

WHAT'S CHANGED OVER THE PAST 30 YEARS?

**Rita F. Fahy
Paul R. LeBlanc
Joseph L. Molis
Fire Analysis and Research Division
National Fire Protection Association**

June 2007



**National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471
www.nfpa.org**

For more information about the National Fire Protection Association, visit www.nfpa.org or call 617-770-3000. To learn more about the One-Stop Data Shop go to www.nfpa.org/osds or call 617-984-7450.

Copies of this analysis are available from:

National Fire Protection Association
One-Stop Data Shop
1 Batterymarch Park
Quincy, MA 02169-7471
www.nfpa.org
e-mail: osds@nfpa.org
phone: 617-984-7450

Copyright © 2007, National Fire Protection Association, Quincy, MA

Introduction

NFPA has published many articles on firefighter deaths over the years, but in 1977 a concentrated effort was made to identify all on-duty fatalities that had occurred in the previous year. Since then, NFPA has conducted an annual comprehensive study of on-duty deaths in the U.S. This marks the 30th year of this study, and provides a good opportunity to see how things have -- and, maybe, have not -- changed over the 30 years.

The average number of on-duty firefighter deaths to occur annually has dropped by one third over the past 30 years. In the late 1970's, an average of 151 firefighters were killed on duty annually. By the 1990's, that average had dropped to 97 deaths per year. So far in this first decade of the 21st century, the annual average has held steady at 99 deaths per year. There have been four years with firefighter death tolls below 90. In 2006, 89 firefighters died as a result of on-duty injuries.

There are two major forces driving this decrease in deaths. First is the drop in the number of on-duty fatalities annually attributed to sudden cardiac death. In the first five years of this study, an average of 65 such deaths occurred. In the most recent five years, the annual average dropped to 41. The other significant drop is in the number of deaths at fires. In the first five years, an average of 79 deaths occurred annually on the fire ground; 59 of those 79 deaths at fires involving structures. In the most recent five years, that number has dropped to an average of 34 deaths annually on the fire ground, with 22 of those deaths at structure fires. There is some overlap here, since a large share of the fatalities at structure fires each year were due to sudden cardiac death.

Deaths due to falls from apparatus, which claimed at least three deaths in most of the first 11 years, virtually disappeared in the 1990s. One such death has occurred in three of the past four years, however.

These and other trends will be discussed in more detail in this brief review of the past 30 years.

Sudden cardiac death

In the first five years of this study, an average of 65 on-duty fatalities each year were due to sudden cardiac death. In the most recent five years, the annual average dropped to 41. Sudden Cardiac Death is defined by the American Heart Association on their website (www.americanheart.org) as "the sudden, abrupt loss of heart function in a person who may or may not have diagnosed heart disease." The number of sudden cardiac deaths annually has fallen by approximately one third from the late 1970s; however, since the early 1990s, the number of deaths each year has tended to fluctuate between 40 and 50, with no clear trend up or down. There were 34 sudden cardiac deaths in 2006 -- the lowest number recorded over the 30 years of this study. (Figure 1)

The largest proportion of the victims experienced cardiac symptoms during fire ground operations (42.9 percent). The next largest proportion involved firefighters responding to or returning from alarms (25.3 percent). In its investigations of on-duty cardiac-related fatalities, NIOSH reports " Firefighting activities are strenuous and often require firefighters 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 to persist through the course of fire suppression activities."¹ A recent article in the *New England Journal of Medicine* looked at the risk of dying during specific fire department duties, and concluded that the risk of dying of coronary heart disease was 10 to 100 times higher during firefighting activities than during non-emergency fire-department duties.²

Deaths at structure fires

Since 1977, the number of U.S. firefighter deaths annually at structure fires has dropped 69 percent. In the late 1970s, an average of approximately 60 deaths occurred each year at structure fires. That number dropped to an average of 20 per year in the past three years. This finding has

¹ See, for example, "Report Number FACE-F2004-46, Fire fighter collapses and dies while assisting with fire suppression efforts at a residential fire," <http://www.cdc.gov/niosh/face200446.html> The NIOSH studies cite Barnard RJ, Duncan HW [1975]. Heart rate and ECG responses of fire fighters. *J Occup Med* 17:247-250

² Stefanos N. Kales, M.D., M.P.H., Elpidoforos S. Soteriades, M.D., Sc.D., Costas A. Christophi, Ph.D., and David C. Christiani, M.D., M.P.H., "Emergency Duties and Deaths from Heart Disease among Firefighters in the United States," *New England Journal of Medicine*, Vol. 356, No. 12, 2007, pp. 1207-1215.

often been credited to improvements in protective clothing and equipment, fire ground command and control procedures, and training, and although those changes certainly played a role, little attention has been paid to the drop in the number of structure fires themselves. Figure 2 compares the number of structure fires and the number of deaths at structure fires over the 30-year period. While deaths at structure fires has dropped 69 percent, the annual number of structure fires declined by 53 percent.³ To what degree then has the decrease in firefighter deaths been driven by the drop in the number of structure fires?

