Spring 5-10-2021

Examining the Prevalence of Self-Reported Respiratory Symptoms and Respiratory Infection amongst Firefighters in the Presence or Absence of Asthma

Juliana K. Cartwright
Georgia State University

Examining the Prevalence of Self-Reported Respiratory Symptoms and Respiratory Infection amongst Firefighters in the Presence or Absence of Asthma

By

Juliana K. Cartwright

A Thesis

Presented in Partial Fulfillment of Requirements for the

Degree of Master of Science In Health Sciences In the

Department of Respiratory Therapy

Under the supervision of Dr. Chip Zimmerman

in

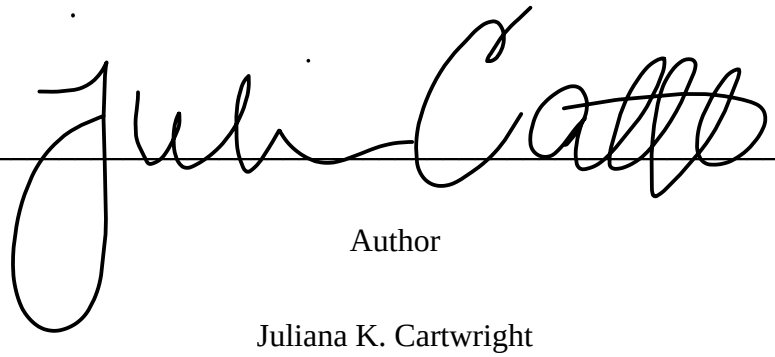
Byrdine F. Lewis College of Nursing and Health Professions

Georgia State University

Atlanta, Georgia 2021

AUTHOR'S STATEMENT

In presenting this thesis as partial fulfillment of the requirements for the advanced degree from Georgia State University, I agree that the library of Georgia State University shall make it available for inspection and circulation in accordance with its regulations governing materials of this type. I agree that permission to quote, to copy from, or to publish this thesis may be granted by the professor under whose direction it was written, by the Byrdine F. Lewis School of Nursing & Health Professions director of graduate studies and research, or by me. Such quoting, copying, or publishing must be solely for scholarly purposes and will not involve potential financial gain. It is understood that any copying from or publication of this thesis, which involves potential financial gain, will not be allowed without my written permission.



Author

Juliana K. Cartwright

NOTICE TO BORROWER

All these deposited in the Georgia State University Library must be used in accordance with stipulations prescribed by the author in the preceding statement. The author of this thesis is:

Juliana K. Cartwright

4201 Rutherford Glen Circle

Doraville, GA 30340

The director of this thesis is:

Chip Zimmerman, PhD, RRT-NPS

Governor's Teaching Fellow

Director of Clinical Education and Clinical Associate Professor

Byrdine F. Lewis School of Nursing and Health Professions

Department of Respiratory Therapy

Georgia State University

P.O. Box4019

Atlanta, GA 30302-4019

VITA

Juliana Kathryn Cartwright

ADDRESS: 4201 Rutherford Glen Cir

Doraville, GA 30340

EDUCATION:

MS RT 2021 Georgia State University

Lewis College of Nursing and Health Professions

Atlanta, GA

EXPERIENCES: Pre-Graduation (B.S E.S Internship, Respiratory Technician, and Externship)

BS in Kinesiology and Health

Northside Hospital Outpatient Services

Piedmont Atlanta Hospital

Children's Healthcare of Atlanta (Egleston)

Wellstar Kennestone Hospital

Post-Graduation Employment:

Piedmont Atlanta Hospital

Children's Healthcare of Atlanta (Egleston)

EXAMINING THE PREVALENCE OF SELF-REPORTED RESPIRATORY SYMPTOMS AND RESPIRATORY INFECTION AMONGST FIREFIGHTERS IN THE PRESENCE OR ABSENCE OF ASTHMA

By

Juliana Kathryn Cartwright, BS-ES, MS-RRT

(Under the Direction of Dr. Ralph "Chip" Zimmerman)

ABSTRACT

BACKGROUND: Firefighters are exposed to numerous chemicals, fumes, and particulate matter on a regular basis. Current research shows a notable correlation between the number of years exposed to these chemicals, and the presence of respiratory related symptoms in firefighters. **PURPOSE**: The aim of this study was to determine if a significant positive correlation exists between the number of years in service as a firefighter and the development of respiratory symptoms. **METHODS:** An online survey utilizing the St. George's Respiratory Survey was used to determine if there is a positive correlation between the number of years a fireman has served and the frequency of developed respiratory symptoms. Respiratory symptoms listed in the survey included coughing, shortness of breath, sputum production, and wheezing. Telephone, email, and Facebook were used to recruit fire departments within a large southern metropolitan area. Both active and retired firemen were included in the study. Inferential statistical tests included a Spearman's correlation test and Whitney-Mann U test to determine if an association existed between years of service, respiratory symptoms, use of respirators and respiratory symptoms. **RESULTS:** A total of 43 surveys were completed and recorded. Among all respondents, 88% (N = 38) of were male, 4.7% (N = 2) were female, and 7.0% (N = 3) were

unidentified. 48.8% (N = 21) of participants were between the ages of 45-54 years, 32.6% (N = 14) were 35-44 years, 4.7% (N = 2) were 25-34 years and 18-24 years, respectively, and 7.0% (N = 3) accounted for unidentified age. Spearman's correlation test for a computed score of respiratory symptoms (M 2.74, STD ± 2.85) was p = 0.81, suggesting no significance in correlation for the presence of respiratory symptoms. In addition, a Spearman's test was used to examen each of the symptoms individually, those results indicated no significant correlation between number of years in service and the presence and frequency of respiratory symptoms (coughing r = 0.014, p = 0.93, phlegm production r = 0.030, p = 0.856, shortness of breath r = 0.007, p = 0.97, and wheezing r = 0.099, p = 0.549). Wheezing showed the most significant results but had a weak positive correlation (r = 0.099 p = 0.549) with the number of years in service. This could suggest an existing correlation between certain respiratory symptoms and the line of work involved in a full-time fireman; however, more research is needed to support this conclusion. Examining the correlation between the use of respirators and respiratory symptoms, a Mann-Whitney U test was used to determine the prevalence in respiratory symptoms in those that used a respirator and those that did not ("YES" N = 28, "NO" N = 11, and N/A N = 4). Results showed no significant relationship between those that use and do not use a respirator and developed respiratory symptoms. **CONCLUSION:** The study findings support the conclusion that developed respiratory symptoms are idiopathic in nature. More research is needed to further determine the source of respiratory symptoms, particularly in those involved with fumes, chemicals, and particulate matter.

DEDICATION

First and foremost, I want to thank my family, friends, colleagues, and professors for their endless support throughout this past year. Amid a pandemic, I realize more than ever how much a support team is necessary to carry on with strength and persistence. Coming together for a purpose bigger than is tangible requires communication, constant effort, and uplifting energy from a support team.

My deepest gratitude goes to my amazing parents, sister, and two brothers who have supported me through this endeavor to become a respiratory therapist upon completion of this degree. Mom and dad, I love you so much and I cannot thank you enough for all that you have done for me.

I dedicate this thesis to all the emergency personnel and healthcare workers out there serving their community every day. You have committed your life to save and preserve others and I have endless gratitude for all of you!

Special thanks to my loving siblings and friends for their constant support and endless love. Thank you from the bottom of my heart!

ACKNOWLEDGEMENTS

I would like to sincerely thank my advisor Dr. Ralph (Chip) Zimmerman, Dr. Rachel Culbreth, and Professor Laryssa Frederick for their constant support and guidance throughout this endeavor and for always reassuring my type A personality that I am staying on top of my game. Your expertise, feedback, and support is invaluable to the completion of this thesis. Thank you, and to all of my classmates, friends, and each of the responding fire departments for your support and aid throughout this process. Words nor actions can describe how grateful I am for all of you!

Juliana Kathryn Cartwright

Spring 2021

Table of Contents

List of Tables

List of Figures

CHAPTER I

INTRODUCTION

Background

Occupational and environmental exposure of human operations, human exploitation of resources, and natural disasters inflicted by dramatic changes in climate are each contributing to our elevated risk of exposure to toxic agents. Fire fighters are increasingly becoming recognized for having an "increased risk for developing acute lung disease throughout the course of firefighting tasks" and an increased risk for chronic lung disease in comparison to the majority of the human population (International Association of Fire Fighters). According to Industrial Safety and Hygiene News, firefighters experience enhanced level of exposure to various toxicants such as carbon monoxide, respiratory tract irritants such as sulfur dioxide, hydrogen chloride, phosgene, nitrogen oxide, aldehydes, and other particulate matter at a heightened rate than most other occupations. These toxic agents are derived from the combustion of building materials. Furthermore, there is an increasing concern for substances such as particulate matter as it pertains to the health of wildland firefighting crews. While wildland firefighters will not be the focus of this research, bush/wildfires have destroyed more acreage of the United States in the past decade than ever recorded, starting at 3.6 million acres in 2014 to an astounding 8.8 million in 2018 (Gupta, 2019). The bushfires of Australia proved worse with over 20 million acres of Australian habitat destroyed by fires. A study more central to the focus of this thesis was conducted in Southern Australian metropolitan firefighters observing the lung function and health-related quality of life (Schermer, Malbon, et al., 2010). Ultimately, the results remained inconclusive but highlighted the significance that occupational exposure could potentially have on the body. These examples are important pieces to include in the overall analysis of health risk

stratification amongst not only fire departments, but also surrounding populations. The level of exposure, environmental or occupational, is valid for concern in the role it plays on overall health regardless of demographic setting. Both upper respiratory tract and lower respiratory tract infections are a cause for concern especially amongst those responding to bigger catastrophic events. Numerous studies reveal the significance of impact that the World Trade Center terrorist attacks had on the health of responding firefighters and other emergency personnel (Berninger, 2010; Feldman, 2004; Prezant, 2002). Despite the decline in number of fires since the 1970s, the United States fire departments are experiencing an increase in calls to respond to emergencies in comparison to past years. Though the cause of this change is unknown, many experts speculate this could be due to drastic changes in weather patterns combined with a dramatic increase in exploitation of resources. The combination of these two terms is called wildland urban interface (NFPA). The relevance of maintaining and enhancing the safety of our emergency service personnel through established protection protocols and more personalized health screenings is vital to minimizing the impact our societal norm has on the physical functioning of our bodies.

Statement of Problem

Little research exists pertaining to the health of firefighters throughout the course of their career, raising concern on the magnitude of this issue. "Health effects of acute exposures beyond susceptible populations and the effects of chronic exposures experienced by firefighters are largely unknown" (Adetona, Reinhardt, et al., 2016; Pauline, 2007; p239-252; Pittman 2012, p99-103; Silva, 2015, p991-999; Yip, 2016, p200-206) leading to the question on what we know will be effective in keeping this population safe on the job. The presentation of upper and lower respiratory infection can vary depending on the type and severity of the condition as well as the level of exposure everyone endures on any given day. Several studies highlighted the

significance of impact that the World Trade Center terrorist attacks and other man-made disasters had on the responding firefighters, EMS workers, veterans. These studies sought to analyze the trends of symptoms in upper and lower respiratory symptoms and their impact on health-related quality of life (Pauline, 2007, p239-252; Pittman 2012, p99-103; Silva, 2015, p991-999; Yip, 2016, p200-206). An exceptional amount of these firemen/women and other responding personnel endured what is now termed World Trade Center (WTC) cough syndrome (Prezant & Weiden, et al., NEJM, 2001). This condition is characterized by a prolonged cough and increase in shortness of breath, likely caused by repeated inhaled WTC dust and smoke from September 11th terrorist attack. In the days following the event, individuals reported being ill for up to four weeks at a time. The magnitude of this attack from an environmental and occupational standpoint is larger than an average call; however, it highlights the significance of impact that certain disasters can have on the respiratory system. Utilizing more proactive measures rather than reactive measures to maintain higher health status and improving quality of life will be key to more enhanced protection. The development of these strategies should not be the sole responsibility of those responding. At the very least, thorough records of fire department employees' health status should be kept. Understanding how the body responds to foreign particles in the lungs is enough to raise concern for what they can do over prolonged periods. Examining both the acute and chronic effects of combusted sites in active fire fighters allows the opportunity to examine the physiological responses and trends of these symptoms that occur at various levels of exposure. Exposure to hazards in this line of work undoubtedly provokes the question, "how are fire men and women staying protected?" In essence, the answer is mixed. Protocols with the sole purpose of protecting firefighters during training exercises, real-life rescues, etc. are established and used daily. However, some research shows that limitations to

these programs exist and vary amongst fire departments worldwide. The adequacy and accuracy of utilization, implementation, and execution of these protection programs varies amongst departments. One related study reviewed the effectiveness of a protection program implemented in Queensland, Australia; called the "Go Home Clean" and results indicated that reliability of the program exists but is limited to the utilization of the program per department (Kirk, Logan, et al. 2019).

This is purely human nature and the resolution to any emergency is difficult if not near impossible to predict at times because of numerous participating factors. Other factors that can determine level of exposure include location, area covered per department, and demographic type. The objective of the established protection programs may be tarnished in their effectiveness to protect purely due to user error raising concern for the reliability of these programs/protocols. For this thesis, further examination of trends in respiratory symptoms amongst firefighters in an urban setting were to further enhance our comprehension on the subject. Understanding the purpose of these protection programs and the optimal effect that they can potentially pose, is not completely understood. To provide more research in support of enhanced protections, the focus will aim to identify patterns of respiratory related symptoms and how they manifest overtime in firefighters and those retired from the job within the Metro-Atlanta area.

Research Questions

1. What is the association between the start of respiratory symptoms and previous occupational exposure of particulate matter among firefighters?
2. Is there an association between frequency of response calls related to fire or toxic chemical combustion with respiratory symptoms among firefighters?

