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Differences in Preventable Cardiovascular-Related Versus Unavoidable Occupational Causes of Firefighter Fatalities on Duty

Amy Goad, DNP, MS, NP-C
George Washington University

Differences in Preventable Cardiovascular-Related Versus Unavoidable Occupational Causes of Firefighter Fatalities on Duty

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Amy Goad, MS, NP-C

The George Washington University

DNP Project Team

Cathie E. Guzzetta, PhD, RN, FAAN

Qiuping (Pearl) Zhou, PhD, RN

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Abstract

Background: Firefighters across the United States face high fatality rates in the line of duty of which many are likely related to preventable cardiovascular risk factors.

Objectives: To assess differences in firefighter cardiovascular-related versus unavoidable occupational-related fatalities by career status, age, smoking, obesity, and hypertension.

Methods: We used an exploratory, comparative secondary data analysis design. We extracted data from a national database of deceased firefighters over 14 years. Variables extracted were career status, age, smoking, obesity, and hypertension as well as the reason for death while on duty (i.e., cardiovascular-related or unavoidable occupational-related death). Data were analyzed using Chi-Square to compare cardiovascular-related versus unavoidable occupational-related fatalities among the variables with significance set at 0.05.

Results: In a sample population of 984 deceased firefighters nationwide, we found that career versus volunteer position status ($\chi2 = 1.14$, $p=0.56$) did not significantly affect cardiovascular-related fatality outcomes compared to unavoidable occupational-related outcomes. Significantly more firefighter with increased age ($\chi2 = 176.16$, $p<0.001$), who smoked ($\chi2 = 10.91$, $p=0.001$), had increased BMI ($\chi2 = 10.91$, $p=0.001$), specifically obesity ($\chi2 =13.14$, $p<0.001$), and hypertension ($\chi2 =84.42$, $p<0.001$), had cardiovascular-related fatalities compared to those with unavoidable occupational-related fatalities.

Conclusions: Our study demonstrated significant differences related to increased age, smoking, increased BMI, obesity, and hypertension in relation to increased cardiovascular fatalities in firefighters compared to unavoidable occupational-related fatalities. Our findings support the development of cost-effective nurse-practitioner (NP) led preventative health programs aimed at reducing cardiovascular-related fatalities in the fire service.

Background

Firefighters are in a unique career where they physically exert themselves in extremely hazardous and dangerous situations on an ongoing basis. As a result of their profession, they are at increased risk for certain preventable diseases including cardiovascular disease (CVD) such as, hypertension (HTN), heart attacks, and strokes, as well as, obesity, cancer, and other chronic illnesses and diseases. Issues such as diet, tobacco use, uncontrolled hypertension, lifestyle factors, and culture of firehouse life all play a significant role in firefighter morbidity and mortality (Eastlake, Knipper, He, Alexander, & Davis, 2015). It is estimated that the rate of firefighter deaths is 3 times that of other occupations in the U.S. (Kunadharaju, Smith, & DeJoy, 2011). While the average risk of CVD throughout the U.S. is about 25%, in the fire service, it is the leading cause of firefighter deaths at approximately 45%, making this an area of concern from a preventative health viewpoint (Soteriades et al., 2011). It is estimated that a firefighter carries between 35-75 pounds of gear and equipment, leading to increased stress on the body, during already strenuous tasks (Barr et al., 2014). Coupled with other risk factors, this additional strain predisposes men and women in this profession to a unique myriad of CVD concerns.

Firefighters are a specific population of individuals who risk their lives daily in an endeavor to save others. They are trained to provide medical care, to rescue victims from entrapment, and to put out fires, all of which put strain and stressors on the body, often times without proper sleep or meals. It is well known that firefighting is an ultra-hazardous profession. Depending on whether a firefighter is a volunteer or career firefighter, they may be performing their duties without any mandatory physical conditioning or mandatory preventative health screenings being performed. With heart attacks among firefighters occurring at a rate of 47.2%

on-duty, and strokes occurring at a rate of 4.9%, it is imperative to implement preventative health and monitoring of cardiac conditions in the firefighter population (USFA, 2015).

Despite this well-known information, some firefighters, especially those who are in volunteer departments, do not always have preventative initiatives available to them. As a result, it is imperative that a review of firefighter mortality data be conducted to find the difference in CVD related deaths versus unavoidable occupational deaths, as well as, differences in career versus volunteer deaths, and the correlation to how these fatalities may have been prevented. Initiatives can then be recommended to prevent further unnecessary deaths in the future.

Problem Statement

For the past five years, I have been a nurse or nurse practitioner (NP) while simultaneously volunteering as a firefighter at a hometown volunteer fire department. In this time I have witnessed the unhealthy lifestyles of firefighters, and the lack of physical preparation and evaluation that is performed prior to firefighters completing their physically dangerous job. More often than not, volunteer firefighters in comparison to their professional counterparts, do not receive physical examinations prior to joining the department, do not undergo routine physicals, or have wellness initiatives offered to them. This is concerning as it puts an already vulnerable population at risk for cardiovascular deaths while on duty.

Since firefighters perform a hazardous and physically stressful job on a daily basis, often times without proper monitoring or health initiatives in place, it is imperative to look at the effects of these health issues. By reviewing the mortality data of firefighters over the course of fourteen years, our study evaluated the differences in preventable cardiac deaths versus unavoidable occupational on-duty deaths. A national firefighter mortality database accessed through the Federal Emergency Management Agency (FEMA) was utilized to undertake this

study; to date, this data has not been utilized to evaluate the preventable causes of firefighter fatalities. Thus, important measures that could prevent future fatalities have not been addressed. By understanding the causes of preventable death, NP-led preventative health care measures can be designed to reduce preventable cardiac deaths for firefighters in the future.

Research Purpose

The purpose of our research was to examine how often firefighter deaths on duty are linked to preventable cardiac causes. The long term purpose of this research was to design a preventative health program geared at maintaining the safety of firefighters.

Specific Aims

The specific aims of this study were to:

1. Assess the primary causes of firefighter fatalities.
2. Compare differences in firefighter fatality data related to preventable deaths versus those with unavoidable occupational causes of fatalities.
3. Compare difference in preventable cardiac disease deaths between volunteer and career firefighters.

The long term aim of the study, based on results of relevant findings, was to recommend preventative changes that can be issued throughout fire departments to improve firefighter health and reduce unnecessary firefighter fatalities.

Research Question

What are the primary causes of firefighter fatalities on duty nationwide over the past 14 years?

Based on the primary causes of firefighter fatalities, how many are caused by preventable cardiac disease fatalities versus unavoidable occupational causes of fatality in volunteer and career firefighters?