This comparison of the decline in the number of structure fires and the decrease in the number of firefighter deaths at structure fires shows that the trends track fairly closely, indicating that the drop in deaths may have been, to a great degree, a result of the reduction in the number of fires. This leads to an important second question: how has the *rate* of deaths at structure fires trended over the same period? In other words, are firefighters just as likely to die at structure fires today as they were 25 or 30 years ago?

In order to smooth out the year-to-year fluctuations in the number of deaths, Figure 3 displays a comparison of the number of structure fires and the *rate* of firefighter deaths at structure fires using a rolling three-year average. Increases in death rates can result in either of two ways: if the number of deaths increases while the number of fires stays the same or decreases, rates will rise. If the number of deaths stays the same, while the number of fires decreases, rates will also rise (e.g., more deaths will occur, per fire). In the same way, rates can decrease either when the number of deaths drops while the number of fires stays the same or increases, or if the number of fires increases while the number of deaths stays the same. When both number of fires and number of deaths move in the same direction, the rate of deaths per fire can remain relatively flat.

The mid-point of each three-year range is shown at the bottom of the graph. The rate of firefighter deaths at structure fires in the late 1990s was roughly the same as the rate in the late 1970s. Since 1999, however, the death rate at structure fires has dropped steadily, to

³ Karter, M.J., "U.S. Fire Loss for 2005," *NFPA Journal*, Vol. 100, No. 5, pp. 46-51 (2006). The number of structure fires in 2006 is estimated from the totals between 2003 and 2005.

approximately 4.0 deaths per 100,000 structure fires over the last three years (2004 through 2006), while the number of structure fires has plateaued.

Given the improvements in personal protective clothing and equipment, training and fire ground command and control over the past three decades, what is the cause of these deaths, and are there any areas where deaths are increasing? A review of the data shows that the rate of sudden cardiac deaths at structure fires has been dropping since the early 1980s. Sudden cardiac deaths at structure fires occurred at the rate of 2.6 deaths per 100,000 fires in the late 1970s and dropped to 1.3 deaths per 100,000 structure fires in the most recent three-year period. The rate of non-cardiac fatalities *outside* at structure fires dropped as well, since the mid-1980s, but rose again over the past few years. The rate of these fatalities fell to a low of 0.4 deaths per 100,000 structure fires, after reaching a peak of 1.7 in the mid-1980s, but has risen recently to 0.7 deaths per 100,000 structure fires. (Figure 4) The five most frequent causes of these fatal injuries over the years were struck by structural collapse (38.6 percent), caught in explosions (17.3 percent), falls (11.8 percent), struck by vehicles (8.2 percent) and electrocution (6.4 percent).

The one area that had shown marked increases during the period is the rate of deaths due to traumatic injuries while operating *inside* structures. In the late 1970s, traumatic deaths inside structures occurred at a rate of 1.8 deaths per 100,000 structure fires and by the late 1990s had risen to approximately 3.0 deaths per 100,000 structure fires. Since that time, the rate has fallen, and now stands at 1.9 deaths per 100,000 structure fires, a rate only slightly lower than that observed in the early 1980s. Almost all of these non-cardiac fatalities inside structure fires were the result of smoke inhalation (62.1 percent), burns (19.1 percent) and crushing or internal trauma (16.5 percent).

In order to reduce the number of deaths of firefighters operating inside structure fires, it is crucially important to understand how they are happening. A detailed look at each incident is beyond the scope of this analysis, but the National Institute for Occupational Safety and Health (NIOSH) has a program of on-site data collection and investigation of on-duty firefighter fatalities that provides a valuable database. Reports on many of the most recent fatalities can be found on their website: www.cdc.gov/niosh/firehome.html. A further review of the NFPA data since 1977 will be completed during the summer.

Deaths related to wildland fires

The largest share of fire ground deaths in 2006 occurred on wildland fires (16 deaths). This is only the second time in the 30-year period that wildland fires accounted for the largest share of fire ground deaths. (The previous time was in 1999.) Just as the severity of the wildland fire season varies from year to year, the number of firefighters deaths can vary widely, as shown in Figure 5. Over the 30-year period, the number of firefighter killed on wildland fires has ranged from a low of six in 1982 to a high of 33 in 1994, the year 14 firefighters were killed on the South Canyon fire. In contrast to 1994, the deaths in 1999 occurred in 24 separate incidents, the most severe of which were two fires that each killed two firefighters. A total of 338 firefighters were killed on wildland fires over the 30-year period.

