



**RESEARCH
& REPORTS**

Smoke Alarms in U.S. Home Fires

September 2015

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Abstract

Smoke alarms provide a critical early warning of fire, allowing additional time to escape. National estimates of reported fires derived from the National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's (NFPA's) fire department survey show that in 2009-2013, fires in homes with no smoke alarms caused an average of 940 deaths per year (38% of home fire deaths). An additional 510 people per year (21% of home fire deaths) were fatally injured in fires in which smoke alarms were present but failed to operate. Power source problems were the leading cause of smoke alarm failures.

Almost all households indicate having smoke alarms, yet smoke alarms were present in slightly less than three-quarters (73%) of reported home fires and operated in roughly half (53%). When present in reported fires large enough to activate them, they operated 87% of the time. Hardwired smoke alarms were more likely to operate than those powered solely by batteries.

The death rate per 100 reported fires was more than twice as high in homes with no or no working smoke alarms (1.18 deaths per 100 fires) as it was in fires with working smoke alarms (0.53 deaths per 100 fires). The lowest fire death rates were seen in homes with hardwired smoke alarms *and* sprinklers. Victims in homes with working smoke alarms were more likely to have been in the area of origin. They were also more likely to be 65 or older, to have a physical disability or to have tried to fight the fire themselves.

More work must be done to ensure that all households are protected by smoke alarms.

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

Acknowledgements

The NFPA thanks all the fire departments and state fire authorities who participate in 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 (USFA) for its work in developing, coordinating, and maintaining NFIRS.

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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. Reporters tell of fires in which blaring smoke alarms alerted sleeping occupants to danger. These devices alert countless others to fires just as they are starting. Telephone surveys, including 2008 and 2010 surveys conducted for the National Fire Protection Association (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. Based on these results, almost five million households still have no smoke alarms.

This report provides the latest information about smoke alarms in home fires¹ reported to local fire departments in the U.S. Most estimates in this report were derived from the U.S. Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and the NFPA's annual fire department experience survey.

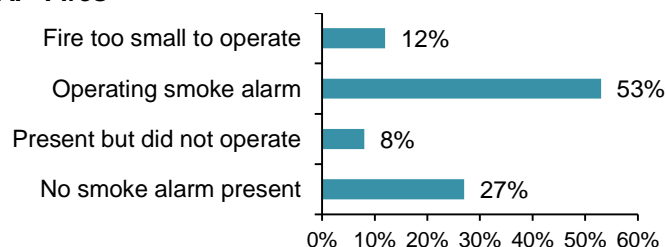
Three out of five home fire deaths resulted from fires in properties with no or no working smoke alarms. In 2009-2013, smoke alarms, including those in fires too small to activate them, operating smoke alarms, and those that failed to operate, were present in almost three-quarters (73%) of reported home fires and sounded in more than half (53%) of the home fires reported to U.S. fire departments.

- Almost two out of five (38%) home fire deaths resulted from fires in which no smoke alarms were present at all.
- One of every five (21%) deaths was caused by fires in properties in which smoke alarms were present but failed to operate.
- Smoke alarms operated in fires that caused two out of five (40%) home fire deaths.
- One percent of the deaths resulted from fires that were too small to activate the smoke alarm.

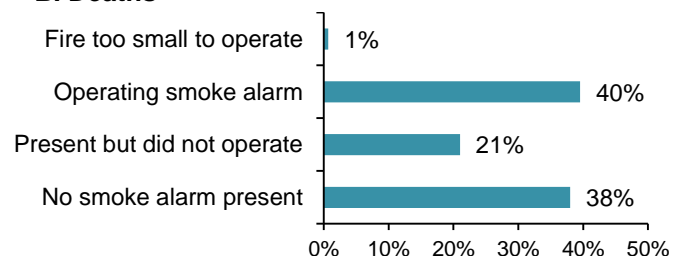
When smoke alarms were present in fires considered large enough to activate them, they operated 87% of the time.

Reported Home Structure Fires and Fire Deaths by Smoke Alarm Performance 2009-2013

A. Fires



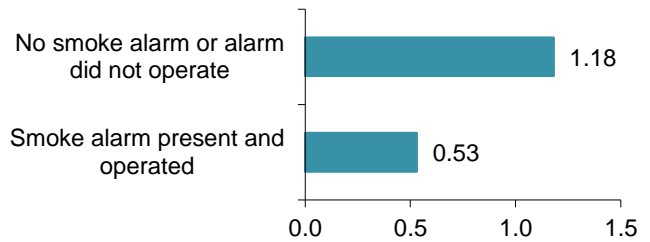
B. Deaths



¹ The term "home fires" includes fires in one- or two-family homes, including manufactured housing, and apartment or multi-family housing.

The risk of dying in reported home structure fires is cut in half in homes with working smoke alarms. 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 (0.53 per 100 fires).

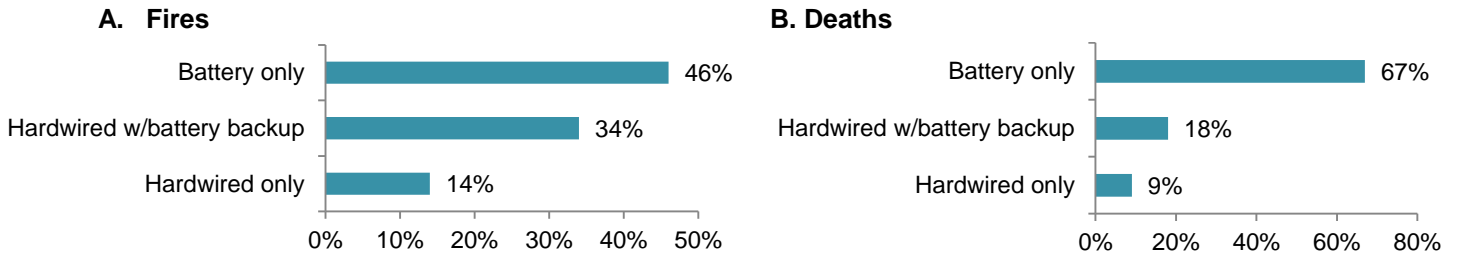
Death Rate per 100 Reported Home Fires by Smoke Alarm Status: 2009-2013



The death rate from reported fires in homes that had at least one smoke alarm (0.59 deaths per 100 fires) was 40% lower than in homes that had no smoke alarms at all (0.98 deaths per 100 fires). Installing smoke alarms is the first step. It is important to be sure they are working.

Hardwired smoke alarms were more likely to have operated than battery-powered alarms. When smoke alarms were present in reported home fires, they were battery-powered in 46% of the incidents and two-thirds (67%) of the associated deaths. Hardwired smoke alarms (with or without battery backup) were present in 48% of such fires and more than one-quarter (28%) of the associated deaths.

Leading Smoke Alarm Power Sources in Home Structure Fires with Smoke Alarms Present 2009-2013



When present, hardwired smoke alarms (with and without battery backup) operated in 94% of the fires considered large enough to trigger a smoke alarm. Battery-powered alarms operated 80% of the time.

Most homes still have smoke alarms powered by batteries only. In the 2011 *American Housing Survey* (AHS), three out of five (61%) respondents who reported having smoke alarms said their alarms were powered by batteries only, one-third (33%) said their alarms were powered by electricity and batteries, and 7% had alarms powered by electricity only.² For many years, NFPA 101®, *Life Safety Code*®, and other codes have required smoke alarms in new construction to be hardwired with battery backup. Yet the AHS found that in 30% of homes less than five years old that had working smoke alarms, the smoke alarms were powered by battery only.

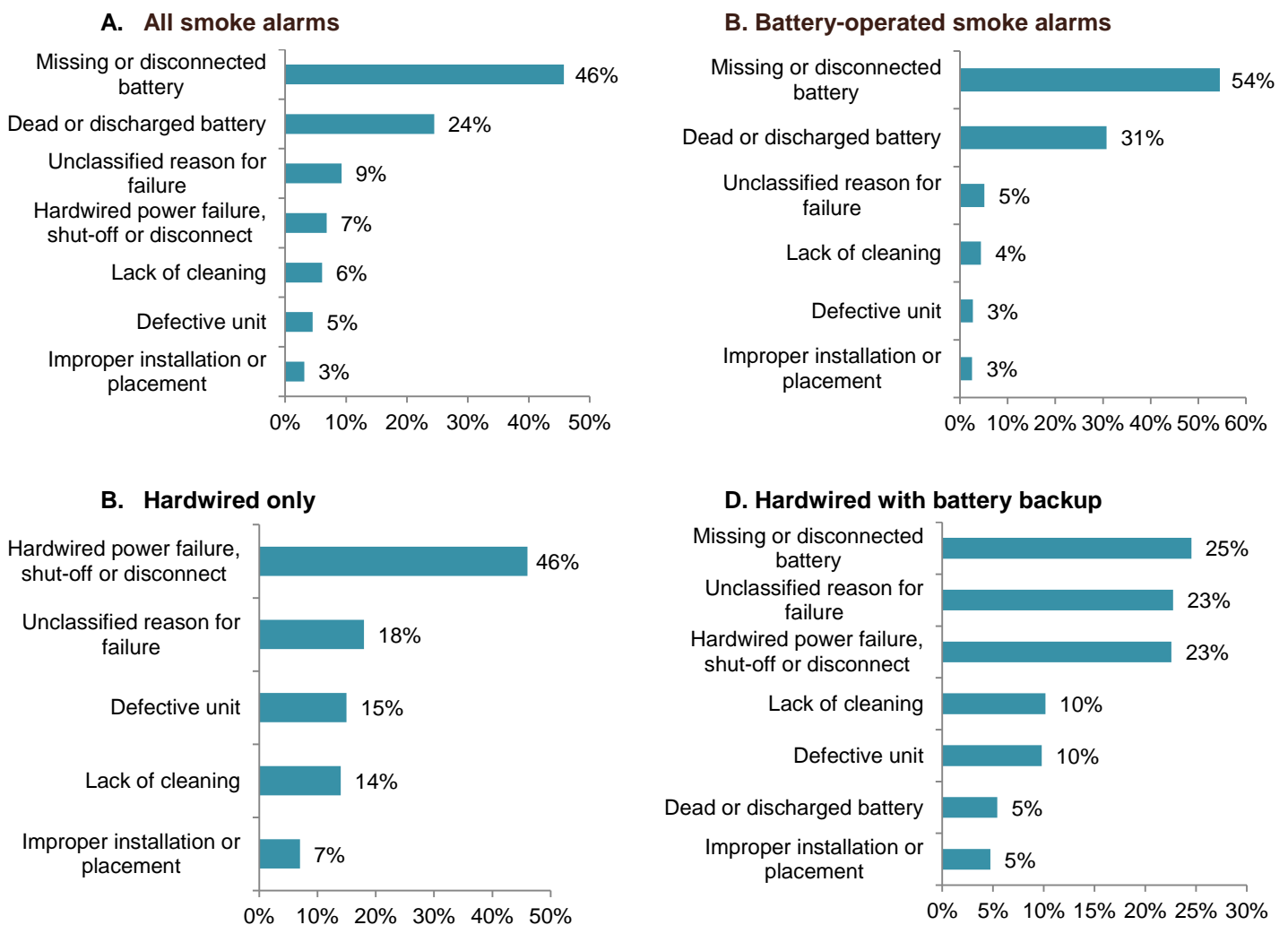
² Percentage calculations exclude unknown data.

In 2009-2013, the death rate per 100 reported fires was 2.5 times as high in fires with smoke alarms powered by batteries as it was in fires with hardwired smoke alarms. To be effective, the codes must be adopted and enforced.

Disconnected or non-working power sources were leading reasons for smoke alarm failures. When smoke alarms should have operated but did not do so, it was usually because batteries are missing, disconnected or dead. In more than half (54%) of reported home fires with battery-powered smoke alarm failures, batteries were missing or disconnected. Almost one-third (31%) of these smoke alarm failures were due to dead batteries. A power-failure, shut-off or disconnect was the leading failure reason for failures of hardwired only smoke alarms (46%), and the second leading cause for failures of hardwired alarms with battery backup (23%).

People are most likely to disable smoke alarms because of nuisance activations. Sometimes the chirping to warn of a low battery is interpreted as a nuisance alarm.

Reason Smoke Alarms Did Not Operate in Home Structure Fires Considered Large Enough to Activate 2009-2013



Nuisance alarms due to cooking are common but can be prevented. 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. [NFPA 72®, National Fire Alarm and Signaling Code®](#) states that unless designed specifically for the area, all smoke alarms should be at least 10 feet away from cooking appliances. If space constraints make it necessary to have a smoke alarm within 10-20 feet of the kitchen stove, either a photoelectric alarm or an alarm with a hush feature that can be temporarily silenced without disabling the alarm should be used.

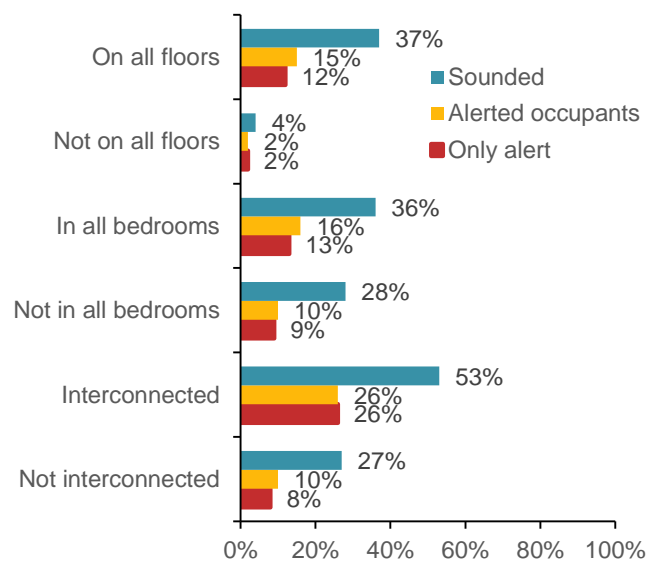
Most homes do not yet have the protection required in recent editions of NFPA 72®. [NFPA 72®, National Fire Alarm and Signaling Code®](#) and [NFPA 101®, Life Safety Code®](#), require new and existing one- and two-family dwellings to have smoke alarms in every bedroom, outside each sleeping area, and on every level. For best protection, they should also be interconnected so that when one sounds, they all sound. Hardwired smoke alarms are more likely to be interconnected, although battery-powered wireless interconnected alarms are available. New homes should have hardwired smoke alarms. 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.

CPSC study shows the importance of interconnected smoke alarms in providing early warnings.

In a 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.³ People may learn about a fire without hearing a smoke alarm. In some cases, they hear the smoke alarm at the same time they notice flames or smoke. In others, only the smoke alarm provided the initial alert.

- 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%.

Smoke Alarm Performance and Effectiveness in CPSC's 2004-2005 Survey of Unreported Residential Fires



³ Michael A. Greene and Craig Andres. [2004-2005 National Sample Survey of Unreported Residential Fires](#). U.S. CPSC, July 2009.

- When smoke alarms were in all bedrooms, they sounded in 36% of the fires and alerted occupants in 16%.
 - When smoke alarms were *not* in all bedrooms, they sounded in 28% of the fires and alerted occupants in 10%.
- 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.
 - Smoke alarms that were not interconnected sounded in 27% of the fires and alerted people in 10%.

To be effective, a smoke alarm’s warning must be heard or received. Another CPSC study found that a closed lightweight door reduced the volume of a smoke alarm signal from another room by 10 to 20 decibels. The signal was weakened by roughly 20 decibels each level it traveled.⁴

In her literature review on sleep and waking to fire alarms,⁵ 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. The 2013 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 provision requires tactile notification appliances in addition to strobes for individuals with moderately severe to profound hearing loss. These provisions take effect immediately upon adoption of the code.

People who died in fires with working smoke alarms often had characteristics or circumstances that made escape more difficult. 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;
- More likely to have been at least 65 years old;
- More likely to have had a physical disability;
- More likely to have been fighting the fire themselves; and
- Less likely to have been sleeping when fatally injured.

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

⁴ Arthur Lee. [The Audibility of Smoke Alarms in Residential Homes](#), Bethesda, MD: U.S. CPSC, September 2005, revised January 2007.

⁵ Dorothy Bruck, “The Who, What, Where and Why of Waking to Fire Alarms: A Review,” *Fire Safety Journal*, Volume 36 (2001), pp. 623-639.

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 do not have an alarm on every level. 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 try 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.

Go to NFPA's Smoke Alarm Central for safety tips, videos and more.

NFPA's 2015 Fire Prevention Week (FPW) theme is "Hear the beep where you sleep. Every bedroom needs a working smoke alarm." Find general safety tips in English and in Spanish, instructions for installing smoke alarms, and more at nfpa.org/smokealarms.

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Smoke Alarms in U.S. Home Fires Fact Sheet

Smoke alarms provide an early warning of a fire, giving people additional escape time. In telephone surveys done for NFPA, almost all households (96%) reported having at least one smoke alarm. That still leaves roughly five million households with no smoke alarms.

Smoke Alarm Presence and Performance in Reported Home Fires

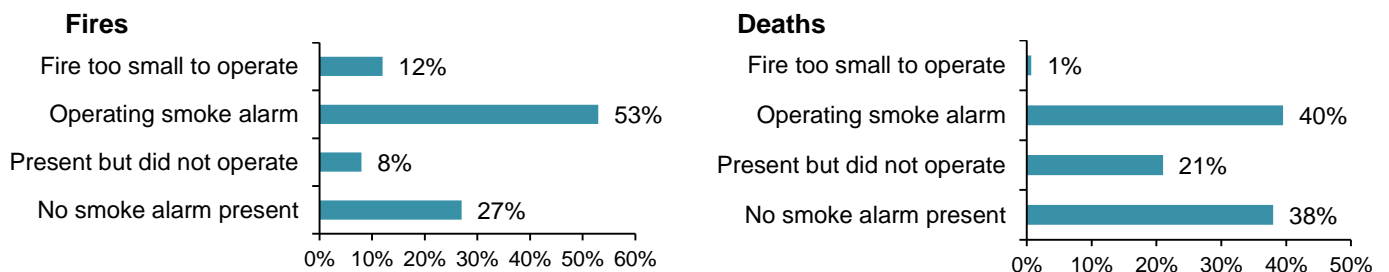
Homes with fires are less likely to have smoke alarms than homes overall.

In 2009-2013, smoke alarms

- Were present in almost three-quarters (73%) of, and
- Sounded in more than half (53%) of the home fires reported to U.S. fire departments.

When present, smoke alarms operated in 87% of the fires considered large enough to activate the alarm.

Reported Home Structure Fires and Fire Deaths by Smoke Alarm Performance 2009-2013



Three of every five home fire deaths resulted from fires in homes with no smoke alarms (38%) or no working smoke alarms (21%).

- The death rate per 100 reported home fires (1.18 deaths per 100 fires) was more than twice as high in homes that did not have any working smoke alarms, either because no alarm was present or an alarm was present but did not operate, as it was in homes with working smoke alarms (0.53 deaths per 100 fires).
- The death rate from reported fires in homes that had at least one smoke alarm (0.59 deaths per 100 fires) was 40% lower than in homes that had no smoke alarms at all (0.98 deaths per 100 fires).

People Who Died in Fires with Working Smoke Alarms

People who died in fires with working smoke alarms often had characteristics or circumstances that made escape more difficult. They 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;
- More likely to have been at least 65 years old;
- More likely to have had a physical disability;
- More likely to have been fighting the fire themselves; and
- Less likely to have been sleeping when fatally injured.