Hypotheses

For U.S. firefighters, ages 18-60:

1. There is a difference in type of firefighters (career vs volunteer) between those who had preventable cardiac disease deaths versus unavoidable occupational deaths.
2. There is a difference in age between those who had preventable cardiac disease deaths versus unavoidable occupational deaths.
3. There is a difference in smoking rates between firefighters who had preventable cardiac disease deaths versus unavoidable occupational causes.
4. There is a difference in BMI rates between firefighters who had preventable cardiac disease deaths versus unavoidable occupational causes.
5. There is a difference in hypertension rates between those who had preventable cardiac disease deaths versus unavoidable occupational causes.

Significance

Our study is significant because it provides breakthrough information for a population who is often overlooked, even though they are the very people who are called to respond to their community's emergencies. Currently, firefighter fatality data has not been used to drastically improve firefighter health. Our study addresses avenues in which a preventative health program could decrease future cardiac events in on-duty firefighter deaths and prolong life expectancy of firefighters, in both career and volunteer departments. Additionally, federal agencies such as the

National Fire Protection Association (NFPA) and the Federal Emergency Management Agency (FEMA) would have compelling evidence to support the institution of preventative health initiatives for improved health and safety outcomes of firefighters in the U.S.

Literature Review

In conducting this study, I have reviewed over 365 articles relevant to the topic were reviewed from CINAHL, ProQuest, and SCOPUS databases. 11 specifically met the inclusion and exclusion criteria. Inclusion criteria included: articles and research studies relating to firefighter fatalities and preventative health issues in firefighter health, in firefighters ages 18-60 years of age, conducted in the U.S. Studies outside of the U.S., pertaining to wildland firefighting in particular, or involving vulnerable populations (underage individuals, pregnancy, etc.) were excluded.

In one retrospective study two groups of male firefighters who either experienced on-duty cardiac related fatalities (n=87), versus those who experienced on-duty cardiovascular incidents but did not die (n=113), were compared to evaluate the effects of cardiovascular disease in a profession that has higher risks of cardiovascular disease (CVD) related fatalities (Geibe, 2008). Using data from the National Institute for Occupational Health and Safety (NIOSH) firefighter fatality data, Geibe found variables that were predictors of CV fatalities including, "a diagnosis of CVD disease (odds ratio [OR] 4.09, 95% confidence intervals [CI] 1.58 to 10.58), current smoking (OR 3.68, 95% CI 1.61 to 8.45), and hypertension (OR 4.15, 95% CI 1.83 to 9.44)" (Geibe, 2008, p.587). Geibe also found that firefighter age, diagnosis of diabetes, or hyperlipidemia without concurrent diagnosis of CVD did not predict CVD fatality. This data provides support for the need to evaluate firefighter health prior to permitting participation in

firefighting. Limitations in this literature include a lack of female data, which limits the generalizability of this study to the entire U.S. firefighter profession.

Smoking has been identified as a predictor for CVD fatalities in firefighters. To identify cultural practices among firefighters regarding tobacco use (both smoking tobacco and smokeless tobacco (SLT)), Haddock and colleagues conducted a longitudinal cohort study of 478 firefighters, recruited from 11 career stations and 13 volunteer stations in Missouri(Haddock, Jitnarin, Poston, Tuley, & Jahnke, 2010). They found that over 13% of male firefighters used SLT, and 2.6% used both regular tobacco products and SLT. Additionally, users of both products (tobacco and SLT), both in volunteer and career departments had a high correlation to having high fat diets that increased their risks for CVD (OR = 8.41, $P < .05$) (Haddock et al., 2010). This data presents the importance of identifying cultural habits and trends unique to firefighters requiring preventative interventions, such as tobacco use. This data is not necessarily generalizable to the entire U.S., or female firefighters.

Another variable to consider in relation to CVD-related fatalities in firefighters is overweight/obesity. In a mixed methods study called the Fuel to Fight (F2F) study, 763 firefighters across 14 different U.S. states completed baseline vitals including body mass index (BMI), questionnaires, and health surveys to evaluate the effectiveness of weight counseling from licensed providers on health outcomes (Brown et al., 2015). In this study, only 25% of participants reported having providers discuss their weight with them; those who did receive provider counseling on weight were more likely to attempt to lose weight (OR=4.14, 95% CI=2.65, 6.47) (Brown et al., 2015). This study demonstrated that weight and healthy initiatives are not prioritized in firefighter culture, and it provided support for the initiation of provider interventions in educating firefighters to promote health practices, reducing CVD risk factors.

The nature of firefighting and the strenuous tasks involved have been cited to predispose firefighters to cardiovascular strain and CVD related fatalities (Barr et al., 2014). As a result of this finding, researchers conducted a pilot study that was funded by the Department of Homeland Security (DHS) in Montgomery County, Maryland, and Fairfax, Virginia (Barr et al., 2014). In this study, firefighters on-duty utilized chest straps and wrist heart rate monitors to evaluate cardiac output. Findings from this pilot showed that cardiovascular strain was evident in all participants at structure fires, leading to an increased risk for CVD fatalities (Barr et al., 2014). Unfortunately, this data is not generalizable to the entire career or volunteer firefighter population; it did not identify controls in the study, or provide an adequate sample demographic overview. Even though the study design is weak, it suggests the importance of conducting future studies to evaluate cardiovascular strain and risk factors in firefighters.

Other literature has looked at contributors to CVD and risk factors to address preventative health initiatives. In a systematic review of hundreds of firefighter studies from 1980 to 2011, reviewers established that smoking, obesity, hypertension (HTN), coronary heart disease (CHD), diabetes mellitus (DM), and age were all correlated with increased cardiac fatalities in firefighting (Soteriades et al., 2011). Over 50% of firefighters were found to be pre-hypertensive, 20-30% were hypertensive; 40% were obese; and 40-50% of those firefighters who had an on-duty CHD fatality, were smokers (Soteriades et al., 2011). This data suggested that cardiovascular fatality predictors exist, and preventative measures can be taken to limit these predictors and risk factors. However, this study failed to mention the number of studies focusing on career versus volunteer firefighters, and information is left overly broad for assumptions.

Researchers have also examined which behaviors or lack of behaviors firefighters may or may not participate in can lead to increased CVD and on-duty fatalities. In one study where

surveys were distributed to 40 fire chiefs in Ohio, and then re-distributed to their crews, in both volunteer and career departments, health behaviors were evaluated. Only 46% of firefighters reported that they engaged in exercise, 83% of firefighters consumed primarily red meats at meals, 90% returned to the station with dangerous soot and toxins on their clothes, 53% were overweight, and 33% were obese (Eastlake et al., 2015). These risk factors associated with adverse on-duty job outcomes are common in the fire service. One strength of this study was that both females and males were included. Limitations of the study included that the survey validity was not discussed in detail, and the information was not generalizable across the U.S.