3. Do firefighters follow all standard precautions or does some leniencies exist in the practice of these protections?
4. What is the overall quality of life in those that are senior firefighters or retired individuals from the profession (those with theoretically the highest exposure rate of particulate matter)?

Assumptions

Assumptions for this analytical study are:

1. Firefighters are exposed to various substances during their workday in addition to standard pollution, either of which can cause a deterioration in lung function. This lung function deterioration may manifest as respiratory symptoms, such as wheezing, cough, and shortness of breath.
2. Existing symptoms suggest a repeated upper respiratory infection or possibly a chronic condition involving the lower respiratory airways due to the prolonged exposure.
3. Reactive airway symptoms are more prevalent in those that have asthma and inhale dust and smoke particles on combustion sites.
4. The variance and possible inconsistency in proper utilization of protection equipment, protocols, and other programs could increase the overall risk of firefighters developing a respiratory-related condition or deteriorated lung function.
5. Firefighter participants remember and accurately recall their symptoms and exposure level.

Procedures

In order to identify what symptomatic data is directly correlated to the work of firefighters, direct feedback from fire emergency personnel is vital. Therefore, recruitment of the Atlanta Fire Department as well as recruits from various social media platforms (Facebook, Reddit, Twitter, Instagram), and by direct word of mouth was conducted for subject recruitment. This study was strictly anonymous in its survey requirements. Information pertaining to personal identification was deleted from the study upon analysis of all collected data. An electronically questionnaire was administered via Qualtrics. An introductory section included questions on demographics and occupation-related aspects, the St. Georges Respiratory Quality of Life (Jones, 1991) questionnaire, and a closing section contained an open-ended section, giving each participant the option to provide additional comments about their current health status as it relates to their occupation.

Limitations

Several limitations could introduce bias into the results. Recall bias could affect the study results as the study is observational and relies on self-reported data. Recalling specific detail as it pertains to specific questions within the study is not guaranteed to be completely accurate. A pre-existing questionnaire along with relevant occupational demographic questions are included to eliminate this bias as much as possible with neutral single-answer (yes/no) questions. The limitations to this type of data are potentially greater than objective data, but it still holds a significant stance in the overall analysis as it pertains to progressive health status and quality of life. The perception of an individual studied, has more significance than, say, a blood sample even though the blood sample can provide some means of truth to the physiological function of the body. The context to which individuals develop physical characteristics within their physiological ability is the general theme that is looked at with this research.

Purpose of this Study

The purpose of this study is to identify the associations of respiratory related symptoms and occupational exposure amongst firefighters in the Metro-Atlanta area as well as various suburban and rural areas in Georgia. This research will assess the general timeline to which symptoms start to occur as well as which symptoms are more prominent amongst the participants. In addition, analysis of frequency in these reported symptoms will be used to assess how symptoms and possible respiratory conditions (whether pre-existing or not) have affected overall quality of life in those active and retired.

Definition of Terms

Atopy: The genetic tendency to develop allergic diseases such as allergic rhinitis, asthma and atopic dermatitis (eczema). Atopy is typically associated with heightened immune responses to common allergens, especially inhaled allergens and food allergens (American Academy of Allergy, Asthma & Immunology, 2020).

$PM_{2.5}$: Particulate matter that does not exceed the spore size of 2.5 μm and contributes to the size level of toxins that travel into the lungs on a major combustion site, construction site, or factorial setting with asbestos being one of the most prominent. Using a nationwide network of monitoring sites, EPA has developed ambient air quality trends for particle pollution, also called Particulate Matter (PM). $PM_{2.5}$ describes fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller (EPA, 2018).

Upper Respiratory Infection: Infections that pertain to the nasal cavity, sinuses, and extends down to the pharynx. Common symptoms reported include nasal congestion, headaches,

coughing, sneezing, sore throat, nasal discharge, difficulty swallowing, fever, otitis media (ear inflammation), and cervical lymphadenopathy

Lower Respiratory Infection: Infections that pertain to anatomical structures of the respiratory system below the pharynx into the bronchial tree known as the lungs. Symptoms related to lower respiratory infections include severe and productive cough, fever, difficulty breathing, others are discovered upon medical examination.

Occupational Asthma (OA): A type of asthma caused by exposure to inhaled irritants in the workplace. Occupational asthma is often a reversible condition, which means the symptoms may disappear when the irritants that caused the asthma are avoided. However, permanent damage can result if the person experiences prolonged exposure. Examples of workplace irritants include dusts, gases, fumes, and vapor (Johns Hopkins, 2020).

Wildland Urban Interface: An area where human made structures and infrastructure (e.g., cell towers, schools, water supply facilities, etc.) are in or adjacent to areas prone to wildfire (WUI, 2020).

Summary

In order to quantify risk on the exposure of inhaled toxic agents on fire emergency personnel, more research needs to be conducted in tracking symptoms amongst active firefighters. Identifying what symptoms are most frequent, quality of life, and also identifying any existing trends in the type of respiratory conditions developed later on in those retired, will help us gain more perspective on what we should be looking for in every annual physical examination. Analyzing the effectiveness of existing protocols and determining their degree of protection amongst firefighters will not be the focus, but it will be noted of its importance in the

health of those abiding by them. The first major step is determining what symptoms are most common amongst firefighters, how many of them have asthma, and how many of them have developed a chronic cough, asthma, or other respiratory-related condition (diagnosed or undiagnosed) over the course of their career. In conclusion, the more we know and comprehend the magnitude of exposure to which this occupation of individuals endure, the more we can improve health and safety protocols that are more proactive in nature rather than reactive.

CHAPTER II

REVIEW OF THE LITERATURE

Exposure of harmful substances is a constant variable in modern society. Fuel emissions from cars, major corporations, smoking/second-hand smoking, even the smoke produced in preparing food with poorly insulated homes, are all vibrantly present in the air we breathe. In terms of occupational exposure, aside from recreational smokers, those that work in factories, farmers, construction workers, emergency service personnel, and even law enforcement officers are exposed to higher levels of toxic particles. The extent of exposure to harmful chemicals is still largely unknown, however more studies are taking place to exploit these unknown variables. One recent study conducted by Poutasse and colleagues revealed eighteen new substances workers are exposed daily using military-style silicone dog tags (Poutasse, Poston, et al, 2020). Another study highlights the numerous substances that are cause for concern in wildland fires. These substances include aldehydes, polycyclic aromatic hydrocarbons, carbon monoxide,

benzene, and respirable particulate matter, some of which could increase an individual's risk for cancer (Booze, 2004). These findings imply that there is a lack of awareness amongst companies/corporations with known exposure hazards and all the substances that are present in the air workers breathe.

Exposure & Symptoms

In terms of exposure, the duration magnitude of exposure has a more significant effect on lung function than just the state of being exposed all together. Several studies (Ahmad, 2020, Jones, 2000; Magdelena, 2017) indicate that there is a direct correlation between the amount and/or length of time exposed and the deterioration of lung function. In a cross-sectional case study, a comparison was made between small scale industry workers regularly exposed to various substances daily to those not exposed to the same substances daily. Utilizing Medical Research Council questionnaires and a Micro Direct computerized automated spirometer, measurements of pulmonary function testing were made to determine in variations in the subject population. All subjects compared matched in demographic and anthropometric measurements to ensure validity of the results. The participating subjects included mechanics (40.9%), welders (31.8%), and painters (27.3%) respectively. The most common of reported symptoms included chest tightness and wheezing among those exposed (22.7%) and those unexposed (10%). Occupational exposure was reported often in 22.7% of the subject population, sometimes in 68.1%, and never in 9.1% of the subject population. Results in pulmonary function testing showed a deterioration in mean values of FEV1 and PEF. This study indicates that occupational exposure could increase the risk of developing respiratory symptoms as well as decreased pulmonary function as compared to those unexposed. This data reveals the level of harm a substance can have on the body even after leaving a primary site of exposure (scene of an

accident where fumes, flames, and/or toxins were involved) thus leading researchers to question which substances are the most detrimental from a physiological standpoint.

Types of Exposure

Carbon monoxide is renowned for its adverse effects on the body upon inhalation. There is extensive research that displays the nefarious nature of carbon monoxide as it pertains to severe illness, coma, and death. For the purposes of this research however, more attention is paid towards the effects it has on firefighters due to their elevated exposure in comparison to the average non-firefighter individual. One study published by the Journal of Occupational & Environmental Hygiene (J OCCUP ENVIRON HYG, 2019), analyzed the effects carbon monoxide on wildland firefighters in various work, fire, and environmental settings. A U.S Forest Service study conducted during the fire seasons of 2009-2012 was included to analyze data of carbon monoxide (CO), logging detectors in 57 different fires throughout the country. Worker tasks, fire characteristics, and environmental conditions were measured at scheduled intervals. A total of seven-hundred and thirty-five wildland firefighter work shifts were analyzed to assess any variations in worker tasks, fire characteristics, and environmental conditions. Average length of work shift was 11 hours and 15 minutes. Geometric mean full shift time-weighted averages were measured in parts per million (ppm). Sawyer/swamper tasks had the highest mean of CO exposure at 6.8 ppm, putting workers at an estimated nine times higher odds of having a one-minute CO measurement that exceeded 25 ppm. After adjustments were made CO exposure in correspondence to shift length, elevation, and work level, 2% and 4% of the wildland firefighters exceeded the recommended level of exposure to CO as established by the National Institute for Occupational Safety and Health as well as the Governmental Industrial Hygienists threshold limit value. Variables used to measure exposure in this study included task,

fuel model, wind orientation, crew type, relative humidity, type of attack, and wind speed. Each of these variables can help quantify the amount of CO exposure and aid in further recognition of conditions that could lead to elevated levels of CO. Further research needs to take place in order to determine the most significant of these variables, however each plays role in the level of exposure each firefighter endures.

Exposure faced by Firefighters

The extent to which each toxic agent impedes normal physiological function is more complex and varies from individual to individual. Comprehending this magnitude of impact on the body requires studies pertaining to specific groups of firefighters. This approach allows researchers to identify and quantify who is at a greater risk for developing a pulmonary condition long-term. Identifying those at greater risk does not exclude those that are at some level of risk of exposure. The entire population of firefighters potentially have an elevated risk simply because of their occupation. For this reason, further quantification of specific firefighter populations will precede after the introduction of conducted research projects on the general assessment of exposure risk.

Firefighters are generally considered to be rather healthy and fit individuals that are thoroughly trained in the work of combating fires and other disaster-related situations. This line of work is often accompanied by exposure to toxic agents, especially combustive agents. A study conducted by Magdalena and her colleagues, sought to examine the effects of common toxic agents present at fire scenes to lung function. The most frequent of these toxins include carbon monoxide, hydrogen cyanide, ammonia, hydrochloride, phosgene, and chloride. The extent of these chemicals and their level of trauma in the airways (airway lesions) was the main objective of this study. Firefighters with a minimum of ten years in the service were included for analysis.

Data was collected through a questionnaire, physical examination, laboratory testing, and lung function testing to ascertain the effects of these toxins in the airways. Results showed a high percentage of pathological symptoms in the targeted group. The frequency of symptoms was directly correlated with the duration of occupational exposure to toxic agents. Other results showed an obstruction of flow in medium-sized airways in about 30% of the studied individuals, a significant finding that reveals much about the effects of chronic exposure to toxic agents. An additional test group of three-month-old rats were insufflated with solution of powdered fire-extinguisher upon collection of lung tissue for morphological study. Dissemination fibrosis was noted amongst these samples further supporting the notion that inhalation of the toxic agents at a combustive scene and even the resources used to combat the flames are major indicators of possible respiratory dysfunction. This further supports the conception that special medical care geared to prophylaxis, early detection, and therapy of pulmonary diseases is imperative to keep firefighters healthy both during their career and after.

Common Pulmonary Conditions, General Health, and Quality of Life

Despite the reputation of firefighters to be strong and healthy, there is a steady increase in the number of firefighters that have present comorbidities. Examples of these comorbidities include but are not limited to hypertension, obesity, high cholesterol, rhinitis, asthma, etc. Not all firefighters have stellar health records, and to maintain the validity of this research, we will focus on firefighters suffering from asthma. Asthma as it is recognized by the general public, is defined as the combination of respiratory symptoms and airway hyperresponsiveness. Asthma is one of the most underdiagnosed pulmonary conditions and can have a major effect on the health of firefighters especially if their asthma is extrinsic in nature. Individuals who suffer from asthma are at a heightened risk for enduring an inflammatory reaction caused by inhaling a substance

that elicits IgE antibodies to be released thus leading to an inflammatory reaction in the airways. The range of these particles, agents, toxins, etc. is very broad and varies for everyone. In addition, it is difficult to treat asthma when other respiratory related comorbidities are present, such as rhinitis, sinusitis, COPD, etc. Studies conducted by Petersen and his colleagues on Danish firefighters and Miedinger and their colleagues both indicate even higher risk for those working in this occupation. However, attention must be noted to the limitations of these studies and the amount of support they contribute to this discussion of occupational exposure. Asthma is complex in nature due to its idiosyncratic etiology but provides as a great starting point to understand the nature of occupational exposure amongst fire crew members and the potential impact it could have on a chronic level, if not treated and managed in a proactive manner.

