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Firefighter Fatalities and Compliance with the National Fire Protection Association (NFPA) 1451 Standard

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Abstract

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by

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MPA, Westfield State University 2011

MA, Anna Maria College, 2004

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Driving emergency vehicles continue to be significant safety hazard for firefighters. National Fire Protection Association (NFPA) standards are designed to provide a national consensus standard for operation of these vehicles based on industry best practice. Existing research has not identified relationships between firefighter compliance with NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*, and any impacts this may have on firefighter fatalities. Using the systems theory as a foundation, the purpose of this cross-sectional, quantitative study was to investigate firefighter compliance to NFPA 1451 and determine any correlations to firefighter fatalities. Survey data were collected from 88 call and volunteer firefighters in Massachusetts. Participants were selected using a simple systematic random sample from members of the Massachusetts Call/Volunteer Firefighters Association. Results from the data were analyzed using a multiple regression. The results from this study found critical information about individual firefighter compliance to the national standard which can be used to further explore and enhance the safety of firefighters driving emergency vehicles. Recommendations include exploring additional independent variables that may be contributing factors to firefighter compliance to NFPA 1451. These results can used by public administrators for positive social change by helping to increase the safety of firefighters and reduce the exposure and risk of damaging emergency vehicles which create financial constraints on communities.

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Dedication

This work is dedicated to my wife Ashleigh Norris and my two beautiful daughters Payton and Clare Norris. I would not have been able to complete this without their continued support. Thank you for everything over the past few years.

Acknowledgments

This work would not have been completed without the continued support from a number of people. I would first like to again acknowledge the love and support from my wife and daughters throughout this process. Additionally, I'd like to thank my mom and dad for their continued support and guidance throughout everything. Their continued encouragement has helped throughout this entire process.

I would like to thank all the members of my committee. Dr. David Milen provided the constant support needed throughout this journey. Thank you for all of the phone calls and emails I sent to you asking for your thoughts and recommendations as how to best proceed. Thank you Dr. Christina Spoons for ensuring that my statics and methodology were in alignment throughout this entire process. The feedback provided throughout this process was greatly appreciated. Finally, thank you to Dr. Karen Shafer for your technical expertise and advice on the final revisions needed for format and alignment.

Finally, I want to thank all of the firefighters who assisted me and participated in this study. Firefighter safety has always been a priority in my career and I will continue to advocate for the best resources and practices that are deserved by all the personnel working in the fire service profession.

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Chapter 1: Introduction to the Study

Introduction

The fire service is a dynamic job and has numerous operations and tasks that are inherently dangerous that could lead to an injury or a fatality. Regardless of whether personnel are required to respond to a structure fire, emergency medical services call, motor vehicle collision, hazardous materials event, fire alarm activations, or any other emergency, there is always one constant element that is required in each of these responses: driving of emergency vehicles. Emergency vehicle crashes killed 390 firefighters between 1994 and 2012 and continue to be one of the leading causes of firefighter fatalities each year (Jung et al., 2018). These fatalities have occurred in departments of all demographics and composition impacting volunteer, call, and career fire service personnel.

The potential for the cause of this fatal trend is not slowing down. Fire service organizations are responding to more emergencies that could lead to a proliferation of fatalities. Fahy (2018) noted that since the National Fire Protection Association (NFPA) has been tracking firefighter injuries, a significant increase in call volume that the fire service responds to throughout the year has shifted the cause for many of the injuries. Technological improvements, enhanced protective equipment designs, and standards have all contributed to safer operations on the fireground. Similar advances in engineering designs and manufacturing of fire apparatus have also been improved; however, the incidences of crash related injuries and fatalities have remained constant and proportionate each year.

This chapter will highlight background information supporting the need for this study and provide an overview of the purpose and mission of the NFPA and their respective standards. Recent examples of emergency vehicles fatalities are illustrated to demonstrate the continued problem for this topic.

Background

In 1986, the federal government implemented the commercial driver's license program (CDL) as part of the Commercial Vehicle Safety Act (Devine, 2008). The purpose of this legislation was to improve the safety of operators driving vehicles more than 26,001 pounds by imposing more stringent requirements for obtaining a license to operate these types of vehicles. Most fire department emergency vehicles, such as engines, tenders (sometimes known as tanker trucks), and aerial ladders (sometimes known as ladder trucks) exceed this weight limit. Oversight and administration of this act was delegated to each respective state Department of Motor Vehicles or Department of Transportation. Part of this act allowed each state to grant exemptions for certain groups, such as the fire service, enabling the continuation and operating these vehicles without a CDL. Based on some of the financial and administrative concerns, the fire service actively lobbied advocacy for such exemptions (Wilbur, 1996). Since 1986, exemptions have been granted to fire service personnel in most states, with a few requiring additional training and endorsements greater than the traditional driver's license.

The United States Fire Administration has conducted an analysis of fire fighter fatality statistics each year since 1986 that outlines the cause of death. Annual fire firefighter fatality statistics showed a consistent pattern between 1986 and 1990 that,

responding to and returning from alarms were always the second leading cause of fatalities each year (United States Fire Administration, 1987, 1988, 1989, 1990, 1991). This consistent trend in firefighter fatalities led to a more focused examination towards emergency vehicle operations.

To address the trend of firefighter's fatalities involving emergency vehicle collisions, in 1991 the National Transportation Safety Board (NTSB) asked the NFPA to develop a standard focused on training fire service personnel in the operations of emergency vehicles (NFPA, 2018). The NFPA (2018) is a worldwide nonprofit organization that was established in 1896 to help prevent death, injury, property, and economic loss due to fire or other related hazards. The NFPA has produced more than 300 consensus codes related to fire, electrical, and other hazards. The process for development of these consensus codes includes technical committee members from a diverse background fire and emergency medical services, insurance industry, manufacturing representatives, academic institutions, NFPA staff representatives, and professional emergency service organizations applicable to the respective standard. The development and revision process of any NFPA standard is an iterative process that allows for public input and comment and ultimately is accredited by the American National Standards Institute (NFPA, 2018).

The NFPA established a technical committee in 1991 to examine training components for emergency vehicles. This committee, NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*, was tasked to develop consensus standards that would prioritize and enhance emergency vehicle training to

prevent accidents (NFPA, 2018). The first version of this standard was completed and released in 1997 (NFPA, 2018). Since then, approximately every 5 years the document has been revised and updated by the committee.

In a retrospective study conducted by Federal Emergency Management Agency (FEMA, 2002) from the years 1977-2000, it was found that emergency vehicle accidents accounted for 25% of firefighter fatalities each year. Since 2000, emergency vehicle accidents have continued to be a leading cause of firefighter fatalities. These accidents have occurred when firefighters were both responding to emergencies and returning from emergencies. In addition, the fatalities occurred with fire department apparatus and personally owned vehicles in which personnel responded.

NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program* was promulgated in 1997 with the intent to provide fire departments with nationally accepted best practices to enhance the operations of emergency vehicles. Since the inception, no research has been conducted related to firefighter compliance with NFPA 1451 and impacts this may have on emergency vehicle accidents. Unfortunately, during this same time, firefighter fatality statistics and trends show emergency vehicle accidents continue to be fatal. This study addressed this gap to help determine if firefighters are compliant with elements as outlined in NFPA 1451 and if alternative areas need to be examined to help reduce firefighter fatalities that are caused by emergency vehicle accidents.

These types of tragedies and causes of firefighter fatalities continue to occur and plague the fire service. On November 3, 2018, a firefighter fatality occurred in

Mississippi when the individual lost control of his personal vehicle while responding to an emergency (Eppes, 2018). Furthermore, on November 15, 2018, a firefighter from Carroll Township Volunteer Fire Department, Ohio was killed when he lost control of his personal vehicle responding to an emergency (Limpf, 2018). On November 30, 2018, a paramedic and a patient in the back of an ambulance were killed in Tennessee when the vehicle they were in went off the road and stuck a rock wall (Glover, 2018). On December 25, 2018, a firefighter from Hamilton Township, NJ was killed when she lost control of her personal vehicle responding to a call (Brooks, 2018). Each of these examples shows the continued dangers and tragedies across the country associated with emergency vehicle operations and demonstrated the need for this study.

Problem Statement

There are national standards for emergency vehicle operations, education, and training, representing industry best practices that can be implemented and executed by firefighters to reduce firefighter fatalities from vehicle collisions (NFPA, 2018). However, there is a problem in the fire service. Firefighter fatalities resulting from the operation of emergency vehicles continue to be a leading cause each year. A study conducted by Fahy et al. (2017) stated that out of the 69 firefighters that died in the line of duty in 2016, 17 (approximately 25%) died from vehicle crashes. A possible cause of this problem is the lack of adherence to the national standards by firefighters operating these emergency vehicles. Investigations into firefighter fatalities conducted by the National Institute of Occupational Safety and Health (CDC, 2010a, 2018a) have recommended adherence to national standards. This problem has negatively impacted

firefighters, fire departments, their families, and the communities as it continues to be a significant public problem (Poplin et al., 2015). There are many possible factors contributing to this problem, among which are the variable conditions in which these vehicles are operated as well as the lack of education and training personnel receive for fire department emergency vehicle operations (Bui, 2017). None of the literature reviewed examined firefighter compliance with the elements in the NFPA 1451. To address this problem, it is necessary to know more about firefighter adherence to this national standard. This study used a quantitative method to investigate and analyze this relationship to help examine this problem and determine if the different demographic composition of firefighters influences compliance to NFPA 1451.

Purpose of the Study

The purpose of this quantitative study was to illustrate any significance to the degree of adherence by individual firefighters to the national standard and analyze the relationship between firefighters and their compliance with NFPA 1451. The intent of this study was to examine firefighter adherence in three different defined elements of NFPA 1451 and determine if there are any differences in compliance to the national standard. This study provided multiple perspectives and helped determine if the elements examined in this national standard were being implemented and executed by firefighters.

Research conducted had one dependent and four independent variables that were used in a multiple regression to determine relationships. The dependent variable for this study was firefighter compliance to NFPA 1451. This was measured by examining the elements of training and education, apparatus inspections and maintenance, and

administrative policies and procedures as outlined in NFPA 1451 for each individual firefighter. The independent variables in this research were compensations status, age, experience, and gender.

Research Question and Hypothesis

The foundational study research question was as follows:

RQ: What is the association between firefighter compliance to NFPA 1451 and compensation status, age, experience, and gender?

H_0: There is no association between firefighter compliance to NFPA 1451 and compensation status, age, experience, and gender.

H_1: There is an association between firefighter compliance to NFPA 1451 and compensation status, age, experience, and gender.

Theoretical Foundation

There are several significant accident causation theories that have been explored throughout history that have provided some explanatory and predictive values towards the outcomes. Theories help to provide information gained from previous research that can then be applied and help to transcend knowledge in future studies (Weibel & Sabatier, 2018). These theories provide the framework and foundation to help structure the research.

Systems Theory

The fire service is a dynamic profession that has multiple variables that could impact the operation of emergency vehicles. The systems theory approaches accident causation in a comprehensive and global perspective in which there are multiple

relationships among variables and the disruption or alteration of any one component can increase the potential of an accident (DeCamp & Herskovitz, 2015). The systems theory was introduced around the 1940s from Rasmussen and focused on the totality of parts, considering all facets of the relationships within the whole (Leveson, 2017). The conditions in which fire service emergency vehicles are operated epitomize the concept of multiple variables. Examples of factors influencing the operation of emergency vehicles include individual training, environmental conditions, vehicle upkeep and maintenance, weight of the vehicle, and understanding of applicable laws and regulations. A systems theory approach to accident causation allows for a more detailed analysis between the relationships of the variables and the complexities of events leading up to the accident.

The systems theory application in this study was applicable to the research question given the multiple elements and variables that were studied within the national standard. Through the exploration of these individual elements within the national standard, analysis was executed to determine relationships between the firefighters and their compliance with the standard. This contributed to a further understanding of firefighter compliance to NFPA 1451 and their compensation status, age, experience, and gender. Identifying firefighter compliance in these elements and variables may help to prevent and eliminate many unsafe acts, or one of the many systems, that could contribute to firefighter fatalities. Chapter 2 provides a detailed explanation of the systems theory and its qualified application for this study.

Nature of the Study

This research was a quantitative cross-sectional research design that used a simple systematic random sample of firefighters in Massachusetts. This type of methodology was logical for this study because the general purpose of quantitative research methodology is to explain relationships and possible impacts or influences on designated outcomes (O'Sullivan, et al., 2017). This met the purpose of this study and aligned with the structure of the research question. Data was collected and analyzed from 88 firefighters in the four counties in Western Massachusetts. These included Berkshire, Franklin, Hampshire, and Hampden counties. The application of this methodology was conducted using a survey which had the data collected electronically and was further evaluated using the Statistical Package for the Social Sciences (SPSS) software program. The electronically-developed testing instrument was sent to firefighters' emails in western Massachusetts that were publicly available through the Massachusetts Call/Volunteer Firefighters Association. The methodology application through this testing instrument allowed me to obtain information from firefighters throughout a large geographical area in a relatively short period of time. Data was analyzed using a multiple linear regression analysis.

The dependent variable for this study, based on the research question, was firefighter compliance to the NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program.* The independent variables related to specific characteristics for firefighters and provided for detailed examination into how these variables impact the elements pertaining to NFPA 1451. The questions focused on the

three defined elements in the NFPA 1451 standard pertaining to training and education, apparatus inspections and maintenance, and administrative policies and procedures. These elements provided a broad perspective of compliance to NFPA 1451. Complete firefighter compliance signified all defined elements in the NFPA 1451 standard were met regarding emergency vehicle operations.

Definition of Terms

Administrative policies and procedures: Detailed written plans that provide organizational personnel guidance for decision making (International Fire Service Training Association [IFSTA], 2018).

Aerial ladder: Power operated ladder that uses hydraulics to operate and is mounted on a vehicle chassis (IFSTA, 2015).

All volunteer: Fire departments that are comprised of 100% volunteer firefighters (NFPA, 2020).

Apparatus inspections and maintenance: Procedures completed by the apparatus operator or other qualified individual to ensure the vehicle is in a state of readiness and roadworthy for safe operations (IFSTA, 2015).

Career fire department: Fire Department comprised of 100% full time firefighters (NFPA, 2020).

Commercial driver's license (CDL): License issued to individual's demonstrating competency and proficiency in operating and inspecting a vehicle with a gross vehicle weight over 26,001 pounds (IFSTA, 2015).

Due regard: Driving emergency vehicles while considering the safety of others on the roads and highways. Although some state laws and codes provide special privileges and rights to emergency vehicle operators, this does not lessen the responsibility to drive safe (IFSTA, 2015).

Engine brake/compression brake: Any device that uses the engine or transmission to slow the forward momentum of the emergency vehicle (IFSTA, 2015).

Engineering and technology: Apparatus design features such as the weight transfer and center of gravity distribution on the vehicle, braking components, mirrors, and traffic control devices utilized during responses (IFSTA, 2015).

Fire and emergency service vehicles: All fire department vehicles including ambulances and personally owned vehicles (NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*, 2018).

Fire apparatus: Vehicle used to transport personnel and equipment to an emergency scene and mitigate the hazard (NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*, 2018).

Mostly career: Fire department that is comprised of 51-99% career firefighters (NFPA, 2020).

Mostly volunteer: Fire departments that are comprised of 1-50%career firefighters (NFPA, 2020).

Procedure: Outline of the steps that must be performed to properly follow organizational policy (IFSTA, 2015)

Pumper/Tender: Emergency vehicle that is used for both a mobile water shuttle and can also be used primarily as a fire pump to attack the fire (IFSTA, 2015).

Quint: Fire vehicle that provides both engine and aerial functions; has a fire pump, water tank, ground ladders, hose, and aerial device (IFSTA, 2015).

Reaction distance: Distance a vehicle travels after the operator determines the need to stop and transfers their foot from the accelerator to the brake (IFSTA, 2015).

Risk: A measure of the probability and severity of a negative consequence from the effects of a hazard (NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*, 2018).

Situational awareness: Ability to perceive the surrounding environment and predict future events (IFSTA, 2018).

Standard operating procedures (SOPs): Formalized process or rule that guides the actions of personnel in an organization (IFSTA, 2015).

Tenders: A mobile piece of apparatus that is used to support or augment another operation such as supplying water to an engine (IFSTA, 2015).

Training and education: Academic knowledge and technical skills that demonstrate cognitive and psychomotor behaviors (Marinucci, 2015).

Assumptions

An assumption I made for this research was that all feedback on surveys were genuine and accurate and that reflected the practices for the individual firefighters. The survey was completely voluntary and no one was required or mandated to complete it.

The survey was sent to each individual firefighter. It was assumed that the individual had the knowledge to accurately answer all questions relevant to their specific organization.

Fire departments have a diverse mix relative to their organizational composition. In the U.S. Fire Department Profile 2018, the NFPA (2020 classified firefighters in these organizations as either career, mostly career, mostly volunteer, and all volunteer. The largest of these classifications are all volunteer firefighters and mostly volunteer firefighters (NFPA, 2020). Using a sample from departments with this type of composition assumed that it will be reflective of all departments of this same organizational demographic.

Firefighters work in an environment that is dynamic, constantly changing, and abound with interruptions. It was assumed that any interruption during the participation of this research did not negatively impact the results or alter the survey.

Scope, Delimitations, and Limitations

Scope

I examined paid on-call firefighters and volunteer firefighters who are members of fire departments which are mostly volunteer or all-volunteer in western Massachusetts. These are the two largest groups of firefighters in the country based on NFPA (2020) statistics. Finally, this sample was used to have a more manageable size for conducting the research.

The scope of fire department emergency vehicle fatality cases included all investigations conducted as part of the NIOSH since the first year NFPA 1451 was

promulgated in 1997. Each case that was pertinent to this study is identified in the literature review.

Delimitations

The NFPA stated that there are 29,705 total fire departments and 1,115,000 firefighters in the United States, of which 18%are all career or mostly career and 82% are mostly volunteer or all volunteer (NFPA, 2020). This study focused on mostly volunteer or all volunteer firefighters in western Massachusetts. I investigated this specific sample designation because 1,115,000 firefighters are too large for this study. The two categories that were investigated as part of this study were the largest two categories of firefighters in the United States. This sample was manageable and reasonable for this research. Future studies may examine other categories along with different populations.

