

Investigation of Fatal Residential Structure Fires with Operational Smoke Alarms

Findings:

- Smoke alarms save lives and money, yet lives are lost despite smoke alarms that operated during a fire.
- In one in three apartment fires in which a fatality occurred, a smoke alarm was working.
- Smoking is the leading cause (32 percent) of fatal fires in residences with working smoke alarms. Smoking was the cause of nearly half (45 percent) of all fatal apartment fires with working smoke alarms.
- The victim was asleep (37 percent) in most fatal residential fires with a working smoke alarm.

From 2001 through 2004, an estimated average of 402,500 fires was reported in residential structures.¹ These fires caused an average of 3,055 fatalities, 14,475 injuries, and \$5.93 billion in property loss.² Given the scale of the U.S. fire problem, fire service and public health experts regularly seek approaches that will reduce the number of lives lost and amount of property destroyed by fire. Since 1970, when battery-powered smoke alarms³ were introduced, smoke alarms have become a familiar presence in American homes. By 2004, they were found in 96 percent of U.S. households.⁴

Smoke alarms play a vital role in the early detection of fire, giving occupants additional warning to escape from a potentially dangerous situation. Yet fatalities still occur in fires with working alarms. From 2001 through 2004, 391 fatal residential structure fires with working alarms were reported with 452 fatalities resulting from these fires.^{5 6}

An earlier topical report, “Smoke Alarm Performance in Residential Structure Fires” (Vol. 1, Issue 15), examined the overall performance of smoke alarms in residential structure fires. This topical report focuses on residential structure fires with fatalities where smoke alarms operated, and addresses the characteristics of the fatalities themselves. Because the numbers of fires and deaths are small, this analysis is presented as preliminary findings only, and no definitive conclusions concerning the operational effectiveness of smoke alarms should be drawn.

Fire Characteristics

Alarms were present in approximately 60 percent of fatal residential structure fires. Of those fatal fires with an alarm present, the detector operated 39 percent of the time. Together, these statistics indicate that alarms were present and operated in 23 percent of fatal residential structure fires.⁷

Twice as many fatal residential structure fires with operational alarms occur in one- and two-family homes as in apartments (65 percent versus 32 percent). These proportions are in contrast to all fatal residential structure fires where only 14 percent of fatal fires occur in apartments. In fact, 34 percent of fatal apartment fires had operating alarms; 12 percent of one- and two-family fatal fires had operational alarms. The high rate of fatal fires in apartments with working alarms may be the result of the lack of alternate exits, although this observation warrants further investigation (Figure 1).

Figure 1. Fatal Residential Structure Fires (2001–2004) (percent)

Residence Type	Fatal Residential Structure Fires		
	Fatal Fires with Operational Alarms	All Fatal Fires	Fires with Operational Alarms as Proportion of Fatal Fires
1- and 2-Family	65.2	81.3	12.0
Apartments	31.7	14.2	33.5

Source: NFIRS 5.0 data only; confined fires are excluded

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Fatal residential fires with working smoke alarms tend to occur in the late evening and early morning hours when most individuals are sleeping—as do most fatal residential structure fires. Half (50 percent) of these fires occurred between 10 p.m. and 6 a.m. There is little difference in this pattern between one- and two-family dwellings and apartments.

Three causes—smoking, arson, and open flame—account for three-quarters of fatal residential structure fires when the alarms operated. Smoking fires are the leading cause and account for 32 percent of these fires. Arson (incendi-

ary and suspicious) fires account for 24 percent, and open flame fires (those caused by matches, lighters, candles, and the like) account for an additional 19 percent. As a reference, during the 2001–2004 period, arson (25 percent), smoking (23 percent), and open flame (14 percent) were also the leading causes of all fatal residential structure fires. Smoking plays a substantially larger role in these fatal fires in apartments (45 percent in apartments versus 22 percent in one- and two-family dwellings), while open flame fires play a larger role in one- and two-family dwellings (22 percent in one- and two-family dwellings versus 14 percent in apartments), as shown in Figure 2.

Figure 2. Leading Causes of Fatal Residential Structure Fires with Working Smoke Alarms (2001–2004)

	1- and 2-Family	Percent	Apartments	Percent	Overall	Percent
Smoking	29	22.5	33	44.6	67	31.8
Incendiary/Suspicious	32	24.8	19	25.7	51	24.2
Open Flame	28	21.7	10	13.5	40	19.0

Source: NFIRS 5.0 data only; confined fires are excluded

In a substantial portion (29 percent) of these fatal fires, fire spread was confined to the room of origin, unlike that of all fatal residential structure fires (Figure 3). In most fatal fires (53 percent), the entire building is involved in the fire.

