F2003
09

NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation *July 10, 2003*

Fire Fighter Suffers Fatal Heart Arrhythmia at Structure Fire - Illinois

SUMMARY

On January 14, 2003, a 46-year-old male career Captain responded to a working fire in a 1½-story, single family dwelling with possible entrapment. While wearing full bunker gear and self-contained breathing apparatus (SCBA) and breathing air from his SCBA, he and his crew members searched the residence and located the fire in the attic, then the Captain exited the structure to replenish his air supply. While sitting on Engine 6, he collapsed. Crew members began cardiopulmonary resuscitation (CPR) and ambulance personnel on the scene loaded him into the ambulance and transported him to the hospital. Advanced life support (ALS) measures were initiated en route to the hospital and continued inside the emergency department (ED) until 0221 hours, when he was pronounced dead. The autopsy and death certificate listed "cardiac arrhythmia" due to "heart disease" as the immediate cause of death and "exertion while fighting a house fire" as a contributing factor.

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 fire service labor/management groups.

- ***Conduct preplacement medical evaluations consistent with NFPA 1582 to determine a candidate's medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.***
- ***Provide <u>mandatory</u> annual medical evaluations to <u>ALL</u> fire fighters consistent with NFPA 1582 to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.***
- ***Incorporate exercise stress tests into the Fire Department's medical evaluation program.***
- ***Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***

INTRODUCTION & METHODS

On January 14, 2003, a 46-year-old male Captain responded to a structure fire with possible entrapment. After searching the residence and locating the fire, he exited the structure to replenish his air supply. While sitting on Engine 6, he collapsed. Despite CPR performed by crew members and ALS treatment provided by ambulance personnel and inside the ED, the victim died. NIOSH was notified of this fatality on January 15, 2003, by the United

States Fire Administration. NIOSH contacted the affected Fire Department January 16, 2003, to obtain further information and on March 7, 2003, to initiate the investigation. On March 17, 2003, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Illinois to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed:

- The Fire Chief
- The FD Training Officer
- The FD Safety Officer
- The Union President
- The Captain's crew members
- The attorney representing the Captain's family

During the site-visit NIOSH personnel reviewed:

- Fire Department policies and operating guidelines
- Fire Department training records
- The Fire Department annual report for 2002
- Fire Department incident report
- Fire Department physical examination protocols
- Fire Department medical records
- Death certificate
- Autopsy record

INVESTIGATIVE RESULTS

On January 13, 2003, the Captain reported for duty at his fire station (Station 6) at 0700 hours. He was the assigned officer on Engine 6. He exercised during the earlier part of his shift. Throughout the shift, Engine 6 was dispatched to three alarms: 1) a barbecue grill on fire inside a garage at 1256 hours, 2) a medical call for an unconscious person at 2044 hours, and 3) the incident at 0129 hours at which the Captain collapsed. See Table 1 for a timeline of the shift.

The crew of Station 6 went to bed at approximately midnight and had spoken with the Captain shortly prior. He exhibited no symptoms of chest pain or any other medical problems.

At 0129 hours, January 14, Battalion 2, E1, E5, E6, E7, and T3 were dispatched to structure fire with possible entrapment. There were 17 personnel on the scene including three crew members per apparatus, a Battalion Chief, and a Safety Officer. Units arrived on scene at 0133 hours to find heavy smoke emitting from the chimney and the eaves. The structure involved was a vacant, 1½-story, wood frame, two unit, multi-family dwelling, measuring approximately 20' x 50'.

Wearing full bunker gear and SCBA (weighing approximately 45 pounds) and breathing air from their SCBAs, Engine companies forced entry to two side doors while the E6 crew (the Captain and a crew member) used forced entry to enter the rear door. The Captain adjusted his mask and his crew member asked him if he was OK. The Captain said he was OK. The E6 crew entered the kitchen area, walking upright. There was smoke present, but visibility was fairly good. E6 searched the first floor for occupants but found none. The Captain attempted to remove a piece of plywood by forcing it with his foot, but the plywood did not give way. Several companies, including E6 crew members searched the residence for occupants but found none. E5 searched the basement for fire, but found no fire. A neighbor soon reported that the house was vacant.

