



RESEARCH



HOME ELECTRICAL FIRES

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March 2019

Key Findings

FIRES INVOLVING ELECTRICAL FAILURE OR MALFUNCTION

- Local fire departments responded to an estimated average of 44,880 home fires involving electrical failure or malfunction each year in 2012-2016.
- Home fires involving electrical failure or malfunction caused an estimated average of 440 civilian deaths and 1,250 civilian injuries each year in 2012-2016, as well as an estimated \$1.3 billion in direct property damage a year.
- Electrical distribution, lighting, and power transfer equipment accounted for half (50%) of home fires involving electrical failure or malfunction, followed by cooking equipment (15%), heating equipment (9%), fans (6%), air conditioners (3%), and clothes dryers (3%).
- Nearly two of five fires (39%) involving electrical failure or malfunction occurred in the cold weather months from November through February. These fires were less likely to occur in the overnight hours between midnight and 8 a.m. (22% of total), but fires during this time period accounted for 60% of the civilian deaths.

FIRES INVOLVING ELECTRICAL DISTRIBUTION AND LIGHTING EQUIPMENT¹

- Local fire departments responded to an estimated average of 35,150 home fires involving electrical distribution and lighting equipment each year in 2012-2016.
- Home fires involving electrical distribution and lighting equipment caused an estimated average of 490 civilian deaths and 1,200 civilian injuries each year in 2012-2016, as well as an estimated \$1.3 billion in direct property damage a year.
- Home fires involving electrical distribution and lighting equipment most often originated in a bedroom (17% of total), attic or ceiling (12%), or a wall assembly or concealed space (9%).
- Approximately one-quarter (24%) of these fires occurred between midnight and 8 a.m., but these fires accounted for 60% of deaths.

¹ Estimates exclude the six structure fire incident types for confined cooking fires, chimney or flue fires, fuel burner or boiler fires, incinerator, compactor, or trash fires.

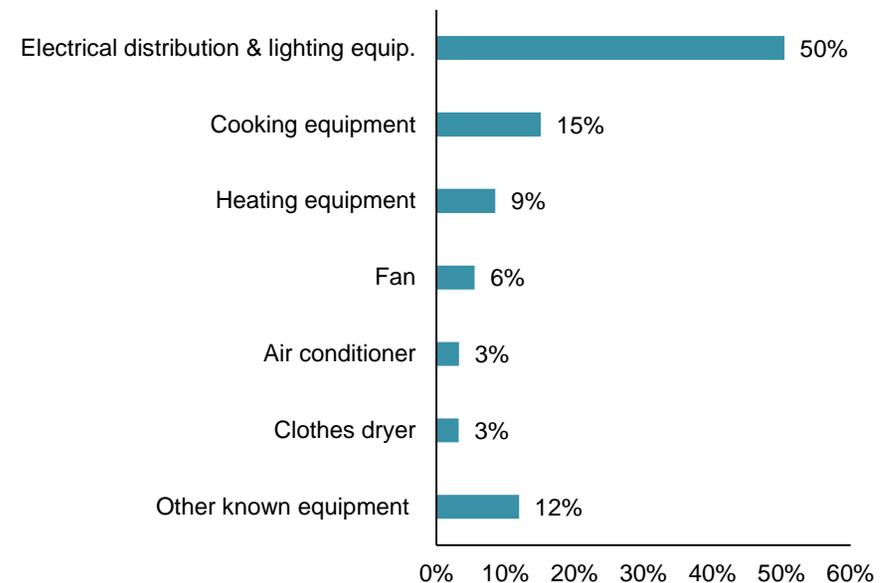
Home Electrical Fires

Home electrical fires can start in wiring, electrical distribution systems, and lighting equipment, as well as in any equipment powered by electricity such as cooking, heating, office and entertainment equipment, washers and dryers, as well as electrical distribution or lighting equipment. To better understand if these types of fires can be prevented through code changes, equipment changes, and/or public education, this report splits home electrical fires into two groups, based on data from two separate data elements in the National Fire Incident Reporting System (NFIRS):

1. Fires in which electrical failure or malfunction is a factor contributing to ignition.
2. Fires involving electrical distribution and lighting equipment. These are fires in which electrical distribution or lighting equipment are somehow involved in a fire's ignition. The form of involvement could include electrical failure or malfunction but may also involve other types of involvement, such as serving as a heat source by being in close proximity to combustible material or by overloaded equipment.