In another retrospective case-controlled study reviewing data on firefighters over the age of 45 with sudden cardiac deaths (SCDs), the authors analyzed 87 SCD fatalities, 915 active controls, and 56 trauma deaths from NIOSH data and found that those firefighters with previous diagnosis of CHD, HTN, obesity, or smoking histories, had an increased risk of SCD fatality (Yang et al., 2013). Additionally, a diagnosis of CHD was seven times more likely to result in SCD (95% CI= 2.87, 16.5) (Yang et al., 2013). In a similar study, NIOSH fatality data was analyzed based on causes of fatality, including: on-duty structural fire fatalities, traumas, wildland firefighting incidents, etc. (Kunadharaju, Smith, & DeJoy, 2011). From this data, 87 out of 99 deaths were cardiac-related fatalities, leading the researchers to recommend physical wellness programs and mandatory health screenings for future fatality prevention (Kunadharaju, Smith, & DeJoy, 2011).

Such mandatory health and wellness programs for firefighters have been examined in a different mixed methods study, where 100 fire chiefs out of 7,400 fire chiefs who are members of the International Association of Fire Chiefs (IAFC) were surveyed, and questions addressing utilization of preventative services versus fatality data were compared (Patterson, Suyama, Reis,

Weaver, & Hostler, 2013). In depth interviews were conducted with the fire chiefs, and results were analyzed using the Content Validity Index (CVI) (Patterson et al., 2013). With a 65% response rate, findings suggested that a cost-effectiveness model could be created and utilized to promote preventative health programs for firefighters. This research filled a gap in literature as cost-effectiveness of health programs is rarely documented in relation to firefighters. This study is limited due to its small sample size; also qualitative data obtained might not encompass all direct and indirect costs associated with creating preventative health programs for firefighters.

Another study evaluated a total of 20 fire departments across the U.S. that incorporated a wellness approach (WA) versus standard departments that did not take wellness initiatives for their firefighters (Poston, Haddock, Jahnke, Jitnarin, & Day, 2013). In this study, WA departments were found to have better health outcomes and less fatalities; firefighters in WA departments "were less likely to be obese (adjusted [A]OR = 0.58; 95% CI = 0.41-0.82), more likely to meet endurance capacity standards for firefighting (AOR = 5.19; 95% CI = 2.49-10.83) and have higher estimated VO2max (40.7 ± 0.6 vs. 37.5 ± 1.3 for firefighters in Standard departments; p = 0.001), and were substantially less likely to smoke (AOR = 0.30; 95% CI = 0.17-0.54)" (Poston et al., 2014, p. 805). This data only evaluated male firefighters, and did not evaluate the use of smokeless tobacco products in either WA or standard departments, so gaps still exist in the literature relating to these topics (Poston et al., 2014). This literature suggests that wellness initiatives can improve firefighter health while limiting firefighter fatalities.

Finally, research has been conducted to assess for effective ways to change firefighter health habits. In 5 career fire departments in Oregon, 599 participants were assigned to either a motivational interviewing (MI), team-based intervention group, or a control group to assess for changes in health behaviors (Elliot, 2007). This study was called Promoting Healthy Lifestyles:

Alternative Models' Effects (PHALMES), and results found both MI and team interventions "increased fruit and vegetable consumption ($P < 0.01$ and $P<0.05$, respectively) and general well-being ($P < 0.01$), with less weight gain occurring in both groups ($P < 0.05$)" (Elliot, 2007, p. 210). These findings suggest that MI and team-based health initiatives can improve firefighter health if offered, but do not address all CVD risk factors that are applicable to preventing cardiac fatalities. Further research would need to be performed to assess smoking behavioral changes, HTN risk factors, and further dietary changes. Limiting factors included the lack of variety in demographics in this study, and the lack of interventions applied.

Overall, a variety of research has been performed evaluating firefighter health behavior, CVD predictors, causes of cardiac related fatalities, and cost-effectiveness of wellness initiatives. Some of the studies are weaker than others, and further research needs to be performed to identify the best ways to prevent CVD fatalities in firefighters. Broader samples and populations need to be included in future research. Additionally, a gap still exists in relation to analyzing firefighter fatality data not obtained through NIOSH, such as the Federal Emergency Management Agency (FEMA) database that was utilized in this study.

Theoretical Framework

The theoretical foundation used in our study was Jean Lave's Situated Learning Theory which proposes that when people are put into certain conditions, new behaviors and interactions can occur, or be learned (Lave, 1988). Obesity, hypertension, diet, lifestyle, and smoking can play a role in preceding on-duty cardiac deaths in firefighters (Barr, Moore-Merrell, Benedict, & Smith, 2014). Various studies support that social factors and culture are linked to higher risk factors for cardiovascular-related issues (Barr et al., 2014; Eastlake et al., 2015; Soteriades et al., 2011). Some of these behaviors have been learned from the environmental impact of the fire

department. It stands to reason that with proper education, cultural changes to existing protocols, and dynamic changes to focus on firefighter wellness, healthier habits could be learned.

The application of this theory is intended to explain the relationship between the independent variables of age, smoking, obesity, hypertension, and type of firefighter (career versus volunteer) on the dependent variable, cause of firefighter fatalities. Firefighters are prone to lifestyle choices and mannerisms that are less common among the general public. When preventative health is not a priority, firefighters are more likely to eat fast food, not participate in non-mandatory physical training (PT), and use tobacco products (Eastlake et al., 2015). The application of the Situated Learning Theory as the driving design in this study is expected to provide data to support the need for preventative health changes in the fire service, hopefully reducing preventable cardiac fatalities in firefighters in the future. Please see Figure 1.

Identifying and Defining Study Variables

The official FEMA database for national firefighter fatality data was utilized to measure the dependent variable causes of death while in the line of duty (cardiac versus unavoidable/occupational) against independent variables including: age, smoking, BMI status, and history of HTN (Appendix A). No interventions were applied to our study but data were analyzed to find differences in the independent variables between cardiac related and unavoidable occupational-related fatalities. Independent variables cover both demographic and clinical variables related to firefighter well-being and health status at the time of fatality. While it is important to note that some information may be lacking in the database, variable categories of unknown status were excluded to account for this issue.

Methods

Research Design

A descriptive comparative design was used in this retrospective secondary data analysis to explore whether firefighter cardiac-related deaths were different from unavoidable occupational-related deaths. This design is appropriate to answer the research questions. Moreover, this design was achievable in the study time allotted.

Study Sample

The target sample of our study was firefighters, both men and women, volunteer and career, ages 18-60, living and working in the U.S who died in the line of duty. Ethnic backgrounds and demographics varied across settings in the U.S. Volunteer and career firefighters were examined and their data analyzed to account for differences in rates between preventable cardiac fatalities and unavoidable occupational-related fatalities. These classes of firefighters differ on required physical fitness and health, as volunteer firefighters do not always have mandatory physical training (PT) or health assessments that career firefighters receive. No vulnerable populations were examined including: pregnant women, mentally disabled adults, or minors.

