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NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation October 1, 2001

Fire Fighter Dies After Assisting an Injured Person – Ohio

SUMMARY

On February 19, 2000, a 55-year-old male "paid/call" Fire Fighter was assisting ambulance crew members in preparing an injured person for ambulance transport. After leaving the scene, the Fire Fighter drove approximately 1 mile to his home. As he entered his driveway, he had an unwitnessed collapse. Approximately 40 minutes later, despite cardiopulmonary resuscitation (CPR) and advanced cardiac life support (ACLS) administered on the scene and at the hospital, the victim died. The autopsy revealed severe coronary artery disease (CAD) and a recent thrombus (blood clot). The death certificate listed "severe occlusive coronary artery disease" as the immediate cause of death.

The following recommendations address some general health and safety issues. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These selected recommendations have not been evaluated by NIOSH but represent published research or consensus votes of technical committees of the National Fire Protection Association (NFPA) or labor/management groups within the fire service.

- ***Provide mandatory annual medical evaluations to ALL fire fighters to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.***
- ***Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***
- ***Provide fire fighters with medical evaluations and clearance to wear self contained breathing apparatus (SCBA).***
- ***Ensure public safety telecommunicators (dispatchers) are properly trained to provide all necessary information to emergency response agencies.***

INTRODUCTION AND METHODS

On February 19, 2000, a 55-year-old male Fire Fighter lost consciousness after assisting with an EMS call and then driving home. Despite CPR and ACLS administered by fire fighters, the ambulance crew, and in the emergency department, the victim died. NIOSH was notified of this fatality on February 22, 2000, by the United States Fire Administration. On March 8, 2001, NIOSH contacted the affected Fire Department to initiate the investigation. On April 10, 2001, a Safety and Occupational Health Specialist and a Visiting Scientist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Ohio to conduct an on-site investigation of the incident.

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at

www.cdc.gov/niosh/firehome.html

or call toll free **1-800-35-NIOSH**

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During the investigation NIOSH personnel interviewed the following

- Fire Chief
- Crew members on duty with the victim
- Responding ambulance service personnel
- Victim's wife

During the site visit NIOSH personnel reviewed

- Fire Department policies and operating guidelines
- Fire Department training records
- Fire Department annual report for 1999
- Emergency medical service (ambulance) incident report
- Fire Department physical examination protocols
- Death certificate
- Autopsy record
- Past medical records of the deceased

INVESTIGATIVE RESULTS

Incident. On February 19, 2000, at 1615 hours, the involved Fire Department was dispatched for a person injured in a sledding accident. Ambulance 211 (three Emergency Medical Technicians) responded and arrived on the scene at 1619 hours. The sledder was in a field at the bottom of a hill, approximately 75 yards away from where the ambulance could park. The temperature was approximately 30° Fahrenheit, wind speed was 6 miles per hour, and there was approximately 8" of snow on the ground at that time. After surveying the scene and determining that additional help was needed, a general alarm was requested. Engine 221 and three additional fire fighters, including the victim, responded in privately owned vehicles and arrived on the scene at 1621 hours. The victim, a paid/call fire fighter, drove his four-wheel-drive pickup from his home to the scene. Once on the scene, the victim, wearing insulated coveralls, helped carry rescue equipment (Stokes basket, backboard, and patient restraint devices) to the bottom of the hill. The victim walked back up the hill to drive his pickup to the bottom of the hill, where he assisted in preparing the injured sledder for ambulance transport. After loading the injured sledder, who weighed approximately 185 lbs, onto the bed of his pickup, he drove up the hill to the awaiting ambulance. The ambulance departed for the hospital at 1638 hours, and the remaining crew members at the scene departed.