Besides the deaths on the fire ground, an additional 138 firefighters died while responding to and returning from wildland fires. In 2003, 15 firefighters died while traveling to or from fires, including one incident where eight firefighters were killed when their van crashed while they were on their way home. In two other years, 1984 and 1994, 10 firefighters died while responding to or returning from wildland fires.

Wildland fires frequently claim a large number of lives in a single incident. Besides the South Canyon fire, there have been eight fires that killed four or more firefighters, most recently the Esperanza fire in California in 2006 that killed five firefighters.

There is no clear trend in wildland fire deaths over the past year, except when looking at deaths in aircraft crashes (see Figure 6). These deaths, which have occurred both during firefighting operations and while responding to or returning from the fire ground, have been increasing. The increase in crashes is due, to some degree, to the increased use of aircraft in wildland firefighting over the years.

Almost half of the victims of wildland fires were volunteer firefighters (45.2 percent), followed by contractors for state and federal land management agencies (17.0 percent), employees of federal land management agencies (16.8 percent), and employees of state land management agencies (9.8 percent). The remaining victims were career firefighters (6.2 percent), members or

supervisors of prison inmate crews (3.3 percent) or military or industrial firefighters (1.7 percent).

Deaths in road vehicle crashes

Deaths in road vehicle crashes over the past 30 years are shown in Figure 7. Crashes consistently account for the second largest share of firefighter deaths, overall. These crashes occurred during all types of on-duty assignments, not just while responding to or returning from alarms. Three quarters of the victims in these crashes were volunteer firefighters. Fourteen percent were career firefighters and the remaining victims were contractors for, or employees of, state and federal land management agencies. More than one third of the deaths involved firefighters' personal vehicles (37.7 percent). Another 22.7 percent occurred in crashes involving water tenders (tankers) and 21.7 percent involved engines or pumpers. Of the 406 victims, 76 percent were known to not be wearing seatbelts or using restraint systems. Only 13.3 percent were wearing seatbelts or using other restraints. Excessive speed for road conditions is a frequently cited cause of these fatal crashes, as are operator error, including failure to stop at traffic signals and train tracks. Poor maintenance has been a factor in some of the crashes.

Obedying traffic laws, using seat belts, driving sober and controlling driving speeds would prevent most of the firefighter fatalities in road crashes each year. Two NFPA standards are available to help fire departments establish safe driving programs: NFPA 1002, *Standard on Fire Apparatus Driver/Operator Professional Qualifications*, and NFPA 1451, *Standard for a Fire Service Vehicle Operations Training Program*. NFPA 1002 identifies the minimum job performance requirements for firefighters who drive and operate fire apparatus, in both emergency and nonemergency situations. NFPA 1451 provides for the development of a written vehicle operations training program, including the organizational procedures for training, vehicle maintenance, and identifying equipment deficiencies. In addition, *NFPA 1911, Standard for the Inspection, Testing, Maintenance, and Retirement of In-Service Automotive Fire Apparatus*, details a program to ensure that fire apparatus are serviced and maintained to keep them in safe operating condition.

Falls from apparatus while responding to or returning from alarms

From 1977 through 1987 (11 years), a total of 41 career or volunteer firefighters died, at least 3 each year except for 1979, when they fell from apparatus while responding to or returning from alarms. (See Figure 8.)

In 1987, the first edition of NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, was issued with requirements that all firefighters riding on fire apparatus be seated and belted any time the apparatus is in motion. That same year, a Tentative Interim Amendment to NFPA 1901, *Standard for Automotive Fire Apparatus*, required the provision of seats and seatbelts for the maximum number of persons who are going to ride on the apparatus. NFPA 1901 was extensively revised in 1991, including a new requirement for total enclosure of driver and crew areas on apparatus.

Although it cannot be specifically credited to these changes in the standards, no such deaths occurred from 1992 through 1998. Over the past eight years (1999 through 2006), a total of four such deaths occurred. Three of the four deaths involved apparatus built before 1991 (two of which were reserve pieces). The fourth vehicle was a reserve piece built in 1998. None of the four victims was using available seatbelts.

One of the vehicles, an open-cab ladder truck built in 1965, had been modified in 1991, adding an additional forward-facing jumpseat on each side of the apparatus in the crew riding area behind the driver and officer, to eliminate the practice of riding on the back step, and replacing the personnel bar in the jumpseat area with a locking gate across the entrance to the seating area. Seatbelts were installed in all riding positions, but they were not large enough to accommodate firefighters wearing full protective clothing. The victim was standing in the jumpseat area and fell when the truck rounded a turn after leaving the station. In the second incident, a firefighter riding in the jump seat of a 1989 canopy-cab apparatus may have released her seatbelt to retrieve her hearing protection, and fell out of the vehicle as it made a turn. The vehicle had no safety gates or bars. In the third incident, a firefighter fell from the jump seat area of a 1976 canopy-cab apparatus that had been modified in 2001 when half-style doors with slam-type latches were installed at the entrances to the jump seat areas. The victim may have been standing, donning his

gear, when he fell from the apparatus. Investigators believe the lock on the door was not engaged.

