Smoke Alarms in U.S. Home Fires

Marty Ahrens

September 2011

National Fire Protection Association
Fire Analysis and Research Division

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Abstract

Almost all households in the U.S. have at least one smoke alarm, yet in 2005-2009, smoke alarms were present in less than three-quarters (72%) of all reported home fires and operated in half (51%) of the reported home fires. ("Homes" includes one- and two-family homes, apartments, and manufactured housing.) More than one-third (38%) of all home fire deaths resulted from fires in homes with no smoke alarms, while one-quarter (24%) resulted from fires in homes in which smoke alarms were present but did not operate. The death rate per 100 reported fires was twice as high in homes without a working smoke alarm as it was in home fires with this protection. Hardwired smoke alarms are more reliable than those powered solely by batteries.

These estimates are based on data from the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's (NFPA's) annual fire department experience survey.

Keywords: fire statistics, home fires, residential fires, smoke alarms, smoke detectors

Acknowledgements

The National Fire Protection Association thanks all the fire departments and state fire authorities who participate in the National Fire Incident Reporting System (NFIRS) and the annual NFPA fire experience survey. These firefighters are the original sources of the detailed data that make this analysis possible. Their contributions allow us to estimate the size of the fire problem. We are also grateful to the U.S. Fire Administration for its work in developing, coordinating, and maintaining NFIRS.

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National Fire Protection Association
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Executive Summary

Smoke alarms have become such a common feature in U.S. homes that it is easy to take them for granted. Newspapers often report fires in which blaring smoke alarms alerted sleeping occupants to danger. These devices alert countless others to fires just as they are starting. Recent telephone surveys, including 2008 and 2010 surveys conducted for NFPA by Harris and a Consumer Product Safety Commission's (CPSC's) 2004-2005 survey found that 96-97% of the surveyed U.S. households reported having at least one smoke alarm.

Almost two-thirds of home fire deaths resulted from fires in properties without working smoke alarms.
In 2005-2009, smoke alarms were present in almost three-quarters (72%) of reported home fires and sounded in half (51%) of the home fires reported to U.S. fire departments. Homes include one- and two-family homes, apartments or other multi-family housing, and manufactured housing. More than one-third (38%) of home fire deaths resulted from fires in which no smoke alarms were present at all. One-quarter (24%) of the deaths were caused by fires in properties in which smoke alarms were present but failed to operate. Smoke alarms operated in fires that caused roughly one-third (37%) of the deaths. One percent of the deaths resulted from fires that were too small to activate the smoke alarm.

Smoke alarm failures usually result from missing, disconnected, or dead batteries.
When smoke alarms should have operated but did not do so, it was usually because batteries are missing, disconnected or dead. People are most likely to remove or disconnect batteries because of nuisance activations. Sometimes the chirping to warn of a low battery is interpreted as a nuisance alarm.

Half of the households surveyed in a 2010 Harris Poll done for NFPA reported they had smoke alarms in their kitchen. Two out of every five (43%) households reported their smoke alarms had gone off at least once in the past year. Almost three-quarters (73%) said the activation was due to cooking. Eight percent mentioned low battery chirps.

If a smoke alarm in the kitchen is sounding too often, the problem could be solved by moving the smoke alarm. Unless designed specifically for the area, all smoke alarms should be at least 10 feet away from cooking appliances. If space requires you to have a smoke alarm within 10-20 feet of the kitchen stove, install either a photoelectric alarm or an alarm with a hush feature that can be temporarily silenced without disabling the alarm. Smoke alarms should be tested at least once every month to ensure that both the batteries and the units themselves are still working. Replaceable batteries should be replaced in accordance with the manufacturer's instructions, at least once every year.

In one-fifth of all homes with smoke alarms, none were working.
In 1992, the U.S. Consumer Product Safety Commission (CPSC) sent surveyors to people's homes to find out how common smoke alarms were and what portion of these devices were working in the general population's homes. In one of every five homes that had at least one smoke alarm installed, not a single one was working. Including homes without smoke alarms and homes with only non-working alarms, one-

quarter of U.S. households do not have the protection of even one working smoke alarm. In follow-up visits after smoke alarm installation programs, typically a substantial portion of the installed alarms were not working. Unfortunately, the 1992 CPSC study with home visits and smoke alarm tests, has not been done again at a national level.

Most homes do not yet have the protection recommended in recent editions of NFPA 72®.
Both the 2007 and 2010 editions of NFPA 72®, *National Fire Alarm and Signaling Code®* require smoke alarms in every bedroom, outside each sleeping area, and on every level. They should also be interconnected so that when one sounds, they all sound. New homes should have hardwired smoke alarms. Most homes do not yet have this level of protection. A 2010 Harris Interactive survey done for the NFPA found that roughly two out of every five households had smoke alarms in all bedrooms. Only one-quarter of all homes had interconnected smoke alarms.

Most homes still have smoke alarms powered by batteries only.
In the 2009 *American Housing Survey* (AHS), almost two-thirds (65%) of the respondents who reported having smoke alarms said their alarms were powered by batteries only, slightly more than one-quarter (28%) said their alarms were powered by electricity and batteries, and 8% had alarms powered by electricity only. For many years, NFPA 72® has required smoke alarms in new construction to be hardwired with battery backup. Yet the AHS found that in more than one-third (36%) of homes less than five years old that had working smoke alarms, the smoke alarms were powered by battery only. The death rate per 100 reported fires is twice as high in fires with smoke alarms powered by batteries as it is in fires with hardwired smoke alarms. To be effective, the codes must be adopted and enforced.

CPSC found that households that had fires had somewhat less smoke alarm protection.
The CPSC's *2004-2005 National Sample Survey of Unreported Residential Fires* asked about all fires, including incidents that were not attended by the fire service. Based on respondents' reports, 82% of the households that had unreported fires and 84% of non-fire households had smoke alarms on every level. Less than one-quarter (22%) of fire households had smoke alarms in all bedrooms. In contrast, almost one-third (31%) of non-fire households had the devices in all bedrooms. Thirteen percent of the fire households and 19% of the non-fire households had interconnected smoke alarms.

CPSC study also showed how important interconnected smoke alarms were in providing early warnings.
When interconnected smoke alarms were present, they operated in half (53%) of the incidents and provided the only alert in one-quarter (26%) of the fires. When the smoke alarms were *not* interconnected, they operated in only one-quarter (27%) of the fires and provided the only alert in 8%. In many cases, people are in the room or nearby when a fire starts and notice it before the smoke alarm sounds. In cases where the smoke alarms provided the only alert, the occupants had not been aware of the fire until the smoke alarm sounded. When smoke alarms did not operate, it was typically reported that smoke did not reach the alarm.

People 55 or older were more likely to have smoke alarms that were more than 10 years old.
NFPA has long recommended that smoke alarms be replaced every ten years. The previously mentioned 2010 Harris Interactive survey found that among households with smoke alarms, 12% of respondents of all ages and 17% of those at least 55 years old reported that their smoke alarms were more than ten years old.

A 2008 Harris survey, also done for NFPA, asked for perceptions of how often smoke alarms should be replaced. Only 12% reported that smoke alarms should be replaced every 10 years. One-third (35%) simply did not know or refused to answer the question. Four percent thought these devices never need replacing. Roughly two in five believe that smoke alarms should be replaced at least every 4-6 years, if not more often. Some of the confusion about how often smoke alarms should be replaced is likely due to different recommendations for replacement schedules of devices that detect smoke *and* carbon monoxide. Manufacturers of carbon monoxide alarms and combination smoke/carbon monoxide alarms often recommend more frequent replacement.

Fire Protection Research Foundation study found that strobe lights, used alone, were ineffective in waking people who were hard of hearing.
The Fire Protection Research Foundation studied the waking effectiveness of different types of alarm signals for various high risk groups. The authors of the 2007 report found that a loud low frequency square wave auditory signal was most effective in waking those with moderate to severe hearing loss. This signal performed better than bed or pillow shakers and strobe lights. Strobe lights, when used alone, were not effective in waking this population. The 2010 edition of NFPA 72®, *National Fire Alarm and Signaling Code*, requires audible notification appliances used in bedrooms for those with mild to severe hearing loss to produce a low frequency signal. Another new provision requires tactile notification appliances in addition to strobes for individuals with profound hearing loss. These provisions will take effect immediately upon adoption of the new code.

Progress has been made but more work is needed.
The households with smoke alarms that don't work now outnumber the households with no alarms by a substantial margin. Any program to ensure adequate protection must include smoke alarm maintenance. In the 2010 Harris poll, only one in five respondents reported testing their smoke alarms at least once a month. Although most homes have at least one smoke alarm, many homes do not have a unit on every floor. It is easy to forget that a smoke alarm's sole function is to sound the warning. People need to develop and practice escape plans so that if the alarm sounds, they can get out quickly. Because smoke alarms alert occupants to fires that are still relatively small, some people attempt to fight these fires themselves. Unfortunately, some of these attempts are unsuccessful due to either rapid fire spread or inappropriate methods of fire control. Meanwhile, precious escape time is lost.

Follow safety tips.
The Educational Messages Advisory Committee (EMAC) to NFPA's Public Education Division developed the following tips for the testing and maintenance of smoke alarms. A condensed list is below. Appendix C of this report contains additional tips with supporting material to explain and back-up the tips.

- Choose a smoke alarm that bears the label of a recognized testing laboratory.
- Install a smoke alarm in every bedroom, outside each sleeping area, and on every level of your home, including the basement.
- For the best protection, interconnect all smoke alarms throughout the home. When one sounds, they all sound.
- Replace all smoke alarms, including alarms that use 10-year batteries and hard-wired alarms, when they are 10 years old or sooner if they do not respond properly when tested.
- Test your smoke alarms at least every month, using the test button or an approved smoke substitute and clean the units, both in accordance with the manufacturers' instructions.
- Smoke alarms with non-replaceable (long-life) batteries are designed to remain effective for up to 10 years. If the alarm chirps, warning that the battery is low, replace the entire smoke alarm. For smoke alarms with any other type of battery, replace batteries at least once a year. If that smoke alarm chirps, replace only the battery.
- An ionization smoke alarm is generally more responsive to flaming fires and a photoelectric smoke alarm is generally more responsive to smoldering fires. For the best protection, or where extra time is needed to awaken or assist others, both types of alarms, or combination ionization and photoelectric alarms, are recommended

For safety tip sheets on a variety of topics, go to www.nfpa.org/safetytips. For all EMAC tips, go to www.nfpa.org/emac.

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Smoke Alarms in Reported U.S. Home Fires

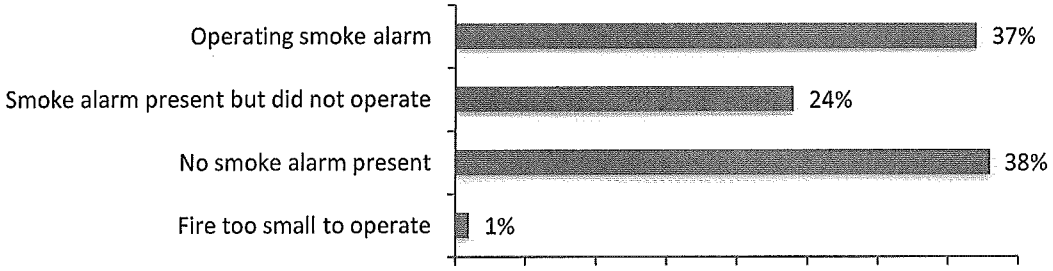
Ninety-six percent of all homes have at least one smoke alarm, according to a 2010 telephone survey. Overall, three-quarters of all U.S. homes have at least one *working* smoke alarm.

Smoke Alarm Presence and Performance

In 2005-2009, smoke alarms sounded in half of the home fires reported to U.S. fire departments.

- Almost two-thirds of home fire deaths resulted from fires in homes with no smoke alarms or no working smoke alarms.
  - No smoke alarms were present in more than one-third (38%) of the home fire deaths.
  - In one-quarter (24%) of the home fire deaths, smoke alarms were present but did not sound.

Home Structure Fire Deaths by Smoke Alarm Performance 2005-2009



Interconnected smoke alarms increase safety

in a Consumer Product Safety Commission (CPSC) survey of households with any fires, including fires in which the fire department was not called, interconnected smoke alarms were more likely to operate and alert occupants to a fire.[1] People may learn about or be alerted to a fire without hearing a smoke alarm.

- When smoke alarms (interconnected or not) were on all floors, they sounded in 37% of fires and alerted occupants in 15%.
- When smoke alarms were not on all floors, they sounded in only 4% of the fires and alerted occupants in only 2%.
- In homes that had interconnected smoke alarms, the alarms sounded in half (53%) of the fires and alerted people in one-quarter (26%) of the fires.

Michael A. Greene and Craig Andres. *2004-2005 National Sample Survey of Unreported Residential Fires.* U.S. Consumer Product Safety Commission, July 2009.

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Homes include one- and two-family dwellings, manufactured homes, apartments, townhouses, roughhouses, and condominiums.

Home Fires with Smoke Alarms

In reported home fires with smoke alarms:

- Half the alarms were powered by battery only.
- Two-thirds of the fatal fire injuries were caused by fires in homes with smoke alarms powered by battery only.

In fires considered large enough to activate the alarm,

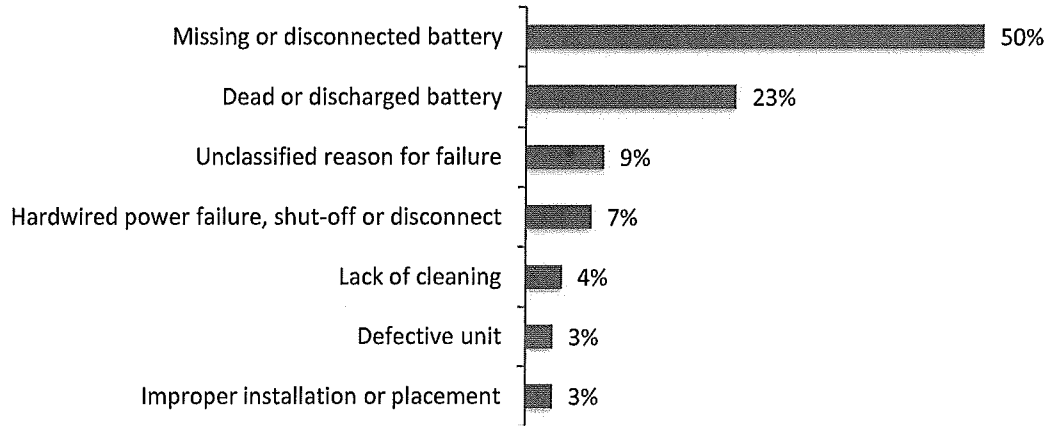
- Hardwired smoke alarms operated 92% of the time.
- Battery-powered smoke alarms operated in three-quarters (77%) of the fires.

Reasons that Smoke Alarms Did Not Operate

In reported home fires[1] in which the smoke alarms were present but did not operate,

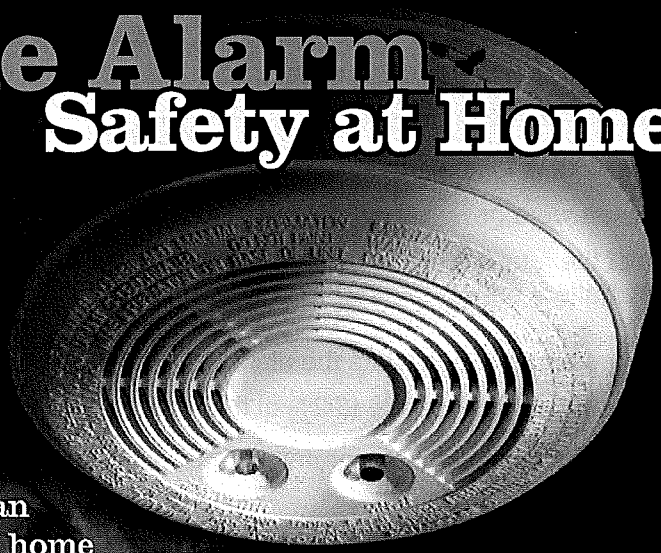
- Half of the smoke alarms had missing or disconnected batteries. Nuisance alarms were the leading reason for disconnected smoke alarms.
- Almost one-quarter (23%) of the smoke alarm failures was due to dead batteries.
- Only 7% of the failures were due to hardwired power source problems, including disconnected smoke alarms, power outages, and power shut-offs.

Reason Smoke Alarm Failed to Operate in Home Structure Fires 2005-2009



Little causal detail is required about certain categories of minor fires, identified by incident type and collectively called confined fires by the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS). Confined fires were omitted from calculations of the reasons for smoke alarm failure.

Smoke Alarm Safety at Home



Smoke alarms are an important part of a home fire escape plan. When there is a fire, smoke spreads fast. Working smoke alarms give you early warning so you can get outside quickly.

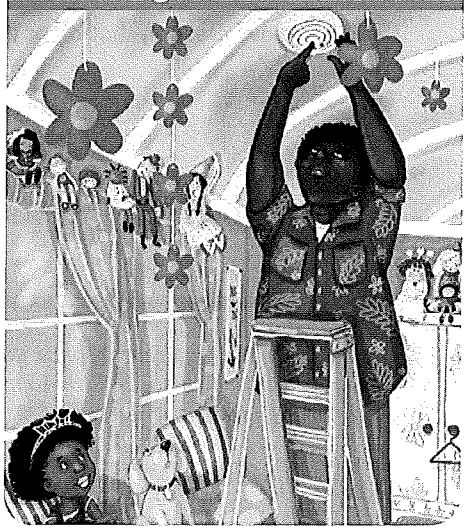
SAFETY TIPS

- INSTALL smoke alarms inside every bedroom, outside each sleeping area and on every level of the home, including the basement.
- Larger homes may need ADDITIONAL smoke alarms to provide enough protection.
- For the best protection, INTERCONNECT all smoke alarms so when one sounds they all sound.
- An IONIZATION smoke alarm is generally more responsive to flaming fires and a PHOTOELECTRIC smoke alarm is generally more responsive to smoldering fires. For the best protection, both types of alarms or combination ionization and photoelectric alarms (also known as dual sensor alarms) are recommended.
- Smoke alarms should be INSTALLED away from the kitchen to prevent false alarms. Generally, they should be at least 10 feet (3 meters) from a cooking appliance.
- REPLACE all smoke alarms when they are 10 years old.

FACTS

- Roughly **two thirds** of home fire deaths happen in homes with no smoke alarms or no working smoke alarms.
- Working smoke alarms cut the risk of dying in reported home fires in **half**.

AND DON'T FORGET...
All smoke alarms should be tested at least once a month using the test button.



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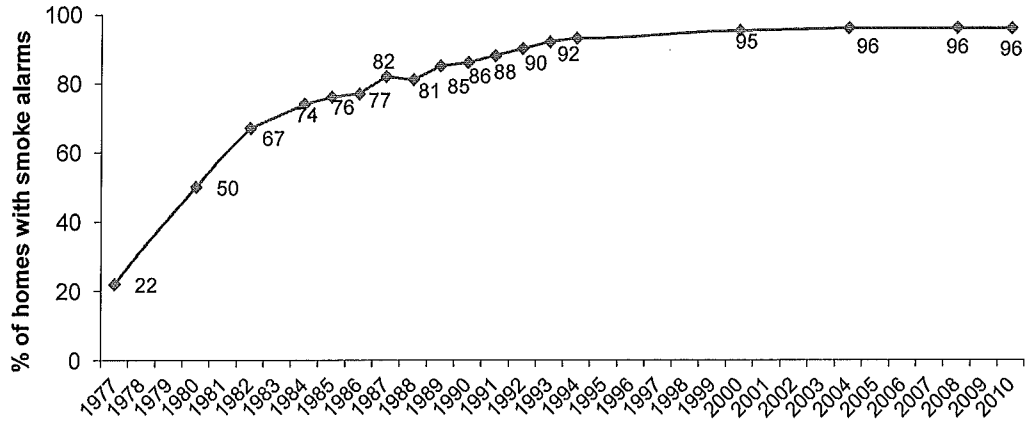
Home Smoke Alarm Presence and Performance

Presence and Operation in Fires

24 out of 25 homes surveyed by phone now have at least one smoke alarm.
In telephone surveys done for NFPA in 2004, 2008, and 2010, 96% of all households reported having at least one smoke alarm.[1] The growth in home[2] smoke alarm usage is shown in Figure 1. From 1977 to 1984, the use of home smoke alarms skyrocketed. Most of these smoke alarms were single-station, battery-operated, ionization-type devices. With this rapid growth in usage and the clear evidence from actual fire stories and fire statistics showing the life-saving effectiveness of these alarms, the home smoke alarm became the fire safety success story of the decade. The percentage of homes with at least one smoke alarm has hit a plateau at 96% in the three most recent phone surveys. Table 1 summarizes key results of the 2010 survey. Based on these results, almost five million households still do not have any smoke alarms.

Figure 1. Growth in Home Smoke Alarm Usage: 1977-2010



"Smoke alarms" are not the same as "smoke detectors."
The terminology used in this report conforms, as much as possible, to industry practices. Most homes have what we now call "smoke alarms." These units detect the presence of smoke and sound the alarm. Many properties, particularly some multi-family complexes and newer single-family homes, have smoke detectors that are components of an alarm system with a panel. The detection unit itself does not necessarily sound the alarm. Instead, the signal is transmitted to the control unit that then sounds the alarm throughout the premises. Older studies of smoke detectors usually studied devices that would now be called smoke alarms.

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[1] Sources for homes with smoke alarms: 1977, 1980, 1982 estimates from sample surveys from by the U.S. Fire Administration; 1983-1995 estimates from Louis Harris Surveys for *Prevention Magazine*; "1997 Fire Awareness Survey for NFPA;" "1999 NFPA National Fire Escape Survey;" "2004 Fire Prevention Week survey for NFPA; Harris Interactive, "Smoke Alarm Omnibus Question Report;" 2008; Harris Poll® National Quorum: "National Fire Protection Association -- Smoke Alarms," September 2010.

[2] The term home encompasses one- and two-family homes, including manufactured homes and apartments. Apartments include tenements, flats, and properties of similar configuration, regardless of ownership.

Methodology

Statistics about smoke alarm performance in reported U.S. fires were derived from NFIRS 5.0 and NFPA's fire department survey.
Unless otherwise specified, the statistics in this analysis are national estimates of fires reported to U.S. municipal fire departments and so exclude fires reported only to Federal or state agencies or industrial fire brigades. These estimates are projections based on the detailed information collected in Version 5.0 of the U.S. Fire Administration's National Fire Incident Reporting System (NFIRS 5.0) and the National Fire Protection Association's (NFPA's) annual fire department experience survey. Consequently, the terminology used to describe the detection equipment and circumstances found in reported fires is based on the NFIRS 5.0 coding choices used by fire officers to complete their incident reports.

NFIRS 5.0 includes a category of structure fires collectively referred to as "confined fires," identified by incident type. These include confined cooking fires, confined chimney or flue fires, confined trash fires, confined fuel burner or boiler fires, confined commercial compactor fires, and confined incinerator fires. For these incidents, the only detection question required in NFIRS 5.0 asks simply if the detection equipment alerted or did not alert occupants. However, this field does not indicate if a smoke alarm *or* occupants were even present. A yes or no answer as to the presence of detection equipment was provided in only 4% of confined home fires. The analyses of confined fires in the body of the report are based on the 4% (five-year total of 23,129 fires) of confined fires in which information about detection equipment presence was provided. In contrast, smoke alarm presence was known in 67% (five-year total of 429,769 fires, 3,880 civilian deaths, and 22,067 civilian injuries) of the non-confined fires. Smoke alarm operation, when alarms were known to be present, was known in 81% of the non-confined fires and 92% of the confined fires.

Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Property damage has not been adjusted for inflation. Fires are rounded to the nearest hundred, civilian deaths and injuries to the nearest ten, and direct property damage to the nearest million. Except for property use and incident type, fires with unknown or unreported data were allocated proportionally in calculations of national estimates. Additional details on the methodology and relevant NFIRS 5.0 forms may be found in Appendix A.

90% of the home fire detection devices were designed to detect smoke only.
Table 2 shows that smoke alarms or system-based smoke detectors were the type of fire detector reported in 90% of the home fires in which the type of fire detection was identified. An additional 6% used a combination of smoke and heat detection. In 2%, more than one type of detection equipment was present. Because home smoke alarms are so prevalent, the term "smoke alarm" is used as an all encompassing phrase throughout this report when describing early fire warning devices or systems. However, names of earlier studies have not been changed.

Smoke alarms were present and operated in half of all reported home fires.
The discussion that follows will focus on different aspects of Table A. Table A shows estimated annual averages of home fires reported to local fire departments in 2005-2009 by smoke alarm performance. Fire departments responded to an estimated average of 373,900 home structure fires per year during this five-year period.

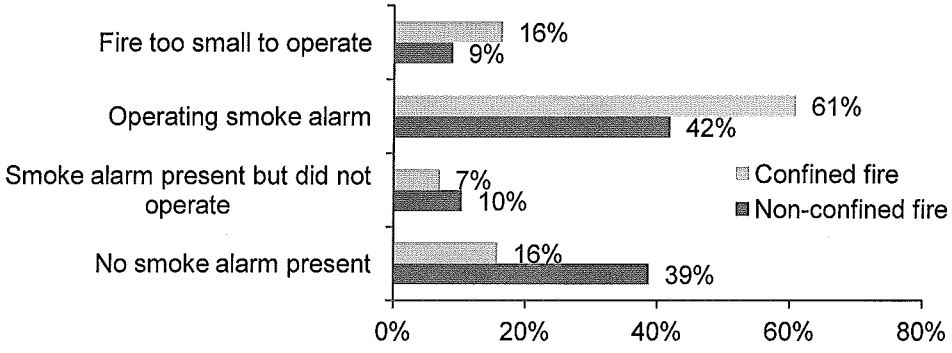
Table A.
Home Structure Fires by Smoke Alarm Performance
2005-2009 Annual Averages

Detection Performance	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Smoke Alarm Present	268,200	(72%)	1,640	(62%)	9,740	(76%)	$5,199	(73%)
Fire too small to operate alarm	46,100	(12%)	20	(1%)	650	(5%)	$142	(2%)
Fire too small to operate in non-confined fire	18,000	(5%)	20	(1%)	450	(3%)	$134	(2%)
Fire too small to operate in confined fire	28,100	(8%)	0	(0%)	210	(2%)	$7	(0%)
Smoke alarm present and fire large enough to operate alarm	222,100	(59%)	1,620	(61%)	9,080	(70%)	$5,058	(71%)
Smoke alarm operated	189,100	(51%)	980	(37%)	6,950	(54%)	$4,279	(60%)
Smoke alarm operated in non-confined fire	85,100	(23%)	980	(37%)	5,910	(46%)	$4,256	(60%)
Smoke alarm operated in confined fire	104,000	(28%)	0	(0%)	1,040	(8%)	$23	(0%)
Smoke alarm present but did not operate	33,000	(9%)	640	(24%)	2,130	(17%)	$779	(11%)
Smoke alarm present but did not operate in non-confined fire	21,100	(6%)	640	(24%)	1,870	(15%)	$776	(11%)
Smoke alarm present but did not operate in confined fire	11,900	(3%)	0	(0%)	260	(2%)	$3	(0%)
No Smoke Alarm	105,700	(28%)	1,000	(38%)	3,150	(24%)	$1,946	(27%)
No smoke alarm present in non-confined fire	78,700	(21%)	1,000	(38%)	2,930	(23%)	$1,939	(27%)
No smoke alarm present in confined fire	27,000	(7%)	0	(0%)	220	(2%)	$7	(0%)
Total	373,900	(100%)	2,650	(100%)	12,890	(100%)	$7,146	(100%)

Note: Sums may not equal totals due to rounding errors. Confined and non-confined fires were analyzed separately. Smoke alarm presence or absence was reported in 67% of non-confined fires and 4% of confined fires. Fires with unknown or missing data were allocated proportionally among fires with missing data.
Source: NFIRS 5.0 and NFPA survey.

Figure 2 shows that smoke alarms were more likely to be present and more likely to have operated in confined fires than in non-confined fires.

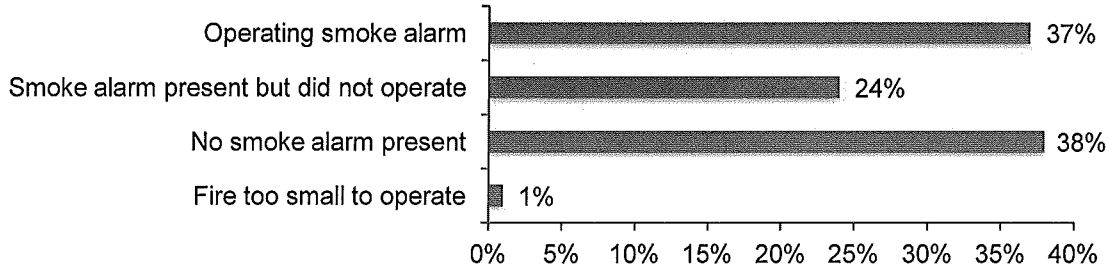
Figure 2. Confined and Non-Confined Home Structure Fires by Smoke Alarm Performance 2005-2009



Source: NFIRS 5.0 and NFPA survey.

Smoke alarms sounded in one of every three fire deaths.
In 2005-2009, more than one-third (37%) of reported home fires occurred in properties with either no smoke alarms at all or no working smoke alarms. Almost two-thirds (62%) of home fire *deaths* resulted from fires without the protection of a working smoke alarm. Figure 3 shows that no smoke alarms were present at all in 38% of the home fire deaths. Alarms were present but did not operate in one-quarter (24%) of the fatalities. Operating smoke alarms were present in roughly one-third (37%) of the home fire deaths. In 1% of the deaths, the fire was too small to trigger the smoke alarm.

