



Fire Fighter Suffers Sudden Cardiac Death and Crashes Tanker While Responding to a Chimney Fire—Colorado

SUMMARY

On December 14, 2001, a 68-year-old male volunteer fire fighter responded to a call of a chimney fire. The victim responded from his home in his personal vehicle to the nearest fire station. As one of the fire department's drivers, he began to drive the 2,200-gallon tanker to the fire scene. At approximately 1457 hours, less than 1 mile from the fire station, the tanker left the roadway and slid down a 100-foot embankment, hitting several trees along the way. Emergency medical technicians and paramedics reached the victim several minutes later, finding the victim unresponsive. Initial assessment found the victim in the driver's seat, lap belt buckled, with some head trauma (lacerations to his forehead and the bridge of his nose) but no chest trauma. Some reports were conflicting as to whether the victim initially had a peripheral pulse, but this quickly degenerated into no pulse and no respirations. Despite cardiopulmonary resuscitation (CPR) and advanced life support (ALS) performed at the scene, in the flight-for-life helicopter, and at the hospital emergency department, the fire fighter died. Based on the fire fighter's clinical history and the post-mortem examination, his death certificate, completed by the Chief Deputy County Coroner, listed heart failure as the immediate cause of death due to arteriosclerotic heart disease.

The following recommendations address some general health and safety issues identified during this investigation. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks, sudden cardiac arrest, and sudden cardiac death among fire fighters. While some of these strategies could be used at this Fire Department, it is unlikely any of these measures could have prevented

this victim's untimely death. These selected recommendations have not been evaluated by NIOSH, but represent published research, consensus votes of technical committees of the National Fire Protection Association (NFPA), or fire service labor/management groups.

- *The medical decision regarding when, or if, to return to duty a member with medical conditions should be made by the physician providing occupational health services for the fire department.*
- *Expand the annual medical evaluation program currently required for "Active Retired Members" to include all members of the fire department. The frequency and content of this evaluation should be consistent with the National Fire Protection Association (NFPA) Standard 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians.*

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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- ***Members who perform active fire suppression should have medical clearance to wear a respirator. This clearance procedure can be incorporated into the annual medical evaluation.***
- ***Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***

- The Emergency Department's records relating to this event
- The Colorado State Patrol post-accident inspection report
- The deceased fire fighter's personnel folder maintained at the FD
- FD training records for the deceased fire fighter
- Various FD policies and operating guidelines
- Medical records of the deceased fire fighter maintained by his spouse
- The death certificate
- The autopsy report

INTRODUCTION & METHODS

On December 14, 2001, a 68-year-old male fire fighter apparently become unconscious while driving a tanker to a reported chimney fire. The driver lost control of the vehicle, which slid down a 100-foot embankment. Despite CPR and ALS procedures, the victim died. A few days after the death, the Fire Chief of the Department notified NIOSH of the death. On March 4, 2002, NIOSH personnel traveled to Colorado to conduct an on-site investigation of the incident.

NIOSH personnel interviewed

- The Fire Chief
- Fire fighters responding to the original chimney fire incident
- Fire fighters who responded to the subsequent motor vehicle incident involving the deceased fire fighter
- The Fire Department (FD) mechanic
- The deceased fire fighter's spouse
- The physician who conducts medical evaluations for the FD

Documents reviewed included

- FD's "Call Incident Report" for the chimney fire
- FD's "Call Incident Report" for the motor vehicle incident (MVI) involving the deceased fire fighter
- The Air Ambulance transport records

INVESTIGATIVE RESULTS

Incident. On December 14, 2001, the affected fire fighter responded to a chimney fire call received at 1445 hours. He drove his personal vehicle to the nearest fire station (#4), climbed into the cab of Tanker #464, and reported in-service at 1456 hours. Approximately ½ mile from fire station #4, while traveling south on a two-lane paved highway under heavy construction to four lanes, Tanker #464 ran off the right side of the road. The tanker collided with several trees while sliding down a 100-foot embankment and rolled a quarter of a turn before coming to rest on its left side. That section of highway was relatively flat, the road was dry, the air temperature was 44 degrees Fahrenheit, and the weather was clear. According to the transport records, witnesses in cars who saw the tanker leave the highway reported that the vehicle did not appear out of control until it left the roadway, and they did not see any tanker brake lights.