Convenience sampling was used for all firefighters who died meeting the study inclusion criteria. Data were extracted from a Federal Emergency Management Agency (FEMA) database. Inclusion criteria for the study included: firefighters of either sex, ages 18-60, of all races and ethnic backgrounds, either career or volunteer, who died during the years of January 1st, 2002-December 31st, 2015 on-duty in the U.S. Exclusion criteria for this study included: firefighters from other countries, firefighters who did not die on-duty (i.e. cancer causes, etc.), deceased firefighters whose data was not provided to FEMA, underage volunteer firefighters (cadets, probationary members, etc.). For the purposes of this study, wildland firefighting was excluded.

Sample Size

Based on my primary aim of differentiating between preventable cardiac disease and unavoidable occupational fatalities, I anticipated that at least 40% of firefighter fatalities were related to preventable cardiac disease. Using a one-group descriptive study calculator from UCSF Clinical &Translational Science Institute (2017), with a CI= 95% and W= 0.1, and with a proportion of 40%, p=0.4, my estimated sample size for this study was at least N= 386. However, to accomplish the goals of this study, and to incorporate a full 14 years of data, I included the 984 available subjects. .

Setting

The setting for this study was fire departments across the U.S. between the years of January 1st, 2002- December 31st, 2015.

Instrumentation/Measurements/Data Collection

No specific instruments were utilized in our study. Instead the FEMA database was used for instrumentation purposes to measure the following variables:

Dependent Variables: cause (type) of death (cardiac vs unavoidable occupational while on duty)

Independent Variables: position status (career vs volunteer), age, smoking, BMI status, hypertension.

The FEMA database is a compilation of information surrounding firefighter fatalities in the United States between the years of 1990-2015. Data includes health information, such as, if the firefighter was a documented smoker at the time of death, obese at the time of death, had documented HTN at the time of death, among other indicators. Additionally, cause of death is

documented by each firefighter fatality. Other identifying information such as, coordinates at time of death, and other personal information were removed from the dataset.

Data were extracted from the FEMA database from January 1st, 2002-December 31st, 2015. The DV, reason of death, was binary having two groups: cardiac versus unavoidable death. Differences in cardiac-related deaths versus unavoidable occupational-related deaths were analyzed by firefighters with known cardiac issues (hypertension, cardiovascular disease, myocardial infarctions, cerebrovascular accidents, heart failure). Age is grouped intervals of: (18 - <40), (40- <50), and (50 - =60).

The first interval of 18-<40 was chosen because few cardiac-related deaths occur in younger populations. Smoking was coded into two categories based on documented smoking at time of death: yes or no. The IV position status evaluated whether firefighters were career (paid) firefighters or volunteer firefighters at their time of death. Wildland firefighting is a separate form of firefighting, and was excluded during data analysis. Career firefighters included industrial, part-time, full-time, and contract firefighters on duty at the time of their deaths. These data were pulled through sorting functions in Excel, and calculated accordingly. The IV BMI status is a clinical/explanatory measure. This category was broken into three subsets: normal, overweight, obese. Finally, hypertension (HTN) was coded as a binary variable with yes or no categories (based on documentation of blood pressures ≥140/90 at time of death).

Data were sorted in Excel (this included categorizing position type so that wildland firefighting was excluded). Excel formulas were utilized and data fields were highlighted and sorted accordingly, to show only the categories of data required for evaluation in our study. This sorting was done with each individual IV category compared singularly against the DV

categories. This method eliminated common human error and misinterpretation of data. The data were then analyzed utilizing IBM SPSS software. A coding chart for each variable, and a code book where IV/DV categories were removed and coded based on coding definitions.

For our study, previously collected data were used. Data were collected by the Federal Emergency Management Agency (FEMA) employees between the years of 1990-2015, including subset and contract employees from the United States Fire Administration (USFA) and National Fallen Firefighters Foundation (NFFF), based on standardized questions. One limitation to this data collection method is that in early years, data gaps existed, but the years with missing data (1990-2001, etc.) were not used in our study. This timeline was the best method for data collection because fatalities are often reported at a federal level, and through federal grants, researchers were able to acquire information from multiple sources to ensure reliability and validity of data collected. For example, coroner reports were obtained to validate that deaths were cardiac-related, versus trauma-related. Methods for data collection were valid and reliable as standardized questions were utilized for each fatality, and all researchers involved in data collection were trained and regulated by a primary investigator.

Data Collection Procedure and Timeline

Since the FEMA database consists of pre-collected data, further data collection was not required by the student investigator. As previously mentioned, only FEMA employees and contracted employees have access to the database, were trained accordingly, and were/are overseen by one primary investigator who is knowledgeable in the field of fire sciences. Due to non-response return of information discussed in the previous section, some gaps in the database do exist over time. Gaps in data were coded accordingly as to not skew the data.

In relation to data collection procedure, the student investigator extracted necessary data from the database to analyze information surrounding IVs and DVs for our study. First, all information in the database was de-identified. Second, topics not relevant to the proposed hypotheses (location of death, alcohol or drug use, etc.) were strategically selected and deleted from the database spreadsheet. All subjects prior to January 1st, 2002 were deleted from the spreadsheet. A filter search was completed to delete Wildland firefighters from the dataset. After these tasks were completed, only 984 subjects remained in the excel spreadsheet to be studied, and from these, only those falling in the age ranges of 18-60 were included. The main database remains in a saved and protected file in Excel in case further data needs to be extracted at a later time; this will ensure that no data is lost in the data extraction/storage process.

Data were coded. An additional person experienced in the FEMA database assessed the accuracy of the coding and data entry that has been performed for 10% of the sample. A data definition code chart was created as a key to help interpret the coded data. This data was then moved from Excel to IBM SPSS software for storage and analysis.

Data Analysis Plan

Excel software was used to sort data points. Data entry accuracy was checked by FEMA employees and a private investigator responsible for the data. After these data points were transitioned from the spreadsheet to code, a professional database analyst with FEMA database experience ran a test to ensure 100% of the sample data had been coded accurately; all 100% of the sample data was accurate. Once accuracy of the data was ensured, data were then uploaded to IBM SPSS software. This software was used to analyze and store data in our study.

Descriptive statistics were performed on all of the data; frequency and percentage were reported. Descriptive statistics were calculated on the following two research questions:

1. What are the primary causes of firefighter fatalities nationwide over the past 14 years?

2. Based on the primary causes of firefighter fatalities, how many are caused by preventable cardiac disease fatalities versus unavoidable occupational causes of fatality in volunteer and career firefighters?