Figure 3. Home Structure Fire Deaths by Smoke Alarm Performance 2005-2009



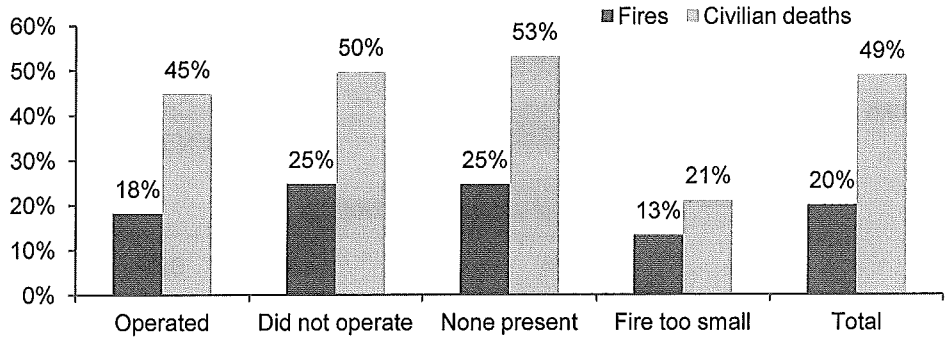
Source: NFIRS 5.0 and NFPA survey.

Differences in fatal home fire victim characteristics and fire circumstances between fires with working smoke alarms, no smoke alarms at all, and smoke alarms that should have operated but did not are explored later in the report.

Half of the home fire deaths resulted from fires reported between 11:00 p.m. and 7:00 a.m.
Figure 4 and Table 3 show that the percentages of home structure fires and fatal fire injuries reported between 11:00 p.m. and 7:00 a.m. were highest for properties with smoke alarms that did not operate or with no smoke alarms at all. Fifty percent of the deaths from fires with non-

working alarms and 53% of home fires with no smoke alarms at all resulted from fires reported during these hours. Slightly less than half (45%) of the deaths from home fires with operating smoke alarms were reported in the same hours. Only 13% of the fires that were too small to activate the alarm and 21% of the associated deaths occurred during these hours.

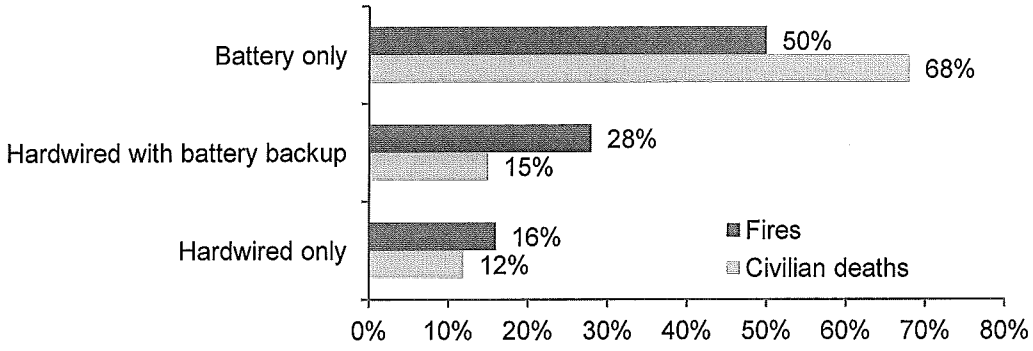
Figure 4. Percent of Home Structure Fires and Fire Deaths Reported between 11:00 PM and 7:00 AM: 2005-2009



Source: NFIRS 5.0 and NFPA survey.

Half of the smoke alarms in reported home fires were powered by batteries only. Table 4 and Figure 5 show that overall, when smoke alarms were present, they were battery-powered in half (50%) of the reported home fires and two-thirds (68%) of the home fire deaths. The smoke alarms were powered only by batteries in two of every five (41%) reported home fires with confined fire incident types and three of every five (60%) non-confined home fires.

Figure 5. Leading Smoke Alarm Power Sources in Home Structure Fires: 2005-2009



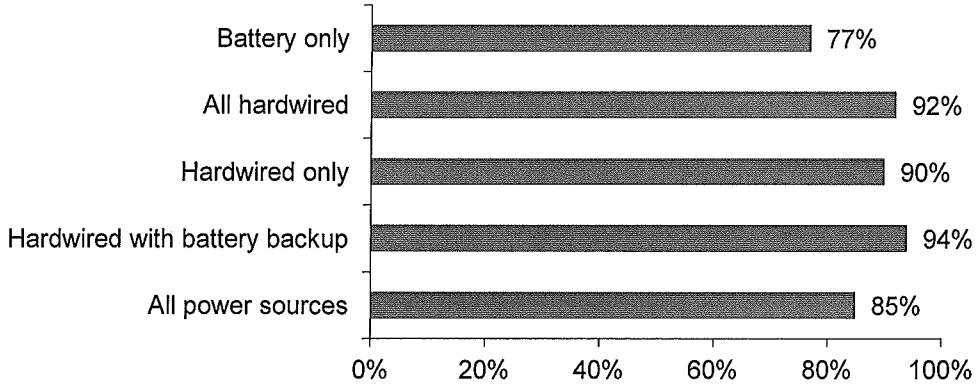
Source: NFIRS 5.0 and NFPA survey.

Hardwired smoke alarms were found in almost half (45%) of the reported home fires and one-quarter (26%) of the fatal fire injuries that occurred when smoke alarms were present. Hardwired smoke alarms were present in more than one-third (36%) of the non-confined home fires and half (52%) of the home fires with confined fire incident types. Hardwired alarms include those with and without battery backup.

Table 5 and Figure 6 show the percentage of smoke alarms operating in fires considered large enough to activate the alarm. When present and the fire was large enough to trigger the device,

smoke alarms overall operated in 85% of the fires. Battery-powered smoke alarms had the smallest percentage operating (77%), and hardwired alarms with battery backup (94%) the highest. For all power sources, higher percentages of smoke alarms operated in confined fires than in non-confined fires.

Figure 6. Smoke Alarm Operation in Home Fires Considered Large Enough to Activate Alarm by Power Source: 2005-2009



Source: NFIRS 5.0 and NFPA survey.

Almost two-thirds of smoke alarms in the 2009 *American Housing Survey* were powered by batteries.

In 2009, the *American Housing Survey* (AHS) asked about working smoke alarms, smoke alarm power sources, and, for smoke alarms powered by batteries alone or by both electricity and batteries, whether the batteries had been replaced within the past six month.

Table 6 shows that 94% of the respondents in occupied housing units reported working smoke alarms.[3] This figure seems implausibly high. The Smoke Alarm Harris Poll® done for NFPA in 2010 found that 96% of homes reported having smoke alarms regardless of whether they were working. It is likely that the AHS did not ask for any testing or verification to be sure that smoke alarms were actually working. For that reason, the other AHS results are presented as results about smoke alarms without mentioning whether they are working.

The AHS found majority of households in all types of circumstances reported this protection. Smoke alarms were reported to be less common in two groups:

- Hispanics (89%);
- Households with income below the poverty line (90%)

In contrast, 98% of respondents in homes that were four years or less old reported having smoke alarms.

Almost two-thirds (65%) of the respondents with smoke alarms reported that the units were powered by batteries only, one-quarter (28%) by electricity and batteries, and 8% by electricity only.

[3] U.S. Census Bureau, Current Housing Reports, Series H150/09, *American Housing Survey for the United States, 2009,* U.S. Government Printing Office, Washington, DC. 20401, 2011. Table 2-4.

Field investigators collected detailed data for CPSC's National Smoke Detector Project.
The most complete study of smoke alarm presence and operational status in the general population was done by the U.S. Consumer Product Safety Commission's (CPSC's) National Smoke Detector Project in 1992. Field investigators went into people's homes to ask a series of questions and to test all the alarms in their homes. This project surveyed the general population, not just people who had fires. Findings were released in 1993. About 88% of the households screened had at least one installed smoke alarm; 41% of households with these devices had more than one.[4]

Homes built since 1980 are more likely to have hardwired smoke alarms.
Codes such as NFPA101®, *Life Safety Code®* have required hardwired smoke alarms in new construction for years. Since 1976, new manufactured homes have been required to have hardwired A/C-powered smoke alarms; only 38% of the manufactured homes (all ages) surveyed in the CPSC study had battery-only smoke alarms. In the 1992 study, 81% of the homes (including apartments and manufactured homes) built *before* 1980 had battery-only devices; only 31% of the homes built in 1980 or later had smoke alarms powered only by batteries. More recent statistics on reported home fires and data about all households from the 2009 *American Housing Survey* suggest that the percentage of smoke alarms powered by batteries has fallen to slightly less than two-thirds. The same survey found that 36% of the smoke alarms in homes less than five years old were powered by batteries only.

In CPSC's 1992 National Smoke Detector Project, 20% of homes with smoke alarms had none that worked.
The National Smoke Detector Project found that in 20% of the households surveyed with at least one smoke alarm present, none were operational. However, *46% of the respondents in households in which no smoke alarms functioned thought that all of them were working.* About 20% of the tested devices did not have functioning power sources. These statistics reinforce the hypothesis that the 94% of homes with working smoke alarms found in the American Housing Survey is unrealistically high. Two studies focusing specifically on the accuracy of self-reporting of working smoke alarms are described in Appendix B.

Best estimates suggest that more than three-quarters (77%) of all homes have at least one working smoke alarm.
If 96% of U.S. homes surveyed by phone[5] now have smoke alarms and 20% of those have non-operational smoke alarms, (based on CPSC's field investigations), then 4% of homes have no smoke alarms at all (100% minus 96%) and another 19% of homes have smoke alarms that do not work (20% of 96%). Therefore, three of every four homes (77% of the homes with telephones) have at least one working smoke alarm (100% minus 4% minus 19%). Restoring operational status to the non-working smoke alarms could have a major impact and should be considered a priority, along with installing smoke alarms in the remaining homes that do not have them.

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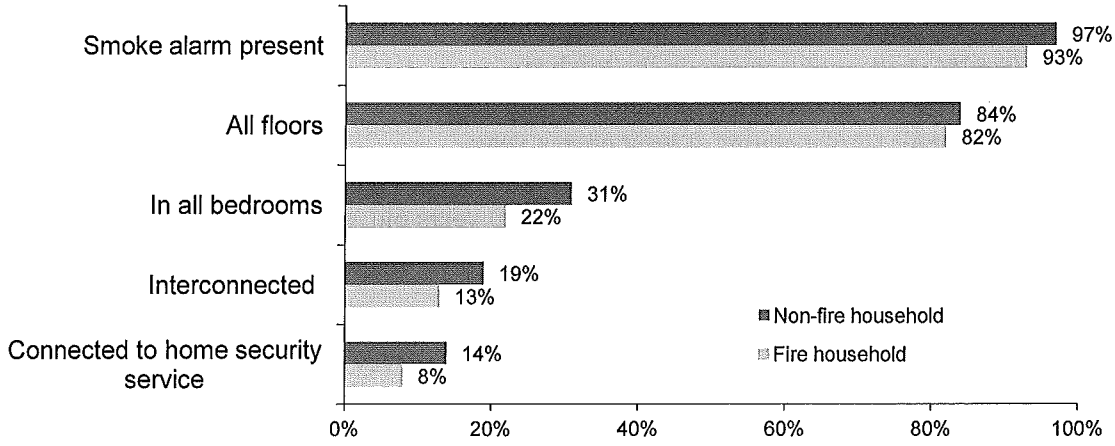
[4] Charles L. Smith, *Smoke Detector Operability Survey – Report on Findings*, Bethesda, MD: U.S. Consumer Product Safety Commission, November 1993.
[5] Table 1131, "Utilization of Selected Media: 2000 to 2008" in the U.S. Census Bureau's *Statistical Abstract of the United States: 2011* shows that 95% of U.S. households had telephone service in 2008.

Homes with fires had less smoke alarm protection than homes in general.
In 2004-2005, CPSC conducted a telephone survey to estimate the total number of residential fires experienced by U.S. households, including fires that were not attended by fire departments.[6] The study also compared differences in households that had experienced fires in the previous three months with households that had not had a fire. They estimated that U.S. households experienced 7.4 million fires per year, including 7.2 million that were not reported to the fire department.

Survey findings related to smoke alarms are shown in Table 7. Figure 7 shows 97% of households that did not have a fire (non-fire households) reported that they had at least one smoke alarm. That is slightly higher than the 93% of households that had fires (fire households) with at least one smoke alarm. Non-fire households reported having an average of 3.54 smoke alarms, while fire households averaged 2.92 alarms each. Eighty-two percent of the fire households and 84% of non-fire households reported having smoke alarms on all levels. Only 13% of the fire households and 19% of non-fire households reported having interconnected smoke alarms. Fourteen percent of non-fire households and 8% of fire households had smoke detection connected to a home security service.

Among fire and non-fire households combined, homes in which at least one person was under 18 were more likely to have smoke alarms on all floors and in all bedrooms. Homes in urban areas were also more likely to have this protection. Homes with at least one person over 65 or older or at least one smoker were less likely to report smoke alarms in all bedrooms.

Figure 7. Smoke Alarm Presence and Coverage in Fire and Non-Fire Households in CPSC's 2004-2005 Residential Fire Survey



Source: Greene and Andres, 2009.

Homes with reported fires are much less likely to have smoke alarms than homes in general. As shown in Figure 1, almost all (96%) of the respondents in Harris phone surveys done for NFPA in 2004, 2008 had at least one smoke alarm. In contrast, more than one-quarter (28%) of reported home fires in 2005-2009 occurred in properties without smoke alarms. People who live in smoke

[6] Michael A. Greene and Craig Andres. *2004-2005 National Sample Survey of Unreported Residential Fires.* U.S. Consumer Product Safety Commission, July 2009.

alarm-equipped homes that have reported fires may be more likely than people in smoke alarm-equipped homes without reported fires to have allowed their smoke alarms to become non-operational. If having a fire is correlated with a lesser concern for fire safety, this lack of concern might be expected to produce a lower rate of smoke alarm usage and a higher rate of non-operational smoke alarms where these alarms were present.

One smoke alarm is usually not enough.
Twelve percent of reported home fires were too small to activate smoke alarms that were present in 2005-2009. Some of these fires may have been out of range of the smoke alarm. Many homes need more than one smoke alarm for code-compliant complete protection. The 2007 and 2010 editions of NFPA 72® require smoke alarms in all bedrooms, outside each sleeping area and at least one smoke alarm on every level of the home. The 1992 CPSC National Smoke Detector Project found that 26% of the households surveyed had less than one alarm per floor, which indicated too few smoke alarms for compliance with the code provisions of the time. Additional households may have had too few smoke alarms to protect widely separated sleeping areas on the same floor. Closed doors that delay the spread of smoke may also delay smoke alarm response and decrease the likelihood that the signal will be heard. Audibility is discussed further later in this report. CPSC's National Smoke Detector Project also estimated that 43% of the households had less than one *working* smoke alarm per floor.[7]

In 2010, NFPA arranged for a Harris Poll® National Quorum to include questions about smoke alarms in telephones surveys of more than 1,000 households.[8] Table 1 shows that, based on the 96% of households with smoke alarms,

- 80% reported at least one smoke alarm in a hallway;
- 43% had a smoke alarms inside every bedroom;
- 14% had a smoke alarms inside most bedrooms;
- *Half* (52%) had smoke alarms in the kitchen;
- One-quarter (25%) had interconnected smoke alarms;
- 87% test their smoke alarms at least once a year;
- One in five (21%) test their smoke alarms at least once a month;
- 12% had smoke alarms that were more than 10 years old; and
- 17% of the respondents who were at least 55 had smoke alarms that were more than 10 years old.

The survey questions change from year to year. The 2008 survey found that 84% of households had an alarm on every level of the home.

[7] Charles L. Smith, Smoke Detector Operability Survey – Report on Findings, 1993, p. 24.
[8] Harris Interactive. *Smoke Alarm Omnibus Question Report,* November 2008.

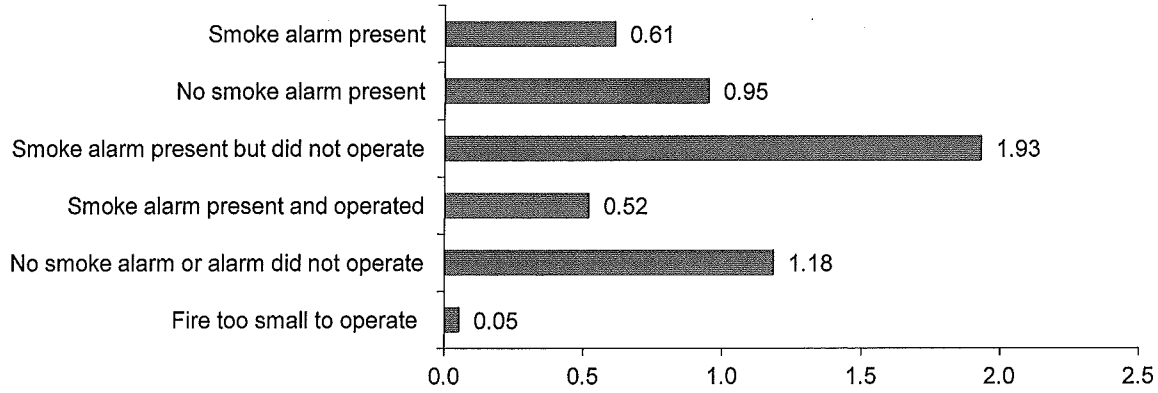
Benefits of Smoke Alarms

LIVES SAVED

The risk of dying in reported home structure fires in half is cut in half in homes with working smoke alarms.
Figure 8 shows that in 2005-2009, the risk of death from a fire in a home that had any smoke alarms (0.61 deaths per 100 fires), regardless of whether they were working, was 36% lower than the risk in a home with no smoke alarms at all (0.95 deaths per 100 fires). Interestingly, the death rate was substantially higher (1.93 deaths per 100 fires) in fires in which smoke alarms were present but failed to operate than in homes that had no smoke alarms at all. Households that have deliberately disabled and/or not maintained their smoke alarms may have different characteristics from households that have not installed smoke alarms.

Figure 8 also shows that the death rate in fires with working smoke alarms (0.52 per 100 fires) was less than half (56% lower) the risk of death from fires that did not have working smoke alarms (1.18 deaths per 100 fires), either because no smoke alarm was present or an alarm was present but did not operate).

Figure 8. Death Rate per 100 Reported Home Structure Fires by Smoke Alarm Status: 2005-2009



Source: NFIRS 5.0 and NFPA survey.

This is not the same as saying you double your chances of *surviving* a fire that is big enough to be reported to a fire department. Ignoring fires where more than one person dies, death rates per 100 fires are the same as percentages of reported fires that are fatal. By that formulation, people die in 0.52% of fires with a working smoke alarm present and in 1.18% of fires with no working smoke alarm present. At first glance, these rates seem low. However, the rate of death per reported home fire is not that different from the death rate per vehicle crash reported to the police department. The National Highway Traffic Safety Administration (NHTSA) reported that only 0.6% of all vehicle crashes reported to the police from 1988 to 2008 were fatal.[9] There is clearly considerable work left to do to increase both fire and vehicle safety.

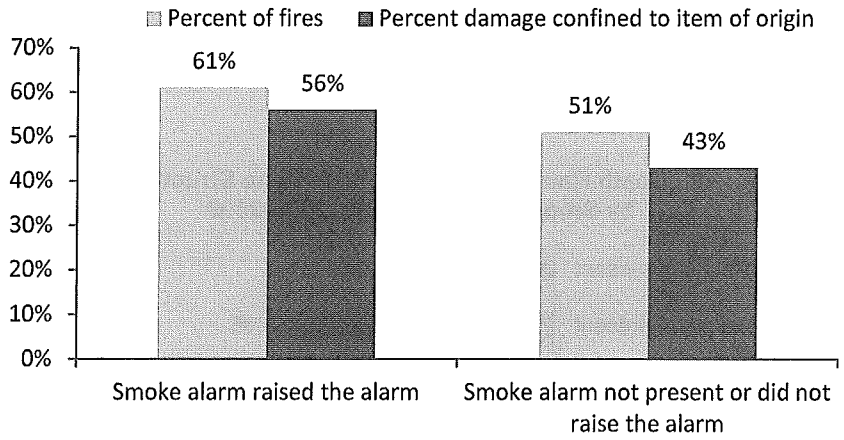
[9] National Highway Traffic Safety Administration. *Traffic Safety Facts 2008,* Washington, D.C.: U.S. Department of Transportation, 2009, pp. 14-15. Online at http://www-nrd.nhtsa.dot.gov/Pubs/811170.pdf.

SMOKE ALARMS AND EARLY DISCOVERY OF FIRE

U.K. data confirm that smoke alarms result in quicker fire discovery.
The United Kingdom tracks the interval between the time of ignition and the time of discovery.[10] Figure 9 shows that in 2008, three of every five (61%) reported home fires in which the alarm was raised by the smoke alarm were discovered within five minutes of ignition. The fire was confined to the item of origin in 56% of these incidents.

Only half (51%) of the fires in which no smoke alarms were present or in which they did not raise the alarm were discovered within five minutes. Forty-three percent of these fires were confined to the item of origin. Households with working smoke alarms tend be alerted to a fire earlier and that fires in these homes are less likely to have the opportunity to spread.

Figure 9. 2008 United Kingdom Home Fires Discovered within Five Minutes of Ignition



Source: *Fire Statistics, United Kingdom, 2008.*

Sometimes, people notice the fire first or no one hears the alarm.
In 2008, home smoke alarms were present, operated, and raised the alarm in more than one-third (37%) of the fires reported in the United Kingdom. (No smoke alarms were present in the area of origin in 38% of the home fires, and the device did not operate in 18% of the incidents.) Smoke alarms operated but did not raise the alarm in 7% of the fires. Analysts explored the reasons why some home smoke alarms operated but did not alert anyone. These situations remind us that smoke alarms merely provide information. In some cases, people are already aware of the problem; in others, no one receives the information. The leading reasons are given below:

- In 58% of these fires, a person raised the alarm before the system operated (Someone in the same room may notice a fire immediately.);
- In 20% of these home fires, no one was in earshot; and
- The occupants failed to respond in 11% of these fires.

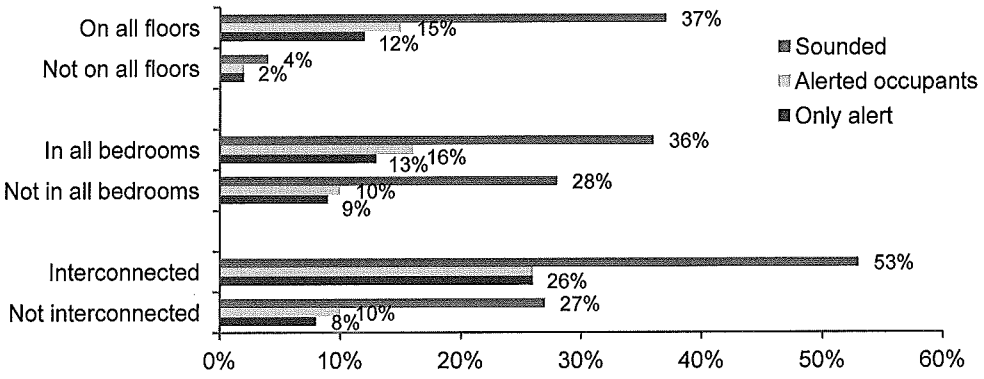
[10] Department for Communities and Local Government. *Fire Statistics, United Kingdom, 2008,* London, U.K, November 2010, pp. 36-43, online at http://www.communities.gov.uk/documents/statistics/pdf/1780609.pdf.

Survey of the English population found that 12% of household fires were discovered when the smoke alarm sounded.
The Survey of English Households asked the general population about fires in or on their home properties, including outdoor fires. In 2004-2005, 1.5% reported having a fire within the past 12 months. Twelve percent of these fires were discovered when the smoke alarm went off. In some cases, someone was in the room and discovered the fire before the smoke alarm sounded. When the smoke alarm did not sound, the most common reason was that the smoke alarm was too far away from the fire.[11]

Smoke alarms provided the *only* alert in 10% of residential fires in CPSC's 2004-2005 survey of reported and unreported fires.
Findings on smoke alarm alerts from CPSC's 2004-2005 *Residential Fire Survey*[12] are consistent with the UK study above. In CPSC's survey, additional detail was sought on low severity fires within the past 14 days or high severity fires within the past 21 days. The authors of the study discovered that someone was home in 96% of these fires and at least one smoke alarm was present in 86%. At least one smoke alarm sounded in 30% of the incidents, the smoke alarm alerted people to the fire in 12% of the fires, and provided the only alert in 10% of the fires. No alarm sounded in 55% of the fires with people home. This included 49% in which the fire was reported not to have produced enough smoke to activate the alarm.

When present, interconnected smoke alarms provided the only alert in 26% of residential fires in CPSC 2004-2005 survey.
Figure 10 shows that in the 2004-2005 CPSC study, greater coverage and interconnectedness increased the likelihood of smoke alarms operating, of alerting occupants, and of being the only alert. In homes that had interconnected smoke alarms, the alarms sounded in 53% of the fires and provided the only alert in 26%.

Figure 10. Smoke Alarm Coverage by Operation and Occupant Alert in Unreported Fires in CPSC's 2004-2005 Residential Fire Survey



Source: Greene and Andres, 2009, p. 181.

[11] Office of the Deputy Prime Minister. Fires in the Home: Findings from the 2004/05 Survey of English Housing, London, U.K., on line at http://www.communities.gov.uk/pub/313/FiresintheHomefindingsfromthe200405SurveyofEnglishHousingPDF423Kb_id1163313.pdf.

[12] Michael A. Greene and Craig Andres. *2004-2005 National Sample Survey of Unreported Residential Fires.* U.S. Consumer Product Safety Commission, July 2009, pp. 150-189.

Less difference was seen between homes with smoke alarms in all bedrooms compared to homes that did not have the devices in all bedrooms. Smoke alarms sounded in 36% of the fires in homes with smoke alarms in all bedrooms and provided the only alert in 13%. In homes that did not have smoke alarms in every bedroom, the alarms sounded in 28% of the fires and provided the only alert in 9%.

When smoke alarms were not on all floors, they sounded in only 4% of the fires and alerted occupants in only 2% of the fires. Such households may be less likely to have smoke alarms that are interconnected. When smoke alarms were present on all floors, they sounded in more than one-third (37%) of the fires and provided the only alert in 15%.
Much of the discussion so far has focused on the level of smoke alarm protection installed in the home and the benefits of working smoke alarms. With one-quarter of the home fire deaths resulting from fires in which a smoke alarm was present, should have operated, but failed to do so, it is clear that the problem of non-working smoke alarms must be addressed.

Factors in Smoke Alarm Non-Operationality

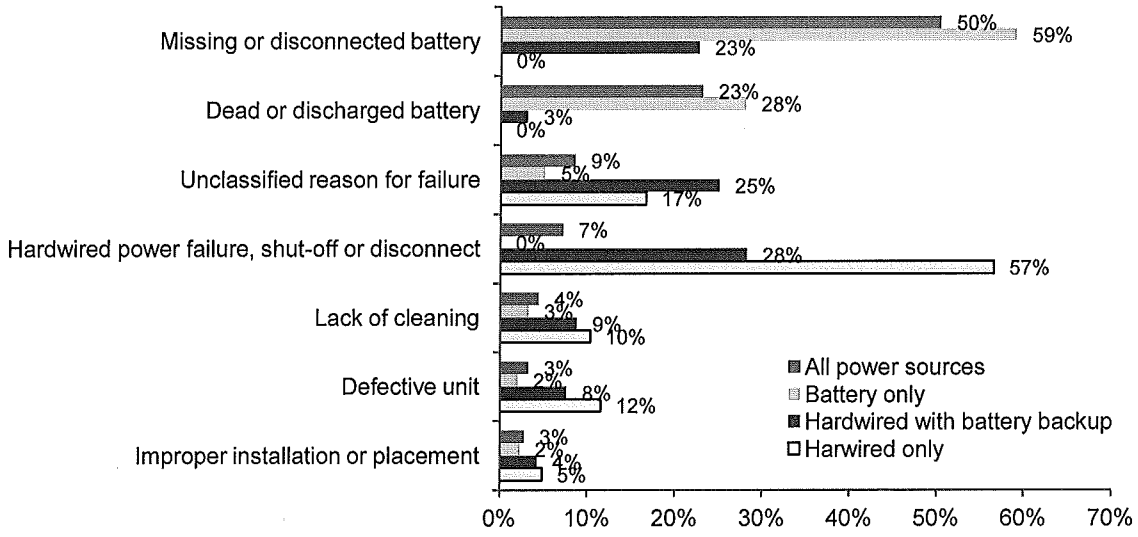
Three-quarters of non-working smoking alarms used battery power only.
Table 4 showed that half of the smoke alarms found in reported home fires were powered by batteries only. Table 8 shows that when smoke alarms did not sound in non-confined fires considered large enough to activate them, three-quarters (76%) used batteries only. Figure 11 and Table 9 show power source issues were the leading reason smoke alarms failed to operate.[13] In three of every five (59%) fires in which battery-powered smoke alarms failed to sound, the batteries were missing or disconnected. Dead or discharged batteries accounted for more than one-quarter (28%) of the battery-powered smoke alarm failures.

When hardwired smoke alarms with no battery backup failed to operate, the power had failed, been shut off, or disconnected in 57% of the fires. This scenario can include both deliberate disabling of the smoke alarm as well as temporary power outages or power shutoff to the home.

