Qualitative Assessment of the Fire Station Food Environment Using Photovoice

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Introduction

While on-duty, a fire fighter will face many dangers. Fire fighters handle hazardous materials, suppress fires, and administer medical care in times of crisis. Yet, all of those dangerous duties that fire fighters bravely perform in the name of protecting the public are not nearly as deadly or likely to injure a fire fighter as a cardiovascular event (3-21). In fact, the number one cause of death on-duty for fire fighters is not burns, collapsing buildings, or other accidents; it's cardiovascular events (3-21). While cardiovascular disease (CVD) is not the first thing to come to mind when one considers causes of on-duty deaths for fire fighters, it makes sense after some thought. After all, CVD is the leading cause of death in the United States (1,2).

There is evidence to indicate that the prevalence of CVD observed in fire fighter populations is not only the result of being consistent with the statistics of the general population, but an occupational hazard. In the general population, for instance, men will experience their first heart attack at the age of 65.6 years old, on average (1). The average age that a fire fighter will die due to a CVD event is 44 years old (5). Even among fellow first responders, fire fighters are suffering higher occurrences of CVD-related events while on-duty. One study found that between the years of 1977 and 2002, 45% of deaths of fire fighters on-duty were due to sudden cardiac death (11, 20), while another 5% were attributed to other CVD events, such as strokes (6, 15). Studies with law enforcement only attribute 22% of on-duty deaths to CVD, while those involving EMS attribute 11% to CVD (10). Researchers have sought to understand why fire fighters are seemingly experiencing not only more CVD events, but more deadly CVD events than the general population and other first responders. Observing risk factors was the etiological starting point.

Fire fighters have many of the same risk factors for CVD as the general population: genetic predisposition for developing CVD, high blood cholesterol, and high blood pressure, among others. In addition to traditional risk factors for CVD, shift-work, high physical and mental demands, noise exposure, and exposure to hazardous materials all add additional risk (3, 5, 6, 8, 9, 11, 12, 14). Of major concern as well, is the high prevalence of obesity among fire fighters brought on by several factors including the obesogenic environment in which they live and work (7, 14, 15, 20, 37, 40).

Reducing one's weight, when overweight and obesity is present, can reduce risk of CVD (17-18, 22, 25-29). As eating a healthy diet is both a modifiable risk factor for CVD and a method of reducing weight, the nutrition status of fire fighters is of interest. Although there aren't many studies about nutrition status among fire fighters, studies have indicated a gap in nutritional knowledge (12, 15), poor dietary habits (6, 7, 15, 20, 47), and a desire for change (12, 15). In that desire to change, fire fighters indicated a preference for the Mediterranean diet (15, 47), which has cardio-protective properties (15, 18, 24). Just as with studies about nutritional status of fire fighters, empirical evidence on effective nutrition interventions for this population is sparse as well. However, there have been some successes, namely with the PHLAME study (48-50). Even with a small pool of studies, data indicates that lifestyle interventions can be both highly efficient and effective at reducing risk for CVD in this population. Fire fighters who work at fire stations with wellness programs are 42-68% less likely to be obese and 50% less likely to be hypertensive (51). Further, the annual cost of CVD-related disability ranges from $250-450K, while the cost of an intervention per fire fighter is estimated to range from $130-150 (13).

Because fire fighters report working in an obesogenic environment, an effective nutrition intervention should address the fire station food environment. This can be done through the use

of behavioral economics, which has seen success in cafeterias, grocery stores, and restaurants (54-77). With the use of low-cost, small, and sustainable changes to their environment in addition to nutrition education, about half of all on-duty deaths could be prevented. Before we can design effective interventions to address the fire station food environment, it must first be better defined, beyond focus group reports. Thus, this study aims to use photovoice to formally define the fire station food environment and identify areas where behavioral economic methods can be employed.

Literature Review

Cardiovascular Disease among Fire Fighters

Cardiovascular disease (CVD) is not only the leading cause of death in the United States (1, 2), but also globally (1). Every year, CVD claims more lives than cancer and chronic lower respiratory disease combined (1). In 2017, CVD was listed as the underlying cause of death for 868,662 people in the United States alone (1). Of the deaths that could be attributable to CVD in the year 2018 in the United States, the majority were caused by coronary heart disease (42.1%) (1). In fact, in 2018, 13% of all deaths reported were due to coronary heart disease (1). According to the American Heart Association, between the years 2015 and 2018, there were 126.9 million Americans that had some form of CVD (1). On average, the age of men who experience their first heart attack is 65.6 years (1). For women experiencing their first heart attack, the average age is 72.0 years (1).

Just as CVD is the leading cause of deaths worldwide, it is also the leading cause of on-duty fire fighter deaths (3-21). A case control study by researchers in 2003 determined that an estimated 45% of on-duty deaths between the years of 1977 and 2002 were attributable to CVD (11, 20). Other studies cite that while 45% are attributed to sudden cardiac death, another 5% are attributable to other CVD related events such as strokes or aneurysms (6, 15). When compared with other emergency responders, fire fighters have significantly higher occurrences of on-duty CVD related deaths. Of on-duty deaths for police, 22% are attributable to CVD (10). EMS can attribute 11% of their on-duty deaths to CVD (10). In fact, fire fighters have the highest occupational CVD deaths compared with any other occupational group (10, 11, 14). It should be noted that for every one fatal CVD event that fire fighters experience on-duty, there are 17 non-fatal CVD events (15).

Recall that the average age that the average man in the United States will experience their first heart attack at 65.6 years old (1). The average age that a fire fighter will die on-duty due to a CVD event is 44 years old (5). For the general population, deaths related to CVD are most likely to occur between the hours of 6am and noon (5, 10, 11). On-duty deaths related to CVD in fire fighters should reflect that statistic since they typically work in 24-hour shifts. However, research has found that most on-duty CVD deaths occur between noon and midnight, peak hours for emergency responses (5, 10, 11) In fact, around 60% of emergency responses occur from noon to midnight as well as 67-77% of on-duty CVD related deaths (10). One study found that 26% of fire fighters who experienced fatal on-duty CVD events had a previous CVD diagnosis (10). Only 18% of fire fighters that experienced non-fatal on-duty CVD events had a previous CVD diagnosis (10). A retrospective study examining on-duty coronary heart disease (CHD) deaths and survivals by Giebe, et. al. found that there was evidence of previous myocardial damage in 74% of fire fighters that died on-duty due to CHD (8). The low rate of CVD diagnosis prior to CVD event may indicate that the rate of undiagnosed CVD is high among fire fighters.

No doubt, fire-fighting is a dangerous profession. We ask these men and women to protect us from fires, respond to our medical emergencies, and take care of our communities when hazardous materials are present. Fire fighters are exposed to toxic chemicals, flames, communicable diseases, and all of the other on-the-job hazards that come with protecting the public. Every year, there are around 100 on-duty deaths reported (7, 11) and about half of them could potentially be prevented by simply making small changes in their environments and lifestyles.

Risk Factors for CVD among Fire Fighters

There are several factors that contribute to the risk of CVD. Some are modifiable through lifestyle changes, while others are inherent and unchangeable. Gender, age, and genetics are risk factors that can't be changed (22). Men have heart attacks more often and at a younger age than women, on average (22). However, women are at a higher risk of dying from a heart attack than men are (22). As age increases, so does risk for cardiovascular disease (22). In the general population, people are more likely to die from CHD when they are sixty-five years old or older (22). If there is a family history of heart disease, the individual risk for developing heart disease is higher (22). Race can also play a factor in risk of developing CVD (22).

Three major risk factors for CVD that are also modifiable are: smoking (or exposure to second-hand smoke), high blood cholesterol, and high blood pressure (21, 23). Forty-seven percent of Americans have at least one of these three major risk factors for heart disease (23). When a person has two or all of these risk factors, the risk of CHD increases (22). The risk of developing CVD is 23% higher in people who are exposed to second-hand smoke (1). An individual's cholesterol level is affected by some inherent factors, such as gender, age, and genetics, as well as some modifiable factors such as diet (22). High levels of LDL cholesterol are a risk factor for CVD (17). LDL levels can be raised when an individual eats a diet that is high in trans-fats and saturated fats (22). Data gathered during the years of 2013-2016 indicate that 28.9% of Americans had high LDL cholesterol levels (1). A person is also at a higher risk for CVD if they have low levels of HDL cholesterol (22). Smoking, being sedentary, being overweight, and having Type-2 diabetes can contribute to low levels of HDL (22). The American Heart Association reported that based on data gathered in 2015-2018, 17.2% of Americans had low HDL cholesterol levels (1). High LDL cholesterol or low HDL cholesterol combined with high levels of triglycerides is associated with atherosclerosis (22). The American Heart

Association found that prevalence of hypertension among U.S. adults from 2015-2018 was 47.3% and in 2018 alone more than 95,000 deaths were attributable to hypertension (1).

Additionally, nutrition, over weight and obesity, physical activity, diabetes, and stress and smoking are all modifiable risk factors for CVD. Adherence to the Mediterranean diet, one of the diets recommended by US nutritional guidelines, for example, is linked to not only a reduction in risk of CVD but also a reduction in all-cause mortality (15, 18). The 2020 Dietary Guidelines Advisory Committee cited dietary patterns that yield a decreased risk of developing CVD as having higher consumption of seafood, whole grains, low-fat dairy, fruits, and vegetables as well as a moderate consumption of alcohol and regular consumption of nuts and legumes (24). Weight is also a modifiable risk factor. Even in individuals that have no other risk factors for CVD, having a BMI in the overweight or obese category, especially if excess adipose tissue is higher at the waist, contributes to a higher risk of developing CVD (22). If individuals are overweight or obese with other CVD risk factors, they can greatly reduce their risk by losing weight (22). The above guidelines for dietary intake to reduce risk of CVD, in addition to lowered intake of red meat, refined grains, and sugar-sweetened beverages, are all associated with favorable weight outcomes (18, 24).

Another modifiable risk factor for CVD is physical activity levels. The American Heart Association reported that only 24% of Americans met the 2018 physical activity guidelines (1). Because physical activity can help to reduce blood pressure, control blood cholesterol and diabetes, and can contribute to weight loss, being physically active is associated with a lowered risk for CVD (22).

Having other chronic conditions like diabetes can also increase risk of CVD. The American Heart Association estimated that 9.8% of adult Americans had diabetes, 37.6% had

prediabetes, and another 3.7% had diabetes and didn't know it (1). Diabetes, regardless of whether or not blood sugar is controlled, contributes significantly to the risk of developing CVD (22). However, the risks of developing CVD is higher if one's blood sugar is not controlled (22).

In addition to all of these modifiable risk factors, stress is a very real concern among first responders. Individual response to stress can involve an increase of risky behaviors, including over-eating, smoking, and consuming excess alcohol which can contribute to a heightened risk of developing CVD (22). Looking specifically at smoking, similar to the general population, a case-control study found that smoking was a strong predictor of on-duty death for fire fighters (11). This was found to be the case in another study as well (8). Additionally, fire fighters may be exposed to second-hand smoke due to working with the public. As stated previously, risk for CVD can rise 23% when an individual is exposed to second-hand smoke (22). Finally, excess alcohol consumption can produce irregular heartbeats, raise blood pressure, contribute to obesity, and contribute to heightened triglycerides (22).