T3 crew members ventilated the roof while E6 went upstairs to search. The smoke condition was very heavy at the top of the stairs, but the heat was not intense. They entered the first room by crawling on their hands and knees. They went through the first room, through a second room, and into the front room. The Captain located the attic entrance and opened it. He saw fire in the attic area. (Most of the fire was located in the front lower level with some extension into the ceiling/attic area). The Captain

advised his crew member that a hoseline was needed.

E1 and E5 stretched a 1½-inch hoseline and began to extinguish the fire on the first floor. Both the Captain and his crew member returned to the first floor and outside to get a hoseline. They stretched 200' of 1¾-inch hoseline into the structure. The Captain went back to E6 to tell the Driver/Engineer to charge the line. After he re-entered the structure, he took the nozzle and the E6 crew advanced the hose to the top of the stairs. The Captain stated to his crew member that he was lost. The crew member advised the Captain more than once that they needed to go to the left. The Captain handed the nozzle to his crew member and they proceeded toward the fire. Again, they were crawling in very heavy smoke with visibility near zero.

When the crew member opened the attic access door, he could find no fire, but the heat was intense. After advising the crew member to spray a stream of water into the attic, the Captain stated "we need to get out of here." Leave the hose, we need to get out." His low air alarm began sounding and he began to exit the structure. He was overheard stating "hurry up, I am running out of air."

Once outside, the Captain sat on the front bumper of T3, which was facing E6. An E5 crew member asked the Captain if he needed anything and the Safety Officer asked the Captain if he was alright. Both times, the Captain said he was OK. The Captain noted to his E6 crew member that he had used almost half of his air supply, while the crew member had not used that much. The Captain advised the crew member that he could go back in if he wanted, but the crew member elected to stay with the Captain. The Captain remarked that "he would be out for awhile." The Captain was breathing very heavily and did not look well. He arose, walked to E6, and sat down on the tailboard. The Driver/Engineer changed the Captain's SCBA bottle and began to change the crew member's bottle. The Captain remarked something about the fire and immediately collapsed face down onto the pavement. (He had been on scene approximately 15 minutes).

A fire fighter yelled that a fire fighter was down, a Code Red (fire personnel injured) was declared, and an ambulance was requested. Since the initial dispatch included possible entrapment, an ambulance had been dispatched during the initial response.

Fire fighters and two paramedics (from the ambulance) were standing near by and immediately. Found the Captain to be unresponsive, pulseless, and not breathing. His bunker coat was opened and a cardiac monitor was attached. He was placed onto a backboard and cot, loaded into the ambulance, and CPR was begun. Crew members had difficulty in removing his bunker coat.

Inside the ED, resuscitation efforts continued until 0221 hours when he was pronounced dead. (Further ambulance and hospital treatment records were not available to NIOSH investigators at the time of this report).

Medical Findings. The death certificate, completed by the Coroner, listed "Cardiac arrhythmia" due to "heart disease" as the immediate cause of death and "exertion while fighting a house fire" as a contributing factor. The carboxyhemoglobin level was 2.2%, indicating the Captain had inhaled some but not an excessive amount of carbon monoxide; possibly due to his cigarette smoking. Pertinent findings from the autopsy, performed by the Medical Examiner, on January 14, 2003, included:

- Atherosclerotic cardiovascular disease
- Coronary artery atherosclerosis
  - Severe, approximately 90%, stenosis in right coronary artery including the region previously stented

Fire Fighter Suffers Fatal Heart Arrhythmia at Structure Fire - Illinois

  - Severe, approximately 80%, focal stenosis in left anterior descending and left circumflex coronary arteries
- Remote myocardial infarct (heart attack), posterior/inferior wall of left ventricle with moderate thinning of the wall
- Diffuse mild and focal moderate aortic atherosclerosis
- Clinical history of hypercholesterolemia
- Hypertensive cardiovascular disease"
- Cardiac hypertrophy (490 grams)(normal < 400 grams)
- Clinical history of hypertension
- Tobacco pneumonitis with early pulmonary emphysema and chronic bronchitis
- History of cigarette smoking
- No ethanol or illicit drugs were detected

