provides the test of significant for police vehicle crashes. The table format is again identical to the previous two tables. Police vehicles experience significantly lower proportions of fatal and injury crashes and significantly more property damage only crashes. One reason this may be occur, is that the general public may be reluctant to report minor property damage crashes, resulting in under reporting. Crashes involving police vehicle are more likely to be reported, regardless of the property damage dollar amount. Contrary to ambulance and fire vehicle, police vehicles are less likely to be involved in angle and sideswipe crashes. Police involved are also less likely to be involved in rear-end crashes. Because police vehicles smaller than ambulance and fire vehicles, an officer is likely better able to maneuver within the traffic and less likely to sideswipe other vehicles. Furthermore, the smaller size of the police vehicle means that officers can park their vehicles further from the right-of-way. The analysis also suggest that police vehicles are more likely to be involved in a crash with drunk, distracted, and drugged drivers. This is likely because officers patrol in areas and during times when these drivers on the road. A lower proportion of police vehicle crashes were found to occur clear and rainy conditions while relatively more police vehicle crashes were observed during fog and severe crosswinds. Police crashes were also more prevalent during dark (with and without lighting). This finding, combined with finding regarding fog, smog, and smoke, may suggest vehicle lighting may play a role in these crashes. Significantly, lower proportions of police vehicle crashes were observed during daylight and dusk hours.

Table 11: Test of Significance results for Police Vehicle Crashes

	Non-Responder	Police Vehicle Involved		
Sample Size	2,147,762	21,084	z-score	p-value
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

Overall, the results show that first responders are generally safer within their vehicles. First responder vehicle involved crashes mostly display significantly lower injury levels. The next results will provide insight into what happens when first responders are not protected by their vehicles.

Struck-by Analysis

From January 2016 to Dec 2018 the state of Florida reported 2,173,853 total crashes. Of those crashes, 195 were struck-by crashes. *Table 24* displays the percentage of these crashes.

Table 12: Percent of Total and Fatal struck-by crashes in Florida from Jan 16 – Dec 18

	Struck-by	Non-Struck-by
Total Crashes	0.01%	99.99%
Fatal Crashes	0.05%	99.95%

Next, the levels of crash severity were plotted and shown in *Figures 25 & 26*.

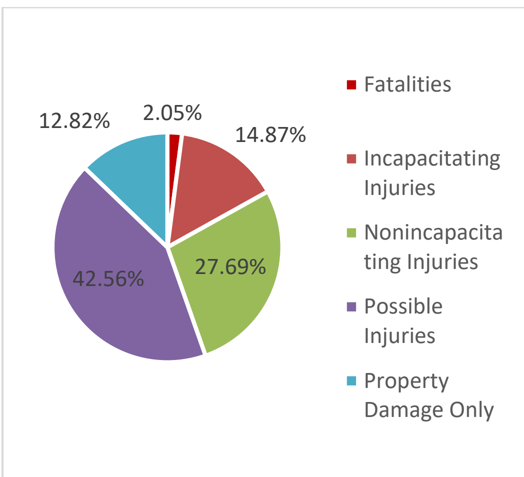

Figure 25: Struck-by Crash Severity

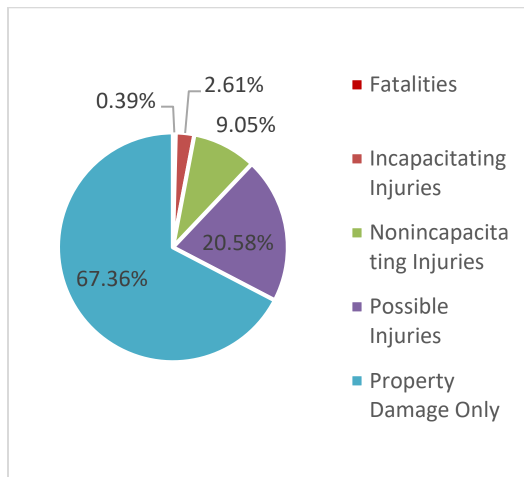

Figure 26: Other crashes Crash Severity

As shown in these figures, struck-by crashes see an extremely higher percentage of all level of injury than normal crashes do. Which should be no shocking discovery since pedestrian have no protection in a struck-by crash; whereas, in most other crashes it involves people who are protected by their vehicles.

Table 25 revels the percent of crashes that were related to influenced drivers, this includes alcohol, distraction and drugs.

Table 13: Influenced crash percentages from January 2016 to December 2018

	Total Non-Struck-by Crashes	Total Struck-by
Alcohol Related	6.06%	10.77%
Distraction	38.41%	14.87%
Drug	1.60%	2.05%
Total	46.07%	27.69%

From *Table 25,* it looks like distracted driving is the largest contributor to struck-by crashes, but lower than a non-struck-by crash. Alcohol and drug seems to be much higher than non-struck-by crashes. This will be further investigated later in this research in the test of significances.

In a review of more characteristic of interest, except for severe crosswinds, weather does not seem to have a significant difference in which types of weather are associated with struck-by crashes verses non-struck-by crashes. This can be seen in *Table 26*.

