U.S. Fire Administration
Working for a fire-safe America

Cardiovascular Disease in the Fire Service

FEMA

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Mission Statement

We support and strengthen fire and emergency medical services and stakeholders to prepare for, prevent, mitigate and respond to all hazards.

U.S. Fire Administration
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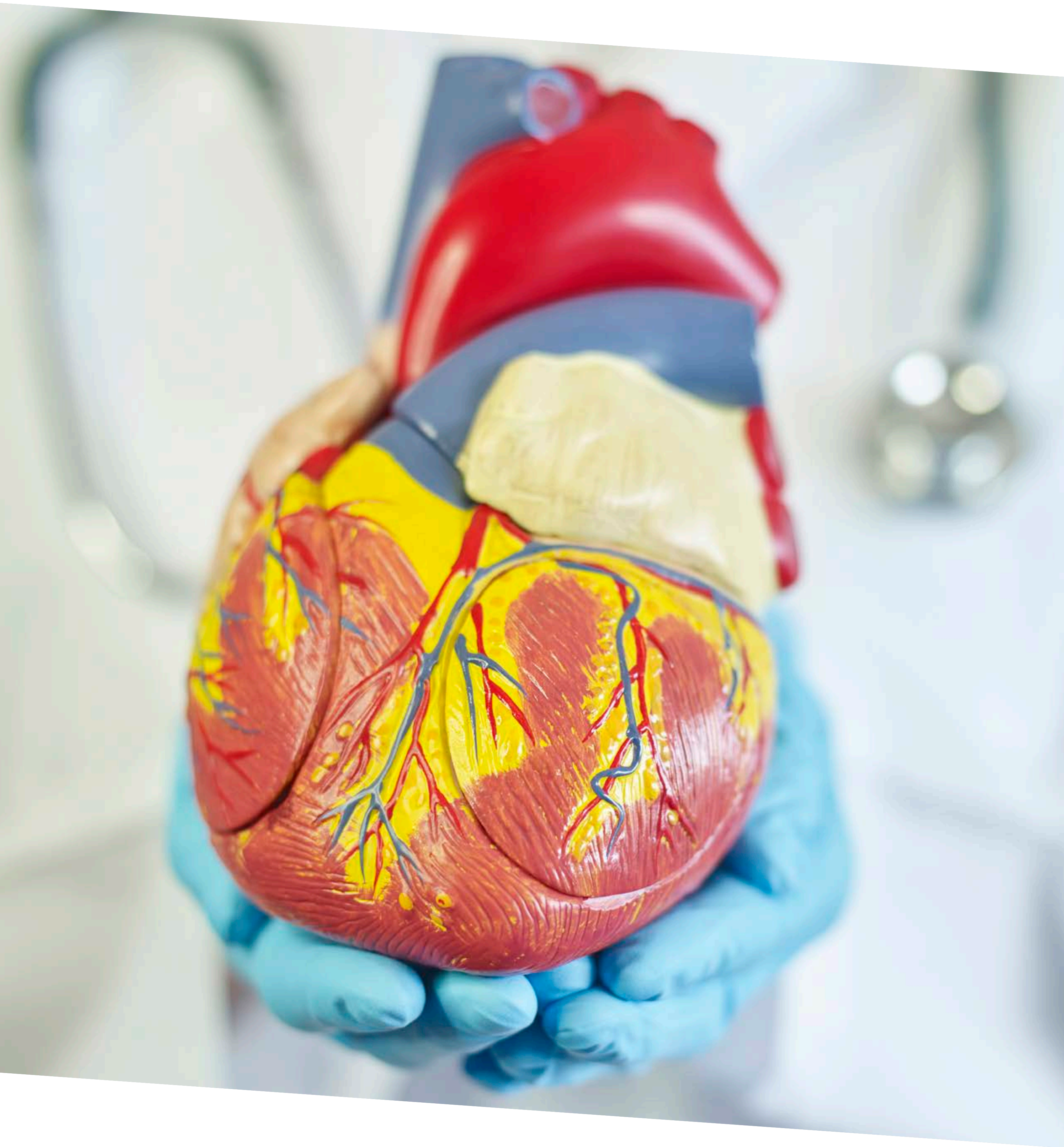


Cardiovascular Disease in the Fire Service

Although this report focuses specifically on firefighters, many of the health and wellness challenges described are shared across other responder and high-risk occupational groups, including law enforcement, dispatch and emergency medical services. Across these professions, workers are exposed to chronic operational stress, shift work, sleep disruption, traumatic events, high physical and cognitive demands, and organizational pressures that compound over time. These shared exposures contribute to overlapping risks for cardiovascular disease, sleep disorders, mental health concerns, injury and long-term chronic disease. The decision to focus this report on firefighting reflects the rapid growth and maturation of the scientific literature in that field, which now allows for more nuanced, evidence-informed conclusions. Importantly, the patterns identified in firefighter health research are likely relevant — and transferable — to other responder populations, underscoring the opportunity to use this work as a foundation for broader, cross-disciplinary health and wellness strategies.

Introduction

Firefighters are the first responders in a wide range of critical situations, including medical emergencies, traffic accidents, hazardous material incidents, natural disasters and, of course, fires. Motivated by courage, resilience and an unwavering commitment to public safety, firefighters perform their duties under strenuous and often perilous conditions that expose them to a host of hazards. Given the dangers firefighters encounter and the unique aspects of their work, it is not surprising that they face several health concerns. To tackle these urgent health issues and mitigate risk, the U.S. Fire Administration's (USFA's) National Fire Data Center has developed a set of comprehensive firefighter health reports addressing cardiovascular health and disease, mental/behavioral health, and heat stress. This report focuses on a persistent threat: cardiovascular health and disease.

Sudden cardiac events, such as a myocardial infarction (heart attack) or cardiac arrest (when the heart stops beating), kill more firefighters on duty than any other cause and are responsible for about 45% of firefighter line-of-duty deaths (LODDs) (see USFA's Firefighter Fatality reports for 2018-2022). These unexpected cardiac events result from cardiovascular disease (CVD), which includes not just one, but a wide array of diseases that affect the heart and blood vessels. Firefighters also experience high levels of CVD risk factors (e.g., high blood pressure, obesity, etc.), which increase the likelihood of these sudden cardiac events (Khaja et al., 2021; Moffatt et al., 2021). Of course, firefighters are not the only ones that suffer from CVD or suboptimal cardiovascular health. Indeed, almost half of American adults (49%) have some type of CVD (American Heart Association, 2024b). However, the unacceptably high number of LODDs due to sudden cardiac events in the fire service, and an appreciation for the relationship between cardiovascular health and effective job performance, demands a focus on this issue for firefighters. As it is related to job performance and personal health, USFA is committed to CVD preven-tion, early detection and proper management to ensure the healthiest workforce possible, from recruits through active firefighters and into retirement.

Sudden cardiac events, like heart attacks and sudden cardiac arrests, continue to kill more firefighters on duty than any other cause. But a sudden cardiac event is not an inevitable part of the job. Indeed, it is often preventable. Departments, stations and firefighters can take steps to cut cardiovascular risk — protecting their lives, their crew and their families. The goal is simple: make sure every firefighter goes home safe and lives to serve another day.

Meeting this goal demands a thorough exploration of CVD. As a complex collection of diseases with a complicated progression, CVD is multifaceted and can be confusing. But, importantly, there are well-established medical/prevention guidelines to reduce cardiovascular risk in the general population that can be leveraged to reduce risk among firefighters. Therefore, this report will seek to clarify the problem and offer possibilities for prevention, detection and management of CVD.

Specifically, this report will:

- Provide an overview of CVD to break down the complex nature of the disease and its risk factors.
- Explore the burden of CVD and CVD risk factors among firefighters.
- Summarize the cardiovascular strain of firefighting.
- Present strategies to reduce CVD and the risk of sudden cardiac events in the fire service.

Overview of Cardiovascular Disease

Understanding cardiovascular disease: Background and terminology

CVD is complicated, in part, because it is not just one disease. CVD represents an umbrella term that includes dozens of conditions affecting the heart structure, heart valves and blood vessels. The most common types of CVD are presented in Table 1, with descriptions of the conditions to help orient readers to common CVD terminology. Reviewing CVD terminology is helpful because there are many cardiovascular conditions, and there may be different names for the same condition (e.g., a myocardial infarction is a heart attack; coronary artery disease (CAD) and coronary heart disease (CHD) are often used interchangeably). Additionally, many of the conditions are interrelated and individuals may experience multiple types of CVD simultaneously. Understanding these terms will help firefighters communicate effectively with health care professionals, describe conditions/symptoms and understand test results.

Although all types of CVD are of concern, this report focuses on atherosclerotic CVD (ASCVD) (leading to CHD) and hypertensive heart disease (HHD) — the CVD conditions most commonly associated with LODDs among firefighters (light blue shaded conditions in Table 1; Smith et al., 2018). Early screening and effective interventions for these types of CVD offer an opportunity to maintain an operationally ready workforce with firefighters who have a better chance of retiring from the job in good health, as well as decreasing LODDs due to cardiovascular causes.

