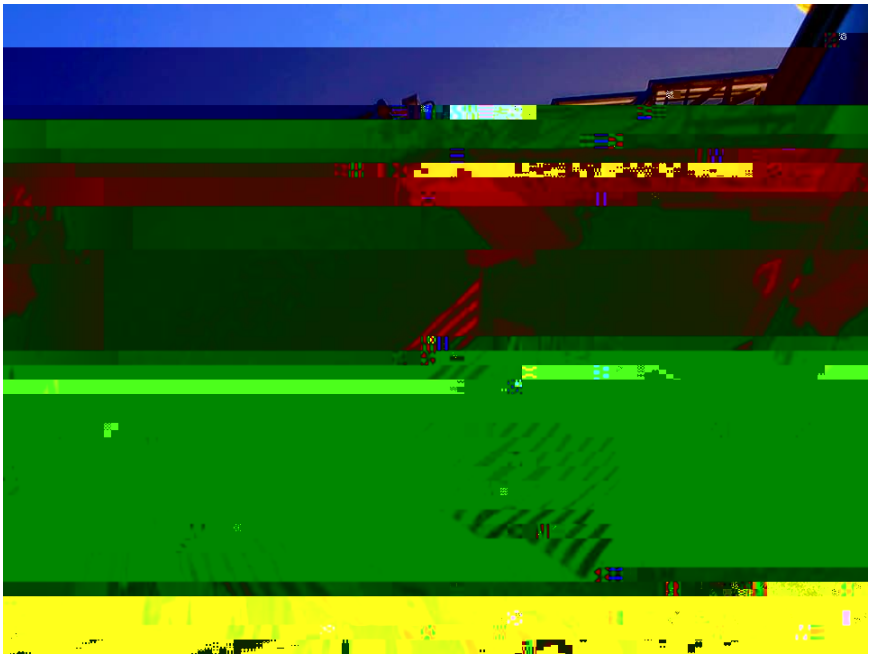

BETTER HEART

Final Report

Building Evaluations That Translate Evidence & Research to Heart Evaluations and Related Training

[redacted]

First Responder Health and Safety Laboratory

Health and Human Physiological Sciences

Skidmore College

May 2023

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EXECUTIVE SUMMARY

The **BETTER HEART** (**B**uilding **E**valuations **T**hat **T**ranslate **E**vidence and **R**esearch for **H**eart **E**valuations **A**nd **R**elated **T**raining) project sought to use the latest medical information, research findings from studies of firefighters, and data from fir

Approximately half of all annual on-duty firefighter deaths are related to CVD. These deaths affect all areas of the fire service, including wildland, volunteer, and career firefighters.

Data obtained from occupational medical evaluations from clinics across the country revealed that firefighters have concerning rates of traditional CVD risk factors. When considered in aggregate, approximately 69% had blood pressure values indicative of hypertension, 33% had elevated blood cholesterol, and 36% were obese based on body mass index (BMI). Moreover, when firefighters were grouped by age, 77% of those in their 50s had hypertensive blood pressure values, 40% had high cholesterol values, and 44% were obese. When individual firefighters were tracked over a 5-year period, 50% of firefighters gained more than 3% of their initial body weight, whereas only 12% lost 3% or more of their body weight, and 38% remained relatively weight stable. Importantly, among those who gained weight, their CVD risk factor profile worsened, while those who lost weight had a better CVD profile despite advancing age.

This data highlights the need for comprehensive wellness and fitness programs focused on CVD prevention as a complement to occupational medical exams.

The Core Project Multidisciplinary Team and the Medical Advisory Team (MAT) believe that an NFPA compliant occupational medical evaluation should form the foundation of cardiac screening for firefighters, including the use of maximal exercise stress testing as recommended. However, it is also clear that even when the current guidelines are fully implemented, they fail to identify some firefighters w

ACUTE CARDIOVASCULAR STRAIN OF FIREFIGHTING

Firefighting involves strenuous muscular work, sympathetic nervous system activation (adrenaline rush), heat stress, and dehydration, and it is performed in an environment that contains multiple hazards.