The etiology of certain pulmonary conditions, such as asthma, are still somewhat unclear due to the numerous phenotypes they exist in. One article published in the Journal of Allergy and Clinical Immunology (2020), focuses on the assumption of these phenotypes of occupational asthma (OA) and how each can differ in their general presentation in affected individuals. Each phenotype contributes to the underlying mechanisms of asthma and reflects existing immunological mechanisms that are indicated in the presence or absence of specific IgE-antibodies as it responds to a sensitizer. Further examination of these phenotypes aids in better understanding and therefor, better diagnostic approaches and management. The term sensitizer is mentioned throughout and refers to the actual allergen, pathogen, irritant that causes a reaction in the airways thus causing respiratory symptoms to occur. Expanding on this concept, evidence revealed differing data in occurrences of OA and corresponding molecular weight sensitizers (chemical sensitizers). This is more relevant for non-occupational asthma. Irritant-induced asthma is the most easily recognized of the types when one or more high-level respiratory irritant

exposures are present, however this is also possible with chronic exposure to lower-level exposures as it is routinely observed in cleaners, farmers, and woodworkers. OA chronic obstructive pulmonary disease is more so overlapped with older populations and low-molecular weight sensitizers. With these points in mind, more research is in order, but minimizing exposure to any work sensitizers is strongly advised until better comprehension of the effects of these sensitizers is obtained.

Pedersen's study analyzed the incidence of asthma and chronic obstructive pulmonary disease (COPD) in a nationwide cohort of male Danish firefighters. Individual employment records of 968 subjects from various fire agencies and information regarding to incidence respiratory issues was retrieved from the nationwide Danish National Patient Registry. A group of military employees was included to compare in the resulting data. Estimation of risk was quantified using age and calendar time standardized incidence ratio and Poisson regression analyses (incidence rate ratio). Results showed a significant increase among full-time firefighters in overall age and calendar-adjusted risk for asthma (SIR=1.58, 95% CI 1.32 to 1.88), but not amongst those that were part-time or volunteered as firefighters. The amount of risk did not vary amongst full-time workers in their duration of employment, no consistent evidence suggested any greater risk of COPD. However, these measurements are significantly influenced by a variety of factors that vary on an international level, indicating a significant limitation in the reliability and validity this study.

Despite these noted limitations, Asthma is complex in terms of diagnostics and thus leads to the question of who has asthma and who doesn't? How reliable are current diagnostic procedures? Asthma has numerous phenotypes (discussed later) and is diagnosed using several different methods. The purpose of this is since test results, depending on the method used, are

individualized, or will vary person to person. The next piece of literature poses as a prime example of this phenomenon and highlights the importance of thorough testing for a more accurate diagnosis, and thus, proper management of the condition.

Another study conducted amongst firefighters in Basel, Switzerland further quantified the level of risk that asthmatic firefighters face. Methods of data collection included questionnaires, spirometry, direct and indirect bronchoprovocation challenge tests, exhaled nitric oxide, and skin-prick test. A total of 101 subjects were included in the data analysis. Of these subjects, six had physician-diagnosed asthma, while 14% were initially diagnosed during the study. Of all known symptoms, wheezing was the most predominant symptom in the diagnosis of asthma with a 78% sensitivity and 93% specificity value. Other respiratory symptoms showed higher specificity but lower sensitivity. The bronchial airway challenge with mannitol proved to be the most sensitive (92%) and specific (97%) for the diagnostic of asthma. Nitric Oxide had a similar specificity, but lower sensitivity compared to more direct methods of the bronchial challenge test. These results indicated that asthma was significantly underdiagnosed in firefighters, an alarming fact that could play a major role in the health of subjects in this line of work as their careers in this field progress and thus their exposure to toxic agents.

The significance of asthmatics working as firefighters is relevant in that it allows researchers to further understand the mechanisms behind which our airways react to certain substances. While asthma is a pulmonary condition characterized by hyper-responsiveness to specific agents causing an inflammatory reaction and thus airway obstruction, similar mechanisms are likely to occur with prolonged exposure to toxic agents and particulate matter (PD20) in normal airways. The next study discussed, relates to bronchial hyper-responsiveness (BHR), lung function, and atopy in fire fighters acutely exposed to fire smoke. Atopy referring to

an allergy of any type. A total of 402 firefighters randomly chosen via survey amongst the fire service community in the Netherlands were the selected subjects for this study. Spirometry, methacholine provocation tests, and blood samples for the assessment of atopy were conducted for each subject. The known exposure to fire smoke was established through the survey. Results indicated that hyper-responsiveness was positively and significantly associated with the number of fires fought in the previous 12 months. This result included and excluded adjustments made for smoking, gender, age, and exposure in the main job position held by everyone. The data pertaining to hyper-responsiveness further supported this result amongst those who were atopic, concluding that atopic individuals (persons with an existing allergy) are at a higher risk of developing a bronchial hyper-response as a result of smoke exposure. With this data in mind, more precautions and adequate use of self-contained breathing apparatuses should be executed in order to minimize exposure to each personnel.

Short-term Exposure and Long-term Effects

While most of this research focuses on the effects of prolonged exposure, there are special case scenarios that reference higher levels of exposure in short periods of time that could lead to long-term health issues. An adequate example of such a case includes the events of Chernobyl, however these events focused on heightened levels of radiation and general deterioration of health as a result. In fact, most firefighters that responded to this event, perished as a result of the radiation they endured from putting out the flames and moving debris, posing as a reliable example for the level of risk firefighters take on when responding to a combustive incident. Another notable example that is more directly correlated to this line of work, references the New York City firefighters who responded to the World Trade Center (WTC) attacks and the numerous hazards they were exposed to. The World Trade Center (WTC) terrorist attacks

invoked tremendous devastation to all of those involved, including the responding emergency personnel.

One study examined a sample of firefighters three weeks following the World Trade Center disaster. Each firefighter completed a medical screening program in order to assess pulmonary function and the effects these hazards may have had on the lungs during the initial response to the attacks. The purpose of this assessment was to determine whether arrival time at the WTC and other exposure variables (discussed later), were associated with symptoms and changes in pulmonary function during the first two weeks at the WTC site. Of those sample, 19% indicated they did not use a respirator and 50% reported using a respirator but rarely. Prevalence ratios (PRs) for skin, eye, respiratory, and NT symptoms showed a dose-response pattern based on time of arrival in compared groups that were present at the WTC site for greater than seven days or less than seven days. Spirometry scores before and after exposure showed even reduction in FVC and FEV1. In comparing these values to incumbent FDNY firefighters prior to September 11th, the reductions were greater than annual reductions measured FDNY firefighters prior to the attacks. There was a 60% increased risk of a decline in FEV1 (>450ml) in those that responded during the first 48 hours compared to the referent group. The symptoms and spirometry results recorded, suggest improved protocols for respirator usage, be implemented into everyday practice for emergency responders as well as extensive medical monitoring for these individuals. It is important to highlight the date of this study and its relevance to current research and statistical findings; considering the age of this study, a lot has changed since the early 2000s in terms of protocols and safety guidelines. However, this example highlights the issue that user error or lack of use despite resources for protection being available, could potentially have an impact on pulmonary function over time.

Another study of the same subject population examines the health-related quality of life (HQoL) in male firefighters suffering from WTC cough syndrome and retired due to 9/11-related pulmonary conditions. Two-hundred and seventy-five disability-retired firefighters were contacted between the time periods of March 2008 and January 2009. All of those contacted were compared in terms of HRQoL and aerodigestive conditions to those non-disable retired WTC veterans. Using a multivariable regression model both HRQoL and explanatory variables were examined. Results indicated that physical component summary (PCS) scores were lowest in disabled retirees compared to those non-disabled. Scores: 36.4 (9.6), 49.4 (8.7), and 53.1 (5.1), respectively ($P < 0.0001$). The mean mental component summary (MCS) scores were closer in relation, 44.5 (11.9), 48.1 (8.5), and 48.7 (7.4), respectively ($P < 0.0001$). When utilizing a multivariable approach with the addition of adjustments to specific factors, PCS was not associated to early WTC arrival, but was inversely associated with disability retirement and all WTC cough syndrome conditions suggesting that pulmonary injury as a result from responding to the WTC events had a major impact long term beyond an active career as a firefighter. MCS scores were inversely associated with early WTC arrival and most WTC cough syndrome conditions, but not associated with disability retirement. This study concludes that there is a relationship between those with WTC pulmonary conditions and lower HRQoL scores even 8 years after exposure. This data suggests that close monitoring of physical condition amongst active firefighters is crucial to developing more proactive measures to protect the health of these individuals.

Military operations are another prime example of how occupational exposure can affect the body. Ongoing operations in Afghanistan and Iraq as well as operations during the Gulf Wars in the Persian Gulf exemplify the long-term effects that exposure to smoke and other chemicals

can have on health. One study by Szema and his colleagues highlights the health issues that aroused as a result of burning pits on military bases in Afghanistan and Iraq. 14% of previously healthy soldiers deployed to Afghanistan and Iraq, reported respiratory symptoms post-deployment and new on-set asthma was established in 6.6% of these subjects. This article utilized survey questions on veterans and an online database called Burnpits360.org, a nonprofit civilian website that voluntarily tracks symptoms of soldiers' post-deployment in the Middle East. Analysis of thirty-eight patients compared the strengths and weaknesses of Iraq/Afghanistan Lung Injury (IAW-LI) as outlined by the VA National Academy of Sciences Institute of Medicine Burn Pits Workshop. Factors analyzed included risk factors of affected populations, existing practices for management of the condition, and future research objectives. Results stated that 23.7% of these soldiers worked in the burn pits, 26.3% stated they did not work in the burn units. Of the sample size 58% reported having respiratory symptoms such as shortness of breath after minimal activity, chronic cough, and asthma-related symptoms. 11% reported cancer post-deployment. The survey also inquired about the availability of post-deployment services however limited information is present in this article.

The Gulf War presented with numerous health hazards that are still somewhat mysterious in current clinical studies, yet more veterans are tracing their current regressing health status as a result of the prolonged exposure to burning oils, burning pits, and other toxins during their tours in the Persian Gulf. One study highlighted the significance of Constrictive Bronchiolitis reported in US Operation Iraqi Freedom/Enduring Freedom (OIF/OEF) deployers. The significance of this report is apparent in that other previous US conflict responding groups did not report this health issue. Respiratory symptoms are a feature associated with many Gulf War-related medical

illnesses that are still unclear in origin or diagnosis and are beginning to regain attention by clinical researchers in terms of their presence in conditions such as Chronic Bronchiolitis.

There are numerous other instances in which acute exposure could provoke adverse effects in the pulmonary system. The WTC attacks and the Gulf War conflicts in the Persian Gulf are a small sample in which exposure to inhaled toxins in one conflict, incident, etc. could increase patrons' chances of having a lower quality of life as a result of decreased pulmonary function.

Protection and Safety Protocols

There is no question that occupational exposure to fumes, chemicals, and other particles, are a relevant hazard to firefighters, this opens the discussion to necessary protection programs and protocols that fire departments must follow in order to adequately protect their crew. Currently, there are existing protocols, guidelines, and programs enforced by the Federal Emergency Management Agency (FEMA) and the U.S. Fire Administration (USFA), that address the different level of exposure and contamination. The most common issue, however, is the extent of implementation, how well these guidelines are followed, and the level of education that is given to each crew members. Each of these factors contributes to overall user error and therefor, an increased risk of exposure over time. Rather than a study, Kirk and their colleagues conducted an article that highlights a research program aimed to identify hazards posed to firefighters of toxic elements that land on their clothing. Experiments included in this research program included residential fires, commercial premises fires, industrial fires, and common firefighter training scenarios. Air contaminants were measured inside and outside of the protective clothing and skin. Methods used to assess levels of exposure included wearing appropriate respiratory and skin protection, establishing operational zones, adopting personal

hygiene practices, and proper cleaning of clothing post-operational procedures. Results of the experiment supported the further promotion and utilization of informed practices within the QFES to improve post fire cleaning, onsite decontamination, and hygiene practices.

Summary

The level of exposure that firefighters endure daily is not a new issue. To ensure the safety and health of firefighters while on duty, implementation of respiratory protection program should be standard for everyone fire department. One study conducted the effectiveness of respiratory protection practices, barriers for program implementation, and medical evaluation programs for firefighters located in Kentucky. A 21-question survey assessing respiratory practices during the previous 12-months, these surveys were mailed to all existing fire departments in Kentucky. Results indicated a 62% survey response rate with 116 of the 120 counties returning at least one survey. All respondents reported to have a respiratory protection program in place, but only 37% reported having a written protection program in place. Compensation status and department size were found to be significant variables in determining whether a fire department had a written respiratory protection program. Lack of funding accrued 48% of surveys, lack of comprehension accrued 39% and were identified to be the greatest barriers to program implementation. Only 51% of surveys required their firefighters be fitted for a respirator and only 23% indicated a health-care provider reviewed medical questionnaires or provided medical evaluations. This concludes that more attention needs to be directed at improving quality of these protection programs and require a more thorough analysis for health screenings in order to have more reliable data that reflects the health of individual working on the frontline of fire emergencies.

Purpose for Research

In order to identify what symptomatic data is directly correlated to the work of firefighters, direct feedback from fire emergency personnel is vital. Most of the mentioned studies review clinically measured data such as pulmonary function testing and medical exams. This research is analyzed for its validity and reliability, both of which have a strong presence in the clinical data collected for each study. A majority if the data, however, is subjective to the individuals who participated in research, but symptoms and signs are data clinicians rely on every day to make a proper diagnosis. The limitations to this type of data are potentially greater than objective data, but it still holds a significant stance in the field of research as it pertains to progressive health status and quality of life. The perception of an individual studied, has more significance than, say, a blood sample even though the blood sample can provide some means of truth to the physiological function of the body.

The purpose of this research is to highlight the prevalence of self-reported respiratory related symptoms as well as reflect on how these symptoms and possible conditions (whether pre-existing or not) have affected overall quality of life. The frequency of respiratory related symptoms will aid in better understanding of the discrepancies and errors fire protection protocols have as well as aid clinicians in more appropriate and relevant health-screening practices for better management of health amongst these workers.