Limitations

The amount of time and effort taken to answer the survey questions honestly and accurately were based upon each individual. The survey was purposely designed with a focus that identified key elements within the national standard and had limited, but specific questions for the research. There was no time limit once the participants opened the survey and began to answer the questions. This should have helped to overcome this identified limitation.

I designed this research study to examine emergency response personnel from fire departments in Massachusetts. This may have created a bias for the study outcome, given the sample size. However, given the limited access to individual firefighter's personal email around the county, and the overall total number of firefighters in the country, it was

not realistic and practical to do a larger sample size. The results from this study were evaluated collectively and interpreted to represent the fire service as a whole; however, to overcome this bias, a larger study may need to be done in the future looking at a larger sample size.

Significance of the Study

Fire department emergency vehicle accidents are a leading cause of firefighter fatalities each year (FEMA, 2017). Every emergency response requires personnel driving fire department vehicles to the scene of the emergency. This practical application of driving these vehicles on every single response significantly increases the potential and exposure of firefighters becoming involved in motor vehicle accidents. This research identified the degree of adherence to which firefighters are compliant with the defined elements in NFPA 1451. This helped to identify if firefighters are following industry best practices.

Numerous firefighter fatality investigation reports have identified and referenced the NFPA standards in their findings. These standards have been referenced as industry best practices and procedures that should be followed. However, no study was found that examined firefighter compliance with these national standards. Although national standards have been referenced in previous literature, this study identified the degree to which firefighters are compliant with this specific national standard. Information obtained through this research examined this gap in the literature and provided insight to the relationship between firefighters and this national standard which is considered the industry best practice in this profession.

Research into this topic may help to affect positive social change by increasing the safety of fire department first responders. Fire department driver safety affects not only the drivers of the vehicles, but all occupants in the vehicles and any public who are part of or witness to a collision. In addition, fire department emergency vehicles are a significant financial investment to any community (ICMA, 2012). The involvement of these resources in an accident could create a serious fiscal deficit that could impact other local community services and investments. Fire department emergency vehicle accidents can also create a burden for neighboring communities as greater reliance are then needed from them for mutual aid while the vehicle involved in the accident is being repaired or replaced (ICMA, 2012). This could lead to increased response times from the neighboring community. Prolonged response times then compound the potential of increased risk to those awaiting the arrival of the mutual aid fire engine from the neighboring community (ICMA, 2012).

Summary

Emergency vehicle accidents continue to be a leading cause of firefighter fatalities annually in the United States (FEMA, 2017). It has been documented in firefighter fatality investigative reports and findings that driver training and education have been factors in some of these outcomes. Furthermore, firefighter fatality reports have referenced the need to follow the criteria outlined in the national standards however this has never been measured. The purpose of this quantitative study was to illustrate any significance to the degree of adherence by individual firefighters to the national standard and analyze the relationship between firefighters and their compliance with NFPA 1451.

Although national standards exist for fire departments that outline specific criteria for their personnel on emergency vehicle training and operations, it was unknown to what extent, if any, that these are implemented. Chapter 2 will present a comprehensive review of the literature pertaining to emergency vehicle training and operations and the current national standards that help to frame the relevance of this problem.

Chapter 2: Literature Review

Introduction

There are national standards for emergency vehicle operations, education, and training, representing industry best practices that can be implemented and executed by firefighters to reduce firefighter fatalities from vehicle collisions (NFPA, 2018). However, there is a problem in the fire service. Firefighter fatalities resulting from the operation of emergency vehicles continue to be a leading cause each year. The purpose of this quantitative study was to illustrate any significance to the degree of adherence by individual firefighters to the national standard and analyze the relationship between firefighters and their compliance with NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*.

Fire department emergency vehicle collisions kill and injure firefighters every year (Bui, et al., 2017). A firefighter was killed in a fire apparatus on September 20, 2019, when the vehicle he was in crashed while responding to motor vehicle accident (Kalsi, 2019). On October 18, 2019, a firefighter from Equality, AL was ejected and killed while driving a fire department water tender responding to a brush fire when the vehicle overturned (Day, 2019). It was reported that in 2018, Jacksonville, FL Fire & Rescue had 53 fire department emergency vehicle accidents alone within their agency (Micolucci, 2019). These examples have been a constant theme and trend in the United States fire service and have not shown any significance in decline over the years.

The occupation of firefighting is inherently a dangerous profession with several risks and hazards. Operation of emergency vehicles is one of the greatest hazards

associated with this profession (FEMA, 2002). Emergency vehicle accidents continue to be one of the leading causes of firefighter fatalities each year (FEMA, 2014). Although some years have fewer fatalities than others that are contributed to emergency vehicle operations, this activity continues to be a constant and theme over the years. A report conducted by NFPA found that out of 69 firefighters that died in the line of duty in 2016, there were 17 that died from vehicle crashes (Fahy et al., 2017). These statistics and data reinforce and solidify the dangers associated with operating these fire department emergency vehicles.

This section includes a review of the literature on fire department emergency vehicle accidents, injuries, and fatalities that occurred from these events and preventative measures and mitigation strategies implemented to eliminate these from occurring. Literature reviewed included previous firefighter fatality reports and recommendations from subject matter experts as well as national consensus standards related to fire department emergency vehicle operations to examine occupational best practice models.

Literature Search Strategy

The initial review of literature was conducted through Thoreau Multi-Database Search tool at Walden University. Keywords used in the literature search included *emergency vehicle accidents, emergency vehicle accident causation, fire apparatus, crash prevention, emergency vehicle crashes, firefighter fatalities, public safety accidents, safety culture, firefighter injuries, and emergency vehicle accident causes* and *investigations*. To broaden the search, truncation operator was used to increase the search in the research topics. Examples include *fire fighter** to equal *fire fighters, emergenc** to

equal *emergencies, emergency* and *fatalit** to equal *fatality* or *fatalities*. To narrow down the search, peer-reviewed journals were the only documents reviewed for the literature review. Boolean operators were also used to narrow down the scope of the search to help refine the literature review.

The literature search strategy initially focused on the years 2013-2020 to ensure there was still an ongoing and continual problem in this topic. This same timeline also helped to establish the need for this study and demonstrated a gap in literature pertaining to this focused topic. To provide background for this study, research on fire fighter fatalities relative to emergency vehicle accidents and the causes were examined beginning in 1997.

Additional databases that were used as part of the literature review and sources of information that used key words as mentioned above included the following:

- Dissertations & Theses @ Walden University
- Goggle Scholar
- ProQuest Science Journals
- EBSCB Databases
- Homeland Security Digital Library
- Public Policy & Administration articles, journals, & books in the Walden University Library

Given the specificity of this research focusing on firefighter fatalities and fire service national standards, additional databases used as part of the literature review included the NFPA standards documents that are all available online in electronic format,

NIOSH line of duty death completed reports available online in electronic format, and information and statistics from the United States Fire Administration (USFA) and the FEMA through the United States Department of Homeland Security websites. These manuals and technical reports published by government agencies provided critical background for understanding this problem. Finally, fire service trade journals and publications were reviewed to examine content related to fire department emergency vehicle accidents.

Theoretical Framework

There are several significant accident causation theories that have been explored throughout history that have provided some explanatory and predictive values towards the outcomes. Theories help to provide information gained from previous research that can then be applied and help to transcend knowledge in future studies (Weibel & Sabatier, 2018). These theories provide the framework and foundation to help structure the research.

Systems Theory

The systems theory applied in accident causation examines the relationships between the different components or variables in a comprehensive manner. The systems theory was introduced around the 1940s from Rasmussen and focused on the totality of parts, considering all facets of the relationships within the whole (Leveson, 2017). A systems theory approach provides the ability to understand relationships between the functional parts of the system.

Some accident causation models examine singular incidents or events as contributing factors. Approaches include looking at just human mistakes or equipment. Others may examine causes from just the environment. The systems theory approaches the accident causation as a synergistic and harmonic relationship between all variables (DeCamp & Herskovitz, 2015). This understanding leads to the interpretation that once the relationship between the variables is disrupted, the potential for an accident increases substantially.

The elements within NFPA 1451 provided several variables that could impact optimum performance of an emergency vehicle. Operators of these vehicles could meet these provisions within the standard, partially meet them, or not meet them at all. Each scenario provided a potentially different outcome for safe operation of the vehicle. Salmon et al. (2014) found that systems cannot be understood by examining the variables in isolation, but rather all the interactions of the variable as a whole. A systematic and comprehensive examination of the NFPA standard in relation to the operation of emergency vehicles can provide this holistic approach to a more detailed understanding of performance.

The systems theory provided the understanding of the structure, components, and dynamics of emergency vehicle operations based on the national standard. This theory outlined how to interpret challenges and obstacles and develop a set of balanced strategies and interventions needed to minimize accidents from occurring. Dallat et al. (2017) noted that it is now widely accepted to understand that accidents are a systems phenomenon. Numerous components constitute the safe operation of emergency vehicles.

Understanding the integration of these and how to minimize them from occurring help to enhance safe vehicle operations.

Previous studies have found that accidents do not happen in a vacuum. Dekker (2015) found that most accidents occur because of a discord or broke relationship between components and not in isolation from a single piece. This concept was noted in both the Challenger Space Shuttle Disaster (Leveson, 2004) and the Three Mile Island explosion (Reason, 1990). Each of these tragic events found systemic failures and not one segregated variable that was the sole contributor to the accident.

Accident causation has been a significant focus for other professions based on financial losses and the number of injuries and fatalities that occurred each year. Like the fire service profession, mining workers are subjected to extremely hazardous working conditions that contribute to a high rate of injuries and fatalities (Margolis, 2010). Investigation into the cause of these injuries and fatalities has used a systems theory approach looking at human error and organizational components to provide greater insight into the cause of these incidents (Lenne et al., 2012). The fire service and mining industry have similar hazards associated to human, environmental, physical equipment and resources, and environmental factors that could contribute to accidents occurring in these respective professions.

In a study conducted by Bagschik et al. (2017), the systems theory contributed to the application of unmanned protective vehicles that were being used on German highways and how applying the international safety standard, ISO 26262, helped to ensure functional safety. This study examined best practice standards for operation of

automated vehicles and found many elements, such as human and machine interaction, influence the safe operations of these vehicles (Bagschik et al., 2017). This study applied the systems theory in a similar manner and examined the interactions with the defined elements with the NFPA standard.

The safe operation of fire apparatus incorporates multiple factors and elements during the operation. The operation of an emergency vehicle can be characterized by the interaction of numerous variables occurring at the same time (IFSTA, 2015). This includes operation of the vehicle under pressure and time constraints to get to the incident quickly, the emotional and mental stress of the vehicle operator, and the environmental elements or road conditions in which the vehicle is being operated (IFSTA, 2015). Although most of these interactions are controlled through the development and implementation of regulations, standards, laws, and policies, many of these are not effective because of various individual, societal, or organizational limitations or factors (Hsiao et al., 2018). The systems approach to accident causation considers all these factors and any disruption between the harmonies of each of the variables contributing to the safe operation of the vehicle. Any disruption to the interaction of these components and the potential for an accident to occur is heightened.

Firefighters integrate several different components into a system during the operation of an emergency vehicle. These components include their training and education, knowledge and understanding of policies and procedures, and the proper maintenance and inspection of the vehicle, age, and experience (IFSTA, 2015). This integration and harmony of components can be viewed and supported through the

implementation of the systems theory. This study incorporated the systems theory and explored the interrelationships of the defined elements within NFPA 1451 as a whole and how they relate to accident causation. I examined if firefighters were compliant with all the defined elements explored, as an entire system, or only in compliance with specific elements and thus not the entire standard in its totality.

Literature Review Related to Key Variables and Concepts

The method for selecting emergency vehicle operators along with required qualifications varies among fire departments. Some departments require written tests, performance evaluations, or a minimum time in service (ICMA, 2012). Other departments have no requirements or qualifications (ICMA, 2012). Although requirements for emergency vehicle operations may vary from department to department, one constant is every emergency response will require the operation of an emergency vehicle. According to Siarnicki (2018), vehicle crashes are one of two nationally recognized leading causes of firefighter fatalities but are certainly within the realm to control. The task of operating these vehicles becomes magnified when any life safety concerns are inherent with the response.

National Fire Protection Association (NFPA) Consensus Standards

The NFPA is a worldwide nonprofit organization that was established in 1896 to help prevent death, injury, property, and economic loss due to fire or other related hazards both domestically and internationally (NFPA, 2018). The NFPA has produced more than 300 consensus codes related to fire, electrical, and other hazards. The process for development of these consensus codes includes technical committee members from a

diverse background fire and emergency medical services, insurance industry, manufacturing representatives, academic institutions, NFPA staff representatives, and professional emergency service organizations applicable to the respective standard.

The development and revision process of any NFPA standard is an iterative process that allows for public input and comment and ultimately is accredited by the American National Standards Institute (NFPA, 2018). Municipal adoption of these consensus standards is not mandatory and not required by law. These consensus standards represent the industry best practices and serve as models that were developed using subject matter experts in differing respective occupational fields.

Development of NFPA 1451

The first publication of NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program* was in 1997 (NFPA, 2018). Although there were other NFPA standards that were already published and marginally addressed emergency vehicle operations, the NTSB emphatically requested the development of a standard that would focus on the safe arrival of emergency apparatus to the scene (NFPA, 2018). The purpose of this new standard would be to provide the framework necessary for outlining the training and education needed to prevent emergency vehicle collisions.

Elements of NFPA 1451

There are several different elements in NFPA 1451 that help to provide the industry expected best practices pertaining to fire and emergency service vehicle operations training programs. These elements are key variables that provide a foundation and structure for operations of fire department emergency vehicles. Some of the key

elements outlined in the standard include training and the scope of training, academic and practical requirements, instructor qualifications, apparatus inspection and maintenance, administrative policies and procedures, engineering and technology, and environmental elements (NFPA, 2018). Each of these elements provides a comprehensive overview for the safe operation of emergency vehicles.

Training and Education

Training and education are critical components of any occupation and particularly those that have a high potential for injury or death. Unfortunately, there have been numerous fire fighter fatality investigations that have found lack of training and education as a contributing factor. On October 17, 2013, a fire fighter was killed when the fire department tanker truck he was driving went off the roadway and overturned (CDC, 2014a). As part of the investigation, it was found that the department had no driver training program, and this individual had no prior emergency vehicle training and was only on the department for approximately 90 days (CDC, 2014a). Training on emergency vehicles is more critical given the vast differences from the day-to-day passenger vehicles that personnel typically drive. Stopping distances, reaction times, weight transfer, and blind spots are just a few examples operators must consider when driving these larger emergency vehicles.

The importance of training and education on emergency vehicles is evident given the multiple sections outlined in other NFPA standards regarding training for emergency vehicle operations. NFPA 1500, *Standard on Fire Department Occupational Safety, Health, and Wellness Program* (2018) highlighted that emergency vehicle operations

should only be conducted by personnel who have completed a training program that complies with NFPA 1451. Specifically, NFPA 1500, *Standard on Fire Department Occupational Safety, Health, and Wellness Program,* references the importance of training personnel on all types of apparatus that they may be required to operate (NFPA, 2018). In many fire departments, this can lead to numerous challenges given the vast number of resources and vehicles needed to perform their tactical operations.

Personnel on fire departments may be required to operate ambulances, engines, ladder trucks, brush trucks, support vehicles, rescue trucks, and water tenders (ICMA, 2012). Each of these vehicles have their own inherent characteristics that make the operation of each different. On August 6, 2005, a firefighter was responding to a flooded basement without lights and sirens activated on the vehicle, and lost control of the vehicle (CDC, 2007c). The firefighter was ejected and killed in this emergency vehicle accident. The investigation completed by the NIOSH found that fire departments should require all drivers to become familiar with all the different models of fire apparatus that they may be expected to operate (CDC, 2007c). One of the biggest differences among these vehicles is the weight associated with each of them. Many ladder trucks weigh upwards of 40 tons and many ambulances weigh approximately 14,000-18,000 pounds (IFSTA, 2015). Comparative to the typical day to day operation of a passenger car or truck, this is a substantial difference in weight and thus the handling and operation between all of these.

Another interrelated standard that references fire fighter driver training is NFPA 1002, *Fire Apparatus Driver/Operator Professional Qualifications*. This standard establishes the minimum criteria for personnel who drive and operate fire apparatus to

ensure they are qualified and competent (NFPA, 2016). This standard emphasizes the pivotal focus on training personnel to safety operate fire department emergency vehicles. In particular, it focuses on identifying the requisite knowledge and training in all aspects of emergency vehicle operations for the understanding vehicle control of the water surge carried on the vehicle during operations, braking and reaction times, load factors from carrying equipment and resources on the vehicle, effects from high center of gravity some of these vehicle may pose during operations, and understanding of the state and local laws as well as any departmental rules and regulations for emergency vehicle operations (NFPA, 2016). Many of these components as outlined in NFPA 1002 have been previously recognized in NIOSH fire fighter fatality reports.

Many NIOSH fire fighter fatality investigations have referenced the importance of following the NFPA 1002 standard. A specific investigation conducted by NIOSH from an emergency vehicle accident on April 7, 2002, found the vehicle that crashed and killed a fire fighter was recently delivered a month prior and the operator had limited experience driving this vehicle (CDC, 2002d). It was found the vehicle was not being operated with the posted speed limits, had a high center of gravity, and had a gross vehicle weight rating of 35,000 pounds (CDC, 2002d). Each of these findings along with the recommendations based on this report, reference NFPA 1002.

Many of the vehicles operated in the fire service are larger vehicles that weight more than 26,001 pounds. The size and weight of these vehicles create additional driving hazards based on these features. Navigation on dirt roads, narrow roads, or highways with limited shoulders creates challenging obstacles. In addition, the weight of these vehicles

requires greater stopping distances, increased driver reaction times, and greater situational awareness of the environment and terrain.

History in the fire service has demonstrated that training exercises can be fatal. In 2016, 10 firefighters died while conducting training operations, 14 percent of the total line of duty deaths for that year (Willette, 2017). To alleviate any safety concerns for practical training applications, some organizations have examined the use of emergency vehicle simulators to augment their driver training programs.

Training simulators provide fire service leaders the ability to replicate hazards that could be encountered in a controlled environment. The configurations and possibilities for training design are immense and allow for a variety of situations (Urban & Gudzbeler, 2014). These simulators allow fire service leaders to train their personnel in high-speed scenarios, dangerous road and weather conditions, sudden stops, and other hazards that reflect the true environment that could be encountered by vehicle operators without jeopardizing the safety and well-being of their personnel. Many fire service training institutions are acquiring simulators to provide such training in these controlled environments that otherwise could not be replicated in other practical training applications.