The Captain completed a medical evaluation for respirator users in October 1995. His blood pressure was 120/84 before donning a respirator and a five minute exercise period and 130/88 after doffing the respirator. The evaluation form was not signed by a physician so it is unclear if he had clearance. He was last cleared to return to work by the City contract physician in January 2002. The Captain was fit tested for SCBA in March 2002. He had a history of angioplasty (balloon procedure) and stent placement in one coronary artery, heart attack, high blood pressure, high cholesterol, and cigarette smoking.

According to his crew members, the Captain had no complaints of chest pains or any other heart-related illness prior to this incident.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this career Fire Department consists of 215 uniformed personnel and a Chief. The Department serves a population of 125,000 in an area of 100 square miles. There are 12 fire stations. The FD provides basic life support medical service. Advanced life support emergency medical service is provided by a private contractor. Fire fighters work the following schedule: 24 hours on-duty, 48 hours off-duty, 0700 hours to 0700 hours, with a Kelly Day off every tenth shift and two personal days off annually.

In 2002, the Department responded to 12,847 calls: 349 refuse fires, 192 structure fires, 155 vehicle fires, 67 fire/explosions, 41 outside of structure fires, 38 tree/grass/brush fires, 2 explosions, 1763 false calls, 1052 good intent calls, 619 service calls, 273 hazardous condition calls, 19 overpressure/rupture calls, 7669 rescue calls, and 608 other calls.

Training. The Fire Department requires all new fire fighter applicants to be less than age 35, pass a written civil service test, have a physical examination performed by a physician chosen by the applicant, a physical agility/strength/endurance test (discussed below), and an oral interview prior to being ranked by score. When a vacancy occurs, the candidate(s) at the top of the list must then pass a psychiatric review, background check, drug screening, and a FD preplacement physical examination prior to being hired. The newly hired fire fighter must then pass a pension board physical examination to be eligible for heart. lung, and cancer benefits. Newly hired fire fighters are on probation for one year. They receive an initial 14 week training program to become certified as Fire Fighter II, EMT-B, Emergency Rescue Technician, Hazardous Materials Operations, Technical Rescue, and Fire Apparatus Engineer.

The physical agility test consists of the following untimed events:

- Ascending and descending an aerial ladder extended 85' at a 75° angle
- Completing a blind crawl exercise by wearing a blackened face mask and SCBA while following a section of hoseline through a room with obstacles

The following are timed events:

- Carry a hose roll up and down stairs
- Hoist a hose roll up two stories
- Advance a charged hoseline and open the nozzle
- Run a short distance and move a dummy.

Recurrent training occurs daily on each shift. The State minimum requirements for fire fighter certification are: (1) be a member of the IL fire service, (2) complete the State Fire Fighter II course, including First Responder and Hazardous Materials Awareness. Training is conducted by in-house State-certified trainers but there is no specific requirement in terms of hours of training, There is no State requirement for fire fighter recertification. The Captain was certified as a Fire Fighter III, Driver Engineer, EMT-I, Hazardous Materials Operations, and Rescue Specialist. He had almost 24 years of fire fighting experience.

Preplacement Evaluations. The FD requires a preplacement medical evaluation for all fire fighter candidates, regardless of age. Components of the evaluation include:

- A complete medical history
- Physical examination
- Blood tests (red and white blood count)
- Urinalysis
- Chest x-ray
- Electrocardiogram (EKG)
- Venereal disease research laboratory (VDRL) test
- Lumbo-sacral spine x-ray

These evaluations are performed by a contract physician hired by the City, who then makes a decision regarding medical clearance for fire fighting duties. This decision is forwarded to the City Personnel Director.

Periodic Evaluations

Periodic medical evaluations are not required by this Department.

