NFPA® RESEARCH

Smoke Alarms in US Home Fires

Tucker McGree

June 2024

Key Findings

Smoke alarms were present in three-quarters (74 percent) of the reported home fires from 2018 to 2022. Nearly three out of five (59 percent) home fire deaths were caused by fires in properties with no smoke alarms (43 percent) or smoke alarms that failed to operate (16 percent).

The death rate per 1,000 home structure fires is approximately 60 percent lower in homes with working smoke alarms than in homes with no alarms or none that operated.

Of the fire fatalities that occurred in homes with working smoke alarms, 28 percent occurred when the alarm failed to alert occupants and 9 percent occurred when the occupants were alerted but failed to respond.

Civilians who were fatally injured in homes with working smoke alarms were more likely to have been in the area of origin and involved in the ignition (37 percent). Most victims were escaping (32 percent), sleeping (29 percent), or unable to act (15 percent) at the time of injury.

Hardwired smoke alarms (with or without battery backup) were found in 50 percent of the reported home fires in properties with smoke alarms; smoke alarms powered by battery were only found in 44 percent of such fires.

Nearly two-thirds (66 percent) of the fatal injuries from fires in homes with smoke alarms occurred in properties with battery-only powered alarms. When present, hardwired smoke alarms operated in 94 percent of the fires considered large enough to trigger a smoke alarm. Battery-only alarms operated 85 percent of the time. Missing or non-functional power sources, including missing or disconnected batteries, dead batteries, and disconnected hardwired alarms, were the most common factors when smoke alarms failed to operate.

Compared to reported home fires with no smoke alarms or automatic extinguishing systems (AES) present, the death rate per 1,000 reported fires was as follows:

- 30 percent lower when battery-powered smoke alarms were present with no AES present.
- 50 percent lower when smoke alarms with any power source were present with no AES present.
- 67 percent lower when hardwired smoke alarms were present with no AES present.
- 71 percent lower when hardwired alarms with a battery were present with no AES present.
- 90 percent lower when a smoke alarm was present in addition to the presence of an AES.

The calculations above are based solely on the presence of fire protection equipment. The equipment's operation was not considered.

Introduction

This report provides the latest information on smoke alarms in home fires reported to local fire departments in the US. Estimates in this report were derived from the US Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and NFPA's annual fire department experience survey.

The term *smoke alarm* in this analysis includes all fire detection equipment. Estimates for the specific types of detection (smoke, heat, combination, etc.) are available in the supporting tables for this report.

Figure 1 shows that in 1977, less than one-quarter of all households had smoke alarms. Home smoke alarm usage increased rapidly in the late 1970s and 1980s. Telephone surveys have found that 96–97 percent of the surveyed US households have at least one smoke alarm.[1] A 2015 study conducted by the US Consumer Product Safety Commission concluded that 95 percent of survey respondents had a smoke alarm in their home.[2]

A 2018 study by the National Institute of Standards and Technology noted that these surveys excluded those without phones and could reflect social desirability bias. Such bias occurs when respondents report what they believe is the proper answer rather than the actual answer. Consequently, the author suggested that actual smoke alarm utilization is more likely to be 92 percent.[3]

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

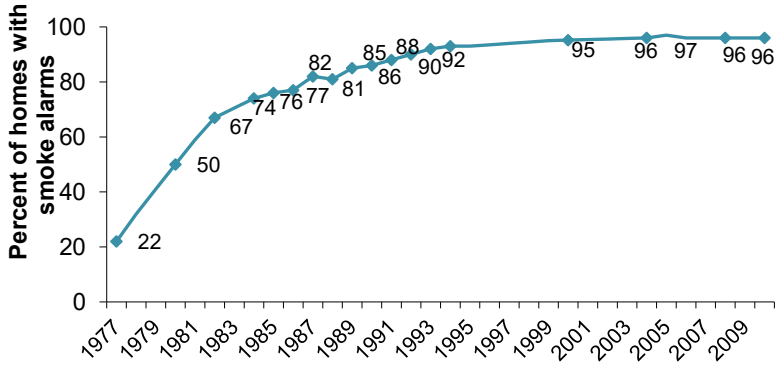


Figure 2 shows that the number of reported fires fell sharply in the 1980s as home smoke alarms became more common.

