U.S. Firefighter Deaths Related to Training, 2001 - 2010

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Training is a vital part of fire department operations, but it too often results in unnecessary deaths and injuries. Between 1977 and 2010, 291 firefighters died during training activities. This represents 7.8 percent of all on-duty firefighter fatalities in the U.S. over that 34-year period. (1977 is the first year for which NFPA has complete records of on-duty firefighter fatalities.) The total number of training-related deaths in a year has ranged from a low of three to as many as 17 (in 1987). (See Figure 1.)

As the total number of on-duty firefighter deaths overall has declined over the years, the lack of a sustained decline in deaths related to training has produced a pronounced increase in the training *share* of deaths. Figure 2 shows the trends for training-related deaths overall and compares trauma deaths and medical-related deaths over the period. (A running three-year average is shown in order to smooth out the year-to-year fluctuations.) As shown on the graph, the proportion of deaths annually has risen since the mid-1990s, but has generally plateaued over the past decade, during which time the share of traumatic deaths during training has fallen and the share due to medical causes has risen.

This special analysis will focus on the most recent 10-year period -- 2001 through 2010. Over that period, 108 firefighters died while engaged in training-related activities (11.3 percent of all on-duty firefighter deaths in those years, not including the 340 deaths at the World Trade Center in 2001). Of these 108 victims, 53 were volunteer firefighters, 43 were career firefighters, six were employees of state land management agencies, three were employees of federal land management agencies, one was a civilian employee of the military, one was a contract pilot, and one was employed by an industrial fire department.

Approximately one quarter of the victims had one year or less of experience. Of these 25 firefighters, 10 were involved in recruit training when they died.

Sudden Cardiac Deaths During Training Activities

Findings for firefighter fatalities overall indicate consistently that the number one cause of on-duty firefighter fatalities is sudden cardiac death, and that holds true, also, during training activities. Of the 108 training-related deaths in the 10-year period, 56 were due to sudden cardiac death. For all but eight of the 56 victims, a brief description of their past and present medical issues was reported. Of those 48 victims with available information, more than half had severe arteriosclerotic heart disease; 11 were hypertensive; 10 had had prior heart attacks; and three were diabetic.

Sudden cardiac death among on-duty firefighters has been discussed in NFPA and NIOSH reports. (See www.nfpa.org/assets/files/PDF/OSCardiacDeath.pdf and http://www.cdc.gov/niosh/docs/2007-133/.) These reports indicate the steps that should be taken to reduce the risk of heart attacks among firefighters, which include:

- conducting annual medical evaluations;
- screening for coronary artery disease (CAD) risk factors;
- conducting exercise stress tests (EST) for those with multiple CAD risk factors;
- giving appropriate treatment for those risk factors; and
- restricting the job tasks that firefighters with positive stress tests are allowed to perform.

The risk factors for CAD include diabetes, smoking, high cholesterol, high blood pressure, family history of the disease and obesity or physical inactivity.

Type of Activity

Training-related deaths occurred during a broad range of activities as shown in Figure 3. The category where the most deaths were reported (39 deaths) involved apparatus and equipment drills. This category includes training on specific apparatus and equipment, ladder climbing, pump and drafting operations, SCBA and smoke drills, driver/pilot training and training in extrication.

The second largest category was physical fitness training, with 30 deaths. This category includes exercising at the station, as well as agility tests and fitness screenings, job task evaluations and pack tests (work capacity testing for wildland firefighting).

Live fire training claimed 13 lives, although not all of these deaths occurred within burn structures.

Eight firefighters died while attending classes, seminars or training meetings.

There were five deaths during water rescue training.

In addition, 13 firefighters died while traveling to or from training activities.

Apparatus and Equipment Drills The 39 fatalities that occurred during apparatus and equipment drills included 25 caused by overexertion, stress or underlying medical issues that resulted in 22 sudden cardiac deaths, one aneurysm, one stroke and one death due to acidosis and dehydration. Five of these 25 victims were involved in recruit training.

