



Fire Fighter Suffers Fatal Heart Attack at Commercial Fire – New Jersey

Executive Summary

On June 8, 2014, a 54-year-old male volunteer firefighter (FF) responded to the scene of a commercial fire and performed interior fire suppression activities. The FF was part of an engine crew that advanced a charged 2.5-inch hoseline into the building. The FF served as the doorman to ensure the hoseline did not get caught on the door. After his second building entry, the FF exited the structure and then collapsed on the curb in the front of the building. On-scene emergency medical service (EMS) personnel immediately initiated cardiopulmonary resuscitation (CPR) and placed the FF in an on-scene ambulance for transport to the emergency department (ED). Despite resuscitation efforts on scene, during transport, and in the ED, the FF died. The death certificate and autopsy report, both completed by the Assistant Medical Examiner, listed the cause of death as "atherosclerotic cardiovascular disease," with physical exertion and smoke inhalation as contributory factors. The autopsy found severely blocked coronary arteries and evidence of an acute heart attack. Based on the FF's undiagnosed coronary heart disease (CHD), NIOSH investigators concluded that the physical exertion associated with fire suppression activities at this fire triggered the FF's heart attack and subsequent sudden cardiac death.

Key Recommendations

- *Provide preplacement and annual medical evaluations to all fire fighters in accordance with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments*
- *Ensure fire fighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582*
- *Phase in a mandatory comprehensive wellness and fitness program for fire fighters.*

The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In 1998, Congress appropriated funds to NIOSH to conduct a fire fighter initiative that resulted in the NIOSH Fire Fighter Fatality Investigation and Prevention Program, which examines line-of-duty deaths or on-duty deaths of fire fighters to assist fire departments, fire fighters, the fire service, and others to prevent similar fire fighter deaths in the future. The agency does not enforce compliance with state or federal occupational safety and health standards and does not determine fault or assign blame. Participation of fire departments and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency's reports do not name the victim, the fire department or those interviewed. The NIOSH report's summary of the conditions and circumstances surrounding the fatality is intended to provide context to the agency's recommendations and is not intended to be definitive for purposes of determining any claim or benefit.

For further information, visit the program website at www.cdc.gov/niosh/fire or call toll free 1-800-CDC-INFO (1-800-232-4636).



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Introduction

On June 8, 2014, a 54 year-old male volunteer FF suffered a fatal heart attack while operating at the scene of a commercial fire. NIOSH was notified of this fatality on June 10, 2014, by the U.S. Fire Administration. A contractor for the NIOSH Fire Fighter Fatality Investigation Team (the NIOSH investigator) contacted the fire department (FD) on March 26, 2015, to schedule the investigation, which took place on April 27, 2015.

During the investigation, the NIOSH investigator interviewed the following people:

- Chief of the FD
- Captain of the FD who was working with the FF
- EMS Chief who provided initial care

The NIOSH investigator reviewed the following documents in preparing this report:

- FD fire report
- FD standard operating guidelines
- FD dispatch records
- Police Department investigative report
- EMS (Ambulance) pre-hospital care report
- Hospital ED medical records
- Death certificate
- Medical examiner's (autopsy) report
- Medical records from preplacement medical screening

Investigation

On June 8, 2014, at 1756 hours the FD received an alarm for a structure fire in a commercial building. The structure was a single-story building (approximately 70 × 70 feet) with terracotta/concrete block foundation and walls. The flat roof was constructed of steel I-beams and steel column supports and covered with tin. The building housed a fabrication company that repaired hydraulic equipment and made custom metal fittings. The weather conditions were clear and sunny with an air temperature of approximately 70°Fahrenheit and relative humidity of 75% [Weather Channel 2015].

The first units arrived on scene at 1800 hours reporting heavy smoke conditions. Dispatch deployed three engines, a truck, a brush truck, chief car, and several support vehicles. Initial fire attack efforts were hampered because the fire was located in the back of the building and the rear door (steel) to the building was covered with a steel bar and there were no windows in the rear of the building from which to attack the fire.

