UNIVERSITY OF CALIFORNIA,
IRVINE

Psychological Occupational Strain and its Association with Cardiovascular Risk Factors in Firefighters

THESIS

submitted in partial satisfaction of the requirements
for the degree of

MASTER OF SCIENCE

In Environmental Health Sciences

By

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2019

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LIST OF ABBREVIATIONS

BP	Blood Pressure
CAD	Coronary Artery Disease
CI	Confidence Interval
ES-MBI	Exhaustion Scale of the Maslach Burnout Inventory
FORWARD	Firefighter Obesity Research: Workplace Assessment to Reduce Disease
GHQ-12	General Health Questionnaire-12
HDL	High Density Lipoprotein (type of cholesterol)
HPA	Hypothalamic-Pituitary-Adrenocortical
MBI	Maslach Burnout Inventory
MS	Metabolic Syndrome
MSI	Mental Stress Ischemia
NCEP ATP III	National Cholesterol Education Program Adult Treatment Panel III
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
OCFA	Orange County Fire Authority
OR	Odds Ratio
PC-PTSD	Primary Care Post-traumatic Stress Disorder (psychological screening test)
PTSD	Post-traumatic Stress Disorder
SA	Sympathetic-adrenomedullary
TG	Triglycerides (type of cholesterol)
WC	Waist Circumference

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ACKNOWLEDGEMENTS

I would like to thank the review committee chair, Dr. Choi, and the members of my review committee, Drs. Baker, and Phalen, for their guidance in completing this project. I would also like to thank the Occupational Medicine residency program directors, Drs. Boomus and Khan, and the Environmental Health Sciences graduate program chair, Dr. Luderer, for their mentorship throughout the Environmental Health Sciences graduate program and the Occupational Medicine residency program.

ABSTRACT OF THE THESIS

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By

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Master of Science in Environmental Health Sciences

University of California, Irvine 2019

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On-the-job deaths due to cardiovascular events are the most common cause of death among firefighters across the U.S. consistently every year since 1977. Work stress is prevalent in the firefighting occupation most often secondary to the strenuous nature of their job duties that can include emergency situations that are sometimes life-threatening and extremely long shift hours. Work stress can contribute to strain or the negative manifestations of stress reactions, which can present mentally and/ or physically. There is extensive literature on the association of psychological strain and metabolic syndrome (MS), which is an indicator of cardiovascular disease risk. Consequently, based on the current literature and known pathophysiology, a causal association between work stress, MS, and cardiovascular disease is biologically plausible. Thus, screening for psychological occupational strain may potentially reveal modifiable cardiovascular risk factors to target in disease prevention efforts.

However, the association between work stress, MS, and cardiovascular disease is understudied in firefighters. This study is the first to examine this relationship in this unique occupational group. In this study, an extensive literature review and cross-sectional analysis of

data from firefighters in Southern California was performed. Psychological strain was investigated through measures of mental health, emotional exhaustion, and post-traumatic stress disorder (PTSD) risk indicators through the General Health Questionnaire-12 (GHQ-12), Exhaustion Scale of the Maslach Burnout Inventory (ES-MBI), and the primary care PTSD (PC-PTSD) screening questionnaires. MS was assessed with data on each component of MS, which included waist circumference (WC), fasting glucose, triglycerides (TG), high density lipoprotein (HDL), and blood pressure (BP). Data analysis revealed statistically significant relationships between GHQ-12 and WC, ES-MBI and TG, and PC-PTSD and WC even after controlling for covariates of age and gender. The analysis revealed negative associations between psychological screening tests and MS (and its components), which are unexpected considering the pathophysiology of cardiovascular strain resulting from stress. Due to potential effects of medications on associations with well-controlled components of MS, such as reverse causality, a sensitivity analysis was performed excluding those on medications. This analysis revealed a stronger statistically significant association with GHQ-12 and WC and more consistent positive associations between psychological screening tests and MS that were apparently negative in the initial analysis. Otherwise no other statistically suggestive associations were found. Furthermore, no statistically significant relationships were found with the number of MS criteria and MS itself.

This study reveals possible associations with indicators of psychological occupational strain and metabolic syndrome (and its components). Due to individual variability of reactions to stressors, indicators of psychological strain were used instead of measures of work stress. Despite the multiple strengths of this study, there are also several limitations making further research on this topic necessary in order to make more definitive conclusions about causation. Further investigation is important in informing prevention programs and achieving the overarching goal of decreasing firefighter morbidity and mortality while increasing quality of life through early intervention and prevention of adverse cardiovascular outcome.

CHAPTER 1: INTRODUCTION AND PURPOSE

Cardiovascular disease is the number one cause of mortality globally and has been over the past 15 years (World Health Organization (WHO), 2018). In the U.S., cardiovascular disease is also the top cause of mortality and firefighters are no less immune to cardiovascular disease than the general population (American Heart Association (AHA), 2018). It is well-known that the firefighting occupation is considered particularly hazardous sometimes resulting in on-duty deaths, which is a death resulting from an exposure or onset of symptoms occur while performing the job duties as a firefighter. In 2017, there were four major categories of job duties that firefighters were performing upon their death that included fire ground, non-fire emergencies, responding to or returning from emergency calls, and training. Not only did physical injuries result in on-duty deaths, but also illnesses including myocardial infarctions. In 2017, firefighter deaths decreased to the lowest level since the National Fire Protection Association (NFPA) started tracking annual death rates in 1977. Despite such promising statistics, there were still 60 on-duty deaths in the fire service across the U.S. in 2017. Although there are numerous physical hazards that are encountered by firefighters in their routine job duties, over half of these firefighter deaths were secondary to overexertion, stress, and medical causes, which is consistent with trends seen in the years past, as seen in Figure 1. Of the 32 deaths in this category, 29 were due to sudden cardiac deaths (Fahy, LeBlanc, & Molis, 2018).

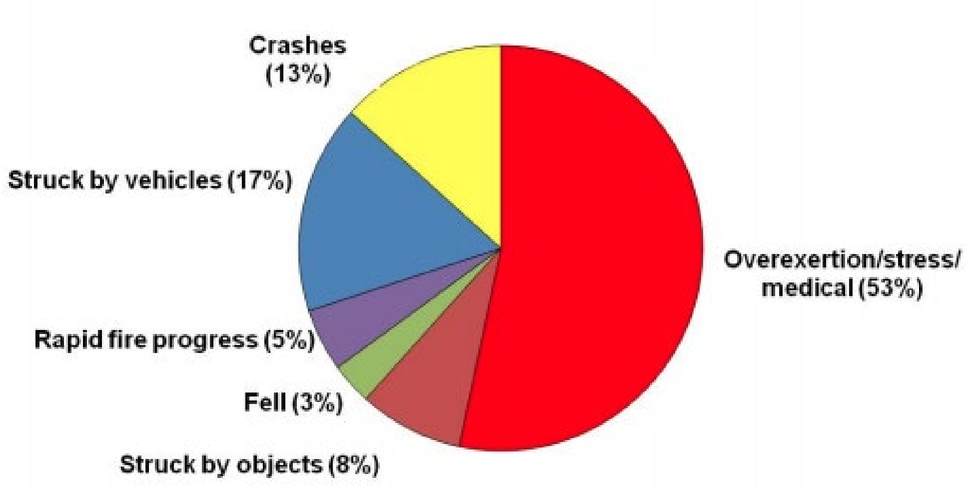

Figure 1: Firefighter deaths by cause of injury in 2017. National Fire Protection Association (NFPA) 2017.

Multiple occupational hazards are inherent within the firefighting occupation. Work stressors can include, but are not limited to the physically strenuous nature of the job; the work schedule that can require on-call readiness, long hours, and overnight shift work; and high levels of emotional labor interacting with the public especially in emergency situations. The effects of these work stressors on firefighters that protect and maintain security for the general public comes at a great cost for some firefighters, especially if these stressors result in actual strain. Occupational strain results if work stress leads to negative health consequences (Thatcher & Miller, 2003). Firefighting occupational hazards have the potential to affect approximately 1,160,450 firefighters, which include both professional and volunteer firefighters, across the U.S. as of 2015 (Haynes & Stein, 2017). Furthermore, the firefighting profession is projected to grow by 7% at an increase of 23,500 firefighters from 2016-2026 (Bureau of Labor Statistics, 2018). The significant breadth and dangers of occupational stressors within the protective services category have begun to receive more attention in recent years, especially since the terrorist attacks in New York City on September 11, 2001. Although protective service occupations include correctional officers, security guards, police officers, bailiffs, detectives and investigators among other occupations, firefighting in particular was named as 2015's "most stressful job in the US" by CareerCast (Bureau of Labor Statistics, 2018).

Cardiovascular Disease in Firefighters

Firefighters have been found to have a high risk for on-duty deaths secondary to cardiovascular events. Not unexpectedly, sudden cardiac death has been the number one cause of on-duty deaths in U.S. firefighters. Cardiac causes of death have accounted for 43% of on-duty deaths over the past 10 years. Out of the 60 firefighter deaths in 2017, the majority or 29 of the on-duty deaths were due to sudden cardiac deaths as demonstrated by Figure 2 (Fahy et al., 2018).

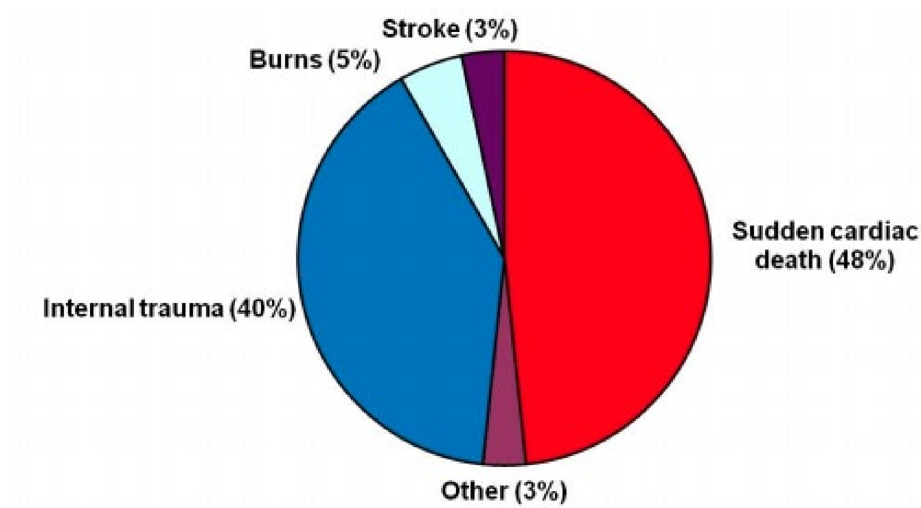

Figure 2: Firefighter deaths by nature of injury in 2017 (Fahy et al., 2018).

In fact, deadly cardiovascular events including myocardial infarctions are recognized and accepted as a line of duty fatality during non-routine strenuous activities in firefighters. This policy was established in the worker's compensation system per the Hometown Heroes Survivors Benefit Act, which was signed in 2003 (Angleman, 2010). Per the act, deaths may also qualify as in the line of duty if they also occur within 24 hours of duty (Fahy et al., 2018). Deaths due to cardiovascular disease could conceivably be significantly higher if off-duty deaths were also included in the on-duty death totals.

The importance of firefighter health especially cardiovascular health has been recognized by multiple agencies. The NFPA has established medical standards upon pre-hire and regular medical screening after hire that firefighter candidates and firefighters must meet in order to be hired or remain safely employed (2018). The National Institute for Occupational Safety and Health (NIOSH) published an alert entitled "Preventing Firefighter Fatalities Due to Heart Attacks and Other Sudden Cardiovascular Events." The NIOSH alert provides guidance on identifying and controlling exposures as well as preventive efforts like medical screening standards and comprehensive wellness and fitness programs (2007). Despite these efforts, cardiovascular risk factors, such as low fitness levels and obesity, are prevalent in this population and are likely contributing to such a high proportion of cardiovascular deaths.