Figure 3 summarizes the effect of firefighting on the different components of the cardiovascular system: cardiac, vascular and blood/coagulatory. The graphic indicates that the work performed and the firefighters' individual characteristics (such as their physical fitness) will affect the

and its clotting ability. Firefighting leads to a decrease in blood volume because of dehydration, which makes the blood more viscous and harder to pump. Furthermore, several coagulatory factors in the blood increase, thus elevating the potential for blood clot formation.

These acute cardiovascular responses to firefighting reflect the strenuous nature of the work and are similar to what is seen during high-intensity athletic endeavors. Most firefighters recover from the stress of firefighting without incident. On-scene rehabilitation addresses heat stress and dehydration by providing an opportunity to rehydrate and allow the body to physically recover.

In firefighters with CVD, however, firefighting can trigger a sudden cardiac event. Firefighters are more likely to suffer a cardiac event during or after firefighting than during station/administrative duties. In a study which assessed firefighter fatality reports from 1999–2014, we found that sudden cardiac death was 112 times more likely to occur during or after fire suppression compared to station duties (Smith, Haller, & Korre, 2018).

We cannot keep firefighters from performing strenuous work, but we can — and must — do more to identify firefighters with underlying disease so that it can be treated, and preventable firefighter fatalities can be avoided. Annual medical evaluations with appropriate cardiac screening is an important step in protecting firefighters. It is also critical that firefighters actively participate in their own prevention and treatment plans.

CORONARY HEART DISEASE

Coronary heart disease (CHD) is due primarily to atherosclerotic plaque in the coronary arteries. Atherosclerotic cardiovascular disease (ASCVD) is defined as the buildup of cholesterol plaque on the arterial walls. This atherosclerotic process begins with irritants such as high cholesterol, toxins from smoking or exposure, or high blood pressure damaging the inner vessel walls (endothelium). LDL cholesterol (bad cholesterol) enters the

HYPERTENSIVE HEART DISEASE

A heart may increase in size and mass due to uncontrolled hypertension. This is a condition termed hypertensive heart disease. Cardiomegaly refers to a heart that is enlarged (heavy). The heart may also exhibit thickened ventricular wall, known as left ventricular hypertrophy (LVH). The walls of the heart can also become distended leading to an overall dilation of the heart. In general, structural enlargement leads to changes within the heart, such as fibrosis, that alter the electrical stability of the heart and increase the risk of arrhythmias (see Figure 4). Cardiomyopathy is a general term for a diseased heart (myocardium); this condition can either be acquired or inherited. Hypertrophic cardiomyopathy is a specific type of hypertrophy that refers to a genetic abnormality where the left ventricle is thickened. Cardiomyopathy is associated with increased risk of sudden cardiac death.

Hypertensive heart disease, which causes the heart to work harder, has long been recognized as a major non-genetic cause of left ventricular thickening. It is now apparent that other factors that cause the heart to work harder can also lead to a structurally enlarged heart, including coronary artery disease, valvular stenosis, and obesity. Structural enlargement of the heart interferes with electrical and mechanical functioning, thus increasing the risk of an arrhythmia and sudden cardiac arrest.

Hypertension is a complex and potentially devastating disease. In addition to leading to structural and functional changes in the heart, hypertension injures the lining of blood vessels (endothelium) and can lead to decreased blood flow, kidney damage, impaired healing and loss of vision.

INTERACTION OF CORONARY HEART DISEASE AND HYPERTENSIVE HEART DISEASE

CHAPTER 2: FIREFIGHTER CARDIOVASCULAR DISEASE RISK FACTORS

ALTERED BLOOD LIPIDS

Measuring the amount of different lipids in the blood is an important screening tool for CVD risk stratification. Routine blood work (a lipid panel) provides information about total cholesterol, low-density lipoprotein cholesterol (LDL-C; bad cholesterol), high-density lipoprotein cholesterol (HDL-C; good cholesterol) and triglyceride levels.

ROLE OF LIPIDS IN THE CARDIOVASCULAR DISEASE PROCESS

Cholesterol accumulation in vessel walls is a hallmark of coronary heart disease (atherosclerotic disease). As discussed in Chapter 1, coronary heart disease is caused by atherosclerotic plaque buildup in arterial walls, which can lead to heart attack, stroke, aortic aneurysm, peripheral vascular disease,

METABOLIC DISORDERS

The term cardiometabolic disease recognizes the overlap between metabolic disorders and CVD. Those with metabolic disorders typically have altered blood lipids, obesity and/or altered blood glucose.