The victim drove home, approximately 1 mile away. As the victim entered his driveway, he collapsed onto the seat of his truck. His pickup truck kept moving forward until it struck a 500-gallon propane tank. His wife heard the crash and came outside to see what was wrong, but could not enter the pickup truck due to the truck door's automatic door locks. Her daughter called 911 and advised the 911 dispatcher that her father had passed out behind the wheel of his pickup truck, that they could not gain access to him because the truck doors were locked, and that the truck had struck the propane tank behind their house. Ambulance 211, which had just delivered the injured sledder to the hospital, and Engine 221 were dispatched (1647 hours) for a vehicle striking a propane tank.

Units arrived on the scene at 1652 hours and found that the truck had severed the propane gas line (which connects the tank to the house) and that the truck's engine was still running. The truck tires were smoking heavily because the victim's foot was still on the accelerator pedal. Crew members broke the window from the passenger door to access the victim and turned off the ignition. Finding the victim unresponsive, the crew members removed him from his truck and placed him onto a backboard and cot. Initial assessment found the victim to be unresponsive, pulseless, not breathing, and cyanotic. He was intubated and loaded into the ambulance, where his coveralls and shirt were removed and CPR (chest compressions and bag-valve mask ventilations) was begun. A semi-automatic external defibrillator

(SAED) attached to the victim revealed "shock not indicated." The ambulance departed the scene at 1700 hours. CPR was continued throughout the trip to the hospital. The ambulance arrived at the hospital's emergency department (ED) at 1701 hours. Advanced cardiac life support (ACLS) protocols were provided in the ED for 24 minutes, until the victim was pronounced dead at 1725 hours.

Medical Findings. The death certificate, completed by the County Coroner, listed "severe occlusive coronary artery disease" as the immediate cause of death. The carboxyhemoglobin level was 0.9%, suggesting that the fire fighter was not exposed to excessive concentrations of carbon monoxide (CO), even taking into account that he was treated with 100% oxygen during resuscitation efforts. Pertinent findings from the autopsy, performed by the County Coroner, on February 20, 2000, included

- Severe occlusive coronary artery disease with calcification
  - 70-80% narrowing of the left anterior descending coronary artery
  - 70-80% narrowing of the right coronary artery
  - Recent thrombus right coronary artery
- Left ventricular hypertrophy
- Pulmonary congestion and edema
- Congestion of viscera

The Fire Fighter had the following risk factors for coronary artery disease (CAD): family history of CAD, advancing age (greater than 45 years old), male gender, hypertension (approximately 160/94), hypercholesterolemia (269 mg/dl), obesity, and lack of physical activity. The victim was prescribed one cholesterol-lowering medication and aspirin and took the medications regularly. (His most recent serum cholesterol level was 216 mg/dl). In 1989 the victim had an EST which showed good aerobic capacity, good exercise tolerance, good blood pressure (BP) response to exercise, and no evidence of exercise-induced arrhythmias or ischemia. The most recent measurement of height and weight, in 1998, revealed a height of 6' 6" and a weight of 233 lbs. During the victim's most recent periodic physical examination, in January 1999, a resting electrocardiogram (ECG) revealed no abnormalities. He was still being treated for hypercholesterolemia.

According to his spouse, the victim's only recent illness began 1 month prior to his death. He reported flu-like symptoms (generally felt badly), had stumbled some, and had fallen once outside his house and once at work due to dizziness. This was probably not related to a heart attack since the autopsy did not show signs of an old myocardial infarction (e.g., scarring). The day of the incident, the victim worked around his house and did not report any symptoms suggestive of angina or heart attack to his spouse or anyone else.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the combination Fire Department consisted of 37 uniformed personnel (20 career and 17 paid/call volunteers) and served a population of 30,000 residents in three townships, a geographic area of 92 square miles for emergency medical response and 32 square miles for fire response. There is one fire station.

In 1999, the Department responded to 1653 calls: 1276 rescue calls in which 1367 victims were treated, and 377 fire calls. The day of the incident, the victim worked around his house until the incident response, his first emergency response that day.