Academic and Practical Training

The complexities of operating an emergency vehicle require the ongoing and systematic review of vehicle operations and performance on a regular basis. This requires both practical and academic applications. On November 11, 2012, a fire fighter was killed when the fire tanker vehicle he was driving crashed enroute to a grass fire (CDC,

2014b). Investigation into this emergency vehicle accident found that the training received by this firefighter did not include any classroom components (CDC, 2014b). Although the fire fighter had received some practical training applications and skills, there was no comprehensive academic portion to help strengthen these skills and knowledge.

Training on emergency vehicles cannot be linear and limited in scope. NFPA 1451 has both academic and practical applications requiring emergency vehicle operators to review information about the vehicles they are driving, review previous vehicle crash reports, understand performance capabilities of the vehicle, and have knowledge about federal, state, and local laws relative to emergency vehicle operations (NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*, 2018). These academic components help to traverse the operator's skill set to the practical components.

The training components for practical applications for emergency vehicle operators include a comprehensive program to provide hands-on experience. Operators are expected to complete exercises consisting of operating the vehicle through diminishing clearances, backing up the apparatus in a confined space, guiding the vehicle through a narrow alley, and maneuvering the vehicle around and through different objects (NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*, 2018). Each of these components are designed to represent similar situations and obstacles that could be encountered during operations of the emergency vehicle.

A comprehensive training program consisting of both academic and practical components can help to provide a solid foundation to the operations of these vehicles. As noted by Zygowicz (2017), a global vehicle training program has both practical and academic elements that provide a thorough review for the operator. The classroom components provide the academic rigor to review department policies, procedures, and standard operations procedures. Practical applications enable personnel to perform tactical exercises to enhance their abilities.

NFPA 1500 further supports the critical nature of academic comprehension for emergency vehicle operations. Section 6.2.2.1 underscores the importance of all fire department emergency vehicles being operated in compliance with all applicable traffic laws, which includes any specific or special provisions that pertain to emergency vehicles as established by the authority having jurisdiction, in addition to any rules, regulations, and procedures that may have been adopted by the fire department (NFPA, 2018). These laws, rules, regulations all require the academic rigors to inform and educate in a cognitive manner to help support the operations of any emergency vehicle.

An emergency crash that occurred on January 19, 2003, further accentuated the importance of academic training for emergency vehicle operations. As part of the recommendations from NIOSH for this accident that killed one fire fighter, it was stated that all fire department personnel who are expected to driver emergency vehicles should be trained in both academic and practical components and written examinations should be part of this process (CDC, 2003b). NFPA 1002 further supports this concept in section 4.3.1 stating that the driving and operation of fire apparatus shall be operated in

compliance with all applicable state and local laws and departmental rules and regulations (NFPA, 2016). The importance of having this requisite knowledge and understanding of the academic criteria for the operations of fire apparatus for all operators is just as important as personnel instructing these topics having the comprehension.

Instructor Qualifications

The fire service is a dynamic profession that is constantly evolving requiring that individual's upkeep their skills, knowledge, and abilities in the profession. Although much of this can be done on an individual level, many topics need the guidance of a certified and trained instructor for teaching the information. Fire service personnel often face life threatening situations and must react to those situations quickly and safely. The safety of other fire service personnel and the public depends on the quality of training and instruction received by each emergency vehicle operator.

Fire and emergency service organizations rely on training delivered professionally and competently to safely, efficiently, and effectively mitigate any emergency that they respond. Increased public expectations and scrutiny of operations demand greater accountability that requires extensive and continual training for responses to all-hazards emergencies. It is no longer acceptable for emergency services to use personnel to train fire fighters that are not certified and qualified to teach in each subject (Thiel & Jennings, 2012). Failure to properly train fire fighters for performance of their roles, responsibilities and associated hazards of the occupation could be a prescription for legal ramifications,

injuries, or fatalities. Utilizing a competent and qualified Instructor can help minimize the potential for any of these factors from occurring.

On February 11, 2000, a fire fighter was killed in an emergency vehicle accident when the fire engine he was driving on the way to a motor vehicle incident crashed into a tree (CDC, 2001b). It was found during the investigation that the department required all new drivers to demonstrate their driving skills to an officer of the department (CDC, 2001b). This could be any officer in the department regardless of their qualifications or certifications. It was noted in the recommendations of this investigation that personnel need to be trained by a certified driver trainer (CDC, 2001b). This concept meets the requirements as outlined in NFPA 1451 which states that at a minimum, all fire department instructors shall meet the qualifications for Instructor I as specified in NFPA 1041 (NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*, 2018). As noted with other NFPA standards, this represents qualifications for the recognized industry best practice and provides a consistent framework for all instructors.

An instructor's responsibility is to prepare personnel to provide services professionally and safely to meet the needs of the public. Fire service instructors understand that individuals can no longer rely on experience alone. It is the responsibility of a qualified instructor to remain competent and current on all the new information and technology to the constantly changing work environment in the fire service. Training programs are not immune from national standards, and it is the responsibility of the instructor to ensure personnel are getting taught to these standards (Reeder & Joos,

2014). Instructor qualifications help to reduce organizational and personal liability through a well-planned and properly developed program that follows accepted standards and industry best practices. In addition, a properly qualified instructor can ensure that the most accurate and current information is delivered to the audience and help meet any training requirements that can be found in federal, state, and local mandates.

NFPA 1041, *Standard for Fire and Emergency Services Instructor Professional Qualifications*, provides the framework and outlines the requisite knowledge expected in a fire service instructor for emergency vehicle operations. Basic concepts outlined in NFPA 1041 include instructors having the knowledge, skills, and abilities to understand the components of a lessons plan and the ability to deliver that information to the student, understand instructional aids and teaching props to facilitate the delivery of the lesson, and prepare and adjust lesson plans as needed to accomplish the objectives and learning outcomes along with any other safety standards and procedures as necessary for the lesson and material taught (NFPA, 2019).

Fire service instructors have a variety of roles and responsibilities and need to fully understand their audience when presenting information. Many times, instructors are required to adjust their presentations to adapt them to individual's different learning styles, abilities, and behaviors (Reeder & Joos, 2014). Instructors need to have professional credentials and qualities to teach the knowledge, skills, and abilities needed to safely operate emergency vehicles. Emergency vehicles have significant differences then a typical automobile. Instructors need to have a strong understanding and background about these differences when teaching emergency vehicles operations.

Apparatus Inspections and Maintenance

Emergency apparatus must always be in a state of readiness to respond under sometimes the most severe conditions. Apparatus inspections and maintenance are critical elements to ensure the vehicle remains in the highest state of readiness and will function safely and efficiently for any emergency response. The proper operation and performance of these vehicles literally determines life or death outcomes for emergency responses.

Many departments use fire fighters to complete routine maintenance and upkeep of emergency vehicles. Most of these fire fighters are not certified as EVT's. Certifications demonstrate an individual has met a recognized competency in the field of study. Emergency services have certifications for fire fighters, emergency medical services personnel, training officers, fire prevention officers, and emergency vehicle technicians. NFPA 1071, *Standard for Emergency Vehicle Technician Professional Qualifications* (2020), establishes minimum job performance requirements for an individual qualified as an emergency vehicle technician who is responsible for the inspection, diagnosis, repair, testing, and maintenance of emergency vehicles. Specifically, skills such as operational checks, performance checks, and supervision and managerial skills for recording keeping on vehicles should all be completed by personnel with EVT certifications (NFPA, 2020). The intent of this standard is to ensure that personnel working on fire apparatus are qualified to perform the duties and responsibilities of these tasks.

On January 9, 2009, a Lieutenant was killed because of a ladder truck losing its brakes and crashing into a building (CDC, 2010a). Although a recommendation resulting from this incident stated all maintenance performed should be done by a qualified emergency vehicle technician (EVT), it also emphasized the importance of inspection procedures and sheets for operators to document any repairs or work needed to the EVT (CDC, 2010a). Many basic preventative maintenance tasks can be performed by the vehicle operator while others can be documented and forwarded to the appropriate individual.

To provide for an operational state of readiness, operators of emergency vehicles have several apparatus inspection and maintenance functions that can be completed. Basic procedures include checking mirrors to ensure they are all functioning and adjusted, ensuring all wheels are properly inflated, all doors and cabinets are secured, and equipment and external caps to discharge outlets are secured. NFPA 1451 further identifies the need for operators to take vehicles out of service if anything is found to be unsafe and to have the vehicle inspected prior to being placed back into service (NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*, 2018). Many of these are routine tests and inspections in which operators can be trained to perform prior to the operation of any vehicle.

Apparatus inspections provide a functional check for the operator to help determine if the vehicle is ready for operation. During these inspections, operators should be looking for any leaking transmission fluid, radiator fluid, oil, water, or other unknown substances that may lead to further complications (IFSTA, 2015). The use of a

department checklist can help provide consistency and standardization to this process and ensure no elements missed during this important process.

Additional national fire service standards reference requirements for emergency vehicle inspections and maintain. NFPA 1500 specifies in section 6.4.1 that all fire apparatus be inspected and maintained in accordance with NFPA 1911 (NFPA, 2018). Further research into this requirement found that NFPA 1911 states that the authority having jurisdiction shall determine who is qualified to perform any daily or weekly visual checks and operational checks of emergency vehicles as required in NFPA 1002 (NFPA, 2016). This creates an administrative challenge to fire service organizations requiring criteria and documentation for personnel able to perform such duties and responsibilities.

Further investigation into the requirements as outlined in the NFPA 1002 standard found that more specific criteria for conducting inspections and maintenance on emergency vehicles was outlined. Specifically, fire department vehicles should have the batteries, braking system, coolant system, electrical system, fuel, hydraulic fluids, oils, tires, steering, system, belts, tools, appliances, equipment, and any built-in safety features inspected to ensure the operational readiness of each vehicle (NFPA, 2016). These inspections provide personnel to ability to recognize any deficiencies in these specified areas. Furthermore, these inspections provide a means to verify the safety and operational capacity of each of the components on the vehicle.

Administrative Policies and Procedures

Organizational policies, procedures, and guidelines all provide framework necessary to establish safe operational practices for personnel. On July 2, 2000, a fire

fighter was killed in his personally owed vehicle when it collided with another vehicle enroute to an emergency (CDC, 2001d). The Department had no standard operating procedures for operating personally owned vehicles which enabled individuals to determine for themselves the best actions for operation.

Driving regulations are guided by federal and state laws, city, or department policies, and NFPA standards. The Department of Transportation (DOT) is responsible for establishing the criteria for licensing a driver in the United States (IFSTA, 2015). The weight of emergency vehicles would require the public to obtainment a commercial driver's license (CDL). In 1986, the federal government implemented the commercial driver's license program as part of the Commercial Vehicle Safety Act (Devine, 2008). The purpose of this legislation was to improve the safety of operators driving vehicles more than 26,001 pounds by imposing more stringent requirements for obtaining a license to operate these types of vehicles. Oversight and administration of this Act was delegated to each respective state Department of Motor Vehicles or Department of Transportation. Part of this Act allowed each state to grant exemptions for certain groups, such as the fire service, enabling the continuation and operating these vehicles without a CDL. Based on some of the financial and administrative concerns, the fire service actively lobbied advocacy for such exemptions (Wilbur, 1996). Since 1986, exemptions have been granted to fire service personnel in most states, with a few requiring additional training and endorsements greater than the traditional driver's license.

The practice of exempting fire fighters from obtaining a CDL for the operation of emergency vehicles with the gross weight exceeding 26,001 pounds continues to be

questioned. A fire fighter fatality occurred on March 28, 2008, when the operator of a Tanker Tender, responding to structure fire, lost control of the vehicle and was killed in the accident (CDC, 2008). The results of an investigation, completed by the National Institute of Occupational Safety and Health, found that the operator only had approximately ten hours of driver training and recommendations noted fire departments should consider the value of personnel obtaining their CDL's (CDC, 2008). The vehicle involved in this crash had a gross vehicle weight of 50,000 pounds, and excluding the operation by a fire fighter, would have had to have had an operator with a CDL in any other profession.

There are other exemptions afforded to operators of emergency vehicles that are allowed in some state laws. For example, Massachusetts General Law, Chapter 90, Section 13A states passengers and operators of any private motor vehicle weighing less than 18,000 pounds shall wear a seat belt, however emergency vehicles are exempt (2019). Federal Motor Carrier Standards further outline this same exemption for firefighters operating emergency vehicles (Donoughe, Whitestone, Gabler, 2012). NFPA has found that a contributing factor towards firefighter injuries and fatalities over the past few years has been the non-existent use of seatbelts (Fahy, LeBlanc, & Molis, 2018). Most departments have varying administrative operating procedures pertaining to the use of seatbelts. Additionally, oversight and enforcement of these administrative procedures is typically the responsibility of numerous individuals with differing tolerances and understandings. These organizational policies and practices can be critical to the safety of

emergency responders and can impact outcomes just as engineering and technological enhancements have on vehicle operations.

Although exemptions may be provided to fire service personnel for the operation of emergency vehicles, NFPA 1451 still references and acknowledges the importance for drivers to be familiar with the content in the Commercial Motor Vehicle Safety Act (NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*, 2018). This recognizes the importance for emergency vehicle operators to know and understand the content pertaining to these commercial size vehicles. Found in section 4.3 of NFPA 1451 is documentation that fire service emergency service organizations shall establish and enforce rules, regulations, and standard operating procedures to meet the intent and objectives of the national recognized standard (NFPA, 2018). Examples of administrative policies and procedures for operation of emergency vehicles are procedures for safely driving, riding within, and operating all the different fire service emergency vehicles. Such policies and procedures should identify and address proper procedures for both emergency response and non-emergency response.

NFPA 1500, Standards on Fire Department Occupational Safety, Health, and Wellness Program further expounds on the importance of administrative and policies and procedures by addressing this topic in numerous sections. Although most emergency vehicle accidents have occurred when the apparatus was moving forward, there have been incidents where fatalities have occurred when the vehicle was moving backwards. From 1984 to 2004, fire fighter fatality reports have found that there were ten instances that killed fire fighters when the vehicles were moving backwards (NFPA, 2018). This is

another area that is a significant issue in the fire service and must be addressed in regard to standard operating procedures and administrative policies.

NFPA 1002 standard has incorporated many administrative policies and procedures into the document for reference by fire service personnel. In addition to acknowledging the importance for operators of emergency vehicles to having the requisite knowledge and understanding of the fire service organizations standard operating guidelines, policies, and procedures, it also highlights the critical nature of understanding the manufacturer's specifications and recommendations (NFPA, 2016). These specifications provide specific information and many times detailed instructions on the proper operations and procedures for the safe operation of the vehicles.

Engineering and Technology

On July 26, 2010, two fire fighters were killed when responding to an emergency in a fire engine (CDC, 2011). The investigation into these fatalities found the fire engine had gone through a red light at an intersection when it was responding to a structure fire in a neighboring community and was struck by another vehicle (CDC, 2011). Recommendations based on this incident suggested the use of intersection control devices or pre-emptive device to assist with intersection and traffic control. This type of technology has a transmitting device that is installed on the fire apparatus and a receiver that is installed at the intersections. Once the receiver picks up a signal from the transmitter, it will control the flow of traffic at intersections by changing the lights to allow passage of the emergency vehicle thus reducing the potential of apparatus going through a red light.

The National Fallen Firefighters Foundation convened a workshop of fire service personnel representing numerous stakeholders in the profession to address the ongoing issue of numerous fire fighters dying each year in the line of duty. The first workshop was in 2004 in which 16 life safety initiatives were identified to help reduce line of duty deaths in the fire service. One of these initiatives identified utilizing available technology wherever it can produce higher levels of health and safety (NFPA, 2016). In 2014, a second workshop was held to revisit these 16 life safety initiatives and reaffirmed that these areas of focus were still applicable and relevant. It was found during this second workshop that use and implementation of technology was still a significant focus that needed to be examined in the operations of the fire service.

Engineering and technological advancements have continued to evolve in the fire service. Engineering and technological advancements are specifically identified as elements within NFPA 1451. Chapter 7, *Emergency Response*, references the use of pre-emption devices, which are automated traffic control devices that can be used on emergency apparatus to control the flow of traffic and provide the right of way for emergency vehicles at intersections (NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*, 2018). This type of resource provides an additional control for emergency vehicle operators to help limit the potential for accidents.

Intersections at roadways create additional vehicle operation challenges for emergency apparatus. Accidents at intersections can contribute to both civilian and fire fighter fatalities. Hazards at intersections include number of vehicles, blind spots,

multiple lanes converging to one area, and typical distractions. Given these hazards, it is further recommended in NFPA 1500 that intersection control devices, otherwise known as pre-emption devices, be installed in these areas to help facilitate emergency vehicles safely through these intersections (NFPA, 2017). The use of this technology will enhance the safe operations of emergency vehicles particularly in congested areas and hazardous intersections.

NFPA 1451, Chapter 7, *Emergency Response*, also identifies the need to coordinate responses between multiple apparatus responding to the same incident from different deployment points. As noted in the standard, the purpose is to prevent the vehicles from colliding on the road and specifically at intersections (NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*). One platform some services are utilizing is the Heedful Audio Alert System (HAAS). These systems enable drivers to download an app on their phones that can be received in their vehicles and displayed to alert them of any oncoming emergency vehicles (Jackson, 2016). This technology can be installed in any emergency vehicle and provides another valuable resource to help minimize the potential for motor vehicle collisions.

Technological advances have made significant improvements towards improving the safety of personnel during emergency vehicle operations. Many times, the sheer size of these vehicles provides challenges to the operator. Obstacles and challenges such as blind spots, increased weight of the vehicle and the speed of operation all present constant challenges outside the norm of operating a typical passenger vehicle. Fire Departments are increasingly embracing the use of backup cameras and proximity

sensors to provide greater situational awareness to the operators to prevent accidents (Combs, 2017). These cameras and sensors provide for a 360-degree view around the vehicle for the operator that virtually eliminates any blind spots.

Improvements and advancements in technology and engineering have continued to transform and improve the capabilities in the fire service. New fire department vehicles have data recording devices incorporated into the design that store information such as speed, seat belt use, and use of braking devices (NFPA, 2017). In addition, improvements have been made with reflective striping, lights, and sirens, advanced warning alerts for the operators of the vehicle, customization of the chassis and cab and pre-emption devices for the vehicles have all helped to enhance the safety of emergency vehicles (Bui, et al., 2018). These same types of engineering and technological advancements have reduced or prevented fatalities and injuries in other vehicles (Meyers, 2016). These engineering and technological improvements provide for an active safety system that negates the need for operator performance unlike some passive safety systems that require actions of the driver.