Table 14: Struck-by comparison for Weather Condition Percentages

Weather	Non-Struck-by	Struck by
Clear	79.52%	76.41%
Cloudy	13.87%	13.85%
Fog, Smog, Smoke	0.30%	0.51%
Other	0.63%	2.56%
Rain	7.81%	6.15%
Severe Crosswinds	0.01%	0.51%

Next, lighting conditions, shown in *Table 27,* indicate some possible significance differences between struck-by and non-struck-by crashes. These results suggest that struck-by crashes are more prevalent during dark. This could be due to the fact that pedestrians are harder to see in the dark. First responders should be wearing personal reflective gear, but sometimes individuals may not wear their gear.

Table 15: Struck-by comparison for lighting Condition Percentages

Lighting	Non-Struck-by	Struck by
Dark - Lighted	16.73%	24.62%
Dark - Not Lighted	5.02%	12.31%
Dark - Unknown Lighting	0.22%	0.51%
Dawn	1.54%	1.54%
Daylight	74.90%	56.41%
Dusk	2.91%	2.56%
Unknown	0.78%	2.05%

After the frequency and percent analysis, a z distribution test for significance explain in the methodology was conducted on the characteristics of interest similar the pervious analysis. *Table 16* provides the test of significance results for struck-by-vehicle crashes. The table is partitioned into sections for crash severity, influence factors, weather, and time of day. The first column defines the parameter being compared. The second column provides the proportion and number of crashes attributed to each parameter for non-responder crashes. The third column provides the proportion of crashes and number for struck-by crashes. While the fourth and fifth columns compare the two populations by providing the z-score and p-values, respectively. Factors determined to be significant at a value of 0.05 are shaded in gray.

Table 16: Test of Significance for Struck-by-vehicle Crashes

	Non-Struck-by	Struck-by		
Sample Size	2,173,658	195	z-score	p-value
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)	3.09	0.0010
Dark - Unknown Lighting	0.22% (4,725)	0.51% (1)	0.58	0.2818
Dawn	1.54% (33,563)	1.54% (3)	-0.01	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

The analysis suggest that struck-by-vehicle crashes are significantly more likely to result in injury and death, when compared to non-struck-by crashes. This was an expected finding because a vehicle does not protect the victims of these crashes. These crashes also appear to be occurring as result of drunk driving. The analysis found that distraction lead to fewer struck-by crashes. However, it more probable that a person involved in a struck-by-vehicle crashes is not going to self-report being distracted. Lighting also appears to play a significant role in these crashes, with significantly more occurring during dark and significantly fewer occurring during daylight. Weather was not found to be a significant factor for struck-by-vehicle crashes.

Summary of Findings

In general, responder vehicle crashes tended to be less fatal when compared to non-responder involved crashes. While underreporting of property damage only crashes among the general public may have impacted these results, this is a positive finding. The size of ambulance and fire vehicles also likely played a role in reducing crash severity among responders. Struck-by crashes did, however, result in a higher likelihood of injury and death. This was expected, as a vehicle does not protect these victims. Ambulance and fire vehicles were shown to suffer a relatively higher proportion of sideswipe crashes, while police vehicles were shown to be less prone to these types of incidents. This may suggest that these larger vehicle struggle to maneuver in confined spaces and when passing slower moving vehicles. Also, fire vehicles blocking the scene of an incident likely increase the occurrence of sideswipe and angled crashes. The results also suggest that crashes influenced by alcohol, drugs, and distraction were less likely to occur in ambulance and fire vehicle crashes and more likely to occur in police and struck-by crashes. It should be noted that the distracted driving results are likely skewed by underreporting. Weather, to the extent that it did not affect lighting conditions, did not appear to be a significant factor among any of the study groups. However, time of day and lighting were found to be influential. The results suggested that dark conditions with the presence of lighting was more likely to increase the occurrence of crashes for ambulance and fire vehicles, while dark conditions without lighting appeared to reduce the likelihood of a crash. This was an interesting finding and suggest that ambient light may obscure the emergency lighting of responder vehicles. Police and stuck-by-vehicle crashes were more prevalent during dark hours.

Discussion, Conclusions, and Recommendations

States around the United States are concerned about crashes involving first responders, especially, struck-by crashes. The nation's first responders are very valuable in the community and should be protected because they work to protect the community. This is not only important to keeping the community safe by keeping the first responders safe, but it is also very important to their friends and family that they return home safely from each shift. This project contributes to efforts by highlighting characteristics of crashes that could be essentials to understanding how to reduce these types of crashes.

While the ultimate goal is to prevent future secondary crashes, completely eliminating secondary incidents may not be realistic. Therefore, reducing the impact is critical in protecting the emergency workers on the roadways. The project exposed statistically significant characteristics that commonly stimulate secondary crashes. Using the data from this project could impact the efforts towards prevention. It will show a need or focus group of certain factors that need to be targeted.