Another five of the 39 firefighters in this category died in falls - two fell 85 feet (26

meters) while practicing getting on and off a roof from an aerial platform; one fell from a height of 65 feet (20 meters) off a fully-extended 105-foot (32-meter) aerial ladder set at a 65-degree angle during a drill; a recruit fell from the roof-level of a structure while attempting to descend a ground ladder; and one fell while rappelling from a helicopter.

Three firefighters were struck by objects. Two of the three were involved in separate tree-falling training exercises when trees fell on them. The third victim was struck in the head and fatally injured by an air jack during a training exercise involving putting tire chains on a pumper.

Two firefighters died in crashes during training exercises – one in a single-engine air tanker practicing a simulated fire retardant drop and one in a road crash involving a water tender during driver training. The aircraft crash was due to pilot error. The victim in the road crash was not wearing a seatbelt and the vehicle had several defects.

Two firefighters were struck by vehicles -- one by a backing pumper being driven by an operator with a suspended license and one by a driver operating under the influence of prescription medications and alcohol.

While making preparations for a training exercise, a firefighter standing on top of a rescue vehicle in the station became caught between the vehicle and a ceiling beam and was crushed when the driver drove out of the station without realizing he was there.

One firefighter hit his elbow while inside the compartment of a rescue vehicle during training and died of necrotizing fasciitis (also known as flesh-eating disease) less than three months later.

Physical Fitness Training Physical fitness training accounted for 30 firefighter deaths -- 24 were the result of sudden cardiac death, three due to heat stroke or hyperthermia, and three due to strokes. These 30 victims include three recruits, all of whom died of heat stroke.

Six of the victims were taking work capacity (pack) tests to qualify for wildland firefighting duties. Five suffered sudden cardiac death and one suffered a stroke. Three of the six were career employees of land management agencies, two were volunteer firefighters and one was a career firefighter. Four of the six had severe arteriosclerotic heart disease and one had an unspecified heart problem.

Two of the sudden cardiac death victims were undergoing fitness or agility testing -- in one case as part of his annual fitness evaluation and in the other case to determine fitness to return to duty. That victim had previously failed two job task evaluations and had been

placed on light duty and scheduled for rehabilitation. He was found to have CAD and underwent cardiac catheterization. He was released for return-to-work with no restriction by a private physician in spite of ischemia during an exercise stress test. He died two days after returning to work, during a job task evaluation. According to the NIOSH investigation report, based on NFPA 1582, *Comprehensive Occupational Medical Program for Fire Departments*, he should not have been cleared to return to full active-duty fire suppression.

The other 17 victims of sudden cardiac death and the other two stroke victims were working out (e.g., running, lifting weights, etc.), usually at the fire station, when they died. All of these 17 sudden cardiac death victims were found to have significant health problems, but interestingly, in several of the cases involving younger victims (under age 40), the NIOSH investigation reports indicated that they would not have been candidates for the sort of screening that could have detected their problems.

Eleven of the 24 victims of sudden cardiac death belonged to departments that required annual physical examinations (but one of the 11 fire departments only required them for firefighters over a specified age and another did not require them for firefighters hired before 1991, which included the victim). Another department only required annual physicals for those who were on the city's health insurance. Eight did not require annual physicals. Information on requirements for annual physicals was not reported for the other four victims of sudden cardiac death.

The three heat stroke victims were jogging as part of their recruit training. In one of those cases, the investigation report of an independent board of inquiry described a long list of issues with the conduct of the training exercise, including: no acclimatization or time for conditioning, given the high heat and humidity conditions; no rest or water for over an hour; dark clothing; only one instructor, and that instructor was untrained; and the instructor's failure to recognize the symptoms of distress. In another case, a firefighter collapsed during a class run at the end of a training day and died nine days later as a result of severe heat stroke with multisystem organ failure. The NIOSH investigation report stated that the physical stress of training, the heat and humidity were the cause of his death. In the third case, the NIOSH investigation report stated that the victim's death might have been prevented if the department's recruit fitness program had been consistent with the IAFF/IAFC Candidate Physical Ability Test (CPAT) and if opportunity for hydration had been provided during his run and ice water immersion therapy had been rapidly available

when he collapsed.