Figure 1 shows the types of equipment involved in home fires in which electrical failure or malfunction contributed to ignition. As indicated, electrical distribution and lighting equipment accounts for half of these fires.

Figure 1. Home Fires Involving Electrical Failure or Malfunction by Equipment Involved in Ignition 2012-2016



Home Fires Involving Electrical Failure or Malfunction

Electrical failures or malfunctions are a leading factor in the ignition of fires in U.S. homes. Electrical failures or malfunctions were responsible for 13% of home structure fires in 2012-2016, ranking as the second leading contributing factor behind fires caused by unattended equipment. Electrical failure or malfunction fires also accounted for nearly one-fifth (18%) of civilian deaths (the second leading contributing factor behind fires caused by heat sources too close to combustibles), 11% of civilian injuries, and accounted for the greatest share of direct property damage (20%).

TYPES OF ELECTRICAL FAILURE OR MALFUNCTION CONTRIBUTING TO THE IGNITION OF HOME FIRES

As shown in [Figure 2](#), home fires due to electrical failure or malfunction primarily involve some form of arcing, which results from an unintentional discharge of electrical current between conductors. Given sufficient time and level of current, arc faults can produce enough heat to ignite a fire. Arc faults are produced by damaged conductors and connectors and may involve damaged wiring, frayed appliance cords, loose connections in wall outlets, or faulty switches and junction boxes. Arc faults may originate in different areas of the home or virtually any electrical fixture or equipment.

Electrical fault sparks fire that displaces residents

An electrical fault in a ceiling fan was blamed for an early morning fire in a multifamily residence.

Firefighters were dispatched to the fire following a 911 call from one of the occupants after a smoke alarm in his unit activated just after midnight. On arrival, crews reported fire on the second floor of a two-and-a-half-story wood-frame structure.

The fire escalated to four alarms before firefighters were able to knock it down. News reports indicated that 11 occupants were displaced by the fire, but none were injured. One firefighter was reported to have suffered a back injury at the scene.

Investigators determined that the fire was caused by an electrical short circuit in a ceiling fan in a second-floor bathroom.

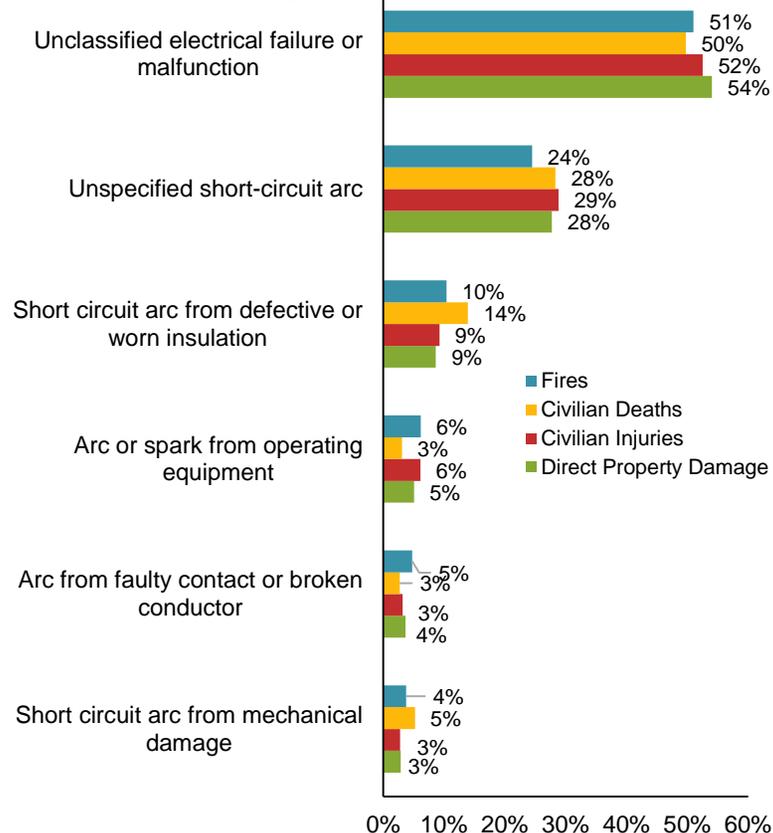
The building was composed of five residential units. According to news reports, a city inspector indicated that he did not find the number of smoke alarms in the building that were required by municipal codes. The building did not have sprinkler protection.