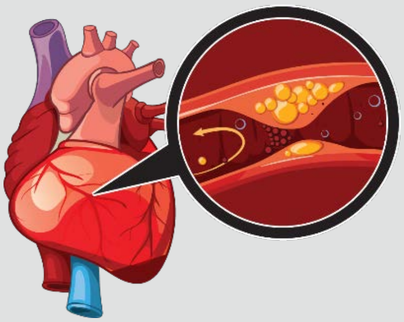
Table 1. Common types of CVD*

Type of CVD	Description and potential clinical outcomes
Arrhythmia (Irregular heartbeat)	A condition where the heart's rhythm is irregular, causing it to beat too fast, too slow or erratically. *Atrial fibrillation (A-fib)*, when the heart beats rapidly and irregularly, is the most common type of arrhythmia. *Ventricular fibrillation*, when the ventricles beat chaotically and do not effectively pump blood, is an arrhythmia associated with sudden cardiac arrest.
ASCVD	A group of cardiovascular conditions caused by the buildup of fatty deposits (plaque) in the arterial walls causing them to become thicker and harder. This narrows the arteries, reduces blood flow, and increases the risk of heart and vascular complications. The plaque is also vulnerable to rupture, which can lead to a blood clot and an acute event. **CAD/CHD** CHD is a result of CAD (though the terms are often used interchangeably) and involves the narrowing or blockage of coronary arteries due to plaque buildup (atherosclerosis), reducing blood flow to the heart muscle. It may lead to an acute *myocardial infarction* (heart attack) — classically this occurs when the plaque ruptures, leading to a blood clot that obstructs the artery. **Cerebrovascular diseases** Refers to conditions (commonly atherosclerosis) that impair blood vessels and blood supply to the brain. Atherosclerotic plaque rupture in a brain artery and resultant clotting blocks blood flow and causes an *ischemic stroke*.
Peripheral artery disease	A circulatory problem where narrowed arteries (usually from atherosclerotic plaque) reduce blood flow to the limbs, typically the legs, causing pain and mobility issues. This may lead to *claudication* (muscle pain, cramping or discomfort).
HHD	*High blood pressure* stresses the heart, making it more difficult to pump blood and leading to structural remodeling of the heart (including thicker heart walls, dilated heart or cardiomyopathy). These changes make the heart vulnerable to an arrhythmia that can trigger a sudden cardiac arrest, as well as gradual progression to heart failure. Hypertension also damages blood vessel walls, which accelerates plaque development.
Heart failure	A condition where the heart is unable to pump enough blood to meet the body's needs, often resulting in fatigue and shortness of breath. It ultimately progresses to death. Heart failure may be caused by one or more CVD conditions (e.g., CHD, HHD, cardiomyopathy).
Congenital heart disease	Structural heart problems present from birth that affect its normal function.
Cardiomyopathy	A disease of the heart muscle that makes it more difficult for the heart to pump blood throughout the body, potentially leading to heart failure. May be a genetic disorder or the result of CVD, often from hypertension.
Valvular heart disease	Damage or defect in a heart valve, disrupting normal heart blood flow.
Rheumatic heart disease	Damage to the heart valves and muscle due to rheumatic fever, which stems from untreated streptococcal infections.

Sources: American Heart Association, 2024a; Cleveland Clinic, 2021; Heart Research Institute, n.d.; Kraft, 2023
*Italicized words are common clinical terms/outcomes associated with different types of CVD.
*Light blue-shaded conditions are those **most associated** with risk of sudden cardiac events in firefighters.

The types of CVD often associated with risk of sudden cardiac events, ASCVD and HHD, usually progress slowly to heart failure. Heart failure is an eventual result for those who have suffered from CVD for a long time. It indicates that the heart is no longer able to effectively/adequately pump blood. Eventually, the diminished blood supply causes organ failure and/or arrhythmias, which result in death. Sometimes, however, CVD does not progress gradually. Acute cardiac events — sudden life-threatening episodes that can occur unexpectedly — may be fatal and are then commonly referred to as acute cardiac deaths.

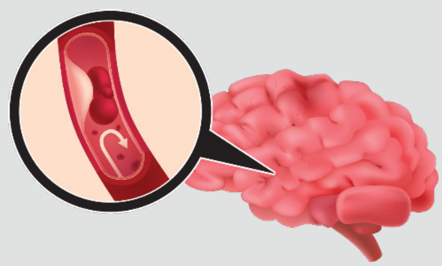
Acute cardiac events



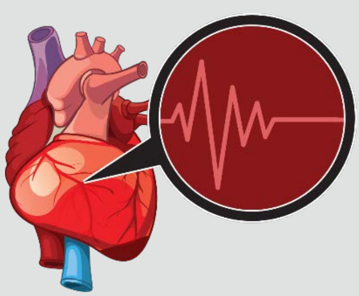
Myocardial infarction (heart attack)

A **myocardial infarction** occurs suddenly when blood flow in one of the coronary arteries of the heart is obstructed, causing tissue death (infarction) in the heart muscle. CAD is the main cause of a sudden myocardial infarction. These can result in varying degrees of damage to the heart and although factors such as timeliness of treatment, underlying health conditions and degree of severity affect prognosis after a myocardial infarction, they are not usually fatal — 30-day mortality rates are about 8% (Yeh et al., 2010). However, the longer that blood flow is restricted, the greater the damage to the heart, and the higher the likelihood of death. A "massive" heart attack, which is more likely to be fatal, typically means that a plaque ruptures in a major coronary artery, forming a blood clot that nearly or completely inhibits blood flow. A major medical/clinical challenge is understanding what plaque may rupture and when or why it might rupture.

When the blood supply to the brain is suddenly reduced or obstructed (as when an atherosclerotic plaque ruptures and a clot forms), the brain is deprived of oxygen, causing a **stroke**. Brain cell death can occur in minutes, making immediate medical attention critical. Timely medical interventions are lifesaving in most ischemic strokes, although many stroke survivors may experience long-term disabilities.



Ischemic stroke



Cardiac arrest

A **cardiac arrest** occurs when the heart suddenly stops beating. There is often little or no warning. They are usually caused by arrhythmias (irregular heartbeat) and are often provoked by a lack of oxygen (ischemia), such as during a myocardial infarction. An arrhythmia is more likely if the heart has been damaged due to long-standing hypertension or other causes. Out of hospital cardiac arrests are fatal about 90% of the time (Martin et al., 2025). Cardiac arrests can occur unexpectedly, such as when a firefighter suffers one during emergency operations, in which case it is called a sudden cardiac arrest. Or it can occur more predictably, such as when an elderly person is hospitalized with progressively worsening cardiac issues.

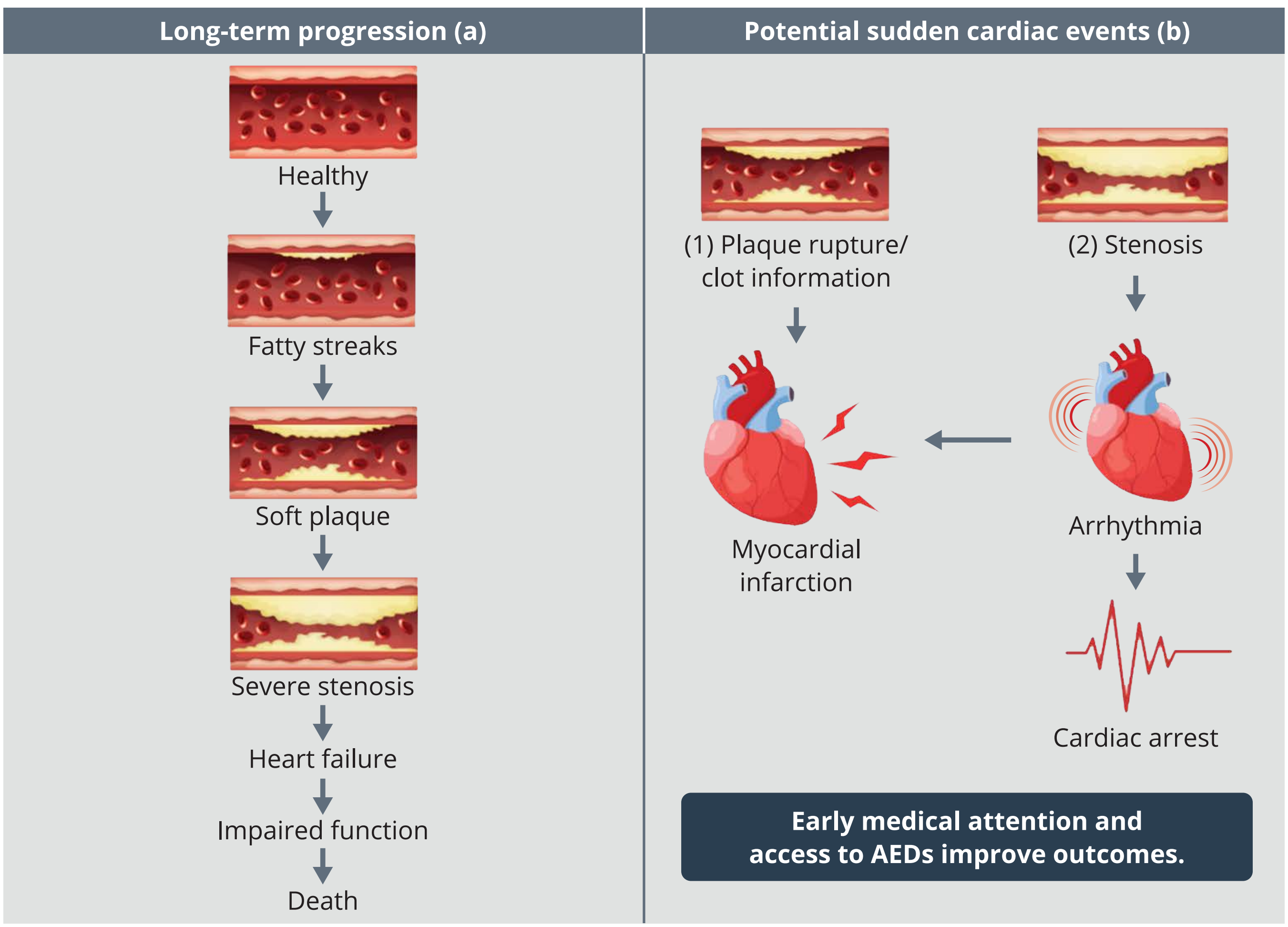
Process and progression of cardiovascular diseases common for firefighters

In the fire service, much of the early concern regarding cardiovascular health was motivated by a recognition that a large percentage of LODDs resulted from sudden cardiac death. A better understanding of the burden of CVD and its progression facilitates identification of early interventions that can interrupt the disease process — ideally before a cardiac event even takes place — promoting an overall healthier workforce.

Figures 1 and 2 summarize the disease process for ASCVD and HHD. These figures show long-term progression and depict acute events that may occur. Initially, a person may not even realize the disease process is occurring in the blood vessels or that the heart muscle is being damaged. With advancing disease progression and increasing age, the damage becomes worse, treatment is often initiated, and the person gradually suffers familiar consequences of the disease, such as decreased stamina, shortness of breath, development of related diseases such as diabetes mellitus and kidney disease, and potentially heart failure. In contrast, and somewhat confoundingly, CVD does not always progress gradually and instead results in an unexpected sudden cardiac event.