Fire fighters experience all of the same CVD risk factors that the general population does in addition to shift work, high physical and mental demands, noise exposure, and exposure to hazardous particulates in the air (3, 5, 6,8, 9, 11, 12, 14). CVD events in on-duty fire fighters are attributable to both the presence of individual risk factors and risk factors associated with the job (3, 11). In other words, the potential for sudden cardiac death exists because of underlying CVD risk factors, but the strenuous work fire fighters perform is what triggers these fatal events (3, 11). In fact, researchers found that CHD deaths weren't likely to occur in individuals that had no individual CVD risk factors (11).

Among fire fighters, there is a high prevalence of high cholesterol (11, 12). In one survey of 96 fire fighters in a north-eastern city, 28% responded that they had been informed by their

doctor that they had high cholesterol and 94% of respondents said they thought that eating less dietary cholesterol would lead to overall lower cholesterol levels (12). These results indicate a gap in nutritional knowledge needed to control high cholesterol. Another study conducted in a mid-western county on 154 fire fighters found that one of the most common personal health issues was high cholesterol (6). Even so, there is evidence that hyper-cholesterolemia is largely untreated in fire fighter populations (5). In one cross-sectional study, low HDL cholesterol levels were found to be the most prevalent metabolic abnormality among its population (3). Increased BMI can contribute to increased cholesterol (5, 6). There are some inherent factors that contribute to high cholesterol, but this risk factor can also be modified through diet (18). One study found that a higher adherence to the Mediterranean diet in a population of 780 fire fighters led to a mean 0.4% decrease in LDL cholesterol levels, a mean 0.4% increase in HDL cholesterol levels, and a total mean 0.7% decrease in total cholesterol levels (16). When fire fighters were given a list of diet descriptions without names, they indicated that they would prefer to follow a Mediterranean diet (15).

Survey results conducted on 154 fire fighters in a mid-western city indicated that one of the most common personal health issues, along with high cholesterol, was high blood pressure (6). In another survey conducted on 96 fire fighters in a north-eastern city, 22% indicated that they had high blood pressure and 86% of respondents with hypertension were also obese (12). Increased BMI is associated with increased blood pressure (5). Similar to hyper-cholesterolemia, hypertension is thought to be largely untreated in the fire fighter population (5). In fact, uncontrolled hypertension may be more common in fire fighters than controlled hypertension (5). Hyper tension was found to be a significant predictor of on-duty CVD death (8, 14). Heart

rate and blood pressure elevate in response to alarms, which can contribute to an observed 5-fold increase of CHD death during alarm responses (11).

Poor nutrition is a major risk factor for CVD (17-18, 22). Many CVD risk factors, especially overweight and obesity, can be reduced with changes to diet (15, 22). Thus, it is important to know the nutrition status of fire fighters. Currently, there are few studies investigating the nutrition status of fire fighters, but there are a few studies that report the healthfulness of the fire station food environment. Volunteer fire stations tend to have fewer health resources available, contributing to an obesogenic environment (7). Several studies indicate that the food environment of fire fighters, both volunteer and career, is detrimental to health factors including overall nutrition and propensity for overweight and obesity (7, 9, 12).

While emergencies are typically what comes to mind when one contemplates the job duties of a fire fighter, actually, a large portion of their time on the job is spent being sedentary, which can contribute to high risk of CVD (3,11, 14). Even though much of their time is spent being sedentary, the physical demands of firefighting are severe (5, 14). The protective equipment fire fighters wear exacts a significant strain on their cardiovascular systems, significantly reducing their VO2 max (5, 6). Consequently, one of the largest CVD risk factors for fire fighters was their level of physical fitness (6). Studies have found that there is a large amount of fire fighters that do not possess the minimum physical fitness required for their job (3, 11). In one study assessing METs of 957 fire fighters, more than 50% of participants lacked the minimum cardiorespiratory fitness required to perform their duties safely (3). Cardiorespiratory fitness is not only an important protective factor against CVD (3), it's also a requirement for the safety of individual fire fighters, their peers, and the communities they serve (14, 17). In a survey conducted on 154 firefighters, 16% indicated that they exercised less than one time per week and

46% reported that they exercised 1-3 times per week (6). Increased BMI is associated with a decrease in exercise tolerance (5). In focus groups, fire fighters indicated that they thought they should be in better physical health than the general population (9). Focus groups in Maryland indicated that they believed they were not exercising enough and that the lifestyle associated with being a fire fighter was a barrier to exercising (7).

To summarize, fire fighters have the same individual CVD risks that the general population has, including age, gender, genetics, nutrition, physical activity, smoking, stress, diabetes, high blood pressure, and high cholesterol. Even though they share the same individual CVD risks, there are still more on-duty CVD deaths than in any other occupation (10, 11, 14). Studies have found that it is a combination of these individual CVD risks, that can be exacerbated by the lifestyle and environment surrounding firefighting, combined with occupational triggers that inflate the on-duty CVD related deaths in this population (3, 5, 6, 8, 9, 11, 12, 14). Fire suppression, for example, has been estimated to account for 32.1% of CHD deaths on-duty (5, 10, 11). Alarm response accounts for 13.4% of CVD deaths (5,10, 11). Further, returning from an alarm (17.4% of CVD deaths) and physical training (12.5% of deaths) were deadly duties (5, 10, 11). In contrast, non-emergency activities accounted for only 15.4% of CVD deaths (5, 10, 11). In a cross-sectional study of 116 fire fighters assessing both traditional and novel risk factors for CVD, it was found that ¾ of participants in this study were classified as moderate or high risk for CVD (14). In addition, a previous CVD diagnosis increased the risk of on-duty CVD death by 15 times (5, 8, 11). It is not just job duties that increase risk, the fire station food environment and lack of physical activity during the majority of working hours also contributes to CVD risk (3, 7, 9, 11, 12, 14). This information highlights the need for

identification of individuals with risk factors such as hypertension or high cholesterol and even more so for creation and implementation of CVD prevention programs in the fire service.

Obesity among Fire Fighters

As mentioned previously, one major modifiable risk factor for CVD is weight (17-18, 22, 25-29). Overweight is defined as a body mass index (BMI) of 25.0 to 29.9 kg/m^2, and obesity is indicated by a BMI equal to 30 kg/m^2 or more (30). Additionally, the obese BMI category is separated into three classes: class I (BMI of 30 to 34.9 kg/m^2), class II (BMI of 35-39.9 kg/m^2) and class III (BMI equal to 40 kg/m^2 or more) (30). According to a report released by the American Heart Association, in 2018 42.4% of adults in America were obese (1). The CDC notes that obesity prevalence increased from 30.5% to 42.4% from 1999 to 2018 (31). During the same time period, severe obesity, also known as class III obesity, increased from 4.7% to 9.2% (31). In 2016, it is estimated that worldwide 39% of adults were classified as overweight while 13% were classified as obese (32).

In 2008, the World Health Organization listed obesity as the fifth leading risk factor of death (33). One systemic review evaluating the hazard ratios of all-cause mortality found that obesity, particularly class II and class III, is associated with a significantly higher risk when compared to those who are normal weight (34). Other studies have published similar results, observing that obesity is associated with increased risk of death (35-37). Obesity is associated with many co-morbidities, including several risk factors for CVD, such as dyslipidemia, hypertension, and diabetes mellitus (5, 14, 19, 22, 27-29, 36-39). Additionally, the condition of obesity is associated with reduced survival from CVD events (27). In fact, it has been observed that for every 1 kg/m^2 increase in BMI there is a 4% increase in risk of ischemic stroke, 6% increase for hemorrhagic stroke, and 5% increase in risk of heart failure for men (27).

Obesity is also associated with decreased job performance and productivity as well as disability (17, 38, 40). It is estimated that the annual U.S. national burden of obesity-related absenteeism is $4 billion dollars (40). One cross-sectional study that assessed trends of CVD risk factors as well as the association of CVD risk factors with overweight and obesity found that, of the four risk factors identified in the study, 13.5% of obese adults had 3 or more risk factors present (28). Each present CVD risk factor contributes to an increased risk of disability (28). In the same study, 26.8% of participants who were obese had untreated hypertension (28). In one report, high blood pressure and high BMI were the second and sixth top risk factors for disability, respectively (28). Additionally, a predictor of premature disability is the presence of obesity in young adulthood (29).

Among fire fighters, there is a high prevalence of overweight and obesity (3-6, 9, 11, 14, 15, 18, 20, 21, 41, 37, 42). In fact, overweight and obesity is more prevalent among fire fighter populations than general populations (6, 9, 18, 21). Fire fighters, along with police officers, have the third highest prevalence of obesity on a list of 41 male occupational groups in the U.S. according to the 2002 National Health Interview Survey (37, 41). In a previous iteration of the same survey administered in 1986-1994, they were ranked fifth, indicating that prevalence of obesity is increasing among fire fighters out of proportion with general increases of obesity (41). One study published in 2015 stated that the obesity rate for fire fighters is around 40% (15) and the prevalence for combined overweight and obesity has been found to be 77-90% (14). Prevalence of overweight and obesity among new recruits is also high (14, 15, 19, 29) and it is estimated that among new recruits that join the service, prevalence of overweight and obesity is estimated to be 67-77% (15). In one prospective cohort study preformed over a five year time period from 1996/1997 to 2001 assessing the distribution of BMI among fire fighters and

evaluating the association between BMI and CVD risk factors, prevalence of obesity among the cohort increased from 35% to 40% (17). In the same study, class III obesity increased from 0.6% to 2.4% (17).

Accuracy of BMI among Fire Fighters

While BMI is a useful and cost-effective health and obesity screening tool, especially for populations, it doesn't directly measure body fat and, therefore, it is possible that an individual with higher muscle mass could be misclassified as overweight or obese (30, 42-44). Because fire-fighting is a physically demanding job, many have suggested that the high prevalence of overweight and obesity among fire fighters is attributable to BMI misclassification due to high muscle mass (4, 18, 37, 42). One study that measured and compared BMI, skin fold body fat percentage, and waist circumference on 355 Californian fire fighters found that BMI overestimated the prevalence of combined overweight and obesity (37). Sixty to sixty-four percent of fire fighters in this study who were categorized into a normal weight category by waist circumference or percent body fat were mis-categorized as overweight when BMI was used as an assessment (37). Waist circumference and BMI agreed on classification about 56% of the time in the case of male fire fighters, while skin-fold measured percent body fat agreed with BMI about 55% of the time (37). It should be noted, however, that the population of this study had, on average, significantly lower BMIs than other studies assessing fire fighters and they had been participating in a wellness program for several years, which is known to lower the prevalence of obesity (13, 21, 37). Even so, 50% of the fire fighters in the study not only had a level of adiposity that is significantly associated with CVD risk factors, one in three did not meet the minimum generally accepted cardiorespiratory fitness level for active duty fire fighters (37).

Another study assessing the accuracy of BMI in volunteer fire fighters observed that BMI measurements over 25 kg/m^2 had a 100% sensitivity rate but low specificity (18). Of fire fighters that were classified as overweight by BMI, 15% were false positives (i.e. classified as overweight when they actually had normal fat ranges) (18). Five percent of fire fighters in this study were classified as normal weight by BMI when they were actually overweight, representing a false negative (18). However, a BMI over 30 kg/m^2 accurately predicted that an individual was over-fat (18). Another study measuring BMI, waist circumference, and body fat percentages of 994 mid-western fire fighters observed that, in the case of obesity, false positives were low (42). In fact, when body fat percentage and waist circumference were assessed, it was more likely that a fire fighter was mis-categorized as non-obese by BMI (42). Evidence seems to indicate that, especially in the case of BMIs equal to or over 30 kg/m^2, BMI is an accurate measure of excess adiposity in fire fighters (4, 14, 18, 37, 42, 44).