For the first research question, percentage and frequency of the main categories of death were calculated. For the second question, percentage and frequency of preventable cardiac disease fatalities versus unavoidable occupational causes of fatality in volunteers and career firefighters were calculated. In addition, descriptive statistics were reported similarly for the 5 hypotheses. As most of the variables related to the hypotheses are binomial/categorical, frequency and percentage were reported.

For research hypotheses 1-5, chi square analyses was performed. Significance was set at 0.05.

Ethical Considerations

For our study, the George Washington University (GWU) IRB was contacted. Since we were using fatality data, our study was not considered human subject research; per IRB personnel, it did not require IRB oversight or approval (GW IRB, personal communication, April 13th, 2017). Even though all subjects in the dataset were deceased, all identifying data was de-identified to protect confidentiality of the data prior to developing the data codebook. To ensure security and accuracy of the data used, only the principal investigator, the student investigator, and a supervised database analyst (one-time access), accessed the Excel database.

Additionally, none of the data collected included any of the 18 PHI identifiers. The following data were extracted from the FEMA firefighter fatality database: cardiac versus unavoidable occupational fatalities, career versus volunteer status, age ranges, BMI status, smoking, and hypertension. All variables were in a yes or no coded format (e.g.: obese: yes or no, smoker: yes or no), and age ranges were categorized as 18-40, 41-50, 51-60. These coding strategies, protected medical and identifying information for both the deceased subjects and their descendants. No HIPAA waivers were required and privacy was ensured.

Results

Demographic and Clinical Characteristics of Sample

Out of 984 firefighters included over the course of 14 years, 461(46.8%) firefighters were career and 523(53.2%) were volunteer (Table 1). Of the total sample, there were approximately one-third fatalities in each of the age groups, with 339(34.5%) firefighter fatalities in the 18-40 age range, 327(33.2%) firefighter fatalities 41-50 age range, and 318(32.3%) fatalities in the 51-60 age range. In this sample, among the 429 (43.5%) firefighters with data of smoking status (555 (56.5%) firefighters had missing data for this category). Of the 429(43.5%) firefighters assessed for smoking status at time of death, 94/429(21.9%) firefighters were smokers, while 335/429(78.1%) firefighters were non-smokers at time of death. In relation to BMI, 577(58.6%) firefighters had available data for evaluation; 407(41.4%) firefighters in our sample were missing this data. Of the 577 firefighters, 273/577(47.3%) firefighters were obese, 210/577(36.4%) firefighters were overweight, and 94/577(16.2%) had normal BMIs at their time of death. Of the 355 (36.0%) firefighters with available data regarding hypertension diagnosis at time of death, 126/355(35.5%) firefighters had hypertension diagnoses at their time of death, and 229/355(64.5%) did not.

Research Questions Results

Our first research question addressed the primary causes of firefighter fatalities while on duty over the past 14 years. Findings from this research study revealed 13 main causes of death presented as most frequent to least frequent: 470(47.8%) myocardial infarction (MI), 232(23.6%) trauma, 105(10.7%) asphyxiation, 41(4.2%) other, 40(4.1%) crushed, 38(3.9%)cerebrovascular accident (CVA), 35 (3.6%) burns, 8 (0.8%) violence, 7(0.7%) electrocution, 4(0.4%) heat exhaustion, 2(0.2%) drowning, 1(0.1%) disease exposure, and 1(0.1%) blanks.

Our second research question explored how many deaths were caused by preventable fatalities versus unavoidable occupational fatalities on duty. Of these 984 firefighter deaths over the course of 14 years, cardiac deaths while on duty accounted for the majority of deaths with 508(51.6%) firefighter deaths being caused by cardiac causes (i.e., myocardial infarctions, stroke, hypertension). In contrast, 476(48.4%) firefighter deaths were caused by unavoidable occupational causes while on duty over 11 different categories (i.e., trauma, asphyxiation, other, burns, violence, electrocution, heat exhaustion, drowning, and disease exposure).

Hypothesis Testing Results

We utilized chi-square testing to assess the significant difference of career versus volunteer status on reason of death. There were 237(51.4%) career firefighter cardiac- related fatalities, and 271(51.8%) volunteer firefighter cardiac-related fatalities, there was no significant difference between position status by cardiac versus unavoidable occupational fatalities ($\chi 2$ = 1.14, p=0.56; Table 1).

In the second hypothesis related to age at time of death, it was discovered that there were significant differences among the three age groups by cardiac versus occupational causes of death ($\chi 2 = 176.16$, $p<0.001$). There were 80(23.6%) firefighter fatalities in the 18-40 age group, 196(59.9%) firefighter fatalities in the 41-50 age group, and 232(73.0%) firefighter fatalities in the 51-60 age group occurred due to cardiac-related causes. Bi-group chi-square comparisons showed that all three age groups were significantly different; as age increased so did the cardiac-related fatalities.

In our third hypothesis looking at firefighter smoking status, significantly more firefighters who were smokers (n=63, 67.0%) suffered cardiac-related deaths compared to smokers in the occupational-related deaths group (n=31, 33%) at time of death, ($\chi 2 = 10.91$, $p=0.001$).

In our fourth hypothesis, BMI status also appeared to have significant findings overall. In this category, overall significant differences in BMI were found in cardiac-related deaths compared to unavoidable occupational-related deaths, ($\chi 2 =14.49$, $p=0.001$). Due to the multiple divisions in this category, further chi-square bi-group comparisons were run. More cardiac-related deaths (74.6%) occurred in overweight firefighters than that in firefighters with a normal BMI 33(25.4%) ($\chi 2 =3.26$, $p=0.071$). Firefighters who were obese at time of death 155(61.5%) suffered significantly more cardiac-related fatalities than their overweight counterparts 97(38.5%) ($\chi 2 =5.33$, $p<0.021$). The obese group 155(82.4%) also suffered more cardiac-related fatalities than the normal BMI group 33(17.6%), ($\chi 2 =13.14$, $p<0.001$).

Finally, for hypothesis 5, a chi-square analysis was also performed to assess the differences in hypertension diagnosis at time of death on cardiac-related fatalities versus unavoidable occupational fatalities. This analysis revealed that 106(84.1%) firefighter fatalities

were related to cardiac-related deaths in firefighters with hypertension, versus 76(33.2%) fatalities in those who did not have hypertension. Significantly more firefighters with hypertension have cardiac-related firefighter fatalities compared to those in the unavoidable occupations fatalities group without hypertension ($\chi 2 = 84.42$, $p<0.001$).

Discussion

In conducting our study, we were investigating the issue of cardiac versus occupational deaths in firefighters while on duty. In choosing this topic, we saw a perceived need to evaluate clinical variables that could be altered in the future to prevent unnecessary fatalities in this population. Smoking, BMI, and hypertension are all cardiovascular risk factors that likely could be prevented or changed in an effort to reduce cardiac diseases and death in firefighters.