In general the results of the research showed that there are characteristics that are different than the average crash. An example of this was illustrated by *Table 16* where struck-by crashes have statically significant differences in all levels of injury and fatality. These finding were expected and consistent with prior research or experience which tends to traditional indicate that these types of crashes are detrimental to the first responder community.

Based on the findings of this research it is expected that a discussion will be held with stakeholders, a review of mitigating strategies employed by responder agencies will be conducted with a focus toward evidence based success at the identified factors. An extensive amount of unpublished or otherwise not widely disseminated guides and programs have been developed by responder agencies to target many of the factors which may be linked to secondary crashes involving first responders. The adoption of proven best practices toward mitigating risk factors associated with traffic crashes and fatalities will likely lead to decreased risk and, over time, could potentially decrease the number and severity of secondary crashes among responder groups.

Based on the findings of this research it is expected that some of the common counter measures that influence these characteristics of interest are first responder training, community awareness, emergency vehicle lighting research and road rangers. For example, ambulance involved crashes were shown to have a higher proportion of sideswipe crashes. Fire vehicles were also subject to significantly more angle and sideswipe crashes. These types of crashes can be reduced by emergency responder driver training, community awareness of the move over law and future vehicle connectivity. It would be great to reduce these crashes, but fire vehicles are strategically placed to protect pedestrians attending to crash scene. Those involved would much rather these sideswipes and angle crashes occur than see more struck-by crashes. Another example, is lighting conditions, ambulance vehicles, police vehicles and struck-by crashes saw significantly higher nighttime crashes, specifically with roadway lighting among ambulance. Interesting, 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. The analysis also suggest that police vehicles are more likely to be involved in a crash with drunk, distracted, and drugged drivers. Struck-by crashes also saw a significantly higher result in drunk driving crashes. These types are crashes can be reduced by community outreach and awareness and emergency responder safety and preventative training.

The largest limitation is the data the research is based on. As stated before the research reflects the quality of the data. In the past few years, Florida has improved the way officers have recorded crashes and how these types of crashes are filtered into Signal Four database. A limitation that is hard to overcome is the fact that individuals in property damage only crashes may not choose to report a crash. This could skew the general population verse the police vehicle involved crashes since police officers would report all crash their vehicle experiences because each officer is responsible for the maintenance of that vehicle. Therefore, more damages will be reported by emergency vehicles. Florida also has a self-reporting system, Signal Four data is based on officer reports; therefore, these crashes also do not make it into the database. This could also skew non-responder vehicle crashes.

One initial goal of the project was to determine a crash rate for each responder group and the general population. This step was not completed during this project due to the fact that first responder vehicle numbers could not be properly estimated. A future recommendation would be to survey ambulance and EMS agencies, law enforcement departments and all fire departments for their number of vehicles in their fleet. Currently, no agency in Florida has a total count of these vehicles. After these numbers have been collected a crash rate can be determine.

Future researchers will be able to build upon this work by creating a model for crash analysis. Predictive crash frequency models have been developed by traffic engineers to analyze and forecast roadway crashes. The leading models in this field are negative binomial regression and Poisson models. These models work by analyzing large, discrete, and over dispersed data points and identifying statistical correlations between dependent and independent variables. The success of these models is dependent upon rich and meaningful datasets. While the transportation sciences have long since developed the tools to identify risk factors associate with first responder involved secondary crashes, this is yet to be explored because the disparate and dissimilar datasets available for analyzing such crashes.