Impact of Obesity on Job Performance of Fire Fighters

Similar to the general population, obesity among fire fighters is associated not only with reduced productivity, job performance, and absenteeism, but also with increased instances of disability, especially related to CVD and musculoskeletal injuries, and CVD-related on-duty deaths (5, 6, 20, 29, 38, 40, 42, 45). A prospective cohort study following 358 Massachusetts fire fighters found that for every 1 kg/m2 increase in BMI, there was a 5% increased risk of job disability (5, 6, 38). In the same study, it was found that fire fighters who had a BMI above 30.2 kg/m2 were twice as likely to experience adverse employment events than fire fighters who had a BMI below 27.2 kg/m2 (38).

In order to perform their job duties safely and effectively, fire fighters need to be physically fit (3, 5, 6, 9, 11, 14, 17, 38, 42). However, obesity is associated with lowered

exercise tolerance (3, 5, 17, 27, 29) and mobility issues (40). In one study evaluating the prevalence and health associations of obesity in emergency responder candidates, it was observed that for every 1 kg/m2 one unit increase in BMI, there was a 54% greater likelihood that they would not be able to meet fitness standards for duty, measured by metabolic equivalents (29). Fire fighters that are class II and class III obese were found to have almost five times the number of missed work days due to injury than their normal weight coworkers; for every 1 kg/m2 one unit increase of BMI, a 9% increase in missed work days was observed (40). The cost of absenteeism in fire fighters who are class II or class III obese is estimated to be $1,682.90 per year per fire fighter (40). Wellness programs, when adopted by fire stations, have been shown to improve body composition and overall health of fire fighters (13, 21, 37). It is estimated that the cost of a wellness program would be $130-150 per employee (13), which, when compared to the estimated annual cost of a CVD-related disability per one fire fighter ($250,000-400,000), is inexpensive (13).

Risk Factors for Obesity among Fire Fighters

An individual's behavior, genetics, and environmental exposures can be risk factors for developing overweight and obesity (46). Behavioral factors that contribute to obesity are being sedentary and eating a poor diet (20, 46). In one prospective cohort, overweight and obese participants were observed to be less physically active than normal weight participants (35). Of course, behaviors can be influenced by the environment one lives in. For example, a person is less likely to meet physical activity guidelines if they do not have access to a safe place to exercise and are less likely to follow dietary guidelines if they don't have access to affordable, healthy foods or knowledge of what foods they should choose. Work environment can play a role in developing obesity. People who work long hours, are sedentary at work, and who do shift

work are more likely to develop obesity (41). Additionally, low job control, low social support for health at work, and high job demands can contribute to developing obesity (41). Additionally, genes can influence how an individual responds to their environment (36, 46). Age is another risk factor for developing obesity. When compared to older adults, young adults are at a greater risk for weight gain (21, 25). The risk for weight gain is even greater in young adults who are overweight when compared to young adults who are considered normal weight (21). Thus, obesity prevention and intervention programs need to consider numerous causes in multiple domains to be truly effective.

Narrowing in on environment further, fire fighters work in an obesogenic environment (7, 14, 15, 20, 37, 40). In addition to the challenges of shift work (3, 9, 11, 14, 15, 20, 40, 41), the majority of time spent on-duty is sedentary (3, 9, 11, 40) and physical activity is not commonly mandated (14, 40). Additionally, overtime, low job control, and physically strenuous jobs are associated with less leisure time spent active (41), meaning that fire fighters aren't likely to meet physical activity recommendations in their off time. A combination of shift work, long work hours, and high job demands can lead to unhealthy eating behaviors, such as relying on 'fast foods', and interrupted eating rhythms (7, 14, 16, 41, 20). Many fire fighters find themselves relying on fast food and vending machines for sustenance (7, 14, 20). Because emergency calls are unpredictable, fire fighters eat quickly because they aren't sure when they will be interrupted (14); eating quickly can lead to eating more than is needed to be sated and a decreased awareness of amount eaten (41). These emergency calls, which occur most often between noon and midnight (5, 10, 11), can lead to sleep deprivation, which is linked to weight gain (20).

Adding to the obesogenic work environment, there appears to be poor social support for health behaviors in many departments, as evidenced by survey and focus group responses from

fire fighters. In a cross sectional study of 332 fire fighters, researchers who performed focus groups found that fire fighters were concerned about their food environment and its contribution to their health status (9). In one survey conducted on 96 northeastern fire fighters, 97% were dissatisfied with the amount of health information they received from their employer, specifying the need for more nutrition, stress, and physical activity-related information (12). In one cross sectional study, survey results indicated that fire fighters who were obese were more likely to indicate that their nutritional knowledge was insufficient (15). Finally, 90% of the respondents to this survey were men and 80% of those men were overweight or obese by BMI standards (15). In focus groups conducted on 98 volunteer fire fighters, most fire fighters agreed that the fire-fighting lifestyle was a significant barrier to both meeting physical activity guidelines and eating well (7). In addition to physical strain, many fire fighters experience mental/emotional strain on the job (3, 9, 14, 20). When working conditions are psychologically adverse, it can lead to an increase in obesity in individuals who may already have unhealthy eating behaviors (41).

Age is a risk factor for developing obesity (21, 25). In one study, weight gain over a five year period was found to be two times higher for fire fighters below the age of 45 compared to those over the age of 45 (17). Being overweight or obese can be a risk factor for further weight gain. A prospective cohort study found that over the course of five years, fire fighters who were normal weight gained an average of 1.1 pounds per year while fire fighters who had a BMI over 35 kg/m2 gained an average of 1.9 pounds per year (17). Other studies have observed that weight gain for active duty fire fighters can range from 1.1lbs to 3.5lbs per year (42). That is particularly concerning when one considers that many new recruits are joining the force already overweight or obese (14, 15, 19, 29).

Perceptions awareness of health issues and threats can also influence health behaviors. In one cross sectional study, researchers conducted a survey designed to assess health behaviors and CVD knowledge among fire fighters and found that 84% of their participants were overweight and the majority of fire fighters who were overweight did not consider themselves to be overweight, indicating that there may be a lack of awareness about weight status in this population (12, 18). Because weight perception and effective weight control are so strongly correlated (4, 21), there is a need for weight status awareness. A study evaluating the likelihood that fire fighters received weight advice from health care professionals (HCP) found that less than half of fire fighters who were considered obese were given weight advice from their HCP (21). In contrast, it has been found that in the general population, 40-50% of people with obesity are given weight advice by their HCP (21). The likelihood that a fire fighter would receive weight advice from their HCP increased with age, obesity-related comorbidities, BMI, and their fire station's participation in wellness programs (21). Only 13% of fire fighters aged 20-29 that were class I obese were given weight advice (21). In another cross-sectional study that assessed CVD risk factors, cardiorespiratory fitness, and weight perception of 768 male fire fighters, it was found that fire fighters believed the cause of their increased overweight and obesity prevalence was due to excess muscle instead of excess adipose tissue (4). However, when body fat percentage and waist circumference was assessed among fire fighters, it was found that fire fighters were more likely to be mis-categorized as normal or overweight when their body fat indicated overweight or obesity instead of the other way around (3, 4, 14, 42).

To summarize, there is a high prevalence of overweight and obesity among fire fighters (3-6, 9, 11, 14, 15, 18, 20, 21, 41, 37, 42). Obesity is a significant contributing risk factor for CVD in its own right (17-18, 22, 25-29). Unfortunately, obesity is also associated with CVD risk

factor clustering, as found in one prospective study (17). Researchers found that fire fighters with class III obesity had, on average and excluding obesity, 2.1 CVD risk factors (17.) In comparison, fire fighters with obesity (class I or II) had an average of 1.8 risk factors and fire fighters with a normal weight had an average of 1.5 (17). Additionally, the environment that fire fighters live and work within is obesogenic ((7, 14, 15, 20, 37, 40). Thus, an effective nutrition intervention with the purpose of reducing CVD among fire fighters must also address their environment.

Nutrition and the Fire Service

Even though diet is a modifiable risk factor for CVD and obesity, there aren't many studies evaluating the nutrition status of fire fighters. One cross-sectional study administered a survey to members of the International Association of Fire Fighters with the intention of evaluating current nutritional habits, gaps in nutritional knowledge, and desirability of potential diet interventions among fire fighters (15). Most of the fire fighters who responded to the survey indicated that they did not currently follow a diet plan; respondents that indicated they did not follow a diet plan were more likely to be obese (15). Further, 68% of respondents indicated that they believed they had insufficient knowledge about nutrition, while 75% of respondents said they would like to learn more about nutrition (15). Similar findings have been observed in other studies (9, 12). A survey conducted with 96 northeastern fire fighters observed that there were nutritional knowledge gaps about the fat content of certain foods (12). In the same study, 97% of respondents who were dissatisfied with the amount of health information they received from their employer indicated that they would want opportunities to learn more about healthy behaviors (12). Put together, those data points indicate a need and a desire for nutritional knowledge among fire fighters.

In focus groups of volunteer fire fighters in Maryland, fire fighters described their on-duty food options as predominantly unhealthy and limited (7). In large firehouse stations, community meals that consist of high fat and high processed carbohydrates are common (7, 20, 47). However, eating out at fast food restaurants and relying on vending machines for food is also commonplace (7, 14, 20, 47). In a survey of 154 Midwestern fire fighters, 90% of respondents indicated that they ate out 1-3 times per week (6). Fire fighters eat approximately six meals at the firehouse per week, and these meals have been found to be significantly lower in nutritional quality than the meals they eat at home (47). In spite of the awareness fire fighters have of the detriments of their environment on health and indications of desiring more health information, dietary changes were not identified as a priority for them (12). Fire fighters indicated that dietary changes can be confusing (12). Additionally, there are concerns that healthy eating won't be as satisfying or as tasteful as unhealthy eating (12). Fire fighters have described their food environment as being traditional and resistant to change (9, 47).

When it comes to specific dietary patterns, a cross-sectional survey found that fire fighters who were following a diet were most likely to be following a paleo diet (15). Low carbohydrate and low fat diets were also popular among fire fighters in that same study (15). However, when participants were given diet descriptions without diet names, they indicated that they would prefer to follow the Mediterranean diet (15, 47). Fire fighters indicated that they were not interested in following a plant-based diet (15). A survey conducted on 154 Midwestern fire fighters found that 83% of respondents ate red meat 1-5 times per week and only 57% ate fish once per week (6). Seventy-three percent of participants in the same study indicated that their vegetable consumption was anywhere from one to five times per week (6). One cross-sectional study that compared Mediterranean diet scores and CVD risk in 780 fire fighters found that, after

adjusting for BMI and age, a high adherence to the Mediterranean diet was inversely related to several CVD risk factors (16). Another study evaluating lifestyle practices of fire fighters found that consumption of whole grains, a tenant of the Mediterranean diet, was also inversely correlated with CVD (6). Thus, a Mediterranean dietary pattern may be feasible, of interest, and beneficial for firefighting populations.