Smoke Alarm Power Sources

Hardwired smoke alarms were present in 48% of reported home fires with smoke alarms. Alarms powered by battery only were present in 46% of reported home fires.

In reported home fires in which the fire was large enough to activate the alarm,

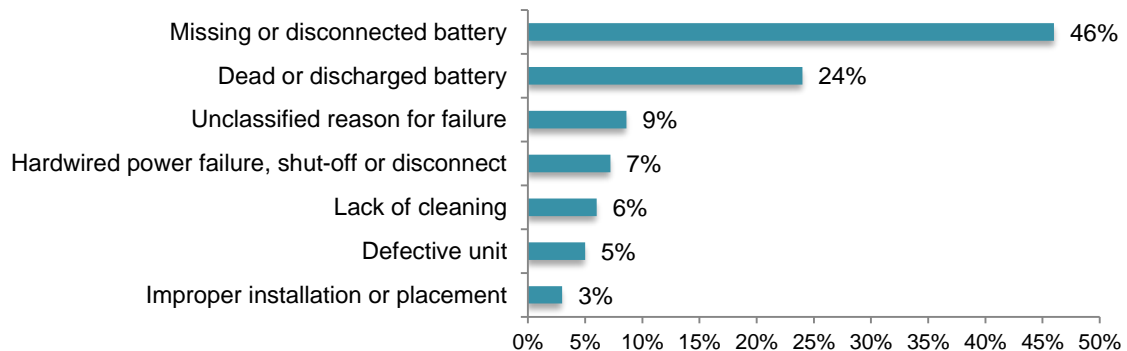
- Hardwired smoke alarms operated 94% of the time.
- Battery-powered smoke alarms operated in four out of five (80%) fires.

Reasons that Smoke Alarms Did Not Operate when Present in Large Enough Fires

In fires in which the smoke alarms were present but did not operate,

- Almost half (46%) of the smoke alarms had missing or disconnected batteries. Nuisance alarms were the leading reason for disconnected smoke alarms.
- Dead batteries caused one-quarter (24%) of the smoke alarm failures.
- 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 Reported Home Structure Fires
2009-2013**



Interconnected Smoke Alarms and Smoke Alarms in the Bedroom Increase Safety

A Consumer Product Safety Commission (CPSC) survey of households with fires in which the fire department was not called asked about smoke alarms and how they learned about the fire.¹ People may know about a fire without hearing a smoke alarm.

- 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.
 - When not interconnected, they sounded in 27% of the fires and alerted people in 10%.
- When smoke alarms (interconnected or not) were on all levels of the home, they sounded in 37% of fires and alerted occupants in 15%.
 - When smoke alarms were not on all levels of the home, they sounded in only 4% of the fires and alerted occupants in only 2%.

According to another CPSC study, when a room's door was closed, a smoke alarm sounded 10-20 decibels softer in the next room. The sound was also about 20 decibels softer on a level above or below.² Having smoke alarms in the bedrooms makes it more likely that a sounding alarm will be loud enough to wake someone who was asleep when a fire started.

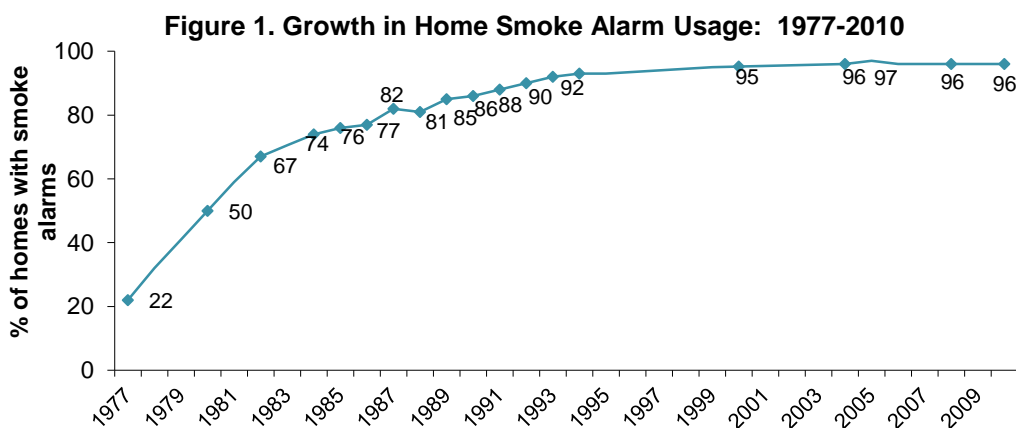
¹ Michael A. Greene and Craig Andres. [2004-2005 National Sample Survey of Unreported Residential Fires](#). U.S. CPSC, July 2009.

² Arthur Lee. [The Audibility of Smoke Alarms in Residential Homes](#), Bethesda, MD: U.S. CPSC, September 2005, revised January 2007.

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.⁸ The growth in home⁹ 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 the increasing usage and clear evidence 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 hit a plateau at 96%-97% 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.



“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.

⁸ 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; CPSC ‘s Michael A. Greene and Craig Andres 2009 report on [2004-2005 National Sample Survey of Unreported Residential Fires](#). U.S., Harris Interactive, “Smoke Alarm Omnibus Question Report;” 2008; Harris Poll® National Quorum: “National Fire Protection Association -- Smoke Alarms,” September 2010.

⁹ 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 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 67% of confined home fires. The analyses of confined fires in the body of the report are based on the 6% (five-year total of 40,471 fires) of confined fires in which information about detection equipment presence was provided. In contrast, smoke alarm presence was known in 68% (five-year total of 449,639 fires, 4,079 civilian deaths, and 24,361 civilian injuries) of the non-confined fires. Smoke alarm operation, when alarms were known to be present, was known in 83% of the non-confined fires and associated injuries, in 64% of the deaths, and in 93% 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.

88% of the fire detection devices in reported home fires were designed to detect smoke only.

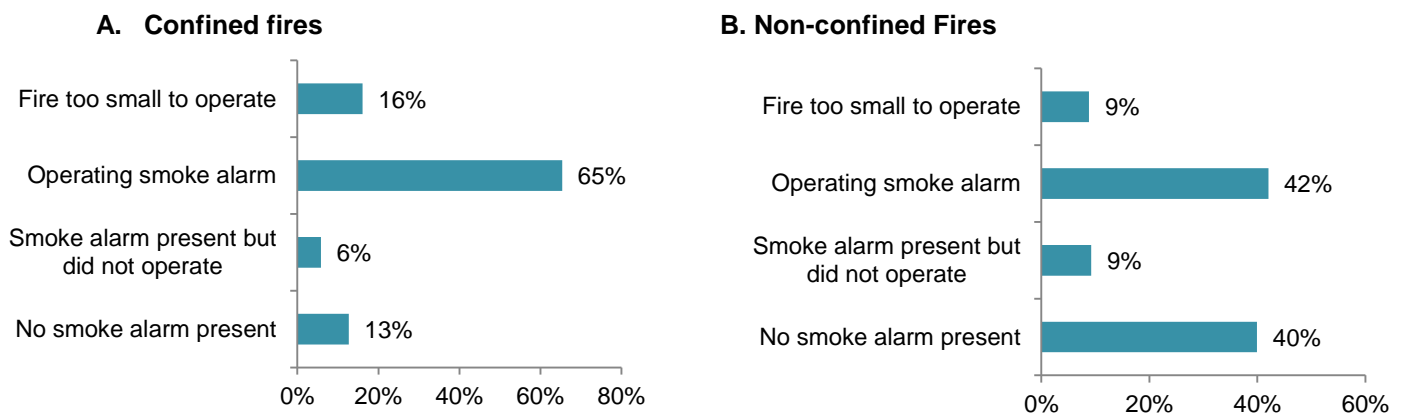
Table 2 shows that smoke alarms or system-based smoke detectors were the type of fire detector reported in 88% of the home fires in which the type of fire detection was identified. An additional 7% used a combination of smoke and heat detection.¹⁰ In 2%, more than one type of detection equipment was 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 more than 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 2009-2013 by smoke alarm performance. Fire departments responded to an estimated average of 357,000 home structure fires per year during this five-year period.

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. Note that the National Fire Incident Reporting System (NFIRS), the source of detailed data about fire department responses, does not capture information about whether the detection is monitored. Monitored detection may result in more fire department responses to very small fires.

Figure 2. Confined and Non-Confined Home Structure Fires by Smoke Alarm Performance 2009-2013



Two of every five home fire deaths resulted from a fire in which a smoke alarm sounded.

In 2009-2013, more than one-third (35%) of reported home fires occurred in properties with either no smoke alarms or no working smoke alarms. Three out of five (59%) home fire *deaths* resulted from fires without the protection of a working smoke alarm. Figure 3 shows that no smoke alarms were present in 38% of the home fire deaths. Alarms were present but did not operate in one of every five (21%) fatalities. Operating smoke alarms were present in two out of every five (40%) home fire deaths. In 1% of the deaths, the fire was too small to trigger the smoke alarm.

¹⁰ Other types of combination detection devices are now available, including smoke alarms with both photoelectric and ionization sensors, and devices that detect both smoke and carbon monoxide not associated with fire. It is possible that some of the devices coded as combination smoke and heat actually had other combinations.

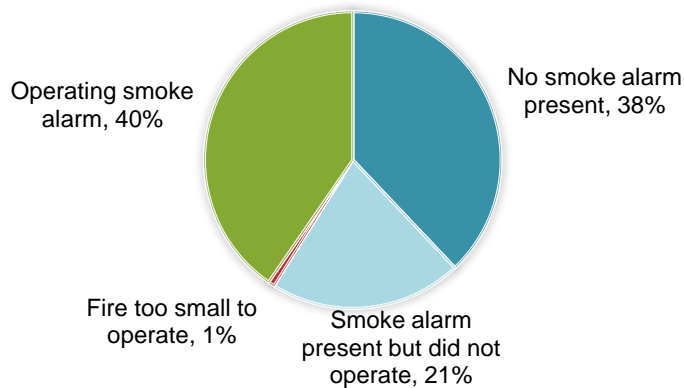
Table A.
Home Structure Fires by Smoke Alarm Performance
2009-2013 Annual Averages

Detection Performance	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Total	357,000	(100%)	2,470	(100%)	12,890	(100%)	\$6,866	(100%)
Non-confined fire	188,300	(53%)	2,470	(100%)	11,170	(87%)	\$6,827	(99%)
Confined fire	168,700	(47%)	0	(0%)	1,710	(13%)	\$39	(1%)
Smoke Alarm Present	260,400	(73%)	1,530	(62%)	9,420	(73%)	\$4,948	(72%)
Non-confined fire	113,100	(32%)	1,530	(62%)	7,910	(61%)	\$4,914	(72%)
Confined fire	147,300	(41%)	0	(0%)	1,510	(12%)	\$35	(1%)
<i>Fire too small to operate alarm</i>	43,800	(12%)	10	(1%)	600	(5%)	\$142	(2%)
Non-confined fire	16,600	(5%)	10	(1%)	390	(3%)	\$138	(2%)
Confined fire	27,200	(8%)	0	(0%)	200	(2%)	\$4	(0%)
<i>Smoke alarm present and fire large enough to operate alarm</i>								
	216,600	(61%)	1,510	(61%)	8,830	(69%)	\$4,806	(70%)
Non-confined fire	96,500	(27%)	1,510	(61%)	7,520	(58%)	\$4,776	(70%)
Confined fire	120,100	(34%)	0	(0%)	1,310	(10%)	\$31	(0%)
<i>Smoke alarm operated</i>	189,400	(53%)	1,000	(40%)	7,020	(54%)	\$4,135	(60%)
Non-confined fire	79,100	(22%)	1,000	(40%)	5,890	(46%)	\$4,107	(60%)
Confined fire	110,300	(31%)	0	(0%)	1,130	(9%)	\$28	(0%)
<i>Smoke alarm present but did not operate</i>	27,200	(8%)	510	(21%)	1,810	(14%)	\$672	(10%)
Non-confined fire	17,400	(5%)	510	(21%)	1,630	(13%)	\$669	(10%)
Confined fire	9,800	(3%)	0	(0%)	180	(1%)	\$3	(0%)
No Smoke Alarm	96,600	(27%)	940	(38%)	3,460	(27%)	\$1,918	(28%)
Non-confined fire	75,200	(21%)	940	(38%)	3,260	(25%)	\$1,913	(28%)
Confined fire	21,400	(6%)	0	(0%)	200	(2%)	\$5	(0%)
Operating alarms as share of those present in fires large enough to activate	189,400	(87%)	1,000	(66%)	7,020	(79%)	\$4,135	(86%)
Fires with no smoke alarms or none that operated in fires large enough to activate	123,800	(35%)	1,460	(59%)	5,270	(41%)	\$2,590	(38%)

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 68% of non-confined fires and 7% 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 3. Home Structure Fire Deaths by Smoke Alarm Performance 2009-2013



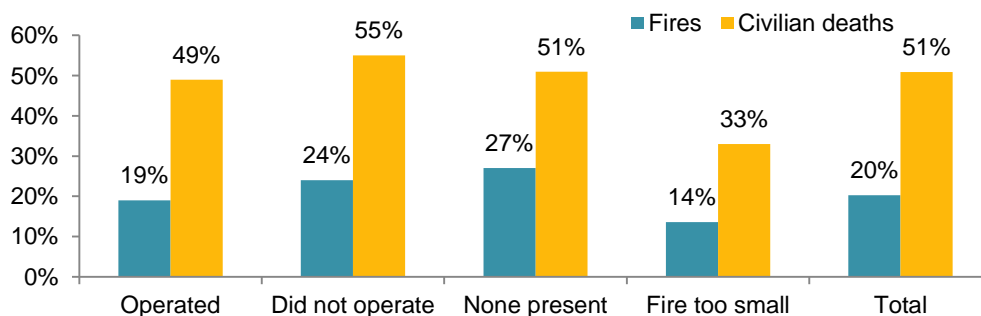
Differences in fatal home fire victim characteristics and fire circumstances between fires with working smoke alarms, no smoke alarms at all, and smoke alarms that should have operated but did not are explored later in the report.

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 civilian fire deaths reported between 11:00 p.m. and 7:00 a.m. were higher for properties with smoke alarms that did not operate or with no smoke alarms than in fires in which smoke alarms operated. Fifty-five percent of the deaths from fires with non-working alarms and 51% of home fire deaths in which no smoke alarms were present resulted from fires reported during these hours.

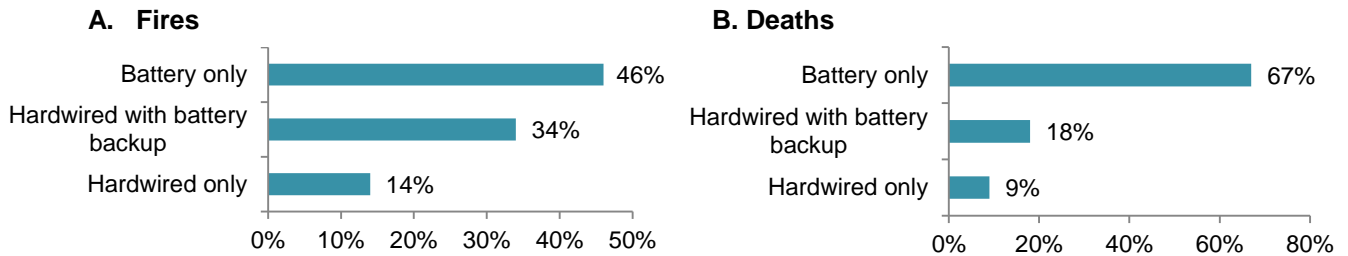
Forty-nine percent of the deaths from home fires with operating smoke alarms were reported in the same hours. Only 14% of the fires that were too small to activate the alarm and one-third (33%) of the associated deaths occurred during these hours.

Figure 4. Percent of Home Structure Fires and Fire Deaths Reported between 11:00 PM and 7:00 AM: 2009-2013



46% 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 almost half (46%) of the reported home fires and two-thirds (67%) of the home fire deaths. The death rate per 100 reported fires was 2.5 times as high in fires with smoke alarms powered by batteries as it was in fires with hardwired (with and without battery backup) smoke alarms.

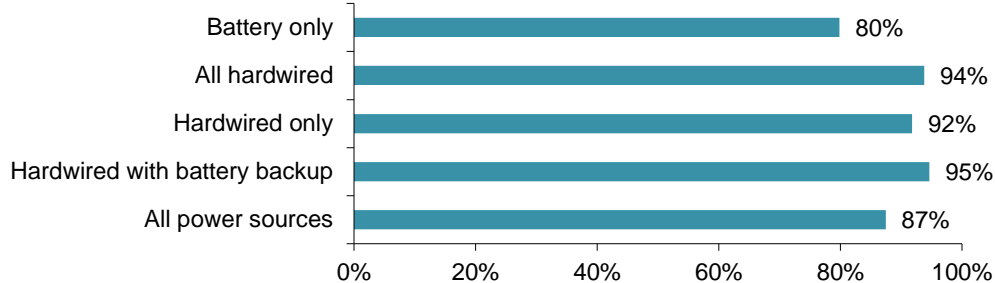
Figure 5. Leading Smoke Alarm Power Sources in Home Structure Fires: 2009-2013



In fires with smoke alarms present, the alarms were hardwired (with or without battery backup) in almost half (48%) of the reported home fires and more than one-quarter (28%) of the deaths. The breakdown of confined and non-confined fires varied by power source. Almost two-thirds (65%) of the fires with hardwired smoke alarms had confined fire incident types indicating smaller fires. Less than half (46%) of the fires with battery-powered smoke alarms had confined fire incident types.

Hardwired smoke alarms were more likely to operate than those powered by batteries alone. Table 5 and Figure 6 show the percentage of smoke alarms operating, when present, in fires considered large enough to activate the alarm. Overall, smoke alarms operated in 87% of these fires. Battery-powered smoke alarms had the smallest percentage operating (80%), and hardwired alarms with battery backup (95%) the highest. For all power sources, higher percentages of smoke alarms operated in confined fires than in non-confined fires. Hardwired smoke alarms are more likely to be interconnected, although battery-powered wireless interconnected alarms are available.

Figure 6. Smoke Alarm Operation in Home Fires Considered Large Enough to Activate Alarm by Power Source: 2009-2013



Three out of five homes with smoke alarms in the 2011 American Housing Survey had smoke alarms powered by batteries. In 2011, 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 months. Results, summarized in Table 6, show that the majority of households in all types of circumstances reported having this protection.¹¹ Smoke alarms were reported to be less

¹¹ U.S. Census Bureau, Current Housing Reports, Series H150/11, *American Housing Survey for the United States, 2011*, U.S. Government Printing Office, Washington, DC. 20401, 2013. Table S-01-AO. Sums of valid reported

common in housing units occupied by Hispanics (90%), and households with income below the poverty line (91%). In contrast, 98% of the housing units that were four years or less old had smoke alarms.

The CPSC’s 1992 National Smoke Detector Project sent field investigators into homes. This study is the gold standard for smoke alarm research. 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 high-risk groups or people who had fires. About 88% of the households screened had at least one installed smoke alarm; 41% of households had more than one.¹²

Home visits are expensive. More recent studies by other groups have usually been combined with smoke alarm installation programs. These typically target high-risk groups, rather than the general population. Although dated, the CPSC study provides the best picture of smoke alarm usage in the general population.

