



Death in the line of duty...

NIOSH
Fire Fighter Fatality Investigation
and Prevention Program

A summary of a NIOSH fire fighter fatality investigation

August, 2014

Fire Fighter Suffers Sudden Cardiac Death While Working at a Grass Fire – Mississippi

Executive Summary

On February 1, 2014, a 57-year-old male volunteer fire fighter (“FF”) spotted a grass fire threatening a local residence and nearby barn. After notifying dispatch, he assisted the local fire department in extinguishing the fire. He pulled a 1½-inch hoseline to the fire in two locations and to the top of the engine’s hosebed. While atop the engine hosebed, the FF was found unresponsive and not breathing (1341 hours). The incident commander of the responding fire department notified dispatch, then began cardiopulmonary resuscitation (CPR). The FF was placed into the bed of a pickup truck and driven to the ambulance station with CPR administered en route. Upon arrival, the ambulance paramedics began advanced life support including cardiac monitoring with defibrillations, intravenous cardiac resuscitation medications, and intubation. The ambulance transported the FF to the hospital’s emergency department (ED) where advanced life support continued an additional 12 minutes without a change in the FF’s clinical status. At 1424 hours the attending physician pronounced the FF dead, and resuscitation efforts were discontinued.

The death certificate, completed by the county coroner, listed “sudden cardiac death due to stress/overexertion at fire scene due to intentionally set fire due to hypertensive heart disease” as the cause of death. No autopsy was performed. Blood tests for carboxyhemoglobin were negative, suggesting the FF had minimal

exposure to the carbon monoxide in fire smoke. National Institute for Occupational Safety and Health (NIOSH) investigators concluded that assisting with fire suppression activities probably triggered either a heart attack or a cardiac arrhythmia resulting in sudden cardiac death.

NIOSH investigators offer the following recommendations to reduce the risk of heart attacks and sudden cardiac arrest among fire fighters at this and other fire departments.

Provide preplacement and annual medical evaluations to all fire fighters in accordance with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, to identify fire fighters at increased risk for coronary heart disease (CHD).

Ensure exercise stress tests are performed on fire fighters at increased risk for CHD.

Ensure that fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the components of NFPA 1582.

Phase in a mandatory comprehensive wellness and fitness program for fire fighters.

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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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Perform a candidate and member physical ability evaluation.

Provide fire fighters with medical clearance to wear a self-contained breathing apparatus (SCBA) as part of the fire department's medical evaluation program.

Conduct annual respirator fit testing.

Perform an autopsy on all on-duty fire fighter fatalities.

Introduction & Methods

On February 1, 2014, a 57-year-old male volunteer fire fighter suffered sudden cardiac death while working at a grass fire. NIOSH was notified of the fatality by the U.S. Fire Administration on February 4, 2014. NIOSH contacted the affected fire department on February 4, 2014, to gather additional information and on May 6, 2014, to initiate the investigation. On May 12, 2014, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Prevention and Investigation Program traveled to Mississippi to investigate the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Incident commander of the responding fire department
- Fire chief of the FF's fire department
- County emergency management director

NIOSH personnel reviewed the following documents:

- Fire department standard operating procedures
- Witness statements
- Sheriff's report
- Fire department annual report for 2013
- Primary care physician records
- Emergency medical service (ambulance) report
- Hospital ED report
- Death certificate

Investigative Results

Incident. At noon on February 1, 2014, the FF left his home to run errands. While driving he noticed a grass fire threatening a local residence and a nearby barn. He notified dispatch, which alerted the local fire department and requested mutual aid from a neighboring fire department where the FF was a member (1249 hours).

By the time the first fire engine arrived (1252 hours), the fire had grown to about 11.5 acres. The FF assisted the engine crew by spraying water for about 20 minutes using a 1½-inch hoseline. The crew disconnected the hoselines as the FF loaded the hoses atop the engine. The engine, crew, and FF then drove to a barn at risk of catching on fire. After extinguishing the grass fire in this area, the FF climbed atop the engine and assisted in loading the hoselines (about 1320 hours).

The engine crew then drove to another nearby location and began to stretch the hoselines but was told to relocate to another area. Again, the FF climbed atop the engine to reload the hose. After a few minutes, the incident commander noticed the hose was not being pulled. He climbed atop the engine to check on the FF and found him unresponsive and not breathing (1341 hours). The incident commander notified dispatch to request an ambulance (1342 hours). The incident commander also alerted the FF's chief, who was also a paramedic, as he began CPR. With the help of the FF's chief, the FF was moved into the bed of a pickup truck and driven to the ambulance station.