In summation, in the United States Fire Service there are incredibly high rates of both CVD (3-21) and obesity (3-6, 9, 11, 14, 15, 18, 20, 21, 41, 37, 42), both of which make the task of firefighting significantly more dangerous. Obesity is a contributing risk factor for developing CVD (17-18, 22, 25-29). Additionally, when obesity is present the risk of surviving a CVD-related event decreases (27). However, while both obesity and CVD are occupational hazards for fire fighters, both can be mediated through improving nutrition and health behaviors. Despite this, wellness programs are not mandated in the fire service. With the implementation of nutrition, and other healthy lifestyle, interventions that target both their environment and individual lifestyle, risk of on-duty injury and death can be reduced significantly.

Nutrition Interventions in the Fire Service

Despite the need for intervention to reduce the prevalence of CVD among fire fighters, there aren't many empirical studies evaluating nutrition interventions for this group. In fact, there has only been one completed randomized controlled trial testing the efficacy of two nutrition intervention strategies for firefighters, both of which involve the PHLAME (Promoting Healthy Lifestyles: Alternative Models' Effects) study. This study consisted of 600 participants from 35 stations across the Pacific Northwest and tested the efficacy of two interventions—a team-based intervention and a one-on-one intervention—against a control group that received no intervention (48-50). All three groups received a health assessment and a brief explanation of the

results (48-50). Both intervention groups received relatively even educational material and contact time with interventionists (48-50). Fire fighters who received the one-on-one intervention underwent nutrition counseling based on individualization of care using the trans-theoretical model and motivational interviewing (48-50). The team intervention was based on Social Learning Theory (SLT) and Social Cognition (48-50). The team intervention involved a designation and training of a peer leader, termed a Squad Leader, and group meetings focused around nutrition information and behavior change (48-50). Both interventions were associated with a significant increase in healthy behaviors (48, 49). In both intervention groups, fruit and vegetable intake increased, some measures of fitness increased, and feelings of general well-being increased (48, 49). The team-based intervention saw an increase in perceived dietary social support and dietary understanding (48). This was not observed in the one-on-one group. All groups, including the control group, experienced weight gain after the study. However, the weight gain in the intervention groups was lower than the control group (48, 51).

In both intervention groups, participation was high. The team intervention consisted of 11 team meetings. Seventy-three percent of fire fighters placed in the team-intervention group attended 7 or more team meetings, while 34% attended all of the team meetings (48). Both the team and one-on-one intervention groups read approximately the same amount of the provided material (48). On average, the team-intervention group spent more overall time in meetings than the one-on-one group spent in meetings with a motivational interview trained counselor (48). It should be noted that both intervention groups had some control over how much time they spent in their respective activities, indicating that the one-on-one group chose to spend less time with their counsellor even when given the opportunity to spend the same amount of time as the team-intervention did in their meetings (48). This suggests that the social aspect of the team

intervention led to more interaction with the intervention. The motivational interviewing endured by the one-on-one group was related to an increase in overall mood (48). However, the total cost of one-on-one counseling was greater than the team intervention. The team intervention materials only cost approximately $25 per fire fighter (48).

Further, specific mechanisms of change were evaluated in the PHLAME study. Researchers recognized a mediated effect between knowledge of the benefits of eating fruit and vegetables obtained through intervention and an increase in fruit consumption but not on an increase of vegetable consumption (49). While the team intervention did not significantly increase the rate of self-monitoring, self-monitoring of diet was associated with an increase in fruit consumption (49). The effect of changing dietary norms among coworkers had a significant and positive effect on the consumption of vegetables (49). Researchers suggest that feelings of personal ownership over the intervention programs may have also contributed to the success of the interventions (49).

While wellness programs are not mandated or common among fire departments, there have been some health initiatives created for implementation in fire departments. One such initiative is the Fire Service Joint Labor Management Wellness-Fitness Initiative (WFI). WFI, created by the International Association of Fire Fighters and others, is a health promotion program for the fire service that consists of a guide with health information that chiefs could choose to implement at their fire stations (51). One study seeking to address the unsatisfactory empirical testing of WFI health programs among firefighters compared a total of 20 departments—10 departments participating in WFI and 10 controls—to each other to evaluate how wellness programs can affect health outcomes (51). Overall, fire fighters who worked at stations that participated in WFI had superior body composition across measures of BMI, waist

circumference, and body fat percentage (51). Additionally, those fire fighters reported significantly higher levels of physical activity and higher VO2 max scores and were 50% less likely to meet the criteria for a hypertension diagnosis (51). Class III obesity was only observed in departments that were not participating in WFI (51).

There have been a few smaller studies with shorter intervention windows evaluating the effectiveness of nutritional intervention among fire fighters. One study with a scant cohort consisting of 10 New York fire fighters administered a low glycemic diet, modelled after the Mediterranean and DASH diets, over a 12 week period and evaluated the effects of this intervention on measures of metabolic syndrome (52). Outcomes were measured at the end of the study. Researchers found that there was a significant reduction in both systolic and diastolic blood pressure (10.8 mmHg and 5.8 mmHg, respectively), weight (9.7lbs), and body fat percentage (5.2%) (52). Additionally, 6 months after the program had ended, the reductions in blood pressure, waist and hip circumferences, and body fat percentage were maintained (52). Researchers noted that the greatest improvement to CVD risk factors was observed at the 6 week mark (52). The social support among fire fighters in this group was suggested to have had an impact on the positive outcome of this study (52).

In another longitudinal study, researchers provided a 12-week nutritional intervention to 492 individuals who were overweight and worked in high stress jobs, 31 of which were male fire fighters (53). The intervention consisted of providing meal replacements for two meals and total calories per day did not exceed 1160 kcal (53). Out of all the professionals included in this study, fire fighters lost the most amount of weight and regained an average of 1kg at three months after the conclusion of the study (53). Researchers attribute the success observed among fire fighters to their communal environment which may increase social support and peer pressure to follow

the diet (53). Another factor that may have contributed to the success of this intervention was the low cost (free) and convenience of the meal replacements, as fire fighters have cited both as important factors in food choices (7). However, the extreme low-calorie diet was likely the main reason for the weight loss observed.

While at present there isn't a lot of data about nutrition interventions for fire fighters, one thing is repeated: their unique work culture that promotes team work and closeness is an asset that can be exploited to improve health outcomes (15, 41, 48-53). When fire fighters work in an environment that promotes and supports healthy behaviors, there is a positive effect on health outcomes (13, 41, 51). There is a need for more research on nutrition interventions for this population, especially emphasizing the environment, culture, and team aspects of the job.

In addition to building on the strength of comradery in the fire service, research indicates that the Mediterranean diet might be an effective part of a nutrition intervention for fire fighters due to its established cardio-protective qualities and acceptability among fire fighters (15, 16, 47). The Mediterranean diet is also a cost effective dietary intervention (47). While comradery and a Mediterranean dietary intervention are promising, it is not enough to overcome an obesogenic environment. In addition to directly addressing lifestyle factors that contribute to CVD and obesity, an effective intervention should also address the environment of participants.

Research indicates that fire fighters work in an obesogenic environment (7, 14, 15, 20, 37, 40) comprised of shift work (3, 9, 11, 14, 15, 20, 40, 41), long hours (7, 14, 16, 41, 20), and long stretches of being sedentary while on the clock (3, 9, 11, 14, 20, 50). Long hours are punctuated by unpredictable emergency calls that can interrupt sleeping and eating (14, 20, 40, 47, 49). Additionally, emergency calls can induce psychological stress (3, 5-7, 9, 11, 12, 14, 20, 40, 52) which can lead to less energy and lower cognitive capacity for making complex health

behavior decisions (54-57). When surveyed, fire fighters have indicated a gap in nutrition knowledge (9, 12, 15) and a desire for more health information from the fire service (12, 15). Availability of healthy food options in the fire house is lacking (7), leading many fire fighters to rely on vending machines and fast food restaurants (7, 20, 47). Accessibility and availability of energy-dense foods, such as those offered in fast-food restaurants, is an identified risk factor for overeating (57, 58). In focus groups conducted in Maryland, fire fighters indicated that convenience and taste were important factors involved in their food decisions (7). Additionally, healthful eating is not the norm in fire stations. When traditional communal meals are served, they are high in saturated fats (20). Fire fighters have also indicated the importance of leadership to model new, healthy behaviors (7).

Behavioral Economics as a Novel Approach to Health Promotion in the Fire Service

With the use of behavioral economics, the fire house microenvironment can be cheaply and easily changed to promote health instead of obesity. While behavioral economics is not a new subject, much of the terminology used to describe it is. According to behavioral economics, nudges can be used to change behavioral outcomes predictably (54, 55, 58, 59, 67, 68). Nudges are changes to the choice architecture that do not forbid any options of the people who operate within that architecture (54, 55, 56, 58-63, 65, 67-69). Choice architecture is a term used to describe the environment where choices are made (54, 55, 56, 59-61, 64-67). For fire fighters, the fire house is a choice architecture that they spend much of their time in, and as a consequence, make many of their food decisions in. Nudges can be used to make healthy choices easier by increasing the availability, salience, and convenience of choosing healthy items. Additionally, interventions that employ behavioral economics can make healthy choices more desirable and normal within the fire house.

Some of the most common nudges include default options and environmental cues (54). At fast food burger restaurants, the default option for meals is usually a side of fries. One example of an environmental cue might be the size of the container, plate, or utensils one's food is served with (56, 57, 60, 70). When people eat food from large containers, they will eat more volume even if they do not like the taste of what they are eating (57, 60). One study testing the effect of the ordering of food items in a breakfast buffet line found that the first three food items a person encountered comprised an average of 65.7% of their total plate (56, 66, 71). When fruit was offered first, it cued 86.4% of participants to select it; when fruit was served last only 53.8% of participants selected it (56, 66, 71). Similarly, patrons of restaurants are more likely to choose a healthy option if it is on the front page of a menu (56, 58, 64). The end caps at grocery stores are another example of an environmental cue that affects food purchasing decisions. Because of the habitual way people move through grocery stores, products that are shelved on the end caps of aisles are more accessible and salient to consumers (61, 70). As a result of that nudge, products on end caps represent 40% of sales in grocery stores (61). In addition to where the shelf is located in the store, the availability of food on the shelf can act as an environmental cue. For example, one study found that when participants chose food from a shelf consisting of 75% healthy options, they were 2.9-3.5 times more likely to choose a healthy snack compared to when they were presented with a shelf consisting of only 25% healthy options (56, 58).

People employ two systems when making decisions: the first system is driven by values and logic while the second is automatic and irrational (57, 68). The huge downside to the first system, which traditional education-only interventions rely on, is that it requires cognitive capacity to function (54, 57, 68, 72). Because people make countless decisions over the course of the day and expend their limited cognitive energy continuously, they more often than not rely on

the automatic system to make food decisions (54, 56, 58-60, 68, 73). While the automatic system requires no cognitive capacity and little time, it is heavily influenced by environmental factors and susceptible to cognitive biases (57, 58, 69). Cognitive biases that influence the decision-making processes include the status quo bias (heuristics/ rules of thumb), sunk-cost fallacy, present-bias (people will make decisions based on present rewards or consequences), and loss-aversion (54, 57, 60, 62, 69). Default cues, for example, exploit the status quo cognitive bias (69) present-bias, and loss-aversion bias (57, 64). Simply put, it is a fallacy to assume that people make food decisions based on logic or that people fail to make healthy decisions because of a lack of willpower. More often than not, food decisions are irrational (57, 58, 60, 64, 65, 69). When it comes to choosing what to eat, people usually make the easiest choice that requires the least amount of mental effort (54-56, 58-60). That is why nudges are so effective at promoting behavioral change (54, 55, 59, 60).