An enclosed crew-riding area does not guarantee protection. In the fourth incident, a firefighter riding in a 1998 quint was not wearing his seatbelt, and investigators believe he was donning his air pack as the quint entered a turn. As the vehicle turned, the passenger door opened, and the victim fell out when he reached out to close the door. The seatbelt monitoring system in the fire apparatus was not functioning and at least one of the seat sensors had been disabled.

All four of these incidents were investigated by NIOSH. The conclusions and recommendations in the four reports are similar:

- Fire departments should ensure, when feasible, that each crew riding position is within a fully enclosed personnel area.
- Fire departments should ensure that the emergency fire apparatus are equipped and functional to provide adequate safety for the riders and drivers/operators, and all seating areas, including seat belts and doors, are inspected during routine maintenance checks and that safety concerns are documented and addressed.
- Fire departments should ensure that all interior crew and driving compartment door handles are designed and installed to protect against inadvertent opening.
- Fire departments should consistently enforce and repeatedly train members on standard operating procedures/guidelines (SOPs/SOGs) that require all persons responding in emergency vehicles to be secured by seat belts or safety restraints at all times the vehicle is in motion.
- Fire departments should ensure that the donning or doffing of equipment and personal protective clothing that requires removal of any personal restraining device is prohibited while the vehicle is in motion.

Deaths during training activities

Deaths during training activities accounted for 7.4 percent of all on-duty firefighter fatalities over the past 30 years. The disturbing fact is that firefighter deaths during training are particularly needless, as the purpose of training is to *prevent* deaths and injuries and should certainly not be

the cause of casualties. The total number of training-related deaths in a year have ranged from a low of three to as many as 17. (See Figure 9.) In the past 10 years, almost twice as many training deaths occurred as in the first 10-year period (102 deaths between 1997 and 2006 vs. 54 deaths between 1977 and 1986). Figure 10 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.)

A detailed review of training deaths was published last year, so only a few points will be re-stated here. The largest shares of training-related deaths occurred while the victims were participating in apparatus and equipment drill and while firefighters were taking part in physical fitness training. Just over half of the firefighters who died while training died due to cardiac events. Traumatic injuries, smoke inhalation and drowning were the next three major causes of death.

Summary

A review of the almost 3,400 on-duty firefighter fatalities that have occurred in the U.S. between 1977 and 2006 shows some areas where significant improvements have occurred, and highlighted areas where much work remains to be done. The average number of deaths annually has dropped by more than one-third, falls from apparatus during responses have almost been eliminated, heart attack deaths are down by a third, and improvements in everything to protective equipment to emergency medicine have reduced deaths at structure fires. However, preventable problems such as the health issues that result in increased risk of heart attack and stroke contribute to making sudden cardiac death the number one cause of on-duty firefighter deaths. Preventable deaths such as road crashes where seatbelts were not used, and training deaths where adequate precautions were not taken, continue to occur.

Snapshots of the changes over the years

- The average number of firefighter deaths to occur annually has dropped by one third over the past 30 years.

- Deaths due to falls from apparatus, which claimed at least three deaths in almost all of the first 11 years, virtually disappeared in the 1990s, but have reoccurred in recent years.
- On-duty sudden cardiac deaths have dropped by more than one third, but remain the number one cause of on-duty firefighter deaths.
- Crashes continue to be the second leading cause of on-duty fatalities, and there has been no sustained trend up or down for such deaths. The victims are mainly volunteer firefighters, and personal vehicles and tankers are the types of vehicle most frequently involved.
- More training deaths occurred in the last decade than in the first 10 years, which may be due to more training activities underway today. Over half were due to sudden cardiac death.

Figure 1
U.S. On-Duty Firefighter Fatalities
Due to Sudden Cardiac Death
1977 - 2006