ASCVD

Figure 1. ASCVD disease process



Plaque build-up in artery walls may result in long-term progression that leads to eventual heart failure and death. (a) For some, an acute event may occur, even if disease progression is not severe. (b) The 2 major pathways responsible for a sudden, unexpected cardiovascular event are: 1) a soft, vulnerable plaque ruptures causing clot formation, precipitating a myocardial infarction; 2) stenosis (narrowing of artery) causes decreased blood flow and ischemia, which induces an arrhythmia leading to a sudden cardiac arrest.

ASCVD occurs when plaques made up of fat, cholesterol and other substances build up in the artery walls. Over time, this plaque becomes larger and more complex, and it hardens (calcifies). This long-term disease progression is depicted in Figure 1a. When this happens in a coronary artery, it is referred to as CHD or sometimes just heart disease. Unless lifestyle and/or clinical interventions are initiated to manage ASCVD, it can eventually progress to heart failure and death.

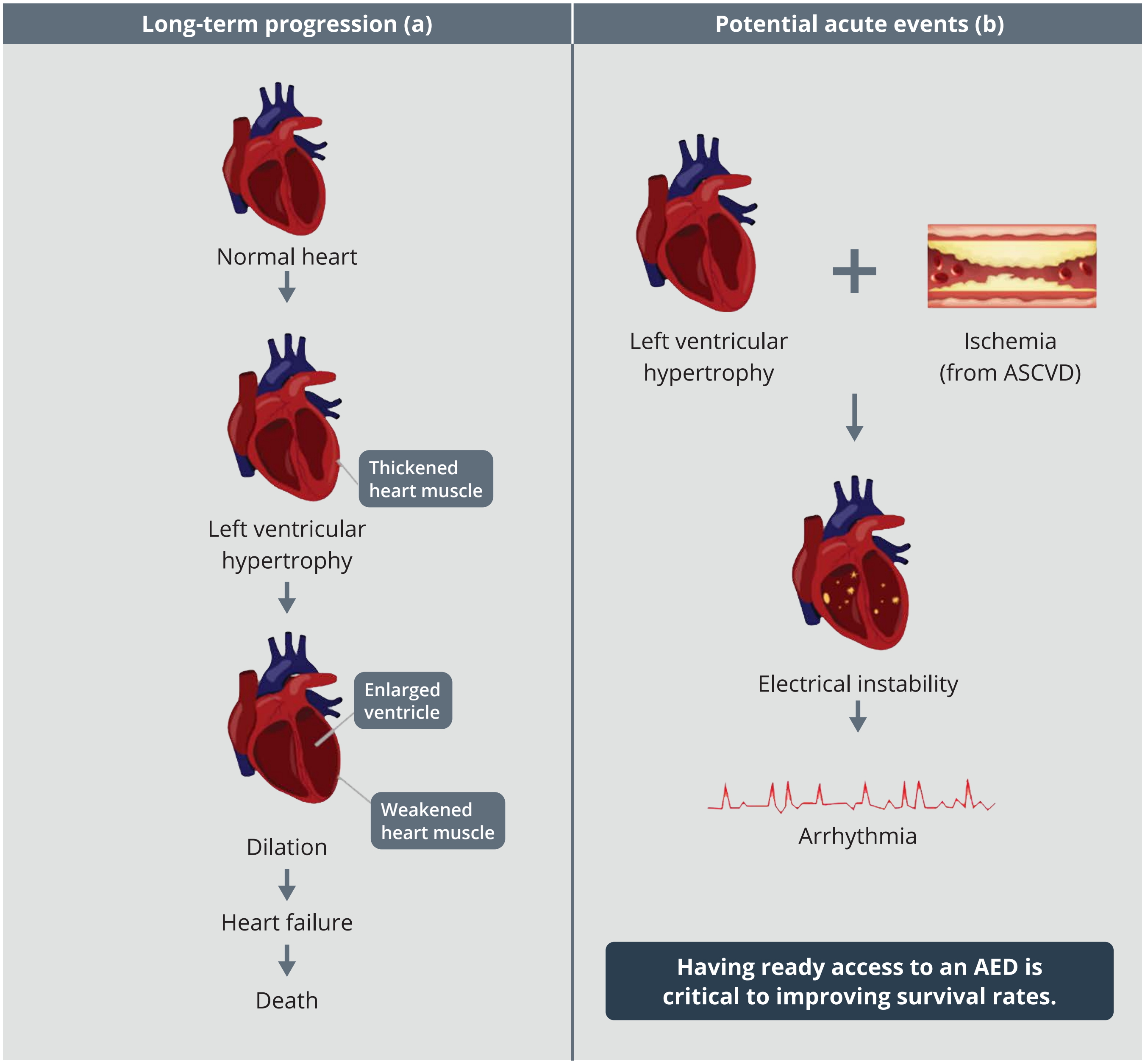
Along this continuum, it is also possible to experience an acute event if a plaque ruptures or if ischemia occurs. If a plaque ruptures, a clot may form which prevents blood from reaching the heart muscle, causing a myocardial infarction. A counterintuitive aspect of ASCVD is that a more advanced disease state does not necessarily cause a sudden cardiac event. Rather, advancing plaque is stabilized by fibrotic tissue and eventually becomes calcified, leading to decreased blood flow and diminished physical capacity in some people; whereas, a relatively small, soft plaque may be unstable and rupture and lead to a blood clot that occludes an artery. It remains a puzzling medical question as to why a vulnerable atherosclerotic plaque may rupture on a given day or at a specific hour.

Even without rupturing, however, an artery that is partially blocked by plaque can result in insufficient blood flow (ischemia) to the heart muscles. Indeed, mild stenosis can cause ischemia when demand for blood flow is high enough (e.g., during vigorous exercise), while severe stenosis may not cause ischemia if oxygen demand and thus blood flow remain low. Ischemia is the underlying cause of pain in the chest, called angina, and it can trigger an arrhythmia, potentially resulting in sudden cardiac arrest.

An ischemic stroke is another type of atherosclerotic disease that occurs due to plaques in the arteries of the brain. A stroke happens when an atherosclerotic plaque ruptures, resulting in a clot that prevents the brain from getting enough blood, and thus oxygen, damaging and killing brain cells.

HHD/enlarged heart

Figure 2. HHD process



HHD is characterized by structural heart changes including left ventricular hypertrophy (LVH) and dilation, which can eventually progress to dilated cardiomyopathy, heart failure and death. (a) For some, an acute, sudden event may occur (even if disease progression is not severe). (b) A sudden cardiac arrest may result when ischemia increases electrical instability. A structurally enlarged heart is more vulnerable to an arrhythmia in the presence of ischemia.

is characterized by cardiac enlargement and structural remodeling of the heart. Structural remodeling of the heart refers to changes in the size, shape, structure and function of the heart in response to various stimuli, such as injury, stress or diseases like hypertension. Although there are multiple conditions that can lead to cardiac enlargement (e.g., hypertension, obesity, CHD, genetic abnormalities), hypertension was the first condition identified as causing structural heart changes. Specifically, cardiomegaly refers to an enlarged (heavy) heart and LVH occurs when the left ventricle walls have thickened.

Long-term progression of HHD is shown in Figure 2a. Prolonged and unmanaged high blood pressure causes the left ventricular walls to thicken in response to the added workload. This makes the heart muscles less flexible and unable to fill properly. Eventually, the heart chamber may become enlarged (dilated) to compensate and maintain cardiac output, a condition known as dilated cardiomyopathy. Dilated cardiomyopathy can create electrical instability in the heart, often secondary to fibrosis (scar tissue formation), and resultant arrhythmias can lead to a cardiac arrest. However, by the time that heart damage has progressed to a dilated condition, the cardiac arrest is not "unexpected" or acute as the condition has typically been treated for a considerable length of time. Heart failure often accompanies late-stage HHD.

HHD can also result in an acute cardiac event (Figure 2b). The major acute risk associated with structural heart change is an increased risk of electrical instability, increasing the heart's susceptibility to arrhythmias, especially if the heart experiences ischemia. Severe structural changes can also interfere with blood flow through the heart.

Integrative pathology of cardiovascular disease

Admittedly, there is considerable complexity in the pathology of each type of CVD. However, the situation is further complicated by the fact that many individuals have both hypertension and ASCVD. Perhaps this is not too surprising given the fact that many types of CVD share the same risk factors (high blood pressure, obesity, sleep apnea). Both types of CVD may complicate long-term progression toward heart failure. And it is also true that these two types of CVD may intersect to cause a sudden, unexpected cardiac death.

Screening and diagnosis of cardiovascular disease

Although prevention of CVD entirely is the most desirable outcome, as that is not always possible, early detection through screening is essential so that progression can be slowed, stalled or even reversed — not only to avert a sudden cardiac event on the job, but to avert a sudden cardiac event entirely, and to ensure adequate cardiovascular health so firefighters enjoy long, productive careers and a healthy retirement.

Screening tools are paramount because often an individual is unaware of a cardiovascular condition(s) even as it leads to damage in the arteries and the heart. Almost half of all sudden cardiac deaths occur in individuals who were unaware that they had heart disease (Fox et al., 2004). Knowing the extent of CVD can be difficult as the process of diagnosis is not always straightforward. It is typical to think of individuals as having or not having CVD. However, the reality is more complicated as CVD is better understood as a spectrum versus a strict dichotomy. Because CVD encompasses many diseases, clinicians use a variety of different diagnostic and screening tools to gauge the progression, magnitude and severity of CVD, rule out certain conditions, suggest others, and identify underlying risk factors that can guide treatment decisions.

During a routine medical evaluation, such as for an occupational medical evaluation or for individuals who have reached an age of increased risk, clinicians may, for example, take blood pressure, perform an electrocardiogram (ECG) to assess heart rhythms, and perform a blood test to evaluate cholesterol (and other lipids) as a form of screening. This provides insight into whether there is underlying disease. Table 2 details how different measures provide information to enable early detection of CVD and CVD risk specifically for CHD and HHD. When screening suggests heightened risk (e.g., high cholesterol, obesity, family history of CVD, etc.) or when symptoms such as chest pain or heart palpitations are present, additional diagnostic tools are used to facilitate diagnosis, treatment and management.