When hardwired smoke alarms with battery backup should have operated but did not, more than one-quarter (28%) of the failures were due to hardwired power failure, shut off, or disconnect; almost one-quarter (23%) were due to missing or disconnected batteries; and 3% were due to dead or discharged batteries. The relatively large share of battery problems mentioned with these alarms is surprising as the household current would be powering these alarms except in unusual circumstances such as power outages or shutoffs. At this time, we have no clear explanation for these patterns. It does appear that the fire service had a harder time identifying causes of non-operation in hardwired smoke alarms. Unknown data were allocated proportionally in the statistics presented. The reason for failure was originally undetermined for half of all hardwired alarms, but only one-quarter of the battery-powered alarms. The percentage of unclassified reasons was 3-5 times as high for hardwired smoke alarms as for battery-powered alarms.

[13] This analysis was limited to home fires with non-confined fire incident types because of the lack of available details about non-operating smoke alarms in confined fires.) The reasons shown are based on the code choices for detector failure reason in the NFIRS 5.0 structure fire module.

Figure 11. Reason Smoke Alarms Did Not Operate in Non-Confined Home Structure Fires Considered Large Enough to Activate: 2005-2009



Source: NFIRS 5.0 and NFPA survey.

Homes that test smoke alarms regularly are more likely to have working smoke alarms. Many smoke alarm owners do not test or maintain their smoke alarms as often as they should. The 1992 National Smoke Detector Project found somewhat more encouraging news, as a majority of respondents who stated their testing frequency – and nearly half overall – had tested their alarms within the past month. Of those surveyed, 78% believed all their alarms worked, in the majority of cases because they had tested the alarm(s). Eighty-eight percent (88%) of this group were correct; testing showed they did indeed have working smoke alarms. Another 11% of those surveyed did not know whether theirs were working, and of those, only 61% proved to have working smoke alarms when testing was done.

In a 2010 telephone survey done for NFPA, 87% of households with smoke alarms said that they had tested their smoke alarms at some point, and 21% said they tested them at least monthly.[14]

NUISANCE ACTIVATIONS AND SMOKE ALARM OPERABILITY

Smoke alarms provide early warning in the event of a fire. Frustration occurs when they operate in response to normal cooking, steam, or for other non-fire reasons or when a smoke detection system malfunctions. Non-fire activations increase the likelihood that the alarm will be disabled or removed. When nuisance alarms are frequent, people may assume that smoke alarms can be ignored.

Unwanted activations far outnumber actual fires.
A 1980 study of home smoke detection as units in an Automatic Remote Residential Alarm System (ARRAS) in The Woodlands, TX, found 27 unwanted activations for every real alarm, or

[14] Harris Poll® National Quorum. *National Fire Protection Association --Smoke Alarms,* September 2010 p. 27, Percentages were based on known data. .

unwanted activations in six of every seven homes each year.[15] A 2000 New Zealand follow-up of smoke alarm installations in 1997-1999 found that smoke alarms provided warnings of actual fires in 7% of the households, but 38% of the households reported problems with nuisance alarms. [16]

When smoke alarm batteries were missing, their removal was most often due to annoyance over alarm activations from cooking.

As noted earlier, batteries were removed or disconnected far more frequently than was AC power. In CPSC's National Smoke Detector Project, when batteries were removed or disconnected from alarms, the leading reason was unwanted activations (32%). Removal for this reason was eight times as frequent as removal to use the batteries in another product (4%).[17] Thirty percent said they forgot to replace the batteries, 7% said the device alarmed continuously. 5% never looked for the reason, 5% had no batteries in the home, and 4% said they hadn't had a chance to install the batteries.

When households with smoke alarms that had missing or disconnected power sources were asked about problems with the smoke alarms, one-third (32%) mentioned that the alarms activated during cooking. When households with smoke alarms with dead batteries were asked about problems with the alarm, almost half (43%) complained that the device alarmed continuously when powered. It is likely that the alarming they described was often the low-battery chirp.

To some people, the stress of nuisance alarms outweighs the benefit of smoke alarm protection.

In 1999-2002, a U.K study conducted group and individual interviews with 58 adults to explore perceptions of fire risk, the benefits and problems associated with smoke alarms, and whether they would recommend smoke alarms to others.[18] They also interviewed children ages 7-11 at school. Some adults described feeling very stressed by false alarms and had difficulty getting the noise to stop. One woman's smoke alarm activated after she burned something. The noise scared her three-year-old daughter and the girl started screaming. The woman used a broom to try to silence the alarm and broke the alarm in the process. High ceilings posed a challenge in dealing with nuisance alarms and for battery changes. One individual expressed resentment about the smoke alarm going off during what was perceived as normal cooking. Equipment activations were not viewed as emergencies. An eight-year-old said, "When the smoke alarm goes off, I have to turn up the television."

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[15] Remote Detection and Alarm for Residences - The Woodlands System, Washington: U.S. Fire Administration, May 1980.

[16] Mavis Duncanson, Katherine Lawrence, Jean Simpson and Alistair Woodward, *Follow-up Survey of Auahi Whakatupato Smoke Alarm Installation Project in the Eastern Bay of Plenty,* New Zealand Fire Service Commission Research Report Number Seven, University of Otago, August 2000.

[17] Charles L. Smith, *Smoke Detector Operability Survey – Report on Findings*, Bethesda, MD: U.S. Consumer Product Safety Commission, November 1993, online at http://www.cpsc.gov/library/foia/foia01/os/operable.pt1.pdf.

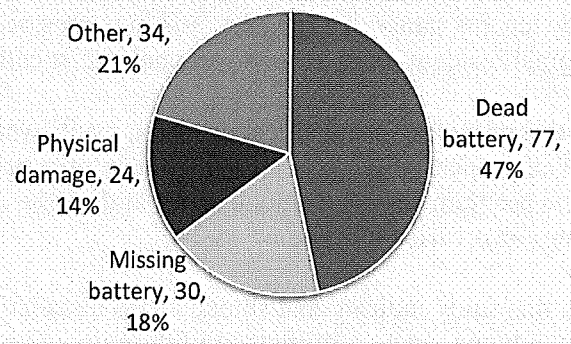
[18] H. Roberts, K. Curtis, K. Liabo, D. Rowland, C. DiGuiseppi, and I. Roberts. "Putting Public Health Evidence into Practice: Increasing the Prevalence of Working Smoke Alarms in Disadvantaged Inner City Housing, *J. Epidemiol. Community Health,* 2004:48:280-285, online at http://jech.bmj.com/cgi/reprint/58/4/280.

Findings from CDC's Smoke Alarm Project Evaluation

After 8-10 years, one-third of "10-year" smoke alarms were present and functional.

The Centers for Disease Control and Prevention (CDC) commissioned the National Center for Healthy Housing to determine if lithium-powered smoke alarms installed in 1998-2001 through CDC's Smoke Alarm Installation and Fire Safety Education (SAIFE) program were still present and operational eight to ten years later. The SAIFE program targeted homes considered at high risk of fire and fire injury. These were typically older properties in low-income neighborhoods. Researchers focused on five states for the follow-up: Georgia, Virginia, Washington, Kentucky and Oklahoma. They had information about 601 smoke alarms installed in 427 homes. The results from home visits and smoke alarm tests were disturbing. *At least one* of the installed alarms was still present and functional in only 38% of the homes visited. Slightly more than one-third (37%) of the installed alarms were missing, one-third (33%) were present and operational, and slightly less than one-third (30%) were present but not operational. These percentages and the reasons for non-functional alarms varied by state. Reasons were provided for 165 of the 180 non-functioning alarms and are shown in Figure 12.

Figure 12.
Reasons for Lithium-Powered Smoke Alarm Non-Operationality
8-10 Years after Installation



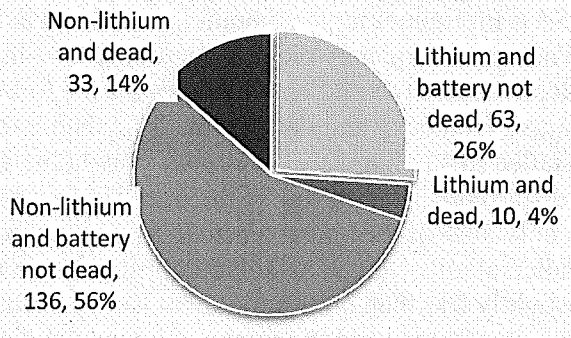
Source: Wilson, Akotomo, Dixon, and Jacobs, 2008.

Researchers also sought information on the type of batteries that were currently in the 351 alarms that were present and powered. Many of the alarms had battery chambers that could be opened. The 242 known battery types and their operationality are shown in Figure 13. In some cases, other factors made alarms with working batteries non-functional.

Although all of the alarms started with lithium batteries,more than two-thirds had non-lithium batteries eight to ten years later. Reasons for battery replacement were not collected. Some may have been replaced when the alarm started chirping, some in response to "change your battery" reminders intended for

conventional smoke alarms, or for some other reason. The batteries were dead in only 14% [10/(63+10)] of the smoke alarms with lithium batteries compared to 20% [33/(136+33)] of the alarms with non-lithium batteries and 31% of alarms with unreported battery types. Three-quarters (78%) of the smoke alarms that still had lithium batteries were still functional at the time of the evaluation.

Figure 13. Known Battery Type and Smoke Alarm Status 8-10 Years after Installation



Source: Wilson, Akotomo, Dixon, and Jacobs, 2008.

Researchers also found that smoke alarms that had been installed in the kitchen were less likely to be functional. Statistically significant variations were also seen between brand of smoke alarm and the state. Although smaller percentages of smoke alarms were functional in the homes of smokers than non-smokers, in homes occupied by tenants rather than owners, and in homes occupied someone other than the original resident, these results were not statistically significant.

Rental properties and properties that had changed occupants were more likely than owner-occupied properties and properties with the same occupants to be missing at least one program-installed smoke alarm at the time of the evaluation. Alarm removal rates also varied by state.

The findings from this study indicate that smoke alarm installation programs cannot assume that a home newly outfitted with lithium-powered smoke alarms will continue to have this protection several years later. Follow-up is necessary, particularly in rental properties and properties with high turnover. The authors noted that many, if not most, of the alarms installed in this program did not have sealed battery chambers. When selecting lithium smoke alarms for installation, select those with battery chambers that cannot be opened by the consumer. This study also confirmed what others have found: smoke alarms installed in the kitchen were more likely to be disabled. Installers should seek alternate locations.

These findings were extracted from the National Center for Healthy Housing's 2008 report, *Evaluation of the "10-Year" Smoke Alarm Project* by, Jonathan Wilson, Judith Akoto, Sherry Dixon, and David Jacobs done for the Centers for Disease Control and Prevention. Online at http://www.nchh.org/Research/Archived-Research-Projects/Smoke-Alarm-Study.aspx

The authors remarked, "In a population already managing a range of health risks, a public health intervention that makes mealtime more, rather than less, stressful, where noise can threaten leisure or relationships with fellow occupants, alarms could pose a threat to immediate wellbeing."

1/3 of alarms cited for nuisance activations in CPSC's 1992 study were installed too close to something that could trigger the alarm.

Nuisance alarm problems often can be addressed by moving the device to a different location or by switching from ionization-type to photoelectric-type devices. One-third of the devices studied for nuisance alarms in the National Smoke Detector Project were found in locations that made nuisance alarms more likely, often *less than five feet* from a potential source of smoke, steam, or moisture sufficient to produce nuisance alarms. Section 29.8.3.4 of the 2010 edition of NFPA 72® spells out locations where smoke alarms should *not* be placed. Many nuisance activations can be avoided by following these requirements.

CPSC conducted an engineering study of reasons for smoke alarm failures in homes that had fires.

The CPSC also conducted a 15-city study of smoke alarm failures in homes with fires in 1992 and 1993. If the alarm did not sound after power was connected and the unit sprayed with aerosol smoke, the unit was, when possible, collected for further study. The devices were also collected if the unit did not respond to the test button, if it had been disconnected due to a problem, if it had a dead battery and the occupant could not recall hearing the warning chirp, and if an AC-powered detector could not be tested but failed during the fire.[19]

The smoke alarm was disconnected from its power source in 59% of the cases when a smoke alarm was present, should have sounded, but failed to do so. Missing batteries were the most frequent problem, followed by disconnected batteries, and then disconnected AC power. These results are consistent with current findings. Because smoke alarms were examined after fires, the fire may have caused some of the conditions found. In some cases, multiple problems were found. Fifteen percent of the smoke alarms were deformed by heat, 13% were missing covers; 8% were clogged with dirt, and 5% showed signs of insect infestation. Nineteen percent of the smoke alarms, including devices that were connected and disconnected at the time of the fire, did not sound when powered.

Half of the smoke alarms that failed to sound in field tests did so when tested in the laboratory. It was suggested that horn corrosion may have been a factor, and that contact continuity may have been restored during removal, packing and transporting. One-quarter sounded after repairs were made. Fire-damaged and corroded components were replaced.[20] Disconnected smoke alarms were collected and tested when the occupants reported that the alarms had been disconnected because of problems. Nuisance alarms were the most common complaint. These devices were found to be more sensitive than devices collected for other reasons and devices tested in the *Smoke Detector Operability Study.* Foreign objects such as dust, dirt or insects can increase sensitivity, as can fire products. Because the sensitivity levels before the fires are unknown, the conclusions that can be drawn are limited.

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[19] Linda E. Smith, *Fire Incident Study: National Smoke Detector Project*, Bethesda, MD: U.S. Consumer Product Safety Commission, January 1995, pp. 4-5. Online at http://www.cpsc.gov/library/foia/foia01/os/national.pdf.

[20] Julie I. Shapiro, *Fire Incident Study Sample Analysis*, Bethesda, MD: U.S. Consumer Product Safety Commission, January 1995, pp. 9-10.

Ionization devices had a disproportionate share of nuisance alarms.
Cooking smoke tends to contain more of the smaller particles (less than one micron) that activate an ionization-type device rather than the larger particles that activate a photoelectric-type device. In the National Smoke Detector Project, 97% of the devices tested for involvement in nuisance alarms were ionization-type devices, although they comprised only 87% of all devices in the study.

Reducing the sensitivity of smoke alarms can reduce the likelihood of nuisance alarms. The National Smoke Detector Project referenced one dormitory study that found that devices involved in nuisance alarms were more sensitive, on average, than those that were not. However, the project report cautioned that reduced sensitivity could adversely affect a smoke alarm's ability to provide timely warning of a real fire.

As part of their research into the performance of smoke alarms in today's homes, the National Institute of Standards and Technology (NIST) conducted tests on a variety of scenarios associated with nuisance alarms. In these tests, they found that ionization smoke alarms had a tendency to activate in response to aerosols produced during some normal cooking. They recommended that such smoke alarms be placed as far as possible from cooking equipment but still in the protected area.[21]

An Alaskan study, published in 2000, installed photoelectric smoke alarms in 58 homes in two rural Eskimo Inupiat villages and ionization smoke alarms in 65 homes in two other similar villages.[22] Home area averaged roughly 1,000 square feet or less. The alarms were installed 10-15 feet from heating and cooking sources. A baseline survey before the program found functional smoke alarms in only 38% of the homes in what would be the ionization group and 22% of the homes in the future photoelectric group. Follow-up visits were made six months after the alarms were installed. At that time, 81% of the ionization homes had working smoke alarms compared to 96% of the homes with photoelectric devices. Ninety-two percent of the ionization homes and 11% of the photoelectric homes had experienced at least one false alarm. Ninety-three percent of the 69 ionization false alarms were due to cooking as were four of the six of the photoelectric false alarms. Eighty-one percent of the ionization cooking false alarms were related to frying. Heating equipment triggered five (8%) of the ionization false alarms and two (one-third) of the photoelectric false alarms. The authors noted that false alarms seemed to be more common in homes that were smaller, that used wood fuel for heat and in which the smoke alarms were located near the cooking areas. The authors conclude that "Photoelectric alarms may be the preferred choice for homes with limited living space and frequent false alarms." The findings in this article and those in the next study discussed support the restrictions in NFPA 72® regarding smoke alarm placement in relation to the kitchen range. Unfortunately, neither study reported how far away alarms that were not working or had frequent nuisance activations were from the equipment.

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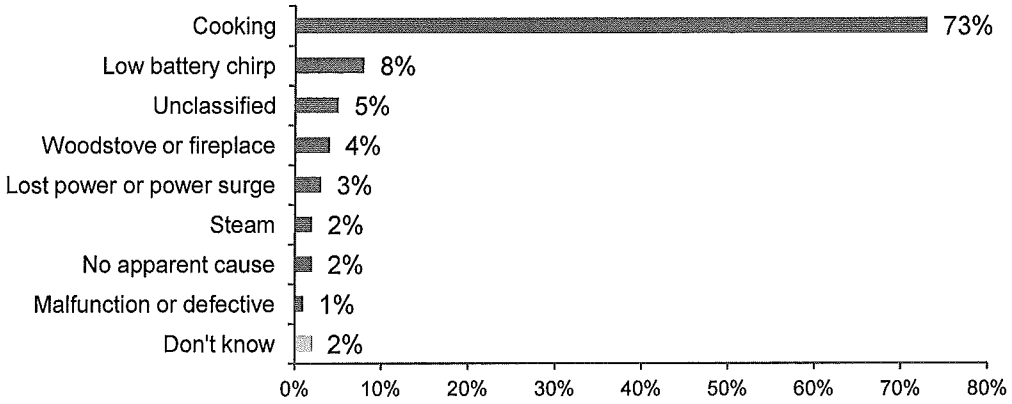
[21] Bukowski, et a.. 2008 revision, p. 250.
[22] Thomas M. Fazzini, Ron Perkins, and David Grossman. "Ionization and Photoelectric Smoke Alarms in Rural Alaskan Homes," *West J. Med;* 2000; 173:89-92. online at http://www.pubmedcentral.nih.gov/picrender.fcgi?artid=1071008&blobtype=pdf.

In their 2008 article, Mueller, Sidman, Alter, Perkins, and Grossman compared the functionality, reasons for any non-working alarms, and nuisance alarm levels of ionization and photoelectric smoke alarms in low- to mid-income homes in a Washington county. [23] Installation teams were instructed to install the alarms on the main living level with rooms next to the kitchen given priority. Typically, the alarms were installed three feet from the kitchen entrance. The average distance between smoke alarms and kitchen ranges was 11-12 feet, with standard deviations of almost four feet. Note that Section 29.8.3.4 of the 2010 edition of NFPA 72® prohibits the installation of smoke alarms within 10 feet of a kitchen range unless the unit is specifically designated for that application. Alarms installed 10-20 feet from kitchen ranges must have either a method to silence the alarm without disconnecting the power source or use photoelectric detection only. Nine months after installation, 78% of the ionization alarms had sounded compared to 39% of the photoelectric. Fifty-six percent of the ionization alarms that had sounded had activated at least four times compared to 17% of the photoelectric. Two percent of the households in each group had actual fires. Fifteen months after installation, 77% of the ionization smoke alarms had sounded compared to 42% of the photoelectric alarms. At 15 months, 80% of the ionization alarms were functional compared to 95% of the photoelectric. Cooking caused 93% of the ionization nuisance activations and 74% of the photoelectric nuisance alarms.

In the 2010 poll done for the NFPA,[24] *roughly half (52%) of all households with at least one smoke alarm reported that a smoke alarm was installed in the kitchen.*

The same poll asked two questions of the 43% of households that said their smoke alarms had gone off in the past year. In one question, they were asked "What do you think caused the smoke alarm to go off in the last year?" Only one response was allowed for this question. The results are shown in Figure 14.

Figure 14. Reasons Given for Smoke Alarm Activations in Past Year



Source: Harris Poll National Quorum. National Fire Protection Association -- Smoke Alarms. 2010.

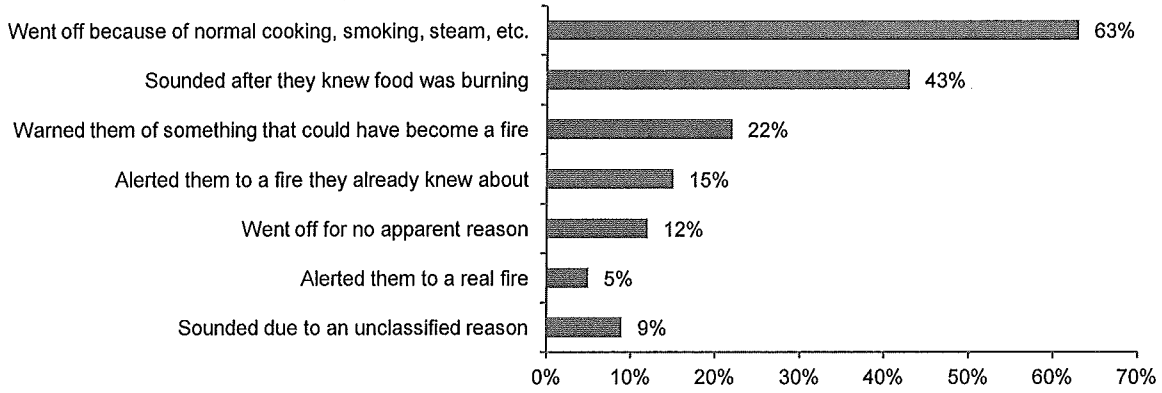
[23] B.A. Mueller, E.A. Sidman, H. Alter, R. Perkins, and D.C. Grossman. "Randomized Controlled Trial of Ionization and Photoelectric Smoke Alarm Functionality," *Injury Prevention* 2008:14:80-86. doi:10.1136/ip.207.016725.
[24] Harris Poll National Quorum. National Fire Protection Association -- Smoke Alarms. September 8-12, 2010.

Cooking was cited as the reason by roughly three out of four (73%) respondents. Eight percent mentioned low battery chirps. None of the respondents indicated that a fire caused the activation.

Respondents were asked to answer yes or no to a series of questions about the last time the smoke alarm went off. These were phrased as "Did it?" questions to be answered either "yes" or "no." The results show some inconsistency with the results shown in Figure 14.

Although no one cited fire as a reason for the activations in the previous question, Figure 15 shows that 5% agreed that that the most recent activation alerted them to a real fire while 15% said the alarm sounded in response to a fire they already knew about. Forty-three percent said the alarm sounded after they already knew that food was burning. This suggests a situation in which the sounding smoke alarm was functioning properly but was likely to be annoying to someone already dealing with the situation. Almost two thirds reported that the activations were due to non-hazardous situations associated with cooking, smoking, steam or other normal household conditions. However, 22% percent said it warned them of something that could have become a fire. Twelve percent said it went off for no apparent reason.

Figure 15. The Last Time a Smoke Alarm Sounded, It...



Source: Harris Poll National Quorum. National Fire Protection Association -- Smoke Alarms. 2010.

In a 2004 survey conducted for the NFPA, 40% of the respondents with smoke alarms reported that one had sounded at least once in the past twelve months.[25] Sixty-nine percent reported activations due to cooking activities, 13% were due to battery problems, including the low-battery chirping, 5% were due to steam (frequently from a shower), and 4% of the activations were due to smoke alarm tests. All respondents who reported that an alarm had sounded were asked for their first thought after they heard it:

- 24% said that food had burned;
- 11% thought about how to turn off the smoke alarm;
- 11% were unconcerned because they knew what caused it to sound;
- 8% investigated;

[25] 2004 Fire Prevention Week Survey conducted for National Fire Protection Association by Harris Interactive Market Research, pp. 11-14.

- *Only 8% thought there was a fire and they should get out;*
- 7% recognized the low battery signal;
- 7% were annoyed at what they assumed to be a nuisance alarm;
- 3% noted that the smoke alarm works;
- 3% thought they should have used the exhaust fan; and
- 2% didn't recognize it as a smoke alarm and wondered what it was.

Batteries in photoelectric smoke alarms tend to wear down faster than those in ionization alarms.

In the previously discussed study by Mueller et al, low batteries were noted as source for 22% of the photoelectric activations but only 5% of the ionization activations. A UK study also found that batteries in photoelectric alarms were more likely to be dead or to have triggered the warning chirp than were batteries in ionization alarms. Rowland et al. examined the percentage of working smoke alarms by type installed in local authority inner city housing in the United Kingdom.[26] Eleven to twelve percent of the smoke alarms found in the homes at the beginning of the study were working. Five different types were installed as part of this study. When the households were visited 15 months later, 93% had smoke alarms installed. Fifty-four percent had a working smoke alarm. The alarm installed for the study was working in 51% of the homes. In homes with at least one smoker, 38% of the photoelectric (called optical in the study) alarms and 48% of the ionization alarms were working. Based only on the smoke alarms installed as part of this study, 15 months after installation,

- 56% of the ionization alarms with zinc batteries and no pause buttons operated;
- 47% of the ionization alarms with zinc batteries and pause buttons operated;
- 66% of the ionization alarms with lithium batteries and pause buttons operated;
- 56% of the photoelectric alarms with lithium batteries operated; and
- 36% of the photoelectric alarms with zinc batteries operated.

The batteries were dead in 6% of the photoelectric alarms with zinc batteries. This was a larger share than was seen in any other type. Reports of low battery signals and battery changing among smoke alarms with zinc batteries were higher for photoelectric sensors (19% and 26% respectively) and with ionization sensors and pause buttons (22% and 25%, respectively), than they were for zinc battery ionization alarms without pause buttons (8% and 13%, respectively).

Some non-fire activations are actually useful warnings.

Chirping is intended to be a useful warning. Other non-fire activations, particularly from cooking, may actually be pre-fire warnings. A sounding smoke alarm may remind a cook who has left the kitchen area of food on the stove requiring immediate attention. While not yet a fire, the potential exists if corrective action is not taken. If such action is taken, the situation is usually resolved without fire department involvement.

Smoke alarms will typically alert only the occupants of a home or dwelling unit to a fire or pre-fire condition. Smoke detection systems alert the whole building and may result in automatic notification of the fire department.

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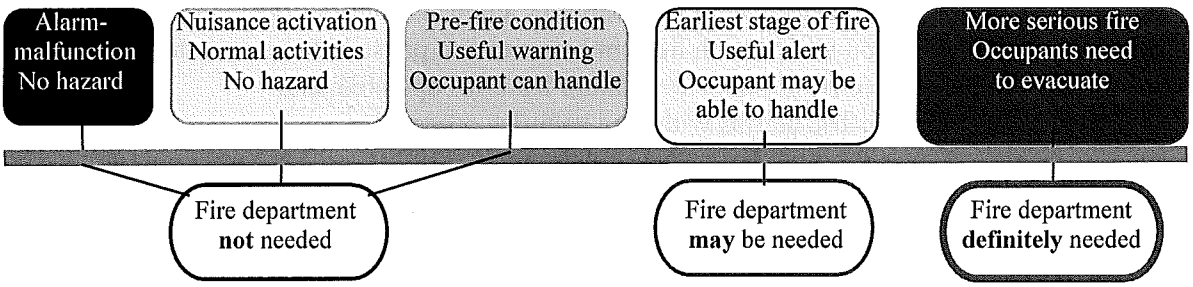
[26] Diane Rowland, Caroub GiGuisseppi, Ian Roberts, Katherine Curtis, Helen Roberts, Laura Ginnelly, Mark, Sculpher, and Angela Wade. "Prevalence of Working Smoke Alarms in Local Authority Inner City Housing: Randomised Controlled Trial, "*BMJ* 2002; 325:998-1001, online at http://www.bmj.com/cgi/reprint/325/7371/998.

Are too many people affected? Section 9.6.10.4 of NFPA 101®, *Life Safety Code®*, states that for smoke alarms inside the private areas of residential occupancies, "The alarms shall sound only within an individual dwelling unit, suite or rooms or similar area and shall not actuate the building fire alarm system, unless otherwise permitted by the authority having jurisdiction." People routinely handle very small fires quickly and effectively. The lid is put on the flaming grease pan. The cigarette smoldering on the carpet is stamped out, leaving only a small burn mark. The burned popcorn is removed from the microwave. In some cases, the incident has been fully dealt with before the detection equipment operates.

In 2004-2005, the Consumer Product Safety Commission (CPSC) conducted a telephone survey to estimate the total number of residential fires experienced by U.S. households, including fires that were not attended by fire departments.[27] They found that 97% of home fires were handled without fire department assistance. Most fires resulted in no flame damage or damage to only the item first ignited. Not surprisingly, the fire department was more likely to have attended fires that spread.

Figure 16 illustrates the continuum of fire detection activations and response. The first category, a malfunctioning alarm with no hazard and no obvious trigger, is probably the most annoying to all parties. If alarms often sound for no obvious reason, most people will assume that any sounding alarm is false. Nuisance activations in response to predictable environmental stimuli such as cooking fumes and shower steam are also disruptive.

Figure 16. Fire Detection Activations and Desired Response: A Continuum



The third category, an alert to pre-fire conditions, is often overlooked in discussions of fire detection. Smoke or fire alarms can alert occupants to a situation that is on the verge of becoming a fire but is very easily remedied. These incidents would not be called false or nuisance alarms, but they would generally not be considered fires either. Green and Anders noted that both reported and unreported home fires fell from the survey done in 1984 to the latest one in 2004-2005. It is possible that more widespread use of smoke alarms has prevented situations from developing into something that would be identified as an actual fire. This is consistent with the 22% of households mentioned earlier who reported that the alarm alerted them to something that could have become a fire. These alerts are highly desirable but a fire department response is unnecessary.