Figure 2. Reported Home Structure Fires by Year: 1980–2022

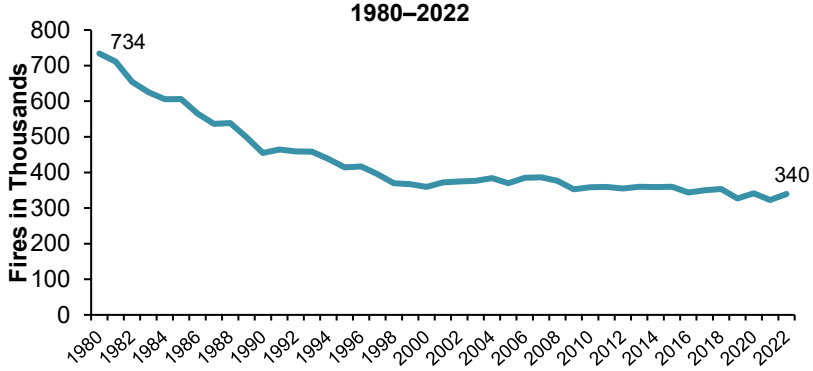
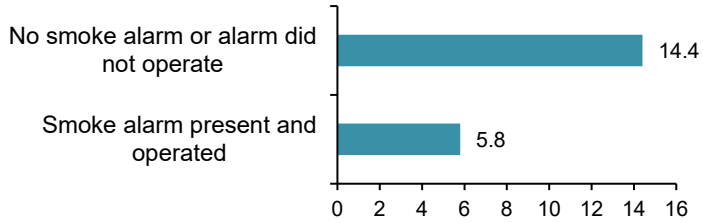


Figure 3 shows that the death rate per 1,000 reported home fires in 2018–2022 was reduced by 60 percent when alarms operated in home structure fires versus when there were not any working smoke alarms present. Table 1 in the supporting tables offers more detail regarding these numbers.

Figure 3. Death Rate per 1,000 Reported Home Fires by Smoke Alarm Status: 2018–2022



[1] Sources for the number of homes with smoke alarms: 1977, 1980, and 1982 estimates from sample surveys by the US 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, *2004–2005 National Sample Survey of Unreported Residential Fires*, 2009; US Harris Interactive survey, "Smoke Alarm Omnibus Question Report," 2008; Harris Poll® National Quorum: "National Fire Protection Association — Smoke Alarms," September 2010.

[2] Lee, Arthur. *Public Benefits to a Smoke Alarm Performance Evaluation Scheme.* Rockville, Maryland: US CPSC, December 2015. Accessed at https://www.cpsc.gov/s3fs-public/WPISmokeAlarmExtendedAbstractSUPDET2016.pdf.

[3] Gilbert, Stanley. *Estimating Smoke Alarm Effectiveness and Spatial Distribution in Homes*. US Department of Commerce, NIST Technical Note 2020, 2018, 15. Accessed at https://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.2020.pdf.