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Appendix A

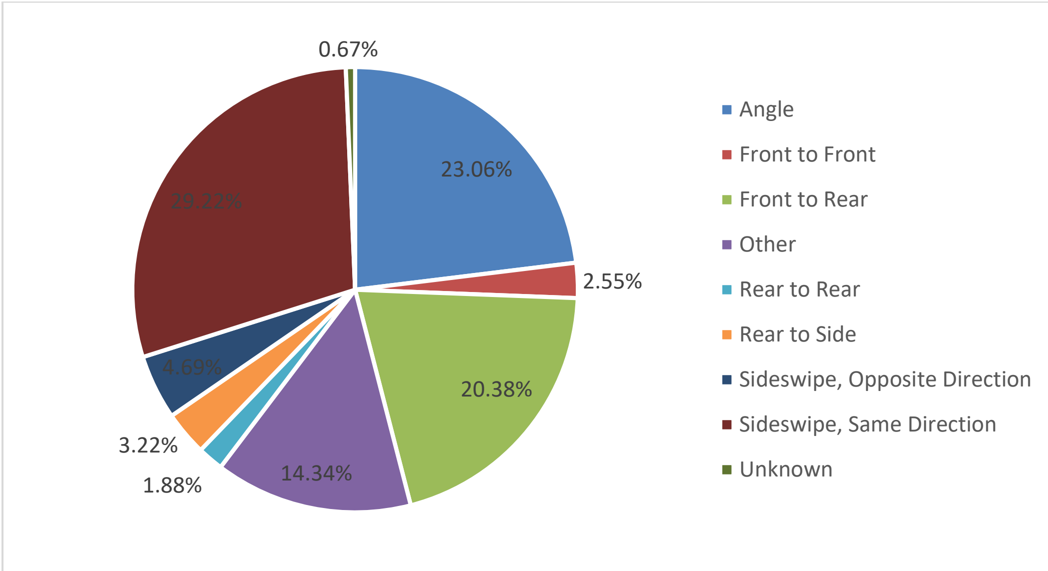

Figure 27: 2016 Ambulance Vehicle Crash Type

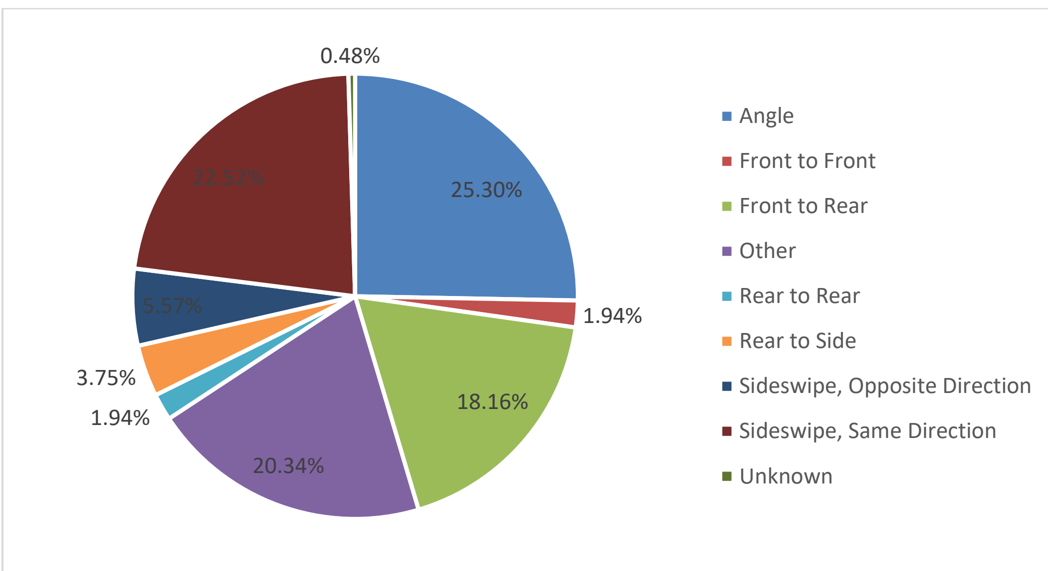

Figure 28: 2016 Fire Vehicle Crash Type

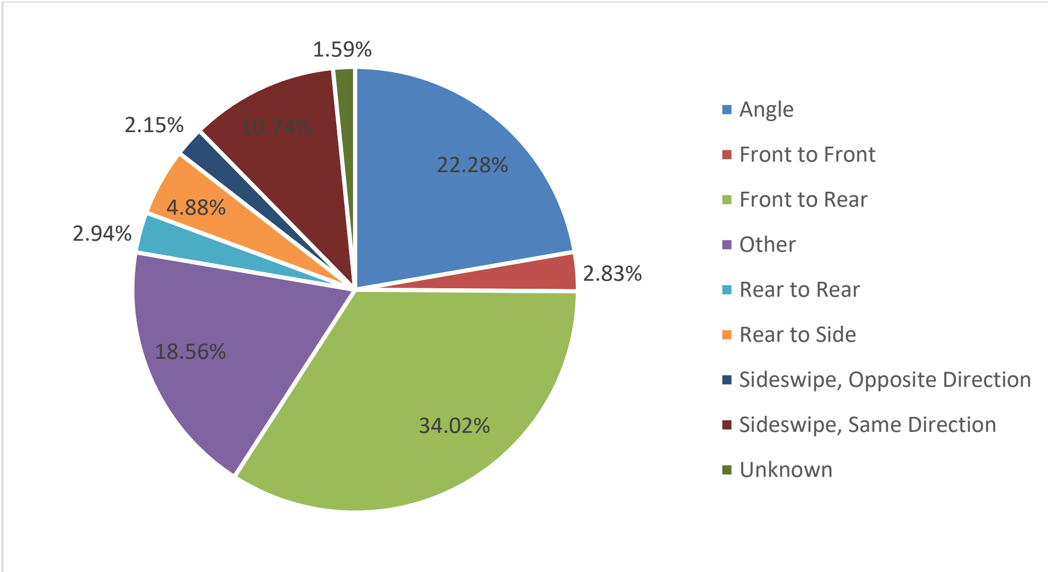

Figure 29: 2016 Police Vehicle Crash Type

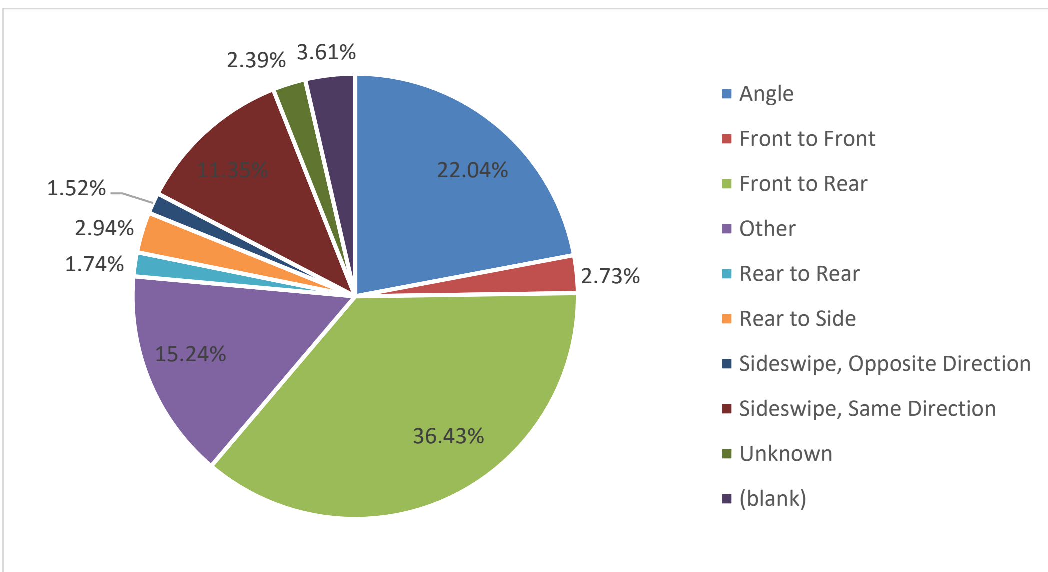

Figure 30: 2016 General Population Vehicle Crash Type

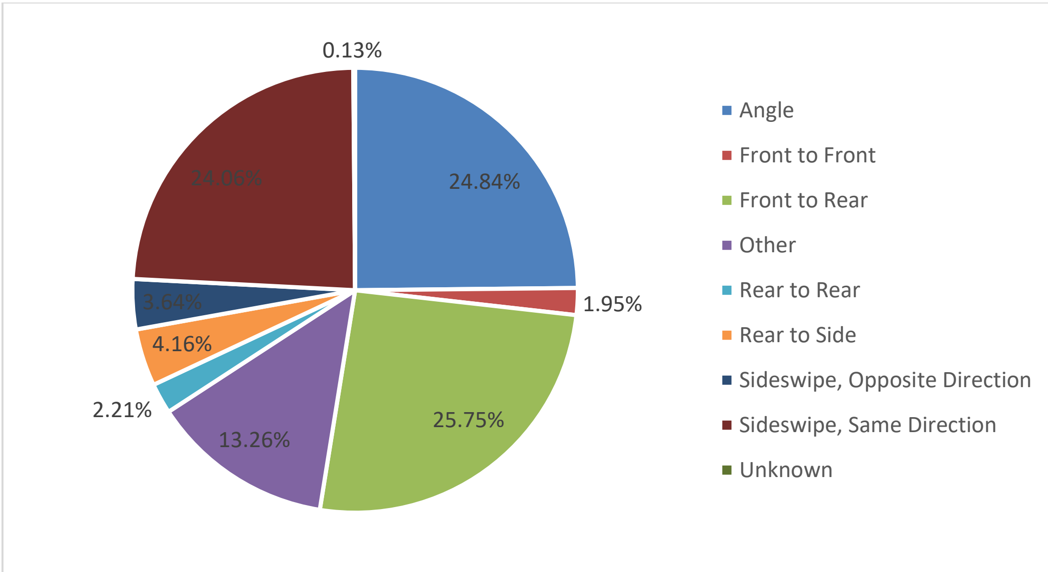

Figure 31: 2017 Ambulance Vehicle Crash Type