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 2011 *American Housing Survey* indicate that the percentage of occupied housing units with smoke alarms powered solely by batteries has fallen to 61%. The same survey found that 30% 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. Table 6 shows that 95% of the occupied housing units had what were reported as “working smoke alarms.” 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 did, in fact, work. For that reason, the AHS results are presented as results about smoke alarms without mentioning whether they are working.

data were used for calculating percentages. Table entries of “not reported” were excluded from the calculations. Respondents were describing occupied housing units.

¹² Charles L. Smith, [Smoke Detector Operability Survey – Report on Findings](#), Bethesda, MD: U.S. CPSC, November 1993.

The CPSC study and two studies focusing specifically on the accuracy of self-reporting of working smoke alarms (described in Appendix B) support the conclusion that the 95% of homes with working smoke alarms found in the American Housing Survey is unrealistically high.

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 phone¹³ 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.

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.¹⁴ 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.

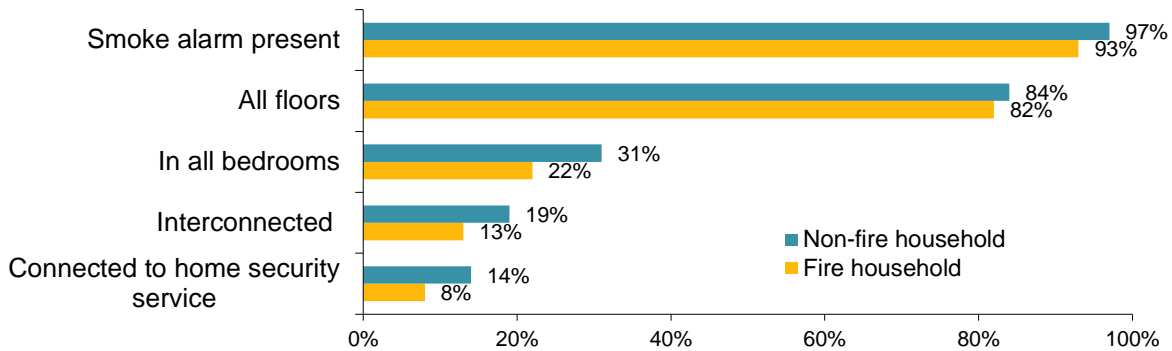
Survey findings related to smoke alarms are shown in Table 7. Figure 7 shows 97% of households that did not have a fire (non-fire households) reported that they had at least one smoke alarm. That is slightly higher than the 93% of households that had fires (fire households) with at least one smoke alarm. 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.

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 and 2010 had at least one smoke alarm. This is consistent with the 97% found in CPSC’s [2004-2005 National Sample Survey of Unreported Residential Fires](#). In contrast, one-quarter (27%) of reported home fires in 2009-2013 occurred in properties without smoke alarms.

¹³ Table 1132, “Utilization and Number of Selected Media: 2000 to 2009” in the U.S. Census Bureau’s *Statistical Abstract of the United States: 2012* shows that 96% of U.S. households had telephone service in 2009.

¹⁴ Michael A. Greene and Craig Andres. [2004-2005 National Sample Survey of Unreported Residential Fires](#). U.S. CPSC, July 2009.

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.

One smoke alarm is usually not enough. Twelve percent of reported home fires were too small to activate smoke alarms that were present in 2009-2013. Some of these fires may have been out of range of the smoke alarm. Most homes need more than one smoke alarm for code-compliant complete protection. The 2007, 2010, and 2013 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. Closed doors can delay the detection of the presence of smoke and the smoke alarm response. Closed doors also make it less likely that the signal will be heard. Note that interconnected smoke alarms in all bedrooms addresses this issue. 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.¹⁵

In 2010, NFPA arranged for a Harris Poll® National Quorum to include questions about smoke alarms in telephone surveys of more than 1,000 households.¹⁶ 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;

The 2008 survey found that 84% of households had an alarm on every level of the home. This was not asked in 2010.

¹⁵ Charles L. Smith, [Smoke Detector Operability Survey – Report on Findings](#), Bethesda, MD: U.S. CPSC, November 1993, p. 24.

¹⁶ Harris Interactive. *Smoke Alarm Omnibus Question Report*, November 2008.

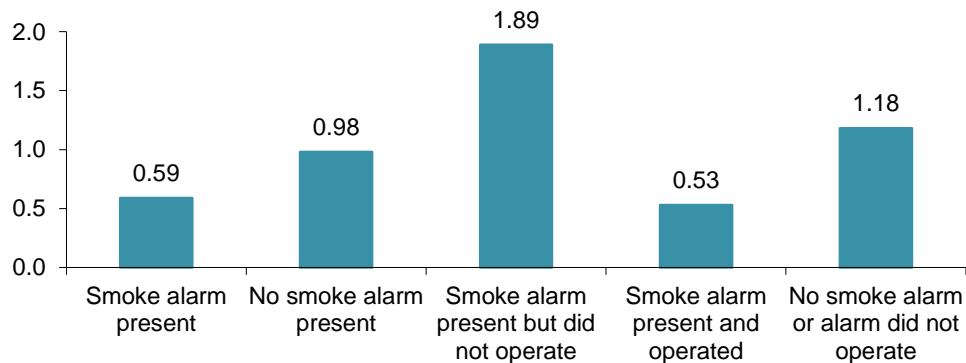
Benefits of Smoke Alarms

LIVES SAVED

The risk of dying in reported home structure fires is cut in half in homes with working smoke alarms. Figure 8 shows that in 2009-2013, the risk of death from a fire in a home that had any smoke alarms (0.59 deaths per 100 fires), regardless of whether they were working, was 40% lower than the risk in a home with no smoke alarms at all (0.98 deaths per 100 fires). Interestingly, the data indicate that the death rate was substantially higher (1.89 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 (0.98).

Figure 8 also shows that the death rate in fires with working smoke alarms (0.53 per 100 fires) was less than half (55% 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: 2009-2013



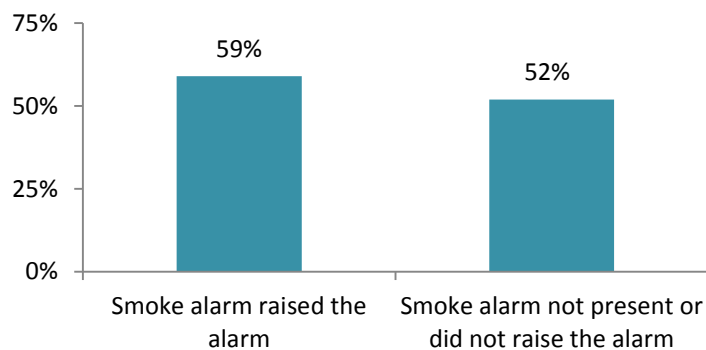
This is not the same as saying you double your chances of *surviving* a fire that is big enough to be reported to a fire department. Ignoring fires where more than one person dies, death rates per 100 fires are the same as percentages of reported fires that are fatal. By that formulation, people die in 0.53% 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. According to National Highway Traffic Safety Administration (NHTSA) data, only 0.6% of all vehicle crashes reported to the police from 1998 to 2013 were fatal.¹⁷ There is clearly considerable work left to do to increase both fire and vehicle safety.

¹⁷ National Highway Traffic Safety Administration. [Traffic Safety Facts 2013](#), Washington, D.C.: U.S. Department of Transportation, p. 17. DOT HS 812 139

SMOKE ALARMS AND EARLY DISCOVERY OF FIRE

U.K. data confirm that smoke alarms result in quicker fire discovery. The United Kingdom (U.K.) tracks the interval between the time of ignition and the time of discovery.¹⁸ Figure 9 shows that in 2013/14, three out of every five (59%) reported home fires in which the alarm was raised by the smoke alarm were discovered within five minutes of ignition. Slightly more than half (52%) of the fires in which no smoke alarms were present or in which they did not raise the alarm were discovered within five minutes. Four deaths were reported per 1,000 fires when smoke alarms operated within that time, compared to eight deaths per 1,000 fires in incidents in which no smoke alarm was present or an alarm was present but did not raise the alarm.

Figure 9. 2013/14 U.K. Home Fires Discovered within Five Minutes of Ignition



Source: *Fire Statistics, Great Britain, 2013 to 2014*

Sometimes, people notice the fire first or no one hears the alarm. In 2013/14, home smoke alarms were present, operated, and raised the alarm in two out of every five (39%) fires reported in the U.K. Smoke alarms operated but did not raise the alarm in 11% 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 three out of five (59%) such fires, a person raised the alarm before the system operated (Someone in the same room may notice a fire immediately.);
- In almost one-fifth (18%), no one was in earshot; and
- The occupants failed to respond in 14% of these fires.

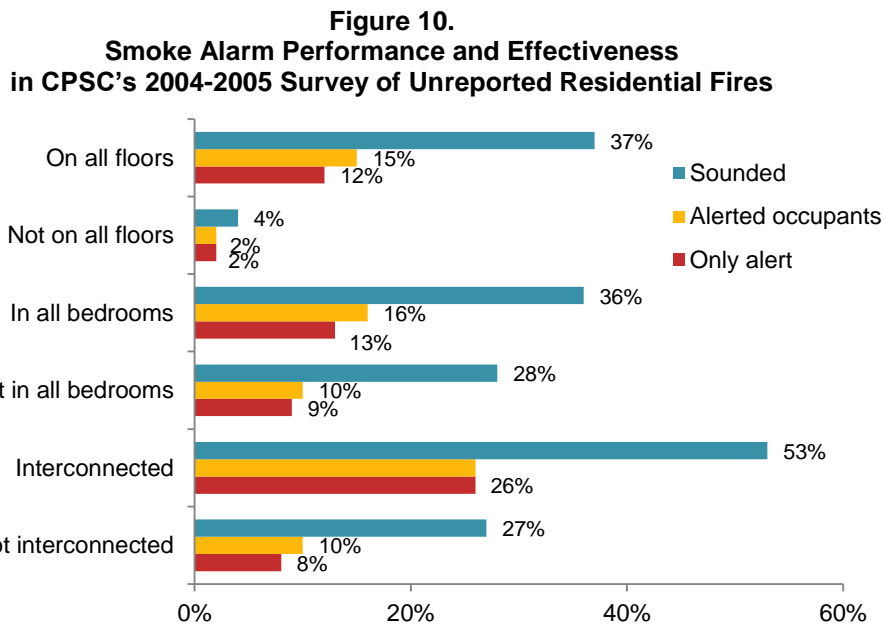
Smoke alarms provided the *only* alert in 10% of residential fires in CPSC's 2004-2005 survey of reported and unreported fires. Findings on smoke alarm alerts from CPSC's 2004-2005 Residential Fire Survey¹⁹ are consistent with the UK study above. In CPSC's survey, additional detail was sought on low 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

¹⁸ Department for Communities and Local Government. [Fire Statistics, Great Britain, April 2013 to March 2014](#), London, U.K., December 2015, pp. 33-41.

¹⁹ Michael A. Greene and Craig Andres. [2004-2005 National Sample Survey of Unreported Residential Fires](#). U.S. CPSC, July 2009, pp. 150-189.

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’s 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%.



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

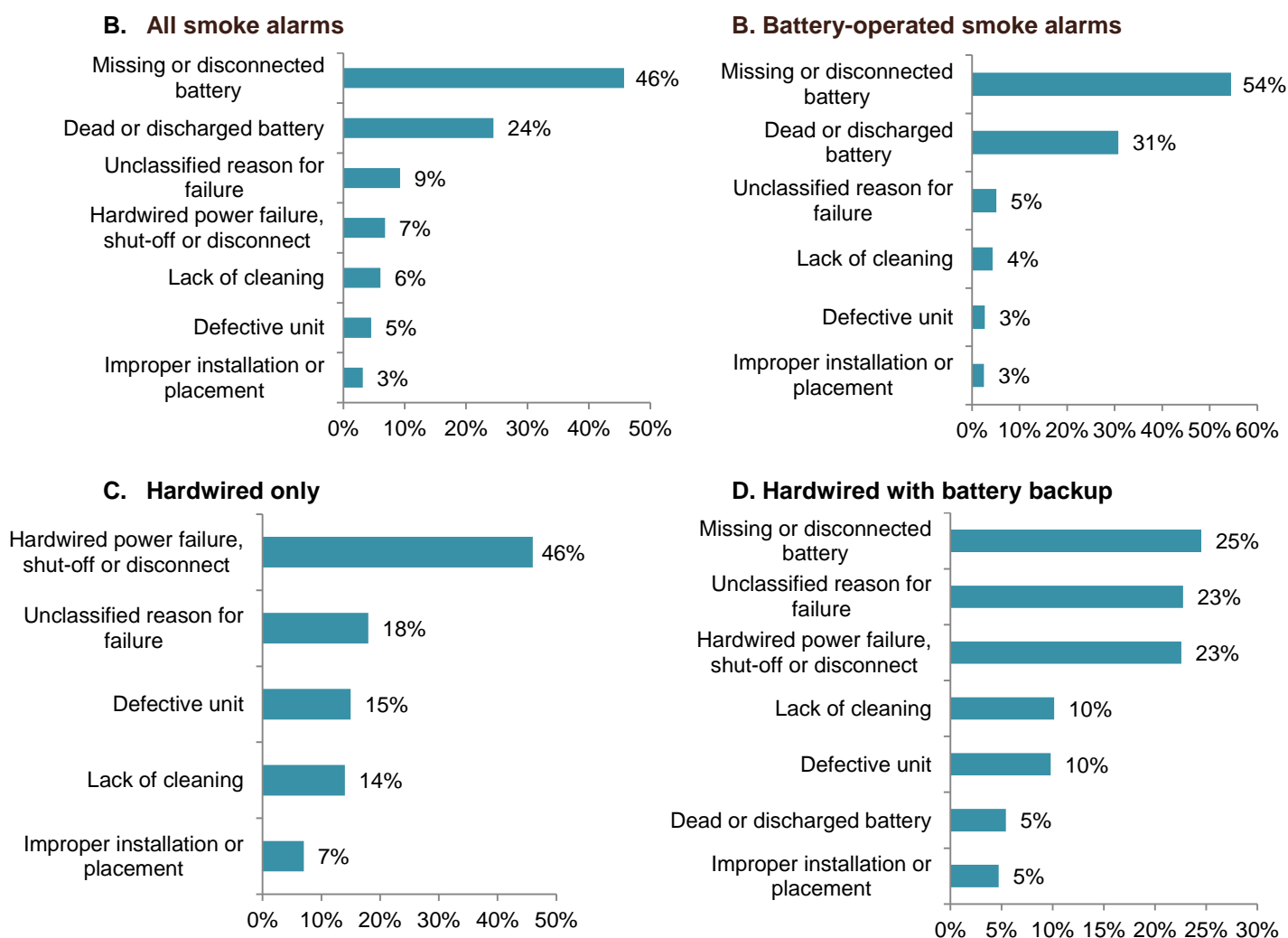
When smoke alarms were not on all levels of the home, they sounded in only 4% of the fires and alerted occupants in only 2% of the fires. Such households may be less likely to have smoke alarms that are interconnected. When smoke alarms were present on all levels, they sounded in more than one-third (37%) of the fires and provided the only alert in 12%.

Much of the discussion so far has focused on the extent of smoke alarm protection installed in the home and the benefits of working smoke alarms. With roughly 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

Almost three-quarters of non-working smoking alarms used battery power only. Table 4 showed that almost half (46%) 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 fires considered large enough to activate them, almost three-quarters (71%) were powered by batteries only. Figure 11A and Table 9 show power source issues were the leading reason smoke alarms failed to operate.²⁰ In more than half (54%) of the fires in which battery-powered smoke alarms failed to sound, the batteries were missing or disconnected. Dead or discharged batteries accounted for almost one-third (31%) of the battery-powered smoke alarm failures.

Figure 11. Reason Smoke Alarms Did Not Operate in Home Structure Fires Considered Large Enough to Activate: 2009-2013



Source: NFIRS 5.0 and NFPA survey

²⁰ The reasons shown are based on the code choices for detector failure reason in the NFIRS 5.0 structure fire module.

One-quarter (25%) of the failures of hardwired smoke alarms with battery backup were blamed on missing or disconnected batteries. The reason was unclassified in almost one-quarter (23%) of the fires. Almost one-quarter (23%) of the failures were due to a hardwired power failure, shut off, or disconnect; 10% were blamed on a lack of cleaning; defective units were blamed in another 10% of these failures; and 5% 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, there is no clear explanation for these patterns.

When hardwired smoke alarms with no battery backup failed to operate, the power had failed, been shut off, or disconnected in almost half (46%) of the fires. This scenario includes deliberate disabling of the smoke alarm, temporary power outages, and power shutoff to the home. In one out of six (18%) hardwired only smoke alarm failures, the reason was unclassified. The failure was blamed on a defective unit in 15% of the incidents. A lack of cleaning was cited in 14%.

It appears 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 less than one-third of the battery-powered alarms. The percentage of unclassified reasons was 3-4 times as high for hardwired smoke alarms as for battery-powered alarms.

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 of this group were correct; testing showed they did indeed have working smoke alarms. Another 11% of those surveyed did not know whether their alarms 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.²¹

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 U.K. 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 U.K.²² In the beginning of the study, 11-12% of the smoke alarms found in the homes were working. Five different types were installed as part of this study. When the households were

²¹ Harris Poll® National Quorum. *National Fire Protection Association --Smoke Alarms*, September 2010 p. 27, Percentages were based on known data.

²² Diane Rowland, Carolyn DiGuseppi, 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.

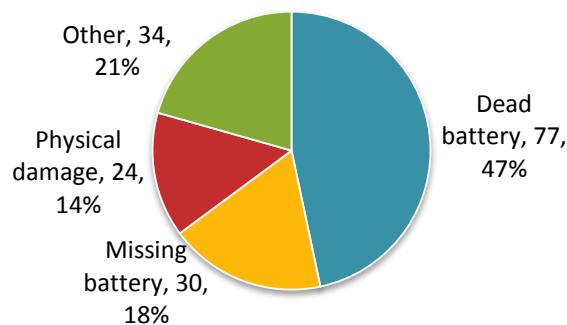
visited 15 months later, 93% had smoke alarms installed. Fifty-four percent had a working smoke alarm. The alarms installed for the study were working in 51% of the homes. In homes with at least one smoker, 38% of the photoelectric (called optical in the study) alarms and 48% of the ionization alarms 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).

CDC found that one-third of “10-year” smoke alarms were present and functional 8 to 10 years after installation. The Centers for Disease Control and Prevention (CDC) commissioned the National Center for Healthy Housing (NCHH) to determine if lithium battery-powered smoke alarms installed in 1998-2001 were still present and operational eight to ten years later.²³ 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 Battery-Powered Smoke Alarm Non-Operationality 8-10 Years after Installation

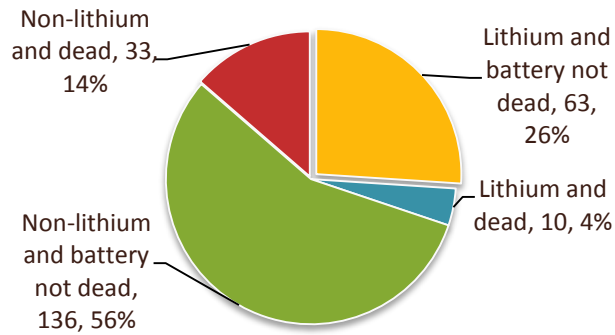


Source: Wilson, Akotomo, Dixon, and Jacobs, 2008.