Environmental Elements

Emergency vehicle accidents have been influenced by several environmental factors. Operators of emergency vehicles are required to perform and operate these vehicles in all different types of challenging situations and areas. Examples include icy roads, wet roads, narrow roads, dirt roads with soft shoulders or outer edges, and others. On November 16, 2000, a fire fighter died when the vehicle the vehicle he was driving left the roadway and crashed (CDC, 2002c). Factors contributing to the cause of this

accident included heavy fog conditions, crumbling pavement on the shoulder of the road minimizing the integrity of this area, and a narrowing of the road where the accident occurred (CDC, 2002c). Unfortunately, emergency responders don't get to choose whether they want to respond or not based on environmental conditions.

NFPA 1451, Chapter 5, *Training and Education*, specifically outline the parameters for addressing these environmental conditions and challenges. It is noted that fire department personnel shall be trained on the hazards of environmental conditions such as driving on a paved or dirt road, in addition to training personnel to drive during inclement weather (NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*, 2018). Research conducted by Hsiao, Chang, and Simeonov (2018) further support this concept and found that environmental conditions such as weather, daylight conditions, road speed limits, and road design all can negatively impact the operation of emergency vehicles. Operators of emergency vehicles are continually subjected to all different types of environmental conditions and emphasis needs to be placed on these elements.

Further research into operations of emergency vehicles in differing environmental elements found this topic is further emphasized in NFPA 1002, *Standard for Fire Apparatus Driver/Operator Professional Qualifications*. This standard outlines provisions for driver/operators of emergency vehicles to meet prior to operation of the vehicle. Specifically, expectations for operators of emergency vehicles includes requisite skills to maintain control of the vehicle while accelerating, decelerating, and turning given road, weather, and traffic conditions and operate under adverse environmental or

driving surface conditions (NFPA, 2016). The nature of emergency fire apparatus responses accentuates the importance of this component within the national standard as response times are imperative for improved quality of service and care. Operators of these vehicles don't have the luxury or ability to wait for the environmental elements to subside. Drivers of fire apparatus are responsible for the safe and prudent operation of these vehicles under all conditions including those that pose significant environmental challenges.

Environmental elements can increase the risk of emergency vehicle crashes through direct impacts on the operators of these vehicles. These direct impacts negatively affecting the operation of the vehicle can include decreased visibility, loss in steering control, and increased distances needed to bring the vehicle to a stop. Operation of emergency vehicles may be increased during these adverse weather events given the actions of others requiring the response of emergency services. This includes motor vehicle accidents of civilian vehicles going off the road or crashing, utility lines down creating a hazardous situation, fires during snow and ice related events, and medical emergencies of any type. According to Missikpode, et al. (2018), inclement weather increased the crash risk for emergency vehicles during many of these types of responses. Safe driving of emergency vehicles becomes increasing challenging when having to navigate road conditions with hazards conditions.

Demographic Composition of Firefighters

Firefighters are highly trained, respected professionals that perform a variety of critical life safety tasks and procedures. These procedures require mastery in a variety of

critical skills and decision making by firefighters. Although each individual firefighter may not possess the totality of skills needed for a successful outcome, the diverse demographic composition of the fire company collectively achieves the objectives. Some of the diverse demographic compositional characteristics of individual firefighters include their compensation status, age, experience, and gender. These same demographic compositional characteristics are also examined on many annual firefighter fatality reports from the National Fire Protection Association and the United States Fire Administration.

Compensation Status

There are many different types of fire departments in the United States. These organizations can be either public or private. Most of the fire departments in the United States are public and are funded by the community or jurisdiction in which they serve. This funding is typically done through local taxes or other revenue sources such as fees, grants, fundraisers, donations, or contracts. Firefighters may work for different types of departments based on how personnel are compensated. Fire departments are typically classified into three categories based on the compensation status of their personnel: career, call, and volunteer organizations.

Career firefighters are employed fulltime and fully compensated for their duties. Fulltime career firefighters work in an organization that have personnel that continually staff their department to provide an immediate response to an emergency (ICMA, 2012). Fire department organizations have more control over career members as fulltime employees and the requirements needed to maintain that fulltime status. Training,

education, policies, and procedures can be embedded into actions and requirements for all employees.

On-call firefighters receive payment for the actual hours they work or a stipend for their services (ICMA, 2012). These types of departments with paid on call personnel or those that receive stipends offer some advantages of greater control over personnel and offer an incentive for personnel to participate and actively engage in training and responses (ICMA, 2012). These firefighters do not provide these services as a career but have other fulltime employment. Typically, fire departments require call firefighters to complete a specific number of hours of training and number of emergency responses to remain an active member. However, these requirements can vary for jurisdiction to jurisdiction.

Volunteer firefighters do not receive any compensation and have other full-time employment (ICMA, 2012). Requirements for volunteer firefighters for training and emergency response vary from jurisdiction to jurisdiction. Volunteer firefighters typically stop what they are doing at home or work to respond to emergencies as they are never scheduled to be on duty. Volunteer departments depend on individual personal commitment as part of a civic duty to serve the community. This commitment and community spirit many times is the motivating factor for individuals to engage in the organization to give back and help serve.

Each year, the United States Fire Administration publishes an annual report outlining the previous year's firefighter line of duty deaths. These fatalities include emergency vehicles operations or accidents along with other activities such as fireground

operations, building collapses, physical fitness and health of individual firefighters and training. These annual reports specifically examine compensation status (career, part time, call, stipend, volunteer) as a category on their overall annual statistics. The reports of the last five years found that out of the 410-firefighter line of duty deaths between 2015-2019, there were 146 career firefighters that died, 35 on-call, part time firefighters that dies, and 229 volunteer firefighters that died (USFA 2015-2019).

Age

Firefighters of different generations have different experiences, skill sets, and abilities that they apply in their profession. One generation of firefighters may have a more practical application of understanding and learning information while another generation of firefighters may comprehend and understand information better through cognitive methods. Different generations place different value on information and learning and how the information is process and applied in differing applications. Examples of this include Baby Boomers who were born between 1946 and 1964 place a higher value on equality, hard work, and competition, compared with Generation X who were born between 1965-1980 and place a greater emphasis on their leisure time and prefer to work independently with minimal supervision (IFSTA, 2012). These differences in age along with the associated characteristics among the differing generation's means individual firefighters will all have their own unique perspective and experiences on how they learn and approach other aspects of their profession.

The age of firefighters has been researched by numerous organizations that examine annual statistical data for the fire service. Profiles of US fire departments in

2018 found that fifty percent of firefighters were between 30 and 49 years old (2020). In addition, further research conducted in 2018, on the same topic found the age of firefighters that accounted for the largest share of that specific workforce were between the ages of 30-39 (Evarts & Stein, 2020).

The United States Fire Administration (USFA) completed an analysis from 2015-2019 on all the line of duty deaths in the fire service. Part of this analysis looked at age ranges and the number of firefighters that died in each age range each respective year. There were 9 age ranges that the USFA used for this analysis: under 21, 21-25, 26-30, 31-35, 36-40, 41-45, 46-50, 51-60, 61 and over. It should be noted that all these categories are in increments of five years except for the last two categories. Research conducted by the USFA from 2015-2019 found that the total line of duty deaths for each of the categories was as follows:

- Under 21- 8 firefighters
- 21-25- 13 firefighters
- 26-30- 22 firefighters
- 31-35- 34 firefighters
- 36-40- 38 firefighters
- 41-45- 44 firefighters
- 46-50- 54 firefighters
- 51-60- 101 firefighters
- 61 and over- 93 firefighters

Experience

The fire service is a dynamic organization that is constantly changing and is expanding services to meet the community expectations. No longer do fire departments just respond to fire, but also emergency medical services, hazardous materials response,

motor vehicle collisions, and technical rescues that has required the fire service to evolve into an all-hazards emergency response organization. In a time of increasing expectations, expanding services, personal time constraints, and limited funding, fire departments and public administrators will face significant challenges to meet the demands of the public.

These increasing demands places greater strain and requirements on personnel. Without highly trained, educated, and experienced personnel, local fire, and emergency service organizations- career, on-call paid, stipend, or volunteer- will not be able to keep pace with the changes in society for a safe, efficient, and effective emergency response (ICMA, 2012). Experience of a firefighter is not predicated, nor does it directly correspond with their age. Many departments, career, call, and volunteer, hire personnel of all ages. Someone may not join a fire department until much later in their life which then limits the amount of experience, in terms of years of service on a fire department, individuals have in these organizations. Limited experience minimizes the exposure personnel have to specific areas in the department and thus requires a greater amount of training, education, and responses to help overcome some of these constraints.

An analysis done on the years of experience, for 58 line-of-duty deaths conducted by NIOSH from 1999 through 2017 for all completed investigations for emergency vehicle accidents, found the average years of experience for the firefighters that died was 7.02 years (Appendix D). These fatality reports found firefighters with only a few months of experience to one with thirty years of experience. This varied range of experience,

along with the overall average of all fatalities, reinforced the concerns about fire service personnel with limited experience.

Gender

Historically, women have held limited positions in the fire service. However, the role of women in the fire service is changing and more females are now playing critical roles in the fire service. A recent report by the National Fire Protection Association found that the number of women in the fire service is increasing, but still make up less than 10 percent of the United States fire service (2020). This increase from women in the fire service labor force is providing a broader demographic composition of the work force that is slowly starting to reflect the public more accurately in which emergency services are provided.

Although women currently have a limited number of positions within the fire service, this certainly is not the same overall in the United States workforce. In fact, according to the U.S. Bureau of Labor Statistics, the role of women in the labor market has changed and there are more women than men working which make up most of the workforce (U.S. Bureau of Labor Statistics, 2019). Specifically examining the fire service in 2018, women constituted four percent of the total workforce in career departments and 11 percent in volunteer departments (NFPA, 2020). Women in various parts of the country are becoming more engaged and active in the fire service and taking on more lead roles within many of the fire service organizations.

The annual firefighter fatality reports from the United States Fire Administration specifically examined gender as a category in the analysis. These fatalities include

emergency vehicles operations or accidents along with other activities such as fireground operations, building collapses, physical fitness and health of individual firefighters and training. The reports of the last five years found that out of the 410-firefighter line of duty deaths between 2015-2019, there were nine women that were killed (USFA 2015-2019). This represents just over two percent of the overall fatalities for firefighters during this time frame.

Adherence to the NFPA Standards

A primary source of reference for prevention of emergency vehicle accidents is the standards developed by the NFPA (Hsiao, Chang, & Simeonov, 2018). This study investigated and examined firefighter compliance and adherence to national fire and emergency service vehicle operations training programs. The purpose of NFPA 1451 is to provide fire departments a reference and standard outlining industry best practices, based on collaboration from subject matter expects, pertaining to emergency vehicle training components and elements. Some of the previous accident investigations conducted by the National Institute for Occupational Safety and Health (NIOSH) have referenced the standards in their findings.

NIOSH Investigations

The National Institute for Occupational Safety and Health (NIOSH) is part of the Center for Disease Control and Prevention with a goal of conducting research to minimize worker injuries and fatalities. Within NIOSH are the Fire Fighter Fatality Investigation and Prevention Program (FFFIPP) that is responsible to determine the cause of fire fighter fatalities. NIOSH does not investigate every fire fighter fatality but uses a

matrix to help determine whether their resources will be used as part of an investigation when they are notified.

Each investigation that NIOSH completes results in a report that provides an overview of what transpired prior to, during, and after the accident, and a list of recommendations referencing industry best practices for departments to consider for implementation and improvements. According to Peterson, Amandus, and Wassell (2009), these recommendations are based on the findings from experts conducting the investigations and reference standards and procedures from NFPA and the Occupational Health and Safety Administration (OSHA). Many recommendations found in completed investigations identify topics such as training, maintenance of vehicles, fire fighter physical fitness, motor vehicle safety, and improvements for equipment.

Fire Fighter Emergency Vehicle Fatalities Since 1997

Since 1997, NIOSH has completed 59 fire fighter fatality investigations related to emergency vehicle accidents. Appendix B outlines the date, type of activity, type of vehicle, vehicle operator training history, and a summary of the key recommendations from all these investigations. Appendix D outlines the age of the firefighter killed, years of experience on the department, their compensation status, and gender. It's important to note that NFPA 1451 was promulgated in 1997 at the request of the National Transportation Safety Board to reduce fatalities from emergency vehicle accidents.

These fire fighter fatality technical reports were reviewed and examined to try and understand why these events have previously happened and what recommendations have been put forward collectively from these experts that reviewed these incidents. The

review of these fatality reports allowed for a focus on any patterns or trends that could be identified as common or accepted practices in the fire service. In addition, the review of the fatality reports allowed for a focus on individual characteristics that could further be examined to determine if these influenced firefighter compliance to the national standard.

The outcomes for these fatality technical reports found some significant trends as part of the recommendations outlined by NIOSH. Out of the 59 reports, 30 directly referenced in the recommendations about the need to consider adopting or implementing elements as contained in NFPA 1451. These elements included the need for initial and ongoing training and education, use of technology for controlling traffic and traffic awareness, understanding vehicle capabilities, development of standard operating guidelines, and the need for both academic (classroom) and practical training applications.

Administrative policies and procedures such as standard operating guidelines or standard operating procedures were specifically noted as deficiencies in 11 of the reports. These guidelines and procedures provide the framework for activities and tasks within and emergency services organization, yet numerous recommendations found these to be non-existent for their personnel. These standard operating guidelines and procedures also provide for a consistent and standardized approach that establishes expectations when operating emergency vehicles.

The last fire fighter fatality that occurred because of an emergency vehicle accident and was investigated by NIOSH occurred on February 22, 2017. NFPA 1451 was first issued in 1997 with recommendations by subject matter experts for a fire and

emergency service vehicle operations training program; however, twenty years later fire fighters are still killed by emergency vehicle accidents and recommendations are still made to implement elements in this respective standard.

The other significant outcome that was found when these fire fighter fatality reports were reviewed was the number of incidents in which the operator had an unknown amount of driver training or no driver training. For the cases that listed an unknown amount of time for driver training, it is assumed that it was zero hours. Out of the 59 reports completed by NIOSH as part of their fire fighter fatality investigation, 21 of those reports identified the operator as having no training. Elements within NFPA 1451 identify key areas such as training frequency, basic training requirements, laws and driver responsibilities, and vehicle components that all should be addressed in vehicle training.

Further examination into the firefighter fatality NIOSH reports and specifically exploring some of the overall demographic compositional characteristics and variables among the individual firefighters, it was found that the average age of the firefighters killed in the line of duty while operating emergency vehicles was 35.21 year of age. The overall years of experience for those same individuals was 7.02 years. Finally, out of the 59 fatality reports that were examined, 45 of those reports had firefighters who were volunteers that were killed while operating the emergency vehicles.

Summary

The literature reviewed to gather major themes for the study included the following topics:

1. Literature Search Strategy
2. Theoretical Framework- systems theory
3. Literature Review Related Key Variables and Concepts
4. Consensus Standards
5. Development of NFPA 1451
6. Elements of NFPA 1451
7. Compliance to NFPA 1451 Standards
8. NIOSH Investigations
9. Fire fighter emergency vehicle fatalities since 1997

Emergency vehicle accidents which may lead to fire fighter fatalities were presented with supporting evidence indicating the problem and purpose of this research. This study filled a gap in the literature that was focused on firefighter compliance with recognized national standards that represent the industry best practices. The literature provided the context needed to formulate and design the research question that provided direction for the research study and instruments that are described in Chapter 3.

Chapter 3: Research Method

Introduction

The purpose of this quantitative study was to illustrate any significance to the degree of adherence by individual firefighters to the national standard and analyze the relationship between firefighters and their compliance with NFPA 1451. My intent was to examine firefighter adherence in three different elements of NFPA 1451 and determine if there were any differences in compliance to the national standard from individual firefighters.

This chapter focuses on the dependent and independent variables and explains how each one was defined and measured in the study. This study used a cross-sectional research design methodology and my insight is provided as to the value this design methodology had for this type of research. Detailed information is provided pertaining to the pilot testing of this study and how the information gathered was analyzed for interpretation. This chapter also highlights how the sample population was obtained, the reason the sample was chosen, and how consent was obtained for those who participated in this study.

This study was measured using quantitative statistics so the interactions and relationship between variables could be examined. The variables are clearly stated and defined to provide definitive evidence to the readers as to what was compared and what outcomes were measured. Each of the independent variables, otherwise known as predictor variables, were manipulated to test the level of compliance and adherence to

NFPA 1451. The dependent variable, otherwise known as the outcome variable, was measured to examine how it responded to the independent variables.

Research Design and Rationale

I used a cross-sectional design that collected data from multiple variables that were used as part of the analysis. Cross-sectional designs are used many times with surveys and can be used to examine relationships along with identifying hypotheses for future research (O'Sullivan, et al., 2017). Although cross-sectional studies may provide data on just one variable, the greatest attribute is in describing the relationships among several variables (O'Sullivan et al., 2017). This aspect of cross-sectional research design is one component that demonstrates the effectiveness this type of research design had on this study. This research design choice also provided sufficient time for data collection and analysis and required limited resources for implementation and execution of the study.

A quantitative research design was an appropriate method used for this study as it allowed me to measure firefighter compliance to the components and elements set forth by NFPA 1451. These same components and elements were also measured to examine the systems theory and determine if the differing demographic composition of firefighters were influencing compliance with parts of the standard or the standard in its totality.

I used a quantitative researcher-generated survey for data collection. In the survey (Appendix C) I asked questions that examined the compliance to the national standard using three specific elements found in the national standard: training and education, apparatus repairs and maintenance, and administrative policies and procedures. These

elements within the standard helped determine compliance to the standard, deviation of compliance to the standard between the variables, and examined different components and elements within the standard to determine if they were systematically and comprehensively being adhered.