Other associations have been implicated as additional adverse cardiovascular event risk factors. Some of these factors include time of day, time of year, and type of activity where more cardiovascular events are occurring during strenuous duties over non-emergency situations (Soteriades, 2011). Studies have investigated associations between psychological stressors and cardiovascular disease in firefighters. In this context, stress is simply defined as environmental demands exceeding one's own adaptive capacity, resulting in psychological and biological changes leading to strain or untoward health effects and even disease (Melamed, Shirom, Toker, Berliner & Shapira, 2006). Further investigation on the association between stress and cardiovascular disease would provide insight into additional strategies for prevention and early intervention for those firefighters with cardiovascular disease. More aggressive strategies to reduce work stressors on an individual and organizational level may be a part of an overall prevention strategy that may also include regular exercise, diet modifications, and weight loss.

Psychological Health in Firefighters

Firefighters are particularly at risk for various occupational mental health conditions from significant work stress. For example, job duties can include repeated exposure to traumatic experiences and involve long periods away from family and home (Angleman, 2010). Firefighters also undergo a high level of emotional labor, which is a job stressor that can lead to emotional exhaustion (Jeung, Kim, & Chang, 2018). Emotional labor involves regulation or suppression of emotions in order to achieve a task while maintaining composure in interpersonal interactions. Firefighters interact with the local community sometimes involving dire situations, which involves a high level of emotional labor that can be addressed with appropriate coping strategies.

However, if the exposure is excessive or prolonged, symptoms may arise that eventually lead to strain, specifically burnout, which is a job-induced syndrome composed mainly of emotional exhaustion in combination with depersonalization, cynicism, and a sense of reduced personal accomplishment. Emotional exhaustion is a state of emotional depletion that can manifest as decreased job performance, reduced morale, and absenteeism as well as a decline in mental and physical health (Hochschild, 1983; Jeung et al., 2018). Often accompanying emotional exhaustion is depersonalization that results in a lack of empathy with negative or cynical attitudes about others. Reduced personal accomplishment can occur concomitantly and refers to evaluating one's self negatively leading to self-dissatisfaction and depressive attitudes (Maslach, Jackson, & Leiter, 1997). Research in the fields of psychiatry, behavioral psychology, and neurobiology, reveal that depressive symptoms are responses to unresolvable stress even if the individual does not have a previous susceptibility to depression. Additionally, occupational adversity, especially chronic stressors like lack of control, inability to escape or resolve an aversive situation, and loss of status are depressogenic (Bianchi et al., 2017). Together, these symptoms can have detrimental effects in and outside of the workplace. Some effects of burnout outside of work include physical exhaustion, insomnia, drug and alcohol abuse, and social dysfunction including marital and family problems (Maslach et al., 1997).

Another mental health condition known as posttraumatic stress disorder (PTSD) is also a concern in the fire service since the condition affects many firefighters. PTSD is complex involving somatic, cognitive, affective, and behavioral reactions to psychological trauma. Symptoms can include intrusive thoughts, nightmares and flashbacks, avoidance of reminders of trauma, hypervigilance, and disorderly sleep, which can also results in occupational and interpersonal dysfunction (Sareen, 2018). Of the 1,140,750 firefighters in the U.S. across 30,000 fire departments in 2013, 18% to as high as 37% were estimated to have PTSD (Deppa & Saltzberg, 2016). Firefighters have a higher prevalence of PTSD as compared to the general population and even the police force as seen in Figure 3 (Heitman, 2012).

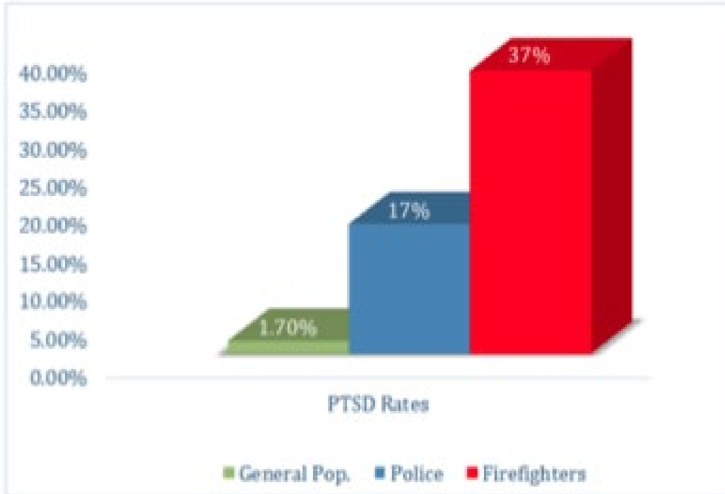

Figure 3: PTSD rates in the general population, police, and firefighters. Adapted from Janet A. Wilmonth, “Trouble in Mind,” NFPA Journal, May-June 2014 (Heitman, S.C., 2016).

Research Objectives

The existing data on cardiovascular health and psychological strain in the fire service, warrant asking the question of whether there are additional factors, such as unidentified occupational determinants like work stress, further contributing to cardiovascular risk factors, such as metabolic syndrome (MS), and ultimately cardiovascular morbidity and mortality in firefighters. If so, these occupational determinants could be addressed by preventive efforts. The essential job duties in the firefighting occupation can lead to high levels of occupational stress in a firefighter. Thus, there is a conceivable association between poor mental health indicators and cardiovascular health. Such an association would merit multiple key players within the fire service to make mental health among firefighters an even higher priority for action for the health and well-being of the fire service.

Further mitigating adverse cardiovascular outcomes is of the utmost importance in preventing firefighter mortality in this unique population. Coronary artery disease (CAD) is the leading cause of mortality globally and well-known cardiovascular risk factors, such as smoking, hypertension, obesity, and hypercholesterolemia, only account for a portion of CAD risk (Bremner et al., 2018). By addressing working conditions and mental health risk factors in addition to addressing well-known cardiovascular risk factors, there is a potential to further prevent firefighter mortality even at subclinical stages. Additionally, reducing the risk of sudden incapacitation due to adverse cardiovascular events is crucial to public safety as it threatens the ability of a firefighter to do their job especially in emergency situations. The risk of a sudden decrease in job capacity or sudden incapacitation places not only the firefighter's life at risk, but also the lives of the general public. As the Firefighter Behavioral Health Alliance aptly states, we must improve on "saving those who save others" (2016).

The primary objective of this cross-sectional study is to investigate the effects of psychological occupational strain on MS (and its components), which is a known predictor of adverse cardiovascular outcomes. The specific relationships to be investigated are outlined in the following research questions:

1. Is emotional exhaustion associated with MS (and its components) that implicates an increased risk of cardiovascular disease in firefighters?
2. Are PTSD indicators associated with MS (and its components) that implicates an increased risk of cardiovascular disease in firefighters?
3. Is psychological stress associated with MS (and its components) that implicates an increased risk of cardiovascular disease in firefighters?

The primary hypothesis is that higher levels of psychological occupational strain lead to a greater risk of adverse cardiovascular outcomes by potentiating the risk of metabolic syndrome. By investigating these relationships, the ultimate goal of this study is to provide guidance for real world applications. This study strives to strengthen the current research literature and inform future studies and health policy. Thus, such research plays an important role in elucidating additional strategies for early intervention and prevention while also increasing firefighter safety and reducing preventable firefighter morbidity and mortality.

CHAPTER 2: LITERATURE REVIEW

The association among emotional exhaustion, PTSD, and psychological stress with MS and cardiovascular disease in firefighters has not been extensively studied in the literature. In those few studies specifically examining the firefighter population applicability may be somewhat limited due to the evolution of job duties in the firefighting profession over time. Due to improved building materials and building codes, there have been less structural fires over the years. Despite this evolution in job duties, firefighters are still crucial in responding to environmental fires, which can spread rapidly, and medical emergencies often performing as paramedics (Bureau of Labor Statistics, 2018). However, working conditions have a well-known impact on employee health that can be positive or negative, the latter resulting in strain. Thus, research in other populations can be applicable to assessing this association in firefighters.

On the other hand, the association between MS and cardiovascular disease risk has been well-established in the literature. In fact, MS is associated with a two-fold increase in risk for cardiovascular disease over the next 5-10 years. MS also confers a 3- to 4-fold increase in risk for myocardial infarction (Kaur, 2014). Mottillo et al. found similar findings across 87 studies that included over 950,000. The meta-analysis ascertained increases in cardiovascular disease risk and myocardial infarction in those with MS at a relative risk of 2.35 (95% CI: 2.02-2.73) and 1.99 (95% CI: 1.61-2.46) respectively across 87 studies that included over 950,000 study subjects (Mottillo et al., 2010).

The Role of Stress in Metabolic Syndrome and Cardiovascular Disease

The pathophysiology of stress resulting in adverse cardiovascular outcomes is a part of a complex chronic and multifactorial process that evolves over time. The complexity of this process is highlighted in Figure 4. The manifestations of these disease trajectories are dependent on one's ability to adapt and respond, which is dependent on individual vulnerabilities and levels of resilience, and coping mechanisms such as cognitive appraisal. Consequently, exposure to stressors does not necessarily result in strain (Thatcher et al., 2003). The prevailing model in stress physiology summarizing these concepts is the allostatic load model. Allostasis refers to the concept of adaptive physiology to achieve a stable state in the setting of multiple interdependent systems and processes reacting to environmental demands. For example, higher cortisol levels and hypertension are the body's adaptive physiological responses to stress (Chandola et al., 2008). Despite these adaptive mechanisms, dysregulation and a maladaptive shift in the baseline state can occur under conditions of chronic stress leading to damaging effects on the body, which may in turn result in pathologic conditions such as cardiovascular disease (Juster, McEwen, & Lupien, 2010).

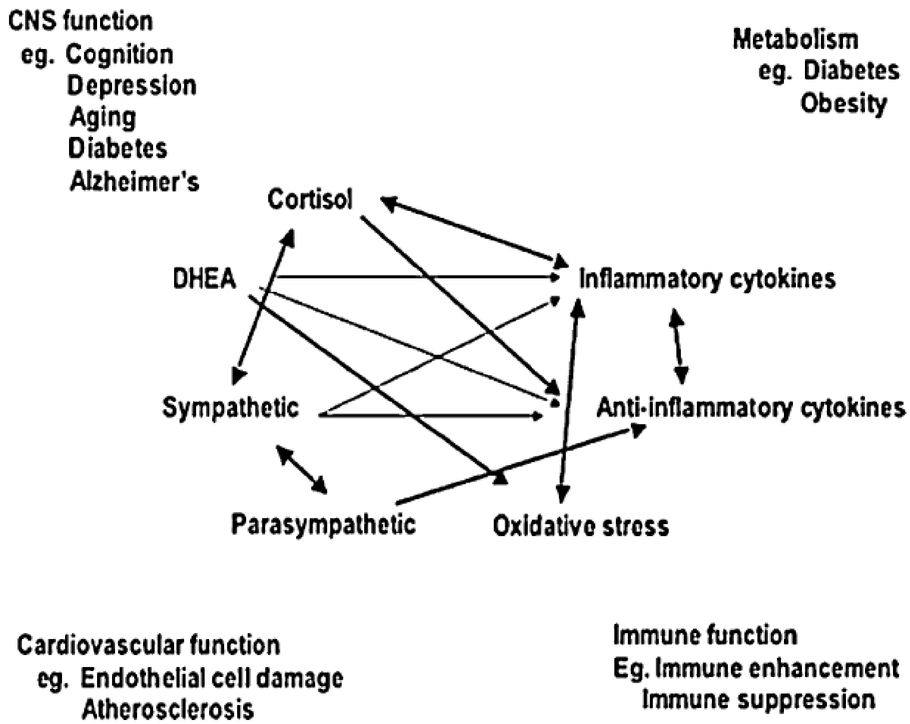

Figure 4: Non-linear network of multiple systems involved in allostasis and the stress response. Arrows indicate that each system regulates the others, which include many systems being influenced by the same mediator (McEwen, 2006).