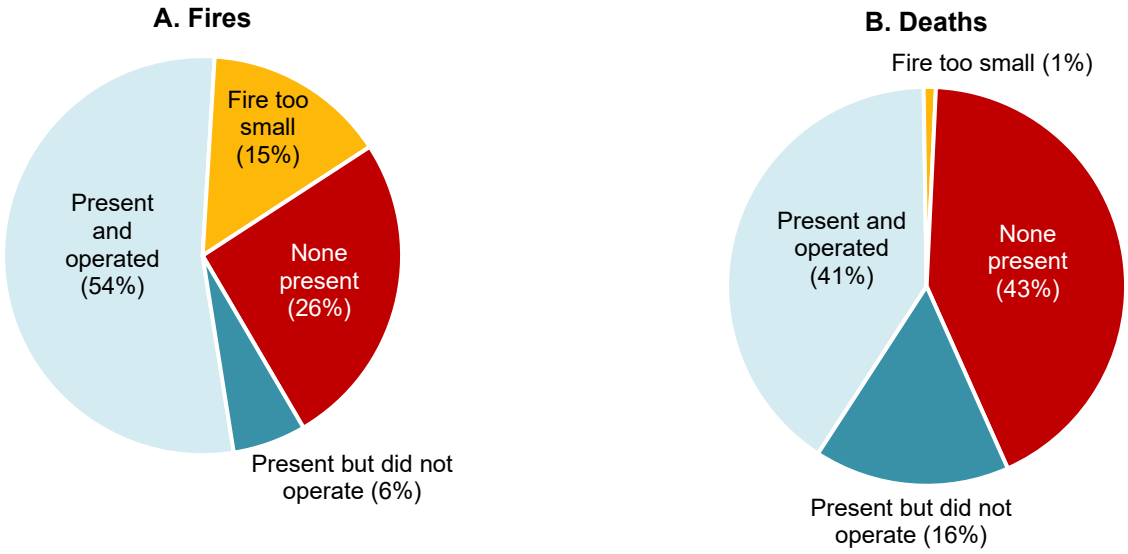
Smoke Alarm Status in Reported Fires

Fire departments responded to an estimated average of 336,848 home structure fires per year in 2018–2022. Smoke alarms, including those in fires too small to activate them, those that operated, and those that failed to operate were present in 74 percent of reported home fires. Figure 4 breaks this number down between fires where a smoke alarm operated, where it was present and did not operate, where the fire was too small to operate the alarm, and where there was no alarm present. It also displays the breakdown of deaths by smoke alarm performance, illustrating that nearly three out of five home fire deaths resulted from fires where there was no smoke alarm or the smoke alarms present did not work.

When present, smoke alarms operated in 90 percent of the reported fires large enough to activate them. Of the deaths in homes with smoke alarms and fires large enough to activate them, 72 percent resulted from incidents in which the smoke alarms operated (see Table 1 in the supporting tables document for more details).

For half of the reported structure fires in which smoke alarms were present, the alarms were hardwired (with or without a backup). These fires accounted for 29 percent of the civilian deaths. Battery-only powered alarms were present for 44 percent of the reported fires. These fires accounted for 66 percent of the civilian deaths. More detail on these numbers is available for review in Table 3 of the supporting tables document. When present, hardwired smoke alarms operated in 94 percent of the fires considered large enough to activate a smoke alarm. Battery-powered alarms operated 85 percent of the time.

Figure 4. Reported Home Structure Fires and Fire Deaths by Smoke Alarm Performance: 2018–2022



Causes of Smoke Alarm Failure

During 2018–2022, local fire departments responded to an estimated average of 19,119 home fires per year in which smoke alarms should have operated but failed to do so. These fires caused an average of 403 deaths and 1,052 injuries annually.

For incidents in which smoke alarms failed to operate, the failure was most likely due to disconnected or non-working power sources. Battery problems, specifically, were most common. Figure 5 illustrates this in greater detail.

One issue with batteries is new technology complicating messaging. Smoke alarms powered by lithium batteries do not require annual battery changes.[4] These batteries are sometimes referred to as 10-year batteries. Reminders to change smoke alarm batteries when changing the clock for Daylight Saving Time might lead some people to replace a lithium battery with a conventional battery with a shorter lifespan.

Power sources are often disabled because of unwanted alarms. The low-battery chirp is sometimes considered a nuisance. While the fire safety community understands the importance of alarms, members of the public might not. In practice, even people committed to fire safety may disable an alarm that starts chirping in the middle of the night. Replacing conventional batteries in battery-powered and hardwired alarms with battery backups annually reduces the likelihood of inconvenient chirping and the subsequent disabling of alarms.

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 the alarms are designed specifically for an 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.