Table 2. Common screening and/or diagnostic tools used to screen for or facilitate diagnosis of CHD and HHD		
Screening/ diagnostic tool	**CHD**	**HHD (LVH and cardiomegaly)**
Blood tests	• Cholesterol and other lipid levels — often used to inform the ASCVD risk calculator. • Blood glucose — important for cardiometabolic disease. • C-reactive protein — marker of inflammation of the arteries. • Cardiac markers (e.g., troponin) — can indicate heart damage during a cardiac event.	N/A
Blood pressure assessment: Measure systolic blood pressure (SBP) and diastolic blood pressure using manual or commercial blood pressure unit.	Elevated blood pressure damages vessels, advances plaque buildup.	Elevated blood pressure leads to heart damage (called end organ damage).
ASCVD risk calculator: An algorithm that uses demographic (e.g., age, sex) and clinical (e.g., blood pressure, cholesterol levels) data to estimate the 10-year risk of an ASCVD event.	Clinicians may determine that patients with a high-risk score require further diagnostic testing, lifestyle interventions or pharmacological treatments.	N/A
ECG (or EKG): Uses electrodes to measure the heart's electrical activity.	• Patterns can show if an individual is having or has had a heart attack. • Used to detect arrhythmias.	May be suggestive of LVH.
Exercise stress test: Monitors ECG (and heart rate and blood pressure) in response to physical stress; usually performed when walking on a treadmill or riding a stationary bike.	Can detect abnormalities in ECG associated with ischemia during high workloads.	N/A
Echocardiogram: Uses sound waves (ultrasound) to visualize heart structure, function and blood flow. Done at rest or following exercise.	May be used to assess functioning of the heart such as wall motion abnormalities, contractility or diastolic dysfunction (impaired relaxation).	Measures size and shape of the heart and can detect thickened heart muscle and determine if the heart is enlarged.

Table 2. Common screening and/or diagnostic tools used to screen for or facilitate diagnosis of CHD and HHD (continued)

Screening/ diagnostic tool	CHD	HHD (LVH and cardiomegaly)
Coronary artery calcium (CAC) scan or heart CT scan: Advanced X-ray imaging (can be used as a screening or diagnostic tool).	Shows extent of calcium deposits in plaque and the degree of blockage in arteries.	N/A
Chest X-ray: Low dose X-rays produce images of structures in the chest.	N/A	Allows visualization to assess if heart is abnormally enlarged.
Cardiac MRI: Uses magnetic fields and radio waves to create detailed images of the heart.	N/A	Shows the structure of the soft tissue that makes up the heart in detail and accurately measures left ventricular mass. Gold standard, but costly.
Cardiac catheterization and angiogram: A medical procedure whereby a thin tube (a catheter) is inserted in a blood vessel and guided to the heart. Dye injected through the catheter helps arteries show up more clearly on X-ray.	An invasive procedure that identifies the location and severity of stenosis (how much obstruction) in the arteries.	N/A

Cardiovascular disease and cardiovascular disease risk in the general population: Providing context

1. Cardiovascular disease mortality and prevalence

CVD has been the leading cause of death in the U.S. for over a century, claiming more lives yearly (941,652 in 2022) than any other cause of death, including cancer (Martin et al., 2025). On a positive note, CVD mortality rates have trended downward, especially in the last 50 years (Martin et al., 2025). The decline in mortality rates is credited to effective prevention (e.g., reductions in cigarette smoking) and evidence-based medical treatments (e.g., control of hypertension) (Mensah et al., 2017).

The overall prevalence of individuals living with some form of CVD or experiencing a cardiac event each year is concerning. The following statistics highlight the prevalence of CVD and key cardiac events.

- Over 127 million U.S. adults, 49%, have some type of CVD (Martin et al., 2025).
- CHD is one of the most common types of CVD, affecting over 20 million American adults (Martin et al., 2025).
- About 805,000 Americans suffer a myocardial infarction each year (Centers for Disease Control and Prevention (CDC), 2024b).
- Hypertension, which is both a disease state and a risk factor for other types of CVD, affects almost half of the adult U.S. population (age-adjusted prevalence of 46.7% using NHANES 2017 to 2020 data; Martin et al., 2025).
- Strokes, which are among the most common cardiovascular events, are experienced by 795,000 people yearly in the U.S. (Martin et al., 2025).

2. Cardiovascular disease risk factors

Although risk factors for CVD, such as increasing age and family history, are important to take note of because they prompt extra vigilance about CVD, they cannot be modified. However, CVD is strongly associated with modifiable factors that can help reduce risk. The American Heart Association has identified eight actionable components, referred to as "Life's Essential 8™," necessary to maximize cardiovascular health and reduce risk of CVD. They include four health factors and four health behaviors (Table 3). The cardiovascular impact of achieving optimal levels of these components can be substantial. As described in Table 3, maintaining optimal levels of each of the health factors and meeting guidelines for the health behaviors can help prevent cardiovascular events and decrease risk of cardiovascular-related mortality.

Table 3 shows the prevalence of U.S. adults achieving optimal levels of these important cardiovascular health behaviors and factors. Although the percentage of some metrics, such as the low number of individuals using nicotine products, is encouraging, other measures provide cause for concern. For example, more than half of the adult U.S. population is not getting enough physical activity, eating well enough, or maintaining levels of blood pressure or blood sugar necessary to reduce CVD risk. Alarmingly, over two-thirds of adults are overweight or obese. These stark statistics illustrate the immense challenges most adults face engaging in heart-healthy behaviors, but to avert the consequences of CVD, it is imperative to do so.

Table 3. CVD risk factors

Health factors	Optimal level	Adults meeting level	Description/CVD impact
Blood pressure	< 120/80 mm Hg	47.7%[1]	High blood pressure (hypertension) is a type of CVD and a major CVD risk factor. Prolonged, unmanaged hypertension can cause structural heart changes, such as left ventricle thickening and an enlarged heart (cardiomegaly) (Di Palo & Barone, 2022). It accelerates plaque buildup and increases CVD-related mortality risk by 77% in untreated individuals (Zhou et al., 2018).
Blood lipids	Non-HDL cholesterol <100 mg/dL	54.2%[2]	High levels of LDL ("bad") cholesterol and triglycerides, and low levels of HDL ("good") cholesterol contribute to atherosclerosis. Elevated total cholesterol can increase CVD mortality risk by 24%, and LDL by 21% (Jung et al., 2022). High HDL levels offer protective benefits.
Weight/body mass index (BMI)	18.5-24.9 kg/m²	29.7%[3]	A BMI of 25–29.9 kg/m² is overweight; ≥ 30 kg/m² is obese. Obesity raises CVD and mortality risk and contributes to other risk factors (Powell-Wiley et al., 2021). Overweight individuals face a 21% higher risk of CVD events, while obesity increases the risk by 67% (Khan et al., 2018).
Blood sugar	Fasting glucose <100 mg/dL (or HbA1c < 5.7%)	47.3%[4]	Type 2 diabetes, marked by insulin resistance and/or deficiency, leads to hyperglycemia (high blood sugar). CVD is the leading cause of morbidity and death in people with type 2 diabetes. Cardiovascular risk is 2-4 times higher in adults with diabetes and rises with poor glucose control (Dal Canto et al., 2019).

A systolic ("top") reading of **120–129 mm Hg** with a diastolic ("bottom") reading **<80 mm Hg** is considered **elevated**. A systolic reading of **>130 mm Hg** and/or a diastolic reading of **>80 mm Hg** is **hypertensive**. These measures were lowered in 2017 to better reflect evidence of the increased CVD risk associated with blood pressure values >120/80 mm Hg (Whelton et al., 2017).

Health behaviors	Optimal level	Adults meeting level	Description/CVD impact
Physical activity	> 150 min. of moderate or > 75 min. vigorous (or combination)/ week	48.1%[5]	Regular physical activity strengthens the heart, reduces hypertension, raises HDL-C, helps with achieving and maintaining a healthy weight, and helps manage blood sugar levels (National Heart, Lung, and Blood Institute, 2022). Regular physical activity can reduce the risk of CVD by 19% (Kazemi et al., 2024).
Diet	Adhering to DASH or Mediterranean diet	47.5%[2]	Studies have demonstrated that following a Mediterranean diet emphasizing fruits, vegetables, whole grains, olive oil and lean proteins reduces risk of cardiac events and CVD mortality (Laffond et al., 2023). A healthy diet reduces risk of CVD by 16% and CVD death by 32% (Hu et al., 2020).

Health behaviors	Optimal level	Adults meeting level	Description/CVD impact
Sleep	7–9 hours/night. Ideally, good quality (e.g., uninterrupted)	69.9%[6*]	Short sleep duration is linked to CVD and can increase risk of CAD by 25% (Yang et al., 2015b). It is also significantly associated with a higher prevalence of other cardiovascular risk factors such as hypertension, type 2 diabetes and obesity (Itani et al., 2017).
Nicotine use	No cigarette, e-cigarette or smokeless tobacco products	81.3%[7]	Nicotine has direct cardiovascular effects. It increases heart rate, raises blood pressure, causes vasoconstriction (narrowing of the blood vessels) and promotes atherosclerosis. Smoking, in particular, causes about one-third (32%) of CHD deaths in the U.S. (U.S. Department of Health and Human Services, 2014).