Figure 3. Extent of Flame Spread in Fatal Residential Structure Fires (2001–2004) (percent)

Fire Spread	Fatal Residential Structure Fires With Operational Alarms	All Fatal Residential Structure Fires
Confined to Object of Origin	8.4	8.3
Confined to Room of Origin	28.9	15.6
Confined to Floor of Origin	15.1	11.4
Confined to Building of Origin	40.4	52.8
Beyond Building of Origin	7.2	11.8
Total	100.0	100.0

Source: NFIRS 5.0 data only; confined fires are excluded

Note: Totals may not add due to rounding.

Fatality Characteristics

Fires in residences with working smoke alarms claim the young, old, and middle-aged in the same general proportions as any other residential fatal fire (Figure 4). As with all fatal residential fires and in similar proportions, more men (57 percent) than women (43 percent) were fatalities where smoke alarms operated. A larger proportion of middle-aged men are fatalities than middle-aged women. Of older adult fatalities (those 65 years and older), however, more older women (55 percent) were victims than older men (45 percent).

Whites accounted for 80 percent of the fatalities; African Americans accounted for 15 percent.⁸ These proportions are in line with the U.S. population in general.⁹ Although African Americans generally are disproportionately represented in fire fatalities overall, it appears that, when smoke alarms are installed and work, race may not be a characteristic of fire fatalities. The races are more similar in this respect than the genders (Figure 5).

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Figure 4. Age Distribution of Residential Structure Fire Fatalities (2001–2004) (percent)