The call reporting the motor vehicle incident was received at 1501 hours. Some of the units en route to the first incident redirected to respond to the second call. These units, staffed by fire fighters who were also certified as emergency medical technicians (EMTs) and/or paramedics, arrived on the scene at 1502 hours. The EMTs who first reached the victim



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found him unresponsive, with some conflicting reports whether the victim initially had a peripheral pulse, but this quickly degenerated into no pulse and no respirations. He had lacerations to his forehead and the bridge of his nose, no chest trauma, and was still buckled into his seat belt. At 1504 hours a call was made for the flight-for-life helicopter, and CPR was initiated.

As CPR was being delivered, attempts were made to extract the victim from the tanker cab. This was difficult because the apparatus was lying on its left side in hilly terrain. After the upper half of the driver's door frame (the window frame) was cut away, the victim was extracted at 1512 hours. Once the victim was extracted from the cab, he was intubated, placed on a long spine board stretcher, and brought to the top of the embankment. A heart monitor was placed on the victim which revealed ventricular fibrillation, a heart rhythm that cannot sustain life. A single shock of 200 joules was delivered, resulting in asystole (no heart rhythm). CPR continued while intravenous access was secured and medications consistent with ALS protocols were administered.

At 1524 hours the flight-for-life helicopter landed. Paramedics affiliated with that unit reassessed the victim, found him to be unresponsive in asystole, and continued CPR and ALS procedures. They departed with the victim at 1545 hours. Upon arrival in the hospital emergency department at 1556 hours, the victim was reassessed and CPR and ALS procedures were continued. Because of the potential for trauma related to motor vehicle incident, bilateral chest tubes were placed which established the victim did not have a pneumothorax (air in the chest cavity) or a hemothorax (blood in the chest cavity). At 1610 hours, approximately 70 minutes after becoming unconscious, the victim was pronounced dead, and CPR and ALS were discontinued.

Medical Findings. Pertinent findings from the autopsy report, completed by the County's forensic pathologist, are listed below:

Cardiomegaly [an enlarged heart]
Old healed myocardial infarct [heart attack] involving the interventricular septum and the anterior wall left ventricle [left side of the heart]
Atherosclerotic coronary artery disease, severe
Post stent replacement coronary arteries
Atherosclerotic degeneration abdominal portion of the aorta
Small old infarct right cerebral hemisphere [stroke], internal capsule, brain
No evidence for any of the following: epidural, subdural, or subarachnoid [skull] hemorrhage, recent stroke, pulmonary embolus.
In addition, the victim's blood screen for illicit drug use or alcohol was negative.

The Medical Examiner concluded that "... the cause of death is due to heart failure secondary to arteriosclerotic heart disease. The autopsy revealed no evidence of any serious internal injuries to the body."

The death certificate, completed by the Chief Deputy County Coroner, recorded "heart failure" as the immediate cause of death and "arteriosclerotic heart disease" as the underlying cause. Other conditions listed as contributing to the death but not related to the cause included "cardiomegaly, arteriosclerotic coronary artery disease—severe, old myocardial infarction."

The deceased fire fighter was a former commercial airline pilot. His risk factors for coronary artery disease (CAD) included male gender, age greater than 45 years, and high blood pressure (well controlled with anti-hypertensive medication). In 1997 he underwent a cardiac catheterization which found significant CAD (100% blockage of his first diagonal artery and 70% blockages of his left anterior



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descending artery proximal and distal to the diagonal.) At that time, his left ventricular ejection fraction (LVEF), a measure of his heart's pumping function, was 65% (normal). These lesions did not receive Percutaneous Transluminal Coronary Angioplasty (PTCA) at this time, but rather 2 weeks later, at which time his LVEF had dropped to 47%. According to the widow, this drop in LVEF was due to a heart attack (myocardial infarction, [MI]) during his cardiac catheterization, which is supported by the autopsy findings of an old, healed MI. Over the next 4 years the victim had annual stress tests. Over this same time period, the victim had four more cardiac catheterizations, with two PCTA involving stent placements in the obtuse marginal artery (for a 70-80% lesion) and the posterior descending artery (for a 60-90% lesion). His most recent stress test using the drug persantine was conducted in April 2001 showing persistent ischemia in the inferior portion of his heart and an ischemia-related arrhythmia (left bundle branch block). His most recent catheterization was in June 2001, which showed no coronary artery lesion amenable to PCTA and a LVEF of 29%.