²³ Jonathan Wilson, Judith Akoto, Sherry Dixon, and David Jacobs, *Evaluation of the “10-Year” Smoke Alarm Project*, National Center for Healthy Housing, Report prepared for Centers for Disease Control and Prevention, 2008.

Researchers also sought information on the type of batteries that were currently in the 351 alarms that were present and powered. The 242 known battery types and their operability are shown in Figure 13.

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



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

Most of the alarms used in the program had battery chambers that permitted replacement. 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.

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 by 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 battery-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. 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.

Dallas study quantified status of lithium battery-powered smoke alarms over time. From December 2011 through October 2012, members of the Dallas Fire-Rescue Department (DFRD) conducted follow-up home visits to 800 homes in which 1,884 smoke alarms with lithium batteries that had been installed from 2001-2010 to monitor how these smoke alarms functioned over time.²⁴

- In the second year group, 88% of the smoke alarms were present and 84% were working.
- In the fourth year group, 75% were present and 55% were working.
- In the sixth year group, 71% were present and 27% were working.
- In the eighth-year group, 63% were installed and 20% were working.
- In the tenth-year group, 55% were installed and 22% were still working.

These findings are consistent with CDC’s recommendations for follow-up.

NUISANCE ACTIVATIONS AND SMOKE ALARM OPERABILITY

Smoke alarms provide early warning in the event of a fire. 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 alarms far outnumber actual fires. Based on his survey of fire department experience in 2013, NFPA’s Michael J. Karter, Jr, estimated that in incidents involving all types of detection equipment, alarm systems and sprinklers in all types of properties, fire departments responded to an estimated

- 1,080,000 unintentional activations,
- 757,000 system malfunctions,
- 165,000 malicious or mischievous false calls, and
- 341,000 other or unclassified false alarms, including bomb scares.

In the same report, he noted that fire departments responded to a total of 1,240,000 fires of all types, including 487,500 structure fires, and, more specifically, 369,500 home (one- or two-family homes and apartments or other multi-family dwellings) structure fires.²⁵ Assuming that most of the unintentional activations and system malfunctions occurred in structures, this translates to a rate of 3.8 fire department responses to an unintentional activation or system malfunction for every one response to an actual structure fire.

Data on the total number of unwanted activations, including those that were handled without the fire department is not easy to come by. However, respondents to surveys that ask smoke alarm owners if the devices have sounded show far more activations than fires. In a 2010 poll done for the NFPA,²⁶ two questions were asked of the 43% of households that said their smoke alarms had gone off in the past year. In the first question, they were asked “What do you think caused

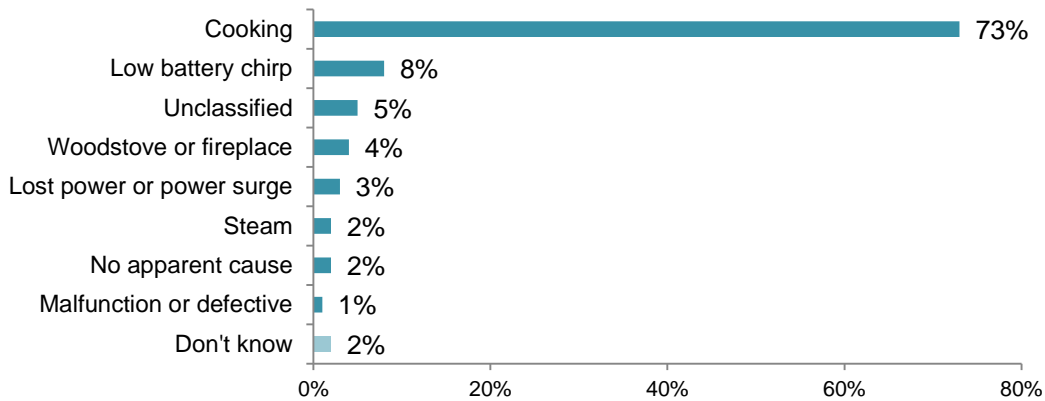
²⁴ Mary A. McCoy, Carey Roper, Emily Campa, Shelli Stephens-Stidham, Debra K. Carlin and Gregory R. Istre. “[How Long Do smoke Alarms Function? A Cross-Sectional Follow-Up Survey of a Smoke Alarm Installation Programme](#)”, *Injury Prevention*, published online first July 9, 2013, doi: 10.1136/injprev-2013-040824

²⁵ Michael J. Karter, Jr. *Fire Loss in the United States during 2013*, Quincy, MA: NFPA 2014.

²⁶ Harris Poll National Quorum. National Fire Protection Association -- Smoke Alarms. September 8-12, 2010.

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



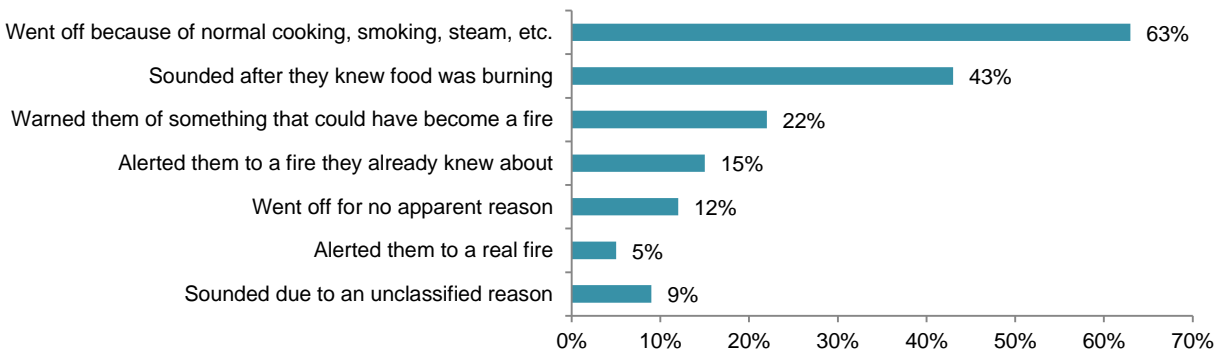
Source: Harris Poll National Quorum. National Fire Protection Association -- Smoke Alarms. 2010.

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

Respondents were then 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 12.

Although no one cited fire as a reason for the activations in the previous question, Figure 15 shows that 5% agreed 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. These responses suggest that the sounding smoke alarms functioned properly but were annoying 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.²⁷ 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;
- *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.

Nuisance activations, particularly due to cooking, were cited as the reason for the largest share of smoke alarms missing batteries or disconnected from power. CPSC's National Smoke Detector Project, conducted in 1992, with over 1,000 in-person interviews and on-site testing of smoke alarms, provided the most complete picture of smoke alarm usage and issues. They documented reasons when smoke alarms were not working. When smoke alarms had missing or disconnected batteries or the alarms had been disconnected from the household wiring, the leading reason was unwanted activations (39% of known reasons). Removal for this reason was eight times as frequent as removal to use the batteries in another product (5%).²⁸ Thirty-seven percent said they forgot to replace the batteries, 9% said the device alarmed continuously, 6% never looked, 6% had no batteries in the home, and 5% said they hadn't had a chance to install the batteries.

Slightly more than half of the respondents in the project reported that their smoke alarms had sounded in the absence of fire or active testing. Cooking was cited as the reason for four out of five nuisance alarms, and low batteries were cited by one in five. Bathroom steam was also a factor.

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.²⁹ They also interviewed children ages 7-11 at school. Some adults described feeling very stressed by false alarms and

²⁷ 2004 Fire Prevention Week Survey conducted for National Fire Protection Association by Harris Interactive Market Research, pp. 11-14.

²⁸ Charles L. Smith, *Smoke Detector Operability Survey – Report on Findings*, Bethesda, MD: U.S. CPSC, November 1993.

²⁹ H. Roberts, K. Curtis, K. Liabo, D. Rowland, C. DiGuseppi, 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>.

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."

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."

One-third 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 2013 edition of NFPA 72® spells out locations where smoke alarms should *not* be placed. Many nuisance activations can be avoided by following these requirements.

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."³⁰

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

³⁰ Bukowski et al., 2008 revision, p. 194.

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.³¹

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.³² 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.

Several studies support NFPA72® restrictions regarding smoke alarm placement in relation to kitchen ranges. The authors of the Alaska study 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 of this article, of the NCHH evaluation of the 10-year smoke alarm project already discussed, and those of the next study support the restrictions in NFPA 72® regarding smoke alarm placement in relation to the kitchen range. Unfortunately, the first two studies did not report how far away alarms that were not working or had frequent nuisance activations were from the equipment.

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 King County, Washington.³³ Installation teams were instructed to install the alarms on the main living level. Rooms next to the kitchen were 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 2013 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

³¹ Bukowski, et al. 2008 revision, p. 250.

³² Thomas M. Fazzini, Ron Perkins, and David Grossman. “[Ionization and Photoelectric Smoke Alarms in Rural Alaskan Homes](#),” *West J. Med*; 2000; 173:89-92.

³³ 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.

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,³⁴ *roughly half (52%) of all households with at least one smoke alarm reported that a smoke alarm was installed in the kitchen.*

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. Such systems may be triggered when someone with a smoke alarm sounding in an apartment opens the door to a common hallway to let the smoke out. Are too many people affected? Section 9.6.2.10.4 of the 2012 edition 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.

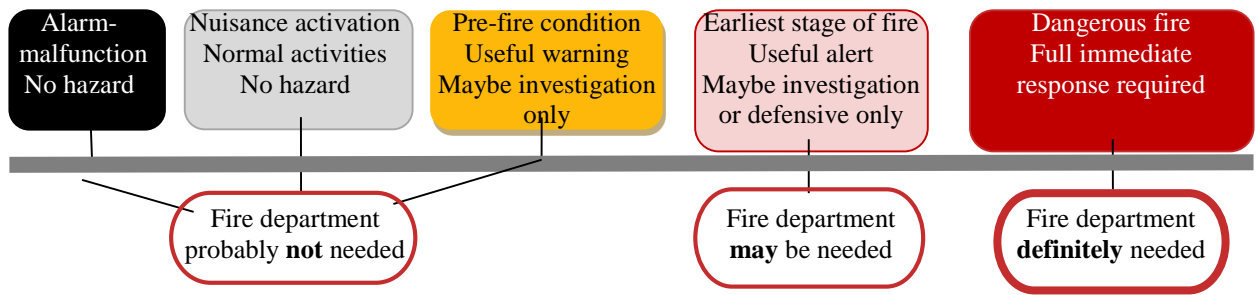
In 2004-2005, the CPSC conducted a telephone survey to estimate the total number of residential fires experienced by U.S. households, including fires that were not attended by fire departments.³⁵ They found that 97% of home fires were handled without fire department assistance. Most fires resulted in no flame damage or damage to only the item first ignited.

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, people may 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. Sounding smoke alarms during predictable times may not be heeded, but those at unexpected hours may be taken more seriously.

³⁴ Harris Poll National Quorum. National Fire Protection Association -- Smoke Alarms. September 8-12, 2010.

³⁵ Michael A. Greene and Craig Andres. [2004-2005 National Sample Survey of Unreported Residential Fires](#). U.S. CPSC, July 2009.

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. Greene and Andres 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 generally 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 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 and full fire department response is essential. It is important to remember that the primary purpose of smoke alarms in homes is to give people time to escape.

Section 29.7.9.2 of [NFPA 72®, National Fire Alarm and Signaling Code®](#) allows monitoring 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.³⁶ 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.

³⁶ 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, pp. 27-40.

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

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. NFPA also produced the [Fire Service Guide to Reducing Unwanted Alarms](#) to assist fire departments with this issue. A Fire Protection Research Foundation project, [Development of a Risk-Based Decision Support Tool to Assist Fire Departments in Managing Unwanted Alarms](#), provides a tool that fire departments can use to determine the costs and benefits of various response strategies to commercial fire alarms, including fire alarms coming from apartments or multi-family housing. A literature review with supporting and background information is also provided.

[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.

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
2009-2013 Annual Averages

Type of Detection Equipment	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Smoke	230,200	(88%)	1,430	(94%)	8,710	(92%)	\$4,483	(91%)
Non-confined fire	103,700	(40%)	1,430	(94%)	7,360	(78%)	\$4,455	(90%)
Confined fire	126,400	(49%)	0	(0%)	1,350	(14%)	\$28	(1%)
Combination smoke and heat	18,200	(7%)	40	(3%)	340	(4%)	\$282	(6%)
Non-confined fire	5,600	(2%)	40	(3%)	270	(3%)	\$279	(6%)
Confined fire	12,600	(5%)	0	(0%)	60	(1%)	\$2	(0%)
More than one type present	6,100	(2%)	40	(2%)	240	(3%)	\$110	(2%)
Non-confined fire	2,000	(1%)	40	(2%)	180	(2%)	\$108	(2%)
Confined fire	4,200	(2%)	0	(0%)	60	(1%)	\$1	(0%)
Unclassified detection equipment	2,500	(1%)	10	(0%)	40	(0%)	\$32	(1%)
Non-confined fire	700	(0%)	10	(0%)	40	(0%)	\$31	(1%)
Confined fire	1,800	(1%)	0	(0%)	10	(0%)	\$0	(0%)
Heat	1,800	(1%)	0	(0%)	40	(0%)	\$20	(0%)
Non-confined fire	600	(0%)	0	(0%)	30	(0%)	\$17	(0%)
Confined fire	1,200	(0%)	0	(0%)	10	(0%)	\$2	(0%)
Sprinkler with water flow detection	1,700	(1%)	10	(1%)	50	(1%)	\$23	(0%)
Non-confined fire	700	(0%)	10	(1%)	30	(0%)	\$22	(0%)
Confined fire	1,100	(0%)	0	(0%)	20	(0%)	\$0	(0%)
Total	260,400	(100%)	1,530	(100%)	9,420	(100%)	\$4,948	(100%)
Non-confined fire	113,100	(43%)	1,530	(100%)	7,910	(84%)	\$4,914	(99%)
Confined fire	147,300	(57%)	0	(0%)	1,510	(16%)	\$35	(1%)

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
2009-2013 Annual Averages

Alarm Time	Operated	Did Not Operate	None Present	Fire Too Small	Total
Midnight - 12:59 a.m.	3%	4%	None	2%	3%
1:00 - 1:59 a.m.	3%	4%	4%	2%	3%
2:00 - 2:59 a.m.	2%	3%	4%	1%	3%
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%	3%	1%	2%
6:00 - 6:59 a.m.	2%	2%	3%	2%	2%
7:00 - 7:59 a.m.	2%	3%	3%	3%	2%
8:00 - 8:59 a.m.	3%	3%	3%	3%	3%
9:00 - 9:59 a.m.	3%	3%	3%	3%	3%
10:00 - 10:59 a.m.	4%	4%	3%	4%	4%
11:00 - 11:59 a.m.	5%	4%	4%	4%	4%
Noon - 12:59 p.m.	5%	4%	4%	5%	5%
1:00 - 1:59 p.m.	5%	5%	4%	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%	5%	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%	6%	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%	5%	3%	4%
			4%		
Total	100%	100%		100%	100%
Average	4%	4%	100%	4%	4%
11:00 p.m. - 7:00 a.m.	19%	24%	4%	14%	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
2009-2013 Annual Averages

Alarm Time	Operated	Did Not Operate	None Present	Fire Too Small	Total
Midnight - 12:59 a.m.	6%	7%	6%	13%	6%
1:00 - 1:59 a.m.	6%	8%	7%	0%	7%
2:00 - 2:59 a.m.	5%	9%	6%	13%	7%
3:00 - 3:59 a.m.	7%	9%	7%	0%	7%
4:00 - 4:59 a.m.	7%	7%	7%	0%	7%
5:00 - 5:59 a.m.	6%	5%	7%	0%	6%
6:00 - 6:59 a.m.	7%	4%	5%	0%	5%
7:00 - 7:59 a.m.	3%	4%	5%	14%	4%
8:00 - 8:59 a.m.	3%	4%	4%	6%	3%
9:00 - 9:59 a.m.	4%	4%	3%	14%	3%
10:00 - 10:59 a.m.	3%	3%	3%	13%	3%
11:00 - 11:59 a.m.	3%	4%	2%	0%	3%
Noon - 12:59 p.m.	3%	1%	3%	0%	3%
1:00 - 1:59 p.m.	2%	4%	3%	0%	3%
2:00 - 2:59 p.m.	2%	2%	2%	0%	3%
3:00 - 3:59 p.m.	3%	1%	3%	7%	3%
4:00 - 4:59 p.m.	3%	2%	2%	0%	2%
5:00 - 5:59 p.m.	3%	3%	2%	7%	2%
6:00 - 6:59 p.m.	4%	3%	3%	0%	3%
7:00 - 7:59 p.m.	3%	2%	3%	0%	3%
8:00 - 8:59 p.m.	3%	2%	3%	7%	3%
9:00 - 9:59 p.m.	4%	3%	4%	0%	4%
10:00 - 10:59 p.m.	4%	4%	4%	0%	4%
11:00 - 11:59 p.m.	6%	6%	6%	6%	5%
Total	100%	100%	100%	100%	100%
Average	4%	4%	4%	4%	4%
11:00 p.m. - 7:00 a.m.	49%	55%	51%	33%	51%

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
2009-2013 Annual Averages

Power Source	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Battery only	120,600	(46%)	1,030	(67%)	5,230	(55%)	\$2,446	(49%)
Non-confined fire	64,900	(25%)	1030	(67%)	4610	(49%)	\$2,432	(49%)
Confined fire	55,700	(21%)	0	(0%)	610	(7%)	\$14	(0%)
Hardwired with battery backup	87,700	(34%)	280	(18%)	2,570	(27%)	\$1,703	(34%)
Non-confined fire	31,900	(12%)	280	(18%)	2020	(21%)	\$1,690	(34%)
Confined fire	55,700	(21%)	0	(0%)	560	(6%)	\$13	(0%)
Hardwired only	36,600	(14%)	140	(9%)	1,110	(12%)	\$486	(10%)
Non-confined fire	11,100	(4%)	140	(9%)	890	(9%)	\$481	(10%)
Confined fire	25,500	(10%)	0	(0%)	220	(2%)	\$5	(0%)
Multiple detection devices and power supplies	8,300	(3%)	50	(3%)	300	(3%)	\$179	(4%)
Non-confined fire	2,500	(1%)	50	(3%)	240	(3%)	\$178	(4%)
Confined fire	5,900	(2%)	0	(0%)	60	(1%)	\$1	(0%)
Plug-in with battery backup	3,900	(2%)	10	(0%)	110	(1%)	\$78	(2%)
Non-confined fire	1,600	(1%)	10	(0%)	80	(1%)	\$77	(2%)
Confined fire	2,300	(1%)	0	(0%)	30	(0%)	\$1	(0%)
Unclassified power source	2,100	(1%)	10	(1%)	60	(1%)	\$35	(1%)
Non-confined fire	700	(0%)	10	(1%)	40	(0%)	\$35	(1%)
Confined fire	1,300	(1%)	0	(0%)	20	(0%)	\$0	(0%)
Plug-in	900	(0%)	0	(0%)	30	(0%)	\$14	(0%)
Non-confined fire	300	(0%)	0	(0%)	20	(0%)	\$14	(0%)
Confined fire	600	(0%)	0	(0%)	10	(0%)	\$0	(0%)
Mechanical	400	(0%)	0	(0%)	10	(0%)	\$8	(0%)
Non-confined fire	100	(0%)	0	(0%)	10	(0%)	\$7	(0%)
Confined fire	300	(0%)	0	(0%)	0	(0%)	\$0	(0%)
Total	260,400	(100%)	1,530	(100%)	9,420	(100%)	\$4,948	(100%)
Non-confined fire	113,100	(43%)	1,530	(100%)	7,910	(84%)	\$4,914	(99%)
Confined fire	147,300	(57%)	0	(0%)	1,510	(16%)	\$35	(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
2009-2013 Annual Averages

Power Source	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Battery only	77,200	(80%)	560	(57%)	3,420	(71%)	\$1,859	(80%)
Non-confined fire	41,900	(76%)	560	(56%)	3050	(70%)	\$1,849	(80%)
Confined fire	35,300	(84%)	0	(NA)	370	(73%)	\$10	(82%)
All hardwired	100,100	(94%)	370	(84%)	3,160	(90%)	\$1,990	(92%)
Non-confined fire	33,300	(90%)	370	(84%)	2520	(89%)	\$1,975	(92%)
Confined fire	66,800	(96%)	0	(NA)	650	(94%)	\$16	(95%)
Hardwired only	70,200	(95%)	260	(90%)	2,250	(92%)	\$1,577	(93%)
Non-confined fire	25,100	(91%)	260	(90%)	1790	(91%)	\$1,565	(93%)
Confined fire	45,100	(97%)	0	(NA)	460	(94%)	\$12	(96%)
Hardwired with battery	29,900	(92%)	110	(74%)	920	(87%)	\$414	(86%)
Non-confined fire	8,200	(85%)	110	(74%)	730	(85%)	\$410	(86%)
Confined fire	21,700	(95%)	0	(NA)	190	(92%)	\$4	(92%)
All power sources	189,400	(87%)	1,000	(66%)	7,020	(79%)	\$4,135	(86%)
Non-confined fire	79,100	(82%)	1,000	(66%)	5,890	(78%)	\$4,107	(86%)
Confined fire	110,300	(92%)	0	(NA)	1,130	(86%)	\$28	(90%)

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 present 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.
2011 American Housing Survey Findings on Occupied Housing Units with Smoke Alarms
Based on Self-Reports

Characteristic	SMOKE ALARM POWERED BY				Batteries Replaced in Last Six Months*
	All Homes	Electricity and Battery	Electricity Only	Battery Only	
Total	95%	32%	7%	61%	76%
Owner-occupied	95%	37%	6%	57%	75%
Renter-occupied	94%	24%	8%	69%	77%
Newer home - four years old or less	98%	63%	8%	30%	72%
Manufactured home	92%	36%	11%	53%	74%
Black householder	94%	24%	6%	69%	77%
Hispanic householder	90%	22%	7%	71%	78%
Householder at least 65 years old	93%	29%	9%	62%	75%
Household below poverty line	91%	23%	7%	70%	78%
Northeast	96%	30%	7%	63%	80%
Midwest	96%	30%	6%	64%	77%
South	93%	35%	7%	58%	75%
West	95%	33%	7%	56%	71%

* Based on smoke alarms powered by batteries or electricity and batteries only.