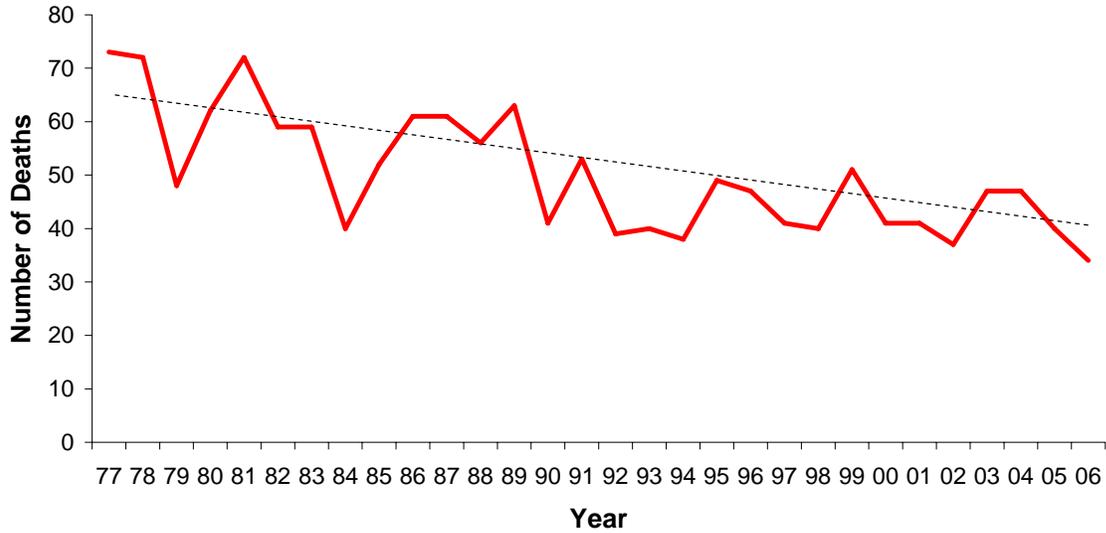


Figure 2
The drop in firefighter deaths at structure fires
follows, and recently surpasses, the drop in structure fires.

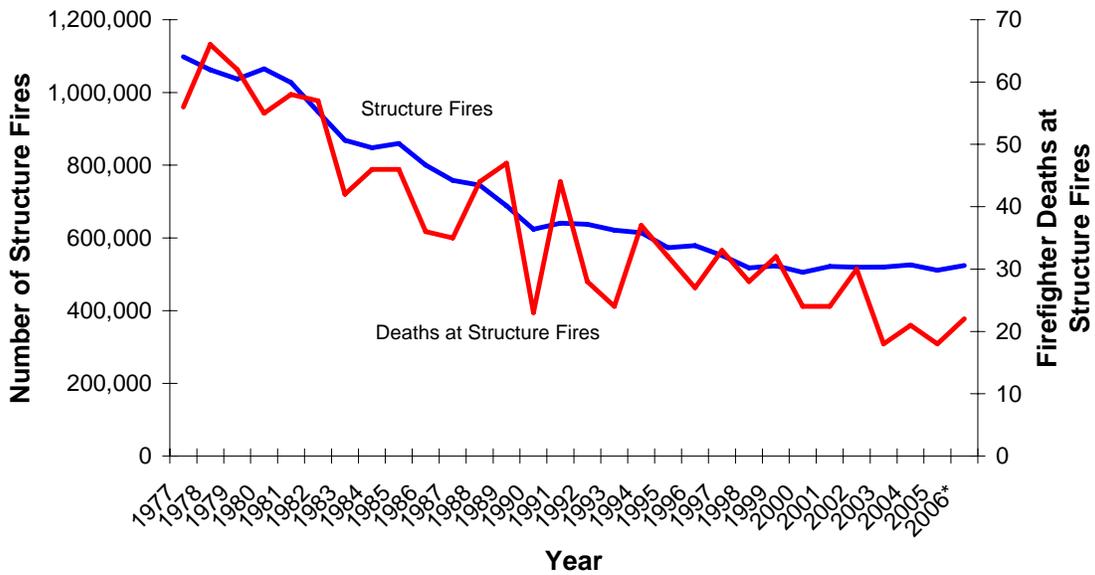


Figure 3
While the number of structure fires and deaths at structure fires has dropped, the rate of firefighter deaths at structure fires has not dropped as much.