Live Fire Training Live fire training resulted in 13 of the 108 deaths. Four of the 13 firefighters died of burns and/or smoke inhalation during live burns:

- Two of these four firefighters were killed in one incident when they were caught in a flashover during search and rescue training in an acquired structure. One of the two was a 20-year-old in his first week on the fire department. The fire department had no written policy concerning live fire burns in acquired structures but used portions of NFPA 1403, *Live Fire Training Evolutions*, as a guide, in that they held a briefing prior to the training, stationed safety officers inside the structure, had a second backup hose line for safety and a third line available on a separate water supply, and ensured that all participants were certified firefighters and were equipped with appropriate personal protective equipment including SCBA and PASS devices. The fire involved wooden pallets, straw and a foam mattress placed on the fire after it was ignited. Others involved in the training thought the search and rescue team had left the fire room, and could not determine why they had stayed in the room. A walk-through had been done before the exercise began.
- An 18-year-old firefighter recruit died of smoke inhalation during a training exercise where he was playing the victim in a second-story apartment of an acquired structure. In that exercise, in addition to the burn barrel, a fire was ignited in the foam mattress of a sleep sofa in the living room on the first story, close to the bottom of the stairs and quickly burned out of control. There was no pre-drill walk-through; no one knew about the sofa fire; no back-up/safety line was in place; and no emergency evacuation ladders were in place. Two other firefighters were injured. This exercise was the first time the victim, who had received no formal training, wore an SCBA in fire conditions. Although he was wearing his facepiece when found, his face was burned, indicating that he had removed the facepiece during fire development. The officer in charge of the drill was convicted of negligent homicide.
- A probationary firefighter became trapped by fire in an acquired building and died of burns and asphyxia. The victim and an instructor were on the third

story of the three-story structure with three other students behind them when conditions deteriorated on the stairway above the second story. The instructor went out a window onto the second-story roof and assisted one of the students out after him. The victim also tried to go out that window, but was impeded by the window's height and possibly by obstructions at the window. The two other students were able to make their way down the stairs, but the victim was lifeless when she was finally pulled out the window. The NIOSH investigation report stated that the training exercise was not conducted in accordance with NFPA 1403; not all instructors were qualified or had experience as instructors; the fire department had a physical ability test but did not require that a candidate pass the test before being hired, and the victim had not passed it; and there was an insufficient water supply, inadequate and outdated personal protective equipment, and a shortage of radios.

Another two of the 13 firefighters in this category died of heat stroke. One victim collapsed at the end of the training day after having completed a succession of live fire training drills in hot humid weather with insufficient cool-down time and water. The other victim was a recruit in his sixth week who died of heat stroke at a live fire training exercise while operating a handline in a shipboard simulator. Four other recruits were treated for heat stress and burns. The training exercise did not follow NFPA 1403, and the investigation reports list a wide range of safety issues concerning the conduct of the drill, including no assigned safety officer or formal safety plan, no written pre-burn plan, no formal EMS plan, no RIT provision, and no monitoring of the fire environment, which became excessively hot. There was no walk-through before the exercise, and trainees were not told of alternative escape routes or exits. There was little oversight of the training class. Two fires were burning in the structure simultaneously, and the fuel used had not been specifically identified before the drill. Discipline at the drill included threats of termination if the recruits left the structure prematurely or were injured.

Sudden cardiac death claimed the lives of four firefighters during live fire training. One of them had had a prior heart attack and another had severe arteriosclerotic heart disease. One of the four had been acting as an observer during the training. One was setting up command at a training fire at which he was to be evaluated on his incident command knowledge. One was exposed to smoke at a controlled burn when the wind changed and he

collapsed while trying to pull a stuck vehicle out of the mud. The fourth victim collapsed after extinguishing an exterior propane tank fire.

Two firefighters died at live fire training exercises as a result of an aneurysm or stroke. One was preparing to enter a structure to conduct a search and the other was in rehab after having completed live fire training.