Despite his old heart attack and significant congestive heart failure (CHF) (as demonstrated by his low LVEF), the victim never complained of angina (heart pain) or of symptoms of congestive heart failure (shortness of breath upon exertion or ankle swelling). In March 2000, his cardiologist cleared the victim to drive the FD apparatus as long as he did "no heavy lifting or straining—nothing greater than 20 pounds." In November, 2000, the FD's contract physician cleared the victim for his commercial drivers license (CDL), a requirement to operate FD apparatus. This certification was for a two year period, expiring on November 21, 2002. No statement regarding CDL clearance was made after his April 2001 stress test or his June 2001 cardiac catheterization by either his private physician or the FD contract physician.

The victim's spouse related he had been feeling much better over the 6 months before his death, probably due to a change in his heart medications. The day of the fatal incident, the victim was at home. He had not done any strenuous activity that morning and had not responded to any emergency calls in the previous 24 hours. At the time of his death, he was taking medications to control his blood pressure and congestive heart failure.

DESCRIPTION OF THE FIRE DEPARTMENT

The Fire Department consists of 69 fire fighters: 9 paid and 62 volunteer. It serves a small city and surrounding rural area with a total population of about 15,000 residents in a geographic area of 98 square miles. There are four fire stations. In 2000, the Department responded to 1,044 calls, the majority related to emergency medical services.

Applicants, Members, Retired Members, and Training. To qualify for an interview with the FD Recruitment Committee, an applicant must be at least 18 years old, have a valid Colorado driver's license, have a good driving record over the past 3 years, and pass a background check. After initial acceptance by the Recruitment Committee, the candidate must pass a medical evaluation (discussed below) conducted by the FD's contract physician, and a drug screen. After passing the medical evaluation and drug test, the applicant becomes a probationary member. The probationary period lasts between 12 and 24 months depending on how quickly the following requirements are completed:

- Rookie training program
- Fire Fighter I certification
- CPR card
- Wildland Firefighter Basic course
- First Responder or EMT course
- Respond to at least 10% of the FD toned calls
- Attend at least 10 of the FD business meetings



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- FD training requirements for infectious disease control (annual tuberculosis skin tests, the hepatitis B vaccination series, and the diphtheria/pertussis/tetanus vaccine booster), driver safety, and hazardous materials
- A physical ability test, added in 2002 for paid and volunteer fire fighters

At the end of this probationary period, provided all the above requirements are met, the candidate will be considered for placement as an active member of the FD.

The State of Colorado administers a pension program for volunteer fire fighters who have served their communities for a minimum of 10 years. Fire fighters in this FD who qualify for this pension yet remain active members of the FD are termed, “active retirees” or “retired members.” The deceased fire fighter had been a volunteer fire fighter at this FD for 32 years and an active retiree since 1987. In 2001, he had completed over 68 hours of training, including 8 hours of vehicle operation, equipment inventory, and defensive and emergency driving. He was certified in CPR and was certified as a first responder. As a retired member, he was not allowed to participate in “strenuous duties,” and, as mentioned previously, his private physician placed him on lifting restrictions: no heavy lifting or straining—nothing greater than 20 pounds. As a result, the deceased fire fighter’s primary duties consisted of driving and operating the FD vehicles, assisting with traffic control, assisting with rehab, and being one of the FD driving instructors.

Preplacement Evaluations. All applicants to the Fire Department, both paid and volunteer, must pass a FD preplacement medical evaluation. The evaluation is performed by a contract physician from a nearby clinic. The components of the evaluation are the same as required for a commercial driver’s license from the Colorado Department of Transportation (DOT).¹

The clinic makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the Fire Department.

Periodic Evaluations. Only active retirees are required to have periodic medical evaluations. These are conducted annually by either their personal physician or the FD contract physician. If the evaluation is done by the contract physician, the components are the same as the preplacement evaluation, with the decision regarding medical clearance forwarded to the FD. The deceased fire fighter was last cleared by the contract physician 13 months (November 2000) before this fatal incident.

A paid or volunteer fire fighter who is injured or becomes ill, whether work-related or not, must be cleared to return to work as a fire fighter by his or her personal physician or the contract physician. Exercise equipment is available for use during work hours, but the Department does not have a mandatory exercise/fitness program or other health promotion programs.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.² Risk factors for its development include increasing age, male gender, heredity, tobacco smoke, high blood cholesterol, high blood pressure, physical inactivity, obesity and overweight, and diabetes.³ The deceased firefighter had three of these risk factors (increasing age, male gender, and hypertension) and was found to have CAD in 1997.