In the fourth category, events have progressed enough to produce a recognizable fire. With an early warning from the system, the occupant is often able to extinguish the fire prior to fire

[27] Michael A. Greene and Craig Andres. *2004-2005 National Sample Survey of Unreported Residential Fires.* U.S. Consumer Product Safety Commission, July 2009.

department arrival. However, there is a risk of fire spread if the occupants cannot quickly put the fire out. Because not all spaces in a building are in the same proximity to the smoke alarm and some types of fires are detected earlier by some types of sensors than others, there is no obvious way to distinguish in advance between this type of fire and the last category of a more serious fire. In these cases, a prompt fire department response is essential.

Section 29.7.8.2 of NFPA 72®, *National Fire Alarm and Signaling Code®* allows supervising stations to verify alarm signals from household fire alarm systems before notifying the fire service if such verification will not delay reporting by more than 90 seconds and the authority having jurisdiction agrees.

One study found that actual fires caused roughly 3% of the fire department responses to residential fire alarm activations but most departments surveyed did not permit pre-response verification.

Peter Finley of the Vineland, New Jersey Fire Department won a 2002 outstanding research award for his analysis of the verification and response dilemma with residential fire alarm systems.[28] Half of the fire responses in 1999 and 2000 in Vineland, New Jersey were to automatic fire alarm system activations, with roughly one-third of these in one-or two-family homes. In 1998, the Vineland, New Jersey City Council ruled to ban verification of residential fire alarms before fire department notification and to immediately alert the fire department of any unscheduled activations..

Finley conducted research to determine if the ban should be overturned. As part of his study, he surveyed fire departments of comparable size and people in his own community who had unwanted residential alarms. He sent surveys to 203 departments protecting populations of 47,000 to 67,000 and received 67 usable responses. Actual fires caused only 3% of the residential fire alarm activations.

Three-quarters (78%) of the departments did not permit verification of residential fire alarms prior to responding. However, almost nine out of ten (88%) would modify the response if dispatch was informed that the alarm might be false. Almost two-thirds (64%) of the departments provided education about detector placement, maintenance and related issues if false alarms were becoming a problem. One-quarter of the departments issue citations or violation notices and almost one-third (31%) use fines or penalties when necessary. Eighty percent of the departments who issue fines permit at least three false alarms in a year before issuing the fines; 43% permitted three false alarms per year. This was the most common threshold. *Most did not consider unintentional activations from cooking, burnt food, candle or fireplace smoke, etc. to be false alarms.*

Finley also obtained survey data from 53 Vineland, New Jersey households that had experienced residential fire alarm system activations and fire department responses. Eighty-four percent said they tried to stop the fire department from responding. However, half (52%) said they would still want the fire department to check while two-thirds (69%) would still want the fire department to check if they came with just one engine and no lights or sirens. Three-quarters

[28] Peter J. Finley, Jr., *Residential Fire Alarm Systems: The Verification and Response Dilemma*, Executive Analysis of Fire Service Operations in Emergency Management, an applied research project submitted to the National Fire Academy as part of the Executive Fire Officer Program, from http://www.usfa.fema.gov/pdf/efop/tr 02pf.pdf, pp. 27-40.

(76%) did not want children who were home alone to be able to cancel the fire department response.

Insurance issues were also addressed in Finley's paper. He noted that homeowners generally get a discount on their property insurance if they have a monitored fire alarm system. Fire department verification or response procedures do not affect the discount. However, ISO required at least two engines and one ladder or truck to all structural incidents. Sending a lesser response could affect the homeowner's discount.

NIST study found that accumulation of cigarette smoke could trigger smoke alarms.
NIST researchers conducted two tests in which two smokers seated in a manufactured home's kitchen area smoked one cigarette each over a period of about four minutes. No alarm thresholds were reached in the first test, but in the second, two thresholds were reached in the ionization alarm closest to the smokers. They also noted that: "The mass concentrations during both tests appear to be approaching threshold levels for photoelectric alarms, suggesting repeated smoking, or more smokers, could produce threshold level values."[29]

Ontario Fire Marshal "Make It Stop" campaign addresses nuisance alarms.
Because of concern that nuisance alarms are driving people to disable their smoke alarms, the Ontario, Canada Fire Marshal's Office has started a campaign to address nuisance alarms called "Make It Stop." Their website, http://www.makeitstop.ca/, provides clear and prominent advice for consumers. They have also been working with local fire departments to get the word out to the media.[30]

Multi-faceted approach is necessary to solving the nuisance alarm problem.
Home owners, occupants, manufacturers, system installers, property managers and the fire service all have a role in addressing the problem of unwanted fire alarm activations. Because of the large number of fire department responses to unwanted fire alarm system activations, the International Association of Fire Chiefs convened a May 2011 summit, jointly sponsored by NFPA and the Federal Emergency Management Agency (FEMA) to address the issue. Verification of alarms was addressed. Although their focus was primarily non-residential settings, many of the issues affect systems in multi-family common areas. A summary of the proceedings may be downloaded from http://www.nfpa.org/assets/files//PDF/FireAlarmResponseSummit.pdf.. NFPA prepared some background material for this summit, available at http://www.nfpa.org/assets/files//PDF/OS.UnwantedAlarms.pdf , including statistics about unwanted fire alarms and some policies and issues related to prevention.

NFPA 72®, *National Fire Alarm and Signaling Code®* provides specific location requirements for smoke detectors and smoke alarms. Some of these are designed to facilitate operation; others are intended to prevent nuisance activations. Sometimes, the threat of penalties may facilitate a search for a solution. However, the threat may also deter and delay the reporting of real fires. Most people do not automatically assume a sounding smoke alarm is an emergency situation. In some cases, they know what caused the alarm and know that they are safe. However, lives have been lost when real alarms were mistakenly considered false. Unwanted activations can generate a dangerous sense of complacency.

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[29] Bukowski, et al, 2008 revision, p. 194.
[30] Gilbert, Bev. Personal communication, February 6, 2006.

Table 1.
Findings from 2010 Harris Poll® National Quorum:
National Fire Protection Association – Smoke Alarms

	Percentage of Homes with Smoke Alarms	All Homes
Homes with at least one smoke alarm	**100%**	**96%**
In hallways	80%	77%
In all bedrooms	43%	41%
In most bedrooms	14%	14%
Basement	29%	28%
Kitchen	52%	50%
Garage	15%	14%
Interconnected smoke alarms	25%	24%
Test their alarms at least once a year	87%	83%
Alarms tested at least once a month	21%	20%
Smoke alarms more than 10 years old	12%	12%
When householder is at least 55	17%	16%

Source: Harris Poll® National Quorum: National Fire Protection Association – Smoke Alarms. September 2010. Unknown and refused responses were allocated proportionally among known data.

Table 2.
Type of Detection in Home Structure Fires with Detection Equipment Present
2005-2009 Annual Averages

Type of Detection Equipment	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Smoke	242,500	(90%)	1,550	(94%)	133,890	(88%)	$126,201	(85%)
Non-confined fire	115,300	(43%)	1,550	(94%)	7,780	(5%)	$4,657	(3%)
Confined fire	127,200	(47%)	0	(0%)	126,110	(83%)	$121,544	(81%)
Combination smoke and heat	15,400	(6%)	30	(2%)	8,220	(5%)	$8,530	(6%)
Non-confined fire	5,100	(2%)	30	(2%)	190	(0%)	$242	(0%)
Confined fire	10,300	(4%)	0	(0%)	8,030	(5%)	$8,288	(6%)
More than one type present	4,800	(2%)	50	(3%)	6,730	(4%)	$6,035	(4%)
Non-confined fire	1,700	(1%)	50	(3%)	160	(0%)	$116	(0%)
Confined fire	3,100	(1%)	0	(0%)	6,570	(4%)	$5,919	(4%)
Unclassified detection equipment	2,100	(1%)	10	(0%)	750	(0%)	$1,930	(1%)
Non-confined fire	800	(0%)	10	(0%)	40	(0%)	$26	(0%)
Confined fire	1,300	(0%)	0	(0%)	710	(0%)	$1,904	(1%)
Heat	2,000	(1%)	10	(1%)	780	(1%)	$773	(1%)
Non-confined fire	700	(0%)	10	(1%)	40	(0%)	$25	(0%)
Confined fire	1,300	(0%)	0	(0%)	740	(0%)	$748	(1%)
Sprinkler with water flow detection	1,400	(1%)	0	(0%)	1,880	(1%)	$5,725	(4%)
Non-confined fire	500	(0%)	0	(0%)	30	(0%)	$100	(0%)
Confined fire	900	(0%)	0	(0%)	1,860	(1%)	$5,626	(4%)
Total	268,200	(100%)	1,640	(100%)	152,260	(100%)	$149,194	(100%)
Non-confined fire	124,200	(46%)	1,640	(100%)	8,230	(5%)	$5,166	(3%)
Confined fire	144,000	(54%)	0	(0%)	144,030	(95%)	$144,028	(97%)

Note: Sums may not equal totals due to rounding errors. Unknowns have been allocated proportionally.

Source: NFIRS 5.0 and NFPA survey.

Table 3A.
Reported Home Structure Fires by Smoke Alarm Status and Alarm Time
2005-2009 Annual Averages

Alarm Time	Operated	Did Not Operate	None Present	Fire Too Small	Total
Midnight - 12:59 a.m.	3%	4%	4%	2%	3%
1:00 - 1:59 a.m.	3%	3%	3%	2%	3%
2:00 - 2:59 a.m.	2%	3%	3%	1%	2%
3:00 - 3:59 a.m.	2%	3%	3%	1%	2%
4:00 - 4:59 a.m.	2%	3%	3%	1%	2%
5:00 - 5:59 a.m.	2%	2%	2%	1%	2%
6:00 - 6:59 a.m.	2%	2%	2%	2%	2%
7:00 - 7:59 a.m.	2%	3%	3%	3%	3%
8:00 - 8:59 a.m.	3%	3%	3%	3%	3%
9:00 - 9:59 a.m.	3%	4%	3%	3%	4%
10:00 - 10:59 a.m.	4%	4%	4%	4%	4%
11:00 - 11:59 a.m.	5%	4%	4%	4%	5%
Noon - 12:59 p.m.	5%	4%	5%	5%	5%
1:00 - 1:59 p.m.	5%	5%	5%	5%	5%
2:00 - 2:59 p.m.	5%	5%	5%	5%	5%
3:00 - 3:59 p.m.	6%	5%	5%	5%	5%
4:00 - 4:59 p.m.	6%	6%	6%	7%	6%
5:00 - 5:59 p.m.	7%	6%	6%	8%	7%
6:00 - 6:59 p.m.	8%	6%	6%	9%	7%
7:00 - 7:59 p.m.	7%	6%	6%	8%	7%
8:00 - 8:59 p.m.	6%	6%	5%	7%	6%
9:00 - 9:59 p.m.	5%	5%	5%	6%	5%
10:00 - 10:59 p.m.	4%	4%	5%	4%	4%
11:00 - 11:59 p.m.	3%	4%	4%	3%	3%
Total	100%	100%	100%	100%	100%
Average	4%	4%	4%	4%	4%
11:00 p.m. - 7:00 a.m.	18%	25%	25%	13%	20%

Note: Sums may not equal totals due to rounding errors. Unknowns have been allocated proportionally.

Source: NFIRS 5.0 and NFPA survey.

Table 3B.
Reported Home Structure Fire Deaths by Smoke Alarm Status and Alarm Time
2005-2009 Annual Averages

Alarm Time	Operated	Did Not Operate	None Present	Fire Too Small	Total
Midnight - 12:59 a.m.	5%	5%	7%	0%	6%
1:00 - 1:59 a.m.	5%	9%	7%	0%	7%
2:00 - 2:59 a.m.	5%	6%	8%	9%	7%
3:00 - 3:59 a.m.	9%	10%	7%	6%	7%
4:00 - 4:59 a.m.	6%	5%	6%	0%	7%
5:00 - 5:59 a.m.	5%	5%	7%	0%	5%
6:00 - 6:59 a.m.	4%	5%	6%	4%	5%
7:00 - 7:59 a.m.	5%	5%	5%	4%	4%
8:00 - 8:59 a.m.	3%	5%	6%	0%	4%
9:00 - 9:59 a.m.	4%	4%	2%	13%	3%
10:00 - 10:59 a.m.	4%	4%	3%	5%	3%
11:00 - 11:59 a.m.	3%	3%	2%	0%	3%
Noon - 12:59 p.m.	3%	2%	2%	10%	2%
1:00 - 1:59 p.m.	2%	3%	2%	11%	2%
2:00 - 2:59 p.m.	3%	2%	2%	0%	3%
3:00 - 3:59 p.m.	3%	2%	1%	10%	2%
4:00 - 4:59 p.m.	4%	2%	2%	0%	3%
5:00 - 5:59 p.m.	3%	3%	2%	4%	3%
6:00 - 6:59 p.m.	3%	3%	3%	9%	3%
7:00 - 7:59 p.m.	4%	2%	3%	10%	3%
8:00 - 8:59 p.m.	3%	3%	3%	0%	3%
9:00 - 9:59 p.m.	4%	5%	3%	0%	4%
10:00 - 10:59 p.m.	5%	3%	5%	4%	5%
11:00 - 11:59 p.m.	7%	5%	5%	0%	5%
Total	100%	100%	100%	100%	100%
Average	4%	4%	4%	4%	4%

Note: Sums may not equal totals due to rounding errors. Unknowns have been allocated proportionally.

Source: NFIRS 5.0 and NFPA survey.

Table 4.
Smoke Alarm Power Source in Home Structure Fires
2005-2009 Annual Averages

Power Source	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Battery only	134,600	(50%)	1,120	(68%)	5,570	(57%)	$2,656	(51%)
Non-confined fire	75,000	(28%)	1,120	(68%)	4,910	(50%)	$2,643	(51%)
Confined fire	59,600	(22%)	0	(0%)	660	(7%)	$13	(0%)
Hardwired with battery backup	75,600	(28%)	240	(15%)	2,270	(23%)	$1,548	(30%)
Non-confined fire	29,000	(11%)	240	(15%)	1,800	(18%)	$1,538	(30%)
Confined fire	46,700	(17%)	0	(0%)	470	(5%)	$9	(0%)
Hardwired only	43,800	(16%)	190	(12%)	1,450	(15%)	$737	(14%)
Non-confined fire	15,100	(6%)	190	(12%)	1,160	(12%)	$729	(14%)
Confined fire	28,600	(11%)	0	(0%)	300	(3%)	$8	(0%)
Multiple detection devices and power supplies	7,900	(3%)	70	(4%)	280	(3%)	$158	(3%)
Non-confined fire	2,500	(1%)	70	(4%)	230	(2%)	$156	(3%)
Confined fire	5,300	(2%)	0	(0%)	50	(1%)	$2	(0%)
Plug-in with battery backup	3,400	(1%)	10	(0%)	100	(1%)	$57	(1%)
Non-confined fire	1,400	(1%)	10	(0%)	80	(1%)	$57	(1%)
Confined fire	2,000	(1%)	0	(0%)	20	(0%)	$1	(0%)
Unclassified power source	1,700	(1%)	10	(1%)	30	(0%)	$28	(1%)
Non-confined fire	600	(0%)	10	(1%)	30	(0%)	$28	(1%)
Confined fire	1,100	(0%)	0	(0%)	0	(0%)	$0	(0%)
Plug-in	800	(0%)	0	(0%)	20	(0%)	$10	(0%)
Non-confined fire	300	(0%)	0	(0%)	10	(0%)	$9	(0%)
Confined fire	500	(0%)	0	(0%)	0	(0%)	$0	(0%)
Mechanical	400	(0%)	0	(0%)	10	(0%)	$6	(0%)
Non-confined fire	200	(0%)	0	(0%)	10	(0%)	$6	(0%)
Confined fire	200	(0%)	0	(0%)	0	(0%)	$0	(0%)
Total	268,200	(100%)	1,640	(100%)	9,740	(100%)	$5,199	(100%)
Non-confined fire	124,200	(46%)	1,640	(100%)	8,230	(85%)	$5,166	(99%)
Confined fire	144,000	(54%)	0	(0%)	1,500	(15%)	$34	(1%)

Note: Sums may not equal totals due to rounding errors. Unknowns have been allocated proportionally. Smoke alarm presence, operation, and power source are not required fields in NFIRS 5.0. Smoke alarm presence was completed in 67% of non-confined fires but only 4% of confined fires. Estimates of these elements in non-confined fires are therefore more reliable than estimates for confined fires and totals but non-confined estimates exclude many minor fires.

Source: NFIRS 5.0 and NFPA survey.

Table 5.
Smoke Alarm Operation in Home Fires Considered Large Enough to Activate Alarm
By Power Source
2005-2009 Annual Averages

Power Source	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Battery only	84,400	(77%)	550	(49%)	3,510	(67%)	$2,033	(79%)
Non-confined fire	47,800	(74%)	550	(49%)	3,120	(67%)	$2,024	(79%)
Confined fire	36,600	(81%)	0	(0%)	390	(73%)	$9	(82%)
All hardwired	93,600	(92%)	310	(74%)	3,010	(87%)	$2,005	(90%)
Non-confined fire	32,900	(88%)	310	(74%)	2,420	(87%)	$1,994	(90%)
Confined fire	60,700	(95%)	0	(0%)	590	(87%)	$11	(94%)
Hardwired only	34,300	(90%)	130	(69%)	1,150	(84%)	$609	(85%)
Non-confined fire	10,700	(83%)	130	(69%)	910	(83%)	$606	(85%)
Confined fire	23,500	(94%)	0	(0%)	240	(87%)	$4	(94%)
Hardwired with battery backup	59,300	(94%)	180	(78%)	1,850	(89%)	$1,396	(93%)
Non-confined fire	22,200	(91%)	180	(78%)	1,500	(90%)	$1,388	(93%)
Confined fire	37,100	(96%)	0	(0%)	350	(87%)	$7	(94%)
All power sources	189,100	(85%)	980	(61%)	6,950	(77%)	$4,279	(85%)
Non-confined fire	85,100	(80%)	980	(61%)	5,910	(76%)	$4,256	(85%)
Confined fire	104,000	(90%)	0	(0%)	1,040	(80%)	$23	(89%)

Note: Sums may not equal totals due to rounding errors. Unknowns have been allocated proportionally. Smoke alarm presence, operation, and power source are not required fields in NFIRS 5.0. Smoke alarm presence was completed in 67% of non-confined fires but only 4% of confined fires. Estimates of these elements in non-confined fires are therefore more reliable than estimates for confined fires and totals, but non-confined estimates exclude many minor fires. Operation was calculated based on the number of fires in which smoke alarms were present and operated/divided by the number preset that operated and failed to operate. Fires that were too small to operate were excluded. Minor power sources are not shown separately but are include in the entry for all power sources.

Source: NFIRS 5.0 and NFPA survey.

Table 6.
2009 American Housing Survey Findings on Occupied Housing Units with Smoke Alarms Based on Self-Reports

Characteristic	All Homes	Smoke Alarm Powered by: Electricity and Battery	Electricity Only	Battery Only	Batteries Replaced in Last Six Months
Total	94%	28%	8%	65%	77%
Owner-occupied	95%	32%	8%	61%	77%
Renter-occupied	93%	19%	8%	73%	76%
Newer home - four years old or less	98%	55%	10%	36%	69%
Manufactured home	93%	31%	12%	57%	75%
Black householder	94%	20%	7%	73%	76%
Hispanic householder	89%	19%	7%	74%	78%
Householder at least 65 years old	93%	23%	10%	67%	77%
Household below poverty line	90%	18%	9%	74%	77%
Northeast	96%	24%	9%	67%	82%
Midwest	96%	25%	6%	69%	79%
South	93%	30%	9%	61%	76%
West	94%	29%	8%	64%	71%

Note: The survey reported these data as "working smoke alarms." However, it appears the survey did not ask separate questions about smoke alarm presence and operability and did not verify that the smoke alarms were working. For that reason, the AHS results presented here do not mention whether they are working.

Source: U.S. Census Bureau, Current Housing Reports, Series H150/09, *American Housing Survey for the United States, 2009,* U.S. Government Printing Office, Washington, DC. 20401, 2011. Table 2-4.

Table 7.
Smoke Alarm Findings from CPSC's 2004-2005 Residential Fire Survey

A. Smoke Alarm Coverage in Fire and Non-Fire Households
Based on weighted responses from 916 fire households and 2,161 non-fire households

Alarm Coverage	Fire Household	Non-Fire Household
Smoke alarm present	93%	97%
On all floors	82%	84%
In all bedrooms	22%	31%
Interconnected	13%	19%
Connected to home security service	8%	14%

Sections B, C and D are based on weighted responses from 270 households having low severity fires within the past 14 days or high severity fires within the past 21 days. In Section B, indentation indicates a sequence – In 86% of the fires, someone was home and at least one alarm was present.

B. Smoke Alarm Performance and Effectiveness

Condition	Percent of All Fires
Fires with someone home	96%
At least one alarm present	86%
Smoke alarm sounded	30%
Alerted people	12%
Provided only alert	10%
Alarm did not sound	55%
Not enough smoke	49%

C. Smoke Alarm Performance and Effectiveness by Extent of Coverage

Alarm Coverage	Sounded	Alerted Occupants	Only Alert
On all floors	37%	15%	2%
Not on all floors	4%	2%	2%
In all bedrooms	36%	16%	13%
Not in all bedrooms	28%	10%	9%
Interconnected	53%	26%	26%
Not interconnected	27%	10%	8%

D. Smoke Alarm Performance and Effectiveness by Cause of Fire

Cause of Fire	Sounded	Alerted Occupants	Only Alert
Stove fires	41%	16%	13%
Other cooking	30%	16%	11%
Cigarette/match	28%	8%	8%
Candle	20%	7%	6%
Lighting/wiring	6%	5%	5%
Heating/cooling	18%	4%	1%

Source: Michael A. Greene and Craig Andres. *2004-2005 National Sample Survey of Unreported Residential Fires.* U.S. Consumer Product Safety Commission, July 2009.

Table 8.
Power Source in Smoke Alarms That Did Not Operate
in Non-Confined Home Structure Fires Considered Large Enough to Activate Alarm
2005-2009 Annual Averages

Power Source	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Battery only	16,000	(76%)	510	(80%)	1,460	(78%)	$517	(67%)
Hardwired only	2,200	(11%)	50	(8%)	190	(10%)	$107	(14%)
Hardwired with battery backup	2,200	(10%)	50	(8%)	170	(9%)	$113	(15%)
Multiple detectors and power supplies	300	(2%)	20	(3%)	40	(2%)	$23	(3%)
Plug-in with or without battery backup	200	(1%)	0	(0%)	10	(0%)	$9	(1%)
Other known power source	100	(0%)	0	(0%)	10	(0%)	$6	(1%)
Total	21,100	(100%)	640	(100%)	1,870	(100%)	$776	(100%)

Note: Sums may not equal totals due to rounding errors. Unknowns have been allocated proportionally.

Source: NFIRS 5.0 and NFPA survey.

Table 9.
Reason Smoke Alarm Did Not Operate in Non-Confined Home Structure Fires Considered Large Enough to Activate Alarm
2005-2009 Annual Averages

A. All Power Sources Combined

Reason for Failure	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Missing or disconnected battery	10,600	(50%)	470	(73%)	1,170	(63%)	$334	(43%)
Dead or discharged battery	4,900	(23%)	50	(8%)	320	(17%)	$138	(18%)
Unclassified reason for failure	1,800	(9%)	20	(4%)	90	(5%)	$165	(21%)
Hardwired power failure, shut-off or disconnect	1,500	(7%)	50	(8%)	120	(6%)	$74	(10%)
Lack of cleaning	900	(4%)	20	(3%)	80	(4%)	$26	(3%)
Defective unit	700	(3%)	10	(1%)	50	(3%)	$13	(2%)
Improper installation or placement	600	(3%)	10	(2%)	40	(2%)	$27	(3%)
Total	21,100	(100%)	640	(100%)	1,870	(100%)	$776	(100%)

B. Battery Only

Reason for Failure	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Missing or disconnected battery	9,500	(59%)	430	(84%)	1,050	(72%)	$303	(59%)
Dead or discharged battery	4,500	(28%)	50	(10%)	290	(20%)	$131	(25%)
Unclassified reason for failure	800	(5%)	10	(2%)	40	(3%)	$47	(9%)
Lack of cleaning	500	(3%)	10	(2%)	40	(3%)	$16	(3%)
Improper installation or placement	400	(2%)	10	(2%)	30	(2%)	$15	(3%)
Defective unit	300	(2%)	0	(1%)	20	(1%)	$7	(1%)
Total	16,000	(100%)	510	(100%)	1,460	(100%)	$517	(100%)

Note: Sums may not equal totals due to rounding errors. Unknowns have been allocated proportionally.

Source: NFIRS 5.0 and NFPA survey.

Table 9.
Reason Smoke Alarm Did Not Operate in Non-Confined Home Structure Fires
Considered Large Enough to Activate Alarm
2005-2009 Annual Averages
(Continued)

C. Hardwired Only

Reason for Failure	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Hardwired power failure, shut-off or disconnect	1,300	(57%)	40	(73%)	100	(53%)	$47	(44%)
Unclassified reason for failure	400	(17%)	10	(15%)	20	(12%)	$50	(46%)
Defective unit	300	(12%)	0	(6%)	30	(14%)	$4	(3%)
Lack of cleaning	200	(10%)	0	(5%)	30	(16%)	$4	(4%)
Improper installation or placement	100	(5%)	0	(0%)	10	(6%)	$3	(3%)
Total	2,200	(100%)	50	(100%)	190	(100%)	$107	(100%)

D. Hardwired with Battery Backup

Reason for Failure	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Hardwired power failure, shut-off or disconnect	600	(28%)	20	(37%)	40	(23%)	$24	(21%)
Unclassified reason for failure	600	(25%)	10	(20%)	40	(22%)	$54	(48%)
Missing or disconnected battery	500	(23%)	10	(24%)	60	(33%)	$21	(18%)
Lack of cleaning	200	(9%)	0	(0%)	20	(11%)	$3	(3%)
Defective unit	200	(8%)	0	(9%)	10	(7%)	$4	(3%)
Improper installation or placement	100	(4%)	0	(5%)	0	(3%)	$3	(3%)
Dead or discharged battery	100	(3%)	0	(5%)	0	(2%)	$4	(4%)
Total	2,200	(100%)	50	(100%)	170	(100%)	$113	(100%)

Note: Sums may not equal totals due to rounding errors. Unknowns have been allocated proportionally.

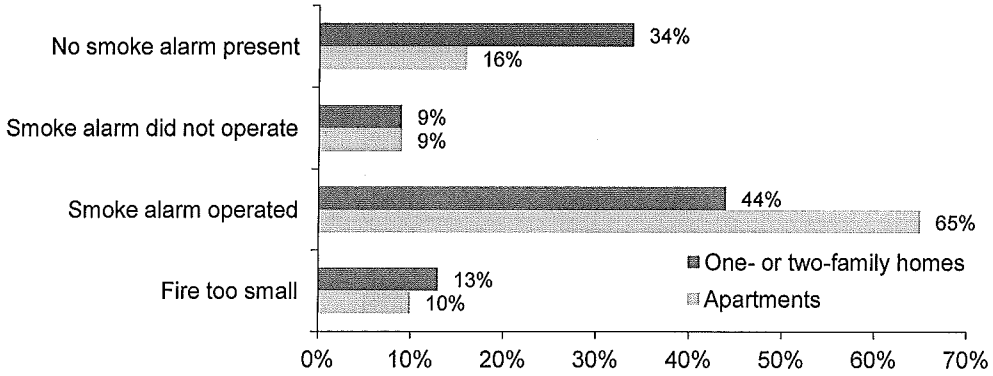
Source: NFIRS 5.0 and NFPA survey.

Smoke Alarms in One- and Two-Family Homes vs. Apartments

Smoke alarms were more likely have been present and to have operated in apartment fires than in fires in one-or two-family homes.
Seventy-one percent of the reported home fires and 84% of the fatal home fire injuries in 2005-2009 occurred in one- and two-family homes (including manufactured homes). Consequently, the profile for smoke alarm performance for all homes resembles that of one-and two-family homes. But there are major differences between one- and two-family homes and the more heavily regulated apartments.[31] Tables 10 and 11 show that smoke alarms were present in 84% of reported apartment fires but only two-thirds (66%) of the fires in one- or two-family homes. Figure 17 shows that smoke alarms operated in roughly two-thirds (65%) of the reported apartment fires but less than half (44%) of the reported fires in one and two-family homes.

The NFIRS coding system counts smoke alarms in the fire area as present, although the term "fire area" is not specifically defined. It does not capture when in the fire's development the device activated or how close it was to area of origin. A fire that starts in an apartment that has no working smoke alarm may activate a smoke alarm in a common hallway or a unit nearby. Residents of the other units may benefit from these smoke alarms' warnings even when the unit of origin lacks the protection. Similarly, a fire that starts on a second story without a smoke alarm may eventually activate a smoke alarm on the first floor.

Figure 17. Smoke Alarm Status in Reported One- and Two-Family Home vs. Apartment Fires: 2005-2009



Source: NFIRS 5.0 and NFPA survey.