In order to determine these trends, the method of research utilized to support this issue will be in the form of an electronically administered survey/questionnaire. An introductory section will cover demographic and occupational-related questions, the St. Georges Respiratory Quality of Life questionnaire will comprise of the middle section, and a closing section will

contain a blank portion, giving each participant the option to provide additional comments about their current health status as it relates to their occupation.

Determining discrepancies within systems of implemented protocols as well as health screenings is of equal importance in this line of research. The goal in conducting this research, is to further enhance protection protocols as they relate to firefighters and the dangerous situations they face daily. Analyzing the effectiveness of existing protocols and determining their degree of protection amongst firefighters will be of focus, but in smaller margins. The first major step is determining what symptoms are most common amongst firefighters, how many of them have asthma, and how many of them have developed a chronic cough, asthma, or other respiratory-related condition (diagnosed or undiagnosed) over the course of their career.

CHAPTER III

METHODOLOGY

Research Questions

1. What is the association between the start of respiratory symptoms and previous occupational exposure of particulate matter among firefighters?
2. Is there an association between frequency of response calls related to fire or toxic chemical combustion with respiratory symptoms among firefighters?
3. Do firefighters follow all standard precautions or does some leniencies exist in the practice of these protections?
4. What is the overall quality of life in those that are senior firefighters or retired individuals from the profession (those with theoretically the highest exposure rate of particulate matter)?

Instrumentation

The instrument used for this descriptive study was the St. George's Respiratory Quality of Life Survey developed by Paul Jones (Jones, 1992) in conjunction with various questions related to the use of respirators and overall application of respirators in the field. Permission was not needed in the utilization of this survey since it is released for public use. Collaboration with the Director of Clinical Education of the Respiratory Therapy program (also appointed chairmen of this study) and assistant clinical professor aided in the formation of this survey and its release to the subject population.

Validity is the extent to which the scores from a measure represent the variable they are intended to (Chiang, 2015). The research team came to a consensus that the validity of the survey was

sufficient for analyzing the effects that years of exposure in the field, have on developed respiratory symptoms. All questions proposed for this study were included in the survey after a thorough discussion on each question and the significance of each for the appointed research.

Reliability identifies the ability of instruments to measure what they intend to measure. The finalized instrument for this study consisted of two sections, a demographic data section and the St. George's RQOL survey questions. This instrument has been previously found reliable and valid in other studies (Furukawa, 2017; Ferrer 2002; Jones, 1991).

Research Design

The study used a descriptive design with self-reporting survey. A survey is a common and popular method of descriptive research that involves gathering data using questions or interviews. The survey was designed to collect data from active and retired firemen in the metro-Atlanta area in reporting their years in the service and the presence of developed respiratory symptoms. Survey research is one of the most effective and cost-effective tools for data collection. Surveys are also useful in reaching many participants.

Sample

For this research, firefighters both active and retired were the subjects of interest. No age, race, or gender exclusions were made in the review of subjects. Age ranged from 17 years of age to 65+ years of age. Those that identified their race, ranged from Caucasian, African American, Native American, Pacific Islander, Alaskan Native, and other. A total of 43 firefighters submitted a survey. Thirty-eight identified as male, two identified as female, and three did not specify.

Data Analysis

Data analysis was conducting using two different statistical analytic tests: The Spearman's correlation test and the Man-Whitney U test. The Spearman's correlation test was used to analyze a possible positive correlation between the number of years served as a firefighter and the frequency of respiratory symptoms. This test measured the statistical dependence of these two variables to see how strongly (or not) one affects the other. The Man-Whitney U test measures the likelihood of two variables deriving from the same population. For this research study, the use of respirators and a computed respiratory score was analyzed. In addition, whether the patient exercises and a computed respiratory score was also analyzed using a Man-Whitney U test.

Protection of Human Subjects

The study proposal was submitted to Georgia State University Institutional Review Board (IRB) for expedited approval. Once IRB was granted, outreach to all counties of the metro-Atlanta area took place. Fire departments throughout metro-Atlanta, were contacted through email and Facebook. Roughly 21% of these counties responded with granted permission to disperse the survey to their department staff. Strategies for protection of human subjects were strictly implemented. Study participation was strictly voluntary with a consent form electronically applied to the start of the survey. If after reading the consent form and the participant no longer wished to participate in the survey, they were be prompted to skip to the end of the survey and exit out.

CHAPTER IV

RESULTS

The purpose of this study was to identify the associations of respiratory related symptoms and occupational exposure amongst firefighters in the Metro-Atlanta area as well as various suburban and rural areas in Georgia. The study aimed to explore the potential positive correlation between years in the field with the presentation, frequency, and severity of respiratory symptoms. Ultimately, this study looked to identify an upward trend in either frequency, severity, or both in respiratory symptoms in conjunction with the increasing number of years in service.

Research Questions

The study intended to answer the following questions:

1. What is the association between the start of respiratory symptoms and previous occupational exposure of particulate matter among firefighters?
2. Is there an association between frequency of response calls related to fire or toxic chemical combustion with respiratory symptoms among firefighters?
3. Do firefighters follow all standard precautions or is practice of these protections determined by the choice of each crew member?
4. What is the overall quality of life in those that are senior firefighters or retired individuals from the profession (those with theoretically the highest exposure rate of particulate matter)?

Demographic Findings

The study included several responses ranging from various county fire departments within the metro-Atlanta area. Metro-Atlanta is defined as encapsulating the counties of: Cobb, Fulton, Dekalb, Gwinnett, Fayette, Forsyth, Clayton, Henry, Newton, Rockdale, Walton, Barrow Hall, Cherokee, Spalding, Carrol, Douglas, Paulding, Bartow, and Coweta. The sample consisted of both active and retired firemen of all ages. There were no exclusion criteria for this study since most research questions are centered around self-reported and subjective data. Forty-three responses were received out of a maximum capacity of 200 participants resulting in a response rate of 21.5%.

Of the forty-three participants, the mean age score and standard deviation (SD) were higher in the age bracket M 4.43, SD ± 0.844. Most responders identified with the age range of 45-54 years of age, accumulating 48.8% (n = 21), 32.6% (n = 14) selected 35-44 years of age, 4.7% (n = 2) selected 25-34 years, 4.7% (n = 2) selected 18-24 years, and 7% (n = 3) did not submit a response.

The mean average and standard deviation for male responders (choice selection 1) and female responders (choice selection 2) was predominantly male, M 1.05, SD ± 0.211, 88.4% (n = 38) identified as male responders, 4.7% (n = 2) identified as female responders, and 7% (n = 3) did not submit an answer choice. In terms of ethnicity, the mean average of ethnicity was M 1.53, SD ± 0.847, with a predominant number identifying as Caucasian 55.8% (n = 24), African American 32.6% (n = 14), American Indian/Alaskan Native 2.3% (n = 1), Native Hawaiian/Pacific Islander 2.3% (n = 1), and ethnicity identified 7% (n = 3).

Mean respirator-usage average and standard deviation of the sample size was M 1.28, SD ± 0.456. The answer choice "1" indicated yes, "2" indicated no, and "3" indicated no answer (N/A). 65.1% (n = 28) reported yes as an answer, 25.6% (n = 11) answered no, and 9.3% (n = 4) did not submit an answer for this question.

Exercise was another factor looked for in order to further understand the general health of each subject. The mean average of firefighters that responded to participating in regular exercise was M 1.05 ± 0.221 "yes" category n = 38 (88.4%) and "no" category n = 2 (4.7%).

Missing Data

Of the data collected 3 participants did not fully complete the survey but still submitted an entry. Three participants did not disclose the years of service they completed or if they had respiratory symptoms, reducing the size of viable data for the research study. Due to incompletion of the survey, these three submissions were excluded from the data analysis relating to the Spearman's and Man-Whitney U tests.

Table 1: Demographic Data for Firemen in the metro-Atlanta area (N) = 43

Demographics	M, ± SD or (%)
Current Age (yrs)	4.43 ± 0.844
(1) 18-24	n = 2 (4.7%)
(2) 25-34	n = 2 (4.7%)
(3) 35-44	n = 14 (32.6%)
(4) 45-54	n = 21 (48.8%)
(5) 55-64	n = 1 (2.3%)
Sex	1.05 ± 0.221
(1) Male	n = 38 (88.4%)
(2) Female	n = 2 (4.7%)
N/A	n = 3 (7.0%)

Race/ethnicity (1) White (2) Black/African American (3) American Indian/Alaskan Native (4) Native Hawaiian/Pacific Islander (5) Other (6) N/A	n = 24 (55.8%) n = 14 (32.6%) n =1 (2.3%) n = 1 (2.3%) n = 0 (0%) n = 3 (7.0%)
Current Years of Service	16.66 ± 9.919 n = 40 (93%)
Shifts per week (1) Daily (2) 4-6 X per week (3) 2-3 X per week	2.35 ± 0.864 n = 10 (23.3%) n = 6 (14.0%) n = 24 (55.8%)
Do you use a respirator? Yes No N/A	1.28±0.456 n = 28 (65.1%) n = 11 (25.6%) n = 4 (9.3%)
Do you exercise? (1) Yes (2) No	M 1.05 ± 0.221 n = 38 (88.4%) n = 2 (4.7%)
Phlegm (1) Never (2) Most days (3) Some days (4) Only with chest infection	M 0.67 ± 1.009 n = 23 (53.5%) **n = 10 (23.3%)** n = 5 (11.7%) n = 1 (2.3%)
Wheezing (1) Never (2) Most days (3) Some days	M 0.26 ± 0.637 n = 32 (74.4%) n = 5 (11.6%) n = 2 (4.6%)
Coughing (1) Never (2) Most days (3) Some days (4) Only with chest infection	M 1.41 ± 1.229 n = 13 (33.3%) n = 7 (17.9%) **n = 18 (46.2%)** n = 1 (2.6%)
Shortness of Breath (1) Never	M 0.41 ± 0.910 n = 30 (69.8%)

(2) Most days	n = 5 (11.6%)
(3) Some days	n = 3 (7%)
(4) Only with chest infection	n = 1 (2.3%)
Respiratory Symptom Computed Score	M 2.744 ± 2.853 n = 39

The mean average of years spent in the field is approximately sixteen years (16.66 ± 9.919) with average weekly shifts occurring 2-3 times (n = 24 (55.8%). According to several credible sources (the Center for Disease Control and Prevention, the United States Environmental Protection Agency, and the New York State Department of Health), smoke inhalation whether voluntary or involuntary can have an immediate onset of symptoms ranging from minutes following exposure to days following exposure. Depending on the type of exposure and the medical history of the responder, this could lead to progressive damage of the pulmonary system therefore potentially increasing the risk of more frequent infection or exacerbation. Figure 1 displays the distribution of years of reported service every participant.

Figure 1. Length of time in the service as a fireman

Findings Related to Question 1

The first research question asked, "What is the association between the start of respiratory symptoms and previous occupational exposure of particulate matter among firefighters?"

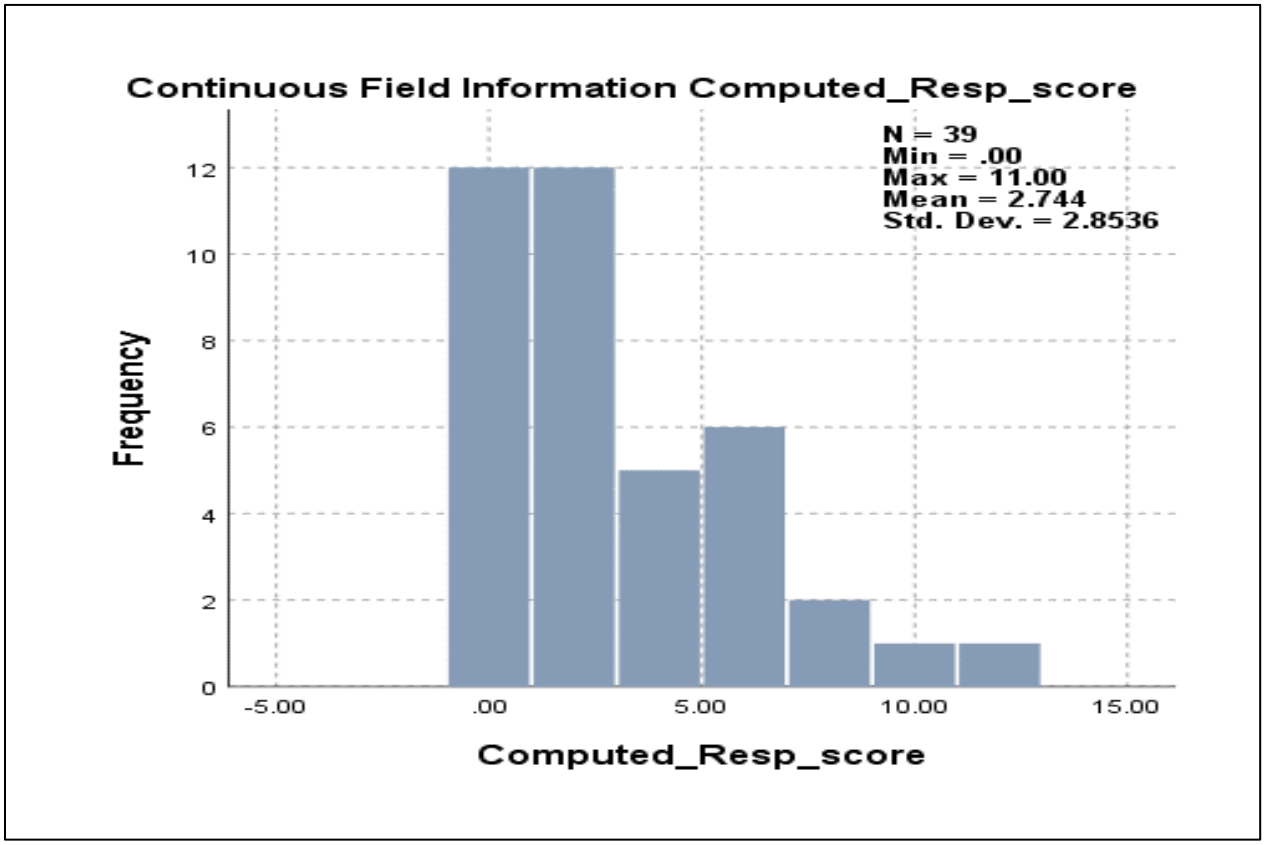
Mean and SD were calculated for each respiratory symptom related question. Table 2 breaks down each survey question and the collected responses to frequency of coughing, shortness of breath, phlegm production, and wheezing. The average mean and standard deviation are M 2.74, STD ± 2.85 and $p = 0.81$, suggesting no significant positive correlation for the presence of respiratory symptoms in years of exposure.