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. Sums of valid reported data were used for calculating percentages. Table entries of “not reported” were excluded from the calculations.

Source: U.S. Census Bureau, Current Housing Reports, Series H150/11, *American Housing Survey for the United States, 2011*, U.S. Government Printing Office, Washington, DC. 20401, 2013. Table S-01-AO.

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%
<i>Smoke alarm sounded</i>	30%
Alerted people	12%
Provided only alert	10%
<i>Alarm did not sound</i>	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%	12%
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. CPSC, July 2009.

Table 8.
Power Source in Smoke Alarms That Did Not Operate
in Home Structure Fires Considered Large Enough to Activate Alarm
2009-2013 Annual Averages

Power Source	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Battery only	19,400	(71%)	420	(81%)	1,400	(77%)	\$456	(68%)
Non-confined fire	12,900	(47%)	420	(81%)	1,270	(70%)	\$454	(68%)
Confined fire	6,500	(24%)	0	(0%)	130	(7%)	\$2	(0%)
Hardwired with battery backup	4,100	(15%)	40	(8%)	210	(12%)	\$118	(18%)
Non-confined fire	2,400	(9%)	40	(8%)	180	(10%)	\$118	(18%)
Confined fire	1,700	(6%)	0	(0%)	30	(2%)	\$0	(0%)
Hardwired only	2,700	(10%)	40	(8%)	150	(8%)	\$65	(10%)
Non-confined fire	1,500	(5%)	40	(8%)	130	(7%)	\$64	(10%)
Confined fire	1,200	(4%)	0	(0%)	20	(1%)	\$0	(0%)
Multiple detectors and power supplies	500	(2%)	10	(2%)	30	(2%)	\$16	(2%)
Non-confined fire	300	(1%)	10	(2%)	30	(2%)	\$16	(2%)
Confined fire	200	(1%)	0	(0%)	0	(0%)	\$0	(0%)
Plug-in with or without battery backup	400	(1%)	0	(0%)	10	(1%)	\$10	(2%)
Non-confined fire	200	(1%)	0	(0%)	10	(1%)	\$10	(2%)
Confined fire	200	(1%)	0	(0%)	0	(0%)	\$0	(0%)
Other known power source	100	(1%)	10	(1%)	10	(1%)	\$6	(1%)
Non-confined fire	100	(0%)	10	(1%)	10	(1%)	\$6	(1%)
Confined fire	100	(0%)	0	(0%)	0	(0%)	\$0	(0%)
Total	27,200	(100%)	510	(100%)	1,810	(100%)	\$672	(100%)
Non-confined fire	17,400	(64%)	510	(100%)	1,630	(90%)	\$669	(100%)
Confined fire	9,800	(36%)	0	(0%)	180	(10%)	\$3	(0%)

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 Home Structure Fires
Considered Large Enough to Activate Alarm
2009-2013 Annual Averages

A. All Power Sources Combined

Reason for Failure	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Missing or disconnected battery	12,400	(46%)	340	(66%)	1,080	(60%)	\$298	(44%)
Non-confined fire	8,300	(30%)	340	(66%)	940	(52%)	\$296	(44%)
Confined fire	4,200	(15%)	0	(0%)	140	(8%)	\$1	(0%)
Dead or discharged battery	6,700	(24%)	80	(15%)	330	(18%)	\$125	(19%)
Non-confined fire	4,200	(15%)	80	(15%)	330	(18%)	\$124	(18%)
Confined fire	2,400	(9%)	0	(0%)	0	(0%)	\$1	(0%)
Unclassified reason for failure	2,500	(9%)	20	(4%)	80	(5%)	\$106	(16%)
Non-confined fire	1,600	(6%)	20	(4%)	80	(4%)	\$105	(16%)
Confined fire	900	(3%)	0	(0%)	0	(0%)	\$0	(0%)
Hardwired power failure, shut-off or disconnect	1,900	(7%)	40	(8%)	130	(7%)	\$67	(10%)
Non-confined fire	1,200	(5%)	40	(8%)	120	(7%)	\$67	(10%)
Confined fire	600	(2%)	0	(0%)	0	(0%)	\$0	(0%)
Lack of cleaning	1,600	(6%)	20	(4%)	90	(5%)	\$37	(5%)
Non-confined fire	900	(3%)	20	(4%)	70	(4%)	\$37	(5%)
Confined fire	800	(3%)	0	(0%)	10	(1%)	\$0	(0%)
Defective unit	1,200	(5%)	0	(1%)	40	(2%)	\$14	(2%)
Non-confined fire	600	(2%)	0	(1%)	30	(2%)	\$14	(2%)
Confined fire	600	(2%)	0	(0%)	10	(0%)	\$0	(0%)
Improper installation or placement	900	(3%)	10	(2%)	60	(3%)	\$25	(4%)
Non-confined fire	500	(2%)	10	(2%)	50	(3%)	\$25	(4%)
Confined fire	300	(1%)	0	(0%)	10	(0%)	\$0	(0%)
Total	27,200	(100%)	510	(100%)	1,810	(100%)	\$672	(100%)
Non-confined fire	17,400	(64%)	510	(100%)	1,630	(90%)	\$669	(100%)
Confined fire	9,800	(36%)	0	(0%)	180	(10%)	\$3	(0%)

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 Home Structure Fires
Considered Large Enough to Activate Alarm
2009-2013 Annual Averages (continued)

B. Battery Only

Reason for Failure	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Missing or disconnected battery	10,500	(54%)	310	(75%)	950	(68%)	\$269	(59%)
Non-confined fire	7,300	(37%)	310	(75%)	840	(60%)	\$268	(59%)
Confined fire	3,300	(17%)	0	(0%)	110	(8%)	\$1	(0%)
Dead or discharged battery	6,000	(31%)	70	(17%)	310	(22%)	\$119	(26%)
Non-confined fire	3,900	(20%)	70	(17%)	300	(22%)	\$119	(26%)
Confined fire	2,100	(11%)	0	(0%)	0	(0%)	\$0	(0%)
Unclassified reason for failure	1,000	(5%)	10	(2%)	40	(3%)	\$32	(7%)
Non-confined fire	700	(3%)	10	(2%)	40	(3%)	\$32	(7%)
Confined fire	300	(2%)	0	(0%)	0	(0%)	\$0	(0%)
Lack of cleaning	800	(4%)	10	(3%)	50	(3%)	\$16	(4%)
Non-confined fire	500	(2%)	10	(3%)	40	(3%)	\$16	(4%)
Confined fire	400	(2%)	0	(0%)	0	(0%)	\$0	(0%)
Defective unit	500	(3%)	0	(0%)	20	(1%)	\$7	(2%)
Non-confined fire	300	(2%)	0	(0%)	20	(1%)	\$7	(2%)
Confined fire	200	(1%)	0	(0%)	0	(0%)	\$0	(0%)
Improper installation or placement	500	(3%)	10	(3%)	40	(3%)	\$13	(3%)
Non-confined fire	300	(2%)	10	(3%)	30	(2%)	\$13	(3%)
Confined fire	200	(1%)	0	(0%)	10	(1%)	\$0	(0%)
Total	19,400	(100%)	420	(100%)	1,400	(100%)	\$456	(100%)
Non-confined fire	12,900	(67%)	420	(100%)	1,270	(90%)	\$454	(100%)
Confined fire	6,500	(33%)	0	(0%)	130	(10%)	\$2	(0%)

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 Home Structure Fires
Considered Large Enough to Activate Alarm
2009-2013 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	1,200	(46%)	40	(90%)	90	(60%)	\$40	(62%)
Non-confined fire	800	(30%)	40	(90%)	90	(67%)	\$40	(62%)
Confined fire	400	(16%)	0	(0%)	0	(0%)	\$0	(33%)
Unclassified reason for failure	500	(18%)	0	(10%)	10	(6%)	\$13	(20%)
Non-confined fire	200	(9%)	0	(10%)	10	(7%)	\$13	(20%)
Confined fire	200	(9%)	0	(0%)	0	(0%)	\$0	(10%)
Lack of cleaning	400	(15%)	0	(0%)	20	(12%)	\$3	(4%)
Non-confined fire	200	(7%)	0	(0%)	10	(5%)	\$3	(4%)
Confined fire	200	(8%)	0	(0%)	10	(67%)	\$0	(12%)
Defective unit	400	(14%)	0	(0%)	20	(16%)	\$4	(6%)
Non-confined fire	200	(7%)	0	(0%)	20	(13%)	\$4	(6%)
Confined fire	200	(7%)	0	(0%)	10	(33%)	\$0	(34%)
Improper installation or placement	200	(7%)	0	(0%)	10	(7%)	\$5	(7%)
Non-confined fire	100	(2%)	0	(0%)	10	(8%)	\$5	(7%)
Confined fire	100	(4%)	0	(0%)	0	(0%)	\$0	(11%)
Total	2,700	(100%)	40	(100%)	150	(100%)	\$65	(100%)
Non-confined fire	1,500	(55%)	40	(100%)	130	(89%)	\$64	(99%)
Confined fire	1,200	(45%)	0	(0%)	20	(11%)	\$0	(1%)

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 Home Structure Fires
Considered Large Enough to Activate Alarm
2009-2013 Annual Averages (Continued)

D. Hardwired with Battery Backup

Reason for Failure	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Missing or disconnected battery	1,000	(25%)	20	(47%)	80	(37%)	\$20	(17%)
Non-confined fire	600	(14%)	20	(47%)	60	(28%)	\$20	(17%)
Confined fire	400	(11%)	0	(0%)	20	(9%)	\$0	(0%)
Unclassified reason for failure	900	(23%)	10	(14%)	20	(11%)	\$42	(35%)
Non-confined fire	600	(15%)	10	(14%)	20	(11%)	\$42	(35%)
Confined fire	300	(8%)	0	(0%)	0	(0%)	\$0	(0%)
Hardwired power failure, shut-off or disconnect	900	(23%)	10	(28%)	70	(32%)	\$28	(24%)
Non-confined fire	700	(16%)	10	(28%)	60	(29%)	\$28	(24%)
Confined fire	300	(7%)	0	(0%)	10	(3%)	\$0	(0%)
Lack of cleaning	400	(10%)	0	(0%)	20	(11%)	\$16	(13%)
Non-confined fire	200	(5%)	0	(0%)	20	(8%)	\$16	(13%)
Confined fire	200	(5%)	0	(0%)	10	(3%)	\$0	(0%)
Defective unit	400	(10%)	0	(3%)	10	(3%)	\$4	(3%)
Non-confined fire	200	(4%)	0	(3%)	10	(3%)	\$4	(3%)
Confined fire	200	(6%)	0	(0%)	0	(0%)	\$0	(0%)
Dead or discharged battery	200	(5%)	0	(4%)	10	(3%)	\$4	(3%)
Non-confined fire	100	(2%)	0	(4%)	10	(3%)	\$4	(3%)
Confined fire	100	(3%)	0	(0%)	0	(0%)	\$0	(0%)
Improper installation or placement	200	(5%)	0	(3%)	10	(3%)	\$5	(4%)
Non-confined fire	100	(3%)	0	(3%)	10	(3%)	\$5	(4%)
Confined fire	100	(1%)	0	(0%)	0	(0%)	\$0	(0%)
Total	4,100	(100%)	40	(100%)	210	(100%)	\$118	(100%)
Non-confined fire	2,400	(59%)	40	(100%)	180	(86%)	\$118	(100%)
Confined fire	1,700	(41%)	0	(0%)	30	(14%)	\$0	(0%)

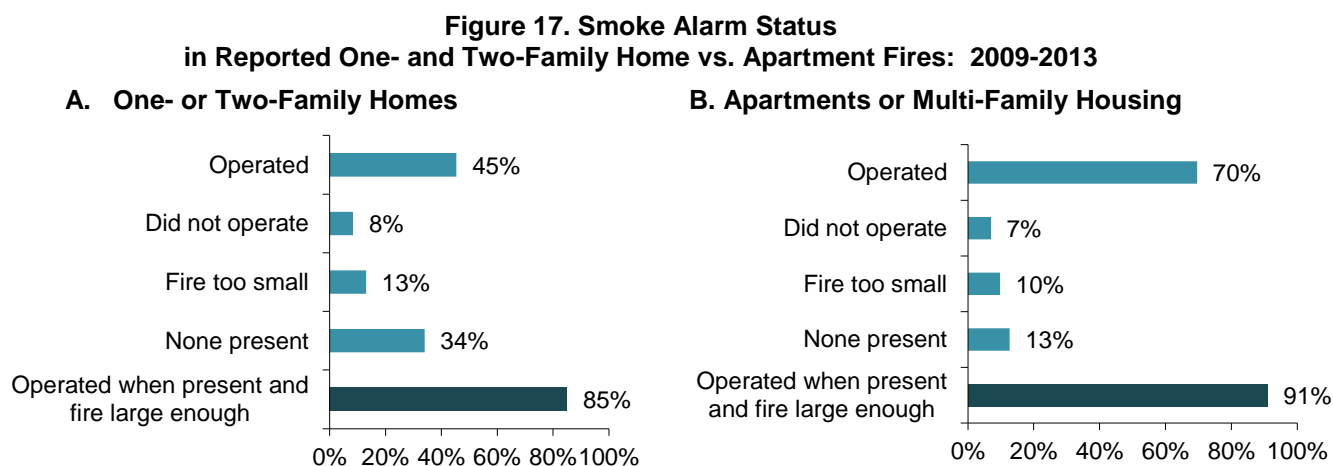
Note: Sums may not equal totals due to rounding errors. Unknowns have been allocated proportionally.

Source: NFIRS 5.0 and NFPA survey.

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

Smoke alarms were more likely to have been present and to have operated in apartment fires than in fires in one- or two-family homes. Seventy percent of the reported home fires and 84% of the home fire deaths in 2009-2013 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 or multi-family housing.³⁷ Tables 10 and 11 show that smoke alarms were present³⁸ in 87% of reported apartment or multi-family housing fires but only two-thirds (66%) of the fires in one- or two-family homes. Figure 17 shows that smoke alarms operated in more than two-thirds (70%) of the reported apartment fires but less than half (45%) of the reported fires in one and two-family homes.

The percentages operating are even greater when calculated for fires in which smoke alarms were present and the fire was considered large enough to activate the alarm. Smoke alarms operated in 85% of such fires in one- or two-family homes and 91% of such incidents in apartments or multi-family housing.



While the NFIRS coding system counts smoke alarms in the fire area as present, 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 the 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.

³⁷ 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.

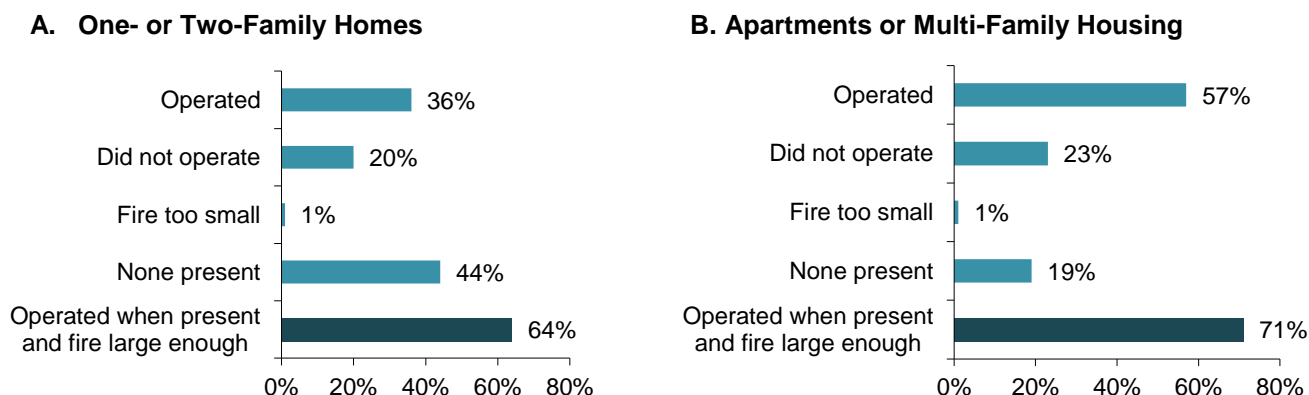
³⁸ The percentages of smoke alarms “present” include fires in which smoke alarms were present and operated, did not operate in fires considered large enough to activate them and fires that were too small to activate them.

Almost three out of five apartment fire deaths resulted from fires with operating smoke alarms. More than half (56%) of one- or two-family home fire deaths were caused by fires in properties with at least one smoke alarm, as were four out of five (81%) apartment fire deaths. Figure 18 shows that more than one-third (36%) of the fire deaths in one- and two-family homes resulted from fires with operating smoke alarms compared to almost three out of five fire deaths (57%) in apartments. Again, with apartments and multi-family housing, we do not know whether the operating smoke alarm was actually in the unit of origin or in a common area.