Congestive heart failure (CHF), listed on the death certificate as “heart failure,” is the inability of the heart to pump blood normally at a sufficient rate to meet the body’s needs.^{4,5} CHF can result from a number of underlying conditions, including CAD, MI,



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hypertension, heart valve abnormalities, and various types of cardiomyopathies.⁵ Given the sudden drop in the deceased fire fighter's LVEF back in 1997, his CHF was most likely due to CAD and an MI (ischemic cardiomyopathy) than his history of hypertension (hypertensive cardiomyopathy).

Shortness of breath is the most common initial presentation of CHF.⁵ Since there are multiple mechanisms by which the body can adapt, or compensate, for impaired cardiac function, CHF can be present without any symptoms or interference with ordinary activity. Given that the deceased fire fighter probably limited his activities to match his cardiac function, it should not be surprising that he was asymptomatic.

The autopsy did not identify significant head or chest trauma, suggesting this was not a traumatic injury death. In addition, the autopsy failed to find any obvious triggers for sudden death such as a heart attack (thrombus in his coronary artery) or a pulmonary embolus (thrombus in his lungs). However, the victim did have a number of heart conditions, putting him at risk for sudden cardiac death (arrhythmias). These include coronary artery disease, cardiomegaly, and CHF.² Therefore, it is possible that responding to the emergency alarm in some way triggered an arrhythmia, which was responsible for his sudden cardiac death.

Fire fighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.⁶ 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.⁷⁻⁹ Epidemiologic studies have found that physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.¹⁰⁻¹⁴ Prior to his

sudden death, the victim had responded in his POV from his home to the fire station and began driving the tanker to the emergency call. This is considered a "light" physical exertion requiring between about 3 or 4 metabolic equivalents (METS).¹⁴⁻¹⁶

The fire department requires preplacement medical evaluations for all applicants. The content of this evaluation is the same as required by the Colorado DOT to obtain a Commercial Driver's License (CDL).¹ Given the different job requirements for fire fighters and driving a commercial vehicle, and since the fire service has developed guidelines for the preplacement evaluations, we suggest the FD consider following the fire fighter guidelines known as NFPA 1582, *Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians*.¹⁷ A copy of this standard has been provided to the FD.

In addition to preplacement medical evaluations, NFPA 1582 recommends a brief medical evaluation annually and a more extensive evaluation periodically according to the age of the fire fighter (less than 30: every 3 years; 30-39: every 2 years; over 40 years: every year). This includes an exercise stress test (EST) for fire fighters over the age of 35 with risk factors for CAD and for all fire fighters over age 40. The DOT also recommends EST for drivers over the age of 45 with more than two CAD risk factors to receive medical certification for their CDL.¹⁸ The deceased fire fighter had two conditions for which the DOT recommends annual EST to stage III of the Bruce protocol: post-PTCA or a heart attack (MI) after the age of 55.¹⁸ Despite the fact that municipal fire departments are exempt from DOT regulations,¹ this regulation and medical advisory criteria had relevance because the deceased fire fighter was a driver/operator for the Fire Department. In fact, the deceased fire fighter's cardiologist conducted annual stress tests with the most recent one showing persantine-induced ischemia and an



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arrhythmia. Unfortunately, a cardiac catheterization conducted 2 months after the stress test and just 6 months before his death did not show any treatable (PCTA) lesions in his coronary arteries. Therefore, it is unlikely any further medical evaluation or treatment could have prevented his untimely death.

Currently the FD restricts “active retirees” from active fire suppression. While this plan has advantages, the FD should consider restricting any fire fighters with medical disqualifying conditions from active fire suppression. Again, NFPA 1582 provides guidance on medical requirements for persons performing fire fighting tasks.¹⁷ Both NFPA 1582 and the DOT CDL medical advisory criteria consider a positive stress test for ischemia and arrhythmias as disqualifying.^{17,18}

RECOMMENDATIONS

The following recommendations address health and safety issues identified during this investigation. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job cardiac arrest among fire fighters. While some of these strategies could be utilized at this Fire Department, it is unlikely any of these measures could have prevented this victim’s untimely death. These selected recommendations have not been evaluated by NIOSH, but they represent published research or consensus votes of Technical Committees of the National Fire Protection Association or fire service labor/management groups.

Recommendation #1: The medical decision regarding an ill or injured fire fighter returning to duty should be made by the physician providing occupational health services for the Fire Department.