MS is comprised of multiple risk factors for cardiovascular disease most notably atherogenic dyslipidemia, elevated blood pressure, and elevated plasma glucose. In those with MS, there is a two-fold greater risk of cardiovascular mortality, but even those meeting only one or two criteria, and thus, no diagnosis of MS, are at an increased risk of mortality. Obesity plays a central role in MS and is associated with cardiovascular disease as it contributes to abnormal cardiac function by increasing the risk for left ventricular hypertrophy, diastolic filling abnormalities, atrial fibrillation, and cardiomyopathy (Zafar, 2015). Glucocorticoids are found to be elevated in stress reactions increasing the risk for obesity in addition to another component of MS, insulin resistance since cortisol is an insulin antagonist (McEwen, 2005).

The aforementioned pathophysiologic mechanisms complement the findings of several epidemiologic studies on work stress and MS. Edwards et al. utilized data from the Coronary Artery Risk Development in Young Adults (CARDIA) data set from the National Heart, Lung, and Blood Institute, National Institutes of Health to carry out a prospective cohort study across 5 years of approximately 3,000 young adults with an average age of 35. This study revealed a significant association with increased incident MS with high job strain, which is different from the previously mentioned psychological occupational strain, compared to low job strain conditions. In this context, job strain is defined as high demand and low control per Karasek's Demand-Control Model (Edwards, Studver, Heeren, & Fredman, 2012). Another study performed on a cohort of Polish police officers, who also have a high psychological burden like that of firefighters, examined the effects of stress assessed by the Perceived Stress Scale-10 (PSS-10), which is a measure of the extent to which situations in one's life are perceived as stressful. The authors detected a higher prevalence of MS with co-existing coronary atherosclerosis confirmed by computed tomography coronary angiography with higher levels of perceived stress (Janczura et al., 2015). Kivimaki et al. performed a meta-analysis of 13 European cohort studies including almost 200,000 participants on job strain, which was identified from job-content and demand-control questionnaires, and the outcome of myocardial infarction or coronary death. The meta-analysis resulted in a hazard ratio of 1.23 (95% CI 1.10-1.37) as compared to those without job strain after adjusting for sex and age. The population attributable risk for job strain was 3.4% (Kivimaki et al., 2012). Furthermore one of the few large scale longitudinal studies in this field were congruent with these findings. Chandola, Brunner, and Marmot (2006) revealed a dose response relationship between stress at work and the risk of MS in a prospective cohort study of over 10,000 London workers from the Whitehall II cohort spanning a 14-year time period. In this study, stress was characterized by examining working conditions in the context of the iso-strain model, which accounts for low social support combined with high job strain, which is high demands and low control. Employees with chronic work stress were more than twice as likely to meet criteria for MS than those without work stress after adjusting for covariates such as health behaviors, occupational status, and health behaviors. Furthermore, the authors reported about 16% of the effect of work stress on coronary heart disease may be attributed to its effect on MS (Chandola et al., 2006). In conclusion, numerous studies support that cardiovascular risk factors defining MS can be influenced by both intrinsic factors, such as genetics, and extrinsic factors that likely include psychological occupational stress (Bremner et al., 2018).

The Pathophysiology of Stress

The brain also plays an integral role in mediating the hormonal reaction to stress that triggers various hormonal pathways, which can eventually adversely affect cardiac function over time. The primary axes of the mammalian stress system are the hypothalamic-pituitary-adrenocortical (HPA) and sympathetic-adrenomedullary (SA) axes. Exposure to stress activates the SA axis and increases the sympathetic outflow. This activation induces vasoconstriction, and repeated stress exposure may then induce vascular hypertrophy eventually leading to increased vascular resistance and increased blood pressure increasing the propensity for cardiovascular disease (Zafar, 2015). Wilson et al. (1998) found chronic changes in systolic blood pressure in those with stress from witnessing and experiencing a traumatic event. A similar reaction to stress to include elevations in blood pressure in addition to parasympathetic withdrawal were found in a longitudinal study by Uchino, Holt-Lunstad, Bloor, and Campo (2005). Furthermore, McEwen

(2005) revealed that the resulting chronic blood pressure elevations from stress lead to atherosclerotic plaques resulting in less pliable arteries and narrowing of arteries. This is especially detrimental to cardiac function when blood flow is limited provoking myocardial ischemia and sometimes infarction (McEwen, 2005)

Stress-induced systemic inflammatory processes are also activated through the brain. In a longitudinal study of almost 300 cardiovascular disease free patients, Tawakol et al. (2017) examined amygdalar activity though advanced imaging and found that amygdalar activity is an independent predictor of cardiovascular disease events. The amygdala is a key component of cognition and emotion involved in fear and stress, such as sympathetic reactions. Its activity is upregulated in stress conditions, such as PTSD, anxiety, and depression. Interestingly, bone-marrow activity and arterial inflammation were also found to be elevated, which was also associated with perceived stress in a cross sectional sub study of the main study population. Perceived stress was assessed via the Perceived Stress Scale (PSS-10) in those with conditions of chronic stress such as PTSD (Tawakol et al., 2017). Furthermore, the release of glucocorticoids and catecholamines are important players in the inflammatory cascade are also mediated by the brain specifically through the HPA and SA axes respectively in response to stress (Juster et al., 2010). Free fatty acids are released from adipose tissue and the liver to produce lipoproteins that are pro-inflammatory and cytotoxic. There is also activation of micro vascular circulation and endothelial dysfunction that also contributes to the evolution of atherosclerosis. Additional inflammatory cells, such as macrophages, and signaling proteins, such as cytokines and interleukins, are released with stress. These inflammatory processes eventually cause oxidative stress, tissue damage with reactive healing and tissue remodeling that over time result in atherosclerosis. Those with MS are in an even greater pro-inflammatory state due to low antioxidant capacity even if the inflammatory state is subclinical (McEwen, 2006; Zafar, 2015). Additionally, inflammatory markers to include elevated C-reactive protein and IL-6 have been found to predict hypertension, coronary heart disease, and cardiac mortality (D'Andrea, Sharma, Zelechoski, & Spinazzola, 2011). Furthermore, psychological reactions, such as fear, anger, and other stress reactions, can also trigger changes in hemodynamic responses affecting platelet function, cardiac conductivity, and cardiac muscle contraction (Bremner et al., 2018).

The Health Effects of Stress Manifesting as Strain

There are multiple manifestations of stress on health also known as strain. Stress may manifest as functional endpoints like myocardial ischemia and even infarction. Bremner et al. (2018) revealed that mental-induced myocardial ischemia may occur in the absence of exercise-induced myocardial ischemia indicating unique contributors resulting from physiologic processes involved in mental health. This phenomenon is known as mental stress ischemia (MSI). MSI is associated with activation of the areas of the brain involved in stress response and autonomic regulation of the cardiovascular system on cardiac and brain imaging. Areas of the brain that regulate emotion and cardiovascular function resulting in the activation of inflammatory, sympathetic, and other pathways were activated. In those with CAD, defects in cardiac perfusion at rest and with stress were greater in those with MSI than those without MSI (Bremner et al., 2018). Moreover, Moller, Theorell, de Faire, Ahibom, and Hallqvist (2005) demonstrated in a case-control and case-crossover study within the Stockholm Heart Epidemiology Program that temporary increases in workload or work competition representing acutely intense stress levels were associated with a six-fold increase in the risk for myocardial infarction in the next 24 hours. Another landmark study by Rosengren et al. (2004) known as the INTERHEART study was a case-control study of approximately 25,000 people across 52 countries that revealed similar results in those with chronic stress. Those who had a myocardial infarction had a higher prevalence of chronic stress including job stress, which was assessed via questionnaire regarding stress at work and home, financial stressors, and generalized locus of control. Study participants reporting stress at work had over twice the odds of a myocardial infarction than those reporting no stress at work. These findings were consistent across regions, ethnicities, and sex in the study population (Rosengren et al., 2004).

Specific stress reactions, such as burnout, have been associated with MS as well as cardiovascular disease. Burnout, which at its core consists of emotional exhaustion, physical fatigue, and cognitive weariness, is often associated with chronic occupational stress and has been recognized as a risk factor for mental health. Emotional exhaustion refers to feelings often accompanying depleted emotional resources and referred to as the "energy component" or the core component of burnout (Maslach, Jackson, & Leiter, 1997). Burnout is consistently more strongly influenced by environmental factors such as job environment and workload as opposed to individual characteristics such as personality traits and demographics. More recently burnout is increasingly being recognized for its effect on physical health including cardiovascular health (Melamed et al., 2006). Melamed, Kushnir, and Shirom (1992) found burnout, which was measured by an 8 item questionnaire with a Cronbach alpha 0.84, to be positively correlated with increased fasting glucose levels and cholesterol levels (total cholesterol, LDL, and triglycerides) as defined by MS criteria in addition to marginal EKG abnormalities. Salvagioni et al. (2017) conducted the first comprehensive systematic review of 62 prospective studies on effects of burnout that were conducted from 2005-2016. Most studies measured burnout by the MBI or the Shirom-Melamed Burnout Measure. The review found that independent of confounders burnout is significant predictor of hypercholesterolemia and type 2 diabetes both of which are risk factors for cardiovascular disease. Two studies in the review revealed a higher incidence of coronary heart disease in those with burnout. Moreover, upon review a 10-year cohort study found hospitalizations from cardiovascular disease were significantly associated with burnout (Salvagioni et al., 2017).

In addition to burnout and emotional exhaustion, there is research specifically linking another manifestation of stress, PTSD with cardiovascular disease, but the mechanism of this disease process has not been clearly identified either. Physical health problems have been associated with even a single traumatic exposure. PTSD is an especially important diagnosis, since an integral component of PTSD is recurrent reactions to trauma arising from specific triggers that lead to intrusive thoughts and memories or re-experiencing the traumatic event, which can elicit pathologic bodily processes in reaction to acute and chronic stress (D'Andrea et al., 2011). These stress pathways trigger multiple mechanisms ultimately leading to developing cardiac risk factors and cardiovascular pathology. Vidal et al. (2018) found that in a nationally representative sample of over 10,000 people in the U.S., those with a clinically significant diagnosis of PTSD were associated with an increased risk for cardiovascular disease. This resulted even after adjusting for known cardiovascular risk factors such as age, BMI, tobacco dependence, and diabetes. The statistical analysis was also adjusted for other mental health diagnoses that are likely to be comorbid with PTSD to include major depressive disorder, generalized anxiety disorder, and substance use disorder (Vidal et al., 2018). These findings are also supported by Boscarino and Chang (1999) who found that chronic PTSD was associated with abnormal electrocardiograms, atrioventricular defects, and myocardial infarctions.