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 of five (19%) deaths from apartment or multi-family home fires with no smoke alarms.

As with fires, the percentages operating were even greater when calculated for deaths resulting from fires in which smoke alarms were present and the fire was considered large enough to activate the alarm. Almost two-thirds (64%) of the victims of such fires in one- and two-family homes and almost three-quarters (71%) of such apartment or other multi-family housing fires died as a result of fires in which at least one smoke alarm operated.

Figure 18. Smoke Alarm Status in Deaths Resulting from Fires in One- and Two-Family Homes vs. Apartments: 2009-2013

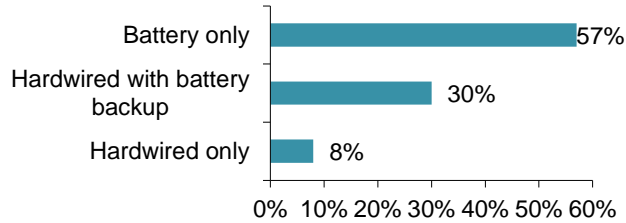


Hardwired smoke alarms were more common in apartment fires. Tables 12 and 13 show the type of detection equipment found in reported fires in one- and two-family homes and apartments. Equipment designed to detect smoke only accounted for 92% of the detection equipment in one- and two-family homes and 83% of such equipment in apartments. Combination smoke and heat alarms accounted for an additional 6% of the detection types found in one- and two-family homes and 9% of the detection types in apartments. Combination smoke alarms that use both ionization and photoelectric sensors to detect smoke are currently available as are units that detect both smoke and carbon monoxide. It is possible that some of these devices were erroneously captured as combination smoke and heat alarms. Apartments were more likely to have more than one type of detection equipment present (5% vs. 1%).

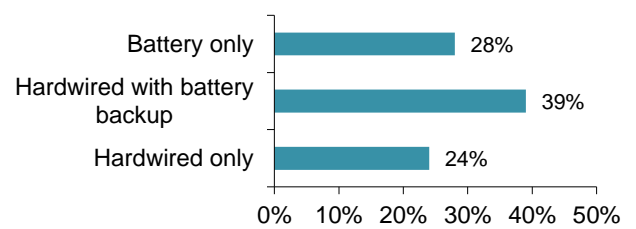
Power sources differ greatly by occupancy. Figure 19 and Tables 14 and 15 show that the 28% of smoke alarms in apartment structure fires powered only by batteries was half the 57% found in one- and two-family home fires.

**Figure 19. Leading Smoke Alarm Power Sources
in Reported Home Fires, by Occupancy
2009-2013**

B. One- or Two-Family Homes



B. Apartments or Multi-Family Housing



When hardwired smoke alarms were present in one-and two-family home fires, four out of five (79%) alarms had battery backup. Battery backup was found in three out of five (62%) 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.

Table 10.
Smoke Alarm Status in One- and Two-Family Home Fires
2009-2013 Annual Averages

Smoke Alarm Status	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Total	250,600	(100%)	2,070	(100%)	8,600	(100%)	\$5,609	(100%)
Non-confined fire	155,400	(62%)	2,070	(100%)	7,720	(90%)	\$5,585	(100%)
Confined fire	95,200	(38%)	0	(0%)	880	(10%)	\$24	(0%)
Smoke Alarm Present	166,600	(66%)	1,170	(56%)	5,900	(69%)	\$3,863	(69%)
Non-confined fire	87,400	(35%)	1170	(56%)	5170	(60%)	\$3,843	(69%)
Confined fire	79,200	(32%)	0	(0%)	740	(9%)	\$20	(0%)
Fire too small to operate alarm	33,100	(13%)	10	(1%)	400	(5%)	\$116	(2%)
Non-confined fire	13,100	(5%)	10	(1%)	270	(3%)	\$113	(2%)
Confined fire	20,000	(8%)	0	(0%)	130	(1%)	\$3	(0%)
<i>Smoke alarm present and fire large enough to operate alarm</i>	<i>133,500</i>	<i>(53%)</i>	<i>1,160</i>	<i>(56%)</i>	<i>5,510</i>	<i>(64%)</i>	<i>\$3,747</i>	<i>(67%)</i>
<i>Non-confined fire</i>	<i>74,300</i>	<i>(30%)</i>	<i>1,160</i>	<i>(56%)</i>	<i>4900</i>	<i>(57%)</i>	<i>\$3,731</i>	<i>(67%)</i>
<i>Confined fire</i>	<i>59,200</i>	<i>(24%)</i>	<i>0</i>	<i>(0%)</i>	<i>610</i>	<i>(7%)</i>	<i>\$17</i>	<i>(0%)</i>
Smoke alarm operated	114,000	(45%)	740	(36%)	4,250	(49%)	\$3,195	(57%)
Non-confined fire	60,400	(24%)	740	(36%)	3,730	(43%)	\$3,180	(57%)
Confined fire	53,700	(21%)	0	(0%)	520	(6%)	\$15	(0%)
Smoke alarm present but did not operate	19,400	(8%)	420	(20%)	1,260	(15%)	\$552	(10%)
Non-confined fire	13,900	(6%)	420	(20%)	1,170	(14%)	\$550	(10%)
Confined fire	5,500	(2%)	0	(0%)	90	(1%)	\$2	(0%)
No Smoke Alarm	84,000	(34%)	900	(44%)	2,700	(31%)	\$1,746	(31%)
Non-confined fire	68,000	(27%)	900	(44%)	2,550	(30%)	\$1,742	(31%)
Confined fire	16,000	(6%)	0	(0%)	150	(2%)	\$4	(0%)
Operating alarms as share of those present in fires considered large enough to activate	114,000	(85%)	740	(64%)	4,250	(77%)	\$3,195	(85%)
Fires with no smoke alarms or none that operated in fires large enough to activate	103,500	(41%)	1,320	(64%)	3,960	(46%)	\$2,298	(41%)

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
2009-2013 Annual Averages

Smoke Alarm Status	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Total	106,400	(100%)	400	(100%)	4,290	(100%)	\$1,258	(100%)
Non-confined fire	32,900	(30%)	400	(56%)	3,460	(57%)	\$3,731	(67%)
Confined fire	73,500	(24%)	0	(0%)	830	(7%)	\$17	(0%)
Smoke Alarm Present	92,600	(87%)	330	(81%)	3,470	(81%)	\$1,049	(83%)
Non-confined fire	24,700	(23%)	330	(81%)	2,690	(63%)	\$1,035	(82%)
Confined fire	68,000	(64%)	0	(0%)	770	(18%)	\$14	(1%)
<i>Fire too small to operate alarm</i>	<i>10,800</i>	<i>(10%)</i>	<i>0</i>	<i>(1%)</i>	<i>200</i>	<i>(5%)</i>	<i>\$26</i>	<i>(2%)</i>
Non-confined fire	3,400	(3%)	0	(1%)	120	(3%)	\$26	(2%)
Confined fire	7,400	(7%)	0	(0%)	80	(2%)	\$1	(0%)
<i>Smoke alarm present and fire large enough to operate alarm</i>	<i>81,800</i>	<i>(77%)</i>	<i>320</i>	<i>(81%)</i>	<i>3,260</i>	<i>(76%)</i>	<i>\$1,023</i>	<i>(81%)</i>
Non-confined fire	21,200	(20%)	320	(81%)	2,570	(60%)	\$1,009	(80%)
Confined fire	60,600	(57%)	0	(0%)	690	(16%)	\$14	(1%)
Smoke alarm operated	74,100	(70%)	230	(57%)	2,710	(63%)	\$902	(72%)
Non-confined fire	17,800	(17%)	230	(57%)	2,110	(49%)	\$889	(71%)
Confined fire	56,300	(53%)	0	(0%)	600	(14%)	\$13	(1%)
Smoke alarm present but did not operate	7,700	(7%)	90	(23%)	560	(13%)	\$121	(10%)
Non-confined fire	3,400	(3%)	90	(23%)	460	(11%)	\$120	(10%)
Confined fire	4,300	(4%)	0	(0%)	90	(2%)	\$1	(0%)
No Smoke Alarm	13,800	(13%)	70	(19%)	820	(19%)	\$208	(17%)
Non-confined fire	8,200	(8%)	70	(19%)	760	(18%)	\$207	(16%)
Confined fire	5,500	(5%)	0	(0%)	60	(1%)	\$1	(0%)
Operating alarms as share of those present in fires large enough to activate	74,100	(91%)	230	(71%)	2,710	(83%)	\$902	(88%)
Fires with no smoke alarms or none that operated in fires large enough to activate	21,500	(20%)	170	(42%)	1,380	(32%)	\$330	(26%)

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
2009-2013 Annual Averages

Type of Detection Equipment	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Smoke	152,900	(92%)	1,110	(95%)	5,640	(96%)	\$3,533	(91%)
Non-confined fire	81,500	(93%)	1,110	(95%)	4,930	(95%)	\$3,515	(91%)
Confined fire	71,400	(90%)	0	(0%)	710	(96%)	\$18	(89%)
Combination smoke and heat	9,700	(6%)	30	(3%)	180	(3%)	\$229	(6%)
Non-confined fire	4,300	(5%)	30	(3%)	160	(3%)	\$228	(6%)
Confined fire	5,500	(7%)	0	(0%)	20	(3%)	\$1	(6%)
More than one type present	1,700	(1%)	10	(1%)	40	(1%)	\$52	(1%)
Non-confined fire	800	(1%)	10	(1%)	40	(1%)	\$51	(1%)
Confined fire	1,000	(1%)	0	(0%)	0	(0%)	\$0	(1%)
Unclassified detection equipment	1,400	(1%)	0	(0%)	20	(0%)	\$27	(1%)
Non-confined fire	500	(1%)	0	(0%)	20	(0%)	\$27	(1%)
Confined fire	900	(1%)	0	(0%)	0	(0%)	\$0	(1%)
Heat	700	(0%)	10	(0%)	20	(0%)	\$16	(0%)
Non-confined fire	300	(0%)	10	(0%)	20	(0%)	\$16	(0%)
Confined fire	300	(0%)	0	(0%)	10	(1%)	\$0	(0%)
Sprinklers with water flow detection	200	(0%)	0	(0%)	0	(0%)	\$7	(0%)
Non-confined fire	100	(0%)	0	(0%)	0	(0%)	\$6	(0%)
Confined fire	100	(0%)	0	(0%)	0	(0%)	\$0	(2%)
Total	166,600	(100%)	1,170	(100%)	5,900	(100%)	\$3,863	(100%)
Non-confined fire	87,400	(52%)	1,170	(100%)	5,170	(88%)	\$3,843	(99%)
Confined fire	79,200	(48%)	0	(0%)	740	(12%)	\$20	(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
2009-2013 Annual Averages

Type of Detection Equipment	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Smoke	76,600	(83%)	290	(90%)	3,050	(88%)	\$925	(88%)
Non-confined fire	21,500	(23%)	290	(90%)	2,410	(69%)	\$915	(87%)
Confined fire	55,000	(59%)	0	(0%)	650	(19%)	\$10	(1%)
Combination smoke and heat	8,300	(9%)	10	(3%)	150	(4%)	\$53	(5%)
Non-confined fire	1,200	(1%)	10	(3%)	110	(3%)	\$52	(5%)
Confined fire	7,100	(8%)	0	(0%)	40	(1%)	\$1	(0%)
More than one type present	4,200	(5%)	20	(6%)	180	(5%)	\$50	(5%)
Non-confined fire	1,000	(1%)	20	(6%)	130	(4%)	\$48	(5%)
Confined fire	3,200	(3%)	0	(0%)	50	(2%)	\$1	(0%)
Sprinklers with water flow detection	1,500	(2%)	0	(0%)	30	(1%)	\$11	(1%)
Non-confined fire	400	(0%)	0	(0%)	20	(1%)	\$9	(1%)
Confined fire	1,100	(1%)	0	(0%)	10	(0%)	\$2	(0%)
Heat	1,100	(1%)	0	(0%)	20	(1%)	\$5	(0%)
Non-confined fire	200	(0%)	0	(0%)	10	(0%)	\$5	(0%)
Confined fire	900	(1%)	0	(0%)	10	(0%)	\$0	(0%)
Unclassified detection equipment	1,000	(1%)	0	(1%)	20	(1%)	\$6	(1%)
Non-confined fire	300	(0%)	0	(1%)	10	(0%)	\$6	(1%)
Confined fire	700	(1%)	0	(0%)	10	(0%)	\$0	(0%)
Total	92,600	(100%)	330	(100%)	3,470	(100%)	\$1,049	(100%)
Non-confined fire	24,700	(27%)	330	(100%)	2,690	(78%)	\$1,035	(99%)
Confined fire	68,000	(73%)	0	(0%)	770	(22%)	\$14	(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 14.
Smoke Alarm or Fire Detection Power Source in One- and Two-Family Home Structure Fires
2009-2013 Annual Averages

Power Source	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Battery only	95,300	(57%)	880	(76%)	3,890	(66%)	\$2,086	(54%)
Non-confined fire	55,600	(33%)	880	(76%)	3,510	(60%)	\$2,076	(54%)
Confined fire	39,700	(24%)	0	(0%)	380	(6%)	\$10	(0%)
Hardwired with battery backup	50,300	(30%)	180	(15%)	1,380	(23%)	\$1,290	(33%)
Non-confined fire	22,600	(14%)	180	(15%)	1,150	(19%)	\$1,283	(33%)
Confined fire	27,700	(17%)	0	(0%)	230	(4%)	\$7	(0%)
Hardwired only	13,500	(8%)	60	(5%)	420	(7%)	\$285	(7%)
Non-confined fire	5,800	(4%)	60	(5%)	340	(6%)	\$283	(7%)
Confined fire	7,700	(5%)	0	(0%)	80	(1%)	\$2	(0%)
Multiple detectors and power supplies	3,200	(2%)	10	(1%)	90	(1%)	\$78	(2%)
Non-confined fire	1,400	(1%)	10	(1%)	60	(1%)	\$77	(2%)
Confined fire	1,700	(1%)	0	(0%)	30	(0%)	\$1	(0%)
Plug-in with or without battery backup	2,800	(2%)	20	(2%)	80	(1%)	\$89	(2%)
Non-confined fire	1,300	(1%)	20	(2%)	70	(1%)	\$89	(2%)
Confined fire	1,600	(1%)	0	(0%)	10	(0%)	\$0	(0%)
Unclassified power source	1,300	(1%)	10	(1%)	40	(1%)	\$30	(1%)
Non-confined fire	500	(0%)	10	(1%)	30	(0%)	\$30	(1%)
Confined fire	800	(0%)	0	(0%)	10	(0%)	\$0	(0%)
Mechanical	200	(0%)	0	(0%)	10	(0%)	\$4	(0%)
Non-confined fire	100	(0%)	0	(0%)	10	(0%)	\$4	(0%)
Confined fire	100	(0%)	0	(0%)	0	(0%)	\$0	(0%)
Total	166,600	(100%)	1170	(100%)	5,900	(100%)	\$3,863	(100%)
Non-confined fire	87,400	(52%)	1170	(100%)	5,170	(88%)	\$3,843	(99%)
Confined fire	79,200	(48%)	0	(0%)	740	(12%)	\$20	(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 or Fire Detection Power Source in Apartment Structure Fires
2009-2013 Annual Averages

Power Source	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Hardwired with battery backup	36,500	(39%)	80	(26%)	1,150	(33%)	\$392	(37%)
Non-confined fire	8,600	(9%)	80	(26%)	830	(24%)	\$386	(37%)
Confined fire	27,900	(30%)	0	(0%)	320	(9%)	\$6	(1%)
Battery only	26,200	(28%)	150	(47%)	1,400	(40%)	\$380	(36%)
Non-confined fire	9,800	(11%)	150	(47%)	1,160	(33%)	\$376	(36%)
Confined fire	16,400	(18%)	0	(0%)	240	(7%)	\$4	(0%)
Hardwired only	22,100	(24%)	60	(18%)	640	(19%)	\$177	(17%)
Non-confined fire	4,600	(5%)	60	(18%)	510	(15%)	\$174	(17%)
Confined fire	17,500	(19%)	0	(0%)	130	(4%)	\$3	(0%)
Multiple detectors and power supplies	5,200	(6%)	20	(7%)	200	(6%)	\$78	(7%)
Non-confined fire	1,000	(1%)	20	(7%)	150	(4%)	\$77	(7%)
Confined fire	4,200	(5%)	0	(0%)	50	(1%)	\$1	(0%)
Plug-in with or without battery backup	1,600	(2%)	0	(0%)	50	(1%)	\$15	(1%)
Non-confined fire	400	(0%)	0	(0%)	30	(1%)	\$15	(1%)
Confined fire	1,200	(1%)	0	(0%)	20	(1%)	\$0	(0%)
Unclassified power source	700	(1%)	0	(1%)	20	(1%)	\$5	(0%)
Non-confined fire	200	(0%)	0	(1%)	20	(0%)	\$5	(0%)
Confined fire	600	(1%)	0	(0%)	10	(0%)	\$0	(0%)
Mechanical	300	(0%)	0	(0%)	10	(0%)	\$3	(0%)
Non-confined fire	100	(0%)	0	(0%)	0	(0%)	\$2	(0%)
Confined fire	200	(0%)	0	(0%)	0	(0%)	\$0	(0%)
Total	92,600	(100%)	330	(100%)	3,470	(100%)	\$1,049	(100%)
Non-confined fire	24,700	(27%)	330	(100%)	2,690	(78%)	\$1,035	(99%)
Confined fire	68,000	(73%)	0	(0%)	770	(22%)	\$14	(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.

Characteristics of Victims in Fires with and without Working Smoke Alarms

Smoke alarms save lives. As shown in Figure 8, the death rate of 0.53 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 without this protection (1.18 deaths per 100 fires). The latter category includes fires with either no smoke alarms present at all (0.98 deaths per 100 fires) and fires in which smoke alarms were present but did not operate (1.89 deaths per 100 fires).

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;
- More likely to have been at least 65 years old;
- More likely to have had a physical disability;
- More likely to have been fighting the fire themselves; and
- Less likely to have been sleeping when fatally injured.

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 had a physical disability).

In fatal home fires with operating smoke alarms, one out of every four victims was alerted but did not respond. NFIRS captures information about the effectiveness of operating smoke alarms in terms of occupant response. Table 16 shows that in four out of five (81%) home fires with operating smoke alarms, the occupants were alerted and responded. The 5% of 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 operating 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. Another 7% of the home fire deaths were caused by the 2% of home fires in which smoke alarms operated but did not alert the occupants. In 12% of the fires, no occupants were present.

Some additional differences can be seen in the circumstances of fatalities resulting from 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 17 shows that when victims of home fires in which the smoke alarms operated were fatally injured, almost two thirds (63%) were in the area of fire origin compared to more than half the victims in fires with no smoke alarms at all (53%) or alarms that did not operate (55%). Figure 20 and Table 18 show that in fatal fires in which smoke alarms operated, almost half (47%) of the victims were involved in ignition *and* in the area of origin at the time of the incident. Only one-third (34%) of the victims in which smoke alarms were present but did not operate or not present at all were in the area of origin and involved in ignition.