The fire caused an estimated \$500,000 in damage to the structure and an additional \$500,000 in damage to its contents.

Source: Richard Campbell, "Firewatch," *NFPA Journal*, July/August, 2018.

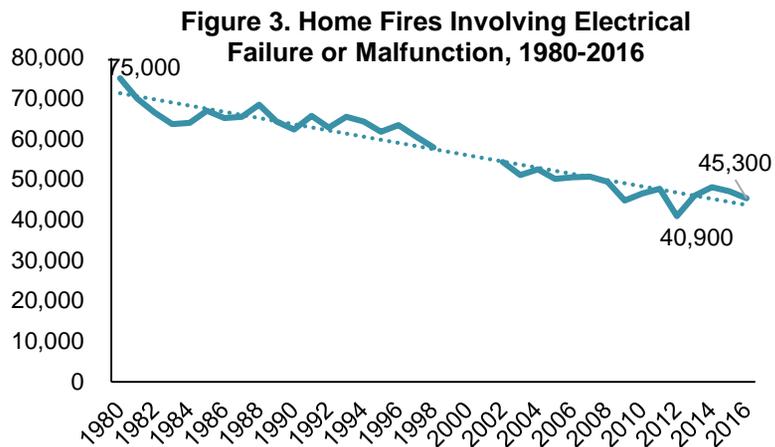
- Short circuits from defective and worn insulation caused 14% of civilian home fire deaths as shown in Figure 2. This can be caused when cords are pinched by doors or furniture or through repetitive flexing of appliance cords. It can also be due to damaged wiring inside walls from nails, screws, or drill bits that puncture insulation during ordinary activities like hanging a picture. Even electrical cords running under carpets can generate enough heat to produce an arc fault.
- Aging electrical systems in older homes can be a source of arc faults, either through normal wear and tear or because the systems cannot accommodate the greater demands of modern appliances. Circuits can also be overloaded by providing electricity to too many appliances, often through power cords.

Figure 2. Home Fires Involving Electrical Failure or Malfunction by Factor Contributing to Ignition, 2012-2016*



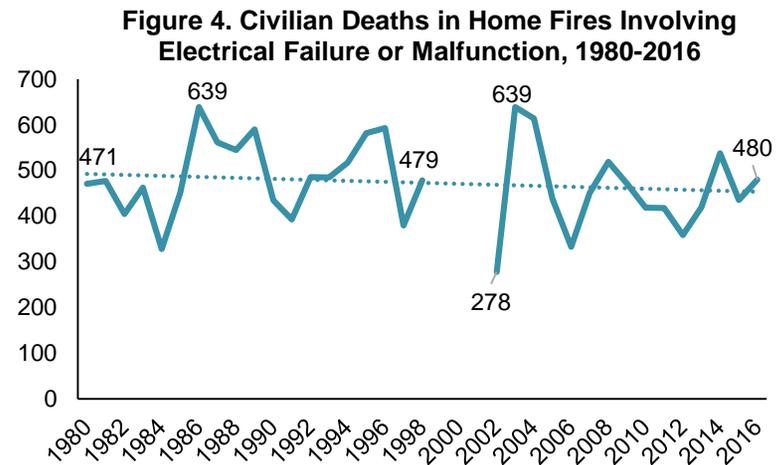
TRENDS IN HOME FIRES INVOLVING ELECTRICAL FAILURE OR MALFUNCTION

The number of home fires involving electrical failure or malfunction has followed a distinct downward trend since 1980, despite year-to-year fluctuations. From a peak of 75,000 fires in 1980, the estimated number of fires involving electrical failure or malfunction has fallen to fewer than 60,000 annual fires since 1998 and fewer than 50,000 each year since 2008, with the 40,900 fires in 2012 representing a new low point (Figure 3).



Note: Because of low participation in NFIRS Version 5.0 during 1999-2001, data from these years is not reported in these graphs.