METABOLIC SYNDROME AND CARDIOVASCULAR DISEASE

Metabolic syndrome is a disease process identified by a cluster of cardiometabolic risk factors. Metabolic syndrome is defined as having three or more of the following:

- Increased waist circumference
- Elevated blood pressure
- Elevated blood glucose
- Low HDL cholesterol
- Elevated triglycerides

The cardiometabolic disease process links risk factors that reflect metabolic dysregulation—such as obesity, altered blood lipids a

DIABETES

High blood glucose levels are associated with an increased risk of CVD, sudden cardiac events, and insulin resistance. Elevated blood sugars lead to vascular damage in the kidneys, eyes, and skin; altered immune function; nerve damage; and increased risk of dementia and Alzheimer's disease. The risk of CVD is especially high in individuals with diabetes, a high BMI, hypertension, and abnormal lipid values.

An analysis of firefighter fatalities found that diabetes was associated with a six-fold increased risk of experiencing a duty-related fatal cardiac event (Kales, Soteriades, Christoudias, & Christiani, 2003). Elevated blood glucose levels are an important component of metabolic syndrome and are a significant risk factor for diabetes mellitus.

Diabetes mellitus is a disorder in which the body does not produce enough insulin or respond normally to insulin, thereby causing blood sugar (glucose) levels to be abnormally high. Early in the progression of diabetes mellitus, insulin is produced by the pancreas, but due to abnormalities in muscle cells and excess fat, the liver becomes resistant to insulin. In this situation, the pancreas is unable to produce enough insulin to properly control blood sugar levels.

There is a direct link between insulin resistance and a high BMI and obesity. The more fatty the tissue within the body, the more resistant the cells become to insulin. Abdominal obesity (a large waist circumference) in particular has a detrimental impact on the body's ability to utilize insulin, thereby increasing the risk of developing insulin resistance and CVD. A waist circumference of >40 inches for men or >35 inches for women is a risk for metabolic syndrome and diabetes.

PREVALENCE OF HIGH BLOOD GLUCOSE IN FIREFIGHTERS

Table 3 reports the percentage of firefighters and general population by decade with high blood glucose levels. A lower prevalence of high blood glucose among firefighters may be due to the "healthy worker effect" and guidelines (1582) that preclude the hiring of candidates with insulin dependent diabetes and job restrictions for members with diabetes. Higher prevalence of high blood glucose with increasing age is concerning because of the risk of diabetes and cardiovascular events. Firefighters and their health care providers need to take aggressive steps to combat elevated blood glucose levels, including medication where appropriate, a regimented weight loss/control program, and ongoing medical assessments.

Table 3: Percentage of male and female firefighters with high blood glucose

OBESITY

Obesity is a significant clinical marker of potential underlying disease. Several national organizations have declared an obesity epidemic in the U.S., and the CDC has listed obesity as one of the top five risk factors for attributable deaths and disability-adjusted life years.

ROLE OF OBESITY IN CARDIOVASCULAR DISEASE

Obesity is a major health concern because it increases the risk of CVD and several other

TOBACCO USAGE

Tobacco use is the leading preventable cause of cancer and cancer deaths. Tobacco use causes lung cancer, and cancers of the mouth and throat, voice box, esophagus, stomach, kidney, pancreas, liver, bladder, cervix, colon and rectum. Sadly, cancers linked to tobacco use make up 40% of all cancers diagnosed (CDC Vital Signs).

Smoking is also a major cause of CVD. Those who smoke are 2 to 4 times more likely to develop CHD than non-smokers, and more than 2 times as likely to have a stroke. Smoking increases the risk of cardiac events and stroke through multiple mechanisms, including increasing blood pressure, raising triglycerides, lowering HDL (good) cholesterol, damaging blood

CHAPTER 3: MEDICAL SCREENING

There is a pressing need to reduce the number of cardiac events in the fire service, and occupational medical evaluations serve as an important role in meeting that goal.