Dependent Variable

The dependent variable for this study, based on the research question, was firefighter compliance to the NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program.* Frankfort-Nachmais and Leon-Guerrero (2015) identified the dependent variable as the factor that is being explained and the independent variable as a factor that may directly or indirectly influence the dependent variable. Questions 6-20 of my survey had questions specifically designed to answer the dependent variable which measured individual firefighter compliance the NFPA 1451. These questions focused on the three elements in NFPA 1451 of training and education, apparatus repairs and maintenance, and administrative policies and procedures as outlined in the research. Questions 6-10 measured compliance to the NFPA 1451 standard for training and education. Questions 11-15 measured compliance to the NFPA 1451 standard for apparatus inspections and maintenance. Questions 16-20 measured compliance to the NFPA 1451 standard for administrative policies and procedures. These questions on the survey collectively examined the overall degree of compliance with NFPA 1451 based on the three elements in NFPA 1451 that were measured. Each question had a “yes” or “no” choice for a response. An answer with a “yes” had a point

value of "1" assigned to the response and an answer with "no" had a point value of "0" assigned to the response.

Independent Variables

Questions 1-5 in the survey were used examine the independent variables to provide specific information on demographic composition for firefighters operating these emergency vehicles. The independent variables helped to identify if any of these characteristics influenced firefighter compliance to NFPA 1451. Previous research outlined in the literature review found that these independent variables were varied among many of the firefighters killed in emergency vehicle collisions and thus required further examination to determine compliance to NFPA 1451. The survey was purposely designed to have the questions for the demographic composition of each individual firefighter answered in Questions 1-5.

Research Question

The foundational study research question was "What is the association between firefighter compliance to NFPA 1451 and compensation status, age, experience, and gender?"

H_0: There is no association between firefighter compliance to NFPA 1451 and compensation status, age, experience, and gender.

H_1: There is an association between firefighter compliance to NFPA 1451 and compensation status, age, experience, and gender.

Population and Sample

The target population for this quantitative cross-sectional study included individual firefighters from all volunteer or mostly volunteer fire departments in four counties in Massachusetts. The NFPA (2019) stated that there are 29,819 total fire departments in the United States of which 9% are all career, 8% are mostly career, 18% are mostly volunteer, and 65% are all volunteer. This sample included 88 firefighters from a large rural area in Massachusetts. This study was approved by the Institutional Review Board (IRB) and the approval number was 12-16-20-0659784.

Recruitment of Participants

I used a simple systematic random sample of firefighters in Massachusetts for my research. The firefighters surveyed for this research were culled from the 2020 membership list of the Massachusetts Call/Volunteer Firefighters Association (MCVFA). Membership to this organization is not a requirement for call or volunteer firefighters in Massachusetts. However, this association represents over 3,400 call and volunteer firefighters in Massachusetts. The purpose of this organization is to advocate the ideals and goals of call and volunteer firefighters in the state (MCVFA, 2020). The membership list is publicly available and can be requested through the association secretary. According to Dion, who is the research analyst/MFIRS manager at the Massachusetts Department of Fire Services, data collected from fire departments in 2018 showed that there was approximately 5,700 call and volunteer firefighters in the state (personal communication, April 15, 2020).

Research Instruments and Procedures

To obtain good data that yielded reliable and useful information, an iterative process was developed that incorporated the use of administering a pilot study and then administering the final survey. Conducting the pilot study provided for evaluation and modification of the survey that allowed for a clearer understanding of the questions and a more reliable and valid outcome (Warner, 2013).

Reliability

Reliability helps to determine the consistency of a measure (O'Sullivan, 2017). Internal consistency of the measurement is improved when more than one item is measured. This study was purposely designed to measure each element to determine overall compliance to the national standard. This was completed by having five questions for each respective element to determine compliance.

Questions from the survey came directly from NFPA 1451. The NFPA standards are pre-existing standards that already exist and have been routinely used and referenced by fire service professionals for years (NFPA, 2018). The first issue of NFPA 1451 was released in 1997 (NFPA, 2018). Each question was designed with a "yes" or "no" response to minimize any ambiguous terms or items that could confuse respondents. Every question pertaining to the elements were directly referenced to the section in the standard and not made up or designed by the researcher.

Validity

Validity of a study helps to establish the credibility of the research (Warner, 2012). I conducted a pilot study to ensure that my measurement tool was valid. The pilot

study stage of the survey design involved sending a link to SurveyMonkey via email to all the volunteer and mostly volunteer firefighters in Essex County, Massachusetts. This provided these firefighters access to a draft survey for this study. The emails for these firefighters were obtained from the Massachusetts Call/Volunteer Firefighters Association data base that is publicly available and can be requested through the Association Secretary. These firefighters were not surveyed as part of the final survey. The focus and purpose of this stage of the survey design was on the feasibility of the sampling, data collection, and analysis procedures. O'Sullivan et al. (2017) found that critically evaluating the survey items is important and a pilot study is a critical safeguard as part of this process. I resolved problems encountered in this pilot study prior to implementing the final study.

Threats to Validity

The NFPA standards used in this study were accepted as consensus standards for all fire departments. Although some NFPA standards are specific for the type of organization in which the standard is applied, such as NFPA 1710 and NFPA 1720, the standard referenced in this study is not. A sample size using the demographic composition of this research provided for a broad perspective within the fire service profession. Once the survey was finalized, it was sent to all call and volunteer firefighters in the four counties of Western Massachusetts.

Quantitative Data Collection

The testing model that was used to examine the relationship between the variables was a multiple linear regression. Data collected from the survey was transferred into the

SPSS statistical software program to examine organizational compliance to the elements in NFPA 1451. A multiple linear regression was a proper fit for this type of examination between variables because it enabled the researcher to assess the relationship between variables while controlling for the effects of others. This analysis helped to examine the strength of association between variables.

Utilizing software titled G*Power (version 3.1.9.2), I determined the appropriate sample size to obtain statistical reliability. The following entries were used to determine the sample size needed for this study: Test Family: F Tests, Statistic Test: linear multiple regression: Fixed model, R squared deviation from zero, Type of power analysis: A priori: Compute required sample size-give alpha, power, and effect size, Alpha = 0.05, power= 0.80, number of predictors=4. Utilizing this data, the calculated minimum sample size was 85 participants. The actual sample size for this study was 88 participants which met and further exceeded this standard.

Data Analysis Plan

The results from the survey were collected utilizing SurveyMonkey and then stored on my computer at home. Results are also stored on a laptop computer in my home as well to ensure redundancy and minimize the potential for loss of information. These technological devices are highly secured that require a protected password for access that is only in my possession. All the information collected from the surveys will be kept for five years after the completion of the study and then permanently deleted from all files and hard drivers. I am the only person with access to this data and any requests from the data will need to be addressed and approved by me. The data was collected from an

anonymous survey that was administered electronically by email to the respective firefighters. There are no individual names associated with any of the data in the study.

Data Analysis

The data analysis plan included the importing of the survey results from SurveyMonkey into a SPSS statistical computer program for interpretation, analysis, and illustration of linear relationships and distributions. A total of 95 participants answered the survey. Seven of these participants did not answer all the questions, and those were removed from the study resulting in 88 completed surveys that were used for analysis.

This study was purposely designed with questions for each element that had a dichotomous level of measurement. It should be noted that the questions in Appendix C had parentheses at the end of each question that provided the detailed location within the standard where the element that was measured could be found. The information in parentheses was not provided as part of the survey sent to the firefighters, but only as reference here in this research paper as part of Appendix C.

Overall firefighter compliance to the national standard, which is the dependent variable, were measured in questions 6-20. Questions 6-10 measured the training and education element. Questions 11-15 measured the apparatus inspections and maintenance element. Questions 16-20 measured the administrative policies and procedures element. Each of the three elements (training & education, apparatus & maintenance, and administrative policies & procedures) had an end value ranging from 0 through 5 for each respective element within the standard. The total value for each element was dictated on the answers provided in the survey.

The total values for each of these elements, from each individual firefighter, ranged from 0-5 for each category. The total value for the dependent variable, for each firefighter, ranged from 0-15. This value of the dependent variable is a reflection, and thus a numeric value for this study, that represents the overall compliance with NFPA 1451 for the elements which were measured. The independent variables had a nominal level of measurement, and the dependent variable had an interval-ratio level of measurement. These values were utilized to conduct the multiple regression analysis in SPSS.

Results from the survey were readily available by providing them to the Massachusetts Call/Volunteer Firefighters Association at the completion of the study. This way all information received remains private and results are made available to anyone who wants them without having to provide any personal information as part of the survey.

Ethical Procedures

Informed, voluntary consent was implemented in this study to provide strong ethical practices that acted as the cornerstone in this research. To facilitate this process, an email was generated and sent to members of the Massachusetts Call/Volunteer Firefighters' Association in the four western counties. Firefighters were not required to complete this survey but were highly encouraged to do so. Exiting the survey was completed by simply clicking the "Done" button at the end of the questions. Once the survey was completed, there was no follow-up needed for this research project. Survey results from firefighters were strictly anonymous and not shared with anyone. Only the

interpretation of the collective results was available from the research and individuals are not able to be identified.

All the information collected was protected and secured and due to the anonymous nature of the research survey, there was no identification for any firefighter that participated in the study. The completed surveys are secured on SurveyMonkey, and I am the only person with access to this data. This data is kept on my laptop at home that is password protected and all data from the survey is backed up on my laptop at home that is password protected. All data and information collected as part of this research will be destroyed after five years.

Summary

This quantitative cross-sectional study was designed to illustrate any significance to the degree of adherence by individual firefighters to the national standard and analyze the relationship between firefighters and their compliance with NFPA 1451, Standard for a Fire and Emergency Service Vehicle Operations Training Program. The intent of this study is to examine firefighter adherence to NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program* and determine if there were any differences in adherence to the national standard based on the differing variables.

The research design, population and sample, strategies for ensuring reliability and validity in the survey, along with research instrumentation and procedures were described. Selection of firefighters was explained based on the random sample procedures along with information pertaining to the informed consent. Analysis of the quantitative data was examined and the procedures for storing and securing all data. Data

gathered through the presented survey methods in this chapter was statistically analyzed and presented in Chapter 4.

Chapter 4: Results

Introduction

Chapter 4 begins with a review of the study purpose, foundational research question and hypotheses, as well as data collection processes. Survey results are presented in Appendix E as part of this overall study. The purpose of this quantitative study was to illustrate any significance to the degree of adherence by individual firefighters to the national standard and analyze the relationship between firefighters and their compliance with NFPA 1451. I analyzed the survey results from 88 firefighters in four counties in Massachusetts regarding their compliance with NFPA 1451. The intent of this study is to examine firefighter adherence in three different elements of NFPA 1451 and determine if there are any differences in compliance to the national standard from these areas.

The foundational study research question was "What is the association between firefighter compliance to NFPA 1451 and compensation status, age, experience, and gender?"

H_0: There is no association between firefighter compliance to NFPA 1451 and compensation status, age, experience, and gender.

H_1: There is an association between firefighter compliance to NFPA 1451 and compensation status, age, experience, and gender.

Pilot Study

A pilot study was conducted to ensure a valid measurement was utilized. The pilot study stage of the survey design involved sending a link to SurveyMonkey via email to

all the volunteer and mostly volunteer firefighters in Essex County, Massachusetts. The pilot study was sent out on January 7, 2021. The emails for these firefighters were obtained from the Massachusetts Call/Volunteer Firefighters Association data base that is publicly available and can be requested through the association secretary. These firefighters were not surveyed as part of the final survey. A total of 18 surveys were returned for this pilot study.

The focus and purpose on this stage of the survey design (pilot study) was examining the feasibility of the sampling, data collection, and analysis procedures. The results and impact of the pilot study on the main study found that the sampling technique, data collection process, and analysis procedures were all able to be delivered, extracted for examination, and exported into SPSS for analysis using a multiple regression. All questions were answered by the respondents and results to the questions were varied in the answers.

Data Collection

The research required anonymous online participation through SurveyMonkey. This platform provided a framework that demonstrated that the surveys were distributed in an expeditious manner to all firefighters chosen for this study while maintaining privacy and anonymity. Dyer, the administrative assistant for the Massachusetts Call/Volunteer Firefighters Association was the point of contact for this organization that was used for data collection. The survey invitation along with the consent form was distributed to four counties in Massachusetts on February 2, 2021. All responses for the survey were requested to be submitted by February 19, 2021. By February 6, 2021, 66

responses had been generated in SurveyMonkey. An additional reminder was sent by Dyer to the same group to stimulate additional responses to meet the needed sample size. On February 19, 2021, a total of 95 firefighters had responded to the survey. 88 firefighters answered all the questions on the survey. This data collection had no discrepancies in the collection process as outlined from the plan presented in Chapter 3.

The results from the survey were well reflective of the fire service and provided a reasonable demographic mix. Most notably was the number of females that responded to the survey. Out of the 88 respondents, only eight were females. However, although the number of women in the fire service over the past few years has begun to increase, currently there are still a limited number of women on most departments and this overall number is reflective of the current representation within fire departments.

Results

To effectively interpret the data results and produce viable statistical analyses, I conducted a multiple linear regression model. The study consisted of four independent variables that measured compliance to the elements of NFPA 1451. The described independent variables were compensation status, age, experience, and gender. These independent variables were designed to gather responses to help contribute to an understanding of the association of adherence to this specific NFPA standard.

The dependent variable for this study measured overall compliance to the standard. This was conducted by measuring specific elements, as detailed in the standard, five different times for each element. This was completed by asking five specific questions for each individual element. The three specific elements in the standard that

were measured were training and education, apparatus inspections and maintenance, and administrative policies and procedures.

The descriptive statistics identify 88 participants that were used as part of this analysis. The dependent variable had a measurement range in the survey from 0-15, with a score of 15 representing a firefighter that is completely compliant to the standard. Analysis of the data found a mean score of 9.06 for overall compliance. This average indicates overall compliance to the national standard for all participants is greater than fifty percent.

Table 1

Descriptive Statistics of Variables

	Mean	Std. Deviation	N
Compliance	9.06	3.472	88
Experience	2.98	1.241	88
Gender	0.09	0.289	88
Age	2.64	1.03	88
Compensation Status	1.91	0.539	88

Table 2

Correlation Model Summary

		Compliance	Experience	Gender	Age	Compensation Status
Pearson Correlation	Compliance	1.000	-0.205	0.144	-0.168	-0.089
	Experience	-0.205	1.000	-0.25	0.713	-0.02
	Gender	0.144	-0.25	1.000	0.158	0.127
	Age	-0.168	0.713	-0.158	1.000	0.002
	Compensation Status	-0.089	-0.02	0.127	0.002	1.000
Sig. (1-tailed)	Compliance		0.028	0.091	0.059	0.204
	Experience	0.028		0.009	0.000	0.426
	Gender	0.091	0.009		0.071	0.118
	Age	0.059	0.000	0.071		0.493
	Compensation Status	0.204	0.426	0.118	0.493	
N	Compliance	88	88	88	88	88
	Experience	88	88	88	88	88
	Gender	88	88	88	88	88
	Age	88	88	88	88	88
	Compensation Status	88	88	88	88	88

The results for the Pearson Correlation in Table 2 examined the strength of the linear relationship between variables. Results showed that females are more compliant than males with a value of 0.144. Results for compensation status showed that the relationship decreased in compliance the more respondents were compensated with a value of -0.089. Results for age found the relationship with compliance decreased given the older the respondents indicated with a value of -0.168. Results for experience found the relationship decreased in compliance given the greater experience respondents had with a value of -0.205.

Table 3

Coefficients Summary

	Unstandardized Coefficients					95 % Confidence Interval for B	
Model	B	Std. Error	Standardized Coefficients Beta	t	Sig.	Lower Bound	Upper Bound
(Constant)	11.868	1.695		7.00	0	8.496	15.239
Experience	-0.411	-0.432	-0.147	0.951	0.344	-1.271	0.449
Gender	1.361	1.329	0.113	1.024	0.309	-1.282	4.004
Age	-0.151	0.511	-0.045	0.296	0.768	-1.167	0.864
Compensation Status	-0.687	0.69	-0.107	0.996	0.322	-2.06	0.685

The Coefficients Summary in Table 3 displays further analysis for the results. Gender analysis found that women have a higher compliance score than males with a value of 1.361. This relationship was not statistically significant with a p value of .309 which is greater than .05. Compensation status, age, and experience all were found to decrease in compliance. As the compensation status increased, there was a greater decrease in compliance to the national standard with a value of -.687. This relationship is not statistically significant as the p value was .322 which is greater than .05. As the age of the respondent increased, there was a greater decrease in compliance to the national standard with a value of -.151. This relationship was not statistically significant as the p value was .768 which is greater than .05. Analysis of experience found that as the experience increased in each respondent, the compliance to the national standard decreased with a value of -.411. This relationship was not statistically significant as the p value was .344 which is greater than .05.

Table 4

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	0.252	0.063	0.018	3.44	0.063	1.406	4	83	0.239

a. Predictors: (Compensation, Age, Gender, Experience)

The results in the Model Summary in Table 4 found an R Square value of .063 incorporating all the variables into the model. R-Squared measures how close the data are to the fitted regression line. This result shows 6.3% indicating almost a 94% variance in compliance from other variables not included in the model. This indicates that when compensation status, age, gender, and experience are all used as predictors of compliance to the NFPA standard, about 6.3% of the variance in compliance can be predicted.

To approach the research question, a multiple linear regression analysis was conducted. The dependent variable was *Firefighter compliance to NFPA 1451.* The predictor variables were *compensation status, age, experience, and gender*. The analysis showed no statistical significance for any of the four predictor variables ($p > .05$). Therefore, I reject the alternative hypothesis and retain the null that *there is no association between firefighter compliance to NFPA 1451 and compensation status, age, experience, and gender*.

Summary

This chapter included a detailed description of the analysis for this study. Survey reliability results and multiple linear regression methods, models, and analysis were presented, and all tables were included for this cross-sectional quantitative study. The intent of this research was to examine what factors are associated with the degree of firefighter compliance to the national standard to the elements of NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*. My inferential analysis found that although compensation status, age, gender, and experience all influence firefighter compliance to the national standard, there is no statistical significance to these findings. The direction of compliance based on the variables is extremely interesting and worth investigating on a larger scale. However, based on the findings, the researcher rejected the alternative hypothesis and retained the null hypothesis that there is no association between firefighter compliance to NFPA 1451 and compensation status, age, experience, and gender. Chapter 5 includes the integration, synthesis, and interpretation of the survey findings and the literature review as it relates to the Research Question. The chapter concludes with a presentation of social change implications.