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The FF was part of a four-person engine crew that was the third engine on scene arriving at 1805 hours. The FF and his crew were assigned to advance a 2.5-inch attack line into the building. Dressed in full personal protective equipment, the engine company made entry through the front door, but were inside for only about 5 minutes before exiting due to an inoperable thermal imaging camera.

The Chief of the FD arrived on scene at 1818 hours. After being briefed on ongoing operations including the difficulty gaining access to the back of the building, he assigned the FF's engine crew to reenter the front of the building and progress toward the rear of the building. After approximately 5 minutes, the FF and the entire engine crew were again forced to exit the building, this time due to rapidly deteriorating fire conditions and intense heat. The Chief checked on each engine crew member and then assigned the entire engine crew to rehabilitation (set up across the street). Nearly simultaneously, the Chief received a radio transmission that the roof was no longer safe for firefighting operations; he ordered all personnel to evacuate the building and activated the evacuation horn.

At approximately 1829 hours, with the Chief still standing in front of him, the FF sat down on the curb in front of the building and slumped onto his self-contained breathing apparatus (SCBA). Nearby fire fighters immediately rushed to the FF and carried him approximately 30 feet to the EMS personnel in the rehabilitation area. The FF was placed on a stretcher and his bunker gear was removed. He was quickly loaded into the ambulance which departed for the ED.

Initial assessment inside the ambulance revealed that the FF had no pulse, was not breathing, and was unresponsive. CPR was begun, an oral airway was secured with oxygen supplied by a non-rebreather bag. An external automated defibrillator was attached to the FF and three shocks were administered; the last shock at 1838 hours without a change in his heart rhythm or clinical condition.

The FF was admitted to the ED at 1842 hours in asystole and CPR in progress. The FF was intubated with an endotracheal tube, and a central line catheter was inserted. The FF was given cardiac medications through this central line, including epinephrine, atropine, sodium bicarbonate, and lidocaine, but he never regained a viable heart rhythm. Two attempts to defibrillate the FF were made at 1914 and 1916 hours without any change in his cardiac rhythm. At 1917 hours the FF was pronounced dead by the ED physician and resuscitation efforts were discontinued.

Medical Findings

The death certificate and autopsy, both completed by the Assistant Medical Examiner, listed the cause of death as "atherosclerotic cardiovascular disease" with physical exertion and smoke inhalation as contributory factors. Pertinent autopsy findings included "severely occlusive calcified atherosclerosis" in all three main coronary arteries, and evidence of an acute heart attack (myocardial infarction) based on segmental thrombosis of the left main coronary artery and appearance of the myocardium. The FF also had an enlarged heart (cardiomegaly), and left ventricular hypertrophy (LVH). His carboxyhemoglobin level was 7.2%, suggesting minor to moderate exposure to carbon monoxide during this incident. See Appendix A for more detailed autopsy information.

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The FF was 74 inches tall and weighed about 233 pounds, giving him a body mass index of 29.9 kilograms per meter squared [CDC 2015]. The FF had not received a medical evaluation from the FD and little is known about his medical history. According to his wife, the FF had no history of cardiovascular disease, did not see a physician regularly, and took no medications. He was a non-smoker. The FF worked as a driver for a shipping company, and reportedly had biannual medical evaluations to maintain his commercial driver's license. These records were not available to NIOSH at the time of this report.

Fire Department

The FD consists of 63 volunteers operating four stations serving approximately 6,500 people over 2 square miles. In 2014, the department responded to over 100 emergency calls.

Membership and Training

The FD requires new fire fighter applicants to be 18 years of age. Applicants must complete a form and be investigated by an "investigation committee" at the company level. If the investigation committee provides a positive recommendation, the potential member is presented to the entire company for a vote. If members vote to accept a potential member, a police department background check is performed. If the background check is acceptable, the potential member becomes a member and completes a state application form to be registered as a firefighter. Once registered with the State, the firefighter is enrolled in a County Fire Academy and required to complete a 192-hour state firefighter course (if he/she does not join the department with this credential).