Proposed Mechanism of Action of Psychological Occupational Strain in Cardiovascular Disease Pathology

Based on the current body of literature on psychological strain and MS (and its components), and cardiovascular disease in combination with known pathophysiology, there is a biologic plausibility for a causal association. Therefore, the following mechanism of action is proposed in context of the aforementioned hypotheses:

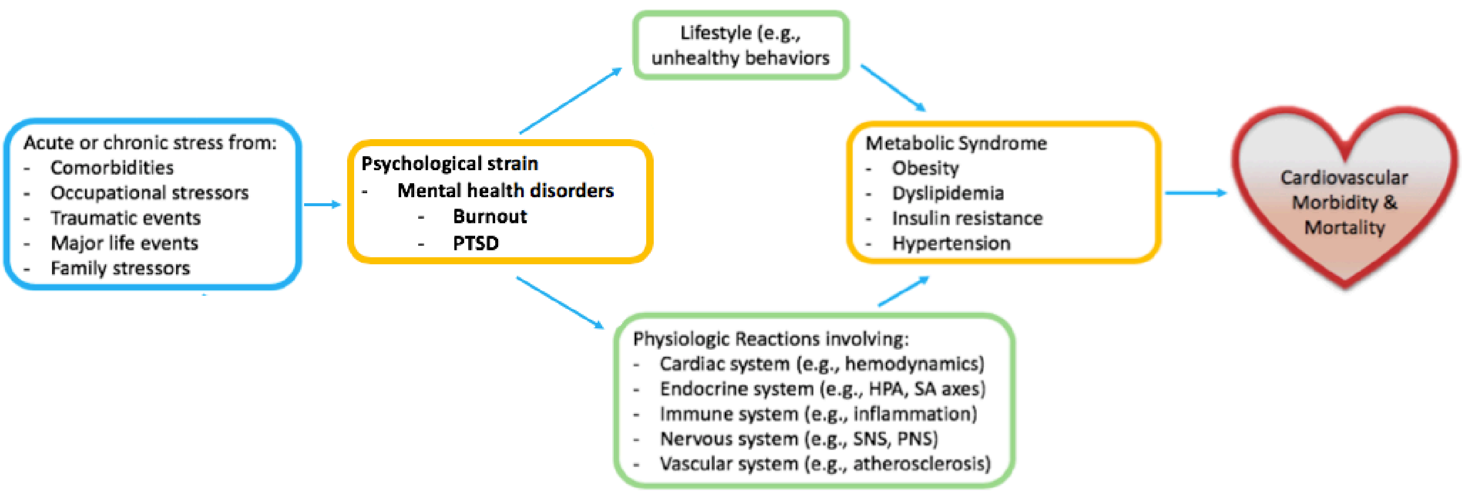

Figure 5: Proposed pathway of acute and chronic stress resulting in cardiovascular morbidity and mortality. The lists of acute or chronic stress and physiologic reactions are not all inclusive (Boscarino et al., 1999; Bremner et al., 2018; Chandola et al., 2006; Chandola et al., 2008; D'Andrea et al., 2011; Edwards et al., 2012; Janczura et al., 2015; Juster et al., 2010; Kivimaki et al., 2012; McEwen, 2006; Moller, 2005; Rosengren et al., 2004; Salvagioni et al., 2017; Uchino et al., 2005; Vidal et al., 2018; Wilson et al., 1998; Zafar, 2015).

HPA: hypothalamic-pituitary-adrenocortical, SA: sympathetic-adrenomedullary, SNS: sympathetic nervous system, PNS: parasympathetic nervous system

The current body literature recognized that stress is a health hazard yet the current body of literature still leaves several unanswered questions (Kivimaki, et al., 2012). The literature suggests that stress reactions trigger multiple physiologic processes mediated by the brain to induce strain, such as cardiovascular pathology. However, no definite mechanism of action between psychological occupational strain and metabolic syndrome has been established. It is proposed that the measures of mental health regarding emotional exhaustion, PTSD, and psychological stress may be associated with an increased risk for MS and thus, cardiovascular disease. This effect may be greater in combination than individually. However, predictions on whether this relationship would be additive or synergistic for example is not known, especially without a standardized method to quantify stress.

CHAPTER 3: METHODOLOGY

FORWARD Study Background

In order to further investigate the relationship between cardiovascular risk factors and work stress in firefighters, data from the Firefighter Obesity Research: Workplace Assessment to Reduce Disease (FORWARD) Study were utilized. The FORWARD Study is a cross-sectional, epidemiological study of 365 Orange County Fire Authority (OCFA) firefighters. The study was performed by the University of California, Irvine, Center for Occupational and Environmental Health and had strong support from the fire departments and the local union of the International Association of Fire Fighters (Choi et al., 2011). The study was funded by the National Institute for Occupational Safety and Health (NIOSH), which is a division of the Centers for Disease Control and Prevention. The objectives of the FORWARD study was to validate a firefighter-specific work and health questionnaire, investigate the effects of working conditions and health behaviors on firefighter obesity, and identify the relationship of these potential risk factors of obesity. By investigating obesity risk factors, the ultimate goal of this study is to contribute to future studies about cardiovascular risk factors in firefighters through changes in working conditions and health behaviors (Choi et al., 2011; Choi, Dobson, Schnall, & Garcia-Rivas, 2016; Choi, Schnall, & Dobson, 2016).

Measures of Psychological Occupational Strain

Data on measures of occupational strain from the FORWARD study were utilized to assess the effects of stress exposure. The effects of stress on an individual are summarized in the allostatic load model, which involve both physical and mental aspects of pathophysiology. This is dependent on an individual's level of vulnerability, ability to cope with stressors, ability to adapt to stressors, and overall resiliency (Chandola et al., 2008; Thatcher et al., 2003). Thus, the available data on direct measures of stress exposure, such as number of shifts and days away from home, were not utilized as a measure for exposure, since exposure to stress does not necessarily result in strain for any given individual.

The FORWARD study collected data on several measures of psychological occupational strain, such as the Exhaustion Scale of the Maslach Burnout Inventory (ES-MBI), Primary Care Post-traumatic Stress Disorder (PC-PTSD) Screen, and the General Health Questionnaire (GHQ) - 12 (Choi et al., 2011; Choi, Dobson, Schnall, & Garcia-Rivas, 2016; Choi, Schnall, & Dobson, 2016). In this study, these measures of psychological occupational strain are the categorical variables that are hypothesized to be predictors of MS.

Exhaustion Scale of the Maslach Burnout Inventory (ES-MBI). The most widely used burnout measurement tool is the MBI. The MBI was selected due to its reliability, validity, and practicality in measuring the extent of emotional exhaustion, depersonalization, and reduced personal accomplishment that are often found in human service professions. These symptoms together constitute a syndrome known as burnout (Maslach, Jackson, & Leiter, 1997). Burnout research reveals that exhaustion may be the most important indicator of stress-related health outcomes. Consequently, studying these mental health indicators separately are purported to be a better construct of occupation-induced mental health conditions than the MBI. As a result, such an investigative design renders a greater utility in public health policy. Mental health indicators can be better interpreted individually such that various conditions are not combined in one summary indicator, such as the MBI. Thus, more purposeful action in public health policy can be taken since different symptom profiles may require different management approaches. Through this approach, achieving prevention throughout this population becomes an increasingly realistic result (Bianchi et al., 2017).

The full MBI consists of 22 items with three subscales: 5 items for emotional exhaustion, 5 items for cynicism, and 6 items for professional efficacy. A high degree of internal consistency and reliability is evident from the Cronbach's coefficient alpha of the ES-MBI, which is the highest of all three subscales at 0.90 compared to 0.79 for depersonalization and 0.71 for personal accomplishment (Maslach et al., 1997). The following 5 item questionnaire making up the ES-MBI was included in the FORWARD assessment with the answer choices for each question being never, a few times a year, once a month, a few times a month, once a week, a few times a week, or everyday:

"Please read the following items and decide if you ever feel this way about your job. If you have never had this feeling, checkbox for 'Never.' If you have had this feeling, indicate how often you feel this way:

1. I feel emotionally drained from my work.
2. I feel used up at the end of the workday.
3. I feel tired when I get up in the morning and have to face another day on the job.
4. Working all day is really a strain for me.
5. I feel burned out from my work" (Choi et al., 2011; Choi, Dobson, Schnall, & Garcia-Rivas, 2016; Choi, Schnall, & Dobson, 2016).

The grading scale includes a cut off score for a positive ES-MBI screen is ≥ 3.20 based on the original questionnaire, which used a zero to six response set (Maslach, Jackson, & Leiter, 1997). A corresponding equivalent cut off score of ≥ 4.20 was used in the FORWARD Study due to a one to seven response set where the total score, which has a maximum possible score of 35, is divided by five or the number of questions (Choi et al., 2011; Choi, Dobson, Schnall, & Garcia-Rivas, 2016; Choi, Schnall, & Dobson, 2016).

Primary Care Post-traumatic Stress Disorder (PC-PTSD) Screen. The PC-PTSD Screen was selected to screen for PTSD. This screen has been found to be a valid psychometrically sound screen that has outperformed the PTSD Symptom Checklist and the Clinician Administered Scale for PTSD. Additionally, the screen focuses on current symptoms rather than life time symptoms and is easy to administer. There are several advantages to the PC-PTSD Screen. The screen can be administered without an interview, is the shortest PTSD screening questionnaire at 4 items, and is the only questionnaire with a binary yes-no answer format. The following PC-PTSD Screen was included in the FORWARD assessment with the answer choices for each question being yes or no:

"During your work as a firefighter, have you ever had any experience that was so frightening, horrible, or upsetting that, <u>in the past month</u>, you:

1. Have had nightmares about it or thought about it when you did not want to?
2. Tried hard not to think about it or went out of your way to avoid situations that reminded you of it?
3. Were constantly on guard, watchful, or easily startled?
4. Felt numb or detached from others, activities, or your surroundings?" (Choi et al., 2011; Choi, Dobson, Schnall, & Garcia-Rivas, 2016; Choi, Schnall, & Dobson, 2016).

Each yes answer contributes a value of one and each no answer contributes a value of zero for a possible maximum score of four. A score of three or more was shown to be the most efficient in terms of diagnostic accuracy at 85%, which is comparable to other commonly used PTSD screening tools. However, in populations of high prevalence, a score of two or more may be considered as a cut off score due to the increase in sensitivity from 0.78 to 0.91, which also causes a decline in specificity from 0.87 to 0.72 (Prins, Ouimette, Kimerling, Cameron, Hugelshofer, Shaw-Hegwer, Thrailkill, Gusman, & Sheikh, 2003).

General Health Questionnaire (GHQ) - 12. The GHQ-12 is derived from the full GHQ, which is a 60 item psychological stress screening test used to measure the risk of developing psychiatric disorders. Thus, the GHQ-12 screens for potential cases that may be diagnosed as psychiatric disorders upon further evaluation. The GHQ-12 screens for psychological morbidity by assessing several factors associated with psychiatric disorders, such as anxiety and depression, social dysfunction, and loss of confidence. The screening questions focus on the individual's current state as their "usual self" instead of inherent traits as the severity of psychiatric illness can change over time (Goldberg, 1972).

The GHQ-12 was included in the FORWARD assessment as below with the answer choices for each question being either not at all, no more than usual, rather more than usual, much more than usual:

"We want to know how your health has been in general over the last few weeks. Please read the questions below and each of the four possible answers. Check the response that best applies to you.

1. Lost much sleep over worry?
2. Felt constantly under strain?
3. Felt you couldn't overcome your difficulties?
4. Been feeling unhappy or depressed?
5. Been losing confidence in yourself?
6. Been thinking of yourself as a worthless person?

7. Been able to concentrate on what you're doing?
8. Felt that you are playing a useful part in things?
9. Felt capable of making decision about things?
10. Been able to enjoy your normal day to day activities?
11. Been able to face your problems?
12. Been feeling reasonably happy, all things considered?" (Choi et al., 2011; Choi, Dobson, Schnall, & Garcia-Rivas, 2016; Choi, Schnall, & Dobson, 2016).

The GHQ-12 answers are scored on a 0, 0, 1, 1 scale where a score of zero is given for answer choices "not at all" and "no more than usual" while a score of one is given for answer choices "rather more than usual" or "much more than usual" for each question. A positive GHQ-12 is when the total score totals 2 or more (Goldberg, 1972).