Chapter 5: Discussion

Introduction

The purpose of this quantitative study was to illustrate any significance to the degree of adherence by individual firefighters to the national standard and analyze the relationship between firefighters and their compliance with NFPA 1451. The intent of this study was to examine firefighter compliance in three different elements of NFPA 1451 and determine if there are any differences in compliance to the national standard from these areas. The nature of this research was a quantitative cross-sectional research design that used a simple systematic random sample of firefighters in Massachusetts. This type of methodology was logical for this study because the general purpose of quantitative research methodology is to explain relationships and possible impacts or influences on designated outcomes.

Firefighter compliance to NFPA 1451 was examined by examining three specific elements found in this standard. This study did reveal some significant key findings for the outcomes. Most notably were the predictor variables used in this study were found not to be predictors of compliance and therefore other variables need to be examined so firefighters don't continue to get injured or killed driving emergency vehicles. The results indicated that females are more compliant than males, firefighters with greater experience were less compliant, older firefighters were less compliant than younger firefighters to the national standard, and compensated firefighters were less compliant; however, none were found to be statistically significant. Therefore, I rejected the alternative hypothesis and retained the null hypothesis. This chapter includes my

inferential interpretations of the research findings, limitations of the study, recommendations for further research, and implications for social change based on the study.

Interpretation of the Findings

The focus of this study was to investigate the association of firefighter compliance of NFPA 1451. Specifically, three elements were identified in the standard and used to determine compliance by individual firefighters in these areas. These elements were training and education, administrative policies and procedures, and apparatus inspections and maintenance. Overall, these elements were comprehensively captured in the analysis as the overall values to determine compliance which was the dependent variable.

My study further examined four specific variables that represented demographic compositions of firefighters. These variables were identified as part of the literature review and found to be potential factors when examining previous line of duty deaths related to emergency vehicles accidents.

The identified independent variables were presented, measured, and analyzed to provide a structured understanding of firefighter compliance to NFPA 1451. These independent variables were measured against the three specific elements as part of determining the overall compliance to the dependent variable. The analysis found varying degrees of relationship coefficients and analysis. This analysis provided the overall framework and structure to answer the research question. Based on my interpretation of the results, I rejected the alternative hypothesis and retained the null hypothesis.

Although results did show a difference with compliance with the independent variables, they were not statistically significant.

Systems Theory

Examining the functional parts of individual firefighter compliance to the national standard, it was found firefighters were systemically not compliant based on their compensation status, age, gender, and experience. The literature review, completed as part of this research, found significant examples with firefighter line of duty deaths from emergency vehicle accidents in which they were non-compliant with the measured elements. As noted by DeCamp and Herskovitz (2015), the systems theory approaches the accident causation as a comprehensive relationship between all variables. Although results were not found to be statistically significant, compliance to NFPA 1451 systemically decreased with an increase in compensation, age, and experience. The results did indicate that females are more compliant than males.

The individual variables of compensation, age, gender, and experience were all measured and explored to determine if any relationships existed as each of these are part of a comprehensive reflection of the demographic composition of each individual firefighter. My findings indicated that, for three of the independent variables, results decreased in compliance supporting the concept Leveson (2017) purported that the totality of all parts are connected. This information could help explain some of the reasons for emergency vehicle accidents that contribute to firefighter injuries and fatalities.

Numerous variables impact the safe operation of emergency vehicles. Understanding these variables and how they comprehensively effect vehicle operations directly enhance safe vehicle operations. Firefighters integrate several different components into a system during the operation of an emergency vehicle. These components include their training and education, knowledge and understanding of policies and procedures, and the proper maintenance and inspection of the vehicle all of which can be impacted by the firefighter's age, experience, compensation status, and gender (ICMA, 2012).

A firefighter with a comprehensive and total systemic understanding of NFPA 1451 would have detailed knowledge of the elements within this standard. However, as noted by Hsiao et al.(2018), many standards, such as NFPA 1451, are not effective because of the various individual, societal, or organizational limitations and factors. The findings in this study, although not statistically significant, demonstrate how just one of these individual firefighter demographic variables can negatively impact the overall comprehensive outcome.

Compensation Status Against Elements of NFPA 1451

The first analysis was conducted by measuring the three elements of the NFPA 1451 standard against the compensation status for the individual firefighters. My findings indicated that most of the respondents in the survey were "on-call paid-compensation for response and training". Compared with the information found in the detailed literature review, an overwhelming majority of the firefighter line-of-duty fatalities pertaining to emergency vehicle operations were volunteer firefighters (Appendix D).

Expectations conducting this analysis focused on determining whether there was a significant difference in compliance to the national standard between volunteer, on-call paid firefighters, or firefighters who receive a stipend. The grouping for this variable was used to help understand if firefighters who are compensated at a higher level have a greater compliance with the standard. Exploring the elements measured for compliance in the standard, it is reasonable to expect a firefighter that is compensated could devote more time to training and education, apparatus inspections and maintenance, and administrative policies and procedures. All three of these elements could be continually completed or assigned by the department and public administrators of these organizations while the individual was being compensated. Volunteer firefighters may not have the same amount of time to invest into these same elements to conform to the overall compliance of the standard. It is understood, based on the literature review that daily or even weekly checks of the emergency vehicles is needed to ensure a state of operational readiness based on national standards (NFPA, 2016). This requires an individual's capacity to absorb these daily or weekly time commitments to complete these requirements for compliance.

Further analysis of this study found that firefighter compliance decreased based on compensation status. A firefighter who was completely volunteer and received no compensation was found to be more compliant than a firefighter was on-call paid or received a stipend. This finding suggests that volunteer firefighters may be more diligent and focused on the need for strict adherence to the training and education, apparatus inspections and maintenance, and administrative policies and procedures. Firefighters

that are compensated for their time may get complacent and not value the need for conforming to the elements within the standard while compensated. Firefighters that are compensated may also be tasked with additional responsibilities for the organization given they may be around more than others and these ancillary tasks require a greater time commitment that thus takes away from other elements within the standard (citation).

Firefighter Age Against Elements of NFPA 1451

The second analysis was conducted by measuring the three elements of the NFPA 1451 standard against the age of the individual firefighters. My findings indicated that most of the respondents in the survey were between the ages of 41-55 years. Compared with the information found in the detailed literature review, an overwhelming majority of the firefighter line-of-duty fatalities pertaining to emergency vehicle operations were younger (Appendix D). The average age of the firefighters killed operating emergency vehicles based on the completed NIOSH Firefighter Fatality Reports since the inception is 35 years old (Appendix D).

Expectations conducting this analysis focused on determining whether there was a significant difference in compliance to the national standard based on the age of the individual firefighters. The literature review found that different generations placed different priorities on work, leisure time, and the ability to work independently with limited supervision (IFSTA, 2012). The range of ages found in the detailed literature review found the oldest fatality was 68 years old and the youngest was 17 years old (Appendix D). Comparing the age of the firefighters to the elements measured for

compliance help to understand if this variable is a contributing factor towards and individuals' overall compliance.

Exploring the elements measured for compliance in the standard, it is reasonable to expect a firefighter that is older to have more exposure to the operations of motor vehicles in general. As an individual ages, they have had greater opportunities for the operation of vehicles, understanding the rules and regulations of the road, and have obtained experience operating motor vehicles. Much of this experience, knowledge, and understanding of vehicle operations can then be transitioned over to the operation of emergency vehicles. Understandably, emergency vehicles have many different characteristics from a standard vehicle such as the overall weight and height, however, many ancillary functions for the standard operation of the vehicle can be transferred over.

Firefighter Experience Against Elements of NFPA 1451

The third analysis was conducted by measuring the three elements of the NFPA 1451 standard against the experience of the individual firefighters. Experience is defined as the number of years the individual has been on the department (ICMA, 2012). This is a significantly different measure than the age of the individual as many firefighters may not get involved as a volunteer or call firefighter until later in age. This contributed to the importance of finding this additional measurement in the analysis. My findings indicated that most respondents had between 11-15 years of experience on their department. Compared with the information found in the detailed literature review, the average age of firefighters killed operating emergency vehicles based on the completed NIOSH

Firefighter Fatality Reports since the inception is seven years of experience (Appendix D).

Expectations conducting this analysis focused on determining whether there was a significant difference in compliance to the national standard based on the experience of the individual firefighter. Many recent NIOSH reports for line-of-duty deaths found operators of emergency vehicles that were killed in an accident had less than 90 days of experience on the department (Appendix D).

Exploring the elements measured for compliance in the standard, it is reasonable to expect a firefighter with greater experience to have an increased compliance with the standard. Individuals with greater experience would have more time to complete the required training and education as well as more time to comprehend and review the department administrative policies and procedures. Experience on a department allows firefighters to understand some of the intricacies of the vehicles. Many of these are routine tests and inspections of the vehicle which operators can be trained to perform prior to the operation of any vehicle (NFPA, 2018).

Further analysis of this study found that firefighter compliance decreased based on experience. These findings contradict the concerns from many public administrators that emergency service organizations will not be able to keep pace with the changes in society given the ongoing lack of experience in many emergency service organizations (ICMA, 2012). A firefighter with more experience was found to be less compliant to the standard than a firefighter with less experience.

These finding suggest that firefighters who have been on the department longer may become complacent and not be as meticulous when working towards or achieving compliance. Firefighters with less experience may want to excel in these areas of compliance, they may want to ensure they maintain the upmost in safety, or they may have initial internal benchmarks they need to meet within a specified time frame which has accelerated their compliance status more than someone who has been on longer and may not have the same requirements.

Firefighter Gender Against Elements of NFPA 1451

The fourth analysis was conducted by measuring the three elements of the NFPA 1451 standard against the gender of the individual firefighter. My findings indicated that most of the respondents in the survey were males. Overall, eight females responded. This represented nine percent of the overall respondents. Compared with the statistics from the National Fire Protection Association relative to gender, nine percent is reflective of the current demographic composition in the fire service (NFPA, 2020).

Expectations conducting this analysis focused on determining whether there was a significant difference in compliance to the national standard based on the gender of the individual firefighter. Most NIOSH line-of-duty deaths found operators of emergency vehicles that were killed in an accident were male. The results of this study found females were more compliant than males. This finding could be contributed to females being more diligent than males in their overall job performance and requirements. Females may take a greater interest in training and education than males. Females may be more

meticulous than males when conducting inspections and maintenance of emergency vehicles.

This research extends the annual research conducted by the United States Fire Administration (USFA) focused on the number of females killed each year in the line of duty. Specifically, the USFA looks at the number of females killed each year operating emergency vehicles. The findings in this research help to examine female compliance to NFPA 1451 and extend a knowledge base into understanding potential reasons as to why females are killed each year operating these emergency vehicles.

Limitations of the Study

The first limitation as noted in Chapter 1, was that the research focused on only call/volunteer firefighters in Massachusetts. The composition and makeup of firefighters across the country may be significantly different, however limited public access for survey purposes and access reduced the potential of this option. This limitation provides the understanding that the outcomes may not be generalized for this population given the sample drawn upon.

The other limitation noted was the time needed to properly answer the survey questions. Respondents need to have some desire and interest in the topic that is surveyed to fully invest the time for accurately answering the questions. It is unknown if respondents for this survey invested the time to concisely answer the survey questions or just expeditiously completed the survey to complete the task.

To test the validity of the survey, a pilot survey was used. This survey had 18 responses and additional responses could have assisted in refining the survey. Future

studies should look to expand the number of responses in their pilot surveys. Additional responses may have led to additional modifications to help enhance the final survey design.

Reliability of the survey was structured based on using a pre-existing standard that already existed and had been routinely used and referenced by fire service professionals for years. The first issue of NFPA 1451 was released in 1997 and has had several iterations since this time. Elements used in this survey are clearly found in this standard and are easily interpreted for reference.

Recommendations

My research examined how call/volunteer firefighters in Massachusetts adhere to elements in NFPA 1451. Recommendations for further research in this topic would be to identify publicly accessible respondents and broaden the survey. Broadening the survey would include outreach to additional states in the country or even a wider geographical area, as well as including not only call and volunteer firefighters but also career firefighters. All three of these types of firefighters are held accountable to the elements within the standard and thus would be beneficial to incorporate these groups into a study.

Additional recommendations include future studies allotting increased time for data collection. Data collection for this study was conducted during the height of a national pandemic and may not have been given a priority during this time. Additional time for data collection may have provided greater responses that could have been used for data analysis and interpretation.

Independent variables exploring different areas should be considered. Suggestions for other areas of interest found in firefighter fatality reports that could be considered are actual hours of training for individuals, environmental conditions, and elements for driving, and examining if conditions were during emergency or non-emergency parameters. Each of these could be examined to help determine further compliance to national standards and help understand potential areas that could contribute to firefighter injuries and fatalities while driving emergency vehicles.

Implications for Positive Social Change

I examined a topic that directly impacts the life safety of firefighters and the public. The results of this study revealed that although there are differences in compliance to the national standard between compensation status, age, gender, and experience, these are not statistically significant. However, this information is valuable and contributes to the understanding that there are other variables that need to be explored. The variables examined in this study were found to not be predictors of compliance and therefore future research and expansion of this topic needs to look at other variables, so firefighters stop getting injured or killed while driving emergency vehicles.

Organizationally, the variables examined in the study allow leaders to understand some limitations individuals have as well as some areas where complacency may become a factor. Public Administrators can use this information to examine these areas and determine if greater attention needs to be given to personnel with longer tenures that may

need more direction and oversight for ensuring training, vehicle checks and maintenance, and review of policies and procedures are completed.

Public Administrators can use this information to provide consistency throughout the organization regardless of an individual's compensation, age, gender, or experience. This information can ultimately lead to increased safety for the personnel as well as reducing the exposure and risk of damaging resources in which the public has made a significant financial investment. Significant injuries or fatalities to emergency personnel not only negatively impact the organization and community but also the individual families. Insurance costs, line of duty death benefits, and potential liability claims can all financially impact the community. Replacement costs for vehicles damaged in an accident can quickly exceed hundreds of thousands of dollars for repairs or replacement. Additionally, emergency vehicles damaged or needed to be replaced requires an out of service time that then impacts future responses that could lead to delays in service.

The results from this study produced data that have never been available before. Although annual fire service line of duty deaths statistics and investigations specifically look at the four independent variables examined (compensation status, age, gender, and experience), previous studies have never been done to examine potential reasons as to why these variables continue to be topics and categories for annual firefighter fatalities. The results of this study helped to provide potential answers to this specific gap in the literature and give organizational leaders and practitioners areas to focus their attention for improvements.

Conclusion

Firefighters are continuing to get injured and killed driving emergency vehicles. This research is valuable and found the variables measured are not predictors of compliance and therefore other variables need to be examined to ensure firefighters are safe while driving emergency vehicles. This is an extremely important topic and other variables incorporated into another study could help provide further insight and explanations into areas of focus for improvement that could lead towards increased compliance with the national standard representing industry best practice. This study found critical information about individual firefighter compliance to the national standard and results can be used to further explore and enhance the safety of firefighters driving emergency vehicles.

References

Bagschik,G., Stolte, T., & Maurer, M. (2017). *Safety analysis based on systems theory applied to an unmanned protective vehicle.* Procedia Engineering, *179*. doi.org/10.1016/j.proeng.2017.03.096

Brooks, B. (2018, December, 25). *N.J. firefighter killed responding to call on Christmas morning.* ABC 6 Action News. https://6abc.com/traffic/firefighter-killed-responding-to-call-on-christmas-morning/4965768/

Bui, D. P., Porter, K., Griffin, S., French, D., Jung, A., Crothers, S., & Burgess, J. (2017). Risk management of emergency service vehicle crashes in the United States fire service: Process, outputs, and recommendations. *BMC Public Health.* 10.1186/s12889-017-4894-3

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (1999). *Motor vehicle incident claims the life of volunteer fire fighter- North Carolina* (Report No. 99-F16). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2000a). *A captain and a fire fighter die from injuries in a tanker rollover- Indiana* (Report No. F2000-10). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2000b). *A captain dies and two fire fighters are injured in a motor-vehicle crash- Texas* (Report No. F99-36). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2000c). *Motor-vehicle accident claims the life of a volunteer fire*

fighter and injures a volunteer chief- Virginia (Report No. F2000-01). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2000d). *Motor-vehicle incident claims life of volunteer fire fighter who was responding to alarm- Ohio* (Report No. F99-44). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2000e). *Motor-vehicle incident claims the life of a volunteer fire fighter and injures a lieutenant and another fire fighter- South Carolina* (Report No. F99-33). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2000f). *Motor-vehicle incident involving Amtrak train claims life of career fire fighter/engineer- North Carolina* (Report No. F2000-19). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2000g). *Pumper truck rollover claims the life of a volunteer fire fighter- Missouri* (Report No. F2000-33). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2000h). *Tanker rollover claims life of volunteer fire chief- Missouri* (Report No. F2000-18). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2000i). *Tanker rollover results in the death of one volunteer fire*

fighter- Texas (Report No. F2000-06). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2001a). *A lieutenant dies and three fire fighters of a career department were injured when the truck they were responding in was struck by another vehicle- Illinois* (Report No. F2000-39). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2001b). *A volunteer fire fighter/driver was killed and another volunteer fire fighter was injured while responding to a motor vehicle incident with injuries- California* (Report No. F2000-17). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2001c). *Fire fighter dies after the tanker truck he was driving strikes a utility pole and overturns while responding to a grass fire- Kentucky* (Report No. 2001-06). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2001d). *Junior fire fighter killed responding to call in his privately owned vehicle (POV)- Pennsylvania* (Report No. F2000-35). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2001e). *Motor-vehicle incident claims the life of a volunteer assistant chief- Alaska* (F2001-17). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2002a). *Motor-vehicle incident claims life of volunteer fire fighter-*

Ohio (Report No. F2002-04). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2002b). *Volunteer fire fighter dies after tanker truck is struck by freight train- Kentucky* (Report No. F2002-10). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2002c). *Volunteer fire fighter dies and junior fire fighter is injured after tanker rollover during water shuttle training exercise- Kentucky* (Report No. F2001-01). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2002d). *Volunteer fire fighter dies and two are injured in engine rollover- Alabama* (Report No. F2002-16). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2002e). *Volunteer fire fighter dies when tanker crashes into boulder and tree- Oregon* (Report No. F2001-36). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2002f). *Volunteer fire fighter killed and an assistant chief injured in tanker truck crash- West Virginia* (Report No. F2001-39). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2003a). *Career fire fighter dies in tanker rollover-North Carolina* (Report No. F2002-41). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety

and Health. (2003b). *Career fire fighter/emergency medical technician dies in ambulance crash-Texas* (Report No. F2003-05). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2003c). *Emergency medical technician killed in single-vehicle crash while responding to structure fire-North Carolina* (Report No. F2002-42). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2003d). *Junior volunteer fire fighter dies in tanker rollover-Tennessee* (Report No. F2002-39). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2003e). *Volunteer assistant chief dies in tanker rollover-New Mexico* (Report No. F2003-23). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2003f). *Volunteer captain killed in fire apparatus crash while responding to a training exercise*-Oregon (Report No. F2003-14). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2003g). *Volunteer fire fighter dies in tanker rollover-Ohio* (Report No. F2003-15). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2004a). *Junior volunteer fire fighter is killed while responding to a brush fire with an intoxicated driver-Wyoming* (Report No. F2003-20).