Fire Discovery

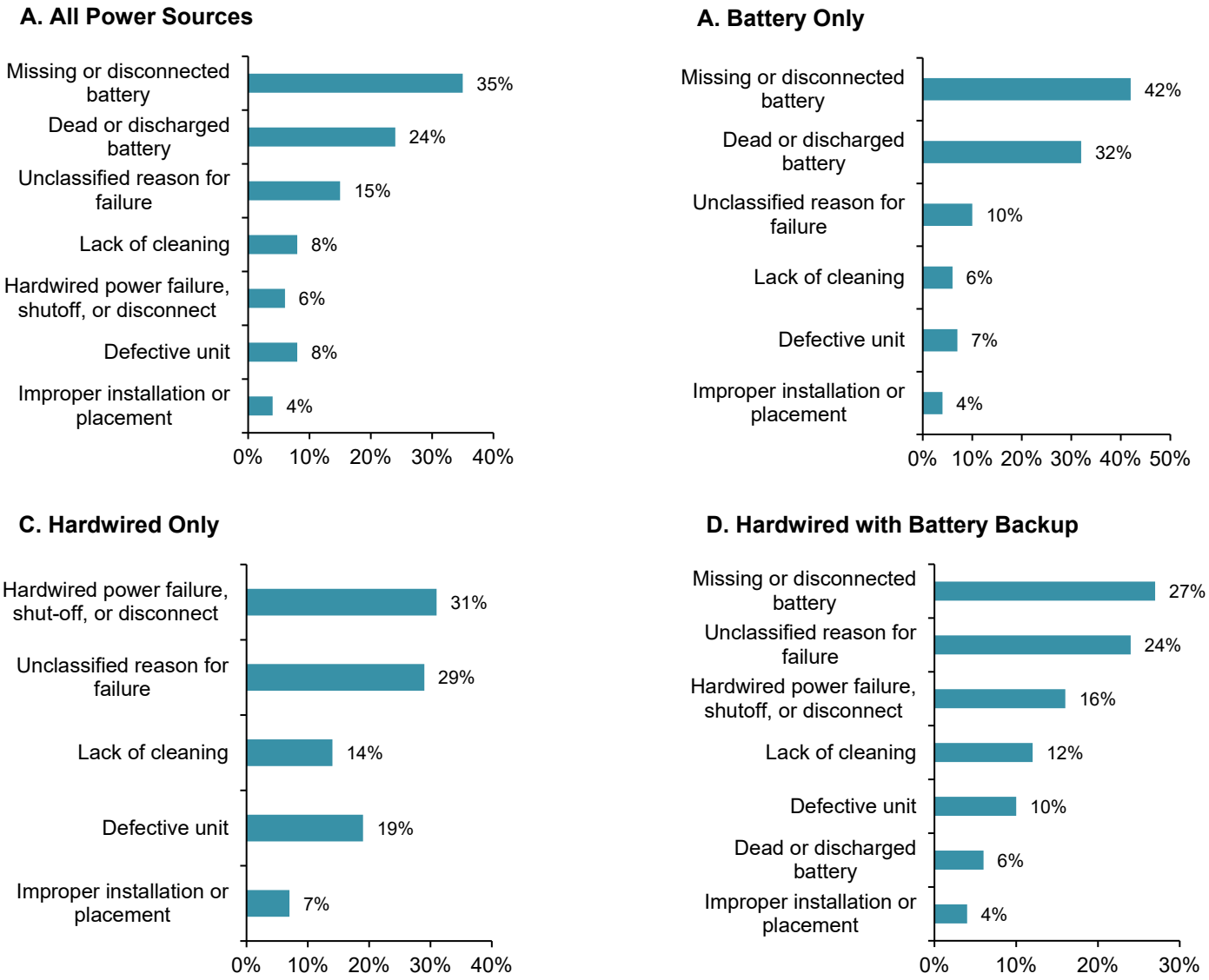
NFIRS data does not capture the extent of smoke alarm coverage or whether the alarms were interconnected. In addition, NFIRS data does not include information on incidents that were not reported to the fire department.

Fire statistics from England provide some insight into the effectiveness of smoke alarms. In 2013/2014–2018/2019, home smoke alarms were present, operated, and alerted occupants to act in 38–43 percent of the dwelling fires reported in England. The smoke alarms operated but did not raise the alarm in 11–12 percent of the fires.[5]

In three out of five (59–60 percent) such fires, a person raised the alarm before the system operated. Someone in the same room may have noticed the fire immediately. In one-fifth of the fires (19–20 percent), no one was within hearing distance of the alarm. The occupants failed to respond in 12–13 percent of the fires.[6]

[4] Ahrens, Marty. *Smoke Alarms in US Home Fires*. Quincy, MA: NFPA, 2021.
[5] "FIRE0702: Primary fires, fatalities and non-fatal casualties by presence and operation of smoke alarms," Home Office Incident Recording System, Fire Statistics, United Kingdom. Accessed at https://www.gov.uk/government/statistical-data-sets/fire-statistics-data-tables#smoke-alarms on September 3, 2020.
[6] "FIRE0702: Primary fires, fatalities and non-fatal casualties by presence and operation of smoke alarms," Home Office Incident Recording System, Fire Statistics, United Kingdom. Accessed at https://www.gov.uk/government/statistical-data-sets/fire-statistics-data-tables#smoke-alarms on September 3, 2020.