Figure 20. Victim’s Location at Time of Incident by Smoke Alarm Status 2009-2013

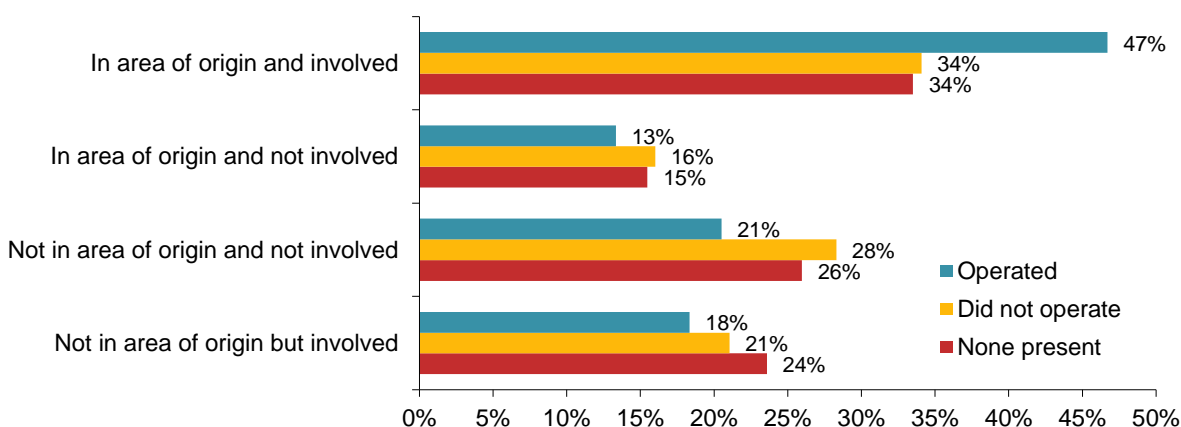


Table 19 shows that flame damage was confined to the object or room of origin in a higher percentage of deaths resulting from fires with working smoke alarms (32%) than in fires with no smoke alarms at all (18%). All these characteristics are probably related. A person in the area of origin is more likely 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 deaths resulting from fires confined to the object or room of origin for fires in which the smoke alarm should have operated but did not was 31%, almost as high as for deaths from fires with working smoke alarms.

Victims of fatal fires with working smoke alarms were less likely to be sleeping and more likely to have been hurt while trying to fight the fire than victims without working alarms.

Table 20 and Figure 21 show that when smoke alarms were present and operating, the victims were more likely to have been engaged in fire control or some unclassified activity and less likely to have been sleeping than were victims of fires in which no working smoke alarms were present. Victims with working smoke alarms were somewhat less likely to have been fatally injured while escaping and slightly more likely to have been unable to act to save themselves.

Victims with working smoke alarms were more likely to have had a physical disability.

Table 21 and Figure 22 show that fatal fire victims with working smoke alarms were less likely to be asleep but more likely to have a physical disability than were victims of fires in which the smoke alarms did not sound or were not present at all. In NFPA’s 2014 report, *Physical Disability as a Factor in Home Fire Deaths*, Marty Ahrens noted that in 2007-2011, operating smoke alarms were present in 55% of the home fire deaths in which physical disability was a

factor.³⁹ The estimates of alcohol impairment derived from NFIRS are lower than the results of studies that use autopsy data.

Figure 21. Victim's Activity at Time of Fatal Home Fire Injury by Smoke Alarm Status 2009-2013

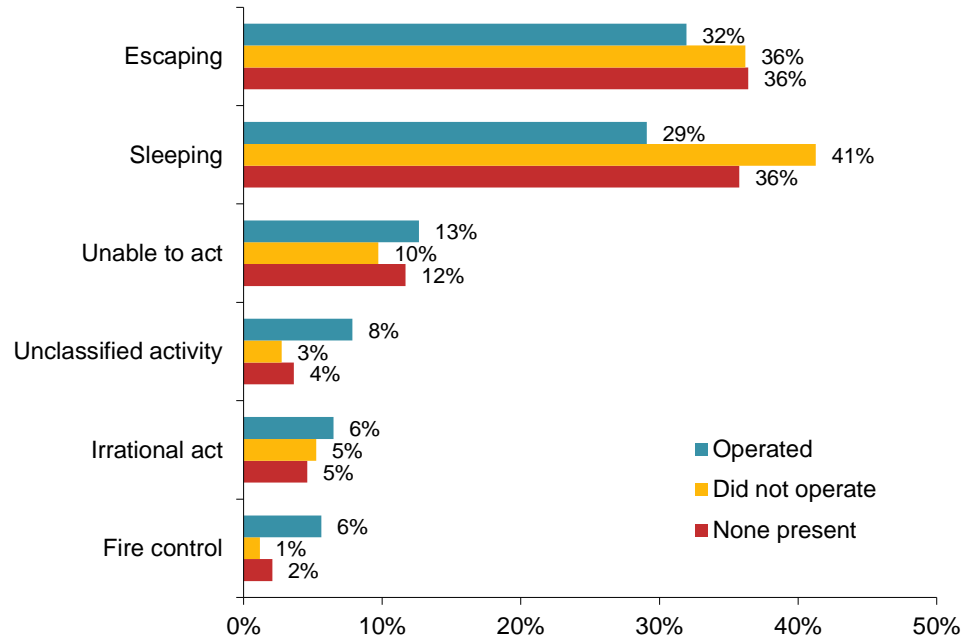
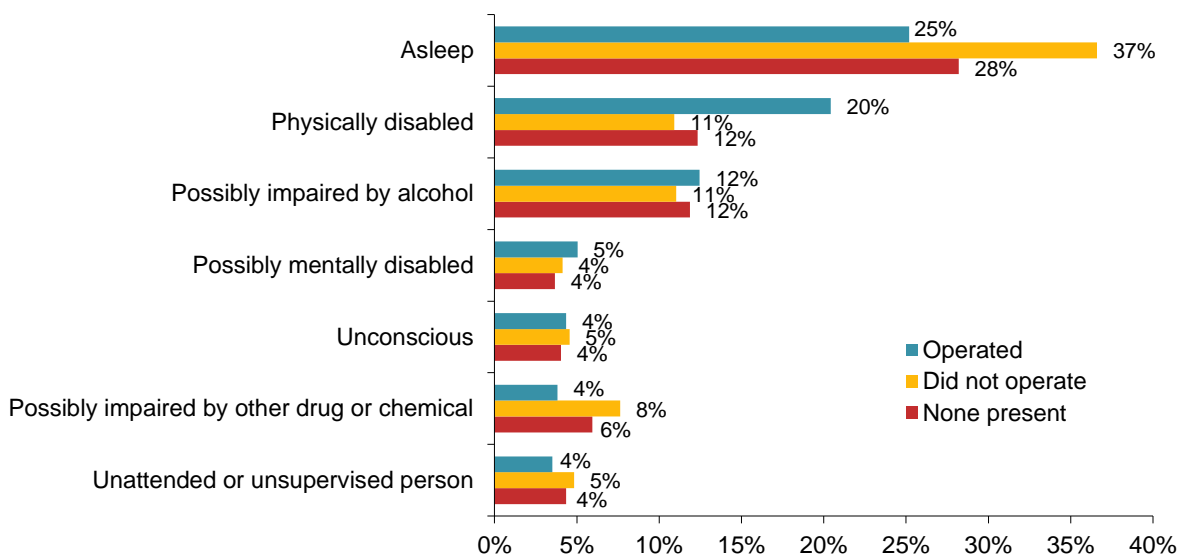


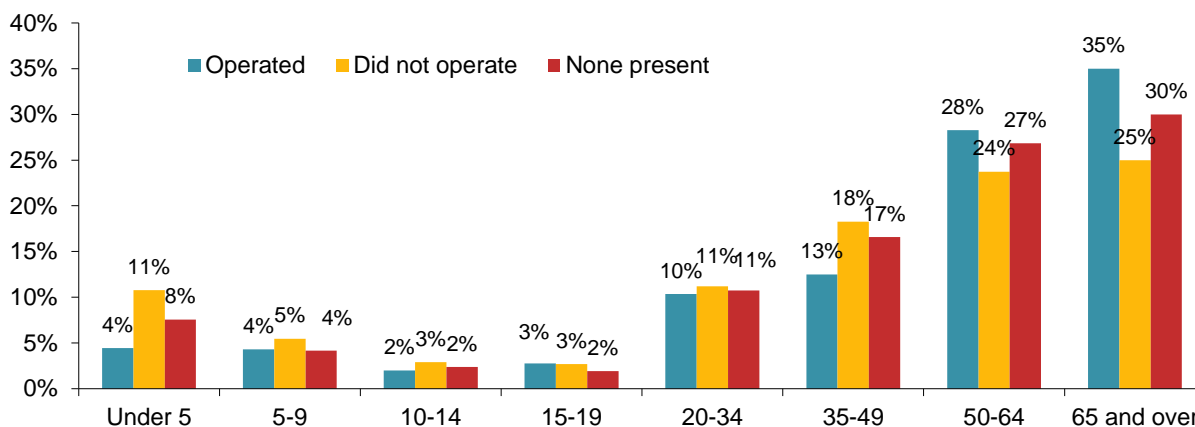
Figure 22. Human Factors Contributing to Fatal Home Fire Injury by Smoke Alarm Status 2009-2013



³⁹ Marty Ahrens. [Physical Disability as a Factor in Home Fire Deaths](#), Quincy, MA: NFPA, 2014, p. 4.

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 22 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 (25%) of the victims with smoke alarms that did not operate and 30% of the victims of fires in which no smoke alarms were present were at least 65 years of age. Victims were more likely to be children in fires in which smoke alarms should have operated but failed to do so. It is possible that unwanted alarms are even more disruptive in households with young children.

Figure 23. Fatal Home Fire Victims by Age and Smoke Alarm Status, 2009-2013



Apartment fatal fire victims were more likely to be in the room of fire origin. Table 23 is an overview of characteristics of fatal victims and their fires during 2009-2013, in a) one- and two-family homes, and b) apartments or multi-family housing, with operating smoke alarms, with smoke alarms that were present but did not operate, and with no smoke alarms at all. Many of the differences in Table 23 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.

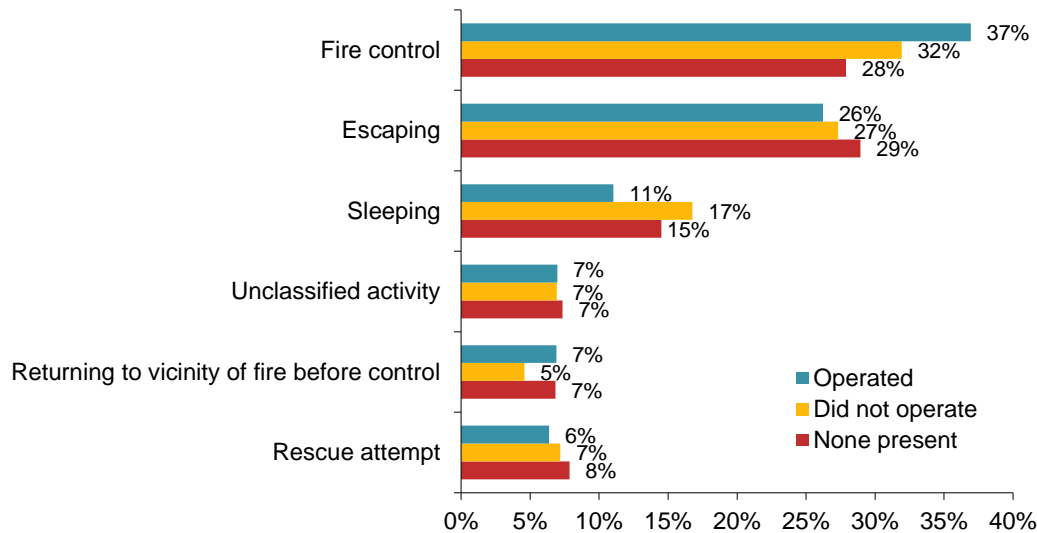
The most striking differences in Table 23 are seen in the victim's proximity to the fire. Regardless of smoke alarm status, apartment victims were more likely to have been in the general area of the fire at ignition than were the victims in one- and two-family homes. When smoke alarms operated, 59% of the victims of fatal fires in one- and two-family homes were in the general area of origin at the time of fatal injury compared to 69% of the apartment victims with operating smoke alarms 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 sounding smoke alarm.

In most cases, apartment units are smaller than one- or two-family homes. This could be a factor in victim's proximity to the fire. It also helps explain why deaths in one- or two-family home fires were more likely to result from fires that spread beyond the room of fire origin.

Victims in one- or two-family homes were also more likely to be at least 65 years of age than were victims of apartment fires, regardless of smoke alarm status.

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 more than one-third (37%) of 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, 32% of the civilian fire injuries occurred while trying to control the fire. In homes with no smoke alarms, only 28% were injured during 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.

Figure 24. Victim's Activity at Time of Non-Fatal Home Fire Injury by Smoke Alarm Status, 2009-2013



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.⁴⁰ 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.

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.

⁴⁰ Guylène Proulx. [“Response to Fire Alarms.”](#) *Fire Protection Engineering*, Winter 2007, pp. 8-15.

- 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 16.
Effectiveness of Operating Smoke Alarms in Home Structure Fires
2009-2013 Annual Averages

Effectiveness	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Alerted occupants and occupants responded	153,900	(81%)	690	(69%)	6,060	(86%)	\$2,939	(71%)
Non-confined fire	61,900	(33%)	690	(69%)	5090	(73%)	\$2,914	(70%)
Confined fire	92,000	(49%)	0	(0%)	970	(14%)	\$24	(1%)
Alerted occupants but occupants failed to respond	8,600	(5%)	240	(24%)	500	(7%)	\$142	(3%)
Non-confined fire	2,700	(1%)	240	(24%)	410	(6%)	\$141	(3%)
Confined fire	5,900	(3%)	0	(0%)	90	(1%)	\$1	(0%)
No occupants	22,200	(12%)	0	(0%)	160	(2%)	\$860	(21%)
Non-confined fire	12,300	(6%)	0	(0%)	150	(2%)	\$858	(21%)
Confined fire	9,900	(5%)	0	(0%)	10	(0%)	\$2	(0%)
Failed to alert occupants	4,700	(2%)	70	(7%)	300	(4%)	\$194	(5%)
Non-confined fire	2,200	(1%)	70	(7%)	230	(3%)	\$193	(5%)
Confined fire	2,400	(1%)	0	(0%)	60	(1%)	\$0	(0%)
Total	189,400	(100%)	1,000	(100%)	7,020	(100%)	\$4,135	(100%)
Non-confined fire	79,100	(42%)	1,000	(100%)	5,890	(84%)	\$4,107	(99%)
Confined fire	110,300	(58%)	0	(0%)	1,130	(16%)	\$28	(1%)

Table 17.
Victim's General Location at Time of Fatal Injury
by Smoke Alarm Presence and Operation in Home Structure Fire Deaths
2009-2013 Annual Averages

Victim's Location	Present and Operated		Present but Did Not Operate		None Present	
In area of origin	630	(63%)	280	(55%)	500	(53%)
In building, but not in area of origin	370	(37%)	230	(44%)	440	(47%)
Outside of building	0	(0%)	0	(1%)	0	(0%)
Total	1,000	(100%)	510	(100%)	940	(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 18.
Victim's General Location at Time of Incident by Smoke Alarm Presence and Operation
in Home Structure Fire Deaths
2009-2013 Annual Averages

Victim's Location	Present and Operated		Present but Did Not Operate		None Present	
In area of origin and involved	470	(47%)	180	(34%)	320	(34%)
In area of origin and not involved	130	(13%)	80	(16%)	150	(15%)
<i>Subtotal – In area of origin</i>	600	(60%)	260	(50%)	460	(49%)
Not in area of origin and not involved	210	(21%)	150	(28%)	250	(26%)
Not in area of origin but involved	180	(18%)	110	(21%)	220	(24%)
<i>Subtotal – Not in area of origin</i>	390	(39%)	250	(49%)	470	(50%)
Unclassified	10	(1%)	0	(1%)	10	(1%)
Total	1,000	(100%)	510	(100%)	940	(100%)

Table 19.
Extent of Flame Damage by Smoke Alarm Presence and Operation
in Home Structure Fire Deaths
2009-2013 Annual Averages

Extent of Flame Damage	Present and Operated		Present but Did Not Operate		None Present	
Confined to object of origin	50	(5%)	20	(4%)	40	(4%)
Confined to room of origin	270	(27%)	140	(28%)	130	(14%)
Confined to floor of origin	160	(16%)	90	(17%)	120	(12%)
Confined to building of origin	460	(46%)	220	(43%)	530	(56%)
Extended beyond building of origin	70	(7%)	50	(9%)	130	(14%)
Total	1,000	(100%)	510	(100%)	940	(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.
Activity at Time of Victim's Fatal Injury by Smoke Alarm Presence and Operation
in Home Structure Fire Deaths
2009-2013 Annual Averages

Activity	Present and Operated		Present but Did Not Operate		None Present	
Escaping	320	(32%)	190	(36%)	340	(36%)
Sleeping	290	(29%)	210	(41%)	340	(36%)
Unable to act	130	(13%)	50	(10%)	110	(12%)
Unclassified activity	80	(8%)	10	(3%)	30	(4%)
Irrational act	60	(6%)	30	(5%)	40	(5%)
Fire control	60	(6%)	10	(1%)	20	(2%)
Returning to vicinity of fire before control	30	(3%)	0	(1%)	30	(3%)
Rescue attempt	30	(3%)	10	(2%)	20	(3%)
Returning to vicinity of fire after control	10	(1%)	0	(0%)	0	(0%)
Total	1,000	(100%)	510	(100%)	940	(100%)

Table 21.
Human Factor Contributing to Injury by Smoke Alarm Presence and Operation
in Home Fire Deaths
2009-2013 Annual Averages

Human Factor	Present and Operated		Present but Did Not Operate		None Present	
Asleep	250	(25%)	190	(37%)	270	(28%)
Physically disabled	200	(20%)	60	(11%)	120	(12%)
Possibly impaired by alcohol	120	(12%)	60	(11%)	110	(12%)
Possibly mentally disabled	50	(5%)	20	(4%)	30	(4%)
Unconscious	40	(4%)	20	(5%)	40	(4%)
Possibly impaired by other drug or chemical	40	(4%)	40	(8%)	60	(6%)
Unattended or unsupervised person	40	(4%)	20	(5%)	40	(4%)
Physically restrained	0	(0%)	0	(1%)	10	(1%)
None	410	(41%)	180	(35%)	380	(40%)
Total	1,000	(100%)	510	(100%)	940	(100%)
Total entries*	1,160	(116%)	590	(116%)	1,050	(111%)

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

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 22.
Home Structure Fire Deaths by Victim's Age and Smoke Alarm Status
2009-2013 Annual Averages

Age Group	Present and Operated		Present but Did Not Operate		None Present	
Under 5	40	(4%)	60	(11%)	70	(8%)
5-9	40	(4%)	30	(5%)	40	(4%)
10-14	20	(2%)	10	(3%)	20	(2%)
15-19	30	(3%)	10	(3%)	20	(2%)
20-34	100	(10%)	60	(11%)	100	(11%)
35-49	130	(13%)	90	(18%)	160	(17%)
50-64	280	(28%)	120	(24%)	250	(27%)
65-74	130	(13%)	60	(12%)	130	(13%)
75-84	150	(15%)	40	(8%)	100	(10%)
85 and over	70	(7%)	20	(4%)	60	(6%)
Total	1,000	(100%)	510	(100%)	940	(100%)
Selected age groups						
14 and under	110	(11%)	100	(19%)	130	(14%)
65 and over	350	(35%)	130	(25%)	280	(30%)

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 23.
Characteristics of Fatal Home Structure Fire Victims
by Occupancy and Smoke Alarm Status
2009-2013

Characteristic	<i>One- and Two-Family Homes</i>						<i>Apartments</i>					
	Alarm Operated		Did Not Operate		No Alarms		Alarm Operated		Did Not Operate	No Alarms		
Total*	740	(100%)	420	(100%)	900	(100%)	230	(100%)	90	(100%)	70	(100%)
Victim in area of origin at time of incident and involved	320	(44%)	120	(29%)	280	(31%)	120	(52%)	40	(47%)	40	(48%)
Victim in general area of fire at time of injury	430	(59%)	190	(45%)	450	(50%)	160	(69%)	70	(77%)	60	(79%)
Fire spread flames beyond room of origin	550	(75%)	320	(76%)	760	(84%)	130	(55%)	50	(50%)	50	(64%)
Victim unconscious, restrained, physically or possibly mentally disabled or impaired by drugs or alcohol**	350	(47%)	160	(38%)	340	(38%)	100	(44%)	40	(41%)	30	(44%)
Victim age 65 or older	270	(37%)	120	(28%)	280	(31%)	70	(32%)	10	(15%)	20	(24%)
Victim age under five	40	(5%)	60	(14%)	60	(7%)	10	(4%)	10	(6%)	10	(11%)
Victim unable to act or acted irrationally	150	(21%)	70	(16%)	150	(16%)	40	(16%)	10	(16%)	10	(17%)
Victim attempting fire control or rescue	70	(9%)	10	(2%)	40	(5%)	20	(7%)	10	(7%)	10	(7%)

* 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.