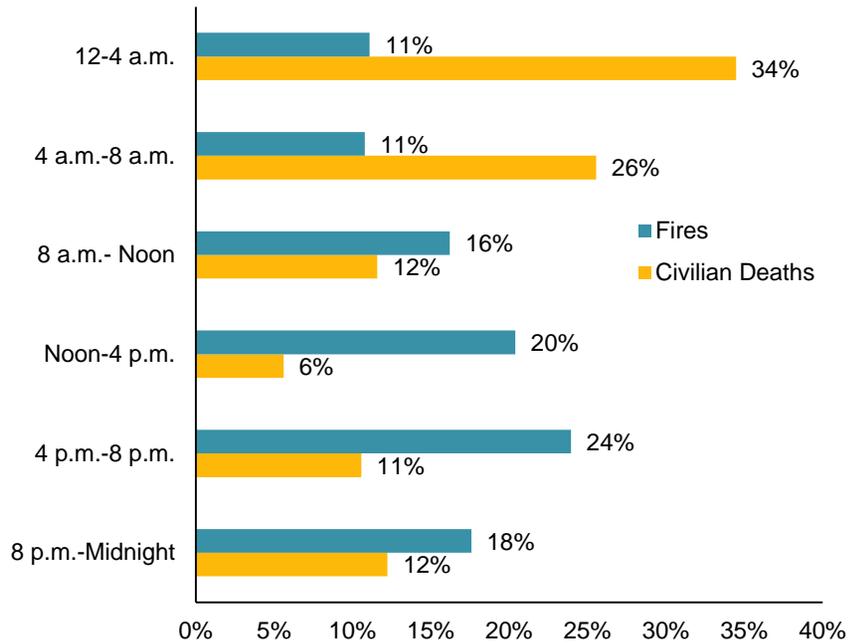
A recent NFPA report on home structure fires by Marty Ahrens found that overall home structure fires have plateaued over the past two decades. The continued, if uneven, decline in home fires involving electrical failure or malfunction over this same period suggests that this is an area of relative progress. The data indicate that civilian deaths in these fires have not followed a similar downward trend to that seen in fires, showing distinct fluctuations from year to year (Figure 4).



WHEN DO HOME FIRES INVOLVING ELECTRICAL FAILURE OR MALFUNCTION OCCUR?

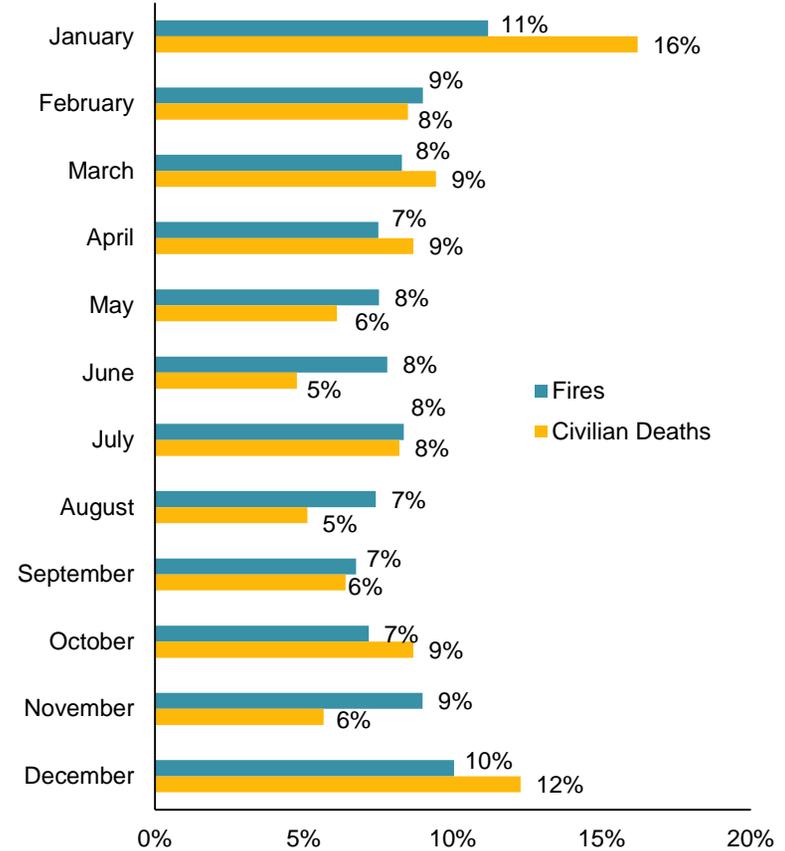
Home fires involving electrical failure or malfunction are less likely to occur in the overnight hours between midnight and 8 a.m. (22% of total), but these fires account for 60% of the civilian deaths. Fires that occur during the night when most people are asleep are more likely to be fatal. Working smoke alarms can provide an early warning of fire and allow additional time for evacuation.