Training. The Fire Department requires all new career fire fighter applicants to pass an agility test, a civil service test (ranked by score), background check, and an interview prior to being recommended to the City Manager for becoming a member. Newly hired career fire fighters must then complete

orientation training, a preplacement physical examination, including an exercise stress test (EST) if over age 40, and a psychological test. The fire fighter is then sent to the Ohio Fire Academy for the 240-hour course to become certified as Fire Fighter I and II and Hazardous Materials (Hazmat) Operations level. Within the first year of being hired, the fire fighter is sent back to the Fire Academy for the 4-week emergency medical technician (EMT)-basic course and the 1-week Engineer's course. The 70-hour EMT-Intermediate course and the EMT-Paramedic course are optional. The Fire Department provides hazardous materials training to the Technician level.

Paid/call (auxiliary) fire fighter applicants must pass an interview, a background check, and a pre-employment physical examination (including an EST) prior to being selected for membership.

All members must complete 4 hours of training monthly and 12 hours of live fire training annually. Career members train daily on their shift. Training is provided in-house and at other local fire departments. The State minimum requirement for fire fighter certification is the 36-hour Fire Fighter 1A and the 40-hour First Responder course. The State requires 12 hours of continuing education annually for re-certification. The victim was certified as a Fire Fighter, EMT, and to perform Hazmat Operations. He had 24 years of fire fighting experience. His full-time job was a heavy equipment operator for a construction company.

Preemployment/Preplacement Evaluations. The Department requires a preemployment/preplacement medical evaluation for all new hires (career and paid/call), regardless of age. The evaluation for career and paid/call is the same. Components of this evaluation include the following:

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Blood tests: Chemical profile, complete blood count with differential (CBC), and lipid panel
- Resting ECG
- Exercise stress test (EST) (performed on all fire fighters over age 40)
- Pulmonary function test (PFT)
- Audiogram
- Vision screen
- Chest X-ray
- Urinalysis
- Tuberculosis skin test
- Protein specific antigen (PSA) (for fire fighters over age 40 and/or high risk)
- Fecal occult blood test
- Tetanus booster (if tetanus immunization is not current)
- Flexible Sigmoidoscopy (for fire fighters over age 50)
- Agility test

A digital body fat analysis may also be performed at the discretion of the physician. These evaluations are performed by a contract physician hired by the City. Once this evaluation is complete, the physician makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the City's personnel director.

Periodic Evaluations. Periodic medical evaluations are offered by this Department to all career fire fighters every 2 years. The content and frequency of this evaluation is the same as the preemployment evaluation and physical examination. Paid/call volunteer fire fighters are not given the option to participate in the periodic physical evaluations nor are paid/call fire fighters required to have biannual medical clearance.

If an employee is injured at work, or is ill and off work for 2 days or more, the employee is evaluated and must be cleared for "return to work" by the contract physician. Exercise (strength and aerobic) equipment is provided by the Department. Voluntary

fitness/wellness programs are in place for the Department.

The victim was last cleared for return to work by his private physician in 1999.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.[1] Risk factors for its development include age over 45, male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity, physical inactivity, and diabetes.[2,3] The victim had seven of these risk factors (age over 45, male gender, family history of CAD, high blood pressure, high blood cholesterol, obesity, and physical inactivity).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.[4] However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.[5] Heart attacks typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply.[6] This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques. A recent thrombus in the victim's right coronary artery noted during the autopsy was consistent with a heart attack (myocardial infarction).