Measures of Cardiovascular Disease Risk

The outcome of interest is MS also known as insulin resistance syndrome or syndrome X (Meigs, 2018). MS is comprised of several cardiovascular risk factors and considered an indicator of long-term risk (Kaur, 2014). MS is defined by specific criteria for abdominal obesity or a waist circumference, cholesterol, blood pressure, and blood glucose. The data are analyzed as categorical, since each values is interpreted as whether it is above or below a certain criteria or for some of the variables whether or not certain medications are taken. According to the NCEP ATP III (National Cholesterol Education Program Adult Treatment Panel III) criteria, which was updated in 2005, those with MS meet three of more specific criteria per Table 1 (Huang, 2009; Kaur, 2014).

Table 1: NCEP ATP III MS Criteria.

Risk Factor	NCEP ATP III MS Criteria
Abdominal obesity	Waist circumference greater than 40 inches in men and greater than 35 inches in women
Hypertriglyceridemia	Triglyceride level greater than or equal to 150 mg/dL or taking antihyperlipidemic medication
Low high density lipoprotein (HDL)	HDL less than 40 mg/dL in males and less than 50 mg/dL in females or taking antihyperlipidemic medication
Hypertension	Blood pressure greater than or equal to 130/85 mmHg or taking antihypertensive medication
Insulin resistance	Elevated fasting glucose greater than or equal to 100 mg/dL or taking insulin or other hypoglycemic medication

MS is diagnosed once three or more NCEP ATP III criteria are met (Huang, 2009; Kaur, 2014).

Statistical Analysis

Descriptive statistics were analyzed to characterize the OCFA firefighter population. The results of the psychological screening tests, which included the GHQ-12, ES-MBI, and the PC-PTSD screens, were examined and recorded as either positive or negative according to the aforementioned scoring criteria. Data on each of the MS components was also gathered and determined to be either positive by meeting MS criteria or negative by not meeting MS criteria set forth by the NCEP ATP III in Table 1. In each category, missing data points resulted as displayed in Table 3. Only subjects with data for all three screening questionnaires and all five MS criteria were included in the total study population, which decreased the number of subjects analyzed from the initial population of 365 to 273 firefighters. Meeting the definition of MS was only determined if there was data for all five MS criteria, which included data for blood pressure, fasting glucose, lipids (specifically HDL and triglycerides), and waist circumference.

Table 2: Missing data pattern for each data category out of the initial 365 firefighter subjects in the study population.

Data Category	Number of Data Points	Number of Missing Data Points
GHQ-12	351	14
ES-MBI	355	10
PC-PTSD	355	10
BP	360	5
Glucose	305	60
HDL	299	66
WC	345	20
TG	309	56
MS	284	81

GHQ-12 - General Health Questionnaire-12, ES-MBI - Exhaustion Scale of the Maslach Burnout Inventory, PC-PTSD - Primary Care Post-traumatic Stress Disorder, HDL – High Density Lipoprotein, SBP – Systolic Blood Pressure, DBP – Diastolic Blood Pressure, TG – Triglycerides, WC – Waist Circumference

The prevalence and association between psychological screening tests and MS components was determined using a Chi-square analysis. Further statistical analysis using logistic regression with and without controlling for covariates individually was then performed between each psychological screening test and for each individual MS criteria and MS. The covariates included in the analysis are age greater than or equal to 45 years of age and gender. In this study population there was no difference in smoking or consumption of tobacco products in those with MS, so this covariate was not included in the statistical analysis (Choi, Ko, & Kojaku, 2017). The same approach using logistic regression was performed between each psychological screening test and the number of MS criteria satisfied up to three or more criteria, which is the definition of MS. The 80% and 95% confidence intervals (CI's) were calculated for each resulting odds ratio (OR).

Since the study is a cross-sectional design, prevalence ratios were considered in order to avoid overestimation of an effect that may be seen in calculations involving OR's for example (Coutinho, 2008). However, due to the low prevalence of positive screening test results OR's were still utilized. Testing and confidence intervals on OR's are Wald based. Due to the small sample size of 273 study subjects, 80% confidence intervals were also calculated as part of an exploratory analysis to detect suggestive results that may be missed when using higher confidence intervals at the standard 95% confidence interval.

To better understand the impact of including those prescribed medications for hypertension, diabetes, and hyperlipidemia, a sensitivity analysis was performed excluding those on these medications decreasing the study population from 273 to 232 firefighters. Those prescribed medications were included in the study population since this also satisfies meeting the relevant MS criteria. Medications possibly influence associations between MS (and its components) and psychological screening tests. Medications used to treat a condition associated with particular MS criteria, such as hyperlipidemia, may also affect other criteria such as BP, blood glucose, and WC. A reverse causation mechanism where treating MS (and its components) results in a reduction in psychological strain may exist or co-exist in a bidirectional relationship. Mansur et al. proposes this concept termed "metabolic-mood syndrome," where the metabolic and behavioral/ emotional phenotypes converge (2015). The concept embodies the complexity and interconnectedness of metabolic systems in the setting of allostatic responses and unique individual factors, such as genetic and developmental factors. The consistent association of neuropsychological abnormalities with objective brain abnormalities and metabolic dysfunction in the literature has supported this principle. This concept has also been demonstrated in studies. For example, in a study involving a variety of weight-loss interventions, weight loss had positive effects on mood symptoms (Mansur et al., 2015).

First, the prevalence of those with and without medications was calculated for the following MS criteria: BP, Glucose, HDL, TG. Excluding those prescribed medications, a logistic regression with and without controlling for covariates individually and in combination was then performed between each psychological screening test and for each individual MS criteria and MS. Logistic regression with and without controlling for covariates individually was then performed between each psychological screening test and the number of MS criteria satisfied up to three or more criteria

All statistical analysis was performed using JMP, version 14.0.0 (JMP, 2018).

CHAPTER 4: RESULTS

The demographic characteristics of the OCFA firefighter study population are shown in Table 2. Most of the firefighters were male (97%), reported their race/ethnicity as White/Non-Hispanic (84%), and were married or living with a partner (78%). The average age was 42 years. The most common job titles among the study population in which the firefighters could report more than one job title were Fire Apparatus (N=67), Captain (N=77), and Paramedic (N=101).

Table 3: Demographic characteristics of the firefighter study population (N=273).

Study Variable	Subcategory	% (N)
Age	Average age in years	42
	Age range in years	25-61
	Average≥ 55 years old	6% (16)
Sex	Male	97% (266)
	Female	3% (7)
Race/ ethnicity	White/ Non-Hispanic	84% (230)
	Asian	4% (12)
	Native American	1% (3)
	Pacific Islander	2% (4)
	Other	9% (24)
Marital status	Married or Living with a partner	78% (213)
	Divorced or Separated	9% (24)
	Never married or Single	13% (36)
Education	High school diploma or GED	1% (1)
	Some college or Associate's degree	51% (140)
	Bachelor's degree	44% (120)
	Graduate degree	4% (12)
Job Title	Rookie Firefighter	2
	Heavy Equipment Operator	0

Fire Apparatus Engineer	67
Battalion Chief	6
Deputy Fire Chief	0
Helicopter Pilot	1
Paramedic	101
Division Chief	2
Hazmat	31
Urban Search and Rescue	51
Captain	77
Assistant Fire Chief	1

Statistical analysis on the prevalence of MS criteria and MS in addition to indicators of psychological occupational strain were performed as displayed in the following Figures 6 and 7. In Figure 6, the prevalence of MS and the prevalence of each MS criteria are outlined for the study population totaling 273 subjects. The prevalence of those meeting the MS component criteria is 17% for the blood pressure (BP) criteria, 19% for the glucose criteria, 20% for the high density lipoprotein (HDL) criteria, 24% for the triglyceride (TG) criteria, and 23% for the waist circumference (WC) criteria. Approximately 14% of firefighters meet the criteria for MS, which is defined as meeting at least three of the five possible MS criteria (Prins et al., 2011). A diagnosis of MS was determined from firefighters who had data for all five criteria such that those with missing data for any of the MS criteria were excluded in that analysis

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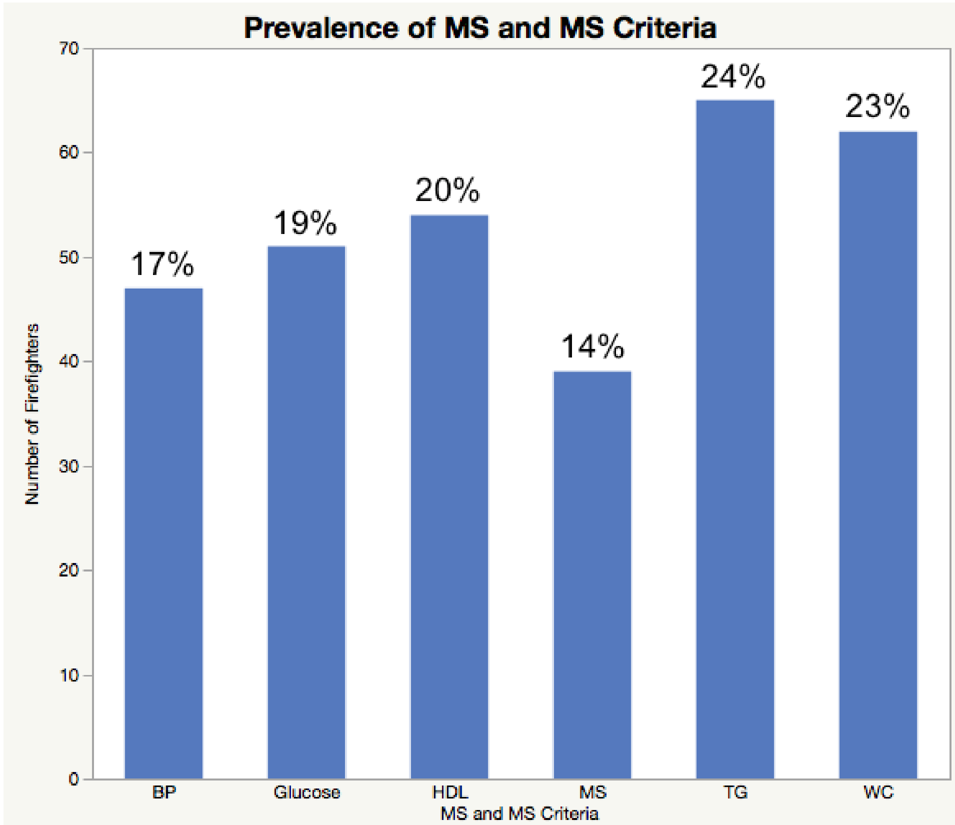

Figure 6: Prevalence of firefighters satisfying criteria for MS (and its components) (N = 273). Meeting the definition of MS was determined by using the NCEP ATP III guidelines (Huang, 2009; Kaur, 2014). The histogram displays the number of firefighters that meet each criteria and the corresponding percentage of firefighters of the total study population (N=273). HDL – High Density Lipoprotein, SBP – Systolic Blood Pressure, DBP – Diastolic Blood Pressure, TG – Triglycerides, WC – Waist Circumference

As displayed in Figure 7, the prevalence of those with positive psychological screening questionnaires are 17%, 24%, and 5% for the ES-MBI, GHQ-12, and PC-PTSD screens in the study population of 273 subjects. Positive screening questionnaire results were based on cut off scores of ≥ 3 on the PC-PTSD Screen, ≥ 4.2 on the ES-MBI, and ≥ 2 on the GHQ-12 (Prins et al., 2003; Choi et al., 2011).