At 1352 hours, the pickup truck arrived at the ambulance station, and paramedics found the FF in cardiac arrest with CPR being performed. The FF was placed onto a long spine board, secured to

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a stretcher, and placed into the ambulance, which departed the scene en route to the ED. Advanced life support began; an intravenous line was placed, cardiac monitoring revealed ventricular fibrillation (a heart rhythm incompatible with life), and two shocks were administered. His heart rhythm reverted to asystole (no heart beat). Cardiac resuscitation medications were administered while the FF was intubated with tube placement verified by capnography [Neumar et al. 2010].

The ambulance arrived at the ED at 1412 hours. Inside the ED, CPR and advanced life support efforts continued for an additional 12 minutes including two additional shocks. At 1424 hours, the FF was pronounced dead by the attending physician, and resuscitation efforts were stopped.

Medical Findings. The death certificate, completed by the county coroner, listed “sudden cardiac death due to stress/overexertion at fire scene due to intentionally set fire due to hypertensive heart disease” as the cause of death. No autopsy was performed. Blood tests for carboxyhemoglobin were negative, suggesting the FF had minimal exposure to the carbon monoxide in fire smoke.

The FF’s risk factors for CHD included: age older than 45, male gender, and high blood pressure. In 1990, the FF was diagnosed with high blood pressure and was treated with beta-blocker medications, exercise, and a weight-loss diet. His most recent blood pressure was 133/83 millimeters of mercury (December 2013). The FF was 69 inches tall and weighed 198 pounds, giving him a body mass index of 29.2 kilograms per meters squared [CDC 2014]. Prior to this incident the FF never complained of chest pain.

Description of the Fire Department

At the time of the NIOSH investigation, the fire department consisted of one fire station with 10 volunteer uniformed personnel. The fire department served 1,000 residents in a geographic area of 100 square miles. In 2013, the fire department responded to 21 fire/rescue calls.

Membership and Training. The fire department requires volunteer fire fighter applicants to be 18 years of age, have a valid state driver’s license, pass a background check, and pass a membership vote. The member is on probation for 6 months prior to becoming a full member. The fire department sponsors two state fire schools to train fire fighters. The FF was trained as a first responder, in various fire fighting skills, and in the incident command system. He had 5 years of fire fighting experience.

Preplacement and Annual Medical Evaluations. Preplacement and annual medical evaluations are not required by the fire department. The fire department does not have a requirement for return to duty medical clearance for members injured on duty, medical clearance to wear a respirator, or an annual self-contained breathing apparatus facepiece fit test.

Health and Wellness Programs. The fire department does not have a wellness/fitness program, and exercise equipment is not available in the fire station. An annual job performance physical ability test is not required for members. The FF did not participate in physical fitness activities.

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Discussion

Atherosclerotic CHD. In the United States, atherosclerotic CHD is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2008]. Risk factors for its development include age older than 45, male gender, family history of coronary artery disease and five modifiable risk factors: smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes [NHLBI 2012; AHA 2014]. The FF had two modifiable CHD risk factors: high blood pressure and physical inactivity.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2013]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion. Heart attacks (myocardial infarctions) typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply. 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 any of the following: characteristic electrocardiogram (EKG) changes, elevated cardiac enzymes, or coronary artery thrombus. In this case, the FF did not have a heart rhythm to obtain an EKG, cardiac enzymes were not tested because of his rapid demise (< 1 hour), and no autopsy was performed to find a coronary artery thrombus. Thus, while it is possible the FF suffered a heart attack, this diagnosis is less likely because the FF did not report angina at the fire scene [Davies 1992; Farb et al. 1995]. The FF's sudden cardiac death may have been caused by

primary cardiac arrhythmia, possibly related to his history of hypertension.

Occupational Trigger. Heavy physical exertion has been linked to heart attacks and sudden cardiac death [Willich et al. 1993; Albert et al. 2000]. Among fire fighters, sudden cardiac events have been associated with alarm response, fire suppression, and heavy exertion during training (including physical fitness training) [Kales et al. 2003; Kales et al. 2007; NIOSH 2007]. The FF's activities at the fire scene would have expended about 8 metabolic equivalents, which is considered moderate physical activity [Gledhill and Jamnik 1992; Ainsworth et al. 2011].

In summary, NIOSH investigators conclude the FF's sudden cardiac death was probably due to a heart attack or an arrhythmia, possibly triggered by the physical exertion associated with fire ground activities.