Table 2. Frequency statistical report of respiratory symptoms

What is the association between respiratory symptoms and previous occupational exposure of particulate matter among firefighters? No. and Item	Mean	Std. Deviation
25 … I have coughed	1.41	1.229
26 …I have coughed up phlegm	0.67	1.009
27 …I have experienced shortness of breath	0.41	0.910
28 …I have had attacks of wheezing	0.26	0.637
Overall mean score for respiratory symptoms	**2.74**	**2.853**

Table 2 shows the frequency variables, mean and standard deviation of each respiratory symptom question. Scores of 1 indicated no symptoms (“never”), 2 indicated most days, 3 indicated some days of the month, and 4 indicated only with respiratory infection. In review of each of the symptom means, from a statistical standpoint, there was not a profound significant relationship between the year of service and respiratory symptoms in the collected sample. However, around half of firefighters reported coughing at least on some days and phlegm on at least some days (around 35%) suggesting a more significant relationship potentially exists if a larger sample were collected. This is further discussed in the discussion section.

Figure 2. Computed Respiratory Symptom Score



A Spearman's correlation test was used to determine a computed score of respiratory symptoms (Figure 2). This score reports the average of frequency and severity of questions related to respiratory symptoms.

Figure 3. Spearman's Correlation Test using a Computed Respiratory Symptom Score

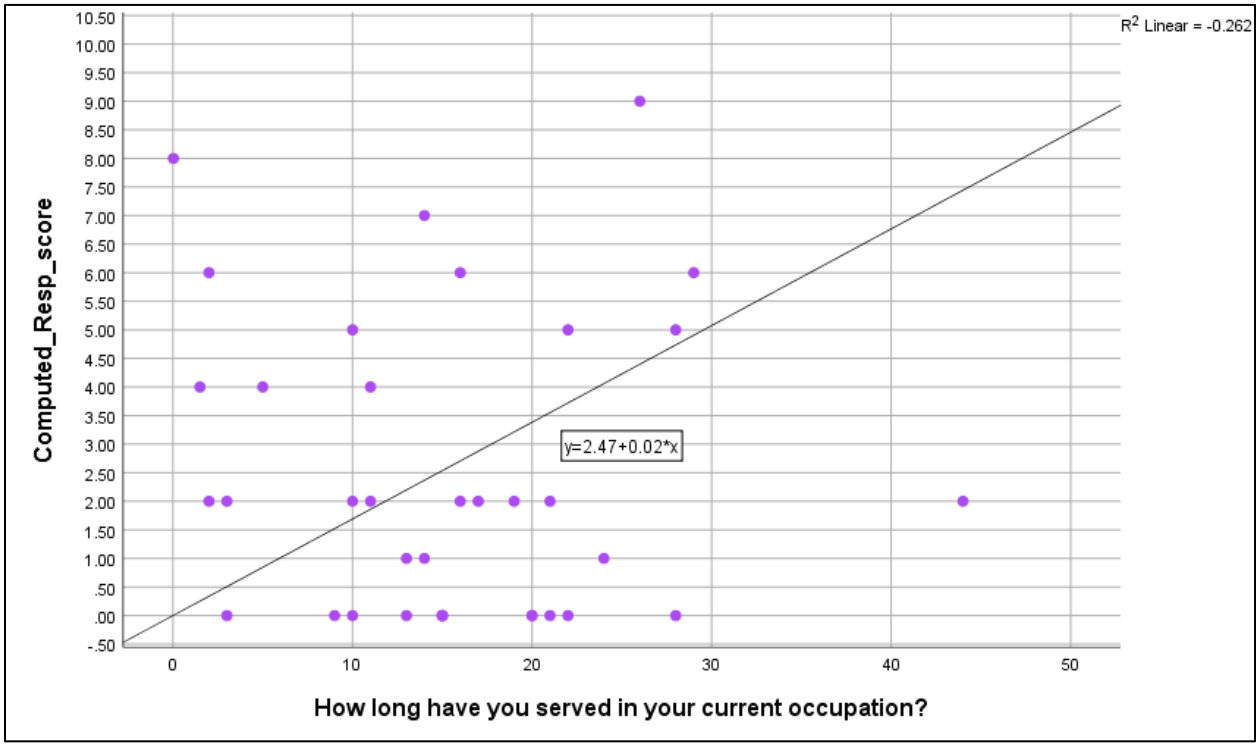


Figure 3 displays the Spearman's correlation test conducted using a computed respiratory score. Results signify a weak positive, non-significant relationship between number of years in service and an average respiratory symptom score (M 2.74, STD ± 2.85; r = 0.041, p = 0.81).

Figure 4. Spearman's correlation test for each respiratory symptom

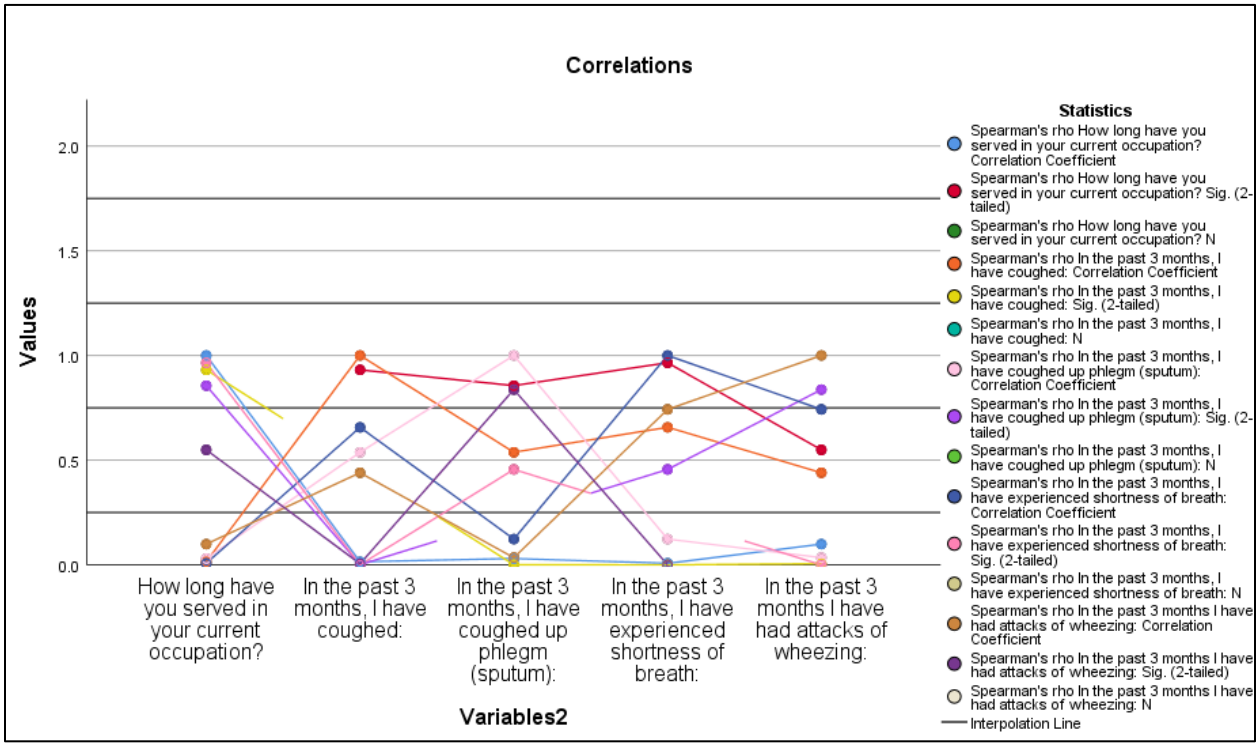


Figure 4 shows a Spearman's correlation test used to examine each of the symptoms individually. The results indicated no significant correlation between number of years in service and the presence and frequency of each symptom (coughing r = 0.014, p = 0.93, phlegm production r = 0.030, p = 0.856, shortness of breath r = 0.007, p = 0.97, and wheezing r = 0.099, p = 0.549). Relative to the computed results, wheezing had the most significant results but had a weak positive correlation r = 0.099 p = 0.549, with the number of years in service.

Findings Related to Question 2

Question 2 asked, "Is there an association between frequency of response calls related to fire or toxic chemical combustion with respiratory symptoms among firefighters?"

Upon the formation of the survey, this question was excluded from the survey study due to the high probability of recall bias and the breach of privacy in obtaining a record of calls from each department.

Findings Related to Question 3

Question 3 asked, "Do firefighters follow all standard precautions for protection or does some leniencies exist in the practice of these protections?"

This question refers to how often and how efficiently firemen use respirators and how informed are they in the purpose of their use as well as the subject of danger they are designed to protect against. Questions 15 through 21 of the survey prompted the use of respirators, how often they are used, and the extent to which crew members are educated and informed on each of the chemicals/fumes/particulate matter they are exposed to in the field.

Table 3. Breakdown of survey responses related to the use of respirators

To what extend do firefighters follow all standard precautions for protection…	Mean	Standard Deviation
…do you utilize a respirator? (1) Yes (2) No	1.28	±0.456
…how often? (1) Always (2) Most of time (3) Half of time (4) Sometimes (5) Never	3.92	±1.075 (1) Always n = 2 (4.7%) (2) Most of time n = 2 (4.7%) (3) Half of time n = 5 (11.6%) (4) Sometimes n = 17 (39.5%) (5) Never n = 12 (27.9%)
…does your department have an established protocol?	1.25	±0.588
…are you aware of chemicals/fumes you are exposed to?	1.08	±0.267
…are you informed of these chemicals/fumes by your department?	1.13	±0.335

The mean average for firemen that replied “yes” to wearing a respirator on duty was M 1.28. ± 0.456. This indicates that most participants claimed to be wearing a respirator on duty. Respirators are one method of protection against smoke, fumes, and other particles.

Figure 5. Data on the use of respirators in the field

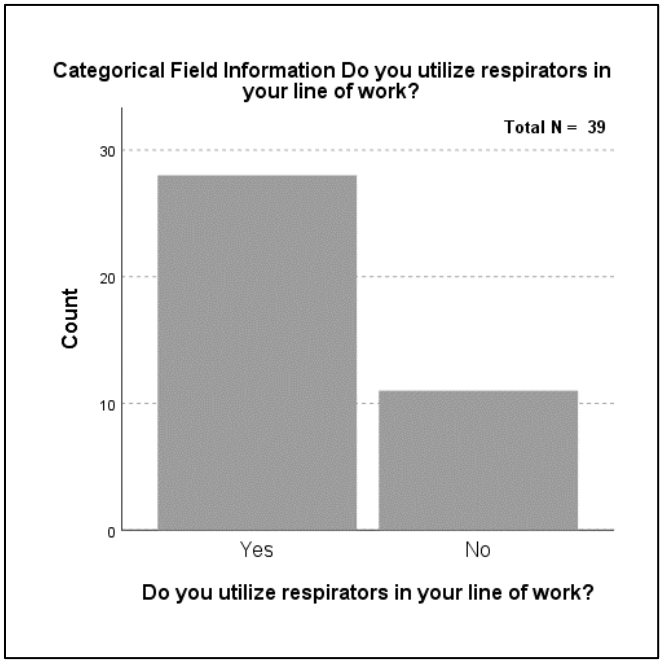


Figure 5 displays the overall response on the use of respirators in the field. The mean average and standard deviation were 1.28 ± 0.456 “Yes” category n = 28 (65.1%), “No” category n = 11 (25.6%), “N/A” category n = 4 (9.3%).

Further analysis of question three prompted a Mann-Whitney U test. This test was used to examen the correlation between the use of respirators and the computed respiratory symptom scores due to the abnormal distribution of each independent sample results.