1. Fryar et al., 2024 (2021-2023 data)
2. Joynt Maddox et al., 2024 (2015-March 2020 data)
3. CDC, 2025 (2023 data)
4. CDC, 2024a (2017-2020 data)
5. Office of Disease Prevention and Health Promotion (ODPHP), 2024a (2022 data)
6. ODPHP, 2024b (2022 data)
*Reflects adults getting > 7 hours sleep per night
7. Cornelius et al., 2023 (2021 data)

Cardiovascular Risk in the Fire Service

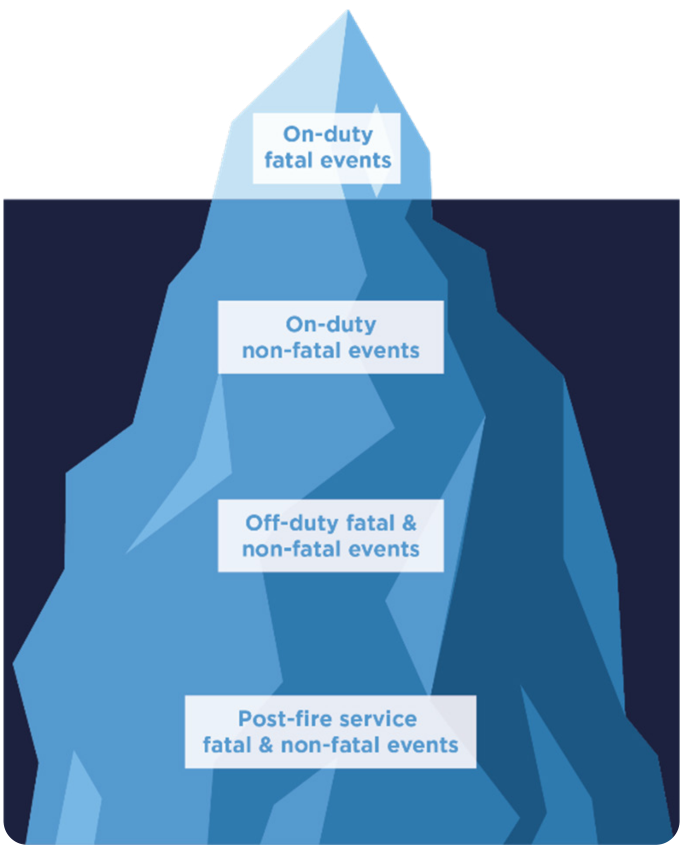
The burden of cardiovascular disease in the fire service

Cardiovascular disease mortality: Line-of-duty deaths

Each year, our nation suffers the loss of too many firefighters in the line of duty. It is the ultimate sacrifice and heartbreaking for loved ones, crew members and the community. Sudden cardiac events, including heart attacks and sudden cardiac arrest, bear the ignoble distinction of being a leading cause of on-duty firefighter fatalities (see USFA's Firefighter Fatality reports for 2018-2022). On average, they account for 45% of on-duty deaths, about eight times more than deaths due to asphyxiation (Figure 3). The risk of sudden cardiac death is 10-100 times higher during fire suppression compared to nonemergency duties (Smith et al., 2019a).

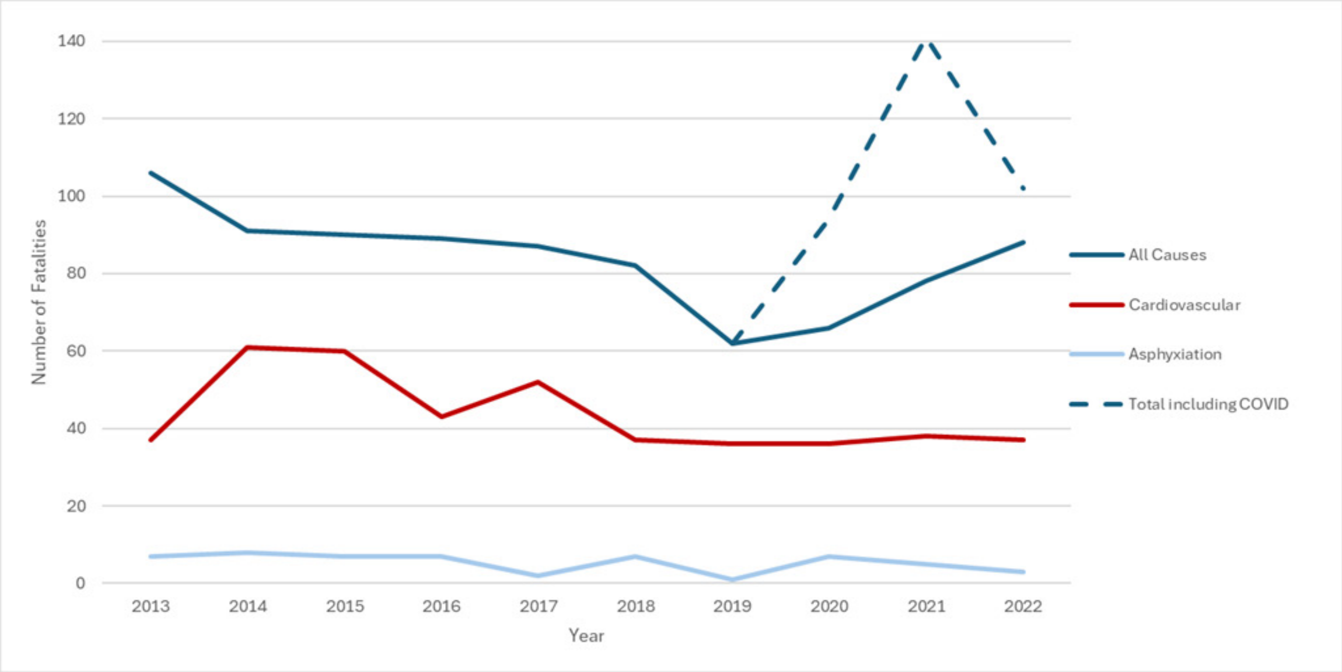
A study that compared pathoanatomic features of firefighters who died in the line of duty due to cardiovascular events versus traumatic events (injury, burn, asphyxiation) helped provide insight into the underlying disease state in those who succumb to cardiovascular events while on duty. The study found that 80% of fatalities had evidence at autopsy of both atherosclerotic disease (CHD) and an increased heart size (cardiomegaly and/or LVH) (Smith et al., 2018).

Prevalence: The full impact of CVD in the fire service



Sudden cardiac events are responsible for too many fatalities — but that is not the full extent of the CVD burden. Actually, it may just be the tip of the iceberg. In addition to fatal sudden cardiac events, which disproportionately occur during emergency operations (Smith et al., 2019a), there are many nonfatal cardiac events that also take place while a firefighter is on duty. Although the exact number of nonfatal, duty-related cardiovascular events is difficult to know, the National Fire Protection Association (NFPA) reported 1,075 nonfatal heart attacks or strokes in 2023 (Campbell & Hall, 2024). Further, cardiac events that occur off-duty are not captured in fire service databases. Regardless of when an event occurs, it can severely impact quality of life by reducing physical capacity, forcing work limitations or early retirements, impairing the ability to perform activities of daily living, and requiring ongoing health care monitoring. Additionally, even if a firefighter does not suffer a sudden cardiac event, progressing CVD can impair operational readiness, diminish quality of life and impose huge financial burdens.

Figure 3. Firefighter fatalities by year and nature of injury, USFA data 2013-2022



Note: Cardiovascular fatalities include heart attacks and cerebrovascular accidents.

The cardiovascular strain of firefighting

It is important to understand the cardiovascular strain of firefighting for two major reasons:

- A healthy cardiovascular response is essential for a firefighter to perform strenuous work.
- The magnitude of cardiovascular strain associated with firefighting may trigger a sudden cardiovascular event in individuals with underlying CVD.

Firefighters perform strenuous physical work, much of which is conducted in heavy and insulated personal protective equipment (PPE), in situations that can be emotionally stressful, under conditions that expose them to extreme heat and environmental pollutants. These unique work demands cause physiological disruption in almost every system of the body, with much of the physiological response being orchestrated by the sympathetic nervous system and the endocrine system. While every system of the body is affected, perhaps the most familiar, and most germane to this report, are the thermal and cardiovascular changes.

Figure 4. The unique physical demands of firefighting cause profound cardiovascular consequences

Cardiovascular strain

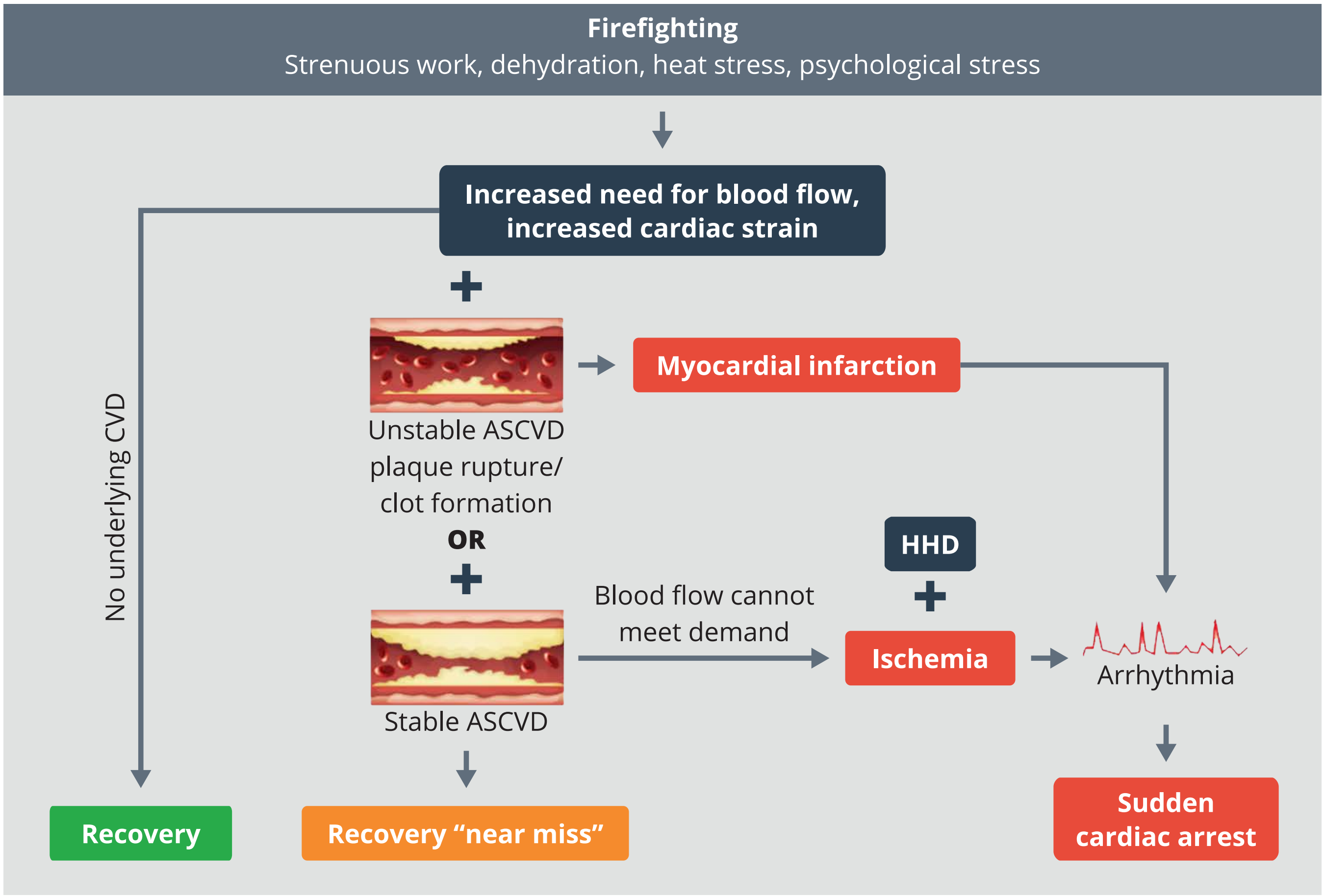
Cardiac
- ↑ Heart rate
- ↑ Myocardial demand
- ↓ Stroke volume