Figure 5. Home Fires Involving Electrical Failure or Malfunction, by Time of Day 2012-2016



The peak months for home fires involving electrical failure or malfunction are November through March (47% of total), and these fires account for 52% of the civilian deaths. This is the time of year when more time is spent indoors, leading to an increased use of electrical equipment.

Figure 6. Home Fires Involving Electrical Failure or Malfunction by Month 2012-2016

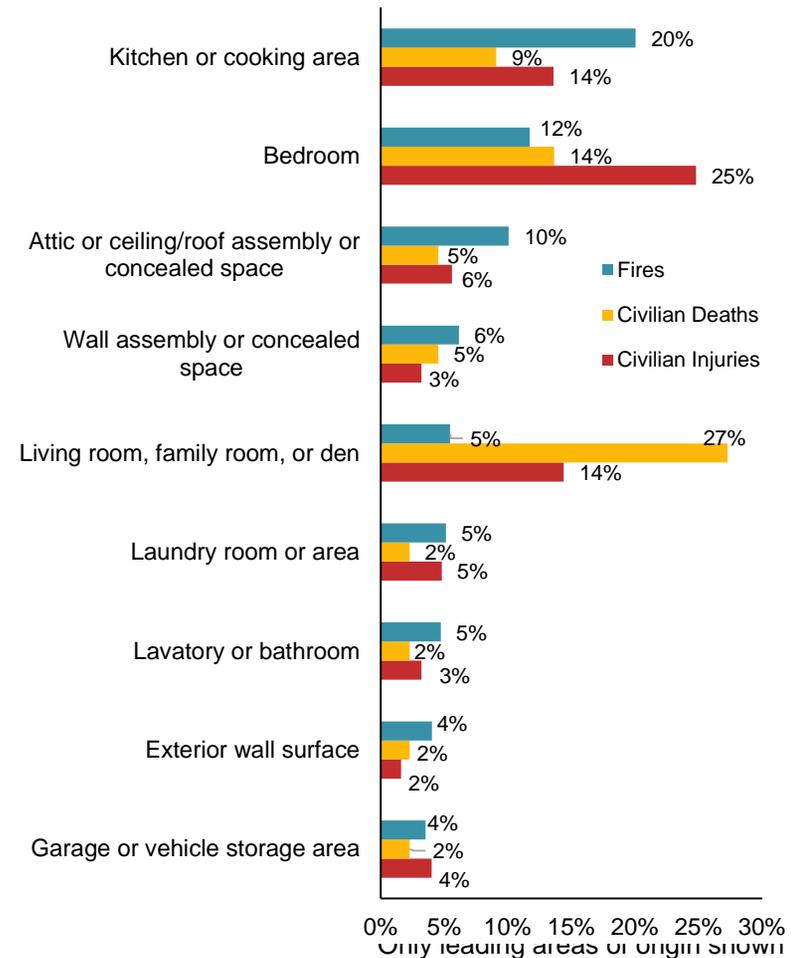


AREA OF ORIGIN IN HOME FIRES INVOLVING ELECTRICAL FAILURE OR MALFUNCTION

One in five home fires (20%) involving electrical failure or malfunction originated in a kitchen or cooking area, with another 12% originating in a bedroom and 10% originating in an attic or ceiling/roof assembly or concealed space. Electrical failures or malfunctions within the wall assembly or concealed space is the fourth leading area of origin for these fires.

Fires originating in a living room, family room, or den accounted for a disproportionately large share of civilian deaths, while those originating in a bedroom accounted for a disproportionately large share of civilian injuries.

Figure 7. Area of Origin in Home Fires Involving Electrical Failure or Malfunction 2012-2016*



Home Fires Involving Electrical Distribution and Lighting Equipment

Electrical distribution and lighting equipment was the third leading type of equipment involved in fires in U.S. homes in 2012-2016, accounting for 10% of fires (behind cooking equipment and heating equipment). These fires accounted for a disproportionate share of home fire deaths (19%) and direct property damage (20%), as well as 10% of civilian injuries.

The previously mentioned change in data entry rules for incidents with an equipment-related heat source or factor contributing to ignition in 2012 is likely to have influenced estimates of electrical distribution and lighting equipment fires.