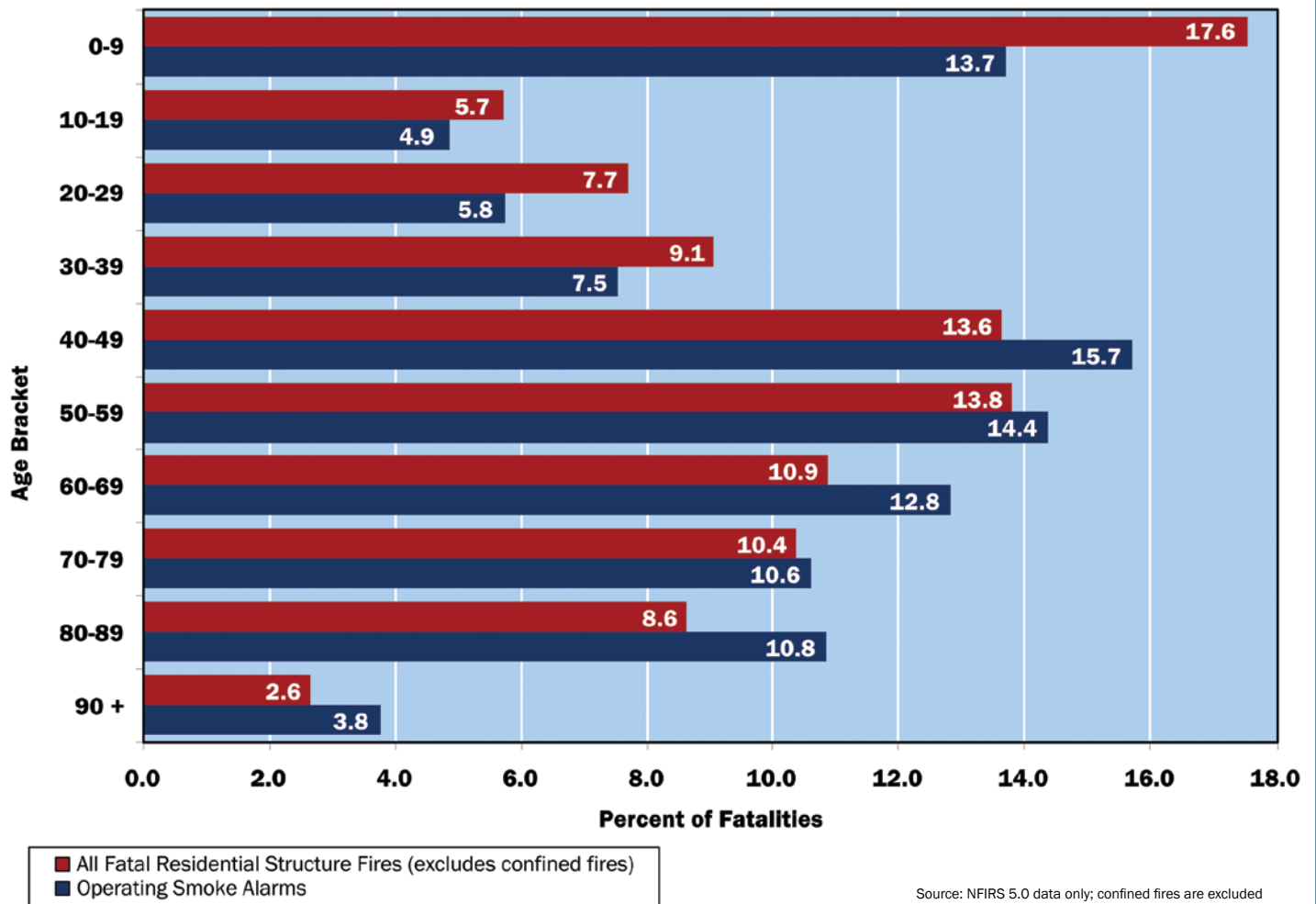


Figure 5. Gender and Race Distributions of Fatalities in Residential Structure Fires with Working Smoke Alarms (2001–2004) (percent)

Age Group	White	African American	Male	Female
0–9	12.8	16.0	15.4	11.4
10–19	3.7	4.0	5.4	4.1
20–64	50.2	44.0	54.4	43.5
65+	33.3	36.0	24.7	40.9
Total	100.0	100.0	100.0	100.0

Source: NFIRS 5.0 data only; confined fires are excluded.
 Note: Totals may not add due to rounding.

Most victims were sleeping at the time of their fatal injury (37 percent). Another large proportion, 29 percent, was trying to escape the fire. An additional 12 percent were unable to act because of age, disorientation, or some other reason. These proportions are relatively consistent across gender, race, and type of residence. The exception is that women were trying to escape more often than men (34 percent versus 25 percent). Where information is available on the location of the victim, 56 percent were found in a bedroom. Not surprisingly, sleeping was most likely to affect children (82 percent). Older adults were sleeping (32 percent) or physically disabled (33 percent). Alcohol impairment was a substantial factor in all other victims (those between the ages of 15 and 64) as was physical disability (15 percent) (Figure 6).

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Figure 6. Human Factors Contributing to Fatal Injury in Residential Structure Fires with Working Smoke Alarms (2001–2004) (percent)

Human Factor Contributing to Injury	Children Ages 0–14	Older Adults Ages 65+	All Others
Asleep, No Known Impairment	82.1	31.8	36.4
Unconscious	7.7	2.4	4.0
Possibly Impaired by Alcohol		10.6	27.8
Possibly Impaired by Other Drug or Chemical		2.4	7.9
Possibly Mentally Disabled		9.4	7.9
Physically Disabled		32.9	14.6
Physically Restrained	-	-	-
Unattended or Unsupervised Person	10.3	10.6	1.3
Total	100.0	100.0	100.0

Source: NFIRS 5.0 data only; confined fires are excluded.

Note: Totals may not add due to rounding.

In 36 percent of the fatalities where a factor contributing to injury was noted, exit problems contributed to the fatality. Exits blocked by smoke or flames were noted in 27 percent of the fatalities. Smoke obscured the vision of the victim for 19 percent of the victims. Older adults were more affected by this (24 percent) than others. Over half (55 percent) of the child fatalities had egress or exit problems.

Conclusions

Although nearly 96 percent of U.S. households have smoke alarms, fatalities can (and do) occur when a smoke alarm operates. Operable smoke alarms have been credited with saving many, many lives. As in any emergency situation, it is critical to have a well-rehearsed escape plan and know more than one way out of any room or building. Knowing these options may save a life. Limiting risky behaviors (e.g., smoking, drinking) are well-documented components that reduce the risk of fatality.

The alarm operated in less than one-quarter of all fatal residential structure fires—a troublesome statistic, since alarms are designed to save lives. In the case of apartments, the operational alarm statistics are especially troubling, as alarms often are provided by landlords and more often are required by law than in single-family homes. In addition, apartment alarms are more likely to be hardwired into the electrical system and professionally maintained than alarms in dwellings.