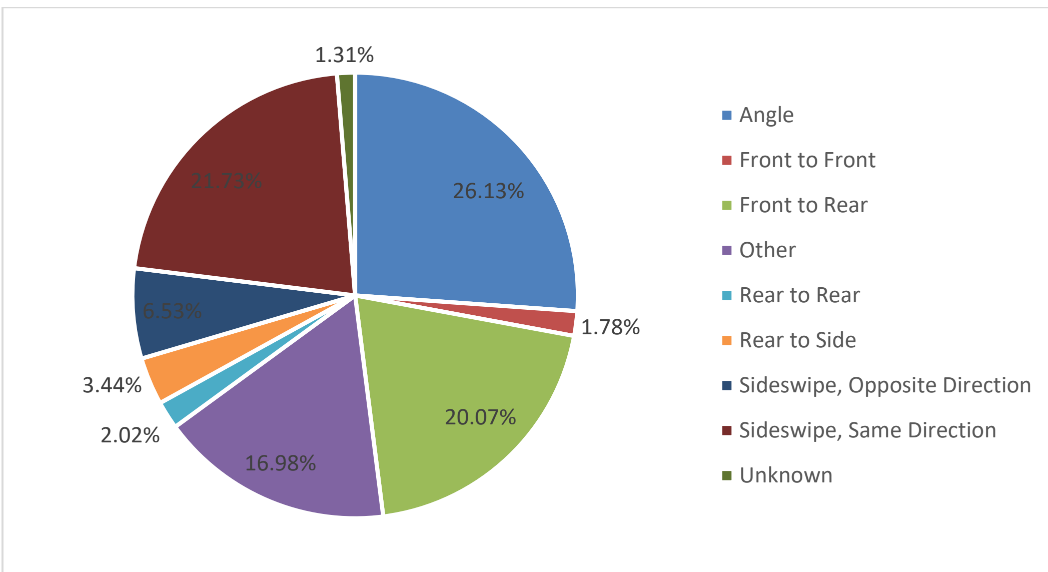

Figure 32: 2017 Fire Vehicle Crash Type

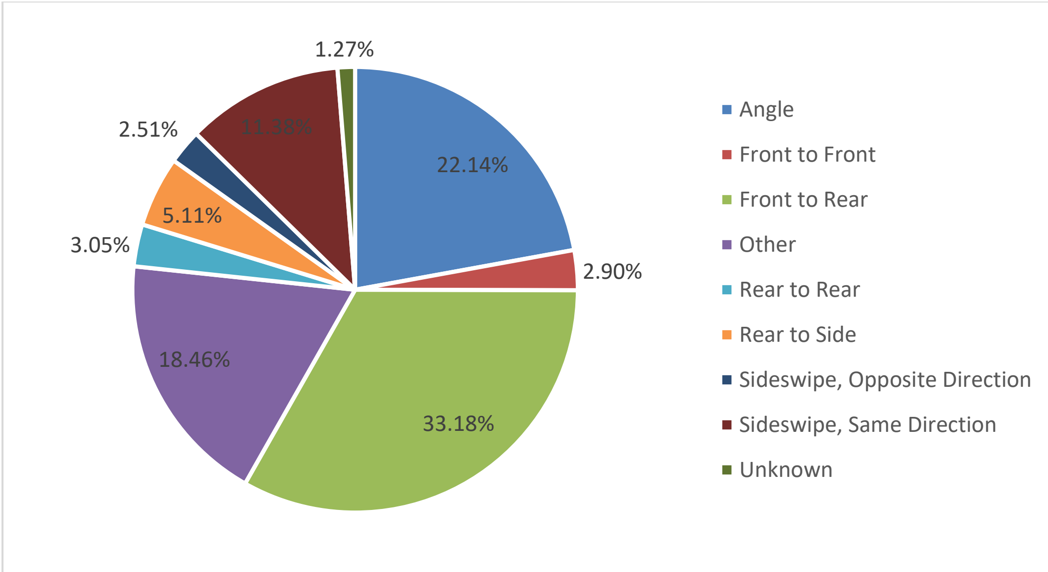

Figure 33: 2017 Police Vehicle Crash Type

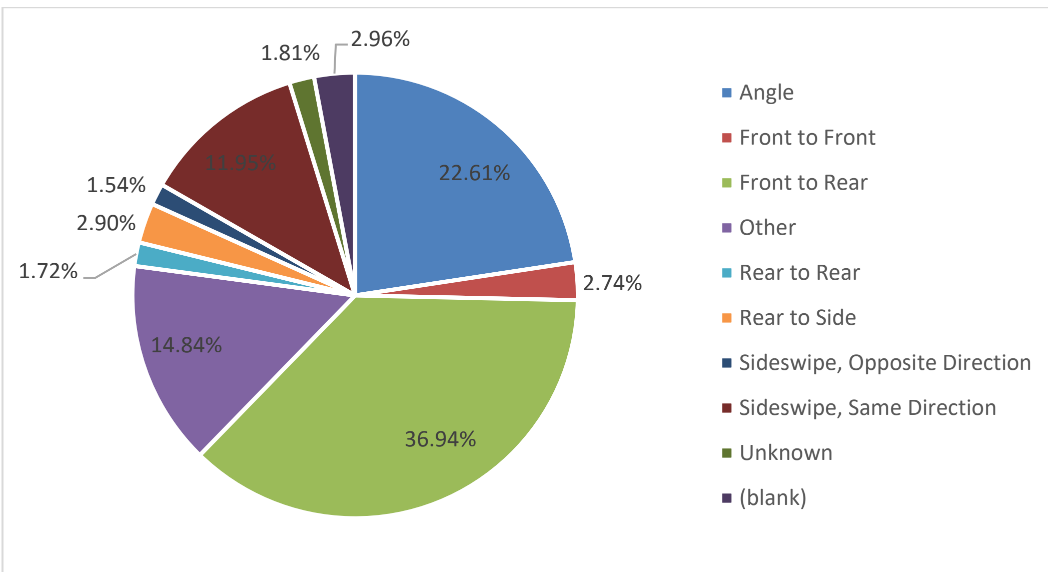

Figure 34: 2017 General Population Vehicle Crash Type

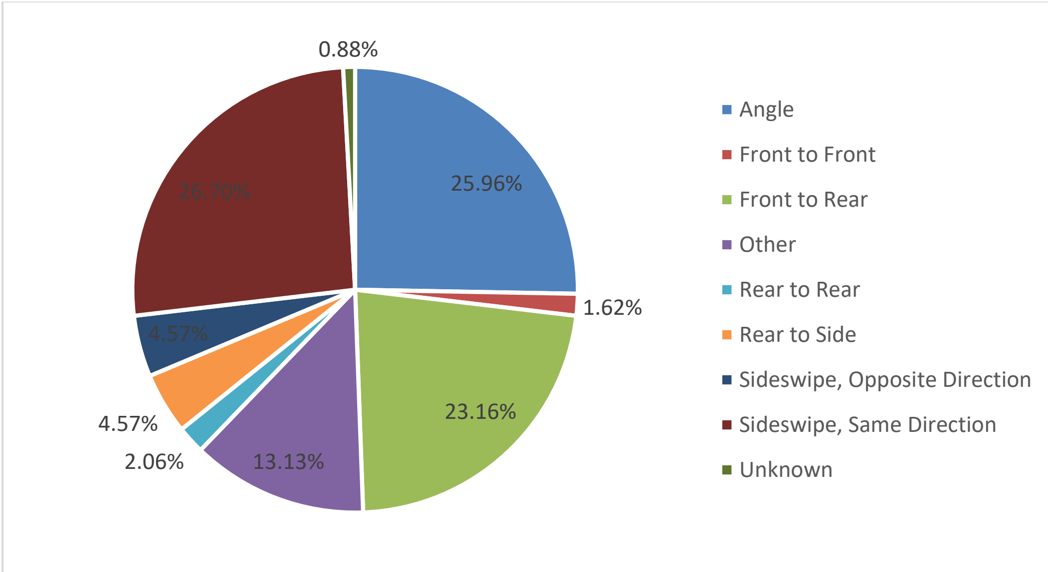

Figure 35: 2018 Ambulance Vehicle Crash Type

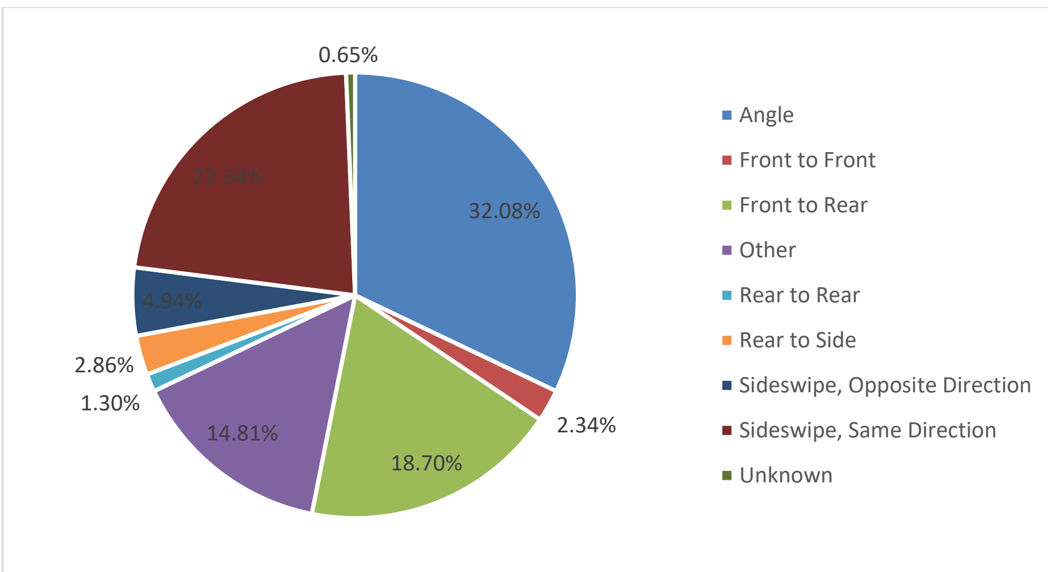

Figure 36: 2018 Fire Vehicle Crash Type

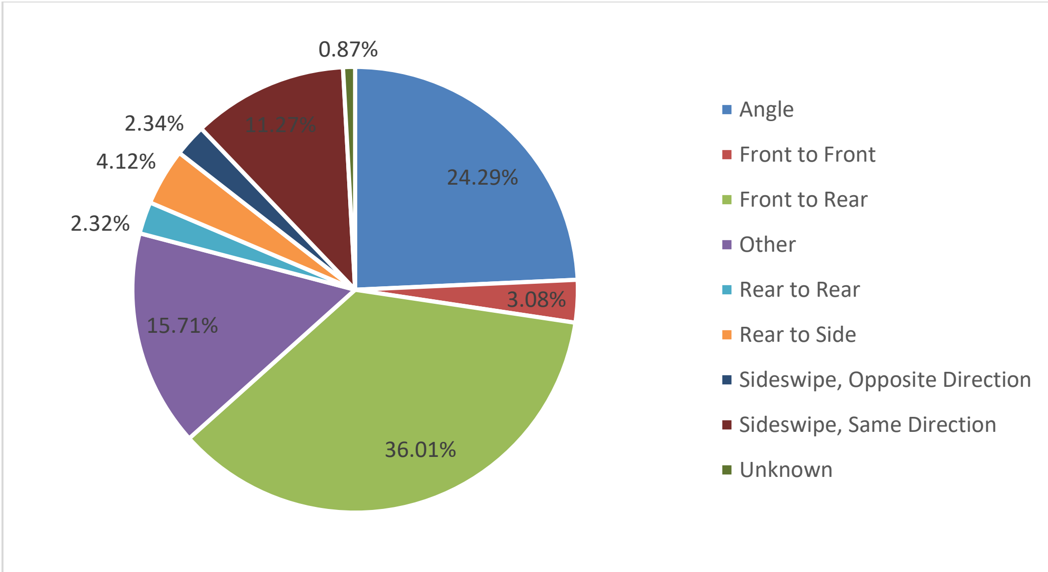

Figure 37: 2018 Police Vehicle Crash Type