Research findings from previous studies are abundant in providing evidence that the variables chosen in this study may increase the risk for preventable cardiac deaths in firefighters. Studies performed previously have focused on systematic reviews, as well as, health promotion interventions or other quantitative studies, which have ranged from weight-based focus, to hypertension and smoking-related studies, to other causes of CVD related deaths (Barr et al. 2014; Eastlake et al., 2015; Elliott, 2007; Geibe, 2008; Haddock et al., 2011; Kunadharaju, Smith, & DeJoy, 2011, Yang et al., 2013). One study demonstrated a correlation between hypertension, smoking, and obesity related to cardiovascular causes of death in firefighters under the age of 45 (Yang et al., 2013). Another study reported that increased BMI and age were modifiable risk factors related to cardiac deaths in firefighters (Eastlake et al, 2013). Age is considered a modifiable risk factor in the research, because although age cannot be changed, care provided to the individual based on age-related risk factors can be changed. Another study had significant findings that CHD, hypertension, and smoking all led to higher CVD deaths in

firefighters, recommending that firefighters should be put on limited duties when showing signs of CHD, and that programs to control hypertension and reduce smoking could be useful (Geibe et al., 2008). Various research findings have consistently suggested a need for preventative health maintenance programs, although current studies are lacking supportive findings for modifying age risk factors, smoking status, BMI, and hypertension, all in one centralized study based on a generalized sample population (Elliott, 2007; Barr et al., 2014, Geibe et al., 2008; Eastlake et al., 2013; Haddock et al., 2011; Yang et al., 2013). As a result, our study undertook investigating these variables, along with career versus volunteer firefighter position status, to evaluate the need for a comprehensive overhaul in preventative cardiac health programs for firefighters.

Our findings are significant because they link increased age at time of death, smoking status at time of death, obesity at time of death, and hypertension at time of death to increased cardiovascular fatalities. In firefighters aged 41-50, and 51-60, both age groups had significantly more cardiac-related fatalities than their 18-40 year old counterparts. Similarly, firefighters aged 51-60 had significantly more cardiovascular-related fatalities than those aged 41-50. Our findings support previous findings that link age > 45 to increased cardiovascular deaths (Yang, et al., 2013). Likewise, in the Eastlake et al. (2013) study, increased age was found to increase the risk of cardiovascular death in firefighters, which supports our own findings. Other studies similarly found that firefighters ≤45 years old were less likely to suffer cardiac-deaths in this profession (Geibe et al., 2008). These findings on age are important because departments can take into account the ages of the firefighters staffing their apparatus. Older firefighters may need more frequent or intensive physicals, and the jobs allotted to them might change with age.

We found that firefighters who were smokers at their time of death while on duty had significantly more deaths related to cardiac causes than those who died of occupational causes. Smoking increases the risk for CHD which is a known risk factor for heart attacks and strokes. Another study similarly found that smoking, hypertension, and obesity all led to significant increases for sudden cardiac deaths (Yang et al., 2013). As smoking has been suggested in literature as being a modifiable risk factor for preventing cardiac-deaths in firefighters, it needs to be addressed in all departments, whether career or volunteer (Geibe et al., 2008). As Haddock et al. (2011) suggests, smoking has not been found to be overly more common in the firefighter population, yet the risks associated with this behavior and other increased risks from occupational hazards make it a poor indicator for firefighter outcomes and health. Smoking is still one of the strongest variables that has been related to an increased risk for cardiovascular deaths, and as such should be a variable that preventative health programs focus on reducing.

In relation to BMI, our study demonstrated a significant difference between obese firefighter cardiac-related deaths, and those who are overweight. Significantly more obese firefighters had a cardiac-related fatality compared to unavoidable occupational-related fatalities. Additionally, there were significantly more obese firefighter cardiovascular deaths compared to those firefighters with a normal BMI. There was no significant difference between normal BMI firefighters' rates of death versus those who were overweight; this indicates that overweight status may not be a significant predictive factor for cardiovascular-related deaths when compared to unavoidable occupational-related deaths. These findings are consistent with findings in previous literature (Yang et al., 2013; Poston et al., 2013; Eastlake et al, 2013). Firefighters are at an increased risk to be obese in relation to the general population, and as a result this is an important finding to consider and address in United States fire departments (Poston et al., 2013).

Interventional programs such as the Promoting Healthy Lifestyles: Alternative Models' Effects (PHALME) suggest that by promoting behavioral/cultural changes to groups in a fire department, such as healthy eating habits and increased physical activity, health outcomes can be impacted and BMIs in firefighters can be reduced (Elliot, 2007). This information, as well as our findings, suggest that the cardiovascular risk factors obesity and overweight are preventable, specifically in regards to obesity. Other firefighters with normal BMIs or who are in the overweight category suffer cardiac deaths at a lesser rate than their obese counterparts. Our findings suggest that identifying firefighters who are obese is critical in introducing preventative health initiatives to reduce BMIs in the future, such as the PHALME program did. Even a program as minimal as health care providers offering weight-loss advice to overweight and obese firefighters could improve health outcomes (Brown et al., 2015). However, these firefighters need to be identified and monitored appropriately to prevent future cardiac deaths.

Finally, firefighters with a history of hypertension had significantly more cardiac-related deaths compared to unavoidable occupational-related deaths. Hypertension has been indicated to be one of the strongest predictors of cardiac-related deaths in male firefighters (Geibe et al., 2008). It has been reported that both undiagnosed and undertreated hypertension resulted in more firefighter cardiac deaths than their healthier or well-managed counterparts (Banes, 2014). Hypertension in firefighters is discussed as being a causative link to MIs and CVA related deaths on the fire ground, making this variable an important one to consider (Kunadharaju et al., 2011). Our findings support that firefighters who have a history of hypertension/current hypertension at the time of their death suffered more cardiac-deaths than those with unavoidable occupational deaths, which means firefighters should be screened for hypertension. Hypertension should be

screened for at a minimum annually, and at fire scenes where cardiovascular strain is expected. Programs to manage hypertension should be offered routinely to firefighters.