Because of the heterogeneity of behavioral economic interventions used, participants, and environments and the small collection size of labelled behavioral economic studies, no definitive statements can be made about the efficacy of choice architecture as a long-term intervention (55, 56, 65, 66, 68-70, 73, 74). One systemic review evaluating the effectiveness of nudging on influencing healthy dietary choices concluded that when salience and priming nudge strategies were combined, positive effects could be observed for 3-21 months post intervention (56). Despite the uncertainty of long-term effectiveness, results from short-term studies, mainly conducted in school cafeterias and grocery stores, indicate that changing the choice architecture of a targeted intervention group is effective at getting people to make healthier decisions about food (54, 56, 59, 65, 70, 73, 74).

In Yorkshire, England, researchers changed the choice architecture of a secondary school lunchroom (59). Researchers made healthier meal options appear more convenient by packaging them in grab-and-go containers; added smiley face and good-for-you stickers to target food items; and displayed fruit next to the register (59). These nudges increased accessibility and desirability of target foods which, in theory, would take advantage of the automatic-decision making in the time pressured environment of school cafeterias and guide students to make healthier food decisions (59). In practice, it worked like a charm. Students who attended the experimental school were 2.5 times more likely to purchase intervention targeted foods and 3 times more likely to purchase fruit and vegetables compared to baseline (59). However, most shockingly, the students at the intervention school were 7 times more likely to purchase a salad when compared to baseline, even though salads were not targeted by the choice architecture strategies employed by researchers (59). As with many nutrition interventions, the greatest effects of this study were observed during the intervention period (59). However, the purchase rate of targeted items and salads continued to be elevated from baseline after the intervention was completed (59).

Another study sought to increase the perception of healthy foods as convenient by instituting a convenience line in a school lunch room that sold only healthier food options (62, 69). The sales of healthier food items increased by 18% and the consumption of healthier food items increased from 33% of total consumption to 36% of total consumption (58, 62, 69). Still, even though the selection of healthier items increased, so too did the food waste of healthier items (62). Additionally, some groups of students increased their consumption of less healthy foods (62). Namely, students who did not indicate participation in extracurricular activities and male students (62). A pilot study conducted in two New York high schools also used a

convenience line for healthy food choices but added nudge strategies to increase the attractiveness of healthy food items (ex. Colored pictures of fruits and vegetables on menu boards) and make choosing healthier options seem more normal (ex. Prompting statements) (63). The changes made to the lunch room were cheap to implement in both time commitment (3 hours) and money (less than $50) (63). With that small investment, the intervention yielded an increase in fruit consumption of 18% and an increase in vegetable consumption of 25% (63).

Behavioral economic interventions in grocery stores and other food retailers have seen success as well. A systemic review evaluating the evidence of efficacy of interventions in the grocery store reported that 36 of the 42 studies included observed increased purchases of healthy food items as a result of the interventions (74). Additionally, research indicates that the effect of an intervention is greater when a combination of nudges are used (68, 69, 74). While interventions that only increased information about healthy choices had inconclusive results of efficacy, interventions that employed both information and availability had positive effects on their outcome measures (74).

One study sought to increase availability of fruits and vegetables at tiendas, small, traditional grocery stores frequented by members of the Mexican and Central American communities (75). The strategy included promotion of fruits and vegetables through novellas and nutrition demonstration events, as well as an addition of a take-and-go salad bar to each tienda and employee training consisting of up-sell techniques that would be used to promote purchase of targeted food items (75). When surveyed, participants reported that they ate nearly an additional serving of fruit and vegetables than they had before the intervention (75). However, their self-efficacy for purchasing and consuming fruit and vegetables decreased after intervention (75).

Researchers tested the efficacy of nutrition marketing interventions on increasing fruit and vegetable purchases in grocery stores by adding a placard to grocery carts that indicated the amount of produce the average shopper purchased per trip (76). The placards were easy to read with text in both English and Spanish, had pictures of fruits and vegetables as well as a smiling emoji giving a thumbs up and the numerical character representing the average amount of purchased produce (72, 76). The pilot study took place in El Paso, Texas and included two grocery stores—one control and one treatment—that participated in a two week trial (76). The treatment store saw a 16% increase in produce spending, without an increase in total spending by patrons or a decrease in store profits (72, 76). In New Mexico, two stores participated (76). Both underwent the intervention and results were compared to baseline (76). In one store, there was a 7.5% increase in produce spending and a 12.6% increase in the other store (72, 76). Again, total shopper spending did not increase and total store profits did not decrease (72, 76). In another experiment, researchers used a yellow line to divide shopping carts in half and affixed a sign to the cart indicating that only healthy foods, such as produce, can go on one side (72). Shoppers were randomly assigned to either a regular grocery cart or a divided cart (72). Shoppers with the divided cart purchased double the amount of produce compared to those with a control cart (72). When green arrows with positive messages about health pointing toward the produce section were placed on the floors of grocery stores, produce purchases increased by 9% compared to baseline (72).

Nudging consumers to make healthier purchases in supermarkets using the traffic light labelling method has been shown to be effective as well (77). One experiment administered an online questionnaire with 3321 comparisons to 183 participants in order to better understand how people use the traffic light labeling system to make decisions about what foods to purchase (77).

Results indicated that consumers are five times more likely to recognize a healthier choice when using the traffic light labeling system instead of the traditional back-of-package nutrition label (77). The traffic light labeling system was used in a behavioral economics experiment that took place in a Massachusetts hospital cafeteria (56, 64). When the traffic light labeling system was instituted without other interventions, sales of green items increased while sales of red items decreased (56, 64). The traffic light labeling method, and other similar interventions, makes nutrition literacy more accessible to those who have low numeracy and literacy skills and those who are just too exhausted to interpret nutrition labels (64, 77).

Behavioral economic strategies have been shown to be effective tools for interventions that aim to promote healthy behaviors. They have the potential to be effective in the fire house. When fire fighters are prompted to make healthier decisions and supported in their environment to continue making healthier decisions, their risk of obesity and CVD can be reduced. First, researchers must accurately capture the fire station food environment, beyond focus groups, to guide behavioral economic interventions. Through the use of photo voice data, specific areas of change in the firehouse environment, as captured by fire fighters themselves and deemed representative of the true fire station food environment, can be targeted.

Photovoice as a Novel Approach to Assessing the Food Environment

Photovoice is a qualitative method of research whose function matches its namesake; it amplifies the voice of community members through the use of photography (78, 79). Through photos, community members can voice concerns about their environment as well as showcase existing strengths (78, 79). This research method typically consists of three steps: training community members to use their cameras as a means to voice their perceptions of their lived environment; photo collection; and discussion of photographs involving both community

members and policy makers (78, 79). While it was originally intended as a means to produce social change (78, 79), it can also be used academically in research. Similar to focus groups, researchers can use collected photographs to find themes and opportunities where small changes could be made to optimize the environment and nudge inhabitants towards healthier choices. Importantly, photo voice can be used a means of accessing the food environment of fire stations.

While photovoice has traditionally been used for broader communities, it has seen success in workplace environments. For example, it was used as a tool to identify areas where workplace safety could be improved by university custodians whose jobs exhibited high rates of workplace injury (78). Using photovoice as a method to improve workplace safety led to greater buy-in from custodial staff and decreased injury rates by 13% (78). A qualitative study evaluating the impact of photovoice on empowerment found that participants were empowered through positive changes in their knowledge, awareness of their community, self-perception, and access to social capital (79).

When it comes to capturing lived environments, the people who work, eat, and live within those environments are the experts. They know what assets are available within the environment, as well as areas of need. As an example, a researcher might include the kitchen table as a part of the food environment. However, because they do not live within the environment, they may not know that many meals are eaten in the living room. Participant perceptions of their own food environment allows for a more complete data set and, as a result, a more accurate assessment of the food environment. The use of photovoice in fire stations will provide an accurate representation of fire fighters' food environments that future research can build on to create effective nutrition interventions.

Methods

Study Design

This cross-sectional study assessed the fire station food environment using Photovoice. Photovoice is a qualitative method of research that is used to assess strengths and weaknesses of certain environments (78, 79). Photos are taken in the 'voice' of community members (78, 79). This allows a better and more complete representation of environments because inhabitants of environments know those environments best (78, 79). Pictures were taken during weekly nutrition classes at each fire station October through December 2021. Because this study did not involve the collection of data from or on humans, it was deemed to not involve human subjects and not require human research ethical approval by the Oklahoma State University Institutional Review Board (IRB-21-386).

Study Sample

This study involved a convenience sample of fire stations from the local fire department. The department has about 75 career firefighters working across four stations and is located in a rural Midwest town. The town spans 32 square miles and has 49,000 inhabitants. Each station has three shift groups working 48-hour shifts. Three stations have four firefighters per shift, while the main station has 12 firefighters per shift. Firefighters in the department are mostly Caucasian males.

In terms of existing wellness initiatives, each station has several peer fitness instructors. The department frequently collaborates with other members of our lab to do regular fitness testing and training programs. A fitness testing and training program was occurring during this study.

Outcome of Interest

The outcome of interest is determining the healthfulness of the fire station food environment. The food environment was captured using Photovoice. The photos were taken before and after nutrition education classes on two separate occasions across the four stations in order to include two-thirds of the shifts. Photos were taken on lab iPads to ensure security and privacy. Index cards were used to indicate the "voice" of the photos. Photos were taken in the voice of the researchers to define the fire station food environment indicated by an index card stating “researcher” in each photo. The same was done for the firefighters using an index card stating “firefighter.” To capture the voice of the firefighters, researchers handed the iPad to each person on shift and asked them to take one or several photos that define the fire station food environment to them.

Data Analysis

The photos were analyzed for themes defining the food environment of the fire stations using NVivo thematic qualitative analysis software. Photos were entered into NVivo with description variables such as ‘station,’ ‘shift,’ and ‘date.’ Researchers also immersed themselves in the images to come up with themes. The images were coded with those themes as well. Researchers then examined the images in order to identify differences in frequency of themes and patterns in themes across image description variables.

Statistical Analysis

Descriptive statics included frequencies and proportions of code frequencies for HEI components and BET overall and across attributes. Chi-square test was performed to determine differences in frequencies of codes between adequacy and moderation HEI components, as well

as between BET promoting adequacy and BET promoting moderation foods. Level of significance was set at $p<0.05$. Statistical analyses were performed using SPSS statistical analysis software (IBM, version 26, Armonk, NY).

Results

Thirty-nine photos were collected and analyzed. Photos were taken at four stations such that 12 photos (30.8% of total photos) were taken at station one, 5 photos (12.8%) at station two, 12 photos (30.8%) at station three, and 10 photos (25.6%) at station four. Photos were taken across two shifts, with 20 of photos (51.3% of total photos) taken at shift A and 19 of photos (48.7%) taken at shift B. Photos were also categorized by location within the station: cupboard, pantry, or locker (6, 15.4% of total photos); countertop (19, 48.7% of total photos); and freezer (14, 35.9% of total photos). Photos were either taken in October 2021 (19 photos; 48.7% of total) or December 2021 (20; 51.3%) and either in the 'voice' of the firefighters (33 photos; 84.6% of total) or researchers (6; 15.4%).