Hazardous materials (HazMat) fire fighters complete the State Department of Labor medical history questionnaire annually and must also complete a physical examination every other year. This program began in the Fall of 2002. Components of this examination include the following:

- A complete medical history
- Physical examination
- Vital signs
- Pulmonary function test
- Chest x-ray

These evaluations are performed by a contract physician hired by the City, who then makes a decision regarding medical clearance for fire fighting duties. This decision is forwarded to the City Personnel Director.

All fire fighters must be medically cleared annually to wear a respirator and complete a State Department of Labor medical history questionnaire and provide it to the City contract physician, who then makes a decision regarding medical clearance for respirator use. This decision is forwarded to the City Personnel Director.

If an employee is injured at work, or is ill and off work for more than two consecutive shifts, the employee is evaluated by their personal physician, who forwards their recommendation regarding "return to work" to the City contract physician, who makes the final determination.

Exercise (strength and aerobic) equipment is located in the fire stations. Voluntary wellness/fitness programs are in place for the Department, however the type of exercise performed is left to the individual fire fighter. Additionally, all fire fighters are given a

membership to a local health club. Approximately 50% of the fire fighters participate in these fitness activities. Health maintenance information is available from the City. There is an annual Job Performance Requirements test (similar to a Job Task or physical ability test).

The victim was last cleared for duty by the City physician in 2002. He exercised regularly by walking on a treadmill.

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 known CAD plus five of these risk factors (age over 45, male gender, smoking, high blood pressure, high blood cholesterol).

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. Although the victim did not have a blood clot in any of his coronary arteries on autopsy (less than 50% of heart attack victims have them), he did have severe coronary atherosclerotic disease.

Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.[7] Firefighting 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.[8-10] 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.[11] Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.[12-15] At the structure fire, the victim wore full bunker gear and SCBA (on air) during victim search and fire extinguishment operations. His activities ranged from crawling through the house to walking up one flight of stairs while pulling a charged 1¾-inch hose line. This is considered a moderate to heavy level of physical exertion.[16]

The physical stress of responding to these alarms and his underlying atherosclerotic CAD contributed to this fire fighter's "probable" heart attack, subsequent cardiac arrest, and sudden death. The term "probable" is used because autopsy findings (thrombus formation), blood tests (cardiac isoenzymes), or ECG findings are required to "confirm" a heart attack (myocardial infarction). The victim did not have a coronary artery thrombus on autopsy; he died prior to the cardiac isoenzymes becoming positive, and he had no heart beat to show the characteristic findings of a heart attack on his ECG.

To reduce the risk of heart attacks and sudden cardiac arrest among fire fighters, the NFPA has developed guidelines entitled "Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians," otherwise known as NFPA 1582.[17] NFPA 1582 recommends a yearly physical evaluation to include a medical history,

height, weight, blood pressure, and visual acuity test.[17] 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 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 HazMat fire fighters.

NFPA 1582 recommends, 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.[18, 19] This has led other expert groups to **not** recommend EST for asymptomatic individuals without risk factors for CAD.[20,21]

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."[20]

- 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 than140 mm Hg or diastolic greater than 90 mm Hg), smoking, diabetes, and family history of premature CAD (cardiac event in 1st 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).[21]

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."[21]

Since the victim had several CAD risk factors, the performance of an EST is recommended by NFPA 1582. Had an EST been performed, it is possible his CAD would have been identified, 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 Captain. 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 fire service labor/management groups.

Recommendation #1: Conduct preplacement medical evaluations consistent with NFPA 1582 to determine a candidate's medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

Guidance regarding the content of 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*[17] and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.[22] The Department is not legally required to follow any of these standards. Nonetheless, we recommend the that the Fire Department be consistent with the above guidelines.

In addition to providing guidance on the 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.[23]

Additionally, preplacement screening radiography (X-rays) of the low back lack clinical and predictive value, while exposing the candidate to unnecessary radiation.[24] These screening tests represent an unnecessary expense for the department.