Preplacement Medical Evaluation

The FD requires candidates to complete a respiratory medical evaluation questionnaire [29 CFR 1910.134]. If there are any positive responses, the candidate is referred to a Borough physician for evaluation. The FF joined this FD approximately 8 years earlier and completed the questionnaire at that time. In his responses, the FF answered no to all questions regarding cardiovascular or heart symptoms and the use of cardiovascular medications. Based on his responses, he did not receive a physician evaluation.

Periodic Medical Evaluations/Return to Work Medical Evaluations

The FD does not require annual medical evaluations for members. However the FD makes members aware of a state-wide program that provides free medical evaluations to all firefighters in New Jersey (Appendix 2). Firefighters who have had a serious injury or illness that requires hospitalization are required to be cleared for return to work by their primary care physician (PCP).

Fitness/Wellness Programs

The FD has no fitness equipment or program and offers no wellness program.

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Discussion

Sudden Cardiac Death

The most common risk factor for cardiac arrest and sudden cardiac death is CHD, defined as the build-up of atherosclerotic plaque in the coronary arteries [AHA 2012]. Risk factors for CHD include three non-modifiable factors (age older than 45, male gender, and family history of CHD) and six modifiable factors (smoking, hypertension, high blood cholesterol, obesity, physical inactivity, and diabetes mellitus) [National Cholesterol Education Program 2002; AHA 2015]. According to the FF's wife, the FF had no known cardiovascular health issues, did not have a PCP, and took no medications. On the FF's self-administered medical questionnaire completed when he joined the department in 2007, he had no symptoms of cardiovascular disease and was taking no medications.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2008]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion [Shah 1997]. Most heart attacks occur when a vulnerable plaque ruptures, causing a blood clot to form and occlude a coronary artery. This sudden blockage is primarily due to blood clots (thrombosis) forming on top of atherosclerotic plaques [Libby 2013].

Establishing a recent (acute) heart attack requires one or more of the following: characteristic electrocardiogram changes, elevated cardiac enzymes, or coronary artery thrombus. At autopsy, the FF had evidence of a thrombus in his left main coronary artery confirming an acute heart attack.

Cardiomegaly/Left Ventricular Hypertrophy

The autopsy revealed that the FF had cardiomegaly and LVH. Both conditions independently increase the risk for sudden cardiac death [Levy et al. 1990]. Hypertrophy of the left ventricle is relatively common among individuals with long-term hypertension, a heart valve problem, or chronic CHD and ischemia to the heart muscle [Siegel 1997]. The FF had severe CHD at autopsy.

Carbon Monoxide, Carboxyhemoglobin Levels, and Cardiac Effects.

Carbon monoxide (CO) is a component of fire smoke. When inhaled, CO crosses the alveolar (lung) membrane gaining access to the body's blood stream. In blood, the CO can dissolve in the serum and displace oxygen on the hemoglobin molecule forming carboxyhemoglobin (COHb). CO disrupts the delivery of, and the intercellular use of, oxygen leading to hypoxia (inadequate oxygen supply) [Alonso et al. 2003; Roderique et al. 2015]. The brain and the heart are the organs most vulnerable to hypoxia, thus, the symptoms and signs associated with CO poisoning include headache, dizziness, weakness, nausea, confusion, fast heart rate, and shortness of breath [Ernst and Zibrak 1998]. During this incident, the FF did not express any of these symptoms.

COHb levels in the blood are used to assess CO exposure and CO poisoning. COHb levels in non-smokers are typically 1-3%, while cigarette smokers have levels that range from 4-8% [Castelden and Cole 1975]. The FF had a COHb of 7.3%, suggesting some CO exposure during his response at this incident. While COHb levels of 6% can increase the frequency of ventricular arrhythmias among patients with ischemic heart disease [Sheps et al. 1990], it is unclear whether CO has an acute effect on

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plaque rupture (e.g., an acute heart attack) [Zevin et al. 2001]. In summary, the FF was exposed to carbon monoxide at some point during this incident causing an elevation of his COHb level. It is unclear what role, if any, this exposure had in triggering his heart attack and sudden cardiac death.