https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2004b). *One volunteer lieutenant dies and a volunteer fire fighter is seriously injured in a motor vehicle rollover incident while en-route to a trailer fire-North Carolina* (Report No. F2003-30). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2004c). *Career captain/safety officer dies in a single motor vehicle crash while responding to a call-Kansas* (Report No. F2004-03). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2004d). *Volunteer fire fighter killed after his privately owned vehicle hydroplaned and struck a billboard signpost-Kentucky* (Report No. F2003-19). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2005a). *Career fire fighter/emergency medical technician dies and paramedic is injured in a three-vehicle collision-Nebraska* (Report No. F2003-33). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2005b). *Forest ranger/fire fighter drowned after catastrophic blow-out of right front tire-Florida* (Report No. F2004-15). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety

and Health. (2005c). *One part-time fire fighter dies and another is seriously injured when two fire engines collide at an intersection while responding to a fire-Illinois* (Report No. F2004-43). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2006a). *Career captain dies and the driver/operator and a fire fighter are severely injured in apparatus crash-Louisiana* (Report No. F2005-35). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2006b). *Career fire fighter/EMT dies in ambulance crash-Florida* (Report No. F2005-12). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2006c). *Volunteer fire chief dies from injuries sustained during a tanker rollover-Utah* (Report No. F2005-27). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2007a). *Career fire fighter dies after engine he was driving collides with a tractor trailer-Alabama* (Report No. F2006-05). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2007b). *Junior volunteer fire fighter dies and three volunteer fire fighters are injured in a tanker crash-Alabama* (Report No. F2006-25). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety

and Health. (2007c). *One career fire fighter dies and two are injured in apparatus crash-California* (Report No. F2005-28). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2007d). *Volunteer fire fighter dies in tanker rollover crash-Texas* (Report No. F2006-06). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2008). *Volunteer fire fighter dies in a tanker crash-Louisiana* (Report No. F2008-10). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2009a). *A career captain dies and a fire fighter/driver is seriously injured when two fire trucks collide at an intersection-Connecticut* (Report No. F2007-17). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2009b). *Fire fighter dies after being ejected from a pumper in a single vehicle rollover crash-NewYork* (Report No. F2008-25). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2009c). *One fire fighter dies and another is severely injured in a single vehicle rollover crash-Georgia* (Report No. F2009-08). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2009d). *Two volunteer fire fighters die in a tanker rollover-North*

Carolina (Report No. F2007-25). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2009e). *Volunteer fire fighter dies in apparatus crash-Ohio* (Report No. F2008-22). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2009f). *Volunteer fire fighter responding to an automatic alarm dies when engine collides with an embankment and tree then overturns-North Carolina* (Report No. F2007-30). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2010a). *A career lieutenant dies and three fire fighters are injured in ladder truck crash-Massachusetts* (Report No. F2009-05). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2010b). *Volunteer captain dies in engine rollover-Colorado* (Report No. F2008-05). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2010c). *Volunteer fire chief dies in motor vehicle incident while responding to a fire alarm-Maryland* (Report No. F2009-12). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2011). *Volunteer chief and fire fighter die after being ejected during a rollover crash-Virginia* (Report No. F2010-19). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2012). *Volunteer fire fighter dies in a single-motor-vehicle crash while responding to a medical assistance call-Louisiana* (Report No. F2011-21). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2013). *Volunteer fire fighter dies after being ejected from front seat of engine-Virginia* (Report No. F2012-23). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2014a). *Volunteer fire department probationary member is killed after the pumper/tanker he was operating leaves the roadway and overturns-Alabama* (Report No. F2013-26). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2014b). *Volunteer fire fighter dies in tanker crash en route to grass fire-Indiana* (Report No. F2012-30). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2018a). *Volunteer fire fighter dies in tanker rollover responding to structure fire-Oklahoma* (Report No. F2017-06). https://www.cdc.gov/niosh/

Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (2018b). *Volunteer firefighter struck and killed by tanker backing into the bay of the fire station-Pennsylvania* (Report No. F2016-16). https://www.cdc.gov/niosh/

Chi, S., & Han, S. (2013). Analyses of systems theory for construction accident prevention with specific reference to OSHA accident reports. *International Journal of Project Management, 31*(7), 1027-1041. doi.org/10.1016/j.ijproman.2012.12.004

Combs, E. (2017). Safety and security through a second set of eyes. *Fire Apparatus and Emergency Equipment*, *22*(12), 20.

Commonwealth of Massachusetts. (2019). Chapter 90: Motor vehicles and aircraft. https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXIV/Chapter90/Section13A

Dallat, Clare & Salmon, Paul & Goode, Natassia. (2017). Risky systems versus risky people: To what extent do risk assessment methods consider the systems approach to accident causation? A review of the literature. *Safety Science*. 119. doi:10.1016/j.ssci.2017.03.012.

Day, S. (2019). *Equality volunteer firefighter laid to rest.* https://www.wsfa.com/2019/10/26/equality-volunteer-firefighter-laid-rest/

DeCamp, W., & Herskovitz, K. (2015). The theories of accident causation. *Security Supervision and Management*, 71–78. doi:10.1016/B978-0-12-800113-4.00005-5

Dekkers, R. (2015). *Applied Systems Theory*. Springer International Publishing.

Devine, J. (2008). *The commercial motor vehicle safety act of 1986.* https://ezinearticles.com/?The-Commercial-Motor-Vehicle-Safety-Act-of-1986&id=1163360

Eppes, M. (2018). *Magee firefighter killed in crash responding to fire.*

http://www.wlox.com/2018/11/04/magee-firefighter-killed-crash-responding-fire/

Evarts, B., & Stein, G. (2020). *US fire department profile 2018*. https://www.nfpa.org/-/media/files/News-and-Research/Fire-statistics-and-reports/Emergency-responders/osfdprofile.pdf

Fahy, R.F. (2018). Trends in U.S. firefighter injuries. *Firefighter Strong*. 10-11.

Fahy, R.F., LeBlanc, P., & Molis, J. (2017). *Firefighter fatalities in the United States-2016*. National Fire Protection Association.

Federal Emergency Management Agency. (2002). *Firefighter Fatality Retrospective Study* (Report No. FA-220). https://www.usfa.fema.gov/downloads/pdf/publications/fa-220.pdf?utm_source=website&utm_medium=pubsapp&utm_content=Firefighter%20Fatality%20Retrospective%20Study%201990%20-%202000&utm_campaign=R3D

Federal Emergency Management Agency. (2017). *Firefighter fatalities in the United States in 2016*. United States Fire Administration..

Frankfort-Nachmias, C., Nachmias, D., DeWaard, J. (2015). *Research methods in the social sciences* (8th ed.). Worth.

Frankfort-Nachmias, C., Guerrero, A. (2015). *Social statistics for a diverse society.* SAGE.

Garrett, J., & Teizer, J. (2009). Human factors analysis classification system relating to human error awareness taxonomy in construction safety. *Journal of Construction*

Engineering and Management, 754-763. doi: 10.1061/(ASCE)CO.1943-7862.0000034

Glover, A. (2018). *Paramedic, patient killed in I-40 ambulance crash identified.* https://fox17.com/news/local/paramedic-patient-killed-in-i-40-ambulance-crash-identified

Hsiao, H., Chang, J., & Simeonov, P. (2018). Preventing emergency vehicle crashes: Status and challenges of human factors issues. *Human Factors*, (7), 1048.

International County City Managers Association (2012). *Managing Fire and Emergency Services*. ICMA Press.

International Fire Service Training Association (2012). *Fire and Emergency Services Instructor,* (8th edition). Fire Protection Publications.

International Fire Service Training Association (2015). *Pumping Apparatus Driver/Operator Handbook,* (3rd edition). Fire Protection Publications.

International Fire Service Training Association (2018). Essentials of Fire Fighting, (7th edition). Fire Protection Publications.

Jackson, C. (2016). Chicago startup tests app that alerts drivers to emergency vehicles. *Chicago Tribune.* https://www.chicagotribune.com/business/blue-sky/ct-haas-alert-system-bsi-20160318-story.html

Jung, A., Bui, D., & Burgess, J. (2018). Reducing emergency service vehicle crashes: What really works? *Fire Apparatus and Emergency Equipment*, *(23)*10, 40.

Kalsi, D. (2019). *Longtime WNC fire captain killed in fire truck crash while responding to another accident.* https://www.foxcarolina.com/longtime-wnc-fire-captain-

killed-in-fire-truck-crash-while/article_fcdcc850-dbb9-11e9-ae27-fffbe5d2789e.html

Lenné, M. G., Salmon, P. M., Liu, C. C., & Trotter, M. (2012). A systems approach to accident causation in mining: An application of the HFACS method. *Accident Analysis and Prevention, 48,* 111–117. doi:10.1016/j.aap.2011.05.026

Limpf, L. (2018). Firemen remembered for his enthusiasm. http://www.presspublications.com/22158-fireman-remembered-for-his-enthusiasm

Margolis, K. (2010). *Underground coal mining injury: A look at how age and experience related to days lost from work following an injury*. Safety Science, 48(4). doi.org/10.1016/j.ssci.2009.12.015

Marinucci, R. (2015). *The Fire Chief's Handbook* (7th edition). PennWell.

Massachusetts Call/Volunteer Firefighters' Association (2020). *About us.* https://mcvfa.org/about-us/

Micolucci, V. (2019). *31 crashes of Jacksonville's first responders last week raise red flags.* https://www.news4jax.com/news/31-crashes-of-jacksonvilles-first-responders-in-past-week-raises-red-flags

Missikpode, C., Peek-Asa, C., Young, T., Hamann, C. (2018). Does crash risk increase when emergency vehicles are driving with lights and sirens? *Accident Analysis and Prevention, 113,* 257–262. doi:10.1016/j.aap.2018.02.002

NFPA 1002, *Standard for Fire Apparatus Driver/Operator Professional Qualifications.*

(2016). National Fire Protection Association.

NFPA 1911, *Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Emergency Vehicles*. (2017). National Fire Protection Association.

NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*. (2018). National Fire Protection Association.

NFPA 1500, *Standard on Fire Department Occupational Safety, Health, and Wellness Program.* (2018). National Fire Protection Association.

NFPA 1071, *Standard for Emergency Vehicle Technician Professional Qualifications*. (2020). National Fire Protection Association.

NFPA. (2018). *NFPA Overview*. https://www.nfpa.org/About-NFPA/NFPA-overview on December 14, 2018.

NFPA 1041, *Standard for Fire and Emergency Services Instructor Professional Qualifications.* (2019). National Fire Protection Association.

NFPA. (2020). *U.S fire department profile 2018.* https://www.nfpa.org/News-and-Research/Data-research-and-tools/Emergency-Responders/US-fire-department-profile

NFPA. (2020). *While the number of women is increasing, females still make up less than 10 percent of the U.S. fire service.* https://www.nfpa.org/News-and-Research/Publications-and-media/Press-Room/News-releases/2020/Females-still-make-up-less-than-10-percent-of-the-US-fire-service

O'Sullivan, E., Rassel, G. R., Berner, M., & Taliaferro, J. D. (2017). *Research methods for public administrators* (6th ed.). Routledge.

Peterson, K., Amandus, H., & Wassell, J. T. (2009). Reducing firefighter vehicle crash fatalities. *Fire Engineering*, *162*(6), 79–84.

Poplin, G. S., Pollack, K. M., Griffin, S., Day-Nash, V., Peate, W. F., Nied, E., Gulotta, J., & Burgess, J. L. (2015). Establishing a proactive safety and health risk management system in the fire service. *BMC Public Health*, *15*407. doi:10.1186/s12889-015-1675-8

Reeder, F. & Joos, A. (2014). *Fire service instructor, 2nd edition.* Jones & Bartlett Learning.

Runyan, C. (2003). Introduction: Back to the future-revisiting haddon's conceptualization of injury epidemiology and prevention. *Epidemiologic Reviews*, Volume 25, Issue 1, pgs. 60–64. doi.org/10.1093/epirev/mxg005

Salmon, P. M., Goode, N., Archer, F., Spencer, C., McArdle, D., & McClure, R. J. (2014). A systems approach to examining disaster response: Using Accimap to describe the factors influencing bushfire response. *Safety Science*, *70*, 114–122. doi: 10.1016/j.ssci.2014.05.003

Siarnicki, R. (2018). *International Fire Service Journal of Leadership and Management*. Fire Protection Publications.

Thiel, A., Jennings, C. (2012). Managing Fire and Emergency Services. International City / County Management Association Press.

United States Bureau of Labor Statistics. (2019). Women in the labor force: a databook. https://www.bls.gov/opub/reports/womens-databook/2019/home.htm

United States Fire Administration. (1987). Analysis report on fire fighter fatalities. United State Fire Administration, Federal Emergency Management Agency, .

United States Fire Administration. (1988). Analysis report on fire fighter fatalities. United State Fire Administration, Federal Emergency Management Agency,.

United States Fire Administration. (1989). Analysis report on fire fighter fatalities. United State Fire Administration, Federal Emergency Management Agency, .

United States Fire Administration. (1990). Analysis report on fire fighter fatalities. United State Fire Administration, Federal Emergency Management Agency, .

United States Fire Administration. (1991). Analysis report on fire fighter fatalities. United State Fire Administration, Federal Emergency Management Agency, .

United States Fire Administration. (2015). Firefighter Fatalities in the United States in 2015. https://www.usfa.fema.gov/downloads/pdf/publications/ff_fat15.pdf

United States Fire Administration. (2016). Firefighter Fatalities in the United States in 2016. https://www.usfa.fema.gov/downloads/pdf/publications/ff_fat16.pdf

United States Fire Administration. (2017). Firefighter Fatalities in the United States in 2017. https://www.usfa.fema.gov/downloads/pdf/publications/ff_fat17.pdf

United States Fire Administration. (2018). Firefighters Fatalities in the United States in 2018. https://www.usfa.fema.gov/downloads/pdf/publications/firefighter_fatalities_2018.pdf

United States Fire Administration. (2019). Firefighter Fatalities in the United States in 2019. https://www.usfa.fema.gov/downloads/pdf/publications/firefighter-fatalities-2019.pdf

Urban, A., & Gudzbeler, G. (2014). Emergency Vehicle Driving Simulator for Typical and Extreme Conditions. *Internal Security, 6*(2), 207–214. doi: 10.5604/20805268.1157192

Warner, R. (2013). *Applied statistics,* 2nd edition. SAGE

Weible, C., & Sabatier, P. (2018). *Theories of the policy process, 4th edition*. Westview Press.

Wilbur, M. (1996). *Who regulates fire apparatus and their operators?* https://www.firehouse.com/apparatus/article/10545426/who-regulates-fire-apparatus-and-their-operators

Willette, K. (2017, September). Training Safe. *NFPA Journal*, 76.

Zygowicz, W. (2017, October). The road to safety. *Journal of Emergency Medical Services*, 28-37.

Appendix A: Overview of Fire Fighter Fatalities from Emergency Vehicle Accidents

Overview of Firefighter Fatalities from Emergency Vehicle Accidents 2000-2015

Year	Total Firefighter Fatalities	Fatalities from responding to and returning from	Overall percentage
2000	103	19	19%
2001	102*	23	23%
2002	100	13	13%
2003	111	36	32%
2004	110	22	20%
2005	99	22	22%
2006	92	15	16%
2007	106	26	25%
2008	110	25	23%
2009	81	15	19%
2010	74	17	23%
2011	65	11	17%
2012	70	17	24%
2013	100	14	14%
2014	69	13	19%
2015	75	8	11%
Avg.	**91**	**19**	**20%**

* Does not include 9/11 fatalities

Appendix B: Summary of NIOSH fire fighter fatality investigations

Date	Vehicle Operator Training History	Summary of key Investigation recommendations	References
2-May-99	6.5 hours of driver training in the past year	Fire departments should ensure all vehicle operators complete state-certified driver operator classes.	CDC, 1999
31-Aug-99	In 1992, completed 32 hours of driver training-no training after this date	Fire department should ensure all drivers received driver training at least twice a year	CDC, 2000
5-Oct-99	Unknown	Department should have SOG's for vehicle operations including vehicle speed, crossing intersections, railroad crossings, use of emergency devices	CDC, 2000
13-Sep-99	Unknown	Fire Departments should ensure all drivers are trained and certified in emergency vehicle operations and provided defensive driving to all personnel.	CDC, 2000
18-Dec-99	Operator had limited experience driving this apparatus	Fire departments should ensure operators of vehicles are familiar with hazardous routes and understand responsible speeds.	CDC, 2000
14-Nov-99	several hours	Fire departments should ensure that operators of emergency vehicles operate them in a safe manner to minimize the potential for a skid.	CDC, 2000

28-Oct-99	unknown	At all times the vehicle's operator should be in control of the vehicle and take into consideration the speed of the vehicle while responding to an emergency incident	CDC, 2000
11-Feb-00	Did not have class "B" fire fighter endorsement as requirement by CA	Referenced NFPA 1451. Additionally, drivers should receive a minimum of 100 hours of driver training which includes a minimum of 5 hours of defensive driving instruction, an annual recertification by a department-certified driver trainer and a refresher course every 3 years by an outside agency.	CDC, 2001
17-Jan-00	Unknown exact number of hours	Referenced NFPA 1451. This training should cover defensive driving techniques during emergency and non-emergency conditions.	CDC, 2000
17-Mar-00	7 years as a certified driver	Following SOPs for safely driving fire department vehicles during emergency response and non-emergency travel should include specific criteria for maintaining appropriate vehicle speed, crossing intersections, traversing railroad grade crossings, and using emergency warning devices.	CDC, 2000
27-May-00	Completed 12-hour emergency response driver training course in 1997	Referenced NFPA 1451. This training should be documented and cover defensive driving techniques during emergency and non-emergency conditions.	CDC, 2000