One firefighter was struck and killed by apparatus at the scene of a training exercise. He was deploying a handline in front of a crash truck when the engine's RPM unexpectedly increased, causing the vehicle to speed forward and strike him. Investigation of the incident determined that the vehicle's transmission was in the wrong gear. After the incident, the department installed safety kits on all similar vehicles.

Classes, Seminars and Meetings Eight firefighters died during classroom training, at seminars or while attending a conference. Sudden cardiac death claimed six lives. Another was shot to death during a meal break at an off-site training session. The eighth died of an accidental overdose of prescription medication.

Water Rescue Training Water rescue training resulted in the deaths of five firefighters – all of them drowned. There is generally little information available as to what exactly went wrong in these training dives. In one case, the victim became trapped under ice. He and his partner had not intended to go under the ice, but they were not tethered to the dock or shore. One victim became trapped underwater by ropes after running out of air. In a third case, after three hours of practicing loading and unloading a personal water craft (PWC) during surf rescue training in deep rough water, a fatigued firefighter wearing a dry suit and using a personal flotation device drowned after his PWC capsized. In the other two cases, divers failed to surface at the end of their dives, and no reason could be determined.

Traveling to and from Training Thirteen firefighters died while traveling to or from training sessions. Eight were killed in seven road vehicle crashes, two fell from the open tailgates of pickup trucks and one was struck by a passing vehicle when he stopped to retrieve something that had fallen off the fire apparatus while the unit was returning from a training exercise. One victim suffered a sudden cardiac death and one suffered a stroke.

Cause of Fatal Injury

Figure 4 shows the distribution of training-related deaths by cause of fatal injury or illness. As was found for total firefighter deaths in most years, the largest proportion of

fatalities (in this case, 63 percent or 68 deaths) were due to stress, overexertion or medical issues, and usually resulted in sudden cardiac death or strokes.

The next largest category is struck by or contact with object with 19 deaths. These included 11 in vehicle collisions, four firefighters struck by vehicles, two struck by a tree or tree limb, one struck by an air jack, and one from a gunshot.

Nine firefighters were caught or trapped -- four by the rapid growth of fire in live fire training exercises, four underwater, and one who became caught between the roof of a rescue vehicle and a ceiling beam as the vehicle was driven out of the station.

Seven firefighters died when they fell, including two from the open tailgates of pickup trucks, two from an aerial platform, one from an aerial ladder, one from a structure roof, and one while rappelling from a helicopter.

Three firefighters were overcome by heat -- two during live fire training and one by hot weather.

One firefighter died of an accidental drug overdose. One firefighter was exposed to smoke during a wildland training fire.

Nature of Fatal Injury

The distribution of training-related deaths by nature of fatal injury is shown in Figure 5. Overall, more than half of the training fatalities (56 deaths) were due to sudden cardiac death. Almost all of these firefighters, for whom medical documentation was available, had had prior heart attacks, bypass surgery, severe arteriosclerotic heart disease, diabetes or hypertension.

Another 25 deaths were due to internal trauma and crushing injuries. This includes mainly the motor vehicle crashes and falls. The remaining deaths resulted from strokes or aneurysms (nine deaths), drowning (five deaths), heat stroke (five deaths), smoke inhalation and burns (four deaths), and one each to a drug overdose, acidosis/dehydration, gunshot and septic shock.

Ages of Firefighters

The distribution of the training-related fatalities by age and cause of death is shown in Figure 6. The victims ranged in age from 18 to 74 years with a median age of 43 years. As can be seen in this graph, fatalities are more frequently the result of sudden cardiac death as

age increases. Figure 7 shows the death rate (for career and volunteer firefighters only) in training-related incidents by age group. The rates for firefighters under age 40 are below the average for all firefighters. When this study was done for the years 1996 through 2005, teenage firefighters had a death rate 50 percent higher than the all-age average; in this 10-year period, their death rate has dropped to just over half the all-age average.[1] The rates climb from age 40 up, with a rate for firefighters age 60 and over that is more than double the all-age average.