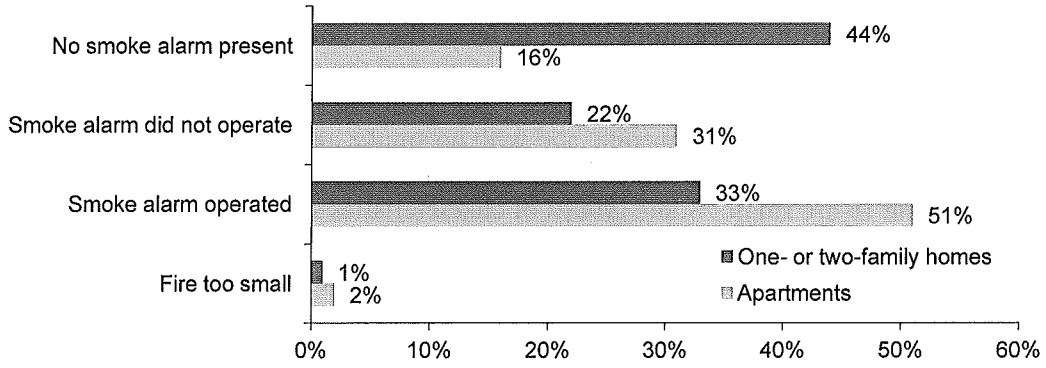
Half of apartment fire deaths and one-third of one-and two-family home fire deaths resulted from fires with operating smoke alarms.

Tables 10 and 11 also show that 56% of the deaths from fires in one and two-family homes had at least one smoke alarm, as did 84% of the apartment fire deaths. Figure 18 shows that only one-third (33%) of the fire deaths in one-and two-family homes resulted from fires with operating

[31] The category of apartment includes tenements, flats and properties of similar configuration. Townhouses normally involve three or more separate housing units per building and so would be grouped with apartments. Most condominiums would also be grouped with apartments, but it is important to note that "condominium" is a type of ownership, not a type of building or property use.

smoke alarms compared to half (51%) in apartments. Almost half (44%) of the deaths resulting from fires in one- or two-family homes occurred in properties with no smoke alarms at all compared to only 16% of the deaths from apartment fires with no smoke alarms.

Figure 18. Smoke Alarm Status in Deaths Resulting from Fires in One- and Two-Family Homes vs. Apartments: 2005-2009

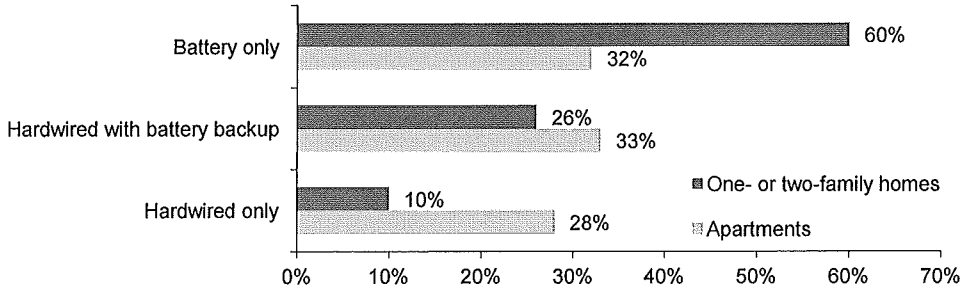


Source: NFIRS 5.0 and NFPA survey.

Hardwired smoke alarms were more common in apartment fires.
Tables 12 and 13 show that there is little difference in the type of detection equipment found in reported fires in one- and two-family homes and apartments. Equipment designed to detect smoke only accounted for 93% of the detection equipment in one- and two-family homes and 86% of such equipment in apartments. Combination smoke and heat alarms accounted for an additional 5% of the detection types found in one-and two-family homes and 7% of the detection types in apartments. Apartments were more likely to have more than one type of detection equipment present (4% vs. 1%).

Power sources do differ by occupancy. Figure 19 and Tables 14 and 15 show that only one-third (32%) of the smoke alarms in apartment structure fires were powered by batteries only compared to 60% in one- and two-family homes.

Figure 19. Leading Smoke Alarm Power Sources in Reported Home Fires, by Occupancy 2005-2009



Source: NFIRS 5.0 and NFPA survey.

When hardwired smoke alarms were present in one-and two-family home fires, almost two-thirds (65%) of the alarms had battery backup. Battery backup was found in slightly more than half (54%) of the hardwired smoke alarms in apartment fires. It is possible that hardwired smoke alarms in one- and two-family homes are newer, on average, because the emphasis on battery backup is a more recent development.

Apartment fatal fire victims were more likely to be in the room of fire origin.
Table 16 is an overview of characteristics of fatal victims and their fires during 2005-2009, in a) one- and two-family homes, and b) apartments, with operating smoke alarms, with smoke alarms that were present but did not operate, and with no smoke alarms at all. Deaths resulting from fires that were too small to activate the smoke alarm are not shown. Many of the differences in Table 16 are small. Some groups of characteristics seem to be measuring the same or similar phenomena but show inconsistent patterns in doing so. In many cases, the differences seem to vary more by occupancy than by smoke alarm status. The number of apartment fatalities is relatively small and should be viewed with caution. The most striking differences in Table 16 are seen in the victim's proximity to the fire. Regardless of smoke alarm status, apartment victims were more likely to have been in the general area of the fire at ignition than were the victims in one- and two-family homes. When smoke alarms operated, 60% of the victims of fatal fires in one-and two-family homes were in the general area of origin at time of fatal injury compared to 73% of the apartment victims who were that close to the fire. Apartment victims were also more likely to have been in the area of origin and involved in the ignition than victims in one- and two-family homes. This suggests that there were proportionally more people in apartments who were so close to the fire that they may not have had time to escape, even with the warning from a working smoke alarm.

Table 10.
Smoke Alarm Status in One- and Two-Family Home Fires
2005-2009 Annual Averages

Smoke Alarm Status	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Smoke Alarm Present	175,800	(66%)	1,240	(56%)	6,190	(70%)	$4,109	(70%)
Fire too small to operate alarm	35,000	(13%)	10	(1%)	430	(5%)	$112	(2%)
Fire too small to operate in non-confined fire	14,400	(5%)	10	(1%)	300	(3%)	$109	(2%)
Fire too small to operate in confined fire	20,600	(8%)	0	(0%)	130	(1%)	$4	(0%)
Smoke alarm present and fire large enough to operate alarm	140,800	(53%)	1,220	(55%)	5,760	(65%)	$3,997	(68%)
Smoke alarm operated	117,500	(44%)	730	(33%)	4,270	(48%)	$3,371	(57%)
Smoke alarm operated in non-confined fire	65,400	(25%)	730	(33%)	3,790	(43%)	$3,355	(57%)
Smoke alarm operated in confined fire	52,100	(20%)	0	(0%)	480	(5%)	$15	(0%)
Smoke alarm present but did not operate	23,300	(9%)	490	(22%)	1,490	(17%)	$626	(11%)
Smoke alarm present but did not operate in non-confined fire	16,900	(6%)	490	(22%)	1,350	(15%)	$624	(11%)
Smoke alarm present but did not operate in confined fire	6,400	(2%)	0	(0%)	140	(2%)	$2	(0%)
No Smoke Alarm	88,800	(34%)	970	(44%)	2,670	(30%)	$1,786	(30%)
No smoke alarm present in non-confined fire	69,800	(26%)	970	(44%)	2,480	(28%)	$1,780	(30%)
No smoke alarm present in confined fire	18,900	(7%)	0	(0%)	190	(2%)	$6	(0%)
No working smoke alarm (Sum of no smoke alarms and alarms that were present but did not operate)	112,100	(42%)	1,470	(66%)	4,160	(47%)	$2,412	(41%)
Total	264,500	(100%)	2,210	(100%)	8,860	(100%)	$5,895	(100%)

Note: Sums may not equal totals due to rounding errors. Confined and non-confined fires were analyzed separately. Smoke alarm presence or absence was reported in 64% of non-confined fires and 4% of confined fires. Fires with unknown or missing data were allocated proportionally among fires with missing data.

Source: NFIRS 5.0 and NFPA survey.

Table 11.
Smoke Alarm Status in Apartment Fires
2005-2009 Annual Averages

Smoke Alarm Status	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Smoke Alarm Present	91,800	(84%)	370	(84%)	3,480	(86%)	$1,052	(84%)
Fire too small to operate alarm	10,700	(10%)	10	(2%)	230	(6%)	$29	(2%)
Fire too small to operate in non-confined fire	3,600	(3%)	10	(2%)	140	(4%)	$25	(2%)
Fire too small to operate in confined fire	7,100	(6%)	0	(0%)	80	(2%)	$3	(0%)
Smoke alarm present and fire large enough to operate alarm	81,100	(74%)	360	(82%)	3,250	(81%)	$1,024	(82%)
Smoke alarm operated	71,500	(65%)	220	(51%)	2,600	(65%)	$875	(70%)
Smoke alarm operated in non-confined fire	18,800	(17%)	220	(51%)	2,060	(51%)	$867	(69%)
Smoke alarm operated in confined fire	52,600	(48%)	0	(0%)	550	(14%)	$8	(1%)
Smoke alarm present but did not operate	9,700	(9%)	130	(31%)	650	(16%)	$149	(12%)
Smoke alarm present but did not operate in non-confined fire	4,100	(4%)	130	(31%)	520	(13%)	$148	(12%)
Smoke alarm present but did not operate in confined fire	5,500	(5%)	0	(0%)	120	(3%)	$1	(0%)
No Smoke Alarm	17,500	(16%)	70	(16%)	550	(14%)	$198	(16%)
No smoke alarm present in non-confined fire	9,900	(9%)	70	(16%)	510	(13%)	$197	(16%)
No smoke alarm present in confined fire	7,600	(7%)	0	(0%)	40	(1%)	$1	(0%)
No working smoke alarm (Sum of no smoke alarms and alarms that were present but did not operate)	27,200	(25%)	200	(47%)	1,200	(30%)	$347	(28%)
Total	109,400	(100%)	440	(100%)	4,030	(100%)	$1,251	(100%)

Note: Sums may not equal totals due to rounding errors. Confined and non-confined fires were analyzed separately. Smoke alarm presence or absence was reported in 79% of non-confined fires and 4% of confined fires. Fires with unknown or missing data were allocated proportionally among fires with missing data.

Source: NFIRS 5.0 and NFPA survey.

Table 12.
Type of Detection in One- and Two-Family Home Structure Fires
with Detection Equipment Present
2005-2009 Annual Averages

Type of Detection Equipment	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Smoke	163,300	(93%)	1,180	(95%)	5,970	(97%)	$3,732	(91%)
Non-confined fire	90,900	(52%)	1,180	(95%)	5,260	(85%)	$3,713	(90%)
Confined fire	72,400	(41%)	0	(0%)	710	(11%)	$19	(0%)
Combination smoke and heat	8,800	(5%)	20	(2%)	130	(2%)	$196	(5%)
Non-confined fire	3,900	(2%)	20	(2%)	110	(2%)	$194	(5%)
Confined fire	4,800	(3%)	0	(0%)	20	(0%)	$1	(0%)
More than one type present	1,500	(1%)	20	(2%)	40	(1%)	$52	(1%)
Non-confined fire	700	(0%)	20	(2%)	30	(1%)	$51	(1%)
Confined fire	700	(0%)	0	(0%)	10	(0%)	$0	(0%)
Unclassified detection equipment	1,300	(1%)	10	(1%)	20	(0%)	$19	(0%)
Non-confined fire	500	(0%)	10	(1%)	20	(0%)	$19	(0%)
Confined fire	800	(0%)	0	(0%)	0	(0%)	$0	(0%)
Heat	800	(0%)	10	(1%)	20	(0%)	$14	(0%)
Non-confined fire	400	(0%)	10	(1%)	20	(0%)	$14	(0%)
Confined fire	400	(0%)	0	(0%)	0	(0%)	$0	(0%)
Sprinklers with water flow detection	100	(0%)	0	(0%)	0	(0%)	$96	(2%)
Non-confined fire	100	(0%)	0	(0%)	0	(0%)	$96	(2%)
Confined fire	100	(0%)	0	(0%)	0	(0%)	$0	(0%)
Total	175,800	(100%)	1,240	(100%)	6,190	(100%)	$4,109	(100%)
Non-confined fire	96,600	(55%)	1,240	(100%)	5,450	(88%)	$4,088	(99%)
Confined fire	79,200	(45%)	0	(0%)	740	(12%)	$21	(1%)

Note: Sums may not equal totals due to rounding errors. Entries of zero may actually be zero or may have rounded to zero.

Source: NFIRS 5.0 and NFPA survey.

Table 13.
Type of Detection in Apartment Structure Fires with Detection Equipment Present
2005-2009 Annual Averages

Type of Detection Equipment	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Smoke	78,600	(86%)	340	(92%)	3,080	(89%)	$926	(88%)
Non-confined fire	23,700	(26%)	340	(92%)	2,470	(71%)	$917	(87%)
Confined fire	54,900	(60%)	0	(0%)	610	(18%)	$9	(1%)
Combination smoke and heat	6,700	(7%)	10	(2%)	140	(4%)	$47	(4%)
Non-confined fire	1,100	(1%)	10	(2%)	80	(2%)	$47	(4%)
Confined fire	5,500	(6%)	0	(0%)	60	(2%)	$1	(0%)
More than one type present	3,300	(4%)	20	(6%)	170	(5%)	$55	(5%)
Non-confined fire	900	(1%)	20	(6%)	110	(3%)	$54	(5%)
Confined fire	2,500	(3%)	0	(0%)	50	(2%)	$1	(0%)
Sprinklers with water flow detection	1,300	(1%)	0	(0%)	40	(1%)	$8	(1%)
Non-confined fire	400	(0%)	0	(0%)	20	(1%)	$7	(1%)
Confined fire	900	(1%)	0	(0%)	20	(0%)	$1	(0%)
Heat	1,200	(1%)	0	(0%)	20	(1%)	$9	(1%)
Non-confined fire	300	(0%)	0	(0%)	20	(1%)	$9	(1%)
Confined fire	1,000	(1%)	0	(0%)	0	(0%)	$0	(0%)
Unclassified detection equipment	800	(1%)	0	(0%)	30	(1%)	$7	(1%)
Non-confined fire	300	(0%)	0	(0%)	20	(1%)	$7	(1%)
Confined fire	500	(1%)	0	(0%)	10	(0%)	$0	(0%)
Total	91,800	(100%)	370	(100%)	3,480	(100%)	$1,052	(100%)
Non-confined fire	26,600	(29%)	370	(100%)	2,730	(78%)	$1,040	(99%)
Confined fire	65,300	(71%)	0	(0%)	750	(22%)	$12	(1%)

NA – Not applicable because total is zero.

Note: Sums may not equal totals due to rounding errors. Entries of zero may actually be zero or may have rounded to zero.

Source: NFIRS 5.0 and NFPA survey.

Table 14.
Smoke Alarm Power Source in One- and Two-Family Home Structure Fires
2005-2009 Annual Averages

Power Source	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Battery only	105,700	(60%)	970	(78%)	4,290	(69%)	$2,280	(55%)
Non-confined fire	64,400	(37%)	970	(78%)	3,820	(62%)	$2,269	(55%)
Confined fire	41,200	(23%)	0	(0%)	480	(8%)	$11	(0%)
Hardwired with battery backup	45,200	(26%)	140	(11%)	1,160	(19%)	$1,165	(28%)
Non-confined fire	20,600	(12%)	140	(11%)	1,010	(16%)	$1,159	(28%)
Confined fire	24,600	(14%)	0	(0%)	140	(2%)	$6	(0%)
Hardwired only	17,700	(10%)	90	(7%)	550	(9%)	$491	(12%)
Non-confined fire	8,200	(5%)	90	(7%)	460	(7%)	$488	(12%)
Confined fire	9,400	(5%)	0	(0%)	80	(1%)	$2	(0%)
Multiple detection devices and power supplies	3,100	(2%)	30	(2%)	80	(1%)	$87	(2%)
Non-confined fire	1,400	(1%)	30	(2%)	70	(1%)	$86	(2%)
Confined fire	1,700	(1%)	0	(0%)	10	(0%)	$1	(0%)
Plug-in with battery backup	2,300	(1%)	0	(0%)	70	(1%)	$49	(1%)
Non-confined fire	1,100	(1%)	0	(0%)	50	(1%)	$48	(1%)
Confined fire	1,200	(1%)	0	(0%)	20	(0%)	$0	(0%)
Unclassified power source	1,100	(1%)	10	(1%)	20	(0%)	$24	(1%)
Non-confined fire	500	(0%)	10	(1%)	20	(0%)	$24	(1%)
Confined fire	600	(0%)	0	(0%)	0	(0%)	$0	(0%)
Plug-in	600	(0%)	0	(0%)	10	(0%)	$9	(0%)
Non-confined fire	200	(0%)	0	(0%)	10	(0%)	$8	(0%)
Confined fire	300	(0%)	0	(0%)	0	(0%)	$0	(0%)
Mechanical	200	(0%)	0	(0%)	0	(0%)	$5	(0%)
Non-confined fire	100	(0%)	0	(0%)	0	(0%)	$5	(0%)
Confined fire	100	(0%)	0	(0%)	0	(0%)	$0	(0%)
Total	175,800	(100%)	1,240	(100%)	6,190	(100%)	$4,109	(100%)
Non-confined fire	96,600	(55%)	1,240	(100%)	5,450	(88%)	$4,088	(99%)
Confined fire	79,200	(45%)	0	(0%)	740	(12%)	$21	(1%)

Note: Sums may not equal totals due to rounding errors. Entries of zero may actually be zero or may round to zero.
Source: NFIRS 5.0 and NFPA survey.

Table 15.
Smoke Alarm Power Source in Apartment Structure Fires
2005-2009 Annual Averages

Power Source	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Hardwired with battery backup	30,100	(33%)	80	(22%)	1,050	(30%)	$359	(34%)
Non-confined fire	7,800	(8%)	80	(22%)	750	(21%)	$355	(34%)
Confined fire	22,300	(24%)	0	(0%)	300	(9%)	$3	(0%)
Battery only	29,000	(32%)	170	(46%)	1,360	(39%)	$396	(38%)
Non-confined fire	11,100	(12%)	170	(46%)	1,150	(33%)	$393	(37%)
Confined fire	17,800	(19%)	0	(0%)	210	(6%)	$3	(0%)
Hardwired only	25,900	(28%)	80	(22%)	840	(24%)	$221	(21%)
Non-confined fire	6,100	(7%)	80	(22%)	640	(19%)	$216	(21%)
Confined fire	19,800	(22%)	0	(0%)	190	(6%)	$5	(0%)
Multiple detection devices and power supplies	4,800	(5%)	30	(9%)	190	(5%)	$62	(6%)
Non-confined fire	1,000	(1%)	30	(9%)	140	(4%)	$61	(6%)
Confined fire	3,800	(4%)	0	(0%)	40	(1%)	$1	(0%)
Plug-in with battery backup	1,100	(1%)	0	(0%)	30	(1%)	$9	(1%)
Non-confined fire	300	(0%)	0	(0%)	20	(1%)	$9	(1%)
Confined fire	800	(1%)	0	(0%)	0	(0%)	$0	(0%)
Unclassified power source	600	(1%)	0	(1%)	10	(0%)	$4	(0%)
Non-confined fire	200	(0%)	0	(1%)	10	(0%)	$4	(0%)
Confined fire	400	(0%)	0	(0%)	0	(0%)	$0	(0%)
Plug-in	200	(0%)	0	(0%)	10	(0%)	$1	(0%)
Non-confined fire	100	(0%)	0	(0%)	10	(0%)	$1	(0%)
Confined fire	200	(0%)	0	(0%)	0	(0%)	$0	(0%)
Mechanical	200	(0%)	0	(0%)	0	(0%)	$1	(0%)
Non-confined fire	100	(0%)	0	(0%)	0	(0%)	$1	(0%)
Confined fire	100	(0%)	0	(0%)	0	(0%)	$0	(0%)
Total	91,800	(100%)	370	(100%)	3,480	(100%)	$1,052	(100%)
Non-confined fire	26,600	(29%)	370	(100%)	2,730	(78%)	$1,040	(99%)
Confined fire	65,300	(71%)	0	(0%)	750	(22%)	$12	(1%)

Note: Sums may not equal totals due to rounding errors. Entries of zero may actually be zero or may round to zero.
Source: NFIRS 5.0 and NFPA survey.

Table 16.
Characteristics of Fatal Fires and Victims in Non-Confined Home Structure Fires
by Occupancy and Smoke Alarm Status
2005-2009

Characteristic	*One- and Two-Family Homes*						*Apartments*					
	Alarm Operated		Did Not Operate		No Alarms		Alarm Operated		Did Not Operate		No Alarms	
Total*	730	(100%)	490	(100%)	970	(100%)	220	(100%)	130	(100%)	70	(100%)
Victim in area of origin at time of incident and involved	320	(44%)	160	(32%)	350	(36%)	120	(56%)	50	(35%)	30	(44%)
Victim in general area of fire at time of injury	440	(60%)	220	(45%)	460	(48%)	160	(73%)	80	(61%)	50	(66%)
Fire spread flames beyond room of origin	540	(75%)	370	(75%)	780	(81%)	130	(57%)	70	(53%)	50	(69%)
Victim unconscious, restrained, physically or possibly mentally disabled or impaired by drugs or alcohol**	310	(42%)	180	(37%)	370	(38%)	100	(47%)	60	(46%)	30	(36%)
Victim age 65 or older	260	(36%)	120	(24%)	280	(28%)	70	(33%)	30	(21%)	10	(19%)
Victim age under five	40	(6%)	80	(15%)	90	(9%)	10	(4%)	20	(13%)	10	(13%)
Victim unable to act or acted irrationally	170	(23%)	70	(14%)	120	(12%)	50	(22%)	20	(11%)	10	(21%)
Victim attempting fire control or rescue	70	(9%)	20	(4%)	40	(4%)	10	(6%)	10	(5%)	0	(2%)

* The totals are provided for context only. Because the entries in this table are pulled from different fields, the sums will greatly exceed the totals. This table does not include fire deaths resulting from fires that were too small to activate the smoke alarm. Entries of zero may actually be zero or may have rounded to zero.

**Multiple entries are allowed in this field so double counting is possible.

Note: Sums may not equal totals due to rounding errors.

Source: NFIRS 5.0 and NFPA survey.

Characteristics of Victims in Fires with and without Working Smoke Alarms

Smoke alarms save lives. As shown in Figure 8, the death rate per 100 reported structure fires in all types of homes (one- or two family homes and apartments) with working smoke alarms is less than half the rate found in reported fires in which either no smoke alarms were present at all or smoke alarms were present but did not operate. But some people do die in fires with working smoke alarms. Why were these victims unable to benefit from a sounding smoke alarm? This section examines the characteristics and circumstances in which death occurred despite the presence of a working smoke alarm and compares them to the victim characteristics and circumstances when no smoke alarms were present or smoke alarms did not operate..

Compared to deaths resulting from fires in which no smoke alarms were present or alarms were present but did not operate, victims of fatal fires with working smoke alarms were

- More likely to have been in the room or area of origin and even more likely to have been in the area of origin and involved in ignition;
- Less likely to have been sleeping when fatally injured;
- More likely to have been fighting the fire themselves or have been unable to act; and
- More likely to have been at least 65 years old,

In other words, victims with working smoke alarms were more likely to have at least one characteristic that meant they would have less time to escape when the alarm sounded (e.g., because they were so close to the fire) or they would be less able to use the escape time effectively (e.g., because they were trying to fight the fire, or were unable to act quickly.)

24% of fatal home fire victims with working smoke alarms were alerted but did not respond.

NFIRS captures information about the effectiveness of operating smoke alarms in terms of occupant response. Table 17 shows that in three-quarters (78%) of the non-confined home fires with operating smoke alarms, the occupants were alerted and responded. The 3% of non-confined home fires in which smoke alarms sounded and occupants were alerted but failed to respond accounted for one-quarter (24%) of the deaths caused by home fires with sounding smoke alarms. It is unclear whether the smoke alarm provided the first notification of the fire, whether there was a delay in alerting, or whether some occupants responded while others did not. Also, another 9% of the home fire deaths resulted from 3% of non-confined home fires in which smoke alarms operated but did not alert the occupants.

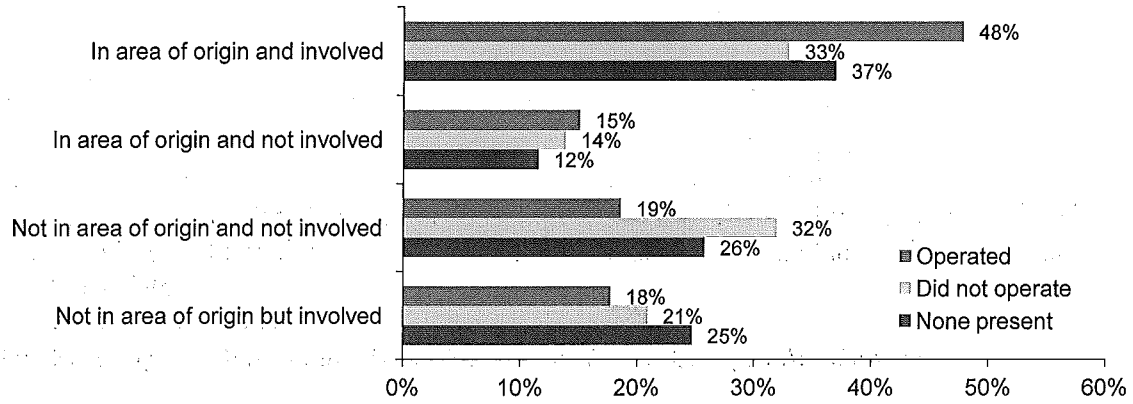
Some additional differences can be seen in the circumstances of fatalities resulting from non-confined home fires with different smoke alarm statuses. Fatalities resulting from fires that were too small to activate the smoke alarm or from confined fires are excluded from this discussion.

When smoke alarms operated, victims of fatal fires were more likely to have been in the area of origin.

Table 18 shows that when victims of home fires in which the smoke alarms operated were fatally injured, almost two-thirds (65%) were in the area of fire origin compared to half the victims in

fires with no smoke alarms at all (49%) or alarms that did not operate (50%). Figure 20 and Table 19 show that in fatal fires in which smoke alarms operated, half (48%) of the victims were involved in ignition and in the area of origin at the time of the incident. Only one-third (33%) of the victims in which smoke alarms were present but did not operate, and 37% in which no smoke alarms were present, were in the area of origin and involved in ignition.

Figure 20. Victim's Location at Time of Incident by Smoke Alarm Status 2005-2009



Source: NFIRS 5.0 and NFPA survey.

Table 20 shows that flame damage was confined to the room of origin in a higher percentage of deaths resulting from fires with working smoke alarms (31%) than in fires with no smoke alarms at all (20%). All these characteristics are probably related. A person in the area of origin is more likely to be fatally injured before a smoke alarm is activated or at least before he or she can respond to an alert. Someone in the area of origin can be fatally injured by a smaller fire than someone a distance away. Surprisingly, the percentage of fires confined to the room of origin was highest for fires in which the smoke alarm should have operated but did not (32%).

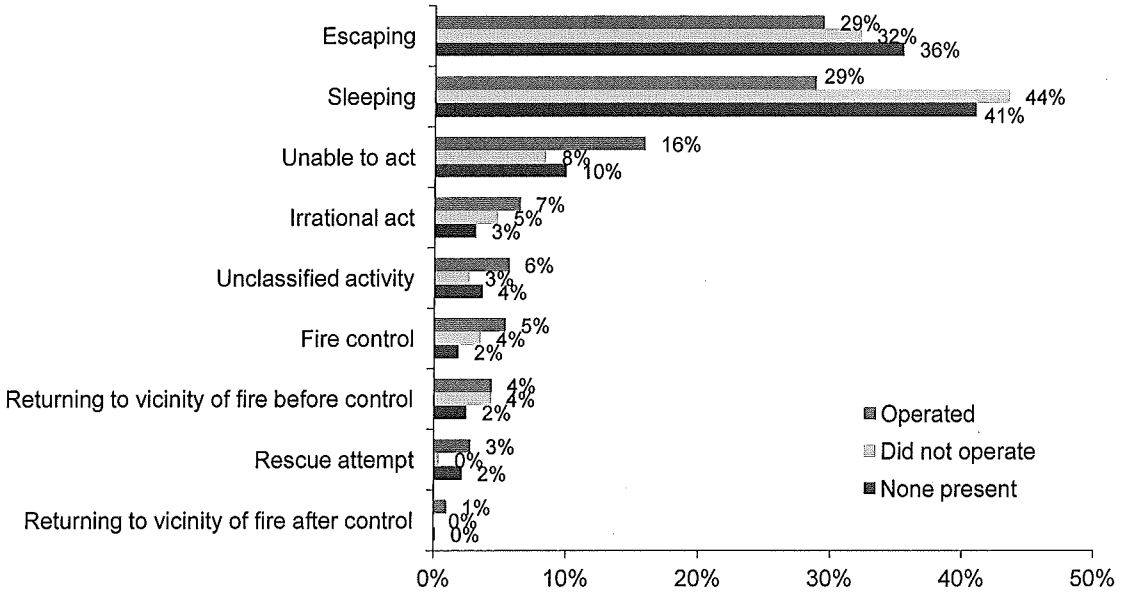
Victims of fires with working smoke alarms were less likely to be sleeping and more likely to be fighting the fire or unable to act when fatally injured than victims without working alarms.

Table 21 and Figure 21 show that when smoke alarms were present and operating, the victims were more likely to be engaged in fire control or unable to take action to save themselves and less likely to be sleeping compared to fires in which no working smoke alarms were present.

Table 22 and Figure 22 show that fatal fire victims with working smoke alarms were less likely to be asleep but more likely to be physically disabled than were victims of fires in which the smoke alarms did not sound or were not present at all. In his 2011 report, *Physical Disability as a Factor in Home Fire Deaths,* Ben Evarts noted that in 2004-2008, operating smoke alarms were present in 55% of the home fire deaths in which physical disability was a factor.[32] The estimates of alcohol impairment derived from NFIRS are lower than the results of studies that use autopsy data.