Vascular
- ↑ Arterial stiffness
- ↑ Blood flow
- ↑ Inflammatory markers

Blood/coagulatory
- ↓ Plasma volume
- ↑ Platelet number and function
- ↑ Coagulatory potential

Figure 4 summarizes major cardiovascular changes that occur during firefighting. Firefighting often demands intense and sustained physical effort, significantly increasing cardiac workload, which is reflected in elevated heart rate, blood pressure, and heightened myocardial oxygen demand. Sympathetic activation also means the heart is contracting more forcefully, thus overall cardiac workload increases. Despite this, stroke volume (amount of blood pumped by the heart) decreases, likely due to dehydration (Smith et al., 2001; Fernhall et al., 2012). Blood pressure likely increases during firefighting activity due to heavy work, including a lot of upper body activity. Importantly, blood pressure decreases following firefighting activity — a phenomenon that parallels post-exercise hypotension, and which may be exacerbated by heat stress and venous pooling. Platelet number increases following firefighting and coagulatory potential increases (Smith et al., 2011; Smith et al., 2014; Smith et al., 2022). There are also a few small-scale studies that indicate changes in ECGs after firefighting (Barnard & Duncan, 1975; Smith et al., 2019b; Al-Zaiti et al., 2015).

Figure 5. Firefighting leads to high levels of cardiovascular strain



The work of firefighting demands increased blood flow and elevates cardiac strain. In those with unstable ASCVD, this may trigger a plaque rupture, clot formation and myocardial infarction. A myocardial infarction can provoke an arrhythmia that leads to a sudden cardiac arrest. In individuals with stable ASCVD, narrowed arteries may cause ischemia when the increased need for blood flow cannot be met. Ischemia can provoke an arrhythmia, triggering a sudden cardiac arrest. The presence of HHD increases the risk of arrhythmia during ischemia.

Note: All firefighters experience high levels of cardiovascular strain during firefighting, but only a few will experience a cardiovascular event, and of these, only a few will suffer a fatal event. Most firefighters recover, but those who have underlying disease and recover may have experienced a "near miss," meaning the next time they perform the same activities, they are still at risk of a sudden cardiac event.

As illustrated in Figure 5, most firefighters recover from the stress of firefighting without incident (green box). Hopefully, recovery occurs because the firefighter is healthy. However, firefighters with CVD may also recover but not realize that they have only narrowly missed a major cardiac event. Repeated recovery can give a false sense of security. A firefighter may mistakenly assume they are not at risk because they have done the work and recovered many times. The truth is that firefighters with underlying CVD are at increased risk — and the risk is amplified by any physical exertion. Further, a firefighter with underlying CVD may not avoid a sudden cardiac event on the next call. Early detection and management of CVD risk, and interventions to support heart healthy behaviors and slow down/manage progression in those with underlying disease, are necessary to help ensure that a "near miss" does not become a sudden cardiac event during the next emergency operation (or at all).

Concerningly, firefighters with underlying CVD do not always escape with a "near miss" and instead suffer a sudden cardiac event. As shown on the right-hand side of Figure 5, the heightened cardiac strain resulting from firefighting may provoke a plaque rupture and clot formation in those with unstable ASCVD. The resultant blood clot can occlude a coronary artery and lead to a myocardial infarction. A myocardial infarction decreases the ability of the heart to pump effectively — the extent of the damage is determined largely by which coronary artery is occluded. If a major coronary artery, such as the left anterior descending artery, is occluded, the myocardial infarction is far more likely to be fatal. A myocardial infarction may also cause an arrhythmia which can lead to a sudden cardiac arrest. In individuals with stable ASCVD, characterized by more fibrous plaques that are less vulnerable to rupture, the narrowed arteries do not allow blood flow to increase sufficiently to meet the physical demands of firefighting, leading to ischemia (lack of oxygen). Ischemia can cause an arrhythmia which may result in a sudden cardiac arrest. Ischemia in a person who has HHD further increases the risk of an arrhythmia. Both myocardial infarctions and sudden cardiac arrests are life-threatening, though sudden cardiac arrests result in a significantly elevated fatality risk; about 90% of sudden cardiac arrests are fatal (Virani et al., 2020).

Risk factors for cardiovascular disease in the fire service

As is true in the general population, the risk of a cardiovascular event for firefighters is driven by a host of modifiable health and behavioral factors. Primary health factors impacting firefighter cardiovascular health include hypertension, altered lipid (cholesterol) levels, obesity, high blood glucose, and structural remodeling of the heart (LVH and cardiomegaly). Behavioral CVD risk factors such as physical inactivity, unhealthy diet, smoking and insufficient sleep mirror those of the general population. It may be argued, however, that firefighters encounter unique barriers to engaging in these behaviors. Firefighters' sleep is interrupted by nighttime calls and long shift schedules; healthy eating may be stymied by limited healthy food options at the station and insufficient time for meal preparation; and physical inactivity can be thwarted if exercise equipment is unavailable at the station, if time is not allotted for structured physical activity, if calls interrupt fitness training, or if firefighters are reluctant to engage in exercise to avoid being tired when going out on a call. Reviewing the research regarding the prevalence of these CVD health and behavioral risk factors in the fire service better defines the problem and helps illuminate prevention opportunities.

Health factors associated with cardiovascular risk in the fire service — Key research findings

Hypertension

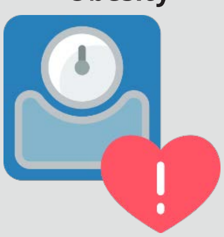
- The rate of on-duty death from CHD is 12 times higher in firefighters with hypertension (Soteriades et al., 2011).
- Firefighters with normal blood pressure are four times more likely to survive a sudden cardiac event than those with high blood pressure (Geibe et al., 2008).
- In a large study of firefighters, 69% were hypertensive and, among males, prevalence rates for firefighters were significantly higher compared to the general population across age groups (Khaja et al., 2021).

Hypertension is one of the most prevalent and dangerous risk factors.

Blood lipids

- Firefighters with high cholesterol are four times more likely to suffer an on-duty CHD death (Soteriades et al., 2011).
- In a large sample of firefighters, 20% had high cholesterol, 12% had high triglycerides and 25% had low HDL cholesterol, and the prevalence of total cholesterol and high triglycerides increased with age (Moffatt et al., 2021).
- Firefighters had a slightly lower prevalence of elevated cholesterol compared to the general population (Moffatt et al., 2021).

Obesity



- The risk of an on-duty CHD death for firefighters increases threefold in firefighters with obesity (Soteriades et al., 2011).
- Studies report both lower (Li et al., 2017; Moffatt et al., 2021; Smith et al., 2020) and higher (Poston et al., 2011) rates of obesity among firefighters compared to the general population, possibly due to regional differences, variability in the mean sample ages, or differences between the risk profiles of volunteer and career firefighters.
- Even if firefighters experience rates lower than the general population, having over one-third (36%; Moffatt et al., 2021) of firefighters at an unhealthy body weight puts a considerable number of firefighters at increased risk of on-duty CHD death.

Type 2 diabetes

- The risk of on-duty CHD death is 10 times higher in firefighters with diabetes (Soteriades et al., 2011).
- A meta-analysis estimated that 21% of firefighters have hyperglycemia, a symptom of diabetes (Beckett et al., 2023).
- The prevalence of diabetes among firefighters has been shown to be much lower than the general population (Li et al., 2017; Smith et al., 2012).

Behavioral factors associated with cardiovascular risk in the fire service — Key research findings

Healthy diet

- Studies of firefighters confirm that greater adherence to a Mediterranean-style diet improves their CVD risk profile (Romanidou et al., 2020; Yang et al., 2014; Yang et al., 2013).
- In a study of U.S. and Canadian career firefighters, fewer than 2% follow a Mediterranean diet, but more than three-quarters indicated an interest in learning more about healthy eating (Yang et al., 2015a).

A Mediterranean diet emphasizes consumption of fruits, vegetables, nuts and legumes, olive oil, unrefined whole grains and fish; moderate consumption of dairy, poultry and eggs; and limited intake of red meat, sweets and processed foods.

Regular physical activity

- Over 75% of more than 500 Midwestern career firefighters reported getting less than the CDC's recommended 150 minutes of weekly moderate physical activity (Durand et al., 2011; CDC, 2023).
- A small study showed that firefighters were more physically active on- versus off-duty, but that over half did not meet physical activity guidelines (Barry et al., 2020).
- Reduced cardiorespiratory fitness (CRF) in firefighters has been linked to the development and progression of CVD risk factors such as obesity, blood pressure and blood lipid concentrations (Ras et al., 2023).