Physiological Stress of Firefighting

Firefighting is widely acknowledged to be physically demanding. Firefighting activities require fire fighters to work at near maximal heart rates for long periods. An increase in heart rate typically occurs in response to the initial alarm and persists throughout the course of fire suppression activities [Barnard and Duncan 1975; Lemon and Hermiston 1977; Manning and Griggs 1983; Smith et al. 2001]. Even when energy costs are moderate (as measured by oxygen consumption) and work is performed in a thermoneutral environment, heart rates may be high (over 170 beats per minute) owing to the insulating properties of the personal protective clothing [Smith et al. 1995]. Recent evidence also indicates the firefighting results in increased clotting potential which persists for 2 hours after firefighting activities [Smith et al. 2014].

Epidemiologic studies in the general population have found that heavy physical exertion can trigger a heart attack and/or sudden cardiac death [Tofler et al. 1992; Mittleman et al. 1993; Willich et al. 1993; Albert et al. 2000]. Epidemiologic studies among fire fighters have shown that fire suppression, training, alarm response, or strenuous physical activity on the job, in the preceding 12 hours, increases the risk for a sudden cardiac event [Kales et al. 2003; Hales et al. 2007; Kales et al. 2007].

In summary, the FF had been performing firefighting activity in full PPE at a commercial fire for about 24 minutes. NIOSH investigators conclude that the strenuous work associated with firefighting duties triggered the FF's fatal heart attack.

Occupational Medical Standards for Structural Fire Fighters

To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the National Fire Protection Association (NFPA) developed NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments [NFPA 2013]. This voluntary industry standard provides (1) the components of a preplacement and annual medical evaluation and (2) medical fitness for duty criteria. The FD only requires a self-administered medical questionnaire for candidate and does not require any medical evaluations for incumbents. If the FD had a comprehensive medical evaluation in place, perhaps the FF's cardiac condition could have been identified, evaluated, and treated prior to this incident.

Recommendations

Recommendation #1: Provide preplacement and annual medical evaluations to all firefighters in accordance with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

Discussion: Guidance regarding the content of these medical evaluations can be found in NFPA 1582 [NFPA 2013]. These evaluations are performed to determine fire fighters' medical ability to perform

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duties without presenting a significant risk to the safety and health of themselves or others. To ensure improved health and safety of candidates and members, and to ensure continuity of medical evaluations, it is recommended the FD comply with this recommendation, particularly the section addressing CHD. However, the FD is not legally required to follow the NFPA standard. Applying this recommendation involves economic repercussions and may be particularly difficult for smaller fire departments to implement.

To overcome the financial obstacle of medical evaluations, the FD could urge current members to get annual medical clearances from their private physicians or their employer. If the FD had a FD physician reviewing medical records from other employers (i.e., the FF's commercial driver's license exam), perhaps this FF's CHD could have been identified, evaluated, and treated.

Another option is having the annual medical evaluations (vital signs, height, weight, visual acuity, and electrocardiogram) completed by paramedics and emergency medical technicians from the local ambulance service. This information could then be provided to a community physician (perhaps volunteering his or her time), who could review the data and provide medical clearance (or further evaluation, if needed).

The more extensive portions of the medical evaluations could be performed by a private physician at the fire fighter's expense (personal or through insurance), provided by a physician volunteer, or paid for by the FD, city, or State. In the State of New Jersey a medical evaluation program titled "A Gift from Captain Buscio" was initiated by Captain's Buscio's widow. It provides free medical evaluations to New Jersey fire fighters (Appendix 2). Sharing the financial responsibility for these evaluations between fire fighters, the FD, the city, the State, and physician volunteers may reduce the negative financial impact on recruiting and retaining needed fire fighters.

Recommendation #2: Ensure fire fighters are cleared for duty by a physician knowledgeable about the physical demands of firefighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.