Conclusion

Firefighting is a dangerous profession but with proper attention to safety and health issues, on-duty fatalities can be reduced. NFPA 1500, *Standard on Fire Department Occupational Safety and Health Programs*, provides the requirements for a program that will reduce deaths and injuries not only during emergency operations but during training operations as well.

Firefighter deaths during training are particularly needless. The purpose of training is to teach proper techniques so as to prevent deaths and injuries during emergency operations and should certainly not be the cause of casualties. Over the past 10 years, 108 firefighters died during training activities. Ten of the 108 were fatally injured during recruit training, and 27 had one year of service or less.

NFPA publishes a range of standards that provide requirements for safely conducting firefighter training. NFPA 1403 describes a process for conducting live fire training evolutions to ensure that they are conducted safely, in safe facilities and environments, and that the exposure to health and safety hazards for the firefighters receiving the training is minimized. The standard provides guidance on the prior qualifications necessary for firefighters to participate in such training, as well as preparation of the training site, its contents, and the manner of igniting the training fire, assignments of safety personnel, provisions for emergency egress, and preparation of records and reports on the training exercise. The standard specifically prohibits the ignition of any type of material whose burning properties are not known or that may be uncontrollable. Flammable or combustible liquids are never to be used in acquired structures, and only in limited amounts in certain circumstances in training center burn buildings.

[1] Fahy, Rita F., "U.S. Firefighter Deaths Related to Training, 1996-2005," NFPA, June 2006.

As is true for all other types of duty, sudden cardiac death (usually heart attacks) accounts for the major share of training-related deaths, and many of the victims had had prior heart attacks, bypass surgery or heart disease. NFPA 1582 provides the medical requirements for candidate firefighters and identifies a category of existing medical conditions "that would preclude a person from performing as a member in a training or emergency operational environment by presenting a significant risk to the safety and health of the person or others." Among many others, these conditions include coronary artery disease, history of myocardial infarction, coronary artery bypass surgery, coronary angioplasty, cardiomyopathy, and myocarditis. NFPA 1582 also establishes that the fire department physician evaluate an incumbent firefighter who has a medical condition and recommend possible restrictions from performing essential job tasks based on the firefighter's medical condition. There is an entire section devoted to cardiovascular disorders and which of the essential job tasks could be compromised if a member has specific cardiac disorders.

NFPA 1002, *Standard on Fire Apparatus Driver/Operator Professional Qualifications*, specifies the minimum job performance requirements for service as a fire department emergency vehicle driver, pump operator, aerial operator, tiller operator, wildland apparatus operator, aircraft rescue and fire-fighting apparatus operator, and mobile water supply apparatus operator. The standard requires that routine tests, inspections, and servicing functions on the systems and components of fire department vehicles be performed and that drivers and operators have the requisite knowledge and skills to safely operate the apparatus.

NFPA 1451, *Standard for a Fire Service Vehicle Operations Training Program*, includes ongoing training requirements for vehicle operators, including operators of personally-owned vehicles.

These and all other NFPA codes and standards can be viewed on NFPA's website as a public service to enhance the safety of the public and the fire service community.

Motor vehicle crashes during training sessions or while traveling to or from training sessions represent an area where ordinary precautions and attention to driving rules and road conditions should have an impact. Seatbelts should be worn at all times in all vehicles.

NIOSH has investigated several deaths that occurred during dive training exercises and has made several recommendations to improve safety:

- develop a pre-dive checklist for all diving situations, including training;
- obtain and update appropriate medical fitness evaluations on all divers for SCUBA work;
- ensure that equipment checks are performed before each dive and any defective equipment is repaired or replaced before the dive takes place;
- ensure that all participants in diver training have practiced the specific evolution in a controlled environment such as a swimming pool before attempting the evolution in open water;
- ensure that positive communication is established among all divers and those personnel who remain on the surface;
- ensure that all divers record each dive in a dive log;
- ensure that divers are trained to perform rescue operations for other divers who may be in distress;
- ensure that search-and-rescue operations establish and use reference points to conduct searches;
- supply divers with an alternative air source;
- upgrade manual underwater communication devices with hands-free underwater communication devices;
- upgrade their diving standard operating procedures (SOPs) and include the 29 Code of Federal Regulations (CFR) 1910 for commercial diving operations.