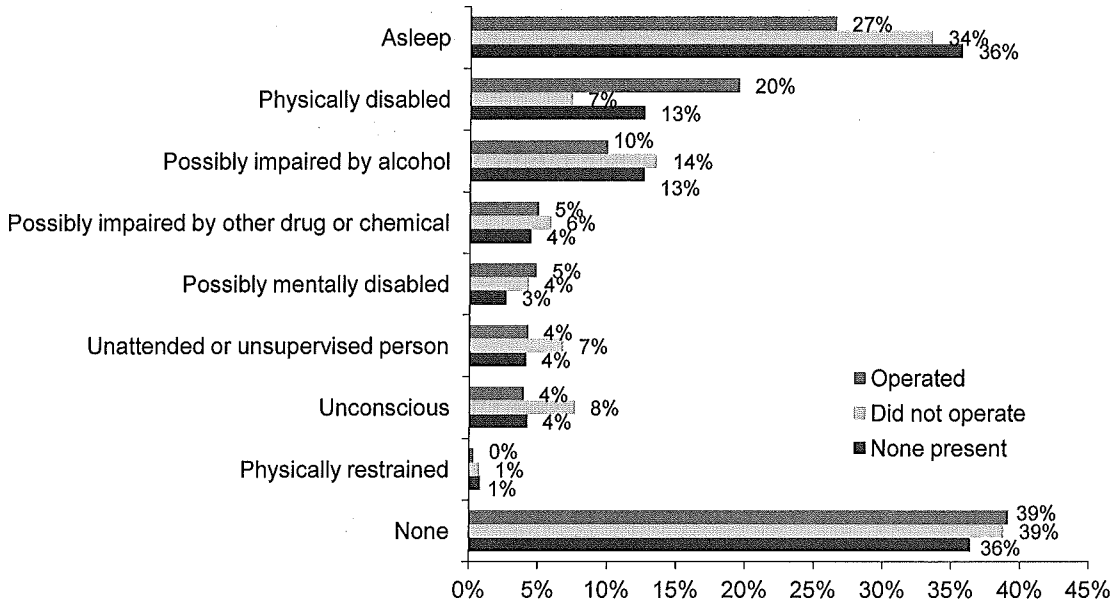
[32] Ben Evarts. *Physical Disability as a Factor in Home Fire Deaths*, Quincy, MA: NFPA, 2011, p. 5.

Figure 21. Victim's Activity at Time of Fatal Home Fire Injury by Smoke Alarm Status 2005-2009



Source: NFIRS 5.0 and NFPA survey.

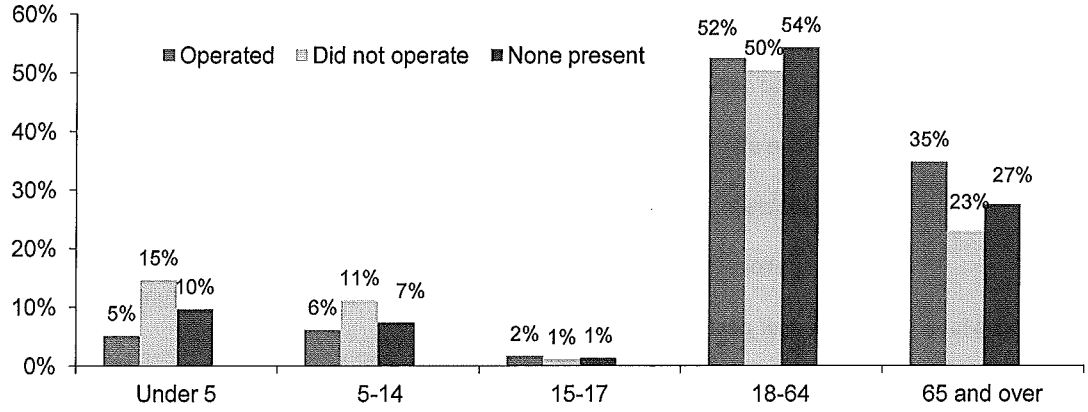
Figure 22. Human Factors Contributing to Fatal Home Fire Injury by Smoke Alarm Status 2005-2009



Source: NFIRS 5.0 and NFPA survey

Victims of fatal fires with working smoke alarms were more likely to be at least 65 years old than were victims of fires without working smoke alarms.
Table 23 and Figure 23 show that one-third (35%) of the victims of fatal home fires with working smoke alarms were 65 years of age or older. Only one-quarter of the victims without working smoke alarms were in this age group, including 23% of the victims in fires in which the alarms did not operate and 27% in which no smoke alarms were present..

Figure 23. Fatal Home Fire Victims by Age and Smoke Alarm Status, 2005-2009



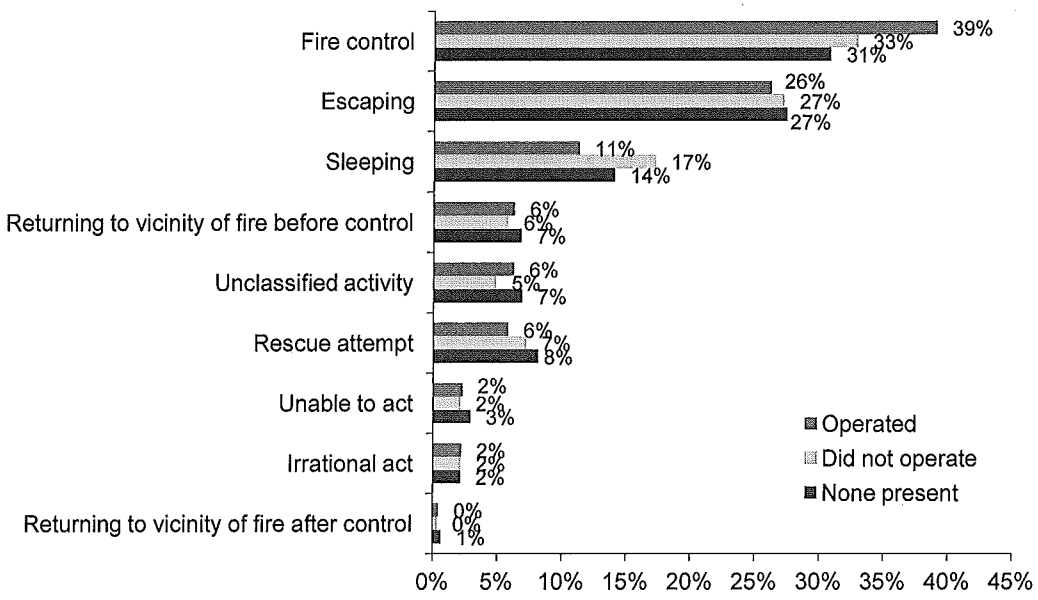
Source: NFIRS 5.0 and NFPA survey.

Civilians injured in fires with working smoke alarms were more likely to have been trying to fight the fire themselves than were those injured in fires without working smoke alarms.
Table 24 and Figure 24 show that two of every five (39%) reported non-fatal civilian injuries in home fires with operating smoke alarms occurred when the civilian was trying to control the fire. When smoke alarms failed to operate, 33% of the civilian fire injuries occurred while trying to control the fire. In homes with no smoke alarms at all, only 31% were injured while attempting fire control. This suggests that civilians may be more likely to attempt fire control when they are alerted by a smoke alarm. Such a fire is more likely to be discovered earlier in its development. More training is needed to help the public learn how and when they can safely attempt to handle a fire themselves and when such efforts are too dangerous.

People do not always evacuate when fire alarms sound.
In her article about how people respond to fire alarms, Guylène Proulx wrote that fire alarms are intended to meet four objectives: 1) warning occupants, 2) getting them to respond immediately, 3) starting the evacuation process, and 4) providing enough time to escape.[33] She found that, in practice, people who hear a fire alarm tend to seek the reason for the alarm rather than assuming that a fire is occurring. They seek other cues such as the smell of smoke, the sound of sirens, etc. If they do recognize a fire, they may engage in other activities such as fighting the fire, calling the fire department before evacuating, collecting belongings, or warning others.

[33] Guylène Proulx. "Response to Fire Alarms," *Fire Protection Engineering,* Winter 2007, pp. 8-15.

Figure 24. Victim's Activity at Time of Non-Fatal Home Fire Injury by Smoke Alarm Status, 2005-2009



Source: NFIRS 5.0 and NFPA survey.

Proulx noted that people often fail to respond for a variety of reasons:

- Sometimes the signal is not recognized as a fire alarm. The alarm may be misinterpreted as a burglar, elevator, or security door alarm.
- Sometimes, particularly outside the home environment, people do not know what they should do. This may be particularly true in a commercial space.
- Because of nuisance alarms, people may not believe the smoke alarm signals a real danger.
- They may not hear the signal due to distance from the alarm, background noise, or individual characteristics.

Audibility and waking effectiveness are discussed at greater length in the next section.

Table 17.
Effectiveness of Operating Smoke Alarms
In Non-Confined Home Structure Fires
2005-2009 Annual Averages

Effectiveness	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Alerted occupants and occupants responded	66,400	(78%)	650	(66%)	5,150	(87%)	$2,963	(70%)
Alerted occupants but occupants failed to respond	3,000	(3%)	240	(24%)	360	(6%)	$169	(4%)
No occupants were present	13,200	(16%)	0	(0%)	150	(3%)	$931	(22%)
Failed to alert occupants	2,500	(3%)	90	(9%)	260	(4%)	$192	(5%)
Total	85,100	(100%)	980	(100%)	5,910	(100%)	$4,256	(100%)

Table 18.
Victim's General Location at Time of Fatal Injury by Smoke Alarm Presence and Operation in Home Structure Fire Deaths
2005-2009 Annual Averages

Victim's Location	Present and Operated		Present but Did Not Operate		None Present	
In area of origin	630	(65%)	320	(50%)	490	(49%)
In building, but not in area of origin	340	(34%)	320	(50%)	500	(50%)
Outside of building	10	(1%)	0	(0%)	10	(1%)
Total	980	(100%)	640	(100%)	1,000	(100%)

Table 19.
Victim's General Location at Time of Incident by Smoke Alarm Presence and Operation in Home Structure Fire Deaths
2005-2009 Annual Averages

Victim's Location	Present and Operated		Present but Did Not Operate		None Present	
In area of origin and involved	470	(48%)	210	(33%)	370	(37%)
In area of origin and not involved	150	(15%)	90	(14%)	120	(12%)
Subtotal --In area of origin	*620*	*(63%)*	*300*	*(47%)*	*490*	*(49%)*
Not in area of origin and not involved	180	(19%)	200	(32%)	260	(26%)
Not in area of origin but involved	170	(18%)	130	(21%)	250	(25%)
Subtotal – Not in area of origin	*360*	*(36%)*	*340*	*(53%)*	*510*	*(51%)*
Unclassified	10	(1%)	0	(0%)	10	(1%)
Total	980	(100%)	640	(100%)	1,000	(100%)

Note: Fire deaths resulting from fires too small to activate the smoke alarm are not included in these tables. Sums may not equal totals due to rounding errors. Entries of zero may actually be zero or may have rounded to zero.

Source: NFIRS 5.0 and NFPA survey.

Table 20.
Extent of Flame Damage by Smoke Alarm Presence and Operation
in Home Structure Fire Deaths
2005-2009 Annual Averages

Extent of Flame Damage	Present and Operated		Present but Did not Operate		None Present	
Confined to object of origin	50	(5%)	30	(4%)	70	(7%)
Confined to room of origin	250	(26%)	180	(28%)	130	(13%)
Confined to floor of origin	140	(14%)	90	(14%)	110	(11%)
Confined to building of origin	470	(48%)	310	(48%)	560	(55%)
Extended beyond building of origin	70	(7%)	40	(6%)	130	(13%)
Total	980	(100%)	640	(100%)	1,000	(100%)

Table 21.
Activity at Time of Victim's Fatal Injury by Smoke Alarm Presence and Operation
in Home Structure Fire Deaths
Excluding Fires Too Small to Activate the Smoke Alarm
2005-2009 Annual Averages

Activity	Present and Operated		Present but Did not Operate		None Present	
Escaping	290	(29%)	210	(32%)	360	(36%)
Sleeping	280	(29%)	280	(44%)	410	(41%)
Unable to act	160	(16%)	50	(8%)	100	(10%)
Irrational act	60	(7%)	30	(5%)	30	(3%)
Unclassified activity	60	(6%)	20	(3%)	40	(4%)
Fire control	50	(5%)	20	(4%)	20	(2%)
Returning to vicinity of fire before control	40	(4%)	30	(4%)	30	(2%)
Rescue attempt	30	(3%)	0	(0%)	20	(2%)
Returning to vicinity of fire after control	10	(1%)	0	(0%)	0	(0%)
Total	980	(100%)	640	(100%)	1,000	(100%)

Note: Fire deaths resulting from fires too small to activate the smoke alarm are not included in these tables. Sums may not equal totals due to rounding errors.

Source: NFIRS 5.0 and NFPA survey.

Table 22.
Human Factor Contributing to Injury* by Smoke Alarm Presence and Operation in Home Fire Deaths
2005-2009 Annual Averages

Human Factor	Present and Operated		Present but Did not Operate		None Present	
Asleep	260	(27%)	210	(34%)	360	(36%)
Physically disabled	190	(20%)	50	(7%)	130	(13%)
Possibly impaired by alcohol	100	(10%)	90	(14%)	130	(13%)
Possibly impaired by other drug or chemical	50	(5%)	40	(6%)	40	(4%)
Possibly mentally disabled	50	(5%)	30	(4%)	30	(3%)
Unattended or unsupervised person	40	(4%)	40	(7%)	40	(4%)
Unconscious	40	(4%)	50	(8%)	40	(4%)
Physically restrained	0	(0%)	0	(1%)	10	(1%)
None	380	(39%)	250	(39%)	370	(36%)
Total entries*	1,110	(114%)	760	(119%)	1,140	(114%)
Total	980	(100%)	640	(100%)	1,000	(100%)

* Multiple entries are allowed, meaning that the totals will exceed the sums.

Table 23.
Home Structure Fire Deaths by Victim's Age and Smoke Alarm Status
2005-2009 Annual Averages

Age Group	Present and Operated		Present but Did not Operate		None Present	
Under 5	50	(5%)	90	(15%)	100	(10%)
5-14	60	(6%)	70	(11%)	70	(7%)
15-17	20	(2%)	10	(1%)	10	(1%)
18-64	510	(52%)	320	(50%)	540	(54%)
65 and over	340	(35%)	150	(23%)	280	(27%)
Total	980	(100%)	640	(100%)	1,000	(100%)

Note: Fire deaths resulting from fires too small to activate the smoke alarm are not included in these tables. Sums may not equal totals due to rounding errors. Sums may not equal totals due to rounding errors. Entries of zero may actually be zero or may have rounded to zero.

Source: NFIRS 5.0 and NFPA survey.

Table 24.
Activity at Time of Victim's Non-Fatal Injury by Smoke Alarm Presence and Operation in Home Structure Fires
2005-2009 Annual Averages

Activity	Present and Operated		Present but Did not Operate		None Present	
Fire control	2,720	(39%)	700	(33%)	970	(31%)
Escaping	1,830	(26%)	580	(27%)	860	(27%)
Sleeping	790	(11%)	370	(17%)	440	(14%)
Returning to vicinity of fire before control	440	(6%)	120	(6%)	210	(7%)
Unclassified activity	440	(6%)	100	(5%)	220	(7%)
Rescue attempt	400	(6%)	150	(7%)	260	(8%)
Irrational act	160	(2%)	50	(2%)	90	(3%)
Unable to act	150	(2%)	50	(2%)	70	(2%)
Returning to vicinity of fire after control	30	(0%)	10	(0%)	20	(1%)
Total	6,950	(100%)	2,130	(100%)	3,150	(100%)

Note: Fire deaths or injuries resulting from fires too small to activate the smoke alarm are not included in these tables. Sums may not equal totals due to rounding errors.

Source: NFIRS 5.0 and NFPA survey.

Issues of Audibility, Waking Effectiveness, Sensor Technology, and Smoke Alarm Age

AUDIBILITY AND WAKING EFFECTIVENESS

A single-station smoke alarm may not be heard in other parts of the home.
An alarm sounding on one floor of a home may not alert a resident on another floor or even in another room with the door closed. In a 2005 CPSC study, Arthur Lee found that a closed lightweight door reduced the volume of a smoke alarm signal from another room by 10 to 20 dB. The signal was weakened by roughly 20 dB each level it traveled. The layout of the home also mattered. Lee concluded that single-station smoke alarms in homes with two or three floors may not be adequate to alert unimpaired adults in all parts of the home.[34] Note that single-station alarms are not interconnected. Since single-station, battery-operated units still predominate in *existing* homes, wider use of interconnected smoke alarms is another opportunity for further improvement in home smoke alarm protection. Table 17 showed that operating smoke alarms failed to alert the occupants in 3% of the reported non-confined home fires and 9% of the associated deaths. Some of these failures to alert may be due to audibility issues.

Several factors influence the effectiveness of smoke alarms in waking people.
One of the main benefits of smoke alarms is the ability to detect a fire while occupants sleep and to sound an alarm that wakes them in time to escape. Several years ago, questions were raised about how effective smoke alarms are at waking particular groups, starting with school-age children. Interconnected smoke alarms, with alarms that sound in each bedroom in response to a fire anywhere in the home, address many of these concerns. Even if a child does not wake, if the parent wakes to the alarm, the parent can in most cases get the child to safety. Table 1 showed that in a 2010 survey done for NFPA, 25% of the respondents with smoke alarms (24% of all households) reported they had interconnected smoke alarms.[35] Table 7 showed that in CPSC's 2004-2005 survey, only 13% of households that had fires and 19% of non-fire households reported having interconnected smoke alarms.[36] Both surveys found that a majority of homes did not have interconnected smoke alarms.

CPSC also studied the sound effectiveness of residential smoke alarms.[37] Although children under 16 have longer periods of deep sleep than adults and do not reliably wake in response to smoke alarms, "There is no evidence that children have a higher fire death rate because of the inability to wake to a smoke alarm." They noted that the smoke alarms that are currently available are effective at waking adults who are not under the influence of alcohol or drugs or

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[34] Arthur Lee. *The Audibility of Smoke Alarms in Residential Homes,* Bethesda, MD: U.S. Consumer Product Safety Commission, September 2005, revised January 2007, online at http://www.cpsc.gov/LIBRARY/FOIA/FOIA05/os/audibility.pdf.
[35] Harris Interactive. *Smoke Alarm Omnibus Question Report,* November 2008.
[36] Michael A. Greene and Craig Andres. *2004-2005 National Sample Survey of Unreported Residential Fires.* U.S. Consumer Product Safety Commission, July 2009.
[37] Arthur Lee, Jonathan Midgett, and Sharon White. *A Review of the Sound Effectiveness of Residential Smoke Alarms,* U.S. Consumer Product Safety Commission, December 2004, online at http://www.cpsc.gov/library/foia/foia05/os/alarm1.pdf.

who are not sleep deprived. They also noted that the devices may not be reliable for older adults with hearing loss. The home layout and smoke alarm locations can influence whether the warning will be heard; earlier warning is provided by interconnected smoke alarms.

Studies examined the effectiveness of different signals in waking high-risk individuals. In general, lower-pitch mixed signal temporal three (T-3) alarms were more effective than the conventional high-pitched signals. Higher volumes also tended to be more effective.

In her review of the literature on sleep and waking to fire alarms,[38] Dorothy Bruck concluded that louder signals are needed when significant background noise is present. She also found that arousal thresholds vary significantly from individual to individual. Sleep deprived adults are less likely to wake to a smoke alarm, as are young children and people under the influence of alcohol, marijuana or sleep inducing medication. The higher frequency hearing loss that often accompanies aging reduces the probability that older adults will wake to a smoke alarm.

Bruck et al. also studied the effectiveness of a pre-recording of the mother's voice, a female actor's voice, a standard Australian smoke alarm with a high pitch signal of roughly 4000 Hz, and a lower-pitch, mixed (dominant tones of 500Hz, 1600 Hz, and 2500 Hz) T-3 signal in waking sleeping children ages 6-10.[39] The voice alarms and the T-3 lower pitch signal were more effective than the high-pitched, standard signal, suggesting that lower frequency may be the most important component in effectiveness.

In their study on the effects of alcohol on waking to fire alarm signals among young adults, Ball and Bruck found that a female voice and the lower-pitch, mixed T-3 signal were both more effective than the high-pitched Australian standard alarm.[40] However, even a blood alcohol concentration of 0.05 significantly reduced the likelihood of waking to any of the auditory signals. With blood alcohol levels of 0.08, the waking was even less frequent but the decrease was much less than was seen between the sober and the 0.05 BAC. Individual responses varied widely.

Bruck, Thomas, and Ball conducted additional research on the effectiveness of different signals in waking young adults with a 0.05 blood alcohol concentration from deep sleep as part of a Fire Protection Research Foundation study.[41] They found that the 400 Hz and 520 Hz square wave T-3 sounds (equivalent to the lower-pitch mixed T-3 signal in previous studies) were more effective than the 500 Hz and 3100 Hz pure tone sounds, bed or pillow shakers, and strobe lights.

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[38] Dorothy Bruck, "The Who, What, Where and Why of Waking to Fire Alarms: A Review," *Fire Safety Journal,* Volume 36 (2001), pp. 623-639.

[39] Dorothy Bruck, Sharnie Reid, Jefoon Kouzma, and Michelle Ball, "The Effectiveness of Different Alarms in Waking Sleeping Children," *Proceedings of the 3rd International Symposium on Human Behavior in Fire 2004,* London, England, Interscience Communications Limited 2004, pp. 279-289.

[40] Michelle Ball and Dorothy Bruck, "The Effect of Alcohol upon Response to Fire Alarm Signals in Sleeping Adults," *Proceedings of the 3rd International Symposium on Human Behavior in Fire 2004,* London, England, Interscience Communications Limited 2004, pp. 291-301.

[41] Dorothy Bruck, Ian Thomas, and Michelle Ball. Optimizing Fire Alarm Notification for High Risk Groups Research Project: Waking Effectiveness of Alarms (Auditory, Visual and Tactile) for the Alcohol Impaired, Quincy, MA: The Fire Protection Research Foundation, June 2007, pp. 7-8, online at http://www.nfpa.org/assets/files//PDF/Research/alcohol&alarmsreport.pdf.

A Fire Protection Research Foundation study on optimizing the smoke alarm signal to reduce fire deaths in older adults played four different auditory signals of increasing volume to 42 older adults (ages 65-85) when they were in deep sleep.[42] The four signals included a high-frequency T-3 signal used in current U.S. smoke alarms, a mixed signal T-3, a male voice, and a 500 Hz tone in the T-3 pattern. Researchers found that these subjects woke to the mixed frequency T-3 signal at a lower volume than the other three signals. They also noted that interconnected alarms with a smoke alarm in each bedroom increased the probability of volume at the pillow of at least 85 dBA. For all types of signals, louder volumes at the pillow reduced the likelihood of sleeping through the alarm. The same study also assessed the abilities of individuals who woke to a smoke alarm. Physical functioning showed a decrement of roughly 10-17% across the first five minutes after waking but no important effects were found on cognitive functioning.

Bruck and Thomas also conducted research on the effectiveness of different signals in waking people with moderate to severe hearing loss. People who were deaf were not included. The authors found that a loud low frequency square wave auditory signal (i.e., the same as the mixed frequency T-3) was most effective. This signal performed better than bed or pillow shakers and strobe lights. Subjects who were 60 or older and hard of hearing were less likely to wake to the bed shaker than younger subjects with impaired hearing. Strobe lights, when used alone, were not effective in waking this population.[43]

PERFORMANCE DIFFERENCES FOR DIFFERENT DETECTION TECHNOLOGIES

Different sensing technologies operate faster in different types of fires.
Most home smoke alarms use either ionization, photoelectric, or both sensing systems to detect a fire. Ionization-type smoke alarms have a small amount of radioactive material between two electrically charged plates which ionize the air and cause current to flow between the plates. When smoke enters the chamber, it disrupts the flow of ions, reducing the flow of current and activating the alarm.

Photoelectric-type alarms aim a light source into a sensing chamber at an angle away from the sensor. Smoke enters the chamber, scattering light onto the light sensor and triggering the alarm. Photoelectric alarms respond slightly faster to smoldering fires; ionization alarms respond slightly faster to flaming fires. Ionization alarms are less expensive and the most widely used.

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[42] Dorothy Bruck, Ian Thomas, and Ada Kritikos. Reducing Fire Deaths in Older Adults: Optimizing the Smoke Alarm Signal Research Project: Investigation of Auditory Arousal with Different Alarm Signals in Sleeping Older Adults. Quincy, MA: The Fire Protection Research Foundation, May 2006, pp. 7-9, online at http://www.nfpa.org/assets/files//PDF/Research/Investigation_of_Auditory_Arousal.pdf.

[43] Dorothy Bruck and Ian Thomas. Optimizing Fire Alarm Notification for High Risk Groups Research Project: Waking Effectiveness of Alarms (Auditory, Visual and Tactile) for Adults Who Are Hard of Hearing, Quincy, MA: The Fire Protection Research Foundation, June 2007, pp. 7-8, online at http://www.nfpa.org/assets/files//PDF/Research/hardofhearing&alarms.pdf.

Most consumers do not know the differences between the technologies.
In a 2008 survey, 72% of people with smoke alarms did not know the difference between ionization and photoelectric smoke alarms.[44] Only 31% said that they knew which single type of smoke alarm(s) they had. Six percent reported having both. In a follow-up question asking these 37% specifically what kind of alarms they had, 24% were not sure, 24% had ionization, 24% had photoelectric, and 27% had combination. When adjustments are made for those who could not answer the question on specific type, 78% either did not know or were not sure what type of smoke alarms were in their homes.

A NIST study found fire growth is faster today but both photoelectric and ionization smoke alarms provided adequate warning in most scenarios.
The National Institute of Standards and Technology (NIST), in cooperation with the CPSC, USFA, NFPA, Centers for Disease Control and Prevention (CDC), and other organizations, conducted tests on different types of smoke and heat alarms under conditions found in today's households. These tests were designed to assess the performance of the different technologies and the effectiveness of current code requirements under different conditions, particularly those found in today's fatal fires. The full report, revised in 2008, may be found at http://smokealarm.nist.gov.

Researchers found that both ionization and photoelectric smoke alarms "consistently provided time for occupants to escape from most residential fires." They also noted that fire growth was faster in the current tests than in 1975, resulting in less available escape time based on reduction in visibility due to smoke. The tests in 1975 were obtained from a store selling used items. The more recent study involved chairs that were a year or two old and mattresses that were new. Products sold today have different properties than those sold in the past. These properties affect their behavior in fires. Adequate escape time may only be available if the fire safety advice is followed. People who are intimate with ignition or directly involved or exposed to the fire when it starts may not be protected by operating smoke alarms.[45]

Smoke characterization study examined how today's homes and home products behave in fires.
The Fire Protection Research Foundation and Underwriters Laboratories (UL) collaborated on a study of the characteristics of smoke and how materials in today's homes burn in fires.[46] Cone calorimeter tests showed that synthetic materials produce higher heat and smoke release rates than natural materials. In the flaming mode, synthetic materials also generate larger mean smoke particle sizes than natural materials. They also found that in non-flaming fires, smoke build-up changes over time, resulting in smoke stratification below the ceiling and less obscuration at the ceiling level.

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[44] Harris Interactive. Smoke Alarm Omnibus Question Report, November 2008.
[45] Richard W. Bukowski, Richard D. Peacock, Jason D. Averill, Thomas G. Cleary, Nelson P. Bryner, William D. Walton, Paul A. Reneke, and Erica D. Kuligowski, NIST Technical Note 1455, *Performance of Home Smoke Alarms: Analysis of the Response of Several Available Technologies in Residential Fire Settings,* Washington, DC: U.S. Department of Commerce, National Institute of Standards and Technology, 2008 revision, pp. xxiii-xxvi, and 248-249, available at http://smokealarm.nist.gov.
[46] Thomas Z. Fabian and Pravinray D. Gandhi. *Smoke Characterization Project,* Quincy, MA: The Fire Protection Research Foundation, 2007, online at http://www.nfpa.org/assets/files//PDF/Research/SmokeCharacterization.pdf.

When does a smoldering fire become deadly?
In a 2007 analysis, John Hall noted that fires starting with upholstered furniture or mattresses and bedding ignited by something other than an open flame caused about one-third of the home fire deaths in 2002-2005.[47] Except for fires in which medical oxygen was involved, almost all of these fires are believed to have smoldered initially. About one-sixth of home fire deaths resulted from fires starting with: other soft goods such as clothing, linen, or curtains; electrical wire or cable insulation; or with the ignition of something other than a flammable or combustible liquid or gas by a lighted tobacco product. About one-quarter of home fire deaths results from fires not started by an open flame such as a match, lighter, candle or torch and were not included in the previous group. When combined, these fatalities account for roughly three-quarters of home fire deaths. Upholstered furniture and mattresses and bedding are large, thick items that can themselves fuel a serious fire. The other items mentioned are thinner and typically insufficient to fuel a serious fire unless secondary items become involved. Fire spread to other items generally does not occur until the fire transitions to flaming. Smoldering fires are unlikely to spread. Hall cites the findings of Babrauskas and Krasny who noted that transition times from smoldering to flaming range from 20 minutes to five hours after ignition. Unfortunately, it is impossible with existing data to document the exact point in actual fires that conditions became lethal.

Use both ionization and photoelectric technologies together to get the best protection.
As noted earlier, an ionization smoke alarm is generally more responsive to flaming fires, and a photoelectric smoke alarm is generally more responsive to smoldering fires. For the best protection, both types of alarms or a combination alarm (photoelectric and ionization) should be installed in homes.