There were 273 total coded references across the 40 photos collected. Frequency of HEI Adequacy and Moderation components can be viewed in Table 1. HEI Adequacy component codes accounted for 26% of total coded references, while HEI Moderation component codes represented 33.3% of total coded references. HEI Adequacy components present in photos included dairy at 2.6% of total coded references, dark greens and legumes at 2.2%, healthy fats at 2.6%, seafood and plant protein at 2.6%, total fruit at 1.5%, total protein at 5.9%, total vegetable at 5.5%, whole fruit at 1.5%, and whole grains at 1.8%. HEI Moderation components present in photos included added sugar at 9.9% of total coded references, saturated fat at 8.4%, refined grains at 6.6%, and sodium at 8.4%. A chi-square test was performed comparing HEI Adequacy component frequency with HEI Moderation component frequency. There are no statistically significant differences between the frequency of the adequacy and moderation components ($p=0.112$).

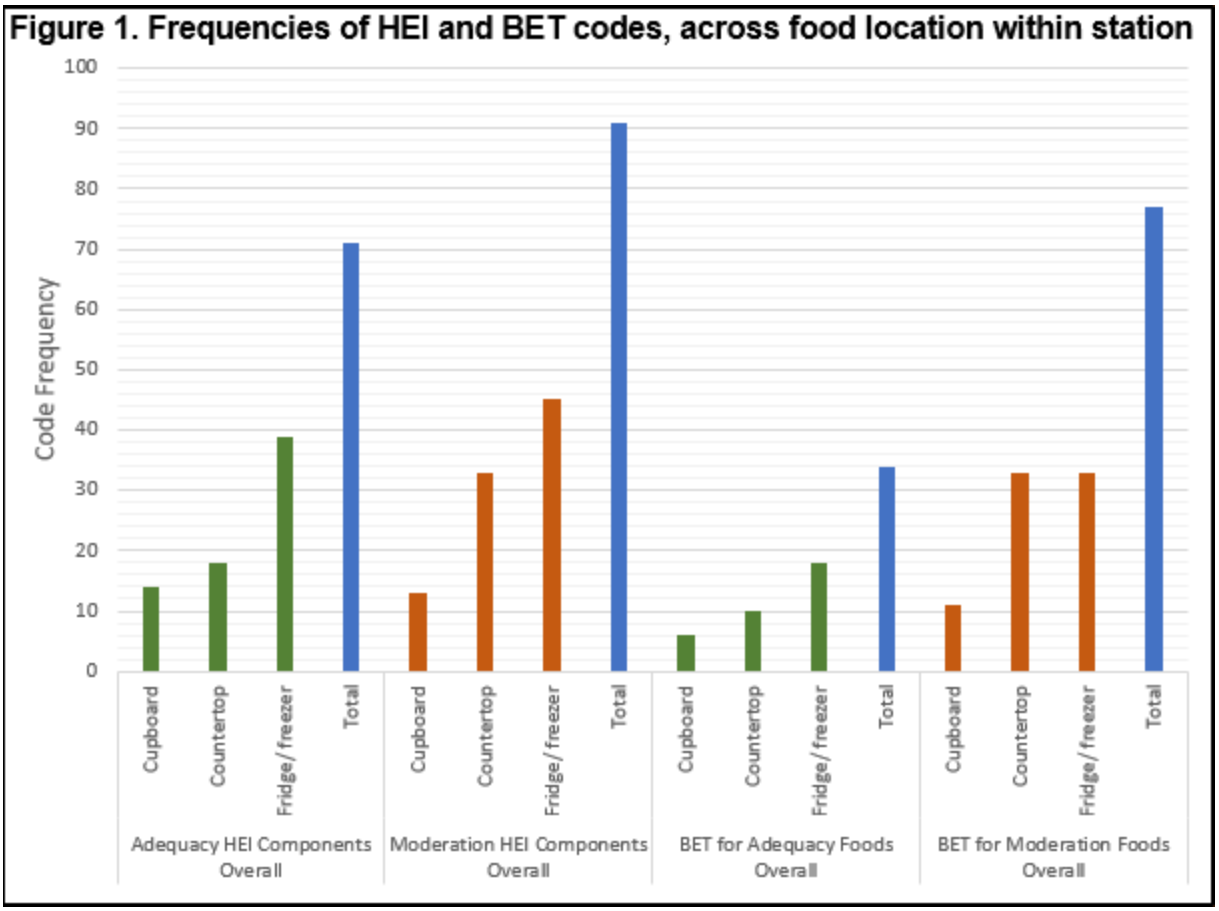
Table 1. Frequencies of HEI and BET codes overall and across attributes

Codes		Date Taken		Location within Station			Shift		Station				Voice through which Photo Taken		Overall Code Fre-quency	% of Total Coded Refer-ences
		Oct. 2021	Dec. 2021	Cupboard, Pantry, Locker	Counter-top	Fridge, Freezer	A	C	1	2	3	4	Fire-fighter	Resear-cher		
Adequacy HEI Components	Dairy	4	3	0	1	6	3	4	1	2	3	1	7	0	7	2.6%
	Dark greens and legumes	3	3	1	0	5	3	3	0	1	2	3	6	0	6	2.2%
	Healthy fats	3	4	3	3	1	4	3	2	2	1	2	7	0	7	2.6%
	Seafood and plant protein	4	3	3	2	2	3	4	2	2	2	1	7		7	2.6%
	Total fruit	3	1	0	2	2	1	3	1	2	0	1	4	0	4	1.5%
	Total protein	9	7	3	2	11	7	9	5	4	4	3	16	0	16	5.9%
	Total vegetable	6	9	3	3	9	9	6	4	2	6	3	15	0	15	5.5%
	Whole fruit	3	1	0	2	2	1	3	1	2	0	1	4	0	4	1.5%
	Whole grains	2	3	1	3	1	3	2	1	1	1	2	5	0	5	1.8%
	Adequacy Total	**37**	**34**	**14**	**18**	**39**	**34**	**37**	**17**	**18**	**19**	**17**	**71**	**0**	**71**	**26%**
BET for Adequacy Foods	Attractively presented	4	4	1	3	4	4	4	1	2	2	3	8	0	8	2.9%
	Conveniently available	6	5	2	3	6	5	6	1	3	3	4	11	0	11	4.0%
	Normal	7	8	3	4	8	8	7	2	3	5	5	15	0	15	5.5%
	Adequacy BET Total	**17**	**17**	**6**	**10**	**18**	**17**	**17**	**4**	**8**	**10**	**12**	**34**	**0**	**34**	**12.5%**
Moderation HEI Components	Added Sugar	13	14	4	11	12	14	13	9	3	8	7	24	3	27	9.9%
	Saturated Fat	12	11	1	9	13	11	12	7	3	7	6	21	2	23	8.4%
	Refined Grains	9	9	4	7	7	9	9	6	1	5	6	15	3	18	6.6%
	Sodium	12	11	4	6	13	11	12	7	3	6	7	22	1	23	8.4%
	Moderation Total	**46**	**45**	**13**	**33**	**45**	**45**	**46**	**29**	**10**	**26**	**26**	**82**	**9**	**91**	**33.3%**

BET for Moderation Foods	**Attractively presented**	11	13	3	11	10	13	11	8	1	8	7	21	3	24	8.8%
	Conveniently available	12	13	4	11	10	13	12	9	1	8	7	22	3	25	9.2%
	Normal	15	13	4	11	13	13	15	10	3	8	7	25	3	28	10.3%
	Moderation BET Total	**38**	**39**	**11**	**33**	**33**	**39**	**38**	**27**	**5**	**24**	**21**	**68**	**9**	**77**	**28.2%**
Total Coded References															273	-

The frequency of Behavioral Economics Techniques (BET) promoting either HEI Adequacy foods or HEI Moderation foods as attractive, convenient, or normal in the fire station can be viewed in Table 1. BET promoting HEI Adequacy foods presented as 12.5% of coded references, while BET promoting HEI Moderation foods presented as 28.2% of total coded references. In reference to BET for HEI Adequacy foods, photos were coded such that 'attractively presented' accounted for 2.9% of total codes, 'conveniently available' accounted for 4.0%, and normal accounted for (5.5%). In regards to BET for HEI Moderation foods, photos were coded such that 'attractively presented' accounted for 8.8% of total codes, 'conveniently available' for 9.2%, and normal for 10.3%. A chi-square test was performed comparing the frequency of adequacy component BET with moderation component BET. No statistically significant difference was indicated between the frequency of adequacy BET and moderation BET ($p=0.306$). Chi-square was also used to compared frequency of both HEI adequacy components and BET supporting adequacy foods combined with both moderation HEI components and BET supporting moderation foods combined. No statistically significant difference was determined ($p= 0.123$). This data can be visualized in Figure 1.

Figure 1. Frequencies of HEI and BET codes, across food location within station



Discussion

The purpose of this study was to use Photovoice, a novel qualitative assessment tool, to define the fire station food environment, as well as to identify areas where behavioral economic methods could be used in a fire station to improve health outcomes for firefighters. When frequency of HEI adequacy components and HEI moderation components were compared, HEI moderation components predominated. Additionally, BET that promoted HEI moderation foods were found to be overall more prevalent than BET that promoted HEI adequacy foods.

While studies aiming to assess the fire station food environment are immerging, the body of literature on the topic remains minimal. Further, existing studies addressing the fire station food environment have used mostly focus groups to collect data. This study not only adds quantification and further confirmation of previous qualitative data to the body of literature regarding fire station food environments, but also contributes a unique perspective through the use of a novel, community engaging approach, Photovoice, which was found to be highly acceptable by the fire department in this study. The results of this study confirm previous findings in focus groups, as well as expert opinion, that the fire station food environment is likely contributing to increased risk for chronic diseases, like CVD, obesity, and cancer, through encouragement of poor nutrition intake among the fire service.

Implications

Photovoice is a novel qualitative assessment tool that has the potential to engage participants in research and capture more themes than traditional focus groups and provides richer data than established food environment survey methods. However, it has not yet been validated as an assessment tool. Future research should involve validation of Photovoice as a tool

to assess food environments against accepted measurement tools, like the Nutrition Environmental Measures Survey. If Photovoice is found to be a valid and reliable tool for assessing food environments, it can be used to assess a myriad of microenvironments including other tactical work spaces, such as police stations and military bases. Additionally, the current small scale study piloting the use of Photovoice to assess the fire station food environment could be expanded to include fire stations from other parts of the country to gather a more representative picture of this food environment. Comparisons between food environments in city, urban, and rural fire stations could then also be made, as well as between career and volunteer departments. Photovoice data on a larger scale could also be used to determine its relationship to chronic disease occurrence in this population. Findings regarding the fire station food environment can also be used as a justification for evidence-based interventions relying on behavioral economic strategies.

Strengths

One strength of this study was the ability to capture the perspective of the firefighters who are posted at the stations. As members of their community, their insights about the environment they live, eat, and work in are incredibly valuable when assessing the food environment and would likely not be captured by inexperienced researchers unfamiliar with the stations. Additionally, using Photovoice as an assessment tool allowed for community-engaged research, which improves buy-in from community members and strengthens the relationship between researchers and participants.

Thematic analysis of dietary quality (DQ) was based on a valid and reliable assessment tool, the Healthy Eating Index (HEI), and on behavioral economic techniques (BET), evidence-based behavior modification techniques used for promoting food consumption in an

environment. Together, these two measures indicate the healthfulness of a food environment and give a more complete picture of the food environment within the fire stations. Additionally, another strength was the use of quantitative assessment to verify the subjective themes in the pictures. Further, consideration was taken as to what non-nutrition related factors could be influencing the food environment. Photos were assigned tags for date, shift, and station number, which allowed researchers to statistically take the influence of these variables into account.