NIOSH investigation reports are available on their website: www.cdc.gov/niosh/fire/.

Since training exercises should be conducted in controlled settings, they must be designed so as not to endanger the participants. This requires that recommended safety procedures be followed. That, in combination with competent instruction, should result in the level of safety necessary to protect the lives of those participating in training.

Figure 1
Deaths of U.S. Firefighters During Training
1977 - 2010

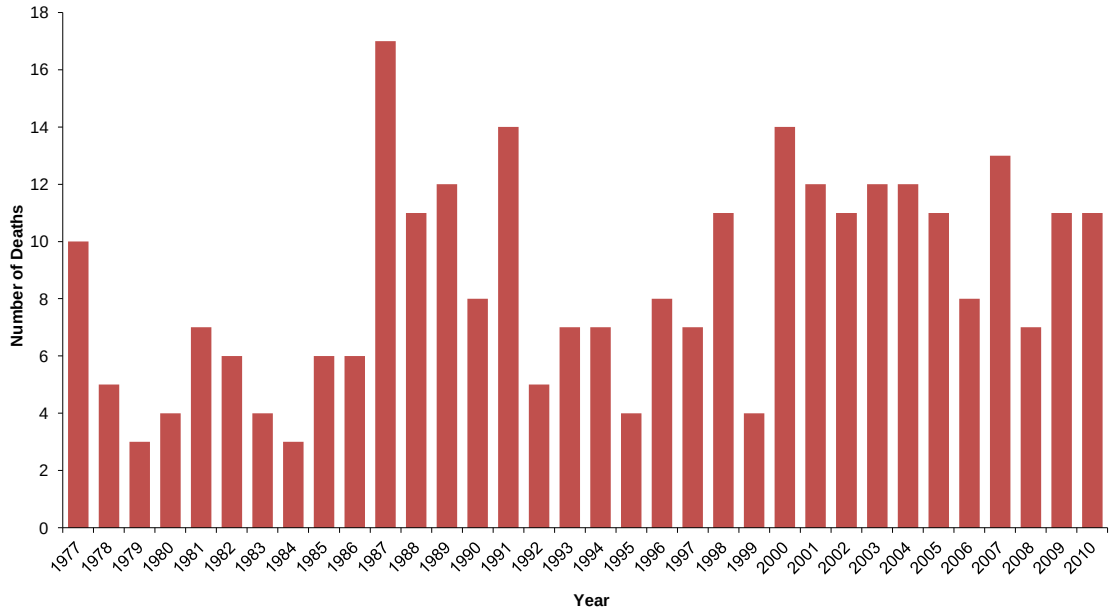

Figure 2
Proportion of training-related deaths annually
(3-year rolling average)