The decision regarding medical clearance for fire fighters requires knowledge not only of the fire

fighter’s medical condition but also of the fire fighter’s job duties and NFPA 1582 medical fitness criteria. Since the deceased fire fighter was a FD driver, using the DOT CDL medical evaluation also has relevance. As part of the return-to-duty evaluation, the fire department physician (in this case, the contract medicine clinic) should review relevant records from the fire fighter’s personal physicians and/or discuss with them clearance issues on an annual basis. Based on the April 2001 stress test, according to NFPA 1582 and the DOT CDL medical advisory criteria, the deceased fire fighter should have been restricted from driving the FD apparatus.^{17,18}

Recommendation #2: Expand the annual medical evaluation program currently required for “Active Retired Members” to include all members of the fire department. The frequency and content of this evaluation should be consistent with the National Fire Protection Association (NFPA) Standard 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians.

The purpose of periodic medical evaluations is to ensure that fire fighters have the ability to perform duties without presenting a significant risk to the safety and health of themselves or others. Guidance regarding the content and scheduling of periodic medical examinations for fire fighters can be found in NFPA 1582.¹⁷ 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.

Applying NFPA 1582 involves legal and economic issues, so it should be carried out in a **confidential, nondiscriminatory** manner. Appendix D of NFPA 1582 provides guidance for fire department administrators regarding legal considerations in applying the standard. The economic concerns go



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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 8-7.2.¹⁹ 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. Unfortunately, the second and third requirements may not be workable in a volunteer department and could thus impair both acceptance by fire fighters and the fire department's ability to retain fire fighters.

Applying this recommendation involves economic repercussions and may be particularly difficult for small, rural, volunteer fire departments to implement. Ideally, the periodic evaluations would be provided by the occupational medicine clinic that provides the preplacement evaluations. Certainly, this could easily apply to the addition of the limited annual physical examination. The more extensive periodic evaluations could be performed by a personal physician or the contract occupational medicine clinic at the fire fighter's expense, provided by a physician volunteer, or paid for by the fire department. In any case, the medical clearance decision should be made by a physician knowledgeable about the physical demands of fire fighting and the personal protective equipment used by fire fighters. Sharing the financial responsibility for these evaluations between volunteers, the fire department and willing physician volunteers should reduce the negative financial impact on recruiting and retaining needed volunteers.

Recommendation #3: Members who perform active fire suppression should have medical

clearance to wear a respirator. This clearance procedure can be incorporated into the annual medical evaluation.

The decision regarding medical clearance for fire fighters requires knowledge not only of the fire fighter's medical condition but also of the fire fighter's job duties. Likewise, the decision regarding medical clearance for respirator use requires knowledge of the respiratory protection devices used by fire fighters and the conditions under which they are used. Since the medical clearances for fire fighting duty and respirator use require much the same health information, it makes sense to coordinate scheduling to obtain both of these clearance decisions from the same medical evaluation.

The Occupational Safety and Health Administration (OSHA) respiratory protection standard²⁰ requires employers whose employees are required to use respirators to have a formal respiratory protection program, including periodic medical evaluations. Since Colorado does not have an OSHA-approved State plan, public employers, including volunteer fire departments, are not legally subject to OSHA standards.²¹ Nevertheless, we recommend that the Fire Department voluntarily adhere to the health- and safety-related provisions of the OSHA standard, including periodic medical evaluations.

The medical evaluation for respirator use should involve considerations beyond respiratory symptoms and pulmonary function testing (PFT).²²⁻²⁴ Although pulmonary status needs to be considered, cardiac health is a more important factor in determining whether a fire fighter is medically fit to use SCBA with turnout gear. The primary physiological burdens are the added weight of the air bottle and other turnout gear and the heat load resulting from the fire, exertion, and turnout clothing. Thus, the medical evaluation for respirator clearance depends more on the medical history and physical examination than on



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PFT. PFT may be useful for evaluating respiratory symptoms or physical examination findings, but it is otherwise not needed routinely for a respirator clearance evaluation. Many workers, however, including firefighters, have periodic PFT for other reasons, and the results should obviously not be ignored. NFPA 1582 does not require PFT as part of the limited annual medical evaluation.¹⁷

Recommendation #4: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

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.¹⁹ The International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) joined in 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 Wellness/Fitness Initiative provides guidance regarding wellness program content to include physical examination and evaluation, fitness, and behavioral health. Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.^{26,27} An unpublished analysis by the Phoenix, Arizona, city auditor found a reduction in disability pension costs following a 12-year commitment to the wellness program at the fire department.

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INVESTIGATOR INFORMATION

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