2-Jul-00	Unknown	Fire departments should ensure that fire fighters follow standard operating procedures (SOPs) and State motor-vehicle codes for safely driving and operating a privately owned vehicle (POV) while responding to a fire alarm.	CDC, 2001
29-Apr-00	1 1/2 years as a certified driver	Fire departments should ensure driver/operators of emergency vehicles follow written standard operating procedures (SOPs) by making a complete stop at all intersections.	CDC, 2001
16-Nov-00	18 hours initial training & 5 hours of refresher training that year	Fire departments should ensure drivers of fire service vehicles are familiar with the potential hazards/conditions that exist on the roadways (e.g., insufficient shoulder) on which they may be traveling.	CDC, 2002
12-Jan-01	8 hours initial training 4 years prior	Fire departments should establish, implement, and enforce SOPs for emergency vehicle operation. Fire departments should develop written SOPs for the safe operation of emergency vehicles and the use of seat belts, which include all department policies, procedures, and any ordinances and laws that pertain to that State and or the department.	CDC, 2001

6-Mar-01	Unknown	Fire departments should ensure that all drivers of fire department vehicles are responsible for the safe and prudent operation of the vehicle under all conditions	CDC, 2001
19-Aug-01	CDL license	Referenced NFPA 1451. This training should be documented and cover defensive driving techniques during emergency and nonemergency conditions. Sound defensive driving skills are one of the most important aspects of safe driving.	CDC, 2002
19-Nov-01	no formal driver training	Referenced department should follow NFPA 1451 and NFPA 1002.	CDC, 2002
21-Jan-02	unknown	Fire departments should develop, implement, and enforce standard operating procedures (SOPs) regarding the safe operation of all vehicles responding to a fire alarm.	CDC, 2002
2-Mar-02	12 hour driving course	SOGs should emphasize that the priority is the safe arrival/return of fire department personnel and vehicles. In communities with a high volume of railroad traffic, SOGs should include procedures for safely traversing railroad crossings during emergency response and nonemergency travel.	CDC, 2002
7-Apr-02	1st time driving this Engine to an emergency call	Referenced NFPA 1451 and NFPA 1002.	CDC, 2002

5-Sep-02	36 hours of driver training & completion of and EVOC, however first time driving this vehicle on an actual emergency response	Referenced NFPA 1451.	CDC, 2003
23-Sep-02	Class B driver's license	The ability to safely control and maneuver fire apparatus is one of the most critical aspects of an operator's responsibilities. While driving, the operator should be in control of the vehicle and take into consideration the vehicle characteristics, capabilities, and limitations (e.g., speed, road conditions, auxiliary braking systems and weight transfer). Operating and controlling the vehicle at a speed from which the vehicle could be safely slowed or stopped could decrease the potential for a skid and loss of control.	CDC, 2003
13-Jun-02	12-hour EVOC	Referenced NFPA 1451 and NFPA 1002.	CDC, 2003

19-Jan-03	Class B driver's license	Fire departments should provide defensive driver training to all emergency vehicle operators. All fire department personnel who are expected to drive emergency vehicles should be trained in the safe operation of each emergency vehicle they will be operating. This training should be completed by following a protocol of classroom (written tests and videos) and hands-on (vehicle operations/procedures) experience. Emergency vehicle operators need to realize that most driving regulations pertain to dry, clear roads. Driver/operators should adjust their speed to compensate for conditions such as wet roads, darkness, fog, or any other condition that makes normal emergency vehicle operations more hazardous.	CDC, 2003
19-Mar-03	completed driver training on defensive driving, driver operations-unknown hours	Referenced NFPA 1451. This training should be documented and cover defensive driving techniques during emergency and non-emergency conditions.	CDC, 2003
3-Apr-03	Apparatus/Engine Operator certification and driven this vehicle on over 100 emergency calls	Referenced NFPA 1451 & NFPA 1002.	CDC, 2003

16-Jun-03	42 hours of driver training	Fire departments should encourage drivers to drive at speeds appropriate for the conditions to prevent hydroplaning and loss of vehicle control	CDC, 2004
22-May-03	CDL license	Referenced NFPA 1451 and incorporate specifics on rollover prevention in standard operating procedures (SOPs).	CDC, 2004
26-Jun-03	The State also requires that emergency vehicle operators hold a Class E driver's license, which the victim held, and that the license be renewed every 4 years. A Class E license is an exemption license that waives fire fighters from the requirements of a Commercial Driver's License and authorizes emergency personnel to operate emergency vehicles more than 26,001 pounds. The volunteer department requires that new fire fighters be trained on each specific apparatus by experienced department personnel.	No recommendations mentioned pertaining to driver training or certifications.	CDC, 2003
28-Jul-03	16-hour EVOC program	Fire departments should develop or revise, as appropriate, and enforce SOGs for the use of privately owned vehicles for emergency response, and provide training on the SOGs to fire fighters in all new-member orientation and driver training sessions	CDC, 2004

6-Aug-03	completed a 2-hour driver training class in 2002	No recommendations mentioned pertaining to driver training or certifications.	CDC, 2005
17-Nov-03	Unknown amount of training hours	All personnel should be trained in the safe operation of each emergency vehicle they will be operating. This training should be completed by following a protocol of classroom (written tests and videos) and hands-on (vehicle operations/procedures) experience.	CDC, 2004
3-Mar-04	EVOC program in 2003	Referenced NFPA 1451 & NFPA 1002.	CDC, 2005
27-Apr-04	Unknown	Referenced NFPA 1451, 1500, and 1002. This training should incorporate specifics on intersection practices.	CDC, 2005
23-Aug-04	EVOC	Referenced NFPA 1451. This training should be documented and cover defensive driving techniques during emergency and non-emergency conditions.	CDC, 2006
21-Jun-05	Unknown	No recommendations mentioned pertaining to driver training or certifications.	CDC, 2006

6-Aug-05	132-hour driver training course in 2002	Fire departments should require all drivers to become familiar with all of the different models of fire apparatus that they may be expected to operate. Fire departments should ensure that all drivers of fire department vehicles are responsible for the safe and prudent operation of the vehicle under all conditions.	CDC, 2007
2-Dec-05	28 hours of driver training between 2002 & 2005	Fire departments should provide refresher training on and enforce standard operating procedures (SOPs) for emergency vehicle operations, including the use of seatbelts.	CDC, 2006
28-Nov-05	Unknown hours of training	Referenced NFPA 1451, 1002, & 1500. This training should incorporate specifics on intersection practices.	CDC, 2007
22-Nov-05	Unknown member of department for three months	Fire departments should ensure that drivers of fire department vehicles receive training at least twice a year on each vehicle that they may be called upon to operate.	CDC, 2007
26-Jul-06	Unknown	Referenced NFPA 1451 & 1002.	CDC, 2007

19-May-07	To operate a vehicle over 26,000 pounds gross vehicle weight in the state where the incident occurred, a driver must first possess a valid automobile driver's license with a "Q" restriction. A "Q" restriction is attained when the driver candidate successfully completes a three-part practical skills examination which is administered by the State Department of Motor Vehicles. Part 1 is a pre-trip inspection, Part 2 is a CDL static course, and Part 3 is a road test.	Referenced NFPA 1451	CDC, 2009
24-Mar-07	The department required a minimum of 26 hours of driving and operation time before being approved to drive the tanker involved in this incident. After receiving the initial driving training, a fire fighter designated to be a driver needed final approval from the Chief. The department provided refresher driver training two times per year, and drivers were required to complete 3-hours of refresher driving training every 6 months.	Fire departments should consider requiring that emergency vehicle operators/drivers receive driver training from a State or other nationally recognized training program, in addition to specific departmental driver training.	CDC, 2009

11-Aug-07	The department requires that drivers complete a minimum of 4 hours and up to six hours of basic driver training and a minimum of ten hours of hands-on-driving. The hands-on-driving consists of demonstrating the ability to safely operate each vehicle and deal with situations that the driver is likely to encounter during normal and emergency operations. The department requires that drivers attend three hours of refresher driver training every six months, for a total of six hours per year.	Fire departments should enhance their driver/operator training programs to include road and apparatus hazard recognition and emphasize the need for new drivers to understand and recognize the potential hazards which may occur while operating a fire department vehicle during emergency operations. Fire departments should consider requiring that emergency vehicle operators/drivers receive driver training from a State or other nationally recognized training program, in addition to specific departmental driver training.	CDC, 2009
23-Feb-08	In July of 2007, he had completed classroom and hands-on driver/operator training on the apparatus involved in the incident. The department training records show that driver training was conducted every two years.	Referenced NFPA 1451 and incorporate specifics on rollover prevention into their SOPs.	CDC, 2010
28-Mar-08	approximately 10 hours of driver training	An emergency vehicle operators' course (EVOC) including a defensive driving segment and practical exercises should be completed once every three years. Fire departments should also consider whether a Commercial Driver's License (CDL) is appropriate based on vehicle characteristics and state requirements. Referenced NFPA 1451.	CDC, 2008

7-Jul-08	Unknown	An emergency vehicle operator course including a defensive driving segment and practical exercise should be completed at least every three years. Fire departments should also consider whether a commercial driver's license is appropriate based on vehicle characteristics and state requirements. Referenced NFPA 1451 & 1002	CDC, 2009
8-Jul-08	Unknown	Referenced NFPA 1451. Fire departments must also ensure that fire fighters are familiar with all the different models of fire apparatus that they may be expected to operate. The members should be trained to operate specific vehicles or classes of vehicles before being authorized to drive or operate such vehicles	CDC, 2009
31-Dec-08	Numerous hours of driver training, however first day operating this apparatus	Referenced NFPA 1451. Fire fighters may have adequate training to operate fire apparatus but may lack adequate experience and specific training needed for the class of vehicle they operate.	CDC, 2009

9-Jan-09	Completed approximately 8 hours of driver training in May 2007	Referenced NFPA 1451 & 1002. Adoption of an air brake endorsement for noncommercial vehicles will better ascertain one's knowledge and skill of air brake systems, thus making the fire apparatus driver better capable of operating the fire apparatus.	CDC, 2010
23-Feb-09	Completed a 1-day driver training course	Referenced NFPA 1451. Fire departments should consider replacing fire apparatus more than 25 years old.	CDC, 2009
15-Apr-09	Unknown	Fire departments should train all apparatus driver/operators on defensive driver techniques.	CDC, 2010
26-Jul-10	EVOC	Referenced NFPA 1451. It is recommended that intersection control devices be installed that allow emergency vehicles to control traffic lights at intersections."	CDC, 2011
3-Sep-11	Driver training- 12 hours in 2009 & 4 hours in 2010.	Referenced NFPA 1451, 1002, & 1500	CDC, 2012
16-Jul-12	EVOC program	Referenced NFPA 1451	CDC, 2013
11-Nov-12	EVOC program	Referenced NFPA 1451	CDC, 2014

17-Oct-13	Had driven only 3-5 times before. No formal training	Referenced NFPA 1451 & 1002. Fire departments should consider developing and implementing a policy prohibiting the wearing of rubber fire boots while operating a vehicle. Wearing shoes not suitable for driving, especially shoes that are thick-soled and irregularly shaped, can impact a driver's ability to safely operate vehicle braking and acceleration pedals and may lead to vehicle crashes.	CDC, 2014
22-Feb-17	Unknown	Referenced NFPA 1451 & 1002	CDC, 2018

Appendix C: Survey Questions

1. How many years have you been a firefighter?
    a. 0-5 years
    b. 6-10 years
    c. 11-15 years
    d. 16 years or more

2. What rank do you currently hold in your department?
    a. Firefighter
    b. Lieutenant
    c. Captain
    d. Assistant Chief
    e. Deputy Chief
    f. Fire Chief
    g. Other

3. What is your gender?
    a. Male
    b. Female

4. What is your age in years?
    a. 17-25
    b. 26-40
    c. 41-55
    d. 55 years or older

5. What is your compensation status?
    a. Completely volunteer- no compensation
    b. On call paid- compensation for response or training
    c. Stipend- paid incrementally or annually

6. I complete driver training at least twice a year (NFPA 1451 reference section 5.2.1)

    (1) Yes
    (0) No

7. I receive driver training that includes practical exercises using the actual fire emergency service vehicles that I am expected to drive (NFPA 1451 reference section 5.2.2)

    (1) Yes
    (0) No

8. Training and education are provided to me when a new vehicle is placed into service (NFPA 1451 reference section 5.2.4).

    (1) Yes
    (0) No

9. I am provided training in regards to the safe operations and handling of emergency vehicles with a high center of gravity that are prone to rollover (NFPA 1451 reference section 8.4.1).

    (1) Yes
    (0) No

10. I am trained on the content of the Fire Apparatus Manufacturers' Association (FAMA) Fire Apparatus Safety Guide (NFPA 1451 reference section 5.3.15).

    (1) Yes
    (0) No

11. I always check the vehicle to ensure a state of readiness and safe operations prior to use (NFPA 1451 reference section 10.2.1).

    (1) Yes
    (0) No

12. I am trained on how to adjust all mirrors and identify blind spots on the apparatus (NFPA 1451 reference section 8.2.8).

    (1) Yes
    (0) No

13. I check emergency vehicle tire pressures prior to operation of the vehicle (NFPA 1451 reference section A. 10.2.1).

    (1) Yes
    (0) No

14. The prior vehicle inspection report is reviewed at the start of each shift or before operation to ensure that any deficiency noted has been resolved (NFPA 1451 reference section B.1)

    (1) Yes
    (0) No

15. As an operator of an emergency vehicle, I conduct a pre-trip inspection with another person, with one person operating the interior controls while the second person is checking for exterior functions such as turn signal lamps, flashers, brake lights, etc. (NFPA 1451 reference section B.1).

    (1) Yes
    (0) No

16. The department has written policies governing speed and the limitations to be observed during inclement weather and under various road and traffic conditions (NFPA 1451 reference section 7.1.1).

    (1) Yes
    (0) No

17. When multiple emergency vehicles are responding to an emergency incident from different locations, the vehicle operators coordinate their response routes to prevent the response vehicles from colliding at road intersections (NFPA 1451 reference section 7.2.2).

    (1) Yes
    (0) No

18. I have knowledge of applicable federal, state, and local regulations governing the operation of emergency vehicle operations. (NFPA 1451 reference section 6.1.1).

    (1) Yes
    (0) No

19. I drive in non-emergency mode (no lights or sirens) and obey all traffic laws when responding for station coverage (NFPA 1451 reference section 7.1.8).

    (1) Yes
    (0) No

20. I provide a copy of a valid driver's license to the department and subsequent copies of the license when renewed. (NFPA 1451 reference section 4.3.11).

    (1) Yes
    (0) No

Appendix D: Age, experience, compensation status, and gender from past line of duty deaths

Overview of FF Line of Duty Deaths with Independent Variables

FF Fatality Report #	Age	Experience	Compensation	gender
F99-16	28	5	volunteer	male
F2000-10	23	2	volunteer	male
F2000-01	22	1	volunteer	male
F99-44	29	5	volunteer	male
F99-33	34	7	volunteer	male
F2000-19	31	7	career	male
F2000-33	27	4.5	volunteer	male
F2000-18	47	12	volunteer	male
F2000-06	46	4	volunteer	male
F2000-39	43	1.5	career	male
F2000-17	25	2	volunteer	male
F2001-06	21	4	volunteer	male
F2000-35	17	1	volunteer	male
F2001-17	41	20	volunteer	male
F2002-04	26	8	volunteer	male
F2002-10	48	1	volunteer	male
F2001-01	19	1	volunteer	male
F2002-16	29	4	volunteer	female
F2001-36	52	1	volunteer	male
F2001-39	21	1	volunteer	male
F2002-41	32	0	career	female
F2003-05	28	0.5	career	male
F2002-42	18	2	volunteer	female
F2002-39	17	1	volunteer	male
F2003-23	46	8	volunteer	male
F2003-14	53	8	volunteer	male
F2003-15	56	30	volunteer	male
F2003-20	46	17	volunteer	female
F2003-30	23	6	volunteer	male
F2004-03	53	29	career	male
F2003-19	30	2	volunteer	male
F2003-33	43	18	career	male
F2004-15	40	13	career	male

Appendix D. continued.

F2004-43	34	3	stipend	male
F2005-35	33	13	career	male
F2005-12	22	3	career	male
F2005-27	52	10	volunteer	male
F2006-05	25	8	career	male
F2006-25	17	1	volunteer	female
F2005-28	23	3	career	male
F2006-06	28	0.25	volunteer	male
F2008-10	33	12	volunteer	male
F2007-17	37	12	career	male
F2008-25	25	0.5	volunteer	male
F2009-08	34	2	volunteer	male
F2007-25	45	4	volunteer	male
F2008-22	58	17	volunteer	male
F2007-30	43	1.5	volunteer	male
F2009-05	52	1	career	male
F2008-05	33	3	volunteer	male
F2009-12	41	22	volunteer	male
F2010-19	59	33	volunteer	male
F2011-21	22	3	volunteer	male
F2012-23	30	1	volunteer	male
F2013-26	28	0.25	volunteer	male
F2012-30	26	5	volunteer	male
F2017-06	68	7	volunteer	male
F2016-16	60	15	volunteer	male
Average	**35.21**	**7.02**		

Appendix E. Answers to Survey Questions

	Answer Choice	Responses
Question #1.		
	0-5 years	21
	6-10 years	13
	11-15 years	12
	16 years or more	49
Question #2.		
	Firefighter	52
	Lieutenant	8
	Captain	9
	Assistant Chief	3
	Deputy Chief	7
	Fire Chief	10
	Other	6
Question #3.		
	Male	87
	Female	8
Question #4.		
	17-25	15
	26-40	26
	41-55	30
	56 years or older	24
Question #5.		
	completely volunteer- no compensation	18
	on call-paid-compensation for response or training	68
	stipend-paid incrementally or annually	7
Question #6.		
	Yes	31
	No	64
Question #7.		
	Yes	70
	No	24
Question #8.		
	Yes	87
	No	8

Question #9.		
	Yes	80
	No	15
Question #10.		
	Yes	34
	No	60
Question #11.		
	Yes	70
	No	25
Question #12.		
	Yes	82
	No	13
Question #13.		
	Yes	16
	No	78
Question #14.		
	Yes	37
	No	57
Question #15.		
	Yes	36
	No	57
Question #16.		
	Yes	66
	No	28
Question #17.		
	Yes	36
	No	57
Question #18.		
	Yes	86
	No	9
Question #19.		
	Yes	59
	No	34
Question #20.		
	Yes	77
	No	18