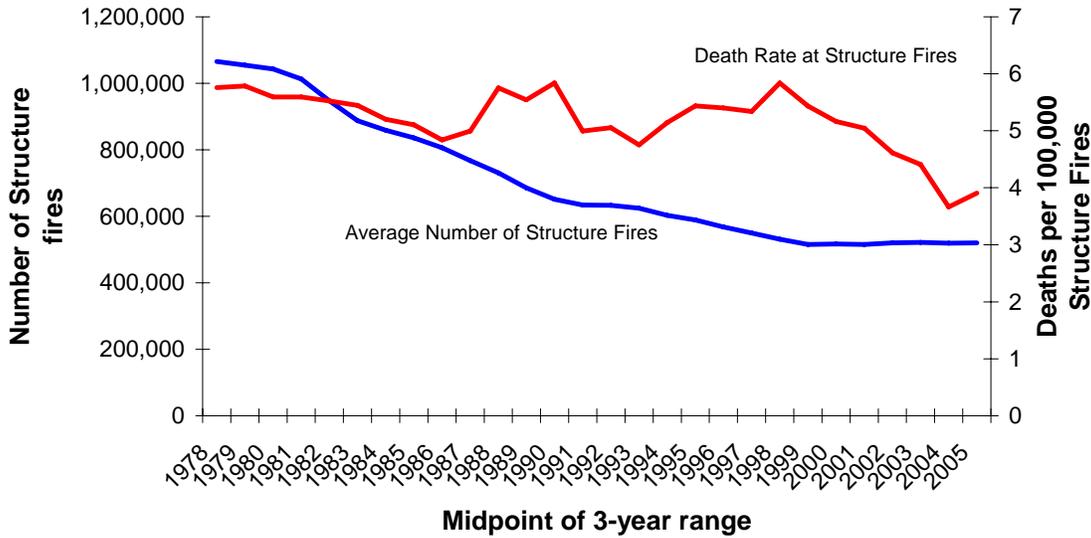


Figure 4
Death Rates for Firefighters at Structure Fires by Location and Nature of Fatal Injury