Lastly, photos were taken on two dates. One date took place before traditionally held holidays in the area of the study (Halloween, Thanksgiving, and Christmas) while the other took place between Thanksgiving and Christmas. Having pre-holiday and post-holiday picture sets allowed researchers to capture what the food environment looks like throughout the year.

Limitations

This study was a pilot and only captured one fire department. However, researchers were able to collect data for all four stations within that department, as well as data for two of the three shifts. Participation in Photovoice was not unanimous. Some firefighters at the stations chose not to engage in collecting data. This means that, unfortunately, not all perspectives were captured. Further, firefighters were made aware of researcher presence and knew when researchers would be collecting data. This could lead to a response bias in the firefighters that did choose to participate in Photovoice, as well as removal or decreased purchasing of "unhealthy" foods before researcher arrival.

Another limitation was the small sample size of photos captured. Because the sample size included only 39 photos, the power to detect significant differences between the frequency of adequacy and moderation components was limited. Further, deductive thematic analysis may

have missed some existing food environment themes, but it did allow for quantitative analysis and will assist in future validation of the Photovoice method. Codes were attached to photos based on the presence of HEI food item or BET and not the amount of food item. This inhibited the ability to capture dosage of food items.

Photovoice has the potential to be an effective and engaging assessment tool of food environments. However, it has not yet been validated as such. As previously mentioned, deductive thematic analysis of DQ using a validated tool like the HEI and BET using an evidence-based theoretical model provided a strong foundation for this novel method. That, as well as expert opinion on this matter and positive firefighter engagement, is evidence that Photovoice worked well as an assessment tool for this study.

Conclusion

This study found evidence that the fire station food environment is potentially harmful to health, as deductive thematic analysis of the photo set revealed high occurrence of moderation HEI components as well as BET promoting those foods. Occurrence of HEI adequacy components and BET promoting them was low in comparison, which would promote healthful nutrition intake. The key to changing the fire station food environment, and the overall health of firefighters, may lie in this novel food environment assessment and subsequent use of BET to promote healthy foods based on the assessment.

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Before I began this project, I did not fully understand the cumulative nature of research. Yes, the studies we publish and present build on each other and it is cumulative in that way. But even individual studies like this one are brought forth from the cumulative effort of many people.

References

1. American Heart Association. 2021 Heart Disease and Stroke Statistics Update Fact Sheet. Heart.org. https://www.heart.org/-/media/phd-files-2/science-news/2/2021-heart-and-stroke-stat-update/2021_heart_disease_and_stroke_statistics_update_fact_sheet_at_a_glance.pdf Date Accessed: 06/12/2021.
2. Centers for Disease Control and Prevention. Leading Causes of Death. CDC.gov. https://www.cdc.gov/nchs/fastats/leading-causes-of-death.htm. Accessed June 18, 2021.
3. Baur DM, Christophi CA, Kales SN. Metabolic syndrome is inversely related to cardiorespiratory fitness in male career firefighters. J Strength Cond Res. 2012; 26(9):2331–2337. Accessed June 14, 2021.
4. Baur DM, Christophi CA, Tsismenakis AJ, Jahnke SA, Kales SN. Weight perception in male career firefighters and its association with cardiovascular risk factors. BMC Public Health. 2012; 12(480):1-8. http://www.biomedcentral.com/1471-2458/12/480. Accessed June 14, 2021.
5. Drew-Nord DC, Hong O, Froelicher ES. Cardiovascular risk factors among career firefighters. Workplace and Health Safety AAOHN Journal. 2009; 57(10):415-422. doi:10.3928/08910162-20090916-02
6. Eastlake AC, Knipper BS, He X, Alexander BM, Davis KG. Lifestyle and safety practices of firefighters and their relation to cardiovascular risk factors. Work. 2015; 50:285-294. doi: 10.3233/WOR-131796.
7. Frattaroli S, Pollack KM, Bailey M, Schafer H, Cheskin LJ, Holtgrave DR. Working inside the firehouse: developing a participant-driven intervention to enhance health-promoting behaviors. Health Promot. Pract. 2013; 14(3):451-458. doi: 10.1177/1524839912461150.

8. Giebe J.R., et. al. Predictors of on-duty coronary events in male fire fighters in the United States. The American Journal of Cardiology. 2008; (101):585–589. doi:10.1016/j.amjcard.2007.10.017.
9. Jahnke SA, Poston WS, Jitnarin N, Haddock CK. Health concerns of the U.S. fire service: perspectives from the firehouse. Am J Health Promot. 2012; 27(2):111-8. doi: 10.4278/ajhp.110311-QUAL-109.
10. Kales SN, Soteriades ES, Christophi CA, Christiani DC. Emergency duties and deaths from heart disease among firefighters in the United States. N Engl J Med. 2007; 356: 1207–1215. Published March 22, 2007. Accessed June 14, 2021.
11. Kales SN, Soteriades ES, Christoudias SG, Christiani DC. Firefighters and on-duty deaths from coronary heart disease: A case control study. Environmental Health. 2003; 2(14):1-14. http://www.ehjournal.net/content/2/1/14. Published November 6, 2003. Accessed June 17, 2021.
12. Kay BF, Lund MM, Taylor PN, Herbold NH. Assessment of firefighters' cardiovascular disease-related knowledge and behaviors. J Am Diet Assoc. 2001; 101(7):807-809. doi: 10.1016/S0002-8223(01)00200-0.
13. Patterson DP, Smith KJ, Hostler D. Cost effectiveness of workplace wellness to prevent cardiovascular events among U.S. fire fighters. BMC Cardiovascular Disorders. 2016; 16(229):1-7. doi: 10.1186/s12872-016-0414-0.
14. Smith DL, Fehling PC, Frisch A, Haller JM, Winke M, Dailey MW. The prevalence of cardiovascular disease risk factors and obesity in firefighters. Journal of Obesity. 2012; 1-9. doi:10.1155/2012/908267

15. Yang J, Farioli A, Korre M, Kales SN. Dietary preferences and nutritional information needs among career firefighters in the United States. Glob Adv. Health Med. 2015; 4(4):16-23. doi: 10.7453/gahmj.2015.050.
16. Yang J, Farioli A, Korre M, Kales SN. Modified Mediterranean diet score and cardiovascular risk in a North American working population. PLoS ONE. 2014; 9(2). doi:10.1371/journal.pone.0087539
17. Soteriades ES, Hauser R, Kawachi L, Liarokapis D, Christiani C, Kales SN. Obesity and cardiovascular disease risk factors in firefighters: a prospective cohort study. Obesity Research. 2005; 13:1756-1763. Accessed June 23, 2021.
18. Ode J, Knous J, Schlaff R, Hemenway J, Peterson J, Lowry J. Accuracy of body mass index in volunteer firefighters. Occupational Medicine. 2014; 64:193-197. doi:10.1093/occmed/kqt143.
19. Fahs CA, Smith DL, Horn GP. Impact of excess body weight on arterial structure, function, and blood pressure in firefighters. Am J Cardiol. 2009; 104:1441-1445. doi: 10.1016/j.amjcard.2009.07.009.
20. Kales SN, Tsismenakis AJ, Zhang C, Soteriades ES. Blood pressure in firefighters, police officers, and other emergency responders. Am J Hypertens. 2009; 22(1):11-20. doi:10.1038/ajh.2008.296
21. Wilkinson M, Brown A, Poston W, Haddock C, Jahnke S, Day R. Physician weight recommendations for overweight and obese firefighters, United States, 2011-2012. Preventing Chronic Disease. 2014; 11:1-9. doi: http://dx.doi.org/10.5888/pcd11.140091.

22. American Heart Association. Understand your risks to prevent a heart attack. Heart.Org. https://www.heart.org/en/health-topics/heart-attack/understand-your-risks-to-prevent-a-heart-attack. Accessed June 18, 2021.
23. Centers for Disease Control and Prevention. Heart disease resources. CDC.gov. https://www.cdc.gov/heartdisease/about.htm. Accessed June 18, 2021.
24. Dietary Guidelines Advisory Committee. 2020. Scientific Report of the 2020 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Agriculture and the Secretary of Health and Human Services. U.S. Department of Agriculture, Agricultural Research Service, Washington, DC.
25. Attard SM, Herring AH, Howard AG, Gordon-Larsen P. Longitudinal trajectories of BMI and cardiovascular disease risk: the national longitudinal study of adolescent health. Obesity. 2013; 21:2180-2188. doi:10.1002/oby.20569.
26. Kee CC, Sumarni MG, Lim KH, et al. Association of BMI with risk of CVD mortality and all-cause mortality. Public Health Nutr. 2017; 20(7): 1226-1234. doi: 10.1017/S136898001600344X.
27. Lavie CJ, Milani RV, Ventura HO. Obesity and cardiovascular disease: risk factor, paradox, and impact of weight loss. Journal of American College of Cardiology. 2009; 53(21): 1925-1932. doi:10.1016/j.jacc.2008.12.068.
28. Saydah S, Bullard KM, Cheng, Y, Ali MK, Gregg EW, Geiss L, Imperatore G. Trends in cardiovascular disease risk factors by obesity level in adults in the United States, NHANES 1999-2010. Obesity. 2014; 22(8): 1888–1895. https://doi.org/10.1002/oby.20761

29. Tsismenakis AJ, Christophi CA, Burress JW, Kinney AM, Kim M, Kales SN. The obesity epidemic and future emergency responders. Obesity. 2009; 17(8): 1648-1650. doi:10.1038/oby.2009.63.

30. Centers for Disease Control and Prevention. Defining adult overweight and obesity. Cdc.gov. https://www.cdc.gov/obesity/adult/defining.html. Updated September 17, 2020. Accessed June 6, 2021.

31. The Centers for Disease Control and Prevention. Obesity is a common, serious, and costly disease. CDC.Gov. https://www.cdc.gov/obesity/data/adult.html. Accessed June 7, 2021.

32. World Health Organization. Obesity and overweight. Who.Int. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight. Accessed June 9, 2021.

33. Kee CC, Sumarni MG, Lim KH, et al. Association of BMI with risk of CVD mortality and all-cause mortality. Public Health Nutr. 2017; 20 (7): 1226-1234. doi: 10.1017/S136898001600344X.

34. Flegal KM, Kit BK, Orpana H, Graubard BI. Association of all-cause mortality with overweight and obesity using standard body mass index categories: a systematic review and meta-analysis. JAMA. 2013; 309 (1): 71–82. Published January 2, 2013. Accessed July 7, 2021.

35. Adams KF, Schatzkin A, Harris TB, et al. Overweight, obesity, and mortality in a large prospective cohort of persons 50 to 71 years old. N Engl J Med. 2006; 355 (8): 763–778. Published August 24, 2006. Accessed July 7, 2021.

36. Laxy M, Teuner C, Holle R, Kurz C. The association between BMI and health-related quality of life in the US population: sex, age and ethnicity. Int J Obes. 2018; 42: 318-326. doi:10.1038/ijo.2017.252.