Recommendation #2: Provide <u>mandatory</u> annual medical evaluations to <u>ALL</u> 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,[17] and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.[22] The Department is not legally required to follow any of these standards. Nonetheless, we recommend the City and Union **work together** to establish the content and frequency in order 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 assigned to hazmat teams to unnecessary radiation and represent an unnecessary expense for the Fire Department.[17,25]

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 #3: Incorporate exercise stress tests into the Fire Department's medical evaluation program.

NFPA 1582 and the IAFF/IAFC wellness/fitness initiative both recommend at least biannual EST for fire fighters.[17,22] They recommend that these tests begin at age 35 for those with CAD risk factors, and at age 40 for those without CAD risk factors. The EST could be conducted by the fire fighter's personal physician, the City physician, or the Department's contract physician. If the fire fighter's personal physician or the contracted physician conducts the test, the results must be communicated to the City physician, who should be responsible for decisions regarding medical clearance for fire fighting duties.

Recommendation #4: 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, or lack of exercise, 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.[23] NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters, provides the minimum requirements for a health-related fitness program.[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.[22] 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. Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.[28-30] A similar cost savings has been reported by the wellness program at the Phoenix Fire Department, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.[31]

REFERENCES

1. Meyerburg RJ, Castellanos A [2001]. Cardiovascular collapse, cardiac arrest, and sudden cardiac death. In: Braunwald E, Fauci AS, Kapser DL, Hauser SL, Longo DL, Jameson JL, eds. Harrison's principles of internal medicine. 15th Edition. New York: McGraw-Hill. pp. 228 233.

2. AHA [1998]. AHA Scientific Position, Risk Factors for Coronary Artery Disease. Dallas, TX: American Heart Association.

3. Jackson E, Skerrett PJ, and Ridker PM [2001]. Epidemiology of arterial thrombosis. In: Coleman RW, Hirsh J, Marder VIJ, et al. eds. Homeostasis and thrombosis: basic principles and clinical practice. 4th edition. Philadelphia: Lippincott Williams and Wilkins.

4. Libby P [2001]. The pathogenesis of atherosclerosis. In: Braunwald E, Fauci AS, Kasper DL, Hauser SL, Longo DL, Jameson JL, eds. Harrison's principles of internal medicine. 15th Edition. New York: McGraw-Hill. p.1378.

5. Shah PK [1997]. Plaque disruption and coronary thrombosis: new insight into pathogenesis and prevention. Clin Cardiol 20 (11 Suppl2): II-38-44.

6. Fuster V, Badimon JJ, Badimon JH [1992]. The pathogenesis of coronary artery disease and the acute coronary syndromes. N Eng J Med 326:242 250.

7. Gledhill N, Jamnik, VK [1992]. Characterization of the physical demands of firefighting. Can J Spt Sci 17:3 207 213.

8. Barnard RJ, Duncan HW [1975]. Heart rate and ECG responses of fire fighters. J Occup Med 17:247 250.

9. Manning JE, Griggs TR [1983]. Heart rate in fire fighters using light and heavy breathing equipment: Simulated near maximal exertion in response to multiple work load conditions. J Occup Med 25:215 218.

10. Lemon PW, Hermiston RT [1977]. The human energy cost of fire fighting. J Occup Med 19:558 562.

11. Smith DL, Petruzzello SJ, Kramer JM, et al. [1995]. Selected physiological and psychobiological responses to physical activity in different configurations of firefighting gear. Ergonomics 38:10:2065 2077.

12. Willich SN, Lewis M, Lowel H, et al. [1993]. Physical exertion as a trigger of acute myocardial infarction. N Eng J Med 329:1684 1690.

13. Mittleman MA, Maclure M, Tofler GH, et al. [1993] Triggering of acute myocardial infarction by heavy physical exertion. N Eng J Med 329:1677 1683.

14. Siscovick DS, Weiss NS, Fletcher RH, Lasky T [1984]. The incidence of primary cardiac arrest during vigorous exercise. N Eng J Med 311:874 877.