Figure 6. Mann-Whitney U sample test of the use of respirators and computed respiratory symptom scores

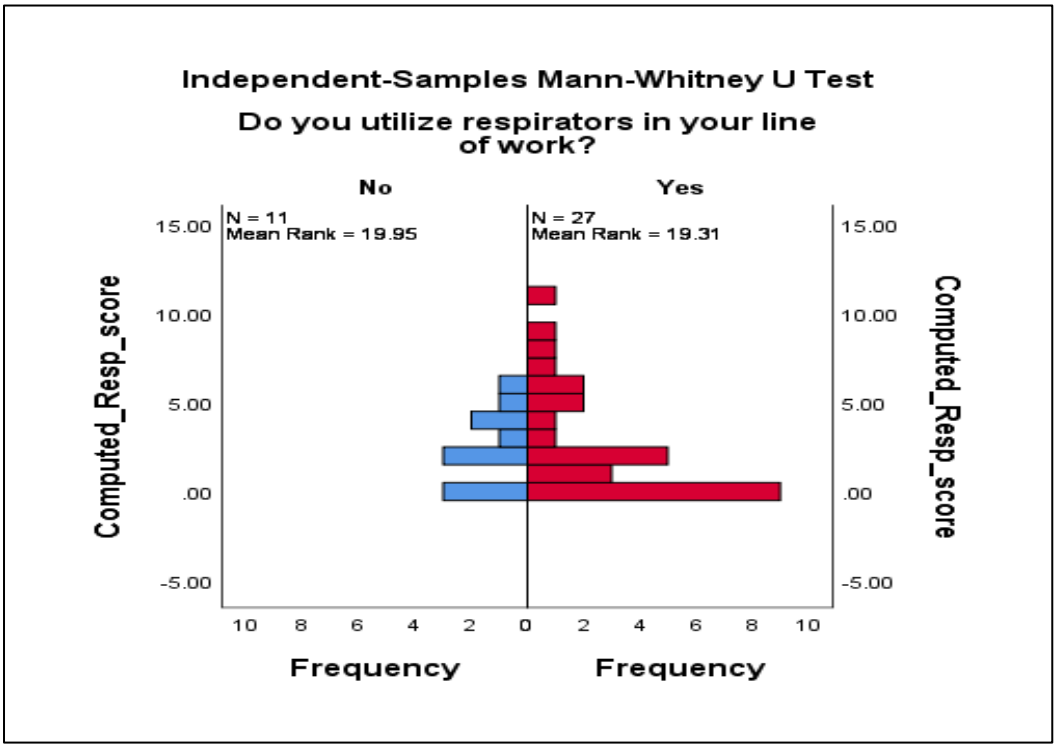


Figure 6 denotes the Mann-Whitney U test conducted using mean scores of respirator usage and a computed respiratory symptom score. The Mann-Whitney U test was used to determine the prevalence in respiratory symptoms in those that used a respirator and those that did not ("YES" N = 28, "NO" N = 11, and N/A N = 4). Results indicated a non-significant weak correlation in both groups (p = 0.874).

Findings Related to Question 4

Question four asked, "What is the overall quality of life in those that are senior firefighters or retired individuals from the profession (those with theoretically the highest exposure rate of particulate matter)?" Based on the data relating to respiratory symptoms and how often they occur, this sample of firefighters showed to have no significant correlation between their frequency of their respiratory symptoms and their quality of life.

Table 4. Breakdown of firefighter's current quality of health related to respiratory function

No. and Item	Mean	Standard Deviation
I feel breathless…sitting, washing, or getting dressed	1.97	±0.164
I feel breathless…walking around the home or outside	1.97	±0.164
I feel breathless… walking up a flight of stairs	1.78	±0.417
I feel breathless… playing sports or games	1.54	±0.505
My coughing or breathing is embarrassing	1.89	±0.315
I have become frail or invalid because of my chest	1.97	±0.167
Exercise is not safe for me	1.97	±0.167
Everything seems like too much of an effort	1.95	±0.229
…impact does your chest trouble have on your quality of life? (1) A great deal (2) A little (3) None at all	4.76 n = 1 (2.3%) n = 4 (9.3%) n = 28 (65.1%)	±0.751

Based on table 4, there is no indication or significant evidence that a low quality of life pertaining to respiratory symptoms exists amongst firemen in this sample. Mean averages of each question related to respiratory symptoms and quality of life indicate no impact in quality of life with answers "true" equivalent to a score of 1 and "false" equivalent to a score of 2. Each mean average relates to how respiratory symptoms affect activity of daily living. The activities of daily living (ADLs) is a term used to collectively describe fundamental skills that are required

to independently care for oneself such as eating, bathing, and mobility (Edemekong, 2020). Based on the recorded data, a weak correlation exists between these two variables. Regarding the existing relationship between activity of daily and respiratory symptoms a Spearman's correlation non-parametric test was used to further analyze their relationship.

Figure 7. Spearman's Correlation of Quality of Life and the presence of respiratory symptoms

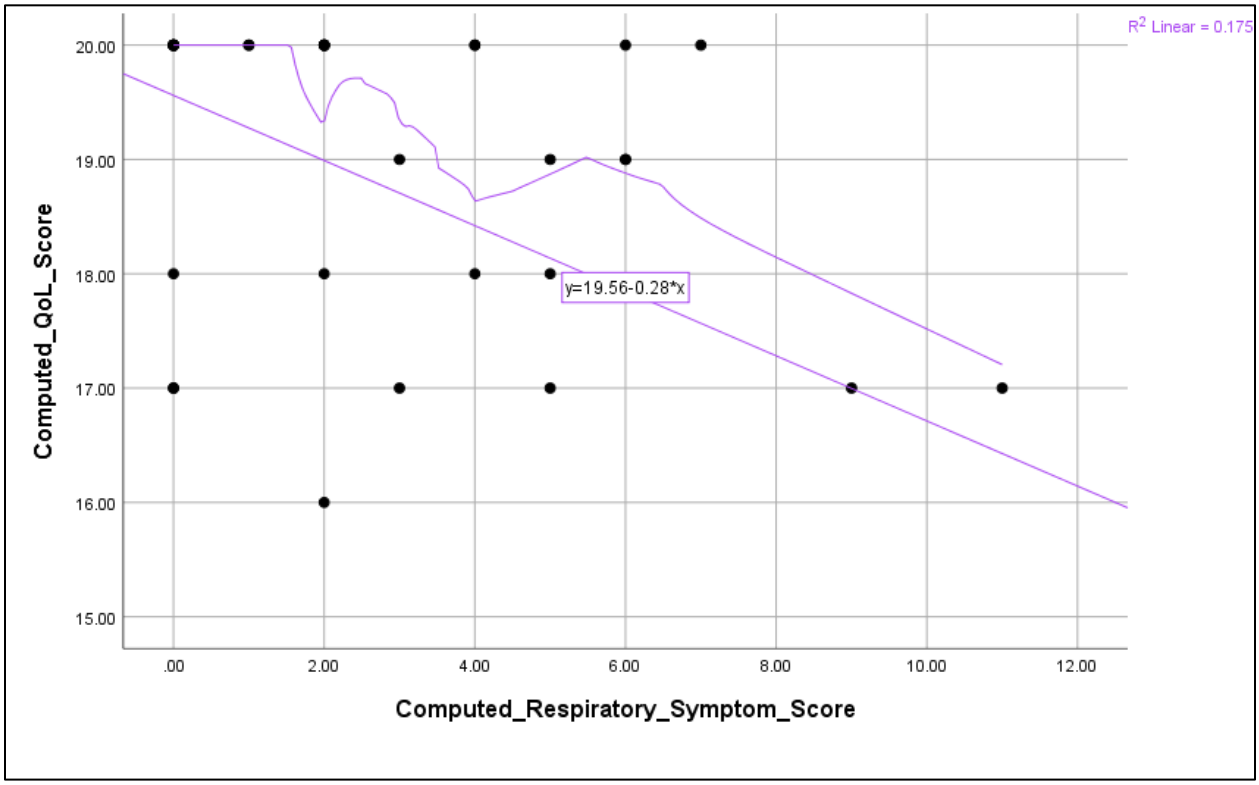


Figure 7 exhibits the relationship between a computed respiratory symptom score and a computed quality of life score. The Spearman's correlation is designed to describe the type and magnitude of the relationship between these two scores. This graph displays a visual correlation between the two variables. According to the Spearman's correlation, there is a small to moderate, statistically significant negative correlation between the computed scores of respiratory symptoms and quality of life ($r = -0.372$ $p = 0.030$).

Other Findings

These findings could suggest an existing correlation between certain respiratory symptoms and the line of work involved in a full-time fireman, however more research is needed to support this conclusion. Other findings related to respirators and their use. There was general consistency amongst firefighters and respirators, however it should be noted that not all firemen claimed to using their respirators all of the time or using one at all (Yes N = 27, No N = 11) which suggests that guidelines and protocols related to respirator usage presents as a strong encouragement rather than required protocol.

CHAPTER V

DISCUSSION

This chapter will present a discussion of the findings present in Chapter IV. There are six major components to this chapter: an overview of the study, discussion of findings, implications for research, future research recommendations, limitations of the study, and the conclusion.

Overview of the Study

The aim of this study was to examine the relationship between years of service in the fire and emergency services and the presence and frequency of various respiratory symptoms. Firefighters face numerous harmful chemicals, fumes, and particulate matter every day, this study sought to look at whether a relationship exists between these two variables in order to better protect those that serve in fire and emergency services. The following questions were addressed in order to help guide this study:

1. What is the association between respiratory symptoms and previous occupational exposure of particulate matter among firefighters?
2. Do firefighters follow all standard precautions or is practice of these protections determined by the choice of each crew member?
3. What is the overall quality of life in those that are senior firefighters or retired individuals from the profession (those with theoretically the highest exposure rate of particulate matter)?

The following question was created during the statistical analysis of the collected data:

4. Does exercise influence the presence of respiratory symptoms?

Findings Related to Research Question 1

The first research question asked, "What is the association between respiratory symptoms and previous occupational exposure of particulate matter among firefighters?". The findings revealed a weak relationship exists between respiratory symptoms and the number of years in service. However, this could be due to the fact of a limited time factor for data collection that potentially could have allowed for more survey submissions into the data analysis. The relationship between exposure of foreign inhaled substances and long-term physiological effects regardless of occupation, is still a relevant topic of research that must undergo more extensive measures in order to pinpoint more specific sources of harm. There is an existing relationship with these two variables in other studies such as Musk, Williams' three-year follow-up study on firefighters in Boston, Ma. This study revealed a significant decrement in forced vital capacity and one-second forced expiratory volume in those with more exposures to fire incidents (Musk, 1974). In addition, studies conducted on the 9/11 first responders showed a considerable increase in respiratory symptoms and pulmonary dysfunction resulting in a coughing disorder named after the attacks, World Trade Center Coughing Syndrome (Berninger, 2010). Each of these studies had more subjects (Musk n = 1430, Berninger n = 377) and a longer response time. Based on the available data, the surveyed metro-Atlanta fire fighters showed to have a weak relationship with the number of years in service and the number of respiratory symptoms, further research is needed to prove that such a relationship exists.

In reference to the demographics table (Table 1), a fairly large number of responders (23.3%) reported to having coughed up phlegm on most days which is significant based on the reported frequency of this symptom occurring alongside coughing, more than other symptoms.

Studies mentioned above regarding World Trade Center Responders also reported similar findings at 24 hours, 48 hours, up to weeks following the event.

Findings Related to Research Question 2

The second question asks, "Do firefighters follow all standard precautions or is practice of these protections determined by the choice of each crew member?". This question focuses more on the awareness and education of each department and if there is a lack there of, potentially increasing the risk of exposure and if a correlation exists between the use of respirators and developed respiratory symptoms. Upon examination of the use of respirators, how frequently they are used, and if each participant is educated by their department on the use and reasoning behind them, results showed no significant relationship between those that use a respirator and exhibit symptoms and those that do not wear a respirator and exhibit symptoms. Just as question one did not have the statistical data to prove a significant relationship exists between years in service and symptoms, this question also lacked the statistical power to generate results that portrayed a significant relationship when in fact respirators are designed to protect individuals against harmful substances. One study conducted by the College of Public Health and the University of Arizona, highlights the dangers of the *overhaul stage* in fire extinguishment. This is the stage in which firemen search for remaining hot spots and extinguish them to prevent a reignition of the flames. The overhaul stage is especially dangerous for firemen due to remaining hazardous substances in the ambient environment. Results showed that 10 of 55 selected chemicals were present in overhaul sites. Chemical, biological, radiological, and nuclear (CBRN) cartridges in air-purifying respirators (APR) showed to be most effective in at reducing concentrations of post-fire ambient chemicals to below occupational exposure limits (Leaton,

2013). This is just one example of a studies conducted to test the overall effectiveness of respirator protection against harmful chemicals.

The factor of education is a simple concept, informing is educating, but county departments, beyond the state of Georgia, vary in how they educate their staff to understand the dangers and protection protocols to mitigate overall exposure. There is a set standard of protection developed by the Federal Emergency Management Agency of the United States Fire Administration (FEMA) that are highly encouraged for all fire departments to follow. However, each department is responsible for communicating this information to their staff. This results in a potentially greater level of variability in education amongst departments that could alter the effectiveness of these protocols simply because of how it is communicated. According to one study involving all registered departments of the state of Kentucky, "Lack of funding (48%) and lack of understanding (39%) were cited as the greatest barriers to program implementation. Only 51% indicated they require their firefighters to receive a fit testing of their respirator, and 23% indicated they had a health-care provider who reviewed medical questionnaires or provided medical evaluations" (Easterling, 2007). The overall conclusion of this study indicated that there is a lack of implementation in protection policy. This may still be true today, but more research is needed from other state departments in order to further verify this conclusion.

Effectiveness of these policies varies based on the type of fires that occur due to difference in terrain, weather conditions, and economy amongst states resulting in a high variability in the type of fires (cause, location, etc.) and thus, the number of chemicals, fumes, and particulate matter that firemen are exposed to. For example, in 2019 California was ranked in the top 5 states for most reported wildfires (8,194 reported wildfires), this is most likely due to its dry and hot conditions. By comparison, Georgia saw <50% in reported wildfires (3,158 fires)

according to the Insurance Information Institute and FEMA. Types of fires determine the types of protocols needed to properly protect department crew members, including what protection gear to use, protocols used during a fire response, and decontamination protocols for post-fire missions. This calls for different levels of protection policies that are approved by FEMA institution and implemented by the Department of Environmental Health and Safety of each state (FEMA, DEHS).