Smoke Alarm Age

Smoke alarms are appliances, just like toasters, televisions and furnaces. Unlike other appliances, these devices function quietly in the background. Its alarm, in response to a real smoke situation or to testing, is the only evidence that it works. A stereo that does not play will not lead to tragedy, but a worn-out smoke alarm, failing to sound in a fire, could.

Roughly half of the smoke alarms collected as inoperable and studied in the National Smoke Detector Project were more than 10 years old, hence older than the currently recommended replacement age.[48] Alarms designed solely to detect smoke should be replaced every 10 years.

Older individuals are more likely to have smoke alarms more than ten years old.
A survey done for NFPA in 2010 found that in 12% of homes with smoke alarms, the smoke alarms were more than 10 years old.[49] Figure 25shows that when the householder is 55 or older, 17% of the smoke alarms were more than 10 years old.

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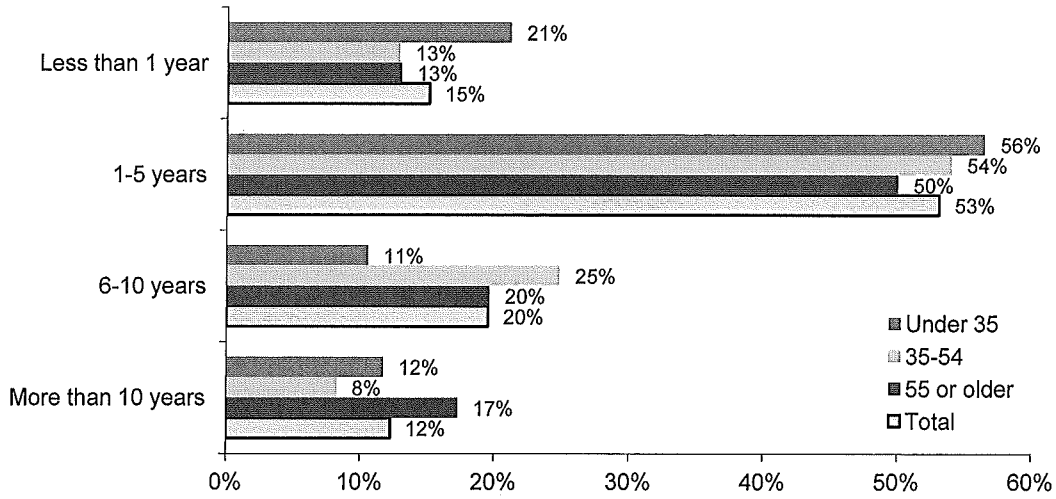
[47] John R. Hall, Jr. Summary of Best Evidence on the Characteristics of Fatal Fires Related to Smoke Alarm performance and Related Issues in the Quantification of Smoke Alarm Performance. Quincy, MA: NFPA, 2008.
[48] Charles L. Smith, *Smoke Detector Operability Survey – Report on Findings*, Bethesda, MD: U.S. Consumer Product Safety Commission, November 1993, Appendix B, p. 23.
[49] Harris Poll National Quorum. National Fire Protection Association – Smoke Alarms, September 2010.

Figure 25. Age of Smoke Alarm by Age of Individual in Homes with Smoke Alarms: 2010

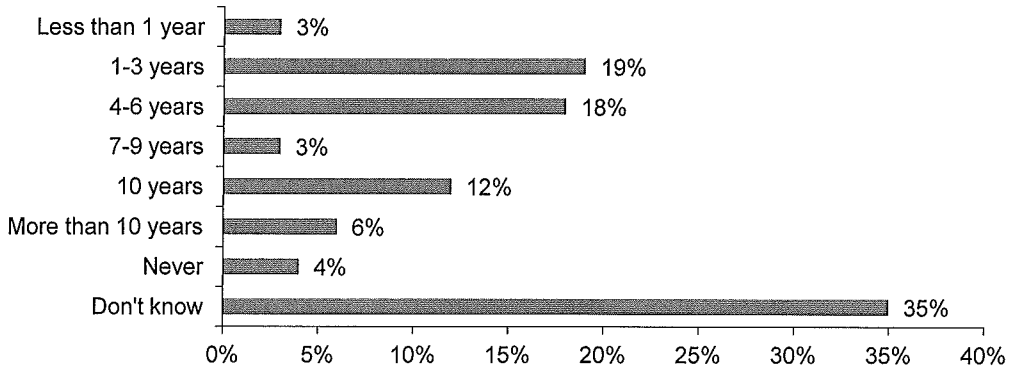


Source: Harris Poll® National Quorum. National Fire Protection Association – Smoke Alarms, September 2010.

Many people don't know how often smoke alarms should be replaced.
A 2008 survey asked individuals how often their smoke alarms should be replaced. Figure 26 shows that only 12% reported that smoke alarms should be replaced every 10 years. One-third (35%) simply did not know. Four percent thought these devices never need replacing. Roughly two in five (18%) believe that smoke alarms should be replaced *at least* every 4-6 years, if not more often. This suggests that most people with an opinion were erring on the conservative side.

Follow manufacturer's directions for replacement of combination smoke/CO alarms.
Some of the confusion about how often smoke alarms should be replaced is likely due to different recommendations for replacement schedules of devices that detect smoke *and* carbon monoxide. Manufacturers of carbon monoxide alarms and combination smoke/carbon monoxide alarms often recommend more frequent replacement due to the expected life of the CO sensor.

Figure 26. Perceptions of How Often Smoke Alarms Should Be Replaced: 2008



Source: Harris Interactive. *Smoke Alarm Omnibus Question Report,* November 2008.

Increasing the Benefits of Smoke Alarm Protection in the Community

Most of the report to this point has focused on the performance of smoke alarms and victim characteristics based on smoke alarm performance. This section focuses on what and how life safety educators and community groups can increase the prevalence of working smoke alarms in the community and help community members get the maximum benefit from the early warning that smoke alarms provide.

CDC-sponsored research supported the need for installation programs.
The National Center for Injury Prevention and Control at the Centers for Disease Control and Prevention (CDC) compared the effectiveness of two programs providing free smoke alarms. Households with either one or more children under five or an adult age 65 or older from selected communities in Arkansas, Maine, Maryland, Massachusetts, and North Carolina received either vouchers for free smoke alarms or installed smoke alarms. At follow-up, six to twelve months after the intervention, 90% of the households in the installation group had working smoke alarms compared to 65% of the households in the voucher group. Forty-seven percent of the households in the voucher group did not redeem them.[50] This study demonstrated how important it was for programs to actually install the smoke alarms.

Planning and Implementing a Successful Smoke Alarm Installation Program
NFPA has published a guide to help communities conduct a smoke alarm installation program. Information is provided on: organizing a planning committee; identifying the target audience; identifying high-risk residents in the community; soliciting financial support and donations; promoting the program; recruiting volunteers; training, tools and materials for volunteers; overcoming challenges; evaluating the program; installation guidelines; and more. The guide is available at http://www.nfpa.org/assets/files/PDF/Public%20Education/AlarmInstallGuide.pdf.

Installing a smoke alarm is the first step. Programs also need to educate the recipients about smoke alarm testing and escape planning. Once installed, smoke alarms should be tested at least once a month to ensure that they are working. Everyone in the household should recognize the sound and know the escape plan.

Plan to Respond When a Smoke Alarm Sounds

Develop and practice home escape plans to use when the smoke alarm sounds.
Buying, installing, testing and maintaining home smoke alarms is essential protection from fire, but it is not enough. A smoke alarm merely sounds the warning. It cannot, by itself, control a fire or remove people from harm's way. Many households have not developed the escape plans

[50] Pauline Harvey, Mary Aitken, George W. Ryan, Lori A. Demeter, Jeanne Givens, Ramya Sunderaraman, Scott Goulette. "Strategies to Increase Smoke Alarm Use in High-Risk Households, "*Journal of Community Health,* Vol. 29, No. 5, October 2004, pp. 375-385.

that would allow them to use the extra warning time smoke alarms provide effectively. Escape plans identify any obstacles to secondary exits if the main door is blocked, a meeting place outside the home for household members to gather, and makes provisions for household members who need help.

High-Rise Building Evacuation

14% of residential high-rise survey respondents had some type of limitation or condition that would make walking to evacuate difficult. Almost 250 people living in high-rise residential buildings in Chicago, New York City, and San Francisco were surveyed about safety and emergency evacuation perceptions in a Fire Protection Research Foundation study.[51]

Ninety-five percent knew that there was a fire exit but 5% were not certain. Eighty-three percent knew that there was an alternative exit, 12% were uncertain, and 5% reported no alternative exit.

Sixty percent knew that their building had a public address system, 30% were uncertain and 14% said their building did not have such a system.

Roughly 14% said they had some type of limiting factor such as difficulty hearing alarms or verbal instructions or physical condition that would make it hard for them to walk out of the structure.

Fifty-eight percent said they would not wait for a floor warden or public address system to tell them to leave if a fire alarm sounded on their floor.

One-quarter believed going to the roof was a possible alternative.

Table B shows that roughly half to almost three-quarter of households said they have an escape plan. However, a much smaller percentage said they had actually practiced it. In the most recent survey, one-third of U.S. households reported that they had actually developed and practiced an escape plan. While progress has been made, there is still considerable room for improvement. More information on developing a home escape plan can be found at www.nfpa.org. For safety tip sheets on a variety of topics, go to www.nfpa.org/safetytips. For all EMAC tips, go to www.nfpa.org/emac.

[51] Mia Zmud. *Public Perceptions of High Rise Building Safety and Emergency Evacuation Procedures Research Report*, Quincy, MA: The Fire Protection Research Foundation, July 2007, online at http://www.nfpa.org/assets/files//PDF/Research/NuStats_Final_HighRise.pdf.

Table B.
Household Escape Plans: Results of Several Studies

Year	Have Escape Plan	Households with Plan That Practiced It	Percent of All Households That Have and Practiced Plans
1994[52]	**60%**	**17%**	**10%**
1997[53]	53%	21%	16%
1999[54]	60%	42%	25%
2001-2003[55]	52%	45%	23%
2004[56]	66%	35%	23%
2010[57]	71%	46%	33%

Safety Tips

The Educational Messages Advisory Committee (EMAC) to NFPA's Public Education Division developed the following tips for the testing and maintenance of smoke alarms. Additional EMAC messages on smoke alarms and escape planning, as well as support for these messages can be found in Appendix C.

- Choose a smoke alarm that bears the label of a recognized testing laboratory.
- Install a smoke alarm in every bedroom, outside each sleeping area, and on every level of your home, including the basement.
- Interconnect all smoke alarms throughout the home. When one sounds, they all sound.
- Smoke alarms with non-replaceable (long-life) batteries are designed to remain effective for up to 10 years. If the alarm chirps, warning that the battery is low, replace the entire smoke alarm right away.
- For smoke alarms with any other type of battery, replace batteries at least once a year. If that alarm chirps, replace only the battery.
- Replace all smoke alarms, including alarms that use 10-year batteries and hard-wired alarms, when they are 10 years old or sooner if they do not respond properly when tested.
- Test your smoke alarms at least every month, using the test button or an approved smoke substitute and clean the units, both in accordance with the manufacturers' instructions.
- An ionization smoke alarm is generally more responsive to flaming fires and a photoelectric smoke alarm is generally more responsive to smoldering fires. For the best protection, both types of alarms, or a combination alarm (photoelectric and ionization), should be installed in homes.

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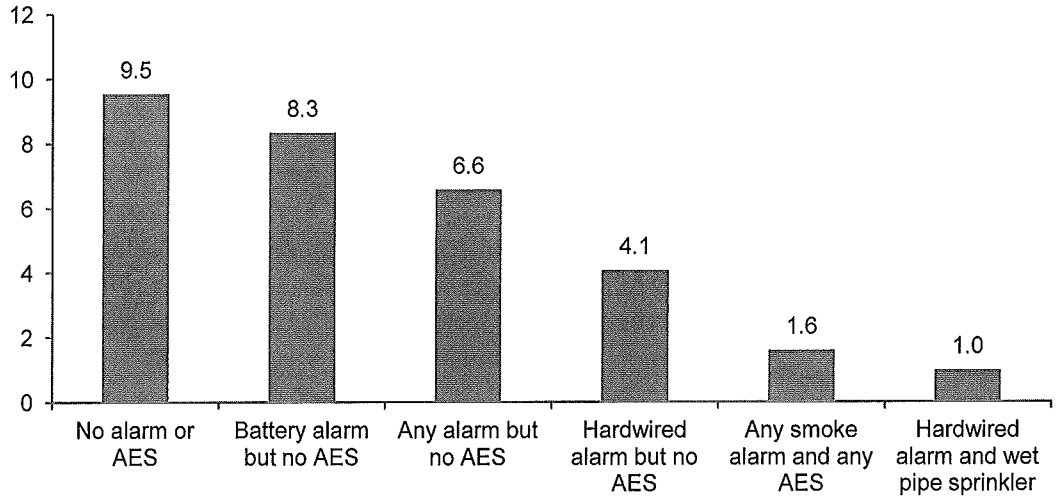
[52] Pauline A. Harvey, Jeffrey J. Sacks, George W. Ryan, and Patricia F. Bender, "Residential Smoke Alarms and Fire Escape Plans," *Public Health Reports,* September/October 1998, Rockville, MD, Volume 113, pp. 459-464.
[53] *1997 Fire Awareness/Escape Planning Study* for National Fire Protection Association, Quincy, MA, August 1997, Table 3.
[54] 1999 NFPA National Fire Escape Survey, pp. 19-20.
[55] Michael F. Ballesteros and Marcie-Jo Kresnow. "Prevalence of Residential Smoke Alarms and Fire Escape Plans in the U.S. Results from the Second Injury Control and Risk Survey (ICARIS-2), *Public Health Reports 2007,* March-April. 122 (2)224-231.
[56] 2004 Fire Prevention Week Survey conducted for National Fire Protection Association by Harris Interactive Market Research.
[57] Harris Poll National Quorum. National Fire Protection Association – Smoke Alarms, September 2010.

Home Fire Death Rate by Fire Protection Equipment Presence

Smoke alarms are an important part of home fire protection, but they are not the only part. The risk of fire death per 1,000 reported home fires steadily declines as levels of fire protection increase. Figure 27 shows that the death rate is lowest in homes with wet pipe sprinklers and hardwired smoke alarms. These rates are based on presence in reported fires only. Operation is not considered.

Figure 27. Average Fire Death Rate per 1,000 Reported Home Structure Fires by Presence of Smoke Alarms and Automatic Extinguishing Systems 2005-2009



Source: NFIRS 5.0 and NFPA survey.

Compared to reported home fires with no smoke alarms or automatic extinguishing systems/equipment (AES) at all, the death rate per 1,000 reported fires is

- 13% lower when battery-powered smoke alarms are present but AES are not;
- 31% lower when smoke alarms with any power source are present but AES are not;
- 57% lower when hardwired smoke alarms are present but AES are not;
- 83% lower when smoke alarms with any power source and any AES are present; and
- 90% lower when hardwired smoke alarms and wet pipe sprinklers are present.

While fires in which partial sprinkler systems were present or sprinklers that were outside the fire area and did not operate were excluded from the calculations, the data did not permit us to exclude fires that did not have enough smoke alarms or in which the smoke alarms were not audible to the occupants. A closed bedroom door is likely to delay operation of a single-station alarm in response to fire on the other side of the door. Similarly, a single-station alarm sounding on a different floor or behind a closed door may not be loud enough to alert someone in another part of the home.

Table 25 shows that in three-quarters (74%) of the home fires in which hardwired smoke alarms were present, the incident type indicated a fire confined to the object or immediate area of origin,

or for incidents with non-confined structure fire incident types, flame damage was confined to the object of origin. Table 26 shows that this was true for only 59% of the home fires with smoke alarms powered by batteries only.

Automatic fire department notification may cause more responses to minor incidents. When automatic notification is not present, many fires will be handled privately without fire department involvement. Green and Andres reported that 14% of all households.[58] Most monitored systems have hardwired smoke detectors.

Table 5 showed that hardwired smoke alarms (with or without battery backup) operated in 92% of fires considered large enough to activate the alarm while smoke alarms powered by batteries only operated in just 77% of the fires. In addition, hardwired smoke alarms are more likely to be interconnected, so that if any of the alarms in the home operates, all sound, and the warning is sounded more widely through the home. A single station smoke alarm must be close enough to the fire for the smoke to activate the device. A smoke alarm sounding on one floor might not be heard by occupants on another. The lowest death rates were observed in fires with wet pipe sprinklers and hard-wired smoke alarms.

NIST researchers compared the performance of sprinkler actuating elements with other detection technologies in their 21st century study of home smoke alarm performance.[59] Sprinklers activated after the smoke alarms in all the scenarios tested. While smoke alarms cannot control or extinguish a fire, the early alert is important even when sprinklers are present.

The rates shown in the graph are based solely on fire data. It is quite possible that people who are more concerned about safety have installed more complete fire protection or that homes with the best fire protection are owned by healthier and more affluent individuals. While it is impossible to state that all of the differences in fire death experience are due to the presence or absence of different types of fire protection, it is clear that the equipment does play a major role. CPSC's study of unreported fires found that interconnected smoke alarms were twice as likely to have sounded and almost three times as likely to have alerted occupants as smoke alarms that were not interconnected.[60]

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[58] Michael A. Greene and Craig Andres. *2004-2005 National Sample Survey of Unreported Residential Fires.* U.S. Consumer Product Safety Commission, July 2009, pp. 83-84.
[59] Bukowski, et al. 2008 revision, page 260.
[60] Michael A. Greene and Craig Andres. *2004-2005 National Sample Survey of Unreported Residential Fires.* U.S. Consumer Product Safety Commission, July 2009, pp. 150-189.

Table 25.
Home Structure Fires with Hardwired Smoke Alarms
(Includes Alarms with and without Battery Backup)
by Extent of Flame Damage
2005-2009 Annual Averages

Extent of Flame Damage	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Confined fire identified by incident type	75,300	(63%)	0	(0%)	760	(20%)	$17	(1%)
Confined to object of origin	13,300	(11%)	30	(8%)	420	(11%)	$105	(5%)
Confined to room of origin	18,400	(15%)	150	(34%)	1,430	(39%)	$423	(19%)
Confined to floor of origin	3,600	(3%)	50	(11%)	340	(9%)	$248	(11%)
Confined to building of origin	8,000	(7%)	180	(43%)	680	(18%)	$1,292	(57%)
Extended beyond building of origin	800	(1%)	20	(4%)	80	(2%)	$199	(9%)
Total	119,400	(100%)	430	(100%)	3,720	(100%)	$2,284	(100%)

Table 26.
Home Structure Fires with Battery-Powered Smoke Alarms
by Extent of Flame Damage
2005-2009 Annual Averages

Extent of Flame Damage	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Confined fire identified by incident type	59,600	(44%)	0	(0%)	660	(12%)	$13	(0%)
Confined to object of origin	20,100	(15%)	60	(5%)	650	(12%)	$169	(6%)
Confined to room of origin	29,200	(22%)	250	(22%)	1,990	(36%)	$431	(16%)
Confined to floor of origin	7,300	(5%)	200	(18%)	660	(12%)	$360	(14%)
Confined to building of origin	16,600	(12%)	530	(48%)	1,370	(25%)	$1,457	(55%)
Extended beyond building of origin	1,800	(1%)	80	(7%)	240	(4%)	$226	(9%)
Total	134,600	(100%)	1,120	(100%)	5,570	(100%)	$2,656	(100%)

Note: Sums may not equal totals due to rounding errors. Unknowns have been allocated proportionally.

Source: NFIRS 5.0 and NFPA survey.

Appendix A.
How National Estimates Statistics Are Calculated

The statistics in this analysis are estimates derived from the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's (NFPA's) annual survey of U.S. fire departments. NFIRS is a voluntary system by which participating fire departments report detailed factors about the fires to which they respond. Roughly two-thirds of U.S. fire departments participate, although not all of these departments provide data every year. Fires reported to federal or state fire departments or industrial fire brigades are not included in these estimates.

NFIRS provides the most detailed incident information of any national database not limited to large fires. NFIRS is the only database capable of addressing national patterns for fires of all sizes by specific property use and specific fire cause. NFIRS also captures information on the extent of flame spread, and automatic detection and suppression equipment. For more information about NFIRS visit http://www.nfirs.fema.gov/. Copies of the paper forms may be downloaded from http://www.nfirs.fema.gov/documentation/design/NFIRS_Paper_Forms_2008.pdf.

NFIRS has a wide variety of data elements and code choices. The NFIRS database contains coded information. Many code choices describe several conditions. These cannot be broken down further. For example, area of origin code 83 captures fires starting in vehicle engine areas, running gear areas or wheel areas. It is impossible to tell the portion of each from the coded data.

Methodology may change slightly from year to year.
NFPA is continually examining its methodology to provide the best possible answers to specific questions, methodological and definitional changes can occur. *Earlier editions of the same report may have used different methodologies to produce the same analysis, meaning that the estimates are not directly comparable from year to year.*

NFPA's fire department experience survey provides estimates of the big picture.
Each year, NFPA conducts an annual survey of fire departments which enables us to capture a summary of fire department experience on a larger scale. Surveys are sent to all municipal departments protecting populations of 50,000 or more and a random sample, stratified by community size, of the smaller departments. Typically, a total of roughly 3,000 surveys are returned, representing about one of every ten U.S. municipal fire departments and about one third of the U.S. population.

The survey is stratified by size of population protected to reduce the uncertainty of the final estimate. Small rural communities have fewer people protected per department and are less likely to respond to the survey. A larger number must be surveyed to obtain an adequate sample of those departments. (NFPA also makes follow-up calls to a sample of the smaller fire departments that do not respond, to confirm that those that did respond are truly representative of fire departments their size.) On the other hand, large city

departments are so few in number and protect such a large proportion of the total U.S. population that it makes sense to survey all of them. Most respond, resulting in excellent precision for their part of the final estimate.

The survey includes the following information: (1) the total number of fire incidents, civilian deaths, and civilian injuries, and the total estimated property damage (in dollars), for each of the major property use classes defined in NFIRS; (2) the number of on-duty firefighter injuries, by type of duty and nature of illness; 3) the number and nature of non-fire incidents; and (4) information on the type of community protected (e.g., county versus township versus city) and the size of the population protected, which is used in the statistical formula for projecting national totals from sample results. The results of the survey are published in the annual report *Fire Loss in the United States*. To download a free copy of the report, visit http://www.nfpa.org/assets/files/PDF/OS.fireloss.pdf.

Projecting NFIRS to National Estimates

As noted, NFIRS is a voluntary system. Different states and jurisdictions have different reporting requirements and practices. Participation rates in NFIRS are not necessarily uniform across regions and community sizes, both factors correlated with frequency and severity of fires. This means NFIRS may be susceptible to systematic biases. No one at present can quantify the size of these deviations from the ideal, representative sample, so no one can say with confidence that they are or are not serious problems. But there is enough reason for concern so that a second database -- the NFPA survey -- is needed to project NFIRS to national estimates and to project different parts of NFIRS separately. This multiple calibration approach makes use of the annual NFPA survey where its statistical design advantages are strongest.

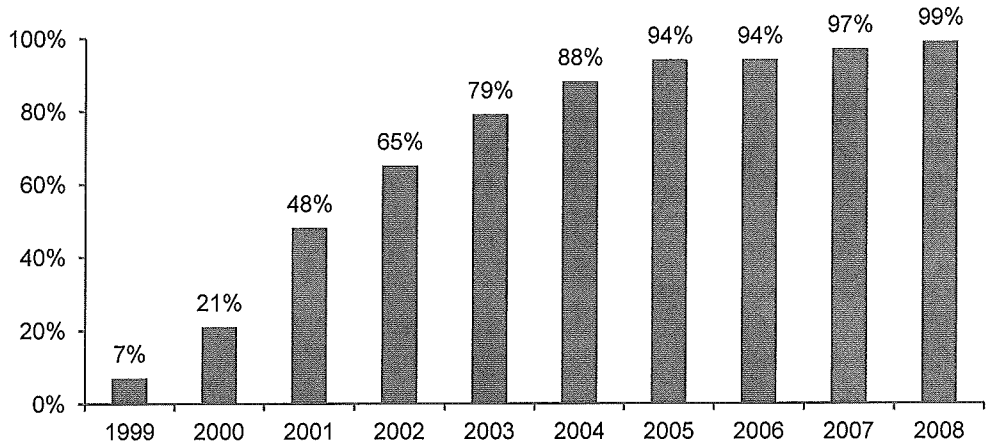
Scaling ratios are obtained by comparing NFPA's projected totals of residential structure fires, non-residential structure fires, vehicle fires, and outside and other fires, and associated civilian deaths, civilian injuries, and direct property damage with comparable totals in NFIRS. Estimates of specific fire problems and circumstances are obtained by multiplying the NFIRS data by the scaling ratios. Reports for incidents in which mutual aid was given are excluded from NFPA's analyses.

Analysts at the NFPA, the USFA and the Consumer Product Safety Commission developed the specific basic analytical rules used for this procedure. "The National Estimates Approach to U.S. Fire Statistics," by John R. Hall, Jr. and Beatrice Harwood, provides a more detailed explanation of national estimates. A copy of the article is available online at http://www.nfpa.org/osds or through NFPA's One-Stop Data Shop.

Version 5.0 of NFIRS, first introduced in 1999, used a different coding structure for many data elements, added some property use codes, and dropped others. The essentials of the approach described by Hall and Harwood are still used, but some modifications have been necessary to accommodate the changes in NFIRS 5.0.

Figure A.1 shows the percentage of fires originally collected in the NFIRS 5.0 system. Each year's release version of NFIRS data also includes data collected in older versions of NFIRS that were converted to NFIRS 5.0 codes.

Figure A.1. Fires Originally Collected in NFIRS 5.0 by Year



From 1999 data on, analyses are based on scaling ratios using only data originally collected in NFIRS 5.0:

NFPA survey projections
NFIRS totals (Version 5.0)

For 1999 to 2001, the same rules may be applied, but estimates for these years in this form will be less reliable due to the smaller amount of data originally collected in NFIRS 5.0; they should be viewed with extreme caution.

NFIRS 5.0 introduced six categories of confined structure fires, including:

- cooking fires confined to the cooking vessel,
- confined chimney or flue fires,
- confined incinerator fire,
- confined fuel burner or boiler fire or delayed ignition,
- confined commercial compactor fire, and
- trash or rubbish fires in a structure with no flame damage to the structure or its contents.

Although causal and other detailed information is typically not required for these incidents, it is provided in some cases. Some analyses, particularly those that examine cooking equipment, heating equipment, fires caused by smoking materials, and fires started by playing with fire, may examine the confined fires in greater detail. Because the confined fire incident types describe certain scenarios, the distribution of unknown data differs from that of all fires. Consequently, allocation of unknowns must be done separately.

Some analyses of structure fires show only non-confined fires. In these tables, percentages shown are of non-confined structure fires rather than all structure fires. This approach has the advantage of showing the frequency of specific factors in fire causes, but the disadvantage of possibly overstating the percentage of factors that are seldom seen in the confined fire incident types and of understating the factors specifically associated with the confined fire incident types.

Other analyses include entries for confined fire incident types in the causal tables and show percentages based on total structure fires. In these cases, the confined fire incident type is treated as a general causal factor.

For most fields other than Property Use and Incident Type, NFPA allocates unknown data proportionally among known data. This approach assumes that if the missing data were known, it would be distributed in the same manner as the known data. NFPA makes additional adjustments to several fields. *Casualty and loss projections can be heavily influenced by the inclusion or exclusion of unusually serious fire.*

In the formulas that follow, the term "all fires" refers to all fires in NFIRS on the dimension studied. The percentages of fires with known or unknown data are provided for non-confined fires and associated losses, and for confined fires only.

Item First Ignited. In most analyses, mattress and pillows (item first ignited 31) and bedding, blankets, sheets, and comforters (item first ignited 32) are combined and shown as "mattresses and bedding." In many analyses, wearing apparel not on a person (code 34) and wearing apparel on a person (code 35) are combined and shown as "clothing." In some analyses, flammable and combustible liquids and gases, piping and filters (item first ignited 60-69) are combined and shown together.

Area of Origin. Two areas of origin: bedroom for more than five people (code 21) and bedroom for less than five people (code 22) are combined and shown as simply "bedroom." Chimney is no longer a valid area of origin code for non-confined fires.

Rounding and percentages. The data shown are estimates and generally rounded. An entry of zero may be a true zero or it may mean that the value rounds to zero. Percentages are calculated from unrounded values. It is quite possible to have a percentage entry of up to 100% even if the rounded number entry is zero. The same rounded value may account for a slightly different percentage share. Because percentages are expressed in integers and not carried out to several decimal places, percentages that appear identical may be associated with slightly different values.