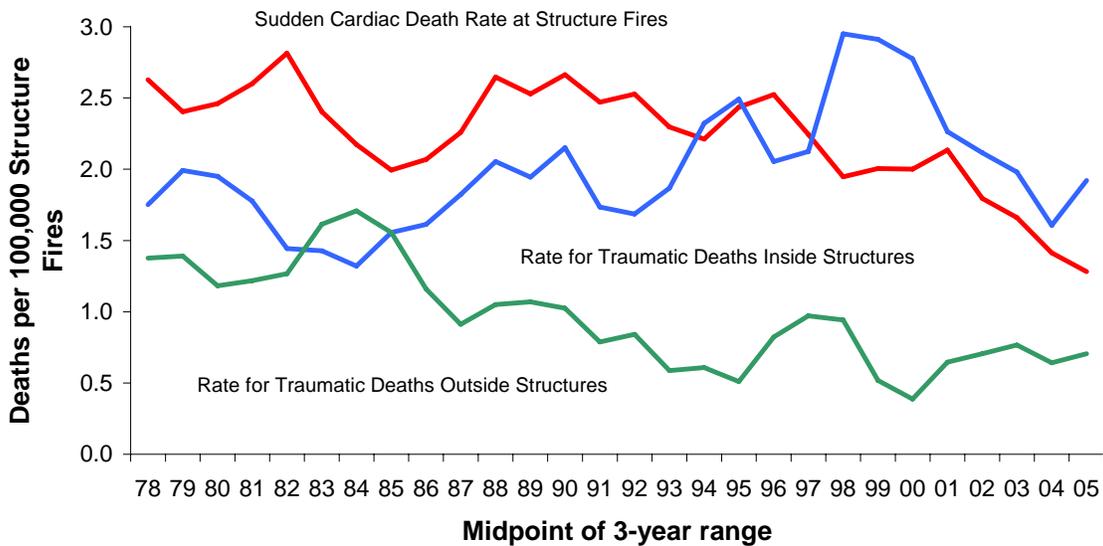


Figure 5
Fatal Wildland Fires and Associated Firefighter Deaths
1977 - 2006

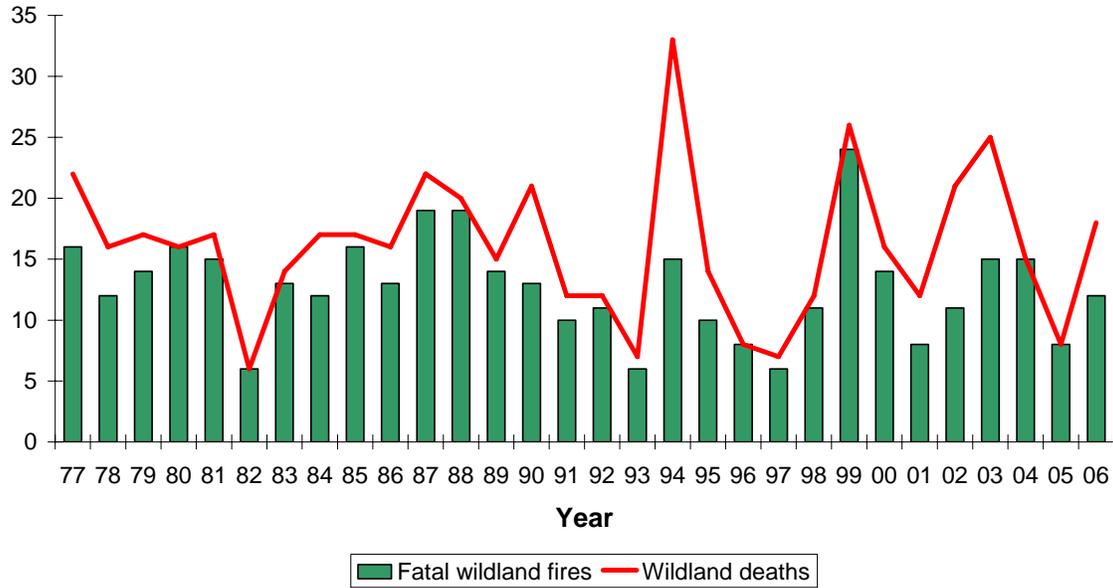


Figure 6
Firefighter Deaths in Aircraft Crashes
Related to Wildland Fires

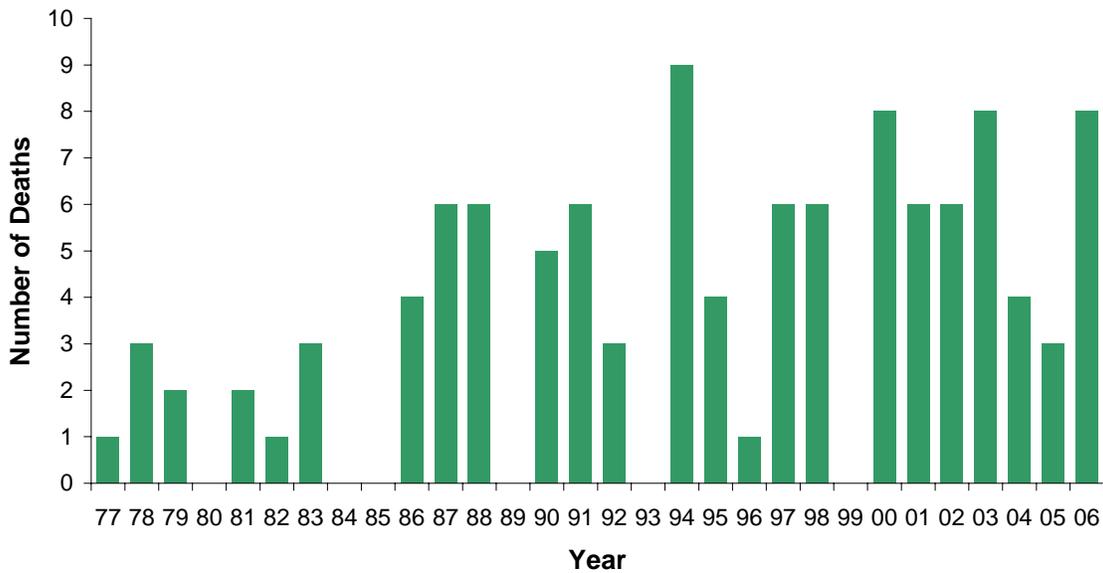


Figure 7
On-Duty Firefighter Deaths in Road Vehicle Crashes
1977 - 2006

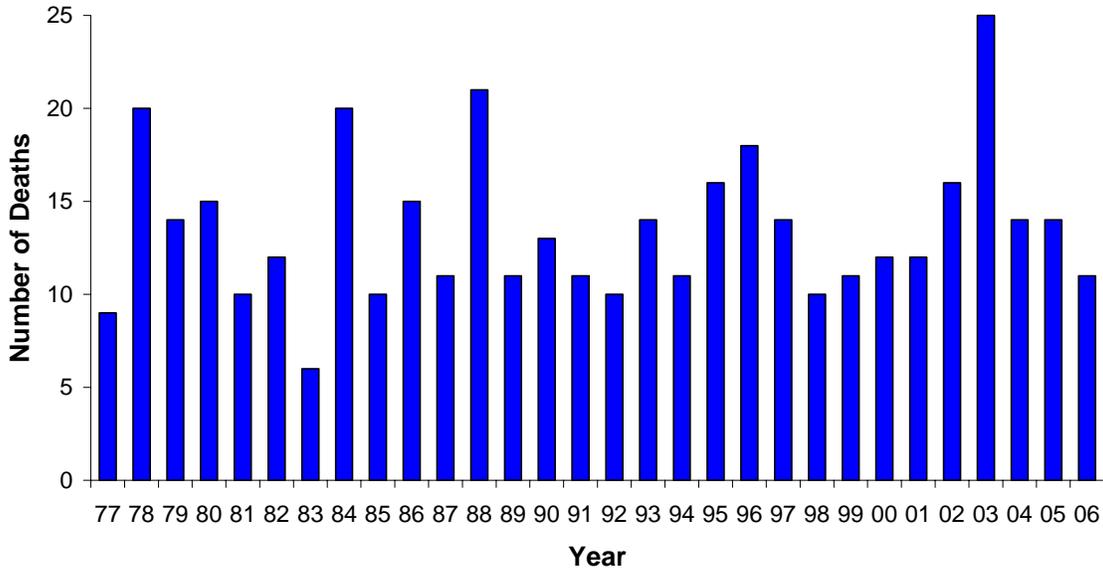


Figure 8
Deaths of Career and Volunteer Firefighters
Resulting from Falls from Apparatus
While Responding to or Returning from Alarms