Figure 5. Reason Smoke Alarms Did Not Operate in Home Structure Fires Considered Large Enough to Activate Smoke Alarms Illustrated by Smoke Alarm Power Source: 2018–2022



Reported Deaths and Injuries in Relation to Operating Smoke Alarms

NIFRS data provides information on how an occupant's location, characteristics, and activity can influence the outcome of a fire. People who died in US home fires with working smoke alarms often had characteristics or circumstances that made escape more difficult. The charts in this section break down the data reported to NFIRS in relation to deaths and injuries when alarms operated versus when they did not operate or were not present.

Figure 6 displays the breakdown of deaths when alarms operated versus when there were no working alarms present by the activity of the victim at the time of fatal injury. There was a greater percentage of victims who were attempting to escape or were sleeping in fires where no alarms were present than in fires where alarms operated. The opposite is true for victims who were unable to act, involved in an irrational act, or returned to the vicinity of the fire prior to the fire being brought under control.

Figure 6. Deaths in Home Structure Fires by Alarm Operation and Victim Activity at Time of Fatal Injury: 2018–2022

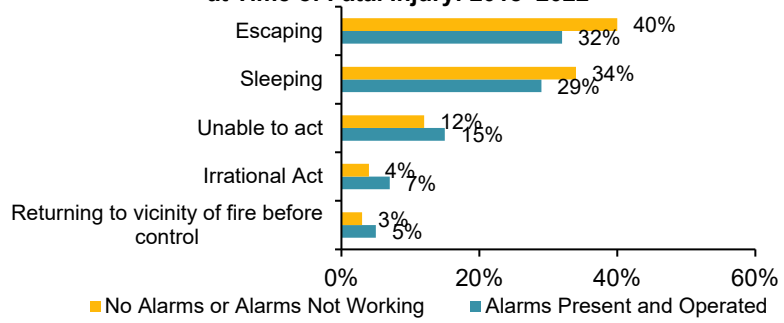


Figure 7 shows the same data for non-fatal injuries in home structure fires. The trend is similar for victims who were attempting an escape or sleeping at the time of injury. Here the greatest percentage of injuries occurred when victims attempted to control the fire.

Figure 7. Non-Fatal Injuries in Home Structure Fires by Alarm Operation and Victim Activity at Time of Fatal Injury: 2018–2022

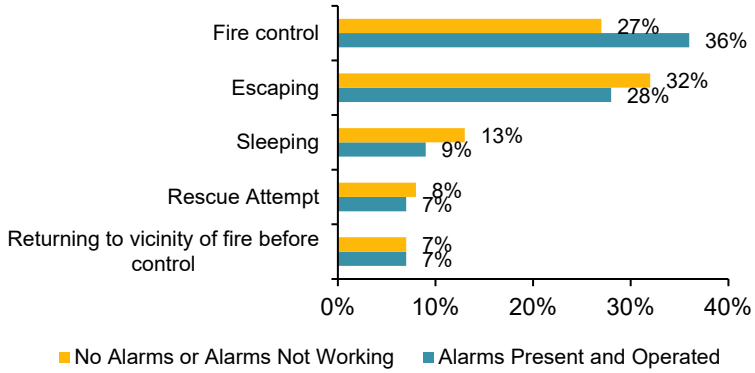


Figure 8 illustrates the breakdown of deaths in home structure fires by the human factor contributing to injury. The largest percentage of deaths were attributed to victims who were asleep or physically disabled. No factor was reported in approximately one-third of the home structure fire deaths included in this analysis.