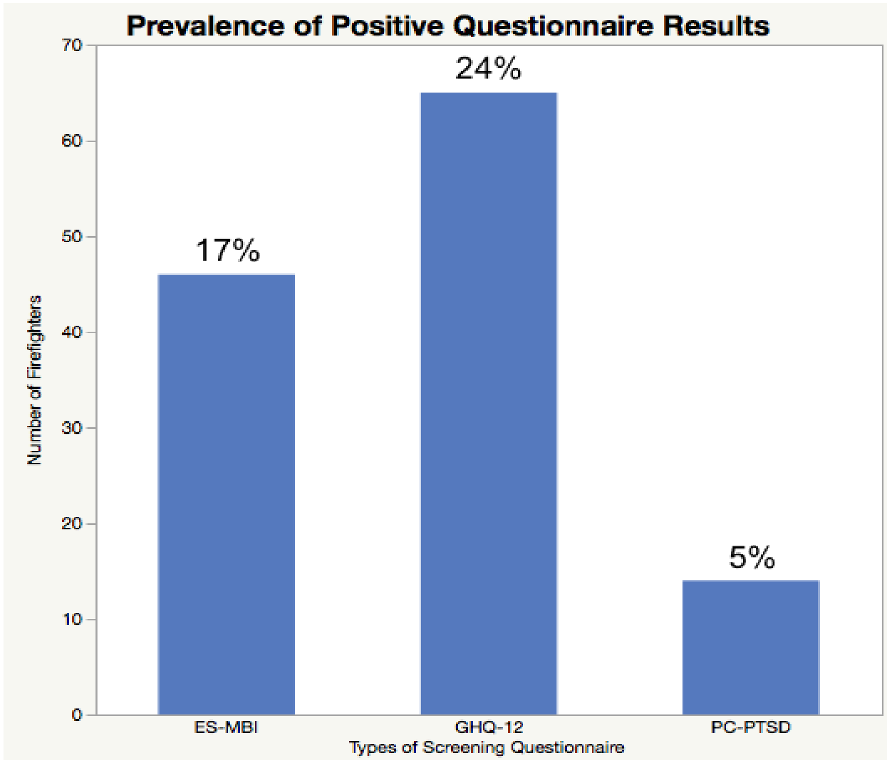

Figure 7: Prevalence of positive screening questionnaire results for the PC-PTSD, ES-MBI, and GHQ-12 with the corresponding percentages of positive results of the total study population, (N=273).

Table 4: Screening test results by MS (and its components) (N=273).

		Screening Test Results by MS Component Criteria and MS					
Screening Test	**Test Result**	**BP**	**Glucose**	**HDL**	**WC**	**TG**	**MS**
GHQ-12	**Yes:** 65	17%	22%	15%	**31%***	20%	17%
	No: 208	17%	18%	21%	**20%***	25%	13%
ES-MBI	**Yes:** 46	17%	17%	13%	24%	**13%***	11%
	No: 227	17%	19%	21%	22%	**26%***	15%
PC-PTSD	**Yes:** 14	21%	14%	21%	36%	21%	14%
	No: 259	17%	19%	20%	22%	24%	14%

In Table 4, the percentages of study subjects meeting the criteria for MS component criteria and MS were are calculated by using the total number with that particular data for each category within the study population of 273 subjects. Relationships with statistically suggestive associations based on significant Chi-square test results are denoted by "*" for $p<0.20$.

Results of Chi-square Analysis. In the initial univariate analysis with Chi-square testing reveals associations of each psychological screening test and MS. The overall prevalence of those meeting criteria for MS was calculated at 14%. Thus, GHQ-12 was associated with a higher than expected number of those with MS at 17%. On the other hand, ES-MBI had a lower than expected prevalence of MS at 11% and PC-PTSD had prevalence that was expected based on the overall prevalence at 14%.

The Chi-square analysis also reveals suggestive associations between certain psychological screening tests and individual components of MS to include GHQ-12 and WC and ES-MBI and TG. Those meeting WC criteria had a higher prevalence of positive GHQ-12 screens than those not meeting WC at 31% and 20% respectively, which is the pattern that was hypothesized. On the other hand, those meeting TG criteria had a lower prevalence of positive ES-MBI screens than those not meeting TG criteria at 13% and 26% respectively, which is not a pattern that would be expected based on the current literature on stress and MS. Stress exposure induces multiple stress pathways that are expected to initiate processes moving towards meeting biomarker requirements that compose MS, which is a part of the process in developing cardiovascular pathology.

Results of Logistic Regression Analysis. Further multivariate analysis was performed and OR's were calculated through a logistic regression analysis with and without controlling for covariates. The results are displayed in Tables 5a and 5b. No statistically significant associations were observed. However, as displayed in Table 5b, statistically suggestive OR's were found for GHQ-12, ES-MBI, and PC-PTSD. Statistically suggestive results were found between the GHQ-12 and WC (OR 1.76, 80% CI 1.17-2.65) without significant change upon controlling for covariates. Statistically suggestive results were also found between ES-MBI and TG (OR 0.43, 80% CI 0.24-0.77) without significant change upon controlling for covariates. However, the ES-MBI and TG relationship indicates that a positive ES-MBI screen was associated with a lower likelihood of meeting the TG criteria for MS, which is the opposite of what would be expected considering the current literature on stress reactions and its concomitant pathophysiologic pathways. Statistically suggestive results were demonstrated between PC-PTSD and WC upon controlling for covariates gender alone, age alone, and gender in combination with age (OR 2.15, 80% CI 1.01-4.58). This association was not even statistically suggestive upon controlling for age only indicating that gender was masking this relationship and that this association may be different in males versus females, which made up only seven of the 273 subjects.

The other MS components, BP, glucose, and HDL did not reveal any statistically significant or suggestive associations with any of the three psychological screening tests. However, stronger positive associations were found between GHQ-12 and glucose and PC-PTSD without significant differences upon controlling for covariates. There was a stronger positive association between PC-PTSD and HDL, but only upon controlling for age and gender. Although not statistically suggestive either, stronger negative associations were found between GHQ-12 and HDL, ES-MBI and HDL, and PC-PTSD and glucose, GHQ without significant differences upon controlling for covariates. Again, these negative associations are not expected, but instead positive associations would be expected based on the hypothesis. However, the differences that were found could have been due to chance alone, especially since most of the strongest relationships were statistically suggestive instead of statistically significant.

Table 5a: OR results of logistic regression analysis for psychological screening tests as a predictor for MS (and its components) with and without controlling for covariates (N=273).

Screening Test	OR for Each MS Component Criteria (N = 273)											
	BP				Glucose				HDL			
	No covariate(s)	Age	Gender	Age + Gender	No covariate(s)	Age	Gender	Age + Gender	No covariate(s)	Age	Gender	Age + Gender
GHQ-12 95% CI 80% CI	0.97 (0.46-2.04) (0.60-1.58)	0.95 (0.45-2.00) (0.58-1.55)	0.98 (0.47-2.06) (0.60-1.60)	0.96 (0.46-2.03) (0.59-1.57)	1.27 (0.64-2.53) (0.81-1.99)	1.24 (0.62-2.48) (0.79-1.95)	1.27 (0.64-2.54) (0.81-2.00)	1.24 (0.62-2.48) (0.79-1.95)	0.68 (0.32-1.44) (0.41-1.11)	0.67 (0.31-1.42) (0.41-1.09)	0.68 (0.32-1.45) (0.42-1.12)	0.67 (0.32-1.44) (0.41-1.11)
ES-MBI 95% CI 80% CI	1.01 (0.44-2.34) (0.59-1.75)	1.03 (0.44-2.38) (0.59-1.78)	1.04 (0.45-2.42) (0.60-1.81)	1.06 (0.46-2.46) (0.61-1.84)	0.90 (0.39-2.07) (0.52-1.55)	0.91 (0.40-2.10) (0.53-1.58)	0.91 (0.39-2.08) (0.53-1.56)	0.92 (0.40-2.12) (0.53-1.58)	0.56 (0.22-1.40) (0.31-1.02)	0.56 (0.22-1.40) (0.31-1.02)	0.57 (0.23-1.43) (0.31-1.04)	0.58 (0.23-1.44) (0.32-1.05)
PC-PTSD 95% CI 80% CI	1.33 (0.36-4.97) (0.56-3.15)	1.31 (0.35-4.90) (0.55-3.10)	1.43 (0.38-5.39) (0.60-3.40)	1.43 (0.37-5.43) (0.60-3.42)	0.71 (0.15-3.30) (0.26-1.94)	0.69 (0.15-3.22) (0.25-1.89)	0.72 (0.16-3.35) (0.27-1.97)	0.70 (0.15-3.27) (0.26-1.92)	0.90 (0.24-3.34) (0.38-2.12)	1.10 (0.30-4.10) (0.47-2.60)	1.19 (0.32-4.48) (0.50-2.83)	1.19 (0.31-4.48) (0.50-2.83)

Each column within each MS component criteria and MS represent analysis where that is uncontrolled for covariates and analysis where covariates are controlled for to include age greater than or equal to 45 years, gender, and both covariates.

Table 5b: OR results of logistic regression analysis for psychological screening tests as a predictor for MS (and its components) with and without controlling for covariates (N=273).

Screening Test	OR for Each MS Component Criteria (N = 273)								MS			
	WC				TG							
	No covariate(s)	Age	Gender	Age + Gender	No covariate(s)	Age	Gender	Age + Gender	No covariate(s)	Age	Gender	Age + Gender
GHQ-12 95% CI 80% CI	**1.76** (0.94-3.29) **(1.17-2.65)**	**1.76** (0.94-3.29) **(1.17-2.65)**	**1.78** (0.95-3.35) **(1.18-2.69)**	**1.79** (0.95-3.36) **(1.18-2.70)**	0.75 (0.38-1.49) (0.48-1.17)	0.73 (0.37-1.45) (0.47-1.15)	0.76 (0.38-1.50) (0.48-1.18)	0.74 (0.37-1.47) (0.47-1.16)	1.31 (0.61-2.80) (0.80-2.15)	1.30 (0.61-2.79) (0.79-2.14)	1.32 (0.62-2.84) (0.80-2.18)	1.32 (0.61-2.82) (0.80-2.17)
ES-MBI 95% CI 80% CI	1.08 (0.51-2.29) (0.67-1.77)	1.08 (0.51-2.29) (0.67-1.77)	1.12 (0.53-2.37) (0.68-1.83)	1.12 (0.53-2.37) (0.68-1.82)	**0.43** (0.17-1.06) **(0.24-0.77)**	**0.43** (0.17-1.07) **(0.24-0.78)**	**0.44** (0.18-1.08) **(0.24-0.79)**	**0.44** (0.18-1.10) **(0.24-0.80)**	0.69 (0.26-1.88) (0.36-1.33)	0.69 (0.26-1.88) (0.36-1.33)	0.71 (0.26-1.93) (0.37-1.36)	0.71 (0.26-1.94) (0.37-1.37)
PC-PTSD 95% CI 80% CI	1.97 (0.63-6.11) (0.94-4.13)	1.97 (0.64-6.12) (0.94-4.13)	**2.15** (0.68-6.83) **(1.01-4.58)**	**2.15** (0.68-6.83) **(1.01-4.58)**	0.87 (0.23-3.21) (0.37-2.04)	0.85 (0.23-3.15) (0.36-2.00)	0.92 (0.25-3.47) (0.39-2.19)	0.92 (0.24-3.48) (0.39-2.20)	1.00 (0.22-4.65) (0.37-2.73)	0.99 (0.21-4.62) (0.36-2.71)	1.06 (0.23-4.98) (0.39-2.92)	1.06 (0.23-4.98) (0.39-2.92)

Each column within each MS component criteria and MS represent analysis where that is uncontrolled for covariates and analysis where covariates are controlled for to include age greater than or equal to 45 years, gender, and both covariates.