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 2013a]. This voluntary industry standard provides the components of a preplacement and annual medical evaluation and medical fitness for duty criteria. The FF's risk for CHD was not identified until this incident. On the basis of the FF's age and history of high blood pressure, the NFPA and the American College of Cardiology/American Heart Association (ACC/AHA) would have recommended a symptom limiting exercise stress test (EST) to screen for CHD. However,

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recommendations for ESTs on asymptomatic individuals without known heart disease are varied. The following paragraphs summarize the positions of widely recognized organizations on this topic.

NFPA 1582, a voluntary industry standard, recommends an EST performed “as clinically indicated by history or symptoms” and refers the reader to Appendix A [NFPA 2013a]. Items in Appendix A are not standard requirements, but are provided for “informational purposes only.” Appendix A recommends using submaximal (85% of predicted heart rate) EST as a screening tool to evaluate a fire fighter’s aerobic capacity. Maximal (i.e., symptom-limiting) EST with imaging should be used for fire fighters with the following conditions:

- abnormal screening submaximal tests
- cardiac symptoms
- known coronary artery disease (CAD)
- one or more risk factors for CAD (in men older than 45 and women older than 55)

Risk factors are defined as hypercholesterolemia (total cholesterol greater than 240 milligrams per deciliter), hypertension (diastolic blood pressure greater than 90 mm of mercury), smoking, diabetes mellitus, or family history of premature CAD (heart attack or sudden cardiac death in a first-degree relative less than 60 years old).

The ACC/AHA has also published exercise testing guidelines [Gibbons et al. 2002]. The ACC/AHA guideline states that the evidence to conduct stress tests in asymptomatic individuals is “less well established” (Class IIb) for the following groups:

- persons with multiple risk factors (defined similarly to those listed by the NFPA)

- asymptomatic men older than 45 years and women older than 55 years:
 - who are sedentary and plan to start vigorous exercise
 - who are involved in occupations in which impairment might jeopardize public safety (e.g., fire fighters)
 - who are at high risk for coronary artery disease due to other diseases (e.g., peripheral vascular disease and chronic renal failure)

The U.S. Department of Transportation provides guidance for those seeking medical certification for a commercial driver’s license. An expert medical panel recommended exercise tolerance tests (stress tests) for asymptomatic “high risk” drivers [Blumenthal et al. 2007]. The panel defines high risk drivers as those with any of the following:

- diabetes mellitus
- peripheral vascular disease
- age 45 and above with multiple risk factors for coronary heart disease
- Framingham risk score predicting a 20% coronary heart disease event risk over the next 10 years. The FF’s Framingham risk score was 10%.

The U.S. Preventive Services Task Force does not recommend stress tests for asymptomatic individuals at low risk for coronary heart disease events. For individuals at increased risk for coronary heart disease events, the Task Force found “insufficient evidence to recommend for or against routine screening with EKG, exercise tolerance test, or electron beam computerized tomography scanning....” Rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking,

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and diabetes) [USPSTF 2004]. The Task Force does note that “For people in certain occupations, such as pilots, and heavy equipment operators (for whom sudden incapacitation or sudden death may endanger the safety of others), consideration other than the health benefit to the individual patient may influence the decision to screen for coronary heart disease.”

Had an EST been performed as recommended by NFPA and AHA/ACC, perhaps the FF’s CHD could have been identified, leading to further evaluation and treatment.

Recommendations

NIOSH investigators offer the following recommendations to reduce the risk of heart attacks and sudden cardiac arrest among fire fighters at this and other fire departments.

Recommendation #1: Provide preplacement and annual medical evaluations to all fire fighters in accordance with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, to identify fire fighters at increased risk for coronary heart disease (CHD).

Guidance regarding the content and frequency of these medical evaluations can be found in NFPA 1582 and in the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC) Fire Service Joint Labor Management Wellness/Fitness Initiative [IAFF, IAFC 2008; NFPA 2013a]. These evaluations are performed to determine fire fighters’ medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. Following this recommendation will require significant resources and may be particularly difficult for smaller

fire departments to implement. The fire department is not legally required to follow the NFPA standard or the IAFF/IAFC guideline.

To overcome the financial obstacle of medical evaluations, the fire department could urge current members to get annual medical clearances from their private physicians. Another option is having the annual medical evaluations completed by paramedics and emergency medical technicians from the local ambulance service (vital signs, height, weight, visual acuity, and EKG). 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 (e.g., EST) 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 fire department, city, or state. Sharing the financial responsibility for these evaluations between fire fighters, the fire department, the city, the state, and physician volunteers may reduce the negative financial impact on recruiting and retaining needed fire fighters.