Figure 8. Deaths in Home Structure Fires by Alarm Operation and Human Factor Contributing to Injury: 2018–2022

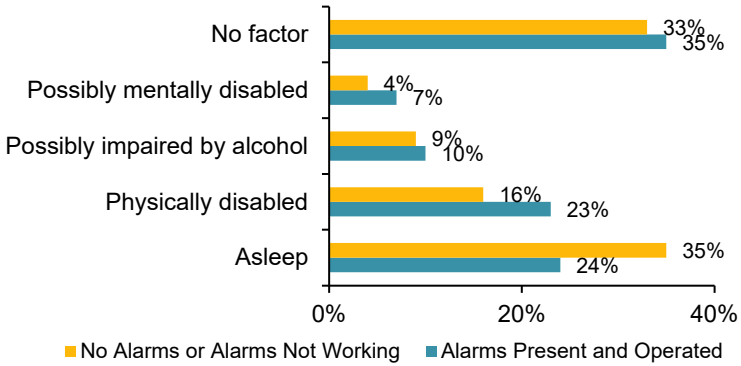


Figure 9 illustrates the breakdown of deaths in home structure fires by age group. The largest share of deaths in homes where alarms were present and operated occurred when victims were 65 years old and older. The 45–64 age group was second in this category but represented the largest percentage of deaths in homes where no alarms were present or those present were not working.

Smoke alarms are an important part of home fire protection, but they are not the only part. The death rate per 1,000 reported home structure fires steadily declines as the levels of fire protection increase.

Figure 9. Deaths in Home Structure Fires by Alarm Operation and Victim Age: 2018–2022

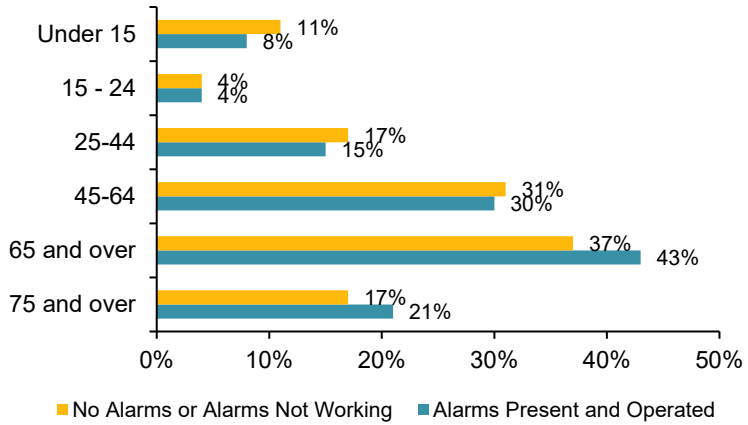


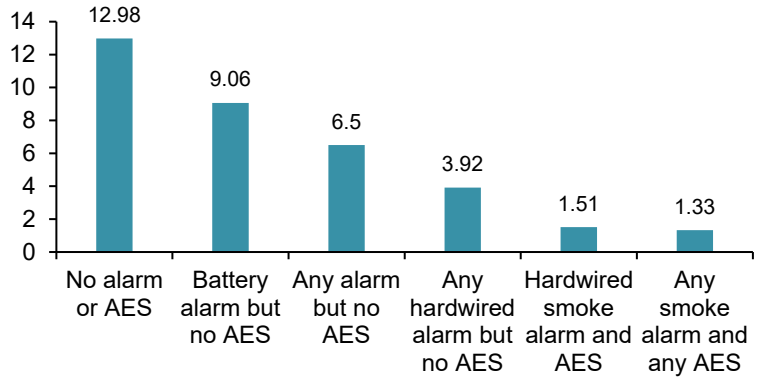
Figure 10 shows that the death rate is lowest in homes with sprinklers and any type of alarm. These rates are based on the presence of sprinklers and alarms in reported fires only. Whether they operated was not considered.

While fires in homes in which partial sprinkler systems were present or in which sprinklers were outside the fire area and did not operate were excluded from the calculations, the data did not permit the exclusion of fires that did not have enough smoke alarms or in which the smoke alarms were not audible to the occupants. A closed bedroom door is likely to delay the operation of a single-station alarm in response to a 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.

New homes should have hardwired smoke alarms, Hardwired smoke alarms are more likely to be interconnected, although battery-powered wireless interconnected alarms are available.

It is easy to forget that a smoke alarm's sole function is to sound a warning. People also need to develop and practice escape plans so they can get out quickly if an alarm sounds. Because smoke alarms can alert occupants to fires that are still relatively small, some people might try to fight these fires themselves. Unfortunately, these attempts could be unsuccessful due to either rapid fire spread or inappropriate methods of fire control, leaving occupants with less time to escape.