Findings Related to Research Question 3

The third question asks, "What is the overall quality of life in those that are senior firefighters or retired individuals from the profession (those with theoretically the highest exposure rate of particulate matter)?" The survey asks a series of questions related to how respiratory symptoms, "chest troubles", have affected the ability to perform activities of daily living (ADLs) such as getting dressed, bathing, cooking, cleaning, walking upstairs, walking the dog, mental/emotional effects, and the impact on self-esteem/confidence. Results showed a significant impact on the quality of life of each participant ($r = -0.372$ $p = 0.030$). This indicates that those experiencing respiratory symptoms also experienced a decline in quality of life. While this study lacked a larger number of respondents, future studies with more respondents could see this relationship at a much higher scale, suggesting that firefighters should have more enhanced protection in their line of duty. Assuming more firemen (active and retired) participated in the study, there would be more representation of participants with symptoms and participants without symptoms; potentially resulting in more comparison in the quality of life between these groups and further defining the impact that impeding respiratory function has on the quality of life of a firefighter.

Findings Related to Research Question 4

The last question asked, "Does exercise influence the presence of respiratory symptoms?" was formed to further explain the impact that physical health has on the quality of life of firemen. Firefighters have a physically demanding job that requires high levels of cardiopulmonary strain and in turn requires extensive physical training both conditional and tactical. Numerous studies exhibit the positive effects that exercise intervention has on improving quality of health, job performance, and reduction of occupation related injury (Andrews, 2018; Jafari, 2020; Mayer, 2015; Matthew, 2020; etc.). This research question refers to certain questions asked in the survey relating exercise and quality of life. Of the 43 participants, 39 participants (88.4%) reported to participating (or not participating) in exercise. Utilizing a Mann-Whitney U Test, while not statistically significant ($p = 0.529$) and thus, not enough evidence to conclude that the difference between the population medians to be statistically significantly, a majority of those that reported "yes" to exercise also had lower computed respiratory scores (N = 37, mean rank score = 19.70). Those that reported "no" to exercise was too small of a sample size to make any predictions (N = 2, mean rank score of 25.5). While more statistical power is needed to confirm predictions of lower respiratory scores for those that do exercise than those that do not, this is a safe assumption when considering that current research shows positive physiological adaptations in cardiopulmonary function on exertion. More research specific to metro-Atlanta fire departments and exercise related variables is needed for confirmation of this prediction.

Other Findings

Based on the data collected on the frequency of respiratory symptoms, a considerable number of firefighters reported to coughing most days and producing phlegm. While this study

did not produce any significant data to prove there is a significant correlation between years in service and the frequency of certain respiratory symptoms, the number of firefighters that reported to having symptoms could foreshadow future studies that produce more significant results and further define a positive correlation between these two variables (years in service and respiratory symptoms).

Implications for Research

The findings of this study do not support current research that the number of years served in emergency fire services can influence respiratory quality of life and pulmonary function. However, this study highlights the important of more research needed on this specific population, to better serve and protect firemen/women of the metro-Atlanta area and firemen/women nation-wide. The negative outcomes of daily fire calls and disasters such as the attacks on the World Trade Center, the spikes in wildfires across the nation, and veterans of the Gulf War are eminent all have shown impendence in overall health and pulmonary function even years after initial exposure. Therefor the need for further observational studies should be considered by researchers and departments nationwide to further enhance protection protocols put in place by FEMA and the execution of training and educating by each department.

Recommendations for Future Studies

Further research with a larger population sample size, is needed to convey a clearer picture of the magnitude to which occupational exposure has on the health of fire emergency personnel today. Replications of this study with modified survey questions to tailor more specificity and a larger time frame for surveyor response, could prove advantageous in studying the effects of occupational exposure amongst firefighters. In addition, further research on the

variability in training, orientation, and continual education amongst departments could better pinpoint areas of improvement as it relates to protection.

Limitations

The present study is limited by a few factors. The findings of this study cannot be generalized to all firefighters as this study focuses specifically on departments in the metro-Atlanta area. Moreover, the study is limited by its small sample size drawn form a large population of firefighters, which limits our statistical power in detecting specific associations. However, it should be stated that greater statistical power does not guarantee more significant results, it could, but rather it increases the likelihood of more significant results. Recall bias on behalf of the individuals participating is also a limiting factor of relevant importance in this study as this study is purely observational. Recalling specific detail as it pertains to specific questions within the study is not guaranteed to be completely accurate. The statistical power to prove the significance of this claim is not possible with the sample collected, however, it is an important relationship to highlight when discussing in future studies and measures of protection and enhancement of occupational health. The findings of this research also invoke the question of what confounders exist, that is, what variables are out of our control that could have impacted the results of this study? A few of these include the current pandemic the world faces, Sars-COVID 19, a respiratory driven infection, obesity and how this affects cardiopulmonary conditioning, comorbidities that are common amongst citizens of the United States, and others. Finally, there is a lack of research in general and this specific population to make any comparisons or stronger predictions of results relating to occupational exposure and impeding respiratory health.

Conclusion

Firefighters of the metro-Atlanta area suffered no significant impact from the occupational exposure hazards of everyday response calls and quality of respiratory health. In addition, the data results collected implied no significant factors (years in service, use of respirators, and exercise) in relation to the frequency of respiratory symptoms. The small sample size is a major attribution to this result and more research is needed to better support the notion that hazardous chemicals, fumes, and particulate matter, have a negative effect on respiratory health and function.

Appendix A: Respiratory Quality of Life Survey

Examination of Respiratory Symptoms in Firefighters

Intro Q Thank you for participating in this survey! Please review terms and procedures for consent before continuing.
Revised consent form copy

- [ ] Yes, I consent (1)
- [ ] No, I do not consent (2)

Skip To: End of Survey If Thank you for participating in this survey! Please review terms and procedures for consent before... = No, I do not consent

Q1 What is your age?

- ○ Under 18 (1)
- ○ 18 - 24 (2)
- ○ 25 - 34 (3)
- ○ 35 - 44 (4)
- ○ 45 - 54 (5)
- ○ 55 - 64 (6)
- ○ 65 - 74 (7)
- ○ 75 - 84 (8)
- ○ 85 or older (9)

Q2 What is your sex?

- ○ Male (1)
- ○ Female (2)
- ○ Non-binary / third gender (3)
- ○ Prefer not to say (4)

Q4 What is your ethnicity?

- ○ White (1)
- ○ Black or African American (2)
- ○ American Indian or Alaska Native (3)
- ○ Asian (4)
- ○ Native Hawaiian or Pacific Islander (5)
- ○ Other (6)

Q5 What is your current height (inches)?

_____

Q6 What is your current weight (lbs)?

_____

Q7 What level of education have you completed?

- ○ Less than high school (1)
- ○ High school graduate (2)
- ○ Some college (3)
- ○ 2 year degree (4)
- ○ 4 year degree (5)
- ○ Professional degree (6)
- ○ Doctorate (7)

Q8 What title do you hold in your occupation (ex. firefighter, driver/engineer, lieutenant, captain)?

_____

Q9 How long have you served in your current occupation?

_____

Q10 How many shifts do you complete per week?

- ○ Daily (1)
- ○ 4-6 times a week (2)
- ○ 2-3 times a week (3)
- ○ Once a week (4)
- ○ Never (5)

Q11 Do you exercise?

- ○ Yes (1)
- ○ No (2)

Q12 If yes, how often do you exercise per week?

- ○ Daily (1)
- ○ 4-6 times a week (2)
- ○ 2-3 times a week (3)
- ○ Once a week (4)
- ○ Never (5)

Q13 If yes, what intensity do you exercise at?

- ○ Mild - easy (walking at an easy pace, cycling with no resistance, activities of daily living) (1)
- ○ Moderate - somewhat hard (walking up hill/stairs, strength training 1-2 times per week, etc.) (2)
- ○ Vigorous - very hard (running, strength training >3 times per week, swimming, etc.) (3)

Q14 What type of exercise activities do you do?

_____

Q15 Do you utilize respirators in your line of work?

- ○ Yes (1)
- ○ No (2)

Q16 If yes, how often per week (approximately) do you wear a respirator?

- ○ Always (1)
- ○ Most of the time (2)
- ○ About half the time (3)
- ○ Sometimes (4)
- ○ Never (5)

Q17 Does your department follow an established protocol for protection and decontamination of each individual involved before during and after training scenarios or emergency response calls?

- ○ Yes (1)
- ○ No (2)
- ○ I don't know (3)

Q18 Do you use a respirator on duty?

- ○ Yes (1)
- ○ No (2)

Q19 If yes, how often?

- ○ Always (1)
- ○ Most of the time (2)
- ○ About half the time (3)
- ○ Sometimes (4)
- ○ Never (5)

Q20 Are you aware of the commonly known chemicals/fumes your line of work is exposed to the most on a daily basis?

- Yes (1)
- No (2)

Q21 Are you informed and/or trained on how to effectively protect yourself from these chemicals/fumes?

- Yes (1)
- No (2)

Q23 The next section will ask about your current quality of health, each question is designed to ask about your respiratory function, symptoms, medications (if any), and how these parameters effect your daily life. Please answer each question as best as you can.

Q24 How would you describe your current health?

- Excellent (1)
- Good (2)
- Average (3)
- Poor (4)
- Terrible (5)

Q26 In the past 3 months, I have coughed:

- ○ Most days a week (1)
- ○ Several days a week (2)
- ○ A few days a month (3)
- ○ Only with chest infections (4)
- ○ Never (5)

Q25 In the past 3 months, I have coughed up phlegm (sputum):

- ○ Most days a week (1)
- ○ Several days a week (2)
- ○ A few days a month (3)
- ○ Only with chest infections (4)
- ○ Never (5)

Q27 In the past 3 months, I have experienced shortness of breath:

- ○ Most days a week (1)
- ○ Several days a week (2)
- ○ A few days a month (3)
- ○ Only with chest infections (4)
- ○ Never (5)

Q28 In the past 3 months I have had attacks of wheezing:

- ○ Most days a week (1)
- ○ Several days a week (2)
- ○ A few days a month (3)
- ○ Only with chest infections (4)
- ○ Never (5)

Q29 During the past 3 months, how many severe episodes or very unpleasant attacks have you had?

- ○ More than 3 attacks (1)
- ○ 3 attacks (2)
- ○ 2 attacks (3)
- ○ 1 attack (4)
- ○ None (5)

Q30 How long did your worst episode/attack of chest trouble last?

- ○ A week or more (1)
- ○ 3 days or more (2)
- ○ 1-2 days (3)
- ○ Less than 1 day (4)

Q31 Over the past 3 months, in an average week, how many good days (without chest trouble) have you had?

- ○ No good days (1)
- ○ 1 or 2 good days (2)
- ○ 3 or 4 good days (3)
- ○ nearly every day is good (4)
- ○ every day is good (5)

Q32 If you have a wheeze, is it worse in the morning?

- ○ Yes (1)
- ○ No (2)

Q33 How would you describe your chest condition?

- ○ The most important problem I have (1)
- ○ Causes me quite a lot of problems (2)
- ○ Causes me a few problems (3)
- ○ Causes no problem (4)

Q62 Do you take any medications for your chest troubles? If so, list them below.

_____

Q34 If you have ever had paid employment

- ○ My chest trouble made me stop work altogether (1)
- ○ My chest trouble interferes with my work or made me change my work (2)
- ○ My chest trouble does not affect my work (3)

Q37 ***Questions about what activities usually make you feel breathless these days. Each question will ask you about your experiences currently (within the last 3 months up until now).***

Q38 Sitting or lying still or getting washed or dressed

- ○ True (1)
- ○ False (2)

Q40 Walking around the home or walking outside on the level

- True (1)
- False (2)

Q41 Walking up a flight of stairs

- True (1)
- False (2)

Q42 Walking up hills

- True (1)
- False (2)

Q43 Playing sports or games

- True (1)
- False (2)

Q45 This section will ask you to describe how your chest trouble presents and effects your daily life currently

Q46 My cough or breathing is embarrassing in public

- True (1)
- False (2)

Q47 My chest trouble is a nuisance to my family, friends or neighbors

- True (1)
- False (2)

Q48 I get afraid or panic when I cannot get my breath

- True (1)
- False (2)

Q49 I feel that I am not in control of my chest problem

- True (1)
- False (2)

Q50 I do not expect my chest to get any better

- True (1)
- False (2)

Q51 I have become frail or an invalid because of my chest

- True (1)
- False (2)

Q52 Exercise is not safe for me

- True (1)
- False (2)

Q53 Everything seems too much of an effort

- True (1)
- False (2)

Q54 **This section will ask about any medications you are currently taking for chest trouble, shortness of breath, etc. If you do not take any medications for this, skip the next 4 questions**

Q55 My medication does not help me very much

- True (1)
- False (2)

Q56 I get embarrassed using my medication in public

- True (1)
- False (2)

Q57 I have unpleasant side effects from my medication

- ○ True (1)
- ○ False (2)

Q58 (Last medication question) My medication interferes with my life a lot

- ○ True (1)
- ○ False (2)

Q59 Do any of the following reflect how your breathing affects your activities of daily living?

☐ I take a long time to get washed or dressed or I cannot take a bath or shower, or I take a long time (1)

☐ I walk slower than other people, or I stop for rests (2)

☐ Jobs such as housework take a long time, or I have to stop for rests (3)

☐ If I walk up one flight of stairs, I have to go slowly or stop or If I hurry or walk fast, I have to stop or slow down (4)

☐ My breathing makes it difficult to do things such as walk up hills, carrying things up stairs, light gardening such as weeding, dance, play bowls or play golf (5)

☐ My breathing makes it difficult to do things such as carry heavy loads, dig the garden or shovel snow, jog or walk at 5 miles per hour, play tennis or swim (6)

☐ My breathing makes it difficult to do things such as very heavy manual work, run, cycle, swim fast or play competitive sports (7)

☐ None of these (8)

Q60 ***We would like to know how your chest usually affects your daily life.***

- ☐ I cannot play sports or games (1)
- ☐ I cannot go out for entertainment or recreation (2)
- ☐ I cannot go out of the house to do the shopping (3)
- ☐ I cannot do housework (4)
- ☐ I cannot move far from my bed or chair (5)

Q61 Finally, how much of an impact does your chest trouble have on your quality of life?