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
2009-2013 Annual Averages

Activity	Present and Operated		Present but Did Not Operate		None Present	
Fire control	2,590	(37%)	580	(32%)	970	(28%)
Escaping	1,840	(26%)	490	(27%)	1,000	(29%)
Sleeping	770	(11%)	300	(17%)	500	(15%)
Returning to vicinity of fire before control	490	(7%)	130	(7%)	250	(7%)
Unclassified activity	480	(7%)	80	(5%)	240	(7%)
Rescue attempt	450	(6%)	130	(7%)	270	(8%)
Irrational act	190	(3%)	40	(2%)	110	(3%)
Unable to act	160	(2%)	50	(3%)	100	(3%)
Returning to vicinity of fire after control	30	(0%)	10	(1%)	10	(0%)
Total	7,020	(100%)	1,810	(100%)	3,460	(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.

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.⁴¹ 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.

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 the effectiveness of smoke alarms in 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.⁴² 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.⁴³ Both surveys found that a majority of homes did not have interconnected smoke alarms.

CPSC also studied the sound effectiveness of residential smoke alarms.⁴⁴ Although children under 16 have longer periods of deep sleep than adults and do not reliably wake in response to smoke alarms, CPSC found that "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 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.

⁴¹ Arthur Lee. *The Audibility of Smoke Alarms in Residential Homes*. Bethesda, MD: U.S. CPSC, September 2005, revised January 2007.

⁴² Harris Interactive. *Smoke Alarm Omnibus Question Report*, November 2008.

⁴³ Michael A. Greene and Craig Andres. *2004-2005 National Sample Survey of Unreported Residential Fires*. U.S. CPSC, July 2009.

⁴⁴ Arthur Lee, Jonathan Midgett, and Sharon White. *A Review of the Sound Effectiveness of Residential Smoke Alarms*. Washington, DC: U.S. Consumer Product Safety Commission, December 2004.

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,⁴⁵ 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 6-10.⁴⁶ 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.⁴⁷ 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.⁴⁸ 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. 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.⁴⁹ The four signals included a high-frequency

⁴⁵ Dorothy Bruck, "The Who, What, Where and Why of Waking to Fire Alarms: A Review," *Fire Safety Journal*, Volume 36 (2001), pp. 623-639.

⁴⁶ Dorothy Bruck, Sharnie Reid, Jefon 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.

⁴⁷ 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.

⁴⁸ 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.

⁴⁹ 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.

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.⁵⁰

SENSOR TECHNOLOGY

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.

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.⁵¹ 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.

⁵⁰ 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.

⁵¹ Harris Interactive. Smoke Alarm Omnibus Question Report, November 2008.

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.

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. 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.⁵²

During the period of code development activities for the 2010 edition of NFPA 72, task groups of the NFPA Technical Committee on Single- and Multiple-Station Alarms and Household Fire Alarm Systems assessed the performance of photoelectric and ionization smoke alarms based on the data documented in the NIST study. Based on the NIST study data, the task group evaluations concluded that for non-specific fires, either detection technology, installed in accordance with the requirements of NFPA 72, generally provided sufficient safe egress time for occupants capable of self-rescue – a fundamental assumption in NFPA 72. The task group recognized that not all occupants are capable of self-rescue and in those cases having both technologies provided a definite benefit. These conclusions were summarized in Annex A of the 2010 edition of NFPA 72. The 2009 edition of NFPA 101 was revised to require smoke alarms in all sleeping rooms of one- and two-family dwellings for both new and existing buildings. This change recognized the importance of having detection in all sleeping rooms as required in NFPA 72.

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.⁵³ 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.

⁵² 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.

⁵³ Thomas Z. Fabian and Pravinray D. Gandhi. [Characterizing Smoke from Residential Materials](#). Quincy, MA: The Fire Protection Research Foundation, 2007.

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

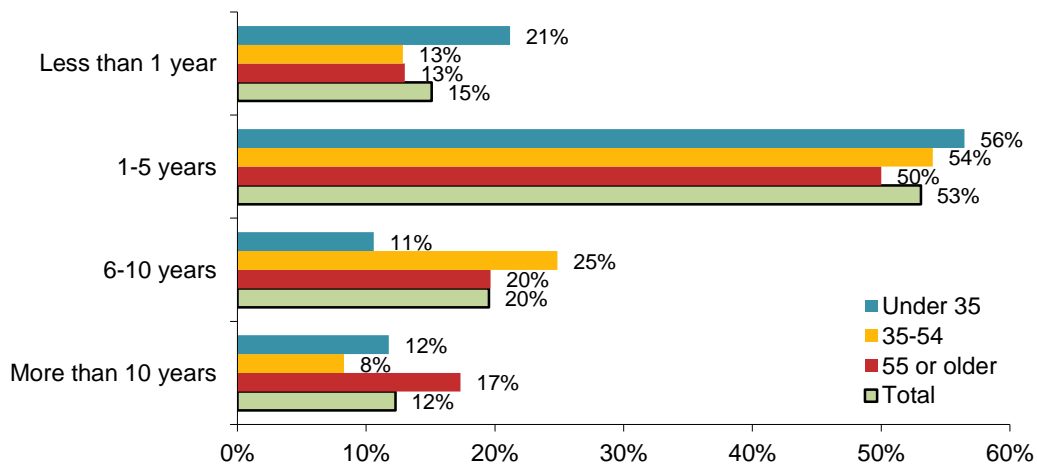
Smoke alarms are appliances, just like toasters, televisions and furnaces. Unlike other appliances, these devices function quietly in the background. Its alarm, in response to a real smoke situation or to testing, is the only evidence that it works. A stereo that does not play will not lead to tragedy, but a smoke alarm that fails 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.⁵⁴ 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.⁵⁵ Figure 25 shows that when the householder is 55 or older, 17% of the smoke alarms were more than 10 years old.

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.

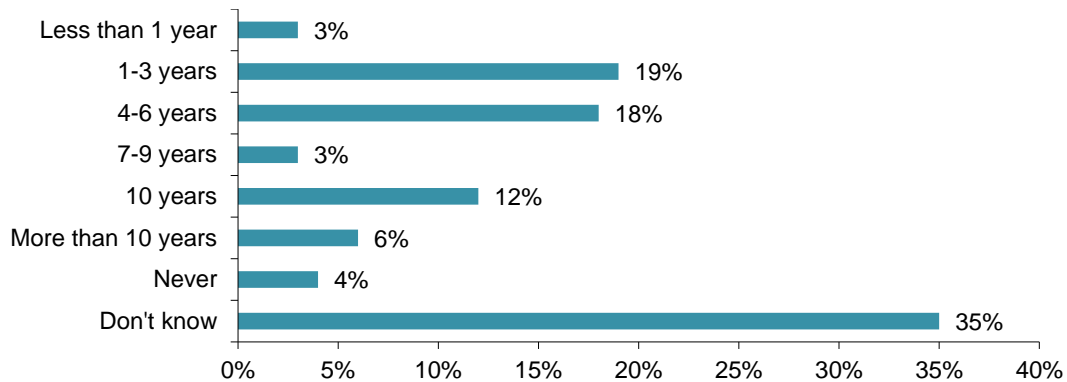
⁵⁴ Charles L. Smith, *Smoke Detector Operability Survey – Report on Findings*, Bethesda, MD: U.S. Consumer Product Safety Commission, November 1993, Appendix B, p. 23.

⁵⁵ 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.

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



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

Follow the 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.

Increasing the Benefits of Smoke Alarm Protection in the Community

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.⁵⁶ This study demonstrated how important it was for programs to actually install the smoke alarms.

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. Many households have not developed the escape plans 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.

Go to NFPA's Smoke Alarm Central for safety tips, videos and more.

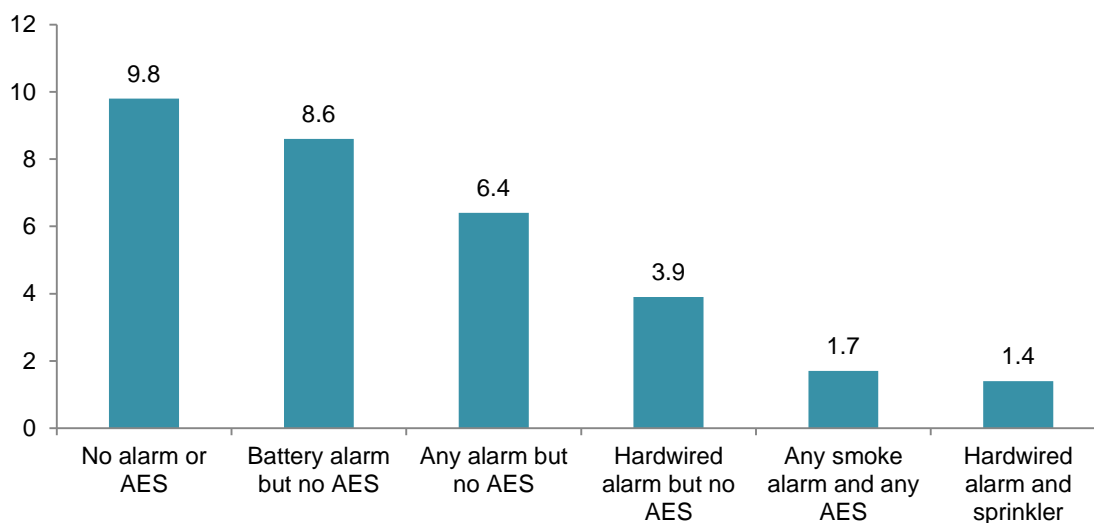
NFPA's 2015 Fire Prevention Week (FPW) theme is "Hear the beep where you sleep. Every bedroom needs a working smoke alarm." Find general safety tips in English and in Spanish, instructions for installing smoke alarms, and more at nfpa.org/smokealarms.

⁵⁶ 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.

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 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 (AES) 2009-2013



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

- 12% lower when battery-powered smoke alarms are present but AES are not;
- 35% lower when smoke alarms with any power source are present but AES are not;
- 60% 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
- 86% lower when hardwired smoke alarms and 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. As discussed earlier, 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 nearly three-quarters (73%) 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 56% of the home fires with smoke alarms powered by batteries only.

Automatic fire department notification may cause more fire department responses to minor incidents. When automatic notification is not present, many fires will be handled privately without fire department involvement. Greene and Andres reported that 14% of all households had monitored fire alarm systems.⁵⁷ Most monitored systems have hardwired smoke detectors.

Table 5 showed that hardwired smoke alarms (with or without battery backup) operated in 94% of fires considered large enough to activate the alarm while smoke alarms powered by batteries only operated in only 80% 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. While smoke alarms provide critical warning, they cannot control the fire. The lowest death rates were observed in fires with sprinklers and hard-wired smoke alarms.

In NIST tests, smoke alarms operated before sprinklers all scenarios. NIST researchers compared the performance of sprinkler actuating elements with other detection technologies in their 21st century study of home smoke alarm performance.⁵⁸ 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. In many cases, a smoke alarm will alert occupants so that action may be taken to prevent a fire from growing large enough to activate the sprinkler system.

The rates shown in Figure 27 are based solely on data about fires reported to local fire departments. Fires that were handled without fire department assistance are not captured. Demographics may also play a role. 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.⁵⁹

⁵⁷ 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.

⁵⁸ Bukowski, et al. 2008 revision, page 260.

⁵⁹ Greene and Andres, pp. 150-189.

Table 25.
Home Structure Fires with Hardwired Smoke Alarms
(Includes Alarms with and without Battery Backup)
by Extent of Flame Damage
2009-2013 Annual Averages

Extent of Flame Damage	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Confined fire identified by incident type	81,200	(65%)	0	(0%)	770	(21%)	\$18	(1%)
Confined to object of origin	8,900	(7%)	20	(4%)	260	(7%)	\$73	(3%)
Confined to room of origin	21,000	(17%)	150	(35%)	1610	(44%)	\$368	(17%)
Confined to floor of origin	3,800	(3%)	70	(16%)	320	(9%)	\$247	(11%)
Confined to building of origin	8,500	(7%)	170	(41%)	640	(17%)	\$1,295	(59%)
Extended beyond building of origin	800	(1%)	20	(4%)	70	(2%)	\$189	(9%)
Total	124,200	(100%)	420	(100%)	3680	(100%)	\$2,189	(100%)

Table 26.
Home Structure Fires with Battery-Powered Smoke Alarms
by Extent of Flame Damage
2009-2013 Annual Averages

Extent of Flame Damage	Fires		Civilian Deaths		Civilian Injuries		Direct Property Damage (in Millions)	
Confined fire identified by incident type	55,700	(46%)	0	(0%)	610	(12%)	\$14	(1%)
Confined to object of origin	11,700	(10%)	30	(3%)	320	(6%)	\$78	(3%)
Confined to room of origin	28,600	(24%)	240	(23%)	2090	(40%)	\$434	(18%)
Confined to floor of origin	6,900	(6%)	180	(17%)	680	(13%)	\$334	(14%)
Confined to building of origin	15,900	(13%)	480	(47%)	1300	(25%)	\$1,378	(56%)
Extended beyond building of origin	1,700	(1%)	100	(10%)	220	(4%)	\$207	(8%)
Total	120,600	(100%)	1030	(100%)	5230	(100%)	\$2,446	(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>.

National estimates approach compensates for fires reported to local fire departments but not to NFIRS. 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. Some departments do not report all of their 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.

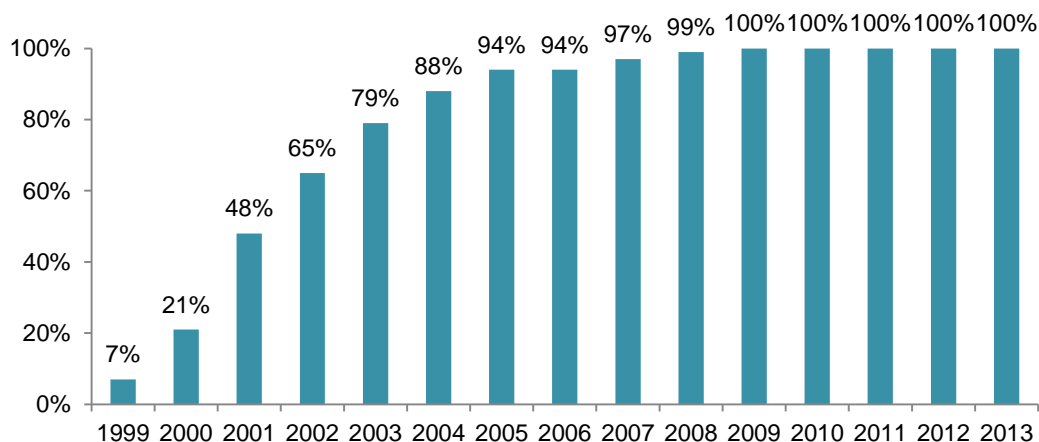
Scaling ratios are obtained by comparing NFPA's projected totals of residential structure fires, non-residential structure fires, vehicle fires, and outside and other fires, and associated civilian deaths, civilian injuries, and direct property damage with comparable totals in NFIRS. Estimates of specific 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 CPSC 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:

$$\frac{\text{NFPA survey projections}}{\text{NFIRS totals (Version 5.0)}}$$

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 detailed information about detection and automatic extinguishing systems 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.

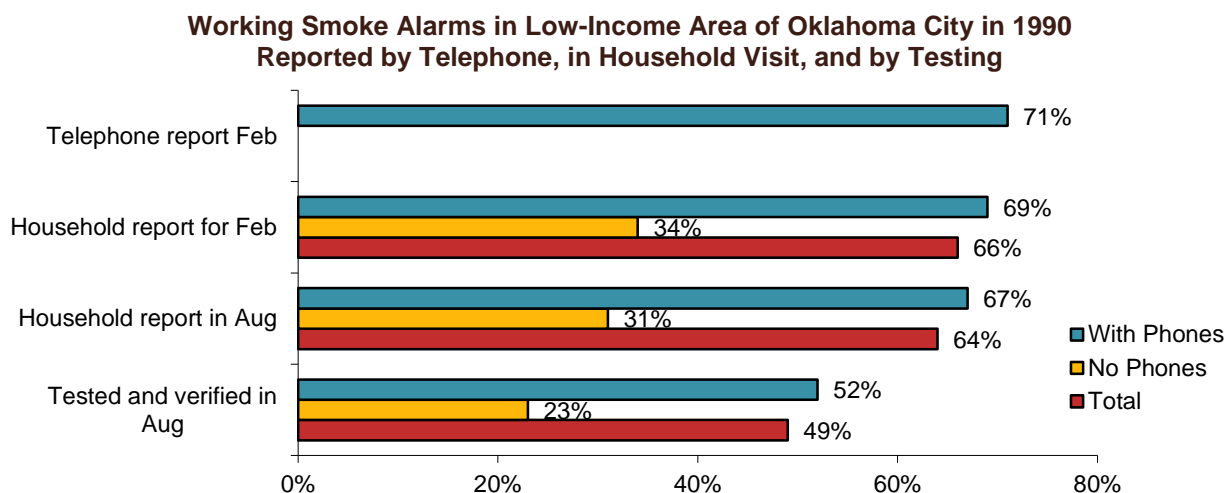
Rounding and percentages. The data shown are estimates and generally rounded. An entry of zero may be a true zero or it may mean that the value rounds to zero. Percentages are calculated from unrounded values. It is quite possible to have a percentage entry of up to 100% even if the rounded number entry 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.⁶⁰ 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.⁶¹



Source: Douglas, Mallonee and Istre, 1999.

⁶⁰ Charles L. Smith, *Smoke Detector Operability Survey – Report on Findings*, Bethesda, MD: U.S. Consumer Product Safety Commission, November 1993.

⁶¹ 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.⁶²

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.

⁶² 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.