CURRENT RECOMMENDATIONS IN THE FIRE SERVICE

NFPA 1582 Standard for Comprehensive Occupational Medical Program for Fire Departments is considered the industry standard for occupational medical evaluations for firefighters. As an "occupational medical evaluation" guideline, the NFPA 1582 Standard is intended to identify risks that could lead to a sudden incapacitation and risks that make a firefighter not suitable to be medically cleared for duty. NFPA 1582 also recommends screening for CVD risk factors, including total cholesterol, HDL cholesterol, LDL cholesterol, blood glucose, and blood pressure, with a goal to initiate early intervention and to slow disease progression in firefighters at risk, even if they are still medically cleared for duty.

As shown in Figure 7, medical evaluations can range considerably from no medical evaluation required to going beyond the NFPA 1582 Standard. Evaluations may vary by location, the provider type, and the funding availability. Researchers of the BETTER HEART project believe that screening requirements should consistently meet NFPA 1582 as a *minimum* standard.

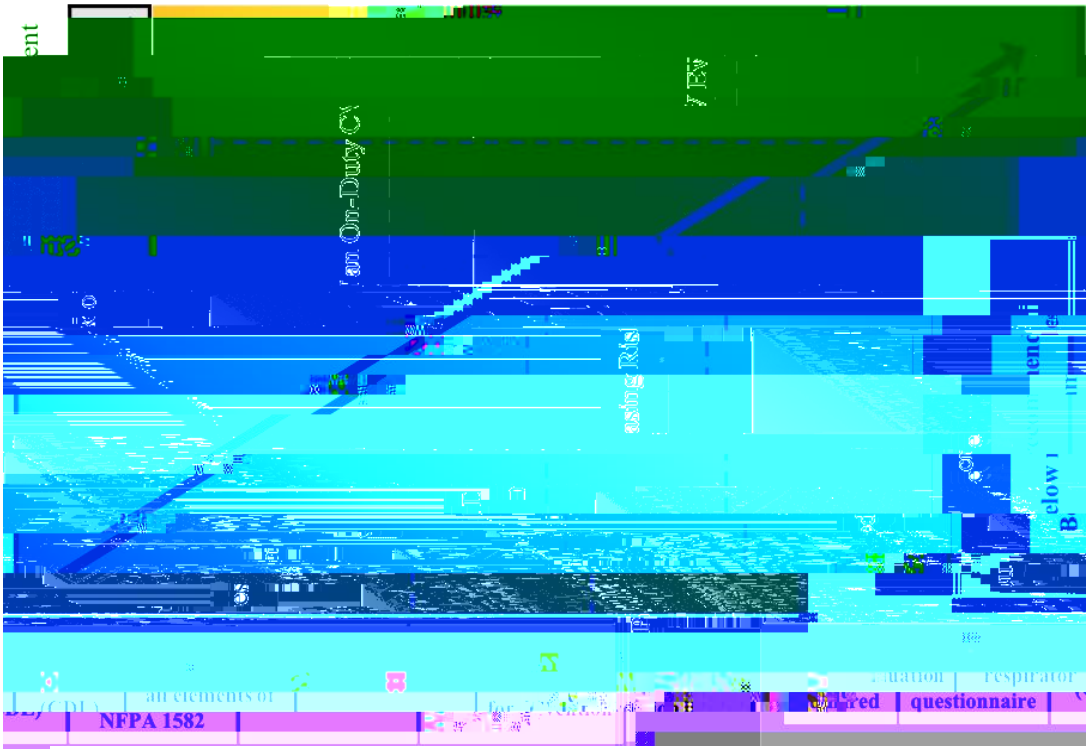

Figure 7: Provision of medical evaluations for firefighters (candidates and incumbents) (From Tobia et al, 2020).