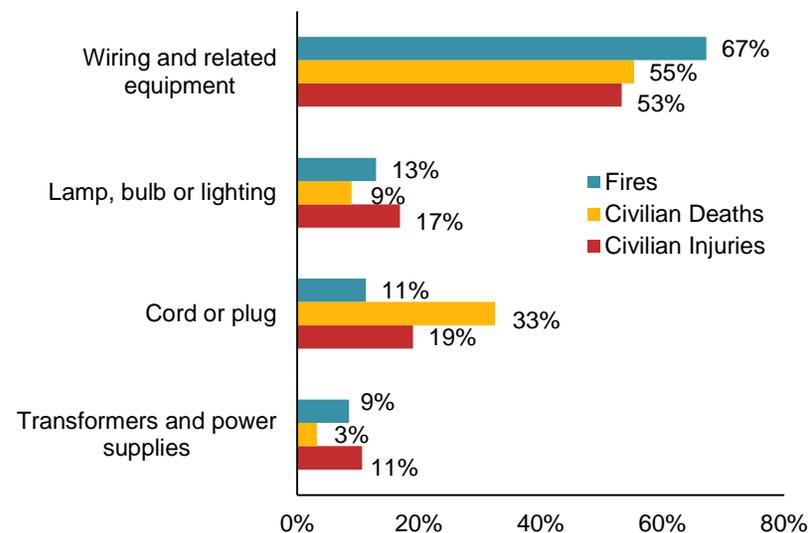
TYPES OF ELECTRICAL DISTRIBUTION AND LIGHTING EQUIPMENT INVOLVED IN HOME FIRES

As shown in Figure 8, wiring and related equipment accounted for two-thirds of home fires caused by electrical distribution and lighting equipment and the same share of direct property damage, as well as over half of the civilian deaths and injuries.

Faulty wiring in concealed spaces, such as attics or behind walls, is particularly dangerous because it can start fires that burn for a prolonged period of time before detection.

Aluminum wire connections have been found to be prone to deterioration that results in increased resistance to electric current, with the cumulative damage capable of producing hazardous overheating, leading the Consumer Product Safety Commission (CPSC) to recommend that home aluminum wiring be replaced or repaired by a qualified electrician to reduce the potential for fire.

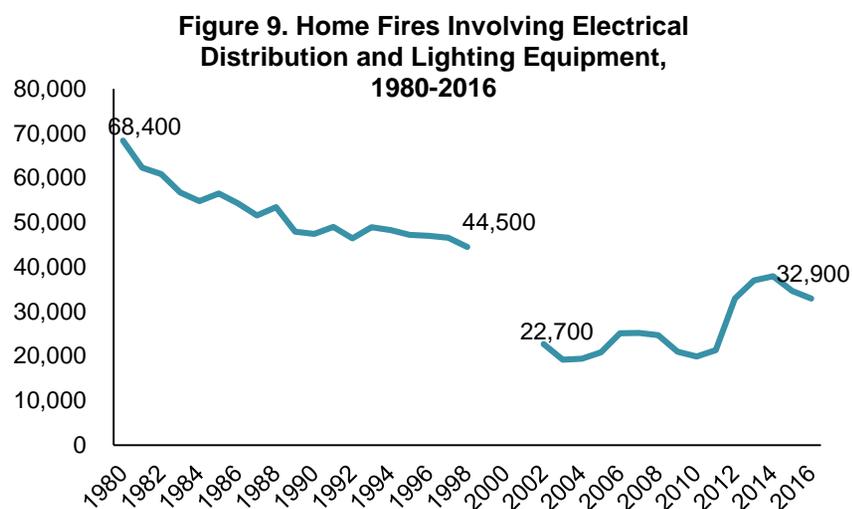
Figure 8. Types of Electrical Distribution or Lighting Equipment Involved in Home Fires, 2012-2016*



*All data in this section are non-confined fires only.

TRENDS IN HOME FIRES INVOLVING ELECTRICAL DISTRIBUTION AND LIGHTING EQUIPMENT

Home fires involving electrical distribution or lighting equipment showed a steady downward trend between 1980 and 1998, declining by about one-third during this period. See Figure 9. Following the introduction of a new version of NFIRS (NFIRS 5.0) and a transition period of 1999-2001, the downward trend was arrested and even reversed between 2011 and 2014 before falling again in 2015 and 2016, although fires are still well below those reported prior to 1999. A 2012 change in NFIRS data entry rules which required a valid entry in the “equipment involved in ignition” field for incidents having an equipment-related heat source or contributing factor had the largest impact on estimates of electrical distribution or lighting equipment fires.