Engaging in regular physical activity enhances CRF, a measure that reflects the maximum amount of oxygen the body can use during intense exercise. It is reported as VO_2max. CRF is cardioprotective and a significant predictor of CVD (Ross et al., 2016). Adequate levels of CRF are necessary for firefighters to perform strenuous tasks safely and without undue risk of a cardiac event.

Smoking

- Smoking rates in one study were about 14% and 17%, for career and volunteer male firefighters, respectively (Haddock et al., 2011).
- Cigarette smoking prevalence among firefighters has continued to decline to about 6% (Phan et al., 2022), which is substantially lower than the prevalence of 18.7% in the general population (Cornelius et al., 2023).
- Firefighters are about three times more likely to use smokeless tobacco than adults in other occupations, with prevalence rates approaching 10% (Phan et al., 2022), which is concerning since long-term use is associated with increased risk of a fatal myocardial infarction or stroke (Piano et al., 2010).

Sleep

- In one study of 258 firefighters, poor quality and quantity of sleep was associated with CVD risk factors such as obesity and hypertension (Romero Cabrera et al., 2021).
- In a small study, firefighters who wore sleep actigraphs averaged a little over 5 hours of sleep per shift (Stout et al., 2021).
- Off-duty, firefighters get more sleep, averaging about 6 hours and 30 minutes — still less than the ideal 7 to 9 hours (Stout et al, 2021).
- Sleep disorders (e.g., obstructive sleep apnea, insomnia, shift work disorder) may affect over one-third of firefighters, further impacting sleep hygiene (Barger et al., 2015).

Mitigating cardiovascular disease in the fire service

Reducing cardiovascular risk will save lives, ensure a healthier workforce, and protect crews and their families. However, lowering rates of CVD in the fire service requires action at every level, from departments setting and implementing strong wellness policies to firefighters committing to the behaviors that protect their lives.

The stakes are high as the consequences of CVD can range from life-altering health limitations to the ultimate sacrifice of a firefighter's life. Losing a firefighter to a sudden cardiac event imposes a profound and painful emotional toll on crew, families and the community. Even when such events are not fatal, their impact can still be deeply felt across the department. A cardiac incident on the fireground can compromise operational effectiveness and crew safety in critical moments. Staffing may be strained if a member needs extended recovery time or takes an early retirement, compounding existing struggles to meet rising call volumes amidst recruitment and retention challenges.

Further, CVD is America's most expensive chronic disease, with medical and indirect costs for 2020-2021 totaling over $417 billion (Martin et al., 2025; AHA, 2017). It is, therefore, unsurprising that the economic burden of CVD on the fire service is staggering. Costs are associated with disability benefits, workers' compensation, the potential loss of productivity, paying overtime and hiring replacements. Data from the National Institute of Standards and Technology estimates that costs related to firefighter injuries can run into the billions (Butry et al., 2019). When assessed by nature of injury, heart disease incurs the largest mean total workers' compensation claims for firefighters amounting to an average cost of $52,885 per claim in 2018 dollars (Butry et al., 2019). Further, the one-year cost of a CVD-related disability was estimated to be $250,000-$400,000 (Ratchford et al., 2014).

As a result, it is essential that the fire service implement strategies to alleviate the health, public safety and economic burden of CVD on the fire service. No single program, recommendation or policy is sufficient to improve the cardiovascular health of firefighters. It will require a blend of medical/screening initiatives, comprehensive health and wellness programs, and policies and protocols to meet the challenge of CVD in the fire service. But those who make the effort will see improvements in firefighter cardiovascular health and an easing of the financial burden of CVD.

Medical/screening

Implementing periodic medical evaluations that include early detection of CVD in firefighters is critical, especially given that some CVD risk factors, and even the advancement of CVD, are often unnoticeable to a firefighter. For example, many people with hypertension feel fine and are unaware of their condition, even though it can cause significant damage over time. Regular health care visits and screenings, such as those listed below, can offer firefighters an opportunity to assess and detect CVD risk factors so that any problems can be managed.

NFPA 1580, *Standard for Emergency Responder Occupational Health and Wellness*

- Provides guidelines for preemployment occupational medical screenings, focusing on identifying any conditions that may disqualify an applicant from safely performing firefighter duties. It includes assessments of cardiovascular health and overall fitness, which are critical given that engaging in intense new-recruit training can be dangerous for those with underlying CVD or poor fitness.
- Establishes guidelines for annual occupational medical evaluations that recommend screening for CVD risk factors. Annual health assessments in line with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, can help identify firefighters at risk for and/or with CVD risk factors

such as high cholesterol, high blood glucose or high blood pressure. Assessment of CRF is included in the medical evaluation because it is an important clinical measure, as well as a marker of fitness. Early detection and subsequent management of these conditions can slow the disease process and help avert a cardiovascular event.

Supplemental CVD screening:

A review of medical information and research findings from recent firefighter studies have led a medical advisor team to recommend enhanced screening for CVD in firefighters.

The BETTER HEART report recommends that:

1. Firefighters be screened for CHD using CAC scans at age 40 years or earlier based on clinical judgment, or in those with risk factors and a family history of premature CAD.
2. Firefighters be screened for structural heart disease (including LVH, cardiac chamber enlargement, valvular abnormalities) using echocardiography at age 40, or earlier in the presence of hypertension, obesity and/or sleep apnea (Smith et al., 2023).

These recommendations differ slightly from NFPA in that they call for all firefighters over 40 years to have additional screening for ASCVD and structural abnormalities recognizing that age is an important factor in disease progression, whereas NFPA recommends such testing in firefighters that have known risk factors for disease.

A Focus on Blood Pressure — A widespread, dangerous, and modifiable risk factor.

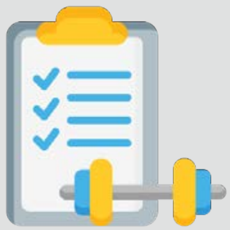
Blood pressure is called the “silent killer” for a reason. It exacerbates atherosclerosis and can cause the heart muscle to become enlarged. It often wreaks havoc on the cardiovascular system without the individual being aware of the condition or the consequences until a great deal of damage has been done. A high percentage of firefighters experience hypertension, perhaps because of the need for vigilance or the stress associated with the job (Khaja et al., 2021).

While it is common to dismiss “mildly” elevated blood pressure, long-term hypertension (even when mild), is like a smoldering fire, quietly causing damage to the vessels and the heart. Firefighters should have their blood pressure checked routinely. If blood pressure is even mildly elevated (>120/80 mm Hg), talk to a health care provider and take action to manage high blood pressure as soon as it is detected. Lowering SBP by even 5 mm Hg reduces risk of a major cardiovascular event by 10% (Rahimi et al., 2021).

Behavioral health and wellness

Risk of a cardiac event among firefighters can be lowered through targeted behavior changes. To mitigate CVD in the fire service, departments must go beyond awareness and implement programs and policies that make healthy choices the easiest choices. Firefighters can dramatically lower their risk of a cardiac event by prioritizing these heart healthy behaviors.

Enhanced training and fitness programs

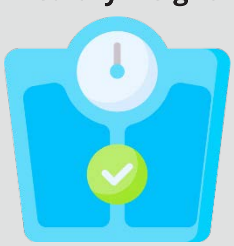


Even though adequate physical activity is critical for cardiovascular health, firefighters can find it difficult to get an adequate amount. Fire departments should implement fitness programs that emphasize cardiorespiratory endurance, strength training and flexibility. Firefighters may undergo CRF testing, results of which can be used to tailor fitness programs aimed at reducing CVD risk. Several experts have suggested that improving CRF (the product of a sound fitness program) is the single greatest step that can be taken to decrease the risk of CVD in the fire service. Fitness also has the advantage of decreasing risk for several types of cancer by 20% (Moore et al., 2016).

Nutrition

Consuming a heart-healthy diet is essential to prevent and/or manage CVD risk factors. Unfortunately, firefighters can encounter many barriers to healthy eating while on duty such as limited access to healthy foods, less time for meal preparation, proliferation of convenience and unhealthy food options, irregular meal schedules, etc. Departments can incorporate nutrition programs, focus on meal planning and preparation strategies, and improve the firehouse nutrition environment by stocking healthy options. Crews can support one another in having healthy meals and snacks at the station. A healthy diet not only decreases cardiovascular risk but also lessens the risk of cancer (Vieira et al., 2017; Zhao et al., 2023).

Maintain healthy weight



Although Americans overall, including firefighters, often struggle to maintain a healthy weight, the connection between high BMI and CVD makes it imperative to do so. Like the general population, firefighters tend to gain weight over time. Mathias et al. found that over five years, 50% of firefighters gained more than 3% of their body weight, 38% remained weight stable (±3% of body weight) and 12% lost more than 3% (2020). Encouragingly, those who maintained or lost weight saw improvements in CVD risk factors (Mathias et al., 2020). In contrast, those who gained weight had worsening cardiovascular risk factors. Programs that blend nutrition and physical fitness can help firefighters achieve a healthy weight.

Stress reduction and mental health support

Given the impact of psychological stress on cardiovascular health, access to mental health resources, counseling and stress management programs can be valuable in reducing overall CVD risk (Osborne et al., 2020; Rosengren et al., 2004). Indeed, risk of CHD and stroke is elevated by 10%-60% among individuals experiencing chronic stress (Kivimäki & Steptoe, 2018). Getting regular physical activity; incorporating mindfulness, meditation and yoga practices into a daily routine; connecting with family and friends; and asking for help when needed are all strategies to help manage the stress inherent in firefighting and mitigate its impact on cardiovascular health.

Substance use management

Both nicotine and alcohol use are risk factors for CVD, and both are addictive substances that are often difficult to manage. Easy access to confidential support, counseling and treatment programs may assist firefighters in addressing nicotine addiction and/or alcohol addiction or misuse.