Blood clots, or thrombus formation, in coronary arteries are initiated by disruption of atherosclerotic plaques. Certain characteristics of the plaques (size, composition of the cap and core, presence of a local inflammatory process) predispose the plaque to disruption.[6] Disruption then occurs from biomechanical and hemodynamic forces, such as increased blood pressure, increased heart rate, increased catecholamines, and shear forces, which occur during heavy exercise.[7,8]

Fire fighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.[9] Fire fighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. The increase in heart rate has been shown to begin with responding to the initial alarm and persist through the course of fire suppression activities.[10-12] 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 insulative properties of the personal protective clothing.[13] Furthermore, fire fighting can result in severe fluid loss which decreases blood volume and decreases the amount of blood pumped from the heart (stroke volume).[14] Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.[15-18] The victim, wearing thick coveralls, had carried EMS equipment down the hill in 8-inch-deep snow, walked back up the hill, then assisted in lifting the sledding victim onto his pickup truck bed. This is considered a moderate-to-heavy level of physical exertion.[19]

NFPA 1582 recommends a yearly physical evaluation to include a medical history, height, weight, blood pressure, and visual acuity test.[20] NFPA 1582 also recommends a thorough examination to include vision testing, audiometry, pulmonary function testing, a complete blood count, urinalysis, and biochemical (blood) test battery be conducted on a periodic basis according to the age of the fire fighter (less than 30: every 3 years; 30-39: every 2 years; over 40 years: every year). The Department requires a preemployment/preplacement medical examination for all new hires but does not require periodic medical evaluations for all fire fighters. Periodic

medical evaluations are offered only to career fire fighters and are offered every 2 years.

To reduce the risk of heart attacks and sudden cardiac arrest among fire fighters, the National Fire Protection Association (NFPA) has developed guidelines entitled "Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians," otherwise known as NFPA 1582.[20] They recommend, in addition to screening for risk factors for CAD, an exercise stress EKG, otherwise known as an EST. The EST is used to screen individuals for CAD. Unfortunately, it has problems with both false negatives (inadequate sensitivity) and false positives (inadequate specificity), particularly for asymptomatic individuals (individuals without symptoms suggestive of angina), young men, and women.[21,22] This has led other expert groups to **not** recommend EST for asymptomatic individuals without risk factors for CAD.[23-24]

When these asymptomatic individuals **have** risk factors for CAD, however, recommendations vary by organization. The American College of Cardiology/American Heart Association (ACC/AHA) identifies four groups for EST although they note that the "usefulness/efficacy is less well established by evidence/opinion."[23]

Group 1: Persons with multiple risk factors. They define five risk factors for CAD: hypercholesterolemia (total cholesterol greater than 240 mg/dL), hypertension (systolic greater than 140 mm Hg or diastolic greater than 90 mm Hg), smoking, diabetes, and family history of premature CAD (cardiac event in first-degree relative less than 60 years old).

Group 2: Men over the age of 40 and women over the age of 50 (especially if sedentary) who plan to start vigorous exercise.

Group 3: Men over the age of 40 and women over the age of 50 who are at high risk for CAD due to other diseases (e.g., chronic renal failure).

Group 4: Men over the age of 40 and women over the age of 50 who are involved in occupations in which impairment might impact public safety.

The U.S. Preventive Services Task Force (USPSTF) does not recommend EST for asymptomatic individuals, even those with risk factors for CAD; rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes).[24] The USPSTF indicates that there is insufficient evidence to recommend screening middle age and older men or women in the general population; however, "screening individuals in certain occupations (pilots, truck drivers, etc.) can be recommended on other grounds, including the possible benefits to public safety."[24]

The Fire Department requires a periodic EST on all career fire fighters; however, paid/call fire fighters are not included in this screening. As of May 1, 2001, the Fire Department requires an EST be performed on all new hires over the age of 40.

Since the victim, a paid/call fire fighter, had several CAD risk factors, the performance of an EST is recommended by NFPA 1582. The Fire Department did not perform EST on paid/call fire fighters as part of a periodic medical evaluation. However, the AHA suggests an EST be performed only on certain individuals and the USPSTF does not recommend an EST be performed on asymptomatic individuals. An EST performed on the victim could have identified his CAD, thereby leading to further evaluation and treatment, and possibly the prevention of his sudden cardiac death.