Discussion: According to NFPA 1582, the FD should have an officially designated physician who is responsible for guiding, directing, and advising the members with regard to their health, fitness, and suitability for duty [NFPA 2013]. The physician should review job descriptions and essential job tasks required for all FD positions to understand the physiological and psychological demands of firefighting and the environmental conditions under which fire fighters perform, as well as the personal protective equipment they must wear during various types of emergency operations. In addition, this physician should oversee all fitness for duty recommendations provided by PCPs and have the final authority for all medical fitness for duty decisions. To ensure the FD physician or other PCP is familiar with NFPA 1582, the NIOSH investigators recommend the FD provide a copy of NFPA 1582 or a link to the NFPA website where a copy could be purchased or viewed on-line at no charge.

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Recommendation #3: Phase in a mandatory comprehensive wellness and fitness program to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

Discussion: Guidance for fire department wellness/fitness programs to reduce risk factors for cardiovascular disease and improve cardiovascular capacity is found in NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters, the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, the National Volunteer Fire Council Health and Wellness Guide, and in Firefighter Fitness: A Health and Wellness Guide [USFA 2004; IAFF, IAFC 2008; NFPA 2008; Schneider 2010]. Worksite health promotion programs have been shown to be cost effective by increasing productivity, reducing absenteeism, and reducing the number of work-related injuries and lost work days [Stein et al. 2000; Aldana 2001]. Fire service health promotion programs have been shown to reduce CHD risk factors and improve fitness levels, with mandatory programs showing the most benefit [Dempsey et al. 2002; Womack et al. 2005; Blevins et al. 2006]. A study conducted by the Oregon Health and Science University reported a savings of more than \$1 million for each of four large fire departments implementing the IAFF/IAFC wellness/fitness program compared to four large fire departments not implementing a program. These savings were primarily due to a reduction of occupational injury/illness claims with additional savings expected from reduced future nonoccupational healthcare costs [Kuehl et al. 2013]. The department should implement a wellness and fitness program to help ensure that their members are physically prepared for the strenuous work of firefighting.

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Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio. Denise L. Smith, Ph.D, led the investigation and coauthored the report. Dr. Smith is professor of Health and Exercise Sciences, and Director of the First Responder Health and Safety Laboratory at Skidmore College. She is a

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member of the NFPA Technical Committee on Occupational Safety and Health. Dr. Smith was working as a contractor with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component during this investigation. Thomas Hales, MD, MPH, provided medical consultation and coauthored the report. Dr. Hales is a member of the NFPA Technical Committee on Occupational Safety and Health, and Vice Chair of the Public Safety Medicine Section of the American College of Occupational and Environmental Medicine (ACOEM).

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Appendix One

Autopsy Findings

- Heart size and structure
 - Heart weight = 560 grams (expected weight 403 grams; lower 95% confidence limit 305 grams and upper 95% confidence limit 531 grams for a male weighing 234 pounds [the FF weighed 233 pounds]) [Silver and Silver 2001]
 - Left ventricular hypertrophy noted
- Coronary arteries
 - Severely occlusive calcified trivascular atherosclerosis
 - Segmental thrombosis of left main stem confirming an acute myocardial infarction (MI)
 - Myocardium changes of the postero-lateral wall of left ventricle suggesting an acute MI
 - 80-90% lumen occlusion of all major arteries
- No evidence of valvular disease
- No evidence for a pulmonary embolus
- Mild atherosclerosis of aorta
- Negative drug screen
- Carboxyhemoglobin (COHb) = 7.2%, suggesting the FF was exposed to carbon monoxide during this incident [Castelden and Cole, 1975; Sheps et al. 1990].

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Appendix Two:

A brochure describing free medical evaluations for fire fighters from the State of New Jersey

A Message from Donna Buscio

Dear Friends,

My late husband Captain Dominick Buscio was a dedicated fire captain of the Jersey City Fire Department. Don was a wonderful husband, father, brother and son to his family, and a true friend to all who knew him. At the age of 39, his life was unexpectedly taken when he suffered a heart attack during our ski vacation. Don was the picture of health. In fact, the results of a complete physical he had only 19 months before his death were normal, except for the presence of a moderately high cholesterol level. Since he was found to be healthy at that time, he decided not to return for his annual physical the following year. While many people his age make the decision not to seek regular checkups, in his case, it resulted in an inconceivable loss to all of us.