A logistic regression was also performed for each screening test and the number of satisfied MS criteria in any combination up to greater than three criteria, which is the definition of MS. Without controlling for covariates, a statistically suggestive association was found with ES-MBI and satisfying one or more MS criteria, which was no longer present after controlling for covariates in any combination. Otherwise no other statistically significant or suggestive relationships were found between each of the screening tests as a predictor for meeting any number of MS criteria.

Results of Sensitivity Analysis. As part of the MS criteria, meeting specific cut off laboratory values or taking specific medications satisfy MS criteria. Apart from the possibility that the findings were result of chance, medications were also considered. Medications may influence the analysis as well and may have contributed to the unexpected negative association between ES-MBI and TG. For instance, those on antihyperlipidemic medication may also have better weight control, since medications in combination with a healthy diet are integral to a hyperlipidemia treatment plan. Primary care providers may utilize nutritionists and dieticians to guide such aspects of treatment. Thus, these individuals may not meet the WC, BP, or blood glucose criteria due to an optimally controlled weight.

As seen in Table 6, those on medications make up a significant proportion of subjects with over half in those meeting the HDL and TG criteria and over the third in those meeting the BP criteria. Thus, further analysis using a subset of the study population excluding those on prescription medications was also performed as displayed in Table 7a and 7b. The study population decreased from 273 to 232 subjects after excluding those on prescription medications. Logistic regression analysis with and without controlling for covariates, decreased the association of positive GHQ-12 screening with MS component criteria and MS except for WC.

The GHQ-12 and WC association was strengthened to reveal statistically results at the 80% and 95% confidence intervals (OR 2.11, 80% CI 1.34-3.31, 95% CI 1.06-4.20), which was consistent after controlling for covariates. This relationship was strengthened, since statistically suggestive results were only found within the 80% CI before excluding those on prescription medications.

After excluding those on medications, no other statistically significant or suggestive relationships were revealed. However, several relationships changed in the direction of association from negative to positive. Nine of the 18 screening test and MS (and its components) relationships became positive after those on medications were excluded. Notably, ES-MBI and MS, PC-PTSD and MS switched from a neutral to negative association to a positive association. Although also not statistically significant, several psychological tests and MS components became a positive association. The association between ES-MBI and glucose, HDL became positive in the sensitivity analysis. Additionally, the association between PC-PTSD and TG, Glucose, and HDL switched from a negative to a positive association. Also to note is that the statistically suggestive association between GHQ-12 and WC remained statistically suggestive without a remarkable change in OR's after excluding those on medications. On the other hand, there are associations that became negative from being positive in this sensitivity analysis. The association between GHQ-12 and MS, glucose resulted in a negative from a positive association after excluding those on medications. However, these results were also not statistically significant.

Thus, medications may partially explain some of associations between the psychological screening tests and MS (and its components). Medications may explain some of the unusual negative correlations. Unlike most of the other MS component criteria, WC is the most consistent that exhibited OR's greater than one across all screening tests in each population whether medications were excluded or not. Furthermore, GHQ-12 and WC were consistently statistically significant in each population and to a lesser extent PC-PTSD and WC as well.

Table 6: Prevalence of reported medication use in the study population (N=273).

	Meets MS Criteria	**On Medications**
BP	**Yes**: 47	**Yes**: 17 (36%)
		No: 30 (64%)
	No: 226	**Yes**: 0 (0%)
		No: 226 (100%)
Glucose	**Yes**: 51	**Yes**: 1 (2%)
		No: 50 (98%)
	No: 222	**Yes**: 0 (0%)
		No: 222 (100%)
HDL	**Yes**: 54	**Yes**: 33 (61%)
		No: 21 (39%)
	No: 219	**Yes**: 0 (0%)
		No: 219 (100%)
TG	**Yes**: 65	**Yes**: 33 (51%)
		No: 32 (49%)
	No: 208	**Yes**: 0 (0%)
		No: 208 (100%)

The prevalence of those prescribed medications for hypertension, diabetes, and hyperlipidemia in the study population of 273 subjects is tabulated. The percentages of those who are or are not prescribed medications out of those who meet specific MS criteria are also calculated. Per the NCEP ATP III, either meeting laboratory cut offs for BP, glucose, HDL, and TG or use of medication to control these biomarkers satisfy those specific MS criteria (Huang, 2009; Kaur, 2014).

Table 7a: OR results of logistic regression analysis for psychological screening tests as a predictor for MS (and its components) with and without controlling for covariates excluding those on prescription medications (N=232).

Screening Test	**OR for Each MS Component Criteria (N = 232)**											
	BP				**Glucose**				**HDL**			
	No covariate(s)	Age	Gender	Age + Gender	No covariate(s)	Age	Gender	Age + Gender	No covariate(s)	Age	Gender	Age + Gender
GHQ-12 95% CI 80% CI	0.86 (0.33-2.25) (0.46-1.61)	0.85 (0.32-2.21) (0.45-1.59)	0.87 (0.33-2.27) (0.46-1.63)	0.86 (0.33-2.24) (0.46-1.61)	0.85 (0.35-2.07) (0.47-1.52)	0.80 (0.32-1.98) (0.44-1.45)	0.85 (0.35-2.07) (0.47-1.52)	0.80 (0.32-1.97) (0.44-1.44)	0.51 (0.14-1.80) (0.22-1.16)	0.49 (0.14-1.75) (0.22-1.13)	0.51 (0.15-1.82) (0.22-1.17)	0.50 (0.14-1.78) (0.22-1.15)
ES-MBI 95% CI 80% CI	0.95 (0.34-2.66) (0.48-1.86)	0.96 (0.34-2.70) (0.49-1.89)	0.97 (0.35-2.73) (0.49-1.91)	0.99 (0.35-2.78) (0.50-1.95)	1.22 (0.49-3.03) (0.67-2.21)	1.28 (0.51-3.21) (0.70-2.34)	1.22 (0.49-3.03) (0.67-2.21)	1.28 (0.51-3.21) (0.70-2.33)	1.42 (0.49-4.12) (0.71-2.85)	1.46 (0.50-4.23) (0.72-2.92)	1.46 (0.50-4.24) (0.73-2.93)	1.50 (0.51-4.37) (0.74-3.01)
PC-PTSD 95% CI 80% CI	1.35 (0.28-6.43) (0.49-3.75)	1.31 (0.27-6.28) (0.47-3.65)	1.44 (0.30-6.93) (0.51-4.02)	1.42 (0.29-6.85) (0.51-3.97)	1.10 (0.23-5.21) (0.40-3.05)	1.02 (0.21-4.89) (0.36-2.84)	1.10 (0.23-5.23) (0.40-3.05)	1.01 (0.21-4.89) (0.36-2.83)	1.91 (0.39-9.28) (0.68-5.37)	1.85 (0.38-9.00) (0.66-5.20)	2.04 (0.42-10.01) (0.72-5.77)	2.01 (0.41-9.87) (0.71-5.69)

Each column within each MS component criteria and MS represent analysis where that is uncontrolled for covariates and analysis where covariates are controlled for to include age greater than or equal to 45 years, gender, and both covariates.

Table 7b: OR results of logistic regression analysis for psychological screening tests as a predictor for MS (and its components) with and without controlling for covariates excluding those on prescription medications (N=232).

Screening Test	**OR for Each MS Component Criteria (N = 232)**								**MS**			
	WC				**TG**							
	No covariate(s)	Age	Gender	Age + Gender	No covariate(s)	Age	Gender	Age + Gender	No covariate(s)	Age	Gender	Age + Gender
GHQ-12 95% CI 80% CI	**2.11** **(1.06-4.20)** **(1.34-3.31)**	**2.13** **(1.07-4.26)** **(1.35-3.35)**	**2.15** **(1.07-4.31)** **(1.36-3.38)**	**2.17** **(1.08-4.37)** **(1.38-3.43)**	0.67 (0.24-1.85) (0.34-1.30)	0.64 (0.23-1.78) (0.33-1.25)	0.67 (0.24-1.87) (0.35-1.32)	0.65 (0.23-1.81) (0.33-1.27)	0.63 (0.13-2.97) (0.23-1.74)	0.62 (0.13-2.92) (0.22-1.71)	0.64 (0.13-2.99) (0.23-1.75)	0.63 (0.13-2.95) (0.23-1.73)
ES-MBI 95% CI 80% CI	1.20 (0.55-2.66) (0.72-2.02)	1.20 (0.54-2.64) (0.71-2.01)	1.24 (0.56-2.75) (0.74-2.09)	1.23 (0.55-2.73) (0.73-2.07)	0.95 (0.34-2.66) (0.48-1.86)	0.98 (0.35-2.76) (0.50-1.93)	0.97 (0.35-2.73) (0.49-1.91)	1.01 (0.36-2.86) (0.51-1.99)	1.50 (0.39-5.79) (0.62-3.63)	1.52 (0.39-5.90) (0.63-3.69)	1.54 (0.40-5.94) (0.63-3.72)	1.56 (0.40-6.06) (0.64-3.79)
PC-PTSD 95% CI 80% CI	1.77 (0.52-6.01) (0.79-3.93)	1.79 (0.53-6.11) (0.80-4.00)	1.92 (0.55-6.67) (0.85-4.34)	1.94 (0.56-6.75) (0.86-4.38)	1.35 (0.28-6.43) (0.49-3.75)	1.27 (0.26-6.12) (0.46-3.55)	1.44 (0.30-6.93) (0.51-4.02)	1.40 (0.29-6.79) (0.50-3.93)	1.58 (0.19-13.24) (0.39-6.34)	1.54 (0.18-12.96) (0.38-6.20)	1.67 (0.20-14.12) (0.41-6.74)	1.65 (0.19-13.97) (0.41-6.66)

Each column within each MS component criteria and MS represent analysis where that is uncontrolled for covariates and analysis where covariates are controlled for to include age greater than or equal to 45 years, gender, and both covariates.

CHAPTER 5: DISCUSSION

Although statistically suggestive associations were found between only certain MS components and each positive questionnaire, this study puts forth the possibility of association between psychological occupational strain and cardiovascular risk factors. The different associations may identify differences between types of stressors assessed by the GHQ-12, ES-MBI, and PC-PTSD, which may present unique pathophysiological processes for each type of stressor since each questionnaire is identifying profiles associated with different mental health diagnoses. Statistically suggestive results were found between GHQ-12 and WC, ES-MBI and TG as previously mentioned. These relationships persisted before and after controlling for covariates that are known to be associated with cardiovascular disease, which included age greater than or equal to 45 years, and gender. There was also a statistically suggestive positive association between PC-PTSD and waist circumference in the 80% CI with OR's up to 2.15 in the larger sample (N = 273). This positive association, although not statistically significant, persistent in the smaller sample (N = 232) with OR's up to 1.94.

Not all relationships revealed positive associations, which is contrary to what would be expected. Negative relationships were consistently found between GHQ-12 and BP; ES-MBI, PC-PTSD and glucose; GHQ-12, ES-MBI and HDL; all screening tests and TG; and ES-MBI and MS. Because of the possible influence of medications, a sensitivity analysis of the population where those on medications were excluded was performed to assess the impact of medications on associations, such as reverse causality. There were more consistent positive associations some of which were negative in the original analysis, between psychological screening tests and MS (and its components). Although all were not statistically significant and the study was limited by a small sample size, these results may indicate the influence of medications on meeting other MS criteria. On the other hand, there is also a potential influence of medications treating MS and mental health. An extensive literature review by Mansur, Brietzke, McIntyre (2015) leads the authors to propose the concept of a "metabolic-mood syndrome." In one study, a significant improvement in depressive symptoms with weight loss and also correlated with a biologic marker, neurotrophin brain-derived neurotrophic factor (BDNF) that is involved in energy metabolism. Although further research is needed, there is a consistent association in the literature between neuropsychological constructs and metabolic dysfunction (Mansur et al., 2015). Thus, including those on medications in this research project could conceivably underestimate the associations between mental health and MS (and its components). This is in contrast to the original hypothesis that psychological strain influences MS (and its components) and may indicate a bidirectional relationship or even reverse causality.