RECOMMENDATIONS

The following recommendations address health and safety generally. It is unclear if any of these recommendations could have prevented the sudden cardiac arrest and subsequent death of this Fire Fighter. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These recommendations have not been evaluated by NIOSH, but represent published research or consensus votes of Technical Committees of the NFPA or labor/management groups within the fire service.

Recommendation #1: Provide mandatory annual medical evaluations to ALL fire fighters to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

Guidance regarding the content and frequency of periodic medical evaluations and examinations for fire fighters can be found in NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians,[20] and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs Wellness/Fitness Initiative.[25] The department is not legally required to follow any of these standards. Nonetheless, we recommend the City and Union **negotiate** the content and frequency to be consistent with the above guidelines.

Specifically, according to NFPA 1582, "the use of chest X-rays in surveillance activities in the absence of significant exposures, symptoms, or medical findings has not been shown to reduce respiratory or other health impairment. Therefore, only preplacement chest X-rays are recommended." The extra chest X-rays being conducted by the Fire Department expose incumbents to unnecessary radiation and represent an unnecessary expense for the Fire Department.

In addition to providing guidance on the frequency and content of the medical evaluation, NFPA 1582 provides guidance on medical requirements for persons performing fire fighting tasks. NFPA 1582 should be applied in a **confidential**, **nondiscriminatory** manner. Appendix D of NFPA 1582 provides guidance for fire department administrators regarding legal considerations in applying the standard.

Applying NFPA 1582 also involves economic issues. These economic concerns go beyond the costs of administering the medical program; they involve the personal and economic costs of dealing with the medical evaluation results. NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, addresses these issues in Chapter 8-7.1 and 8-7.2.[27]

The success of medical programs hinges on protecting the affected fire fighter. The Department must (1) keep the medical records confidential, (2) provide alternate duty positions for fire fighters in rehabilitation programs, and (3) if the fire fighter is not medically qualified to return to active fire fighting duties, provide permanent alternate duty positions or other supportive and/or compensated alternatives.

Recommendation #2: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. Additionally, physical inactivity is associated with other risk factors, namely obesity and diabetes.[26] NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires a wellness program that provides health promotion activities for

preventing health problems and enhancing overall well-being.[27] In 1997, the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) published a comprehensive Fire Service Joint Labor Management Wellness/Fitness Initiative to improve fire fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten fire departments across the United States joined this effort to pool information about their physical fitness programs and to create a practical fire service program. They produced a manual and a video detailing elements of such a program.[25] The Fire Department and the Union should review these materials to identify applicable elements for their Department. Other large-city negotiated programs can also be reviewed as potential models.

Recommendation #3: Provide fire fighters with medical evaluations and clearance to wear self-contained breathing apparatus (SCBA).

OSHA's Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection.[28] These clearance evaluations are required for private industry employees and public employees in States operating OSHA-approved State plans. Ohio is not a State-plan State; therefore, public sector employers are not required to comply with OSHA standards. However, we recommend following this standard, and a copy of the OSHA medical checklist has been provided to the Fire Department.

Recommendation #4: Ensure public safety telecommunicators (dispatchers) are properly trained to provide all necessary information to emergency response agencies.

Requirements for the professional qualifications for public safety telecommunicators are found in NFPA 1061.[29] The public safety telecommunicator is required to acquire information from multiple sources requiring public safety services or assistance; analyze, classify, and summarize the data for dispatch or referral; and then to transmit and relay that information or data to field units or other resources.[29] In this incident, the victim's daughter related to the 911 dispatcher that her father had passed out behind the wheel of his pickup truck, the family could not gain access to him because the truck's doors were locked, and the truck had struck the propane tank behind their house. The Fire Department was then dispatched to a vehicle striking a propane tank and an ambulance and an engine responded, thus providing fire and emergency medical service for that incident. However, even though it probably would not have changed the outcome of this incident, the dispatcher should have informed the Fire Department of the life hazard involved.

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