Volunteer versus career status did not demonstrate a significant difference for cardiac-related firefighter fatalities compared to unavoidable occupational-related deaths. In the United States, approximately 800,000 (72%) firefighters are volunteers, and 300,000 (28%) firefighters are classified as career firefighters (CDC, 2006). With a higher number of volunteers in the U.S., it would seem that volunteers would have a more significant rate of cardiovascular-related fatalities due to the higher overall percentage in this category compared to career firefighters. However, it appears that the rate of cardiovascular death compared to unavoidable occupational deaths in both volunteer and career groups is proportional; about 50% of firefighter fatalities are cardiovascular-related in both groups of firefighters, with about 90% of these fatalities being linked to underlying coronary heart disease (CHD) (Soteriades et al., 2011). Another important consideration is that volunteer firefighters are allowed to be active members over the age of 60, while career firefighters are normally retired by age 60; this increased age bracket is a risk factor for cardiovascular death as suggested in our study, as well as, other current literature (Rosenstock & Olsen, 2007). In fact, in 2015 alone, the NFPA found that the leading cause of firefighter fatality was cardiovascular in nature, with most cardiovascular causes being related to heart attacks; two thirds of these deaths occurred in firefighters over the age of 60 (Fahy, LeBlanc, & Molis, 2016). In our study, we excluded firefighters above the age of 60 to limit differences between career and volunteer firefighters. It is possible that this age exclusion affected the significance of the position status category, although previous findings have had similar outcomes despite the large discrepancy in number of volunteer versus career firefighters.

Limitations

While the significance of our findings will be valuable in future research and firefighter fatality outcomes, there are several limitations that should be addressed. First, the data in our study included some data gaps due to nonresponse issues when the primary investigator attempted to contact specific fire departments; data were missing in up to 50% of certain categories. Also, prior to a centralized database for storing this information, and lack of functionality of previous collection methods, early data were missing. Another limitation is that less than half of the 984 fatalities had data on history of smoking and hypertension, while over 58% had data available for BMI analysis. Wildland firefighters, a type of career firefighter with duties that are significantly more specialized in nature, were not included in this study to increase generalizability of the study findings across firefighters in the U.S. However, these firefighters are career firefighters, and the exclusion of this population may have affected study outcomes. Age limitations were set excluding firefighters under the age of 18 and above the age of 60 to standardize career and volunteer populations. While career firefighters rarely engage in firefighting after the age of 60, older firefighters, such as those who volunteer, are significantly more likely to have cardiovascular events, and the inclusion of all age groups may have affected findings. Finally, research has shown that another leading cause of firefighter fatalities across the U.S. is cancer (CDC, 2012). Cancer is not a direct cause of on duty death as it occurs from multiple exposures overtime, but it is recognized as an unavoidable occupational cause of fatality. In future designs for preventative medicine for firefighter health and fatality reduction, it is recommended that researchers incorporate cancer prevention.

Recommendations/Implications

Most of the findings in our study are valuable in firefighter health and management, demonstrating that significantly more cardiovascular fatalities occurred in firefighters on duty

when increased age, smoking at time of death, obesity, and/or hypertension diagnosis were present compared to those with unavoidable occupational-related deaths. These findings have broad implications for designing preventative health programs tailored to firefighter fatality prevention programs. Weight management programs, nutrition, blood pressure monitoring, smoking cessation programs, and routine care to assess for CVD risk factors, especially in aging firefighters, needs to be designed and implemented in the future. Some career fire departments have implemented health programs, although components that have been highlighted through significant findings may be missing from current programs (NFPA, 2016). Many volunteer fire departments do not have mandatory physicals or wellness programs at all (IAFC, 2010).

Our study suggests that regardless of career versus volunteer status, all firefighters face increased risks for cardiovascular fatalities when significant risk factors exist. As a result, it is important to disseminate these findings so that volunteer departments also get the care that they require; volunteer firefighters perform the same duties as career firefighters that put their lives at risk, and deserve the same level of healthcare prevention nationwide. Programs should be designed that integrate the culture of the fire department, including group incentive programs and support groups to ensure higher success rates (Elliot, 2007). Preventative health programs should be designed to occur in or close to the fire stations where firefighters live and work.

While it has currently not been done, it would be ideal to use our findings to form nurse practitioner (NP) designed and run programs. According to our findings, such a program design would limit costs to volunteer departments incurred sustaining health and wellness programs that could limit firefighter fatalities. As NPs are considered mid-level practitioners, even though they provide equal care to their MD counterparts, they are more affordable. In designing preventative programs for the fire service, fire departments would save in costs that are incurred due to death

disbursement pending on-duty deaths, medical bills for on duty injuries and cardiovascular-related events, loss of work force duty days and reduced staffing levels, as well as, increased financial responsibility for departmental insurance due to increased injuries and deaths.

Using the findings from our study, as the student investigator, I plan to gather firefighter stakeholders and disseminate this information to the FEMA Fire Programs Specialist and the USFA's lead for health and wellness programs. In doing so, I hope to start a discussion with the stakeholders in an effort to ensure that firefighters receive necessary health care. Additionally, funding and grants exist that could be sought to assist in the development of NP-based preventative health firefighter programs nationally. To meet this goal, our research findings will be translated into practice at the student investigator's local volunteer fire department by creating a NP-led preventative health program. This local department approved the proposal for a preventative health program for all members, as designed by the student investigator (AG), a primary care NP, based on firefighter health risk factors. Local cardiology specialists and radiologists already have been contacted to provide low-cost chest x-rays and stress tests to the department personnel. The specifics of this program will be finalized with approval from the local department. Standard operating guidelines (SOGs) have been created for the department by the student investigator for the physical/preventative health program, and funding per the fire chief from the Maryland State Firemen's Association (MSFA) is expected to be available for start-up funding at said local department. After this pilot program has been initiated, it will be evaluated over a one year period to assess firefighter health outcomes and the findings will be taken to FEMA for further discussion and dissemination. This discussion will be important to establishing the need for NP led preventative health programs, and to finding necessary grants and government funding for sustainable programs in the future. Mandatory programs could also

be an achievable outcome if directed by FEMA. Starting at the local level will provide support for this important change in firefighter health and safety.

Conclusion

Firefighters face a wide array of dangers in their field, with one of the highest risks for fatality being linked to cardiovascular causes. Our study demonstrated significantly more firefighters died on duty of cardiac-related fatalities who had increased age at time of death, smoked, were obese, and had hypertension compared to those in the unavoidable occupational group. In recognizing these risk factors, I plan to create NP led preventative health programs in the future, limiting firefighter fatalities at a reduced cost to fire departments. Our findings will be shared with government officials, such as FEMA representatives, enabling a national action plan to reduce cardiovascular deaths in the firefighter population.