It may be that, in an apartment fire, more people will be at risk (e.g., 20 people in a hallway versus 2 to 3 people in a one- or two-family dwelling). Another possibility is that

hallway alarms or alarms in other apartments operated after the victims were overcome. Also, apartments have fewer means of escape, especially apartments on higher floors. Escaping from an apartment can be particularly confusing at night, when people are awakened suddenly. This situation suggests the need to emphasize fire prevention to apartment dwellers. The installation of sprinkler systems could prove highly beneficial in apartments. These and other observations indicate a need for further study.

Fire public education professionals and smoke alarm manufacturers provide a variety of placement, maintenance, and operating recommendations to ensure that smoke alarms work effectively. Some of these recommendations include

- Place smoke alarms on each level of a house and outside each sleeping area (one hallway alarm can serve several bedrooms). Some models sound false alarms when they detect kitchen cooking smoke or high bathroom humidity. Many manufacturers recommend not putting alarms within 20 feet of kitchens, garages, furnaces, hot water heaters, or within 10 feet of a bathroom. Also avoid drafty locations.
- Do not disable smoke alarms, even temporarily. Nuisance alarms can be minimized by relocating alarms farther from sources of fumes or steam as noted above.
- Test smoke alarms regularly. Once-a-month testing is often recommended, following the manufacturer's instructions.
- Replace the batteries in smoke alarms once a year, or as soon as the low battery warning alarm “chirps.” The

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“change your clock, change your battery” schedule for alarm battery replacements is suggested often as a reminder to change smoke alarm batteries the same day you change your clocks from daylight savings time to standard time in the fall.

- Do not “borrow” a battery from a smoke alarm, even if the alarm is hardwired. Smoke alarms cannot work if their batteries are missing or have been disconnected.

- Vacuum or dust smoke alarms regularly, following the manufacturer's instructions, to keep them working properly.
- Never paint smoke alarms. Paint, stickers, or other decorations can keep the alarms from working properly.

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Notes:

¹In NFIRS 5.0, a structure is a constructed item, of which a building is one type. The term “residential structure” commonly refers to buildings. The definition of a structure fire has, therefore, changed to include only those fires where NFIRS 5.0 structure type is 1 or 2 (enclosed building and fixed portable or mobile structure.)

²Estimates of the U.S. residential fire problem are based on the National Fire Protection Association’s (NFPA) annual survey, *Fire Loss in the United States*, for 2001 to 2004. Fires are rounded to the nearest 100, deaths to the nearest 5, injuries to the nearest 25, and loss to nearest \$10M.

³The term *smoke alarm* has superseded the more commonly known term *smoke detectors*. While the two terms are not technically identical, in industry parlance, *smoke alarm* underscores that when the “detector” detects smoke, it also sounds an alarm to alert the occupants of the fire.

⁴The Consumer Product Safety Commission reported over 90 percent of households had a smoke alarm in its press release, “CPSC Warns the Smoke Detectors in About 16 Million Homes Do

Not Work,” October 29, 1999. <http://www.cpsc.gov/CPSCPUB/PREREL/prhtml00/00011.html>. Research from the National Fire Protection Association in *U.S. Experience with Smoke Alarms and Other Fire Detection/Alarm Equipment* (November 2004) suggests as many as 96 percent of households have smoke alarms installed.

⁵NFIRS 5.0 contains both converted NFIRS 4.1 data and native NFIRS 5.0 data. This topical report includes only native 5.0 data.

⁶As this preliminary analysis focuses on alarm operation (variable *det_operat*), confined fires (NFIRS incident types 113 to 118) are excluded.

⁷Smoke alarm statistics are based on incidents where the alarm presence and operational status is reported.

⁸The remaining 5 percent of fatalities were Asian, American Indian, or Alaskan Natives.

⁹USA Quick Facts. Whites comprised 75 percent of the population; African Americans, 12 percent; and the remaining 11 percent were other races or multiple races. <http://quickfacts.census.gov/qfd/states/00000.html>

Related Topics:

- **Topical Fire Research Series: Smoke Alarm Performance in Residential Structure Fires, Vol. 1, Issue 15,** www.usfa.dhs.gov/downloads/pdf/tfrs/v1i15.pdf
- **Fact Sheet: Smoke Alarms: What You Need to Know,** www.usfa.dhs.gov/safety/alarms/