These study results reveal a possible association between mental stress indicators and MS (and its components), which are risk factors for adverse cardiovascular outcomes. The association between mental stress and MS (and its components) are consistent with the existing literature. MS has been repeatedly found to be associated with indicators of stress such as high job strain and positive PSS-10 screens (Edwards et al., 2012; Janczura, 2015). Chandola et al. found this relationship to be a dose response relationship (2006). Furthermore, the association between MS and cardiovascular pathology is also well-established in the literature. Multiple publications reveal at least a two-fold risk of cardiovascular disease and myocardial infarction along with an increased risk of cardiovascular mortality (Kaur, 2014; Motillo et al., 2010; Zafar, 2015). In some cases, the risk is evident even without a diagnosis of MS when only one to two MS criteria are met (Zafar, 2015).

The adverse effects of stress have been well-established in the literature and its adverse effects on cardiovascular health are no exception. Increased work stress has been found to significantly increase risk for MI up to six-fold (Chandola et al., 2006; Kivimaki et al., 2012; McEwen, 2005; Moller at al., 2005; Rosengren, 2004; Tawakol et al., 2017). Bremner et al. found myocardial ischemia in the absence of exercise, but in the setting of laboratory induced stress in a population with CAD (2018).

Health and Policy Implications

Such research is important in order to inform health priorities and public policy, especially in the firefighting population where stress exposures conceivably leading to strain can be above and beyond the typical occupational levels. Further research on this topic increases awareness that job strain not only has mental, but also physical effects on the body that not only results in acute effects but can also result in deadly chronic diseases. Europe has recognized the importance of stress in cardiovascular disease and has published guidelines including stress management as part of a coronary heart disease prevention plan (Kivimaki et al., 2012). Increased education of firefighters and other professionals in the firefighter community like supervisors and other leadership staff, safety officers, and occupational medicine physicians help to properly address these health priorities in firefighters. Physicians require such research to implement effective prevention measures or early interventions and counsel patients founded on evidence-based medicine.

The economic impact of both occupational stress and cardiovascular disease individually is substantial. Although difficult to quantify, the true cost of stress is likely far greater than that of health care alone. Absenteeism, workers' compensation claims, litigation, grievances, interpersonal problems and conflicts, decreased work performance resulting in errors or accidents, and loss of intellectual capital are only a few examples of how stress can manifest an exorbitant extra cost to employers. Additionally, there are other health problems other than cardiovascular disease that can adversely affect job performance. On the other hand, the CDCP cites that cardiovascular disease in the US cost over $193 billion in annual healthcare spending and another $124 billion in lost productivity mostly from premature deaths (CDCP, 2016). Without prevention efforts, it is predicted that by 2030 the direct medical costs from cardiovascular disease will be more than $818 billion per year while lost productivity could be an additional $275 billion per year (CDC Foundation, 2015).

The taxing effects of occupational psychological strain on the workforce have been increasingly recognized. Some state workers' compensation laws specify injuries resulting from repetitive stress on the job. For example, the California labor code compensates injuries from "repetitive mentally or physically traumatic activities extending over a period of time, the combined effect of which causes any disability or need for medical treatment." However, most of the time compensation is often rendered to psychological disorders resulting from stress in cases where stress claims are accepted. Stress research on the detrimental physical effects on the body, such as cardiovascular disease, have the potential to make significant impacts on the worker's compensation system and total worker health. Outlining the magnitude of occupational stress' physical effects could put even more emphasis on prevention through engineering and administrative controls in the workplace, which may include limitations on overtime or shift work and reorganization of staffing structure for example (Fahy et al., 2018).

There are enumerable benefits of preventing adverse cardiovascular outcomes in firefighters that may include but are not limited to a reduction in morbidity and mortality, a reduction in healthcare costs, a healthier workforce, which contributes to preserving public safety in this occupational group. Although there are preventive health programs throughout the fire service there is a lack of focus on mental health prevention and preservation. OCFA has implemented the WEFIT program, which offers comprehensive medical and fitness exams annually. However, more objective and physical measures of health overshadow mental health, such as stress indicators. Thus, such research can help to expand upon existing successful preventive health programs (International Association of Firefighters (IAFF), 2018). Focusing on occupational stress to prevent MS and cardiovascular pathology not only renders benefits to the cardiac organ system, but also on other vital organ systems due to the systemic nature of stress pathophysiology. More importantly, increased effective prevention and early intervention in the pathologic process of cardiovascular disease can decrease deaths from the number one killer of firefighters.

Study Limitations and Strengths

There are several limitations and strengths in this study. First, the cross-sectional study design presents a limitation. Inherent to a study of this design is the lack of ability to make any conclusions on temporality on observed associations. Thus, making arguments for causality are limited. Additionally, the study population was reduced due to missing variables making a small sample size another potential limitation. The population included only those with data for all MS components and all psychological screening tests. Missing variables were due to some participants did not complete the psychological tests and/ or did not complete laboratory studies. Thus, further analysis utilizing a missing value analysis could assess a missing-at-random type of missing variable structure and the extent of the impact of missing values.

One must also consider the possibility of apparent reverse causation upon interpreting stress and MS data where MS may be causing increased stress levels. For instance, those with symptomatic disease and very poor health from MS may become distressed because of this. This may also increase occupational stress as poor social interactions at work or decreased job performance for instance may result. These individuals may opt for early retirement or change jobs and may be excluded from the studied populations (Kivimaki et al., 2012).

According to the multidomain phenomenon, high levels of symptoms typically have sources of stress from both work and home. These symptoms can manifest as strain in either environment. Thus, identifying stress exposures in the most comprehensive manner and detecting strain early after onset is of interest (Bianchi et al., 2017). In this study, the exposure was not assessed directly through measures of work stress, but by measures of strain through the psychological screening questionnaire. However, work stress could have an effect on MS both via psychological strain and directly, but one also must consider that exposure to stress does not necessarily result in strain especially with stressors involving a high level of emotional labor and resiliency. This presents a limitation in interpreting the data and such an analysis could not be performed due to the small sample size.

Multiple other covariates were not factored into the statistical analysis of this study is also a limitation. For example, health behaviors were not included although smoking status was considered in the statistical analysis. Lack of exercise, unhealthy dietary intake, and excessive alcohol intake are among some of the health behaviors that may also increase the risk of MS and cardiovascular disease (Bremner et al., 2018). Otherwise it is conceivable that health behaviors indirectly lead to cardiovascular disease (Chandola et al., 2008). In addition to environmental exposures, other factors such as genetics like family history of cardiac diseases and comorbidities may affect the outcome. Consequently, interactions among various other exposures require further studies and may provide additional insight into mechanisms of action from exposure to outcome (VanderWeele & Mirjam, 2014).

How psychological strain was measured via the GHQ-12, ES-MBI, and PC-PTSD screening tests present another study limitation that is, however, also a study strength. These questionnaires are meant to serve as screening tools usually in clinical applications and not as diagnostic tools, so a margin of error to some degree is expected. Additionally, such characterization of psychological strain is self-reported making reporting bias a factor to consider. Reporting bias can certainly over or under estimate associations. Specifically in the firefighting culture, there is a strong stigma against any health ailments especially mental health conditions, since any detriment to health is regarded as a sign of weaknesses in this occupation that is often regarded as “heroes” (McKenna, 2017). This results in a tendency to underreport medical conditions so that self-reported data collected by questionnaires may underestimate associations between mental health and MS. This in turn can lead to a non-differential exposure misclassification, which would then underestimate associations between mental health and MS (and its components). Such a phenomenon may explain some of the weak associations between the various psychological screening tests and MS (and its components) in this study.

Furthermore, because psychological occupational strain was assessed by the GHQ-12, ES-MBI, and PC-PTSD screens, there was no way to capture the spectrum of exposure because outcomes were binary, either a positive or a negative screen. The degree of the exposure may certainly have varied within the positive screening groups. Additionally, there was not an exposure assessment repeatedly over time. Stress levels can vary greatly over time especially in the firefighting occupation. Thus, there was also no way to assess cumulative exposure, which poses a limitation as some studies have indicated that cumulative measures are a stronger predictor of cardiovascular disease than acute stress (Kivimaki et al., 2012).

There are other limitations, which also present strengths that are associated with using the GHQ-12, ES-EBI, and PC-PTSD questionnaires. For example, the GHQ-12 is a modified version of the full GHQ of 60 questions. The GHQ-12 is more feasible and convenient for study subjects, but eliminating questions inevitably eliminates information that could have been collected and affect reliability and validity as compared the full GHQ (Goldberg, 1972). The GHQ-12, ES-MBI, and PC-PTSD are great screening tools because of the ease of use and succinctness of the assessment. These tools are widely used in research and in clinical settings and have demonstrated validity in their ability to screen mental health conditions (Goldberg, 1972; Maslach et al., 1997; Prins et al., 2003)

A major strength of this study is the outcome measurement of MS and its components. The components of MS were measured with objective measures that included waist circumference, blood chemistry (lipid panel, fasting glucose), and blood pressure. Through these objective measures a diagnosis of MS was determined using the NCEP ATP III MS definition of meeting 3 or more of the MS criteria (Huang, 2009; Kaur, 2014).

Despite the study limitations, there are several study strengths and this study provides information on the potential effects of psychological aspects of the firefighting profession on MS components. Further research is important in answering additional questions such as the effects of different types of stressors including acute versus chronic stressors or cumulative stress on cardiovascular health and effects of stress on various biomarkers of cardiovascular disease. Further investigation may pave the way for more effective prevention of cardiovascular disease by including mental health screening tools as part of a primary prevention plan. Primary prevention is ideal as the disease process can be thwarted even before well-known cardiovascular risk factors are even detected more effectively preventing even more morbidity and mortality.

CHAPTER 6: CONCLUSION

The World Health Organization (WHO) Global Burden of Disease Survey estimates that by 2020, mental health conditions including stress-related conditions will be second to only ischemic heart disease in the extent of disabilities in sufferers (1996). But what if these adverse health outcomes worked hand in hand? What if stress leads to strain and in turn manifest as cardiovascular disease in addition to other mental health pathology? Could job stress screening serve as a tool in preventing mental and physical strain, such as cardiovascular disease?

Even though a variety of stressors are a recognized health hazard additional research is needed to advance the causal association and further delineate the mechanisms of action of actual occupational strain and cardiovascular disease. There are several publications on the associations between psychological occupational strain and cardiovascular health that certainly give rise to consistency and biological plausibility. Some research even places chronic stress with an attributable risk on par with other major cardiovascular risk factors (Tawakol et al., 2017). In the context of the Bradford Hill consideration regarding causation, this study potentially adds to this growing body of evidence. However, there are multiple other concomitant processes including a variety of stress reactions involved in the manifestation of cardiovascular pathology and psychological occupational strain that play a potentially significant role in this complex process. Identifying these roles and addressing these factors increases the arsenal of ways to thwart cardiovascular disease, which would be beneficial to numerous other occupations and industries in addition to firefighters and other first responder occupations.

The Occupational Safety and Health Administration (OSHA) was created in 1970 "to assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance. Under federal law, workers are entitled to a safe workplace free of known health and safety hazards (OSHA, 2018). The health of the workforce is not only invaluable to the economy but is vital to our individual inalienable rights of "life, liberty, and the pursuit of happiness." Addressing how to prevent occupational deaths in firefighters by addressing the number one killer, cardiovascular disease, is of utmost importance, especially since many risk factors for cardiovascular disease are modifiable and thus, preventable. The burgeoning research on psychological occupational strain and its characterization by stress indicators like exhaustion, PTSD, or other mental health presentations open the door for early intervention and preventive life saving strategies.

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