37. Choi B, Steiss D, Garcia-Rivas J, Kojaku S, Schnall P, Marnie D, Baker D. Comparison of body mass index with waist circumference and skinfold-based percent body fat in firefighters: adiposity classification and associations with cardiovascular disease risk factors. In Arch Occup Envrion Health. 2016; 89: 435-448. doi: 10.1007/s00420-015-1082-6.
38. Soteriades ES, Hauser R, Kawachi I, Christiani DC, Kales SN. Obesity and risk of job disability in male firefighters. Occup Med. 2008; 58: 245-250. doi: 10.1093/occmed/kqm153.
39. Korre M, Guilherme L, Farioli A, et al. Effect of body mass index on left ventricular mass in career male firefighters. Am J Cardiol. 2016; 118: 1769-1773. doi: 10.1016/j.amjcard.2016.08.058.
40. Poston WSC, Jitnarin N, Haddock KC, Jahnke SA, Tuley BC. Obesity and injury-related absenteeism in a population-based firefighter cohort. Obesity. 2011; 19(10); 2076-2081. doi:10.1038/oby.2011.147.
41. Choi B, Schnall P, Dobson M, Israel L, Landsbergis P, Galassetti P, Pontello A, Kojaku S, Baker D. Exploring occupational and behavioral risk factors for obesity in firefighters: a theoretical framework and study design. Saf Health Work 2011; 2(4):301–312. http://dx.doi.org/10.5491/SHAW.2011.2.4.301.
42. Jitnarin N, Poston Walker SC, Haddock CK, Jahnke SA. Accuracy of body mass index defined obesity status in US firefighters. Health and Safety at Work. 2014; 5: 161-164. http://dx.doi.org/10.1016/j.shaw.2014.06.003.
43. Nevill AM, Stewart AD, Olds T, Holder R, Relationship between adiposity and body size reveals limitations of BMI. American Journal of Physical Anthropology. 2006; 129 (1);151–156. doi: 10.1002/ajpa.20262.

44. Grier T, Canham-Chervak M, Sharp M, Jones BH. Does body mass index misclassify physically active young men. Prev Med Rep. 2015; 2: 483-487. http://dx.doi.org/10.1016/j.pmedr.2015.06.003.

45. Jahnke SA, Poston WSC, Haddock CK, Jitnarin N. Obesity and incident injury among career firefighters in the central United States. Obesity. 2013; 21: 1505-1508. doi: 10.1002/oby.20436.

46. The Centers for Disease Control and Prevention. Adult Obesity. CDC.Gov. https://www.cdc.gov/obesity/adult/causes.html. Published March 22, 2021. Accessed July 7, 2021.

47. Sotos PM, Cash S, Christophi C, Tolta S, Moffatt S, Muegge C, et al. Rationale and design of feeding America's bravest: Mediterranean diet based intervention to change firefighters' eating habits and improve cardiovascular risk profiles. Contemporary Clinical Trials. 2017;61:101-107. http://dx.doi.org/10.1016/j.cct.2017.07.010.

48. Elliot DL, Goldberg L, Kuehl KS, Moe EL, Breger RK, Pickering MA. The PHLAME (Promoting Healthy Lifestyles: Alternative Models' Effects) firefighter study: outcomes of two models of behavior change. J Occup Environ Med 2007; 49:204–213. doi: 10.1097/JOM.0b013e3180329a8d.

49. Randby KW, MacKinnon DP, Fairchild AJ, Elliot DL, Kuehl KS, Goldberg L. The PHLAME (Promoting Healthy Lifestyles: Alternative Models' Effects) Firefighter study: Testing Mediating Mechanisms. Journal of Occupational Health Psychology. 2011; 16 (4); 501-513. doi: 10.1037/a0023002.

50. Moe EL, Elliot DL, Goldberg L, Kuehl KS, Stevens VJ, Breger RKR., DeFrancesco CL, Ernst D, Duncan T, Dulacki K, Dolen S. Promoting Healthy Lifestyles: Alternative Models'

Effects (PHLAME). Health Education Research. 2002;17(5) 586-596. Accessed July 15, 2021.

51. Poston WSC, Haddock CK, Jahnke SA, Jitnarin N, Day RS. An examination of the benefits of health promotion programs for the National Fire Service. BMC Public Health. 2013; 13(805); 1-14. Accessed July 15, 2021.
52. Carey MG, Al-Zaiti SS, Liao LM, Martin HN, Butler RA. A low-glycemic nutritional fitness program to reverse metabolic syndrome in professional firefighters: results of a pilot study. J Cardiovasc Nurs. 2011; 26(4):298–304. doi:10.1097/JCN.0b013e31820344d7.
53. Winick C, Rothacker DQ, Norman RL. Four worksite weight loss programs with high-stress occupations using a meal replacement product. Occup Med. 2002; 52(1):25–30. Accessed July 15, 2021.
54. Ammerman AS, Hartman T, Demarco MM. Behavioral economics and the Supplemental Nutrition Assistance Program: making the healthy choice the easy choice. The American Journal of Preventative Medicine. 2017; 52; 145-150. http://dx.doi.org/10.1016/j.amepre.2016.08.017.
55. Kraak VI, Englund T, Misyak S, Serrano EL. A novel marketing mix and choice architecture framework to nudge restaurant customers toward healthy food environments to reduce obesity in the United States. Obesity Reviews. 2017; 18; 852-868. doi: 10.1111/obr.12553.
56. Wilson AL, Buckley E, Buckley JD, Bogomolova S. Nudging healthier food and beverage choices through salience and priming. Evidence from a systematic review. Food Qual. Preference. 2016; 51: 47–64. http://dx.doi.org/10.1016/j.foodqual.2016.02.009.
57. Just DR, Mancino L, Wansink B. Could behavioral economics help improve diet quality for nutrition assistance program participants? Economics, Management, and Financial Markets.

2010; 5(2): 174-209. www.ers.usda.gov/publications/err-economic-research-report/err43.aspx. Published 2007.Accessed July 22, 2021.

58. Van Kleef E, Otten K, Van Trijp HCM. Healthy snacks at the checkout counter: A lab and field study on the impact of shelf arrangement and assortment structure on consumer choices. BMC Public Health. 2012; 12: 1072. http://www.biomedcentral.com/1471-2458/12/1072. Accessed July 24, 2021.
59. Ensaff H, Homer M, Sahota P, Braybook D, Coan S, McLeod H. Food choice architecture: an intervention in a secondary school and its impact on student's plant-based food choices. Nutrients. 2015; 7; 4426-4437. doi:10.3390/nu7064426.
60. Just DR, Payne CR. Obesity: can behavioral economics help? Ann. Behav. Med. 2009; 38; 47-55. doi: 10.1007/s12160-009-9119-2.
61. Thorndike AN, Sunstein CR. Obesity prevention in the supermarket– choice architecture and the Supplemental Nutrition Assistance Program. AJPH Perspectives. 2017; 107; 1582-1583. doi: 10.2105/AJPH.2017.303991.
62. Hanks AS, Just DR, Smith LE, Wansink B. Healthy convenience: Nudging students toward healthier choices in the lunchroom. J. Public Health (Oxf.). 2012; 34: 370–376. doi:10.1093/pubmed/fds003.
63. Hanks AS, Just DR, Wansink B. Smarter lunchrooms can address new school lunchroom guidelines and childhood obesity. J. Pediatr. 2013; 162: 867–869. http://dx.doi.org/10.1016/j.jpeds.2012.12.031.
64. Thorndike AN, Sonnenberg L, Riis J, Barraclough S, Levy DE. A 2-phase labeling and choice architecture intervention to improve healthy food and beverage choices. Am. J. Public Health. 2012; 102: 527–533. doi:10.2105/AJPH.2011.300391.

65. Arno A, Thomas S. The efficacy of nudge theory strategies in influencing adult dietary behaviour: a systematic review and metaanalysis. BMC Public Health. 2016; 16: 676. doi: 10.1186/s12889-016-3272-x.

66. Kongsbak I, Skov LR, Nielsen BK, et.al. Increasing fruit and vegetable intake among male university students in an ad libitum buffet setting: A choice architectural nudge intervention. Food Quality and Preference. 2015; 49: 183–188. http://dx.doi.org/10.1016/j.foodqual.2015.12.006.

67. Hollands GJ, Shemilt I, Marteau TM, Jebb SA, Kelly MP, Nakamura R, Suhrcke M, Ogilvie D. Altering micro-environments to change population health behaviour: Towards an evidence base for choice architecture interventions. BMC Public Health 2013; 13: 1218. doi:10.1186/1471-2458-13-1218.

68. Marteau TM, Ogilvie D, Roland M, Suhrcke M, Kelly MP. Judging nudging: can nudging improve population health? BMJ. 2011; 342(7791): 263-265. https://doi.org/10.1136/bmj.d228.

69. Gittelsohn J, Lee K. Integrating educational, environmental, and behavioral economic strategies may improve the effectiveness of obesity interventions. Applied Economic Perspectives and Policy. 2013; 35(1): 52–68. https://doi.org/10.1093/aepp/pps044

70. Liberato SC, Bailie R, Brimblecombe J. Nutrition interventions at point-of-sale to encourage healthier food purchasing: a systematic review. BMC Public Health. 2014; 14(1): 919. https://doi.org/10.1186/1471-2458-14-919

71. Wansink B, Hanks AS. Slim by design: Serving healthy foods first in buffet lines improves overall meal selection. PLoS ONE. 2013; 8: e77055. doi:10.1371/journal.pone.0077055

72. Payne CR, Niculescu M, Just DR, Kelly MP. Shopper marketing nutrition interventions. Physiol Behav. 2014; 136: 111–120. http://dx.doi.org/10.1016/j.physbeh.2014.03.029.

73. Skov LR, Lourenço S, Hansen GL, Mikkelsen BE, Schofield C. Choice architecture as a means to change eating behaviour in self-service settings: A systematic review. Obes. Rev. 2013; 14: 187–196. doi: 10.1111/j.1467-789X.2012.01054.x.

74. Adam A, Jensen JD. What is the effectiveness of obesity related interventions at retail grocery stores and supermarkets? -a systematic review. BMC Public Health. 2016; 16(1), 1247–1247. https://doi.org/10.1186/s12889-016-3985-x

75. Ayala GX, Baquero B, Laraia BA, Ji M, Linnan L. Efficacy of a store-based environmental change intervention compared with a delayed treatment control condition on store customers' intake of fruits and vegetables. Public Health Nutr. 2013; 16(11): 1953–1960. http://dx.doi.org/10.1017/S1368980013000955.

76. Payne CR, Niculescu M, Just DR, Kelly MP. Shopper marketing nutrition interventions: social norms on grocery carts increase produce spending without increasing shopper budgets. Prev Med Rep. 2015; 2: 287–291. http://dx.doi.org/10.1016/j.pmedr.2015.04.007.

77. Scarborough P, Matthews A, Eyles H, Kaur A, Hodgkins C, Raats MM, Rayner M. Reds are more important than greens: how UK supermarket shoppers use the different information on a traffic light nutrition label in a choice experiment. The International Journal of Behavioral Nutrition and Physical Activity. 2015; 12(1): 151–151. https://doi.org/10.1186/s12966-015-0319-9.

78. Center for Community Health and Development and the University of Kansas. Section 20. Implementing Photovoice in your community. Ctb.ku.edu. https://ctb.ku.edu/en/table-of-

contents/assessment/assessing-community-needs-and-resources/photovoice/main. Accessed September 14, 2021.

79. Budig K, Diez J, Conde P, Sastre M, Hernan M, Franco M. Photovoice and empowerment: evaluating the transformative potential of a participatory action research project. BMC Public Health. 2018; 18 (432). https://doi.org/10.1186/s12889-018-5335-7.
80. USDA Food and Nutrition Service. How HEI is scored. Fns.usda.gov. https://www.fns.usda.gov/how-hei-scored. March 16, 2018. March 24, 2022.