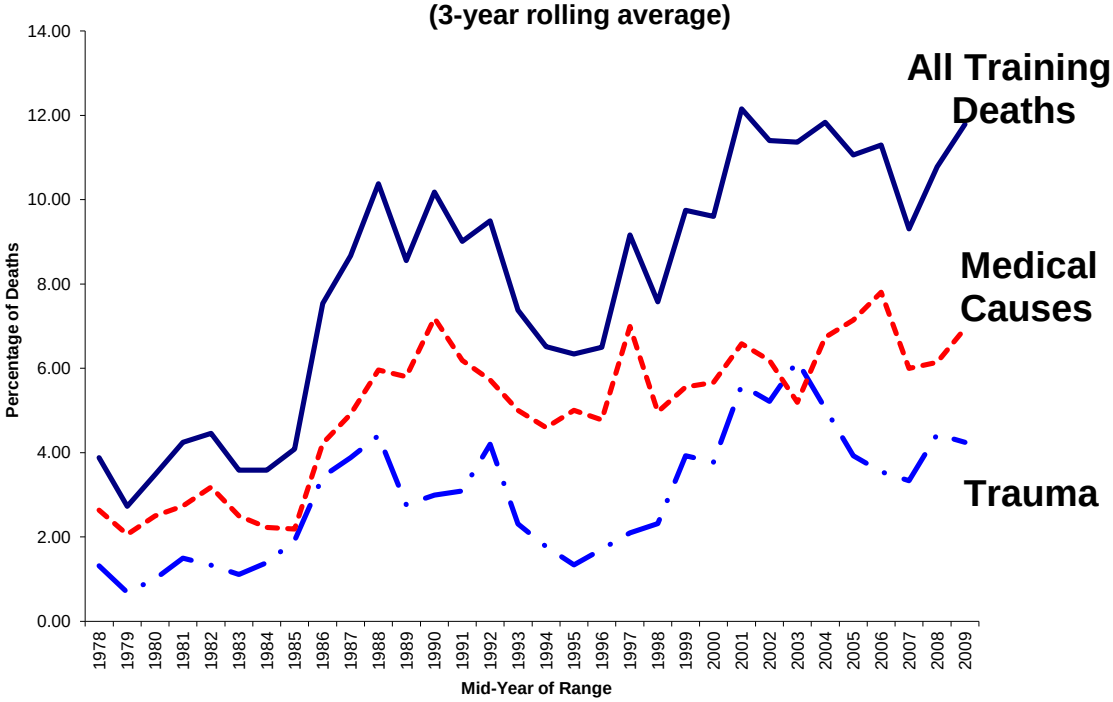

Figure 3
Training Deaths by Category

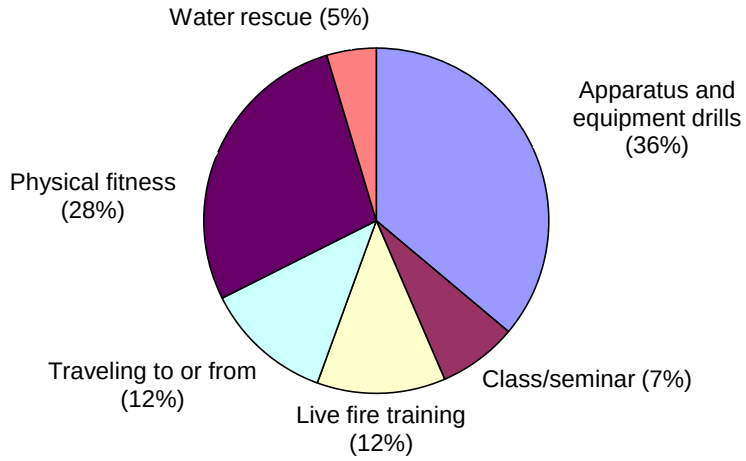

Figure 4
Cause of Fatal Injury

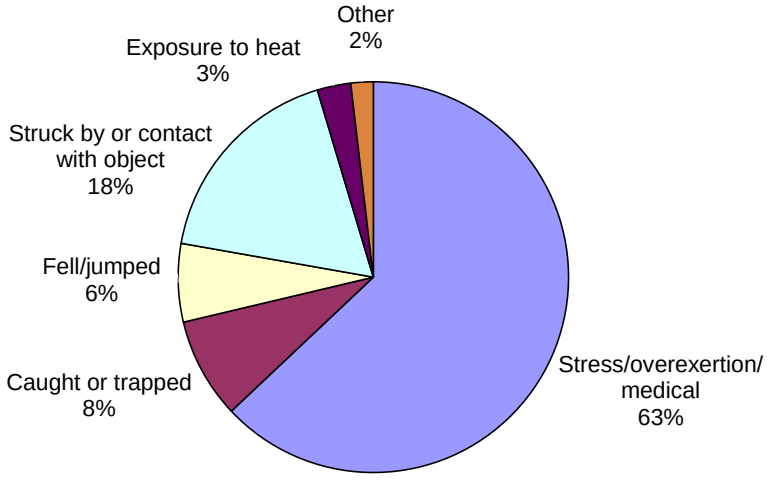

Figure 5 Nature of Fatal Injury