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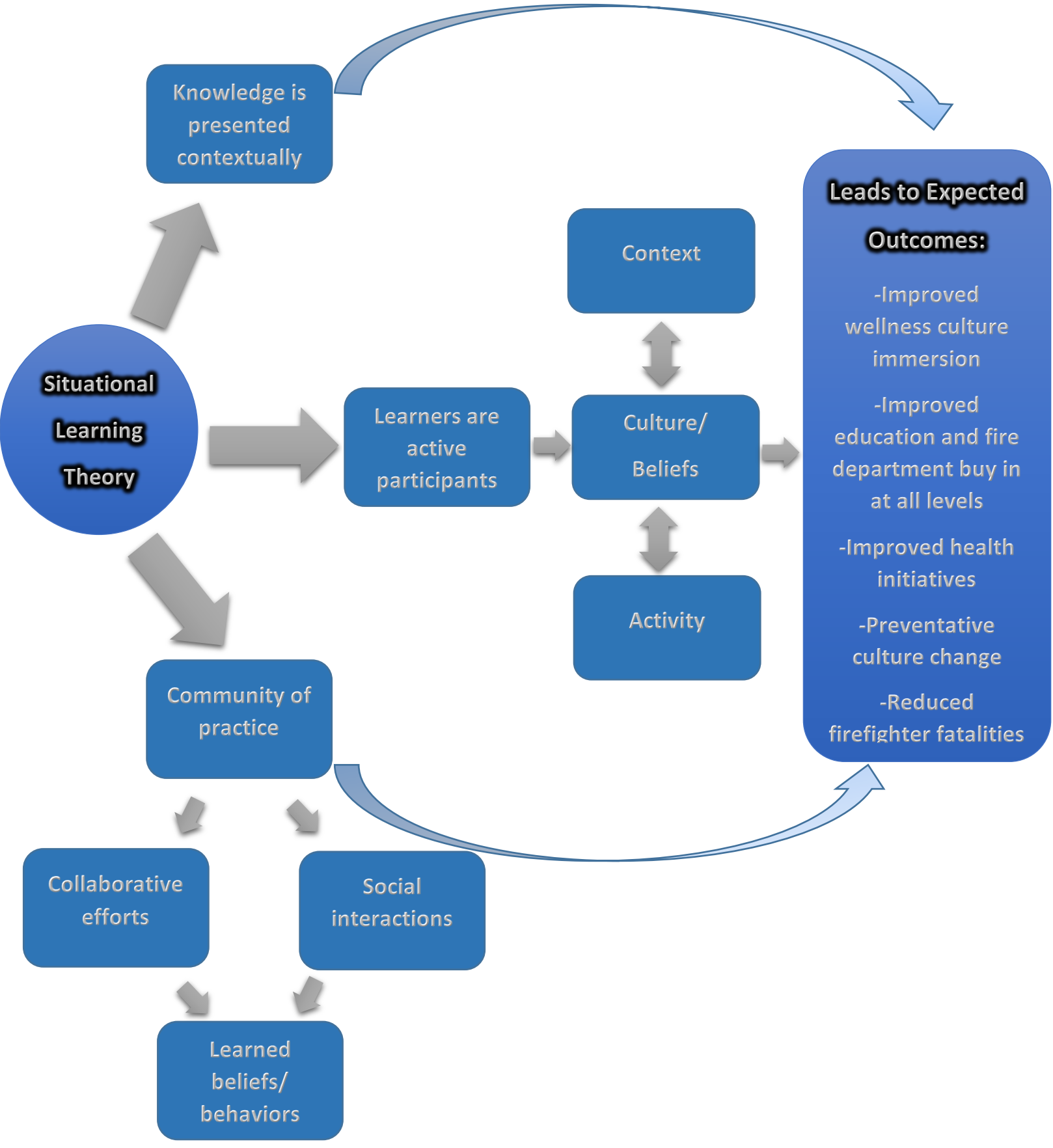
Table 1

Hypothesis Testing Result: Differences in Reason for Death by Demographic and Clinical Variables of Firefighters

Variable	Total Sample	Reason for death		Chi Square χ^2	P Value
	n (%) 984(100)	Cardiac disease n (%) 508 (51.6)	Occupational causes n (%) 476 (48.4)		
Position status				1.14	0.56
• Career (Paid)	461 (46.8)	237 (51.4)	223 (48.4)		
• Volunteer	523 (53.2)	271 (51.8)	252 (48.2)		
Age				176.16	<0.001
• 18-40	339 (34.5)	80 (23.6)	259 (76.4)		
• 41-50	327 (33.2)	196 (59.9)	130 (39.8)		
• 51-60	318 (32.3)	232 (73.0)	86 (27.0)		
Smoking				10.91	0.001
• Yes	94 (21.9)	63 (67.0)	31 (33.0)		
• No	335 (78.1)	160 (47.8)	175 (52.2)		
BMI				14.49	0.001
• Obese (BMI ≥30)	273 (47.3)	155 (56.8)	118 (43.2)		
• Overweight (BMI ≥25-<30)	210 (36.4)	97 (46.2)	113 (53.8)		
• Normal (BMI<25)	94 (16.2)	33 (35.1)	61 (64.9)		
Hx of hypertension				84.42	<0.001
• Yes	126 (35.5)	106 (84.1)	20 (15.9)		
• No	229 (64.5)	76 (33.2)	153 (66.8)		

Figure 1

Situated Learning Theory as Applied to Preventable Firefighter Fatalities



Appendix A

Preventable Firefighter Fatalities in the Line of Duty Variables

Variable	Variable Type and Form	Theoretical Definition	Operational Definition
Dependent Variables			
Cause of death: Unavoidable occupational causes of mortality versus cardiac-related deaths (HTN, CVD, MIs, CVAs, HF)	Dependent Binary	Job-related injuries that are considered unavoidable due to the nature of work, or cardiac related-disease deaths that occur on-duty	Unavoidable occupational causes of mortality are classified as occupational hazards as listed in the NFPA guidelines: traumas, burns, falls, motor vehicle accidents (MVCs), other. Cardiac-related mortalities are defined as deaths caused by diseases that are classified by the American Heart Association (AHA) as being cardiac-related, including: hypertension

			(HTN), cardiovascular disease (CVD), myocardial infarctions (MIs), heart failure (HF), or cerebrovascular accidents (CVAs). 1. Cardiac 2. Non-Cardiac
Independent Variables			
Position Status	Demographic/Explanatory Binary	Whether firefighters are members of a volunteer fire department or career fire department.	Firefighter positions as indicated by professional career fire department status (currently active in paid department), versus strictly participating as a firefighter in a volunteer department (not paid for services). 1. Career (Paid) Firefighter

			2. Volunteer Firefighter
Age at Time of Death	Clinical/Explanatory Interval/Count	The years a person has lived until deceased.	1. 18 - <40 2. 40- <50 3. 50 - =60
Smoker at Death	Clinical/Explanatory Categorical/Nominal	Whether firefighter had a history of smoking	Documented Smoker at Time of Death: 1. Yes 2. No
BMI Status	Clinical/Explanatory Categorical	Whether firefighter was considered obese at time of death.	Documented BMI at Time of Death: 1. Obese 2. Overweight 3. Normal
History of HTN	Clinical/Explanatory Categorical/Nominal	Whether or not a firefighter had a history of high blood pressure.	Documented HTN >140/90 at Time of Death 1. Yes

			2. No