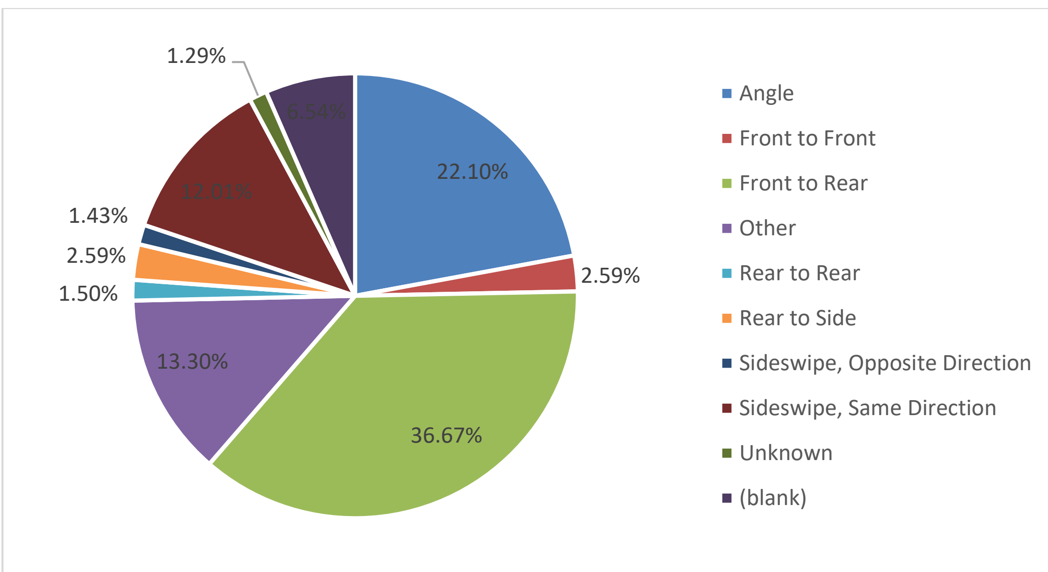

Figure 38: 2018 General Population Vehicle Crash Type

Appendix B

These tables are referenced from another study done in California on law enforcement data (Wolfe, 2016).

Table I

Frequency of officer-involved traffic collisions, injuries, and fatalities during the observation period

Year	Officer-involved collisions *n*	Officer injuries *n*	Officer fatalities *n*	% of collisions that resulted in injury[a]	% of collisions that resulted in fatality[a]