I am sharing our experience with others because I have found that my husband's death was not a rarity. Heart attacks are the largest single killer of firefighters. For that very reason, I created the program "A Gift from Captain Buscio," which began in Jersey City and now spans across the State of New Jersey to offer strictly confidential, comprehensive medical evaluations with no out-of-pocket cost to all firefighters and officers. These annual examinations are provided by the medical director, Manmohan Patel, M.D., and other board-certified cardiologists and pulmonologists who have generously offered firefighters medical care that is specific to their profession.

My intention is not to instill anxiety. On the contrary, it's to provide an opportunity for peace of mind. I'm quite certain that this program would have had Don's full support, given the current limited opportunities for firefighters to obtain physicals.

For me, this program, which was founded in Don's memory, is an attempt to keep your occupational risk limited to fighting fires.

This brochure provides you with details on the program and how you may benefit from it. If you have any questions or concerns regarding information other than the Web site, please contact me at dbuscio@aol.com.

Sincerely,

 Donna Buscio

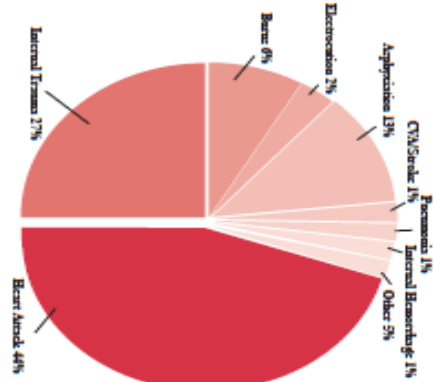
Statistics Tell the Story

When it comes to the relationship between firefighters and heart attacks, the statistics speak for themselves:

- Despite fluctuations, the trend in the proportion of firefighter fatalities from heart attacks has remained constant since 1984.
- More than one-half of all fatal heart attacks strike firefighters while on the scene of a fire or non-fire emergency.

Firefighter victims may not have had a previous medical history of heart disease. For this reason getting a comprehensive medical evaluation that is specific to your profession is not just for peace of mind. It is absolutely necessary.

Fatalities by nature of Fatal Injury (2002)



Injury Type	Percentage
Heart Attack	49%
Inertial Trauma	27%
Other	5%
Cardiac Arrest	1%
Other Burn	1%
Asphyxiation	1%
Electrocution	1%
Burn	6%

For additional details on this statistical data, visit the United States Fire Administration at the Federal Emergency Management Agency's Web site, www.usfa.fema.gov.

How 'A Gift from Captain Buscio' Works

All fire departments whose firefighters and officers are participating in the program throughout the State of New Jersey have the opportunity to receive confidential comprehensive medical evaluations with no out-of-pocket expense. These annual examinations are provided by the medical director Manmohan Patel, M.D., and other board-certified cardiologists and pulmonologists who have generously offered firefighters medical care that is specific to their profession.

Board certified in internal medicine, pulmonary medicine, critical care, emergency medicine and geriatric medicine, Dr. Patel is also a member of the New Jersey Board of Medical Examiners. He offers 20 years of experience working in these disciplines and has provided this annual service in the past, with great success, to railroad workers of New Jersey, and currently to the Jersey City Fire Department.

This comprehensive examination may also include any other testing deemed necessary, including pulmonary function testing, stress testing and laboratory work. Upon completion of the physical, each firefighter/officer will be provided with a full medical report to present to his or her family physician.

All visits will be scheduled by appointment, and the medical staff will direct you on what will be needed for the initial visit, such as bringing a listing of all medications that you currently may be taking. In addition, fasting the previous night is required for blood work, which is part of the evaluation.

To schedule an appointment call 201-216-3055.