Table 5: Cardiovascular Disease Screening Tools

Screening Tool	Description	Notes
CVD Risk Factors	**Modifiable risk factors** - High BP, high cholesterol, diabetes, smoking, obesity, low fitness. **Non-modifiable risk factors** - Age, family history of CVD, sex.	Routinely assessed to determine increased risk of CVD and to guide treatment.
ASCVD Risk Score	A weighted score based on number and severity of risk factors that assesses the 10-year risk for first CVD event.	Provides a quantifiable metric of 10-year risk of atherosclerotic CVD event. Several risk calculators are available.
Electrocardiogram (ECG)	Measures the electrical activity of the heart to evaluate for abnormalities related to ischemia and arrhythmias.	A resting ECG may fail to detect ischemia that occurs with exertion. An ECG is an insensitive tool to detect LVH.
Echocardiogram	Uses ultrasound to evaluate chamber dimensions, valve structure, and wall thickness. Can assess contractility abnormalities.	A common diagnostic tool to assess cardiac structure and function. Requires a skilled sonographer. Can screen for left ventricular hypertrophy.
Stress testing	A stress test assesses cardiac changes during exercise (usually on a treadmill). **Exercise Stress Testing (EST)** –uses ECG during exercise to assess ischemia or arrhythmias. **Treadmill Stress Echocardiogram –** assesses cardiac contractile changes	

BACKGROUND EVIDENCE

The MAT relied on published data and research, including:

- CVD is responsible for approximately 1 in 4 deaths in the U.S.
- Firefighting leads to significant cardiovascular strain (Smith, et al., 2016).
- Firefighters are approximately 50–100 times more likely to die of Sudden Cardiac Death (SCD) following firefighting duties versus station duties or non-emergency assignments (Kales, Soteriades, & Christophi, 2007; Smith, et al., 2019).
- It has been hypothesized that firefighting activity can *trigger* a cardiovascular event because of multiple stressors, including activation of the sympathetic nervous system, heavy muscular work, heat stress, dehydration, and exposure to products of combustion on the fire ground (Smith, Barr, & Kales, 2013; Kales & Smith, 2017).
- The factors related to SCD in the fire service are complex and include disease progression, occupational risk factors, individual behavior, CVD risk factors, and underlying disease substrates (Soteriades, et al., 2011).
- The cause of SCD among firefighters is most reported as myocardial infarction (heart attack) or cardiac arrest due to arrhythmia.
- 80% of SCD among U.S. firefighters occurred in individuals with autopsy-confirmed evidence of atherosclerosis **and** an enlarged heart (either cardiomegaly or left ventricular hypertrophy) (Smith, et al., 2018).
- Cardiac arrest due to arrhythmias may be more common than previously understood. At autopsy, only 16% of cardiac-related fatalities had evidence of a coronary artery thrombus (Smith, et al., 2018); however, 87% had an enlarged heart (cardiomegaly or left ventricular hypertrophy) that increases the risk of arrhythmia and adverse cardiac outcomes (Shenasa, Shenasa, & El-Sherif, 2015; Vakili, Okin, & Devereux, 2001)

CHAPTER 4: BETTER HEART ENHANCED SCREENING RECOMMENDATIONS

The MAT (see page 4 for listing) made two recommendations for enhanced cardiac screening based on current medical literature, research related to firefighter cardiovascular health, and expert opinion.

RECOMMENDATION 1

Firefighters should be screened for coronary heart disease using Coronary Artery Calcium scans at age 40 years, or earlier based on clinical judgement, such

communities, CAC scores are already being offered through voluntary programs based on local clinics or programs that have been provided by donors.

The cost of the screening is often noted as a concern. However, the cost of screening can often be negotiated with health care systems and many departments have found that the cost of the CAC scores are not prohibitive. Furthermore, the cost of not detecting underlying CVD must also be considered in discussions of financial cost. A firefighter who is not properly screened or evaluated for CVD

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KEY TERMS

Angina: A condition caused by CVD manifesting in severe chest pain, often spreading to the shoulders, arms, and neck. The pain is caused by an inadequate blood supply/oxygen to the heart.

Atherosclerotic Cardiovascular Disease (ASCVD): The buildup of fatty deposits and plaque along the arterial walls, which can lead to coronary heart disease, cerebrovascular disease, or peripheral artery disease.

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E

Endothelial Function: The endothelium is a thin membrane that lines the inside of the heart and blood vessels. Endothelial cells release substances that control vascular relaxation and contraction as well as enzymes that control blood clotting, immune function, and platelet adhesion.

Framingham Risk Score: A sex-specific algorithm used to estimate the 10-year cardiovascular risk of an individual.

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