2000	3,622	825	3	22.6	0.1
2001	3,668	829	3	22.2	0.1
2002	3,456	788	3	22.6	0.1
2003	3,508	822	7	23.2	0.2
2004	3,417	779	6	22.6	0.2
2005	3,353	732	5	21.7	0.1
2006	3,376	694	3	20.4	0.1
2007	3,893	756	4	19.1	0.1
2008	3,691	716	3	19.1	0.1
2009	3,856	743	2	19.0	0.1
Total	35,840	7,684	39	21.2	0.1

Note:

[a]Percentages are calculated by dividing the number of collisions that had at least one officer injury/fatality by the total number of officer-involved collisions in each year

Table V

Weather and road conditions during officer-involved traffic collisions during the observation period

	n	%
Weather		
Clear	28,918	80.7
Cloudy	5,161	14.4
Raining	1,202	3.4
Snowing	99	0.3
Fog	202	0.6
Other	59	0.1
Not stated	199	0.6
Road surface conditions		
Dry	31,992	89.3
Wet	2,928	8.2
Snowy or icy	285	0.8
Slippery (muddy, oily, etc.)	285	0.8
Not stated	350	1.0
Lighting		
Daylight	21,163	59.0
Dusk or dawn	1,091	3.0
Dark – street lights	10,368	28.9
Dark – no street lights	2,929	8.2
Dark – street lights not functioning	91	0.3
Not stated	198	0.6