Note: Because of low participation in NFIRS Version 5.0 during 1999-2001, data from these years is not reported in this graph.

Electrical wiring causes house fire that kills elderly resident

An elderly resident died when degraded electrical wiring ignited combustible material in a wall cavity in the kitchen of his residence.

The fire department was summoned to the scene following a neighbor’s call to 911 at 1:15 a.m., but investigators estimated that the fire had burned for an hour before it was detected.

According to news reports, firefighters found flames shooting from the rear of the house upon arrival, but they located the victim on a couch in a front room and quickly rushed him to the hospital. The victim, who had a mobility disability, succumbed to smoke inhalation injuries shortly afterwards.

Reports indicated that the resident had an unspecified physical disability.

The house was equipped with smoke alarms in the living room, bedroom, and on the second floor, and the engine company indicated that they were activated by the fire. It did not have sprinkler protection.

The house was a two story building with brick walls, a wooden roof frame, and an asphalt roof deck. It occupied a ground floor area of 700 square feet (65 square meters).

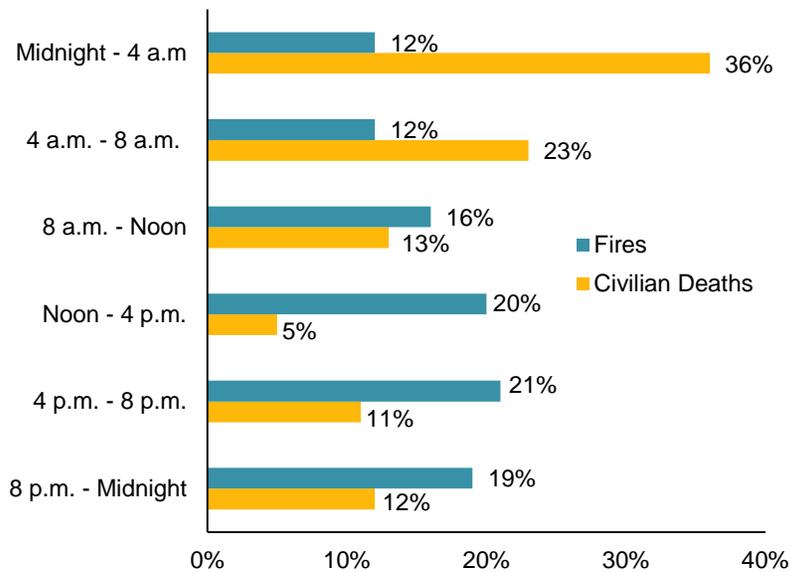
The house, valued at \$80,000, and its contents, with an estimated value of \$50,000, were a total loss.

Source: Richard Campbell, “Firewatch,” *NFPA Journal*, January/February, 2017.

WHEN DO HOME FIRES INVOLVING ELECTRICAL DISTRIBUTION AND LIGHTING EQUIPMENT OCCUR?