Comprehensive wellness programs

Implementing a comprehensive wellness program, such as the fire service Joint Labor Management Wellness-Fitness Initiative (WFI), developed by the International Association of Fire Fighters and the International Association of Fire Chiefs, can improve the health, fitness and overall well-being of firefighters. The WFI emphasizes many of the above elements, including comprehensive annual medical exams, physical fitness programs, behavioral health support and peer-driven wellness efforts. A study by Poston et al. found that fire departments adhering to WFI guidelines demonstrated significant cardiovascular health benefits, including 42% lower obesity rates, higher physical activity, better estimated CRF (VO_2 max) and reduced hypertension (2013). These departments also reported improved job satisfaction and overall physical, behavioral and mental health.

The National Volunteer Fire Council introduced the Heart-Healthy Firefighter Program in 2003 to provide education, raise awareness and offer valuable resources to improve firefighters' cardiovascular health. This program emphasizes the importance of fitness, proper nutrition and overall health awareness for all fire and emergency services members. It equips individuals with the tools to maximize their heart health while also supporting departments in establishing effective wellness programs. The program offers guides, videos, challenges, education information and behavioral support resources (e.g., for smoking cessation).

Overall, an effective, comprehensive wellness program requires:

- Appropriate screening so firefighters know their CVD risk and/or if they have evidence of CVD.
- Education so that firefighters understand the magnitude of risk associated with their type and severity of CVD.
- Primary prevention programs to avoid disease, addressing the behavioral factors to promote cardiovascular health: fitness, nutrition, smoking cessation and sleep hygiene.
- Secondary prevention programs to treat and slow the progression of disease addressing the health factors that promote cardiovascular health: support managing blood pressure, blood lipids, blood glucose and weight.

Protocols

When adopted and consistently practiced, certain procedures for firefighters, described below, have the potential to reduce cardiac events.

Incident scene rehabilitation: Policies to manage heat exposure may help reduce heat stress and lessen cardiovascular strain. Rehab also provides an opportunity to monitor the extent to which a member is recovering as expected and may permit the early detection of an evolving problem. When available, it is desirable that advanced life support personnel are assigned to rehab. Best practices to manage heat stress in the fire service, including NFPA 1584, *Standard on the Rehabilitation Process for Members During Emergency Operations and Training Exercises*, focus on:

- **Hydration:** Ensure regular access to water and electrolytes.
- **Rest and recovery:** Allow cooling down periods.
- **Acclimatization:** Gradually increase heat exposure for new or returning firefighters.
- **Cooling techniques:** Use ice vests, cold-water immersion, fans and shaded rest areas.
- **Monitoring:** Maintain accountability for members in rehab. If a member is not feeling well after others have recovered, assess vital signs, and have a high suspicion for cardiac-related complications. Individuals with shortness of breath, pain, excessive fatigue and malaise should be evaluated medically.

Smoke exposure reduction: Smoke and other products of combustion can lead to the advancement of CVD, induce an acute cardiovascular event and increase the risk of cancer. Fire departments should establish protocols for minimizing exposure to smoke and other toxic agents. NFPA 1584 and NFPA 1850, *Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural and Proximity Firefighting and Open-Circuit Self-Contained Breathing Apparatus (SCBA)*, provide guidelines on medical monitoring during fireground operations to mitigate the effects of smoke and detail PPE cleaning procedures to reduce exposure to toxic residues. The National Institute for Occupational Safety and Health (NIOSH) also offers strategies to minimize firefighter exposure to toxic substances in smoke including the use of self-contained breathing apparatuses at all times when in hazardous environments, as well as enhanced ventilation practices during firefighting operations (NIOSH Publication Number 2002-109).

Emergency response protocols: Rapid access to defibrillators and emergency medical assistance on scene can be lifesaving in the event of a cardiac emergency. A variety of national standards ensure that fire departments train personnel in CPR and the use of automated external defibrillators (AEDs) to enhance emergency response and save lives. NFPA 1500, *Standard on Fire Department Occupational Safety, Health, and Wellness Program*, establishes the need for emergency care plans and preparedness for cardiac events on the fireground and mandates that fire departments establish and maintain a comprehensive safety and health program, including emergency medical response. It requires departments to ensure all personnel are trained in basic life support, including CPR and AED use. NIOSH Firefighter Fatality Investigation reports routinely recommend that AEDs be available on scene to reduce the likelihood of future fatalities. NFPA 1584 requires fireground rehab areas to include medical monitoring for firefighters, including checking vital signs like heart rate, blood pressure and oxygen levels.

Conclusion

CVD is the leading cause of on-duty firefighter fatalities, driven primarily by ASCVD and HHD (see USFA's Firefighter Fatality reports for 2018-2022). The intense physical and emotional demands of firefighting, coupled with high rates of modifiable risk factors such as hypertension, obesity and physical inactivity, elevate the risk of CVD significantly. The good news is that most cardiac events are preventable.

A more robust understanding of CVD processes, progression, diagnosis and risk factors can help fire service personnel engage in prevention activities. By understanding the mechanisms through which firefighting activities increase risk of a cardiovascular event, fire departments and policymakers can take targeted actions to protect the health and safety of firefighters. CVD has a complicated pathological process, and the ways in which it becomes relevant in an occupational setting are complex. Thus, programs to decrease CVD in the fire service must be multifaceted. To safeguard the health of firefighters and maintain operational readiness, the fire service must prioritize CVD prevention by:

- Ensuring comprehensive medical screenings to make early detection and treatment of CVD risk factors easily available.
- Embracing and advocating for fitness, nutrition, smoking cessation and sleep hygiene programs that foster development of cardiovascular health.
- Supporting comprehensive wellness programs that blend primary and secondary prevention strategies.
- Incorporating protocols that address heat stress management, smoke exposure reduction, and emergency response.

By investing in comprehensive strategies that address both clinical and behavioral risk factors, departments can not only save lives but also reduce financial strain, enhance job performance, and support long, healthy careers and retirements for those who serve.

Glossary

Arrhythmia (irregular heartbeat): A condition where the heart's rhythm is irregular, causing it to beat too fast, too slow or erratically. Arrhythmias may be benign, increase risk (e.g., A-fib) or be immediately life-threatening (ventricular fibrillation).

Atherosclerosis: Buildup of fatty plaques in arteries, reducing blood flow and increasing cardiovascular risk

Body mass index: A value calculated from an individual's weight and height, commonly used to categorize individuals as underweight, normal weight, overweight or obese

Cardiac arrest: Sudden loss of heart function due to electrical malfunction

Cardiomegaly: An enlargement of the myocardium (heart) and usually a sign of underlying medical conditions

Cardiovascular disease: A broad continuum of conditions of the heart and blood vessels, such as CAD, hypertension, heart failure and stroke

Cholesterol: A substance found in the blood and needed for building cells and producing hormones. High levels can contribute to the buildup of plaques in arteries (atherosclerosis).

Coronary artery calcium scan: A test that measures the amount of calcium in the walls of the coronary arteries

Coronary artery calcium score: Measure from a CAC scan of calcified plaque in coronary arteries, indicating cardiovascular risk

Coronary artery disease: Atherosclerotic plaque buildup in coronary arteries causing reduced blood flow and heart attacks

Diastolic function: The heart's ability to relax and fill with blood during the diastolic phase of the cardiac cycle

Dilated cardiomyopathy: A condition where the heart cannot pump blood effectively because the left ventricle, the main pumping chamber, is enlarged and weakened

Echocardiogram: A clinical testing procedure that uses ultrasound to create an image of the heart muscle and valves; can be used to evaluate heart structure and function

Ejection fraction: A percentage of blood ejected from the left ventricle (the heart's main pumping chamber) with each heartbeat

Fibrosis: The buildup of scar tissue in an organ or tissue, usually caused by injury, long-term inflammation or disease. This scarring can make the affected area stiff and may prevent it from working properly. It also increases the likelihood of an arrhythmia.

Heart failure: A chronic condition where the heart does not pump blood effectively, causing fluid buildup

High triglycerides: Triglycerides are a type of fat (lipid) found in the blood that serves as a key energy source for the body. High triglycerides can contribute to the buildup of fatty deposits in artery walls (atherosclerosis).

Hypercoagulable state: Increased blood clotting risk, leading to increased risk of heart attacks or strokes

Hypertension: Also known as high blood pressure; it is a condition where the force of blood against the walls of the arteries is consistently too high — causing damage to the blood vessels and leading to structural changes (thickening and enlargement) of the heart.

Hypertensive heart disease: Heart conditions resulting from prolonged high blood pressure, such as thickened or enlarged heart muscle

Ischemia: A condition in which there is insufficient blood flow to a part of the body, usually due to a partial or full blockage in blood vessels

Ischemic stroke: Stroke caused by blocked blood flow to the brain, leading to cell death

Structurally enlarged heart — left ventricular hypertrophy: Enlargement and thickening (hypertrophy) of the walls of the heart's main pumping chamber (left ventricle)

Myocardial infarction: Commonly known as a heart attack, it occurs when blood flow to a part of the heart is blocked, often by a blood clot formed over a ruptured atherosclerotic plaque. This blockage prevents oxygen from reaching the heart muscle, causing tissue damage or death if not treated promptly.

Plaque: The accumulation of fatty substances, cholesterol, cellular waste products, calcium and other materials that build up on the walls of arteries

Stenosis: The narrowing of a blood vessel

Sudden cardiac event: Acute, life-threatening events like heart attacks or cardiac arrest, often unexpected

Sudden cardiac death: An unexpected, acute fatality related to a cardiac condition; usually due to a heart attack or cardiac arrest (a heart attack may also lead to a cardiac arrest)

Systolic function: The heart's ability to contract and pump blood effectively from the ventricles into the arteries. It is commonly assessed by measuring the ejection fraction.

Thrombus: Another word for clot

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Acronyms

AED	automated external defibrillator
ASCVD	atherosclerotic CVD
BMI	body mass index
CAC	coronary artery calcium
CAD	coronary artery disease
CDC	Centers for Disease Control and Prevention
CHD	coronary heart disease
CRF	cardiorespiratory fitness
CVD	cardiovascular disease
ECG	electrocardiogram
HHD	hypertensive heart disease
LODD	line-of-duty death
LVH	left ventricular hypertrophy
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
ODPHP	Office of Disease Prevention and Health Promotion
PPE	personal protective equipment
USFA	U.S. Fire Administration
WFI	Wellness-Fitness Initiative

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