Recommendation #2: Ensure exercise stress tests are performed on fire fighters at increased risk for CHD.

NFPA 1582, the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, and the ACC/AHA recommend an exercise stress test for male fire fighters older than 45 with one or more coronary artery disease risk factors [IAFF, IAFC 2008; Gibbons et al. 2002; NFPA 2013a]. The FF was over the age of 45 and had persistent high blood pressure. A symptom-limiting EST

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Recommendations (cont.)

may have identified his CHD, possibly leading to further evaluation and treatment.

Recommendation #3: Ensure that fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the components of NFPA 1582.

Guidance regarding medical evaluations and examinations for structural fire fighters can be found in NFPA 1582 and in the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative [IAFF, IAFC 2008; NFPA 2013a]. According to these guidelines, the fire department 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. The physician should review job descriptions and essential job tasks required for all fire department positions and ranks to understand the physiological and psychological demands of fire fighters and the environmental conditions under which they must perform, as well as the personal protective equipment they must wear during various types of emergency operations. It is unclear if this FF's personal physician was aware of NFPA 1582.

Recommendation #4: Phase in a mandatory comprehensive wellness and fitness program for fire fighters.

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 [IAFF, IAFC 2008; NFPA 2008; USFA 2009; 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 [Pelletier 2009; Baicker et al. 2010]. Fire service health promotion programs have been shown to reduce CAD 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; Poston et al. 2013]. 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 2013]. The fire department currently does not have a wellness/fitness program, and exercise equipment is not available in the fire station. Given the fire department's structure, the National Volunteer Fire Council program would be applicable [USFA 2009], but NIOSH recommends a formal, mandatory wellness/fitness program to ensure all members receive the benefits of a health promotion program.

Recommendation #5: Perform a candidate and member physical ability evaluation.

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires the

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fire department to develop physical performance requirements for candidates and members who engage in emergency operations [NFPA 2013b]. Members who engage in emergency operations must be annually qualified (physical ability test) as meeting these physical performance standards for structural fire fighters [NFPA 2013b]. This could be incorporated into the annual task-level training program.

Recommendation #6: Provide fire fighters with medical clearance to wear SCBA as part of the fire department's medical evaluation program.

The Occupational Safety and Health Administration (OSHA) Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection [29 CFR 1910.134]. These clearance evaluations are required for private industry employees and public employees in states operating OSHA-approved state plans. Mississippi does not operate an OSHA-approved state plan; therefore the fire department is not required to ensure all members have been medically cleared to wear an SCBA [OSHA 2013]. However, we recommend voluntary compliance with this recommendation to improve fire fighter health and safety.

Recommendation #7: Conduct annual respirator fit testing.

The OSHA respiratory protection standard requires employers whose employees are required to use a respirator (e.g., an SCBA) to have a formal respiratory protection program, including annual fit testing [29 CFR 1910.134]. Therefore, each member should have their own SCBA facepiece or the fire department would have to ensure enough

facepieces of each size were made available on each fire apparatus. As mentioned previously, Mississippi does not operate an OSHA-approved state plan; therefore, the fire department is not required to follow OSHA standards [OSHA 2013]. Nevertheless, NIOSH investigators recommend voluntary compliance with this standard to ensure proper fitting personal protective equipment.

Recommendation #8: Perform an autopsy on all on-duty fire fighter fatalities.

In 2008, the USFA published the Firefighter Autopsy Protocol [USFA 2008]. With this publication, the USFA hopes to provide “a more thorough documentation of the causes of firefighter deaths for three purposes:

1. to advance the analysis of the causes of firefighter deaths to aid in the development of improved firefighter health and safety equipment, procedures, and standards;
2. to help determine eligibility for death benefits under the Federal government’s Public Safety Officer Benefits Program, as well as state and local programs; and
3. to address an increasing interest in the study of deaths that could be related to occupational illnesses among firefighters, both active and retired.”

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Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component in Cincinnati, Ohio. Mr. Tommy Baldwin (MS) led the investigation and co-authored the report. Mr. Baldwin is a Safety and Occupational Health Specialist, a National Association of Fire Investigators (NAFI) Certified Fire and Explosion Investigator, an International Fire Service Accreditation Congress (IFSAC) Certified Fire Officer I, and a former Fire Chief and Emergency Medical Technician. Dr. Thomas Hales (MD, MPH) provided medical consultation and co-authored 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).