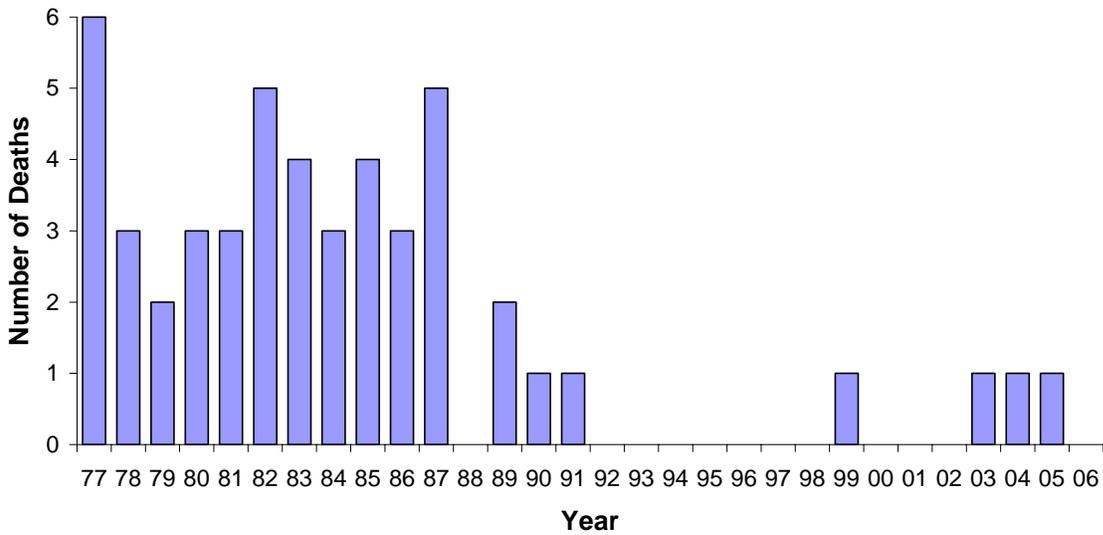


Figure 9
Deaths of U.S. Firefighters during Training
1977 - 2006

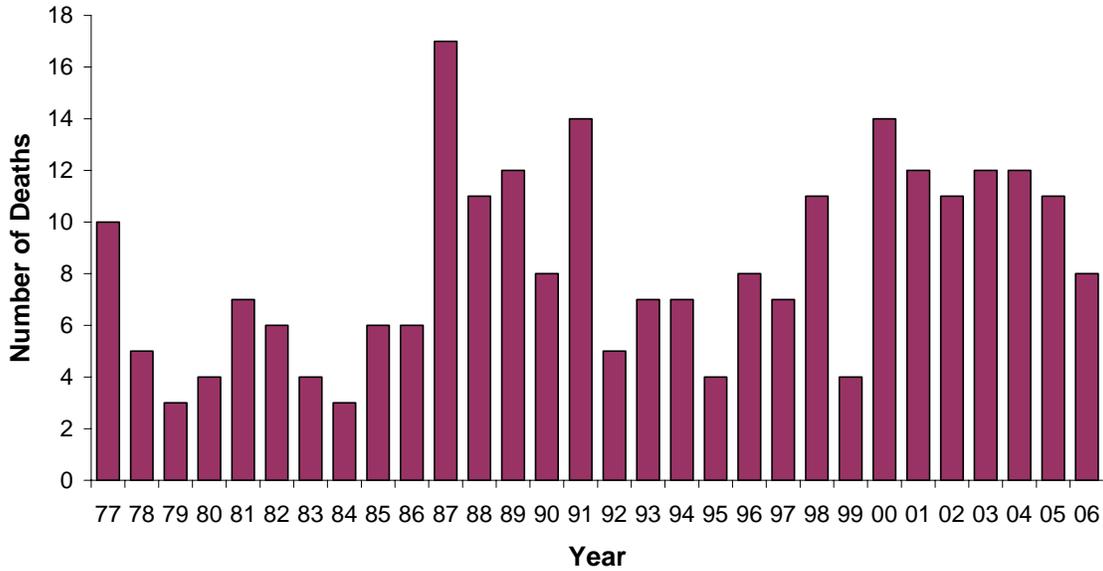


Figure 10
Proportion of Training-Related Deaths Annually
(3-year rolling average)