- ○ A great deal (1)
- ○ A lot (2)
- ○ A moderate amount (3)
- ○ A little (4)
- ○ None at all (5)

Appendix B: Consent Form

Georgia State University

Informed Consent

Title: Examining the Prevalence of Self-Reported Respiratory Symptoms and Respiratory Infection amongst Firefighters in the Metro-Atlanta Area

Principal Investigator: Ralph Zimmerman

Co-Investigator: Rachel Culbreth

Student Principal Investigator: Juliana Cartwright

Introduction and Key Information

You are invited to take part in a research study. It is up to you to decide if you would like to take part in the study. The purpose of this study is to identify the associations of respiratory related symptoms and occupational exposure amongst firefighters in the Metro-Atlanta area as well as various suburban and rural areas in Georgia. This research will assess the general timeline to which symptoms start to occur as well as which symptoms are more prominent amongst the participants. In addition, analysis of frequency in these reported symptoms will be used to assess how symptoms and possible respiratory conditions (whether pre-existing or not) have affected overall quality of life in those active and retired.

Your role in the study will last 15 to 30 minutes for a single occurrence.

You will be asked to do the following:

- ✓ Complete a survey provided through a private link
- ✓ Answer each question as truthfully as possible

Participating in this study will not expose you to any more risks than you would experience in a typical day. The link provided is private and no personal information that could potentially expose your identity will be included in this study.

This study is not designed to benefit you acutely. Overall, we hope to gain information about physiological and anatomical responses to daily smoke inhalation exposure and how that affects an individual's quality of life from a health's perspective.

Purpose

The purpose of the study is to examine respiratory symptoms in emergency personnel that may suggest chronic development of certain lung conditions. You are invited to take part in this

research study because you are a fire fighter with experience of at least one year. A total of 300 people will be invited to take part in this study.

Procedures

If you decide to take part, you will asked to complete detailed survey anonymously provided through a private link to your occupations email. A single completed survey submission is required of each participant for this study. This survey will include health related questions regarding demographics (height, weight) and pulmonary related questions regarding the functionality of your respiratory system (shortness of breath, coughing occurrences, smoking history, etc.)

- ✓ No interaction will occur between participants
- ✓ This survey/questionnaire can be completed anywhere that allots sufficient privacy, this is subject to the participants discretion
- ✓ This survey can be completed anytime between January through the end of February (28^{th}) of 2021
- ✓ One completed survey is required of each willing participant
- ✓ This survey will take between 15-30 minutes to complete.
- ✓ If the participant finds that she/he does not feel comfortable with certain questions, they can choose the *prefer not to answer* option or respond with N/A however a complete answer for all questions is highly encouraged
- ✓ If you no longer wish to participate in the survey, then you can exit the survey link and the submission will not be included in the data analysis.

Future Research

Researchers will remove information that may identify you and may use your data for future research. If we do this, we will not ask for any additional consent from you.

Risks

In this study, you will not have any more risks than you would in a normal day of life. No injury is expected from this study, but if you believe you have been harmed, contact the research team as soon as possible. Georgia State University and the research team have not set aside funds to compensate for any injury.

Benefits

This study is not designed to benefit you personally. Overall, we hope to gain information about how first responders, specifically fire fighters, are affected by daily exposure to smoke, fumes, etc. and how that may affect their quality of life in the long run. With this research, more emphasis on health screenings and protective protocols can be made to further enhance environmental safety for those serving on the frontlines.

Alternatives

The alternative to taking part in this study is to not take part in the study.

Voluntary Participation and Withdrawal

You do not have to be in this study. If you decide to be in the study and change your mind, you have the right to drop out at any time. You may skip questions or stop participating at any time.

You may refuse to take part in the study or stop at any time. This will not cause you to lose any benefits to which you are otherwise entitled.

Confidentiality

We will keep your records private to the extent allowed by law. The following people and entities will have access to the information you provide:

- Ralph Zimmerman, Juliana Cartwright, and Rachel Culbreth
- GSU Institutional Review Board
- Office for Human Research Protection (OHRP)

We will use a study number rather than your name on study records. The information you provide will be stored on a password- and firewall-protected computer. When we present or publish the results of this study, we will not use your name or other information that may identify you.

- Due to the survey only being available through the internet the participant should be aware that data sent over the Internet may not be secure, however no IP addresses will be collected and all submissions will be confined to a single computer for analysis that is password and firewall-protected.

Contact Information

Contact Ralph Zimmerman at chip@gsu.edu or (404) 413-1267 and Juliana Cartwright at jcartwright7@student.gsu.edu or (678) 462-3278

- If you have questions about the study or your part in it
- If you have questions, concerns, or complaints about the study

The IRB at Georgia State University reviews all research that involves human participants. You can contact the IRB if you would like to speak to someone who is not involved directly with the study. You can contact the IRB for questions, concerns, problems, information, input, or questions about your rights as a research participant. Contact the IRB at 404-413-3500 or irb@gsu.edu.

Consent

If you agree to participate in this research, please click the continue button.

If you would like a copy of the consent form, please print or save a copy of this form for your records.

REFERENCES

Atopy: AAAAI. (2020). Retrieved September 27, 2020, from https://www.aaaai.org/conditions-and-treatments/conditions-dictionary/atopy

Ahmad, I., & Balkhyour, M. A. (2020). Occupational exposure and respiratory health of workers at small scale industries. Saudi Journal of Biological Sciences, 27(3), 985–990. https://doi.org/10.1016/j.sjbs.2020.01.019

Berninger, A., Webber, M. P., Weakley, J., Gustave, J., Zeig-Owens, R., Lee, R., Al-Othman, F., Cohen, H. W., Kelly, K., & Prezant, D. J. (2010). Quality of life in relation to upper and lower respiratory conditions among retired 9/11-exposed firefighters with pulmonary disability. Quality of Life Research, 19(10), 1467. https://doi.org/10.1007/s11136-010-9710-9

Booze, T., Reinhardt, T., Quiring, S., & Ottmar, R. (2004). A Screening-Level Assessment of the Health Risks of Chronic Smoke Exposure for Wildland Firefighters. Journal of Occupational & Environmental Hygiene, 1(5), 296–305. https://doi.org/10.1080/15459620490442500

Feldman, D. M., Baron, S. L., Bernard, B. P., Lushniak, B. D., Banauck, G., Arcentales, N., Kelly, K. J., & Prezant, D. J. (2004). Symptoms, Respirator Use, and Pulmonary Function Changes Among New York City Firefighters Responding to the World Trade Center Disaster. CHEST, 125(4), 1256–1264. https://doi.org/10.1378/chest.125.4.1256

Ferrer, M., Villasante, C., Alonso, J., Sobradillo, V., Gabriel, R., Vilagut, G., . . . Miravitlles, M. (2002, March 01). Interpretation of quality of life scores from the St GEORGE'S

Respiratory questionnaire. Retrieved April 12, 2021, from https://erj.ersjournals.com/content/19/3/405.short

Frans Greven, Esmeralda Krop, Jack Spithoven, Jos Rooyackers, Huib Kerstjens, & Dick Heederik. (2011). Lung function, bronchial hyperresponsiveness, and atopy among firefighters. Scandinavian Journal of Work, Environment & Health, 37(4), 325.

Furukawa, T., Taniguchi, H., Ando, M. *et al.* The St. George's Respiratory Questionnaire as a prognostic factor in IPF. *Respir Res* **18,** 18 (2017). https://doi.org/10.1186/s12931-017-0503-3

Gregory H. Easterling, & Scott Prince. (2007). Respiratory Protection Programs for Firefighters: A Survey of Practices for the State of Kentucky. Public Health Reports (1974-), 122(6), 725.

Gupta, A. (2019, November 21). Largest wildfires of the decade. Retrieved July 23, 2020, from https://thestacker.com/stories/3688/largest-wildfires-decade

Henn, S. A., Butler, C., Li, J., Sussell, A., Hale, C., Broyles, G., & Reinhardt, T. (2019). Carbon monoxide exposures among U.S. wildland firefighters by work, fire, and environmental characteristics and conditions. Journal of Occupational & Environmental Hygiene, 16(12), 793–803. https://doi.org/10.1080/15459624.2019.1670833

Jones PW, Quirk FH, Baveystock CM. The St. George's Respiratory Questionnaire. Resp Med 1991;85 (suppl B):2531.

Jones PW, Quirk FH, Baveystock CM, Littlejohns P. A self-complete measure of health status for chronic airflow limitation. Am Rev Respir Dis 1992; 145;1321-1327. Barr JT, Schumacher GE, Freeman S, LeMoine M, Bakst AW, Jones PW. American translation, modification, and validation of the St. Georges Respiratory Questionnaire. Clin Ther, 2000 Sep, 22(9):1121-45.

KIRK, K. M., & LOGAN, M. B. (2019). Queensland Fire and Emergency Services: Promoting the Message of "Go Home Clean." Fire Engineering, 172(1), 32–34.

Magdalena Witt, Mariusz Goniewicz, Witold Pawłowski, Krzysztof Goniewicz, & Wiesława Biczysko. (2017). Analysis of the impact of harmful factors in the workplace on functioning of the respiratory system of firefighters. Annals of Agricultural and Environmental Medicine, 24(3), 406–410. https://doi.org/10.5604/12321966.1233561

Miedinger, D., Chhajed, P. N., Tamm, M., Stolz, D., Surber, C., & Leuppi, J. D. (2007). Diagnostic Tests for Asthma in Firefighters. Chest, 131(6), 1760–1767. https://doi.org/10.1378/chest.06-2218

Occupational Asthma. (n.d.). Retrieved September 27, 2020, from https://www.hopkinsmedicine.org/health/conditions-and-diseases/asthma/occupational-asthma

Particulate Matter (PM) Basics. (2018, November 14). Retrieved September 27, 2020, from https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

Pauline Slottje, Jos W. R. Twisk, Nynke Smidt, Anja C. Huizink, Anke B. Witteveen, Willem van Mechelen, Tjabe Smid, & Pau line Slottje. (2007). Health-Related Quality of Life of Firefighters and Police Officers 8.5 Years after the Air Disaster in Amsterdam. Quality of Life Research, 16(2), 239. https://doi.org/10.1007/s11136-006-9006-2

Pedersen, J. E., Petersen, K. U., Ebbehøj, N. E., Bonde, J. P., Hansen, J., & Ugelvig Petersen, K. (2018). Risk of asthma and chronic obstructive pulmonary disease in a large historical cohort of Danish firefighters. Occupational & Environmental Medicine, 75(12), 871.

Pittman, J., Goldsmith, A., Lemmer, J., Kilmer, M., & Baker, D. (2012). Post-traumatic stress disorder, depression, and health-related quality of life in OEF/OIF veterans. Quality of Life Research, 21(1), 99. https://doi.org/10.1007/s11136-011-9918-3

Poutasse, C. M., Poston, W. S. C., Jahnke, S. A., Haddock, C. K., Tidwell, L. G., Hoffman, P. D., & Anderson, K. A. (2020). Discovery of firefighter chemical exposures using military-style silicone dog tags. Environment International, 142. https://doi.org/10.1016/j.envint.2020.105818

Prezant, D. J., Weiden, M., Banauch, G. I., McGuinness, G., Rom, W. N., Aldrich, T. K., & Kelly, K. J. (2002). Cough and bronchial responsiveness in firefighters at the World Trade Center site. The New England Journal of Medicine, 347(11), 806–815.

Schermer, T., Malbon, T., Morgan, M., Briggs, N., Holton, C., Appleton, S., Adams, R., Smith, M., & Crockett, A. (2010). Lung function and health status in metropolitan fire-fighters compared to general population controls. International Archives of Occupational & Environmental Health, 83(7), 715–723. https://doi.org/10.1007/s00420-010-0528-0

Silva Marconato, R., & Monteiro, M. I. (2015). Pain, health perception and sleep: impact on the quality of life of firefighters/rescue professionals. Revista Latino-Americana de Enfermagem (RLAE), 23(6), 991–999. https://doi.org/10.1590/0104-1169.0563.2641

Szema, Anthony MD, Niely Mirsaidi BA, Bhumika Patel MD, Laura Viens MD, M., Edward Forsyth MD, Jonathan Li BS, Sophia Dang BA, Brittany Dukes BS, Jheison Giraldo BS, Preston Kim, & Matthew Burns MPhil. (2017). Proposed Iraq/Afghanistan War-Lung Injury (IAW-LI) Clinical Practice Recommendations: National Academy of Sciences' Institute of Medicine Burn Pits Workshop. American Journal of Men's Health, 11. https://doi.org/10.1177/1557988315619005

Tarlo, S. M., & Quirce, S. (2020). Impact of Identification of Clinical Phenotypes in Occupational Asthma. The Journal of Allergy and Clinical Immunology: In Practice. https://doi.org/10.1016/j.jaip.2020.06.003

Weiler, B. A., Colby, T. V., Floreth, T. J., & Hines, S. E. (2018). Small airways disease in an Operation Desert Storm Deployer: Case report and review of the literature on respiratory health and inhalational exposures from Gulf War I. American Journal of Industrial Medicine, 61(10), 793–801. https://doi.org/10.1002/ajim.22893

Wildland urban interface (WUI). (2020, July 17). Retrieved July 23, 2020, from https://www.usfa.fema.gov/wui/

Yip, J., Zeig-Owens, R., Hall, C. B., Webber, M. P., Olivieri, B., Schwartz, T., Kelly, K. J., & Prezant, D. J. (2016). Health Conditions as Mediators of the Association Between World Trade Center Exposure and Health-Related Quality of Life in Firefighters and EMS

Workers. Journal of Occupational & Environmental Medicine, 58(2), 200–206. https://doi.org/10.1097/JOM.0000000000000597