15. Tofler GH, Muller JE, Stone PH, et al. [1992] Modifiers of timing and possible triggers of acute myocardial infarction in the Thrombolysis in Myocardial Infarction Phase II (TIMI II) Study Group. J Am Coll Cardiol 20:1049 1055.

16. American Industrial Hygiene Association Journal [1971]. Ergonomics guide to assessment of metabolic and cardiac costs of physical work. Am Ind Hyg Assoc J 560 564.

17. NFPA [2000]. Standard on medical requirements for fire fighters and information for fire department physicians. Quincy MA: National Fire Protection Association. NFPA 1582 2000.

18. Michaelides AP, Psomadaki ZD, Dilaveris PE [1999]. Improved detection of coronary artery disease by exercise electrocardiography with the use of right precordial leads. New Eng J Med 340:340 345.

19. Darrow MD [1999]. Ordering and understanding the exercise stress test. American Family Physician. January 15,1999.

20. Gibbons RJ, Balady GJ, Beasley JW, Bricker JT, Duvernoy WFC, Froelicher VF, Mark DB, Marwick TH, McCallister BD, Thompson PD, Winters WL Jr, Yanowitz FG [1997]. ACC/AHA guidelines for exercise testing: a report of the American College of Cardiology/American Heart

Association Task Force on Practice Guidelines (Committee on Exercise Testing). *J Am Coll Cardiol*. 30:260 315.

21. U.S. Preventive Services Task Force [1996]. Guide to clinical prevention services, 2nd Ed. Baltimore, MD: Williams & Wilkins, pp 3 15.

22. IAFF, IAFC. [2000]. The fire service joint labor management wellness/fitness initiative. Washington, D.C.: International Association of Fire Fighters, International Association of Fire Chiefs.

23. NFPA [1997]. Standard on fire department occupational safety and health program. Quincy MA: National Fire Protection Association. NFPA 1500 1997.

24. Gibson ES [1998]. The value of preplacement screening radiography of the low back. In: Deyo RA, ed. Occupational medicine, state of the art reviews. Philadelphia: Hanley & Belfus, pp 91 108.

25. DHHS [1985]. Occupational safety and health guidance manual for hazardous waste site activities. Washington, DC: Department of Health and Human Services Publication 85-115.

26. Plowman SA and Smith DL [1997]. Exercise physiology: for health, fitness and performance. Boston, MA: Allyn and Bacon.

27. NFPA [2000]. Standard on health-related fitness programs for fire fighters. Quincy MA: National Fire Protection Association. NFPA 1583 2000.

28. Maniscalco P, Lane R, Welke M, Mitchell J, Husting L (1999). Decreased rate of back injuries through a wellness program for offshore petroleum employees. J Occup Environ Med 41:813 820.

29. Stein AD, Shakour SK, Zuidema RA [2000]. Financial incentives, participation in employer sponsored health promotion, and changes in employee health and productivity: HealthPlus health quotient program. JOEM 42:1148 1155.

30. Aldana SG [2001]. Financial impact of health promotion programs: A comprehensive review of the literature. Am J Health Promot 15:296 320.

31. Unpublished data [1997]. City Auditor, City of Phoenix, AZ. Disability retirement program evaluation. Jan 28, 1997.

INVESTIGATOR INFORMATION

This investigation was conducted by and the report written by Tommy N. Baldwin, MS, Safety and Occupational Health Specialist. Mr. Baldwin is with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio.

TABLE 1. Shift Response Timeline

0700 hours:	Reports to work Engine 6/Station 6
1256 hours:	Battalion 1, E1, E4, E5, E6, and T1 dispatched to grills on fire inside a residential garage
1310 hours:	Units arrive on the scene
1312 hours:	Units depart the scene
2044 hours:	E5 and E6 dispatched to an unconscious person
2046 hours:	E 5 arrives on the scene and cancels E6
2052 hours:	E5 departs the scene
0129 hours:	Battalion 2, E1, E5, E6, E7, and T3 dispatched to structure fire with possible entrapment
0133 hours:	Units arrive on the scene