Figure 10. Average Fire Death Rate per 1,000 Reported Home Structure Fires by Presence of Smoke Alarms and Automatic Extinguishing Systems (AES): 2018–2022



What Fires Are Reported? What Counts as a Fire?

The 2018–2022 US national estimates of smoke alarm performance in reported home fires are, by definition, limited to fires reported to local fire departments. Two issues come into play here.

The activation of monitored fire detection systems often results in a fire department response. This results in more minor fires being reported in properties with this level of protection. These systems are often in public areas of apartments or other multi-family houses. Smoke alarms operated in 70 percent of reported fires in apartments or other multi-family housing compared to 46 percent of fires reported in one- or two-family homes. In many cases, the occupants of the monitored property had already handled the situation.

Occupants of properties without monitored systems may not find it necessary to call the fire department for such minor fires.

Additional Information

See *Smoke Alarms in US Home Fires: Supporting Tables* by Tucker McGree, June 2024, for more detailed information on the material presented in this report.

For consumer information about smoke alarms, visit nfpa.org/smokealarms.

Methodology

The statistics in this analysis are estimates derived from the US Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) and the National Fire Protection Association's (NFPA's) annual survey of US fire departments. Fires reported to federal, or state fire departments or industrial fire brigades are not included in these estimates. Only civilian (non-firefighter) casualties are discussed in this analysis.

NFPA's fire department experience survey provides estimates of the big picture. NFIRS is a voluntary system through which participating fire departments report detailed factors about the fires to which they respond.

To compensate for fires reported to local fire departments but not captured in NFIRS, scaling ratios are calculated and then applied to the NFIRS database using the formula below.

$$\frac{\text{NFPA's fire experience survey projections}}{\text{NFIRS totals}}$$

NFPA also allocates unknown data proportionally to compensate for fires for which information was undetermined or not reported.

Smoke alarms are not the same as smoke detectors. Most homes have what we now call smoke alarms. These devices detect the presence of smoke and sound the alarm.

Some 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 a 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. NFIRS does not distinguish between smoke detectors and smoke alarms.

Except where specified, the term *smoke alarm* in this analysis is used inclusively for all fire detection equipment. Estimates of specific types of detection are available in the supporting tables for this report.

Some spaces in homes, such as garages, exterior parts of the structure, concealed spaces, and unoccupied attics, are not expected or required to have smoke alarms. No adjustments were made for these spaces.

Detection in apartments or other multi-family housing also poses coding challenges. A smoke alarm may be missing from or disabled

in the unit of origin, but a detection system in the common areas or a smoke alarm in an adjacent unit may have operated and sounded the alarm. It is unclear whether detection would be considered present and operating in such a fire.

Confined structure fires in NFIRS 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 (NFIRS incident types 113–118). Losses are generally minimal in these fires, which, by definition, are assumed to have been limited to the object of origin. Although detailed data about detection is not required for these fires, it is sometimes present.

Raw NFIRS data for 2018–2022 contained a total of 21,036 confined home structure fires in which some type of detection was present (8 percent) and 19,452 confined fires in which detection was present and its operation was known (92 percent).

Raw NFIRS data for 2018–2022 contained a total of 380,160 non-confined home structure fires (NFIRS incident types 110–123, excluding 113–118) in which detection presence was known (coded as either present or not present) (69 percent). A total of 3,850 civilian deaths (56 percent); 17,724 civilian injuries (77 percent); and $15.4 billion in direct property damage (68 percent) were associated with these fires. A detection system was present in 43 percent of non-confined fires, 32 percent of deaths, 52 percent of injuries, and 50 percent of associated property loss.

When detection was present in non-confined structure fires, detection operation was known (coded “Fire too small to operate,” “Operated,” or “Failed to operate”) in a five-year raw total of 199,887 fires (84 percent) associated with 1,459 deaths (67 percent), 9,959 injuries (84 percent), and $9.01 billion in direct property damage (79 percent).

For more information on the methodology used for this report see, *How NFPA’s National Estimates Are Calculated for Home Structure Fires*.

To learn more about research at NFPA visit nfpa.org/research.

E-mail: research@nfpa.org.

NFPA No. USS04