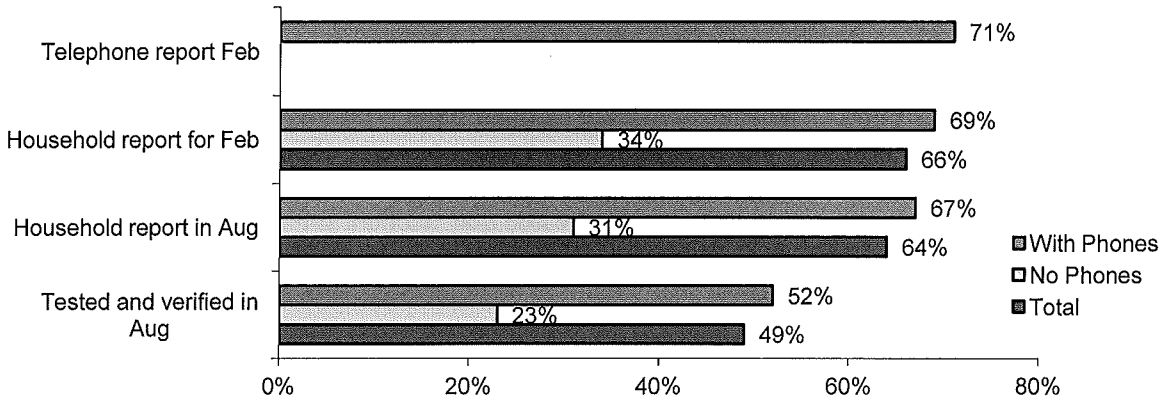
Appendix B.
Working Smoke Alarms: Self-Reported vs. Field Tests

Self-reporting may overstate the presence of working smoke alarms.
As the National Smoke Detector Project found, estimates of working smoke alarms based on actual testing are lower than estimates based on self-reports.[61] When people in that study were asked if their smoke alarms worked, 78% said all worked, 11% said that at least one smoke alarm did not work and another 11% did not know. When researchers tested the alarms, 73% were operable.

Two other studies found similar results. In February 1990, Douglas, Mallonee, and Istre conducted a random telephone survey of functioning smoke alarms in a low-income section of Oklahoma City followed by a retrospective random household survey. Seventy-one percent of the 927 households who completed the phone survey reported working smoke alarms, 18% had no smoke alarms at all, 9% were not sure if their smoke alarm was working, and 2% said that their alarm did not work. Firefighters visited homes in the same area in August 1990. Sixteen percent of the visits were to homes without telephones. Sixty-six percent of the households told the firefighters that their smoke alarms had been working in February; 64% said they were currently working. When the alarms said to be working were actually tested, 20% were not functional. Overall, only 49% of the smoke alarms tested were working.

For households without telephones, 34% said their alarms had been working in February and 31% were currently working. Testing showed that only 23% had working smoke alarms compared to 52% with telephones.[62]

Working Smoke Alarms in Low-Income Area of Oklahoma City in 1990
Reported by Telephone, in Household Visit, and by Testing



Source: Douglas, Malonee and Istre, 1999.

[61] Charles L. Smith, *Smoke Detector Operability Survey – Report on Findings*, Bethesda, MD: U.S. Consumer Product Safety Commission, November 1993.
[62] Malinda Reddish Douglas, Sue Mallonee, and Gregory Istre. "Estimating the Proportion of Homes with Functioning Smoke Alarms: A Comparison of Telephone Survey and Household Survey Results. *American Journal of Public Health,* July 1999, vol. 89, No. pp.113-114.

A smaller but more recent study of working smoke alarms, stair gates or related protection, adult medication in locked cabinets, and environmental feasibility of safety devices was conducted in 2005 and early 2006. Participants were 32 pregnant women and mothers with infants under 12 months old in East Baltimore's Healthy Start program. A parent self-report questionnaire was administered over the phone or in the home. A home safety checklist was completed on site by the principal investigator, typically within a week of the self-report. All participants reported having at least one smoke alarm, 88% reported having working smoke alarms on every level of the home and 81% reported changing batteries within the past month. The home safety checklist revealed that one of the 32 homes did not have a smoke alarm. Non-working smoke alarms were found in 55% of the homes reported to have a working smoke alarm on every level. Only 41% actually had working smoke alarms on every level. Beeping smoke alarms indicating weak batteries were found in 6 (19%) of the 32 homes. The authors noted that high ceilings and battery costs may make replacing batteries difficult. In all measures studied, the self-reports of safety practices were higher than what was found upon investigation.[63]

These findings suggest that the American Housing Survey's estimate of 94% of homes with working smoke alarms is likely to be too high. Despite these limitations, self-reports do provide important indicators of trends, priorities, and the intent people have to comply with codes and recommended practices.

[63] Kimberly E. Stone, Emmanuella M. Eastman, Andrea Gielen, Barbara Squires. Glenda Hicks, Dana Kaplin, and Janet Serwin. "Home Safety in Inner Cities: Prevalence and Feasibility of Home-Safety Product Use in Inner-City Housing," *Pediatrics,* August 2007, Vol. 20, No. 2, pp. 346-353. DOI: 10.1542/peds.2006-2169.

Appendix C.

Why Do I Have to...?
Basic Messages about Home Smoke Alarms and Home Fire Escape Planning and the Reasons behind Them

EDUCATIONAL MESSAGES ADVISORY COMMITTEE

NFPA's mission is to protect people and property from fire. The Educational Messages Advisory Committee (EMAC) meets annually to review NFPA's fire safety education messages and to provide recommendations to NFPA public education staff for updating and revising the messages. The messages are used throughout NFPA's educational programs, curricula and handouts and provide fire and life safety educators with accurate and consistent language for use when offering safety information to the public. Each topic area is self-contained, written so that all the information needed on a certain subject is provided within that category. As a result, some messaging may be repeated throughout topic areas.

Each year, EMAC, seeks suggestions on how our fire safety messages might be improved. EMAC members include fire service personnel, burn nurses, injury prevention specialists, kindred organizations, and NFPA staff. The group works hard to ensure that the messages are clear, concise, and accurate. Sometimes, people want to know the reason why something is important.
The messages about smoke alarms, excluding those specific to rental units, are shown below. The reasons for these messages are shown in italics. The full collection of messages is available at www.nfpa.org/emac.

HOME SMOKE ALARMS

1.1 Fire Deaths — Smoke Alarms Save Lives

NEW! 1.1.1 Working smoke alarms save lives, cutting the risk of dying in a home fire in half. Smoke alarms should be installed and maintained in every home.

The death rate from reported fires in homes during 2005-2009 that had at least one smoke alarm(0.61 deaths per 100 fires) was one-third (36%) lower than in homes that had no smoke alarms at all (0.95 deaths per 100 fires). Installing smoke alarms is the first step. It is important to be sure they are working. Surprisingly, the death rate was much higher in fires in which a smoke alarm was present (1.93 deaths per 100 fires) but did not operate (1.93 deaths per 100 fires) than it was in home fires with no smoke alarms at all

The death rate per 100 reported home fires was more than twice as high in homes that did not have any working smoke alarms (1.18 deaths per 100 fires), either because no smoke alarm was

present or an alarm was present but did not operate), as it was in homes with working smoke alarms (0.52 per 100 fires).

1.2 Installation

1.2.1 Smoke alarms should be installed in every sleeping room, outside each separate sleeping area, and on every level of the home, including the basement. Larger homes may require additional smoke alarms to provide a minimum level of protection.

For smoke alarms to be effective, they need to be
a) close enough to a developing fire to go off, and
b) loud enough or noticeable by people inside.

A closed door can prevent smoke from reaching a smoke alarm in another room and muffle the sound of the activating alarm. Also, an alarm on one floor may not be heard on another.

In their 2009 report detailing survey results of household that had fires that were not attended by local fire departments, the Consumer Product Safety Commission's (CPSC's) Michael Greene and Craig Andres discussed how people learned about the fires. When smoke alarms were not on all floors, they sounded in only 4% of the fires and alerted occupants in only 2% of the fires. When smoke alarms were present on all floors, they sounded in more than one-third (37%) of the fires and provided the only alert in 15%.[64]

In CPSC's 2005 study of smoke alarm audibility, Arthur Lee noted that a closed lightweight door reduced the volume of a smoke alarm signal from another room by 10 to 20 dB. The signal was weakened by roughly 20 dB each level it traveled.

1.2.2 For the best protection, interconnect all smoke alarms throughout the home. When one sounds, they all sound.

Having interconnected smoke alarms increases the chances that you will be alerted by a smoke alarm while a fire is still very small.

In CPSC's 2009 report detailing survey results of household that had fires that were not attended by local fire departments, Michael Greene and Craig Andres discussed how people learned about the fires. In many cases, people were nearby and the smoke never got close enough to activate the smoke alarm. However, when interconnected smoke alarms were present, they operated in half (53%) of the incidents and provided the only alert in one-quarter (26%) of the fires. When the smoke alarms were not interconnected, they operated in only one-quarter (27%) of the fires and provided the only alert in 8%.[65]

1.2.3 Wireless battery-operated interconnected smoke alarms are now available.

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[64] Michael A. Greene and Craig Andres. *2004-2005 National Sample Survey of Unreported Residential Fires.* U.S. Consumer Product Safety Commission, July 2009, pp. 179-182.
[65] Greene and Andres, pp. 179-182.

These can be installed as easily as single-station alarm but will activate all of the smoke alarms when one goes off.

NEW! 1.2.4 An ionization smoke alarm is generally more responsive to flaming fires, and a photoelectric smoke alarm is generally more responsive to smoldering fires. For the best protection or where extra time is needed to awaken or assist others, both types of alarms or combination ionization and photoelectric alarms, also known as dual sensor smoke alarms, are recommended.

A 2004 study by The National Institute of Standards and Technology confirmed earlier findings that either type of smoke alarms provided enough escape time for most occupants from most home fires, but that ionization alarms responded somewhat faster to flaming fires and photoelectric alarms often responded to smoldering fires much earlier.[66] *See smokealarm.nist.gov.*

1.2.5 Choose a smoke alarm that has the label of a recognized testing laboratory.

Testing laboratories verify that a manufacturer's smoke alarms meet standards for loudness, sensitivity, and other factors. Responsible manufacturers submit samples of their products to be sure that their products meet these standards. If you buy an alarm without such a label, you cannot tell if the manufacturer even considered the standards.

NEW! 1.2.6 Smoke alarms should be installed away from the kitchen to prevent false alarms. Generally, they should be at least 10 feet (3 meters) from a cooking appliance.

When smoke alarms are installed too close to the kitchen, normal cooking fumes can cause the smoke alarm to sound.[67,68,69,70]

NEW! 1.2.7 A smoke alarm installed between 10 and 20 feet (3 and 6 meters) of a cooking appliance must be a photoelectric type or have a hush feature, which temporarily reduces the sensitivity of the alarm.

66

[67] Richard W. Bukowski, Richard D. Peacock, Jason D. Averill, Thomas G. Cleary, Nelson P. Bryner, William D. Walton, Paul A. Reneke, and Erica D. Kuligowski, NIST Technical Note 1455, *Performance of Home Smoke Alarms: Analysis of the Response of Several Available Technologies in Residential Fire Settings,* Washington, DC: U.S. Department of Commerce, National Institute of Standards and Technology, 2008 revision, pp. xxv-xxvi, 149-230, and 250-251, available at http://www.nist.gov/el/fire_protection/buildings/upload/NIST_TN_1455-1_Feb2008.pdf.

[68] Charles L. Smith, *Smoke Detector Operability Survey – Report on Findings*, Bethesda, MD: U.S. Consumer Product Safety Commission, November 1993, available at http://www.cpsc.gov/library/foia/foia01/os/operable.pt1.pdf.

[69] Thomas M. Fazzini, Ron Perkins, and David Grossman. "Ionization and Photoelectric Smoke Alarms in Rural Alaskan Homes," *West J. Med;* 2000; 173:89-92. Online at http://www.pubmedcentral.nih.gov/picrender.fcgi?artid=1071008&blobtype=pdf.

[70] B.A. Mueller, E.A. Sidman, H. Alter, R. Perkins, and D.C. Grossman. "Randomized Controlled Trial of Ionization and Photoelectric Smoke Alarm Functionality," *Injury Prevention* 2008:14:80-86. doi:10.1136/ip.207.016725, online at injuryprevention.bmj.com/content/14/2/80.full.

Cooking smoke tends to contain more of the smaller particles (less than one micron) that activate an ionization-type device rather than the larger particles that activate a photoelectric-type device. An ionization smoke alarm will generally respond faster to a flaming fire.

1.3 Testing and Maintenance

1.3.1 Test smoke alarms at least once a month using the test button.

Smoke alarms are appliances. Like every appliance, they can stop working. Batteries can also wear out. In fact, batteries were dead in almost one-quarter of the home fires in which smoke alarms were present and should have operated.

1.3.2 Make sure everyone in the home understands the warning of the smoke alarm and knows how to respond.

We live with alarm clocks, car alarms, and other warning signals. Fires can grow fast. For people to take advantage of the smoke alarm's warning, they need to recognize it, and know how to get out.

NEW! 1.3.3 To keep smoke alarms working well, follow manufacturer's instructions for cleaning. The instructions are included in the package, or can be found on the Internet.

A lack of cleaning was blamed for one of every 25 fires in which smoke alarms should have operated but didn't.

1.4 People Who Are Deaf or Hard of Hearing

NEW! 1.4.1 Smoke alarms and alert devices, called accessories, are available for people who are deaf. Strobe lights throughout the home are activated by smoke alarms and alert people who are deaf to fire conditions. When people who are deaf are asleep, a high intensity strobe light is required along with a pillow or bed shaker to wake them up and alert them to fire conditions so they can escape. Currently this equipment is activated by the sound of a standard smoke alarm.

Someone who is deaf will not hear the warning signal from a smoke alarm. Strobe lights send a visual warning while vibration equipment alerts with tactile sensations.

NEW! 1.4.2 Smoke alarm alert devices, called accessories, are available for people who are hard of hearing. These accessories produce a loud, mixed low-pitched sound. This equipment is activated by the sound of the smoke alarm and is usually installed next to the bed. People who are deaf may find that a pillow or bed shaker is also helpful to wake them up.

In a 2006 Fire Protection Research Foundation study on the waking effectiveness of auditory, visual and tactile alarms for adults who are hard of hearing, but not deaf, Dorothy Bruck and Ian Thomas found that a loud low frequency square wave auditory signal (i.e., the same as the mixed frequency T-3) was most effective. This signal performed better than bed or pillow shakers and strobe lights. Subjects who were 60 or older and hard of hearing were less likely to

wake to the bed shaker than younger subjects with impaired hearing. Strobe lights, when used alone, were not effective in waking this population.

NEW! 1.4.3 Recent research has shown that a loud, mixed low-pitched sound is more effective for waking people of all ages than the loud high-pitched sound of a traditional smoke alarm. As people age, their ability to hear high-pitched sounds decreases.

Dorothy Bruck and colleagues were involved in a number of research projects on the waking effectiveness of smoke alarms, including children ages 6-10,[71]*, young adults with blood alcohol counts of 0.05 and 0.08,*[72] *older adults,* [73] and people with moderate to severe hearing loss. [74] In all of these groups, the loud, mixed low-pitched sound was the most effective.

NEW! 1.4.4 Choose smoke alarms and accessories for people who are deaf that have the label of a recognized testing laboratory. Research the available products and select one that best meets your individual needs.

Testing laboratories verify that a manufacturer's products meet industry standards. If you buy a product without such a label, you cannot tell if the manufacturer even considered the standards.

1.5 Battery Replacement

1.5.1 Smoke alarms with non-replaceable (long-life) batteries are designed to remain effective for up to 10 years. If the alarm chirps, warning that the battery is low, replace the entire smoke alarm right away.

The Center for Disease Control and Prevention (CDC) funded programs to install smoke alarms with long-life batteries in high-risk homes. Unfortunately, many of the alarms had battery chambers that could be opened. A follow up study done eight to ten years after installation found that the long-life lithium batteries had been replaced with conventional, non-lithium batteries in two-thirds of the alarms. Batteries were dead in only 14% of the smoke alarms with lithium batteries and 20% of the alarms with non-lithium batteries. Three-quarters (78%) of the smoke alarms that still had lithium batteries were still functional at the time of the evaluation.[75]

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[71] Dorothy Bruck, Sharnie Reid, Jefoon Kouzma, and Michelle Ball, "The Effectiveness of Different Alarms in Waking Sleeping Children," *Proceedings of the 3rd International Symposium on Human Behavior in Fire 2004,* London, England, Interscience Communications Limited 2004, pp. 279-289.

[72] Michelle Ball and Dorothy Bruck, "The Effect of Alcohol upon Response to Fire Alarm Signals in Sleeping Adults," *Proceedings of the 3rd International Symposium on Human Behavior in Fire 2004,* London, England, Interscience Communications Limited 2004, pp. 291-301.

[73] Dorothy Bruck, Ian Thomas, and Ada Kritikos. Reducing Fire Deaths in Older Adults: Optimizing the Smoke Alarm Signal Research Project: Investigation of Auditory Arousal with Different Alarm Signals in Sleeping Older Adults. Quincy, MA: The Fire Protection Research Foundation, May 2006, pp. 7-9, online at http://www.nfpa.org/assets/files//PDF/Research/Investigation_of_Auditory_Arousal.pdf.

[74] Dorothy Bruck and Ian Thomas. Optimizing Fire Alarm Notification for High Risk Groups Research Project: Waking Effectiveness of Alarms (Auditory, Visual and Tactile) for Adults Who Are Hard of Hearing, Quincy, MA: The Fire Protection Research Foundation, June 2007, pp. 7-8, online at http://www.nfpa.org/assets/files//PDF/Research/hardofhearing&alarms.pdf.

[75] Jonathan Wilson, Judith Akoto, Sherry Dixon, and David Jacobs. *Evaluation of the "10-Year" Smoke Alarm Project,* National Center for Healthy Housing. Online at http://www.nchh.org/Research/Archived-Research-Projects/Smoke-Alarm-Study.aspx.

NEW! 1.5.2 For smoke alarms with any other type of battery, replace batteries at least once a year. If that alarm chirps, replace only the battery.

Smoke alarms need a power source to operate. Batteries were dead in almost one-quarter of the home fires in which smoke alarms were present and should have operated. The chirp tells you that you need a new battery. However, it can be annoying if it occurs in the middle of the night or when you don't have a spare battery handy. For alarms with conventional batteries, you can prevent most chirping by changing the battery once a year, which will usually be before the battery starts to wear out.

1.6 Smoke Alarm Replacement

1.6.1 Replace all smoke alarms when they are 10 years old.
Smoke alarms are appliances. Like every appliance, they can wear out and stop working.

NEW! 1.6.2 Immediately replace any smoke alarm that does not respond properly when tested.

While most smoke alarms should function correctly for at least ten years, some will fail before then. Three percent of the smoke alarms that should have operated were defective. No reason could be found for 9% of the failures. If your smoke alarm does not work when tested, it won't warn you if you have a fire.

NEW! 1.6.3 Combination sensor smoke/carbon monoxide alarms should be replaced per manufacturer's recommendations.

The sensors in smoke alarms are designed to last for ten years. The carbon monoxide sensors often have a much shorter expected lifespan. Different companies give different directions about when to replace their products. You want to be sure you are protected from both hazards.

HOME FIRE ESCAPE

4.1 Planning

NEW! 4.1.1 Make a home escape plan. Draw a map of each level of the home. Show all doors and windows. Discuss the plan with everyone in your household, including visitors.

Fire can block the usual exits. In 2003-2007, fire blocked the exits of one-third of the fatal home fire victims (an average of 910 people per year)[76]. Drawing a plan helps us remember the other options such as windows and doors that are seldom used.

4.1.2 Children, older adults, and people with disabilities may need assistance to wake up and get out. Ensure that someone will help them.

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[76] Jennifer D. Flynn. *Characteristics of Home Fire Victims,* Quincy, MA: NFPA, 2010, p. 69.

Some people are less likely to wake to a sounding smoke alarm, including people with hearing loss, sleep deprived adults, young children and people under the influence of alcohol, marijuana or sleep inducing medication. There are a lot of individual differences.[77] *Some people also need help getting out of bed and may be unable to move quickly. Physical disability was identified as a contributing factor in 14% of home fire deaths during 2004-2008. Operating smoke alarms were present in more than half (55%) of the deaths when physical disability was a factor. Thirty percent of the victims with a physical disability were unable to act.*[78]

4.1.3 Teach your children how to escape on their own in case you cannot help them.

Teach your children to get out and go to the meeting place when they hear a smoke alarm or think there is a fire.

4.1.4 Practice your home fire drill with overnight guests.

In 2003-2007, "unfamiliar with exits" was a factor in an average of 20 (1%) home fire deaths per year[79]*. Guests will be less familiar with the exits. If your kids are having a pajama party, consider having a fire drill early in the evening.*

4.1.5 Know at least two ways out of every room, if possible. Make sure all doors and windows that lead outside open easily.

If fire blocks the door to the room, you want to have another way out. The ways out were blocked by fire for one-third (32%) of the fatal home fire victims in 2003-2007. Some type of egress problem was a factor in 13% of the deaths, including locked ways out or other problems with ways out (3%), security bars (1%), mechanical obstacles to accessing the way out, including items blocking the exit (1%), and unclassified egress problems (8%). An average of 100 victims (3%) per year chose an inappropriate way out, while20 per year (1%) were unfamiliar with the ways out. [80].

Are the windows a realistic option? They might be. Are they big enough for someone to get through? They might be. Could a child open the window? It depends. Be sure everyone knows how to unlock the windows. Also, windows that are not used regularly may be hard to open. If a window is part of your escape plan, you need a way to get through the window and to the ground. Replace any lock that requires a key to get outside with a thumb latch or any other lock that does not require a key from the inside to open the door. In a fire, you may only have a very short time to escape.

4.1.6 Windows with security bars, grills, and window guards should have emergency release devices.

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[77] Dorothy Bruck, "The Who, What, Where and Why of Waking to Fire Alarms: A Review," *Fire Safety Journal,* Volume 36 (2001), pp. 623-639.
[78] Ben Evarts. *Physical Disability as a Factor in Home Fire Deaths"* NFPA, Quincy, MA, May 2011.
[79] Flynn, p. 69.
[80] Flynn, p. 69.

If fire blocks your doorway and you need to leave through a window, you want to be able to get out fast. When you think about protecting your home from people trying to get in, you may also need to get out. In 2003-2007, burglar or security bars were factors in the deaths of an average of 20 (1%) fatal home fire victims per year.[81]

4.1.7 Make sure everyone in your home knows how to call 9-1-1 or your local emergency number from a cell phone or from a neighbor's phone.

If your home is on fire, get out of the home before phoning for help. The fire can grow while you call and block your escape. Once you are outside, you can use a cell phone or go to a neighbor's and have them call the emergency number. Most places in the U.S. use 9-1-1. Check to be sure that is true where you are.

NEW! 4.1.8 Make sure everyone in your home knows the sound and understands the warning of the smoke alarm and knows how to respond.

We live with alarm clocks, car alarms, and other warning signals. Fires can grow fast. To take advantage of the smoke alarm's warning, we need to recognize it, and know how to get out.

4.1.9 Have an outside meeting place (something permanent, like a tree, light pole, or mailbox) a safe distance in front of the home.

You want to know that everyone has gotten out safely. It's much easier to tell if everyone meets at an agreed upon place. Firefighters will also ask if everyone is out. You don't want anyone risking their lives trying to find someone who has already gotten out safely.

4.1.10 Make sure your house number can be seen day or night from the street.
A fire inside your home may not be visible from the street. Posting your house numbers in a place where everyone can see them will help firefighters find your house. This is also important if you ever need an ambulance.

4.1.11 If you have escape ladders for escaping from the second and third floors, make sure they are listed by a recognized testing laboratory. Make sure the escape ladder fits the window. Use only if all other exits are blocked. To prevent injury from a fall, use the ladder only in a real emergency.

A label from a recognized testing laboratory tells you that the ladder was made in accord with industry standards. However, window types and dimensions vary. A ladder that would work in one window may not work in another. Check before you need it. The risk of fall is real. An escape ladder should only be used when absolutely necessary.

4.1.12 Have a plan for everyone in your home who has a disability.

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[81] Flynn, p. 69.

Physical disability was identified as a contributing factor on 14% of home fire deaths during 2004-2008. Operating smoke alarms were present in more than half (55%) of the deaths when physical disability was a factor. Thirty percent of the victims with a physical disability were unable to act.[82]

4.2 If There Is a Fire

4.2.1 When the smoke alarm sounds, get out fast. You may have only seconds to escape safely. *The rate at which a fire grows depends on a lot of factors, including what is burning and how many other things nearby can also burn, how much oxygen the fire has, if there is any wind, and more. Conditions can get very bad very fast. This NFPA video* [83] *shows how quickly a fire can become deadly.*

4.2.2 If there is smoke blocking your door or first way out, use your second way out. *Your best way out may be a window. For 13% of the fatal home fire victims in 2003-2007, the primary ways out were blocked by smoke.*[84]

4.2.3 Smoke is toxic. If you must escape through smoke, get low and go under the smoke to your way out.

More people die from smoke inhalation than from burns. Smoke also makes it very hard to see. Ten percent of the home fatal fire victims in 2003-2007 had their vision blocked or impaired by smoke.[85] *You may see a layer of smoke coming down from the ceiling. You want to keep your head below the smoke. Smoke contains carbon monoxide, hydrogen cyanide and other toxic chemicals. Staying low and going under the smoke, while walking, is the fastest and easiest thing to do.*

4.2.4 Before opening a door, feel the doorknob and door. If either is hot, leave the door closed and use your second way out.

The way out was blocked by fire in one of every five (19%) home fire deaths in 2003-2007. Two percent of the victims' clothing caught fire while they tried to escape. [86] *If the fire is burning on the other side of the door, opening the door could let the fire into the room where you are and give the fire more oxygen. This could make it burn even more intensely.*

4.2.5 If there is smoke coming around the door, leave the door closed and use your second way out.

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[82] Ben Evarts. *Physical Disability as a Factor in Home Fire Deaths"* NFPA, Quincy, MA, May 2011.
[83] NFPA. *Fire Power- Revisited,* online at http://youtu.be/9JU59Nsv2vg.
[84] Flynn, p. 69.
[85] Flynn, p. vi, 69.
[86] Flynn, p. 69.

Fire deaths due to smoke inhalation outnumber fire deaths due to burns.[87] *You want to avoid breathing smoke, getting close to the fire, or giving the fire any more oxygen. Keeping the door closed can help keep the fire and smoke away from you while you escape a different way.*

4.2.6 If you open a door, open it slowly. Be ready to shut it quickly if heavy smoke or fire is present.

You want to avoid breathing smoke, getting close to the fire, or giving the fire any more oxygen. If you see fire or heavy smoke, close the door fast.

NEW! 4.2.7 If you can't get to someone needing assistance, leave the home and call 9-1-1 or the fire department. Tell the emergency operator where the person is located.

During 2003-2007, 40 (2%) people per year were fatally injured in home fires when they tried to rescue someone[88]*. If you also become trapped, you become one more person for firefighters to rescue. Because of their special equipment and clothing, it is safer for them to rescue people than it is for civilians, but it is dangerous for them, too. You can help by telling them where someone is likely to be and by being sure to close doors so that you are not adding more oxygen to the fire.*

4.2.8 If pets are trapped inside your home, tell firefighters right away.

Firefighters will keep an eye out for pets and rescue them when possible. People do come first. Some fire departments even have special oxygen masks to help pets that have been caught inside of a burning building.

NEW! 4.2.9 If you can't get out, close the door and cover vents and cracks around doors with cloth or tape to keep smoke out. Call 9-1-1 or your fire department. Say where you are and signal for help at the window with a light-colored cloth or a flashlight.

Fire deaths due to smoke inhalation outnumber fire deaths due to burns.[89] *Keeping the door closed will help stop both flame and smoke. Consider putting phones in bedrooms. Call the fire department even if you think someone else already called. You know best where you are. You can help the fire department help you by trying to get their attention at a window.*

4.3 Practicing the Home Fire Drill

4.3.1 Push the smoke alarm button to start the drill.

This helps everyone to recognize the sound of the smoke alarm and gives a clear signal to everyone in the home that it is time to MOVE.

4.3.2 Practice what to do in case there is smoke. Get low and go. Get out fast.

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[87] Flynn, p. vi.
[88] Flynn, p. 65.
[89] Flynn, p. vi,

Fire deaths due to smoke inhalation outnumber fire deaths due to burns. Smoke also makes it very hard to see. Ten percent of the home fatal fire victims in 2003-2007 had their vision blocked or impaired by smoke.[90] *Smoke rises in a fire. You may see a layer of smoke coming down from the ceiling. You want to stay under this. The smoke contains fumes that can knock you out or even kill you. The cleaner air is lower. Staying low and going under the smoke while walking is the fastest and easiest thing to do.*

4.3.3 Practice using different ways out.

For one-third (32%) of the fatal home fire victims in 2003-2007, the ways out were blocked by fire.[91] *A fire may block the door you normally use. It can be easy to forget that you have other ways to get out if you have never used them.*

4.3.4 Close doors behind you as you leave.

Closed doors help keep a fire from spreading by limiting the amount of oxygen.

4.3.5 Get out and stay out. Never go back inside for people, pets, or things.

During 2003-2007, an average of 60 (4%) home fire victims per year were fatally injured after they returned to the fire area before it was controlled. It is very dangerous to go back into a fire. You may also put firefighters' lives at risk by giving them one more person to look for. With their special clothing and equipment, they can search and fight the fire more safely than you can, but they can also be hurt.

4.3.6 Go to your outside meeting place.

Once you are outside, you need to move away from the building. During a fire, windows may shatter and fly out, and flaming debris may be falling or blown around. You also want to do a headcount at your outside meeting place to be sure everyone made it out safely.

NEW! 4.3.7 Practice your home fire escape drill twice a year with everyone in your home. Practice at night and during the daytime.

We use different parts of the home at different times of the day. Practice with people starting in different rooms. This is particularly important in households where infants, young children, or people with disabilities will need help from someone else to get out safely.

NEW! 4.3.8 After you've practiced your home fire escape drill, evaluate it and discuss what worked and what could be improved.

How long did it take for everyone to get to the meeting place? If fire had blocked the path you took, how else could you have gotten out? Do you need to make any changes?

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[90] Flynn, p. vi, 69.
[91] Flynn, p. 69.