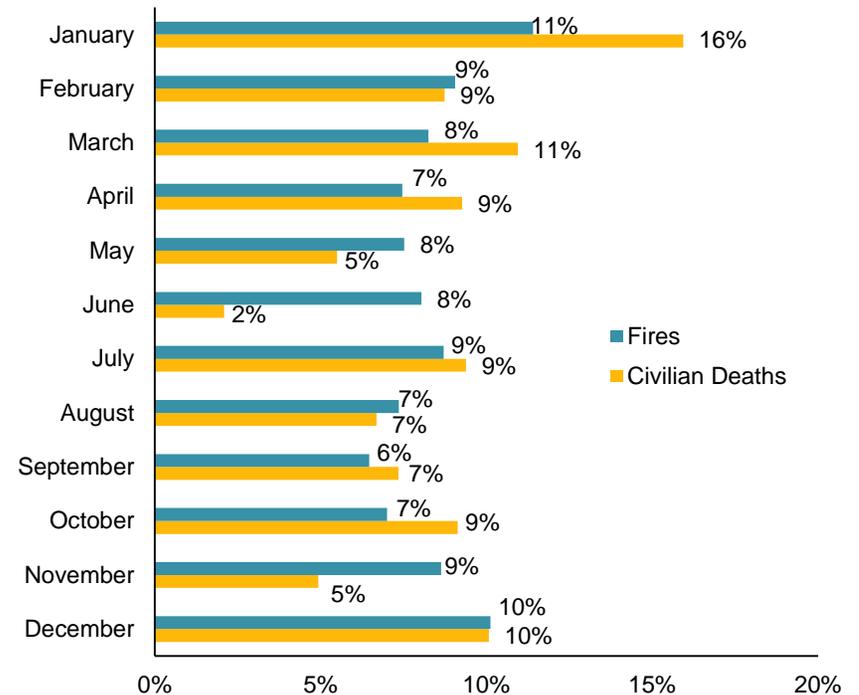
Home fires involving electrical distribution and lighting equipment are less likely to occur in the overnight hours between midnight and 8 a.m. (24% of total), but these fires account for three of five (59%) of the civilian deaths, reflecting the likelihood that people are more apt to be in the home and asleep than in the daytime hours. See Figure 10.

Figure 10. Home Fires Involving Electrical Distribution and Lighting Equipment by Time of Day, 2012-2016



As with fires caused by electrical failure or malfunction, the peak months for home fires involving electrical distribution or lighting equipment are November through March (47% of total). These fires also account for 51% of civilian deaths. This again is likely to reflect the greater tendency for people to be in the home and using electrical equipment during the cold weather months. Another one-quarter (24%) of fires occur from May through July. See Figure 11.

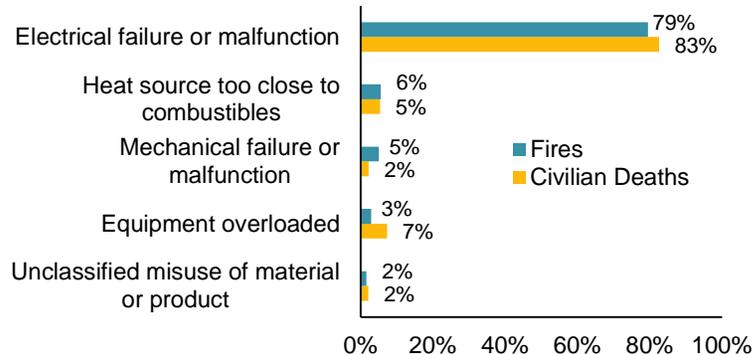
Figure 11. Home Fires Involving Electrical Distribution and Lighting Equipment by Month 2012-2016



FACTORS CONTRIBUTING TO THE IGNITION OF HOME FIRES INVOLVING ELECTRICAL DISTRIBUTION OR LIGHTING EQUIPMENT

Electrical failures or malfunctions were a factor contributing to the ignition of nearly four of five home fires (79%) involving electrical distribution or lighting equipment, and these fires accounted for 83% of civilian deaths. Other factors contributing to home fires involving electrical distribution and lighting equipment included heat sources being too close to combustibles, mechanical failures or malfunctions, overloaded equipment, and unclassified misuse of productions or materials.

Figure 12. Factors Contributing to the Ignition of Home Fires Involving Electrical Distribution and Lighting Equipment, 2012-2016*



*All data in this section is for non-confined fires only.

Some differences can be observed between specific types of electrical distribution and lighting equipment in relation to factors contributing to the ignition of fires. For instance, electrical failure or malfunction is a factor in nearly nine of ten home fires involving wiring and related equipment (Figure 13), but just less than half of those involving lamps, bulbs, or lighting (Figure 14). Approximately three in ten of the latter fires are caused by lamps, bulbs, or lighting being too close to combustible material.

In home fires involving cords and plugs, in addition to the fires involving electrical failure or malfunction (three-quarters of the total), overloaded equipment contributed to just over one in ten fires, as shown in Figure 15.

Electrical failure or malfunction also accounted for a smaller share of home fires involving transformers and power supplies (65%) than those involving wiring and related equipment or cords and plugs, but higher shares of these fires involved mechanical failures or malfunctions (9%), heat sources too close to combustibles (8%), and equipment overloaded (6%), as shown in Figure 16.

Figure 13. Factors Contributing to the Ignition of Home Fires Involving Wiring and Related Equipment, 2012-2016