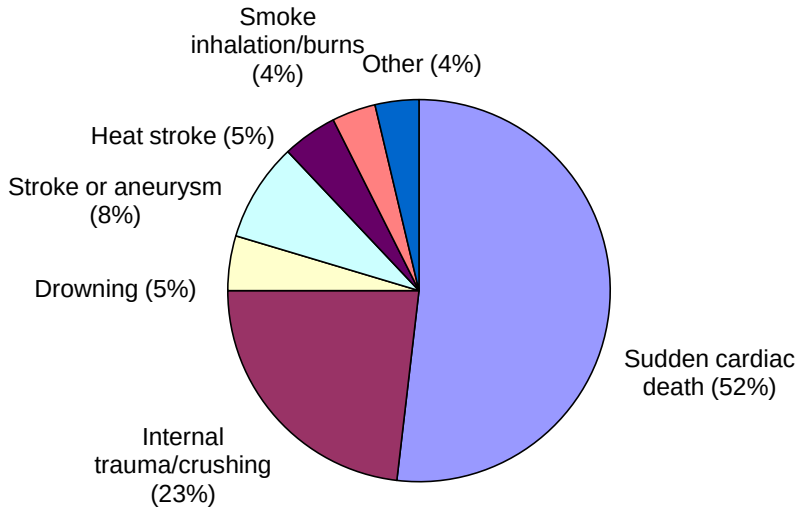

Figure 6
Training Deaths by Age and Cause of Death

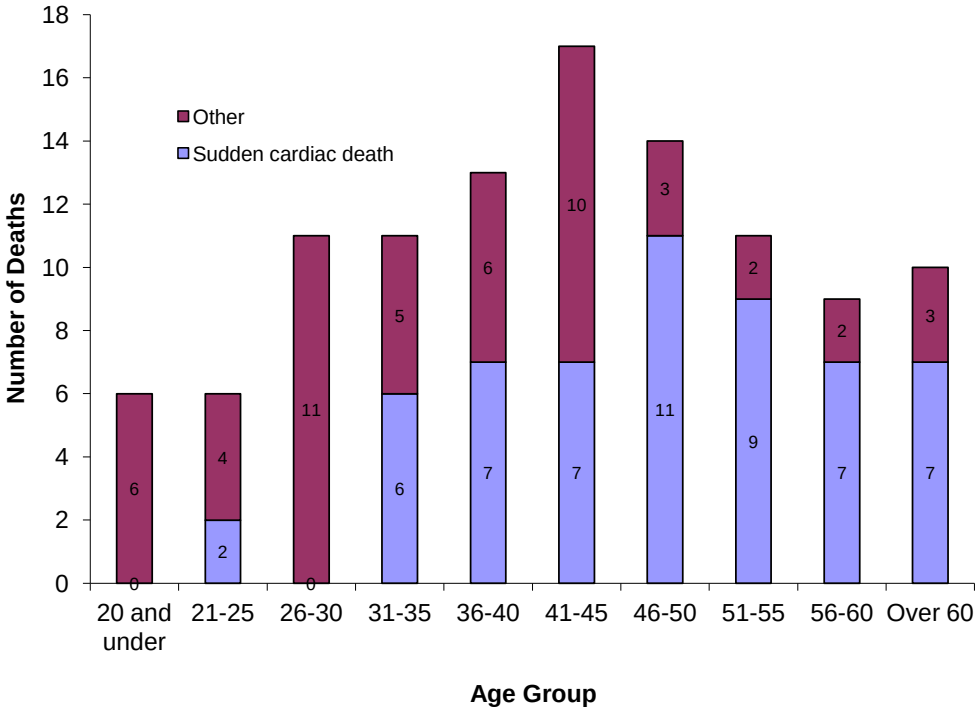

Figure 7
Death Rates for Training-Related Fatalities
per 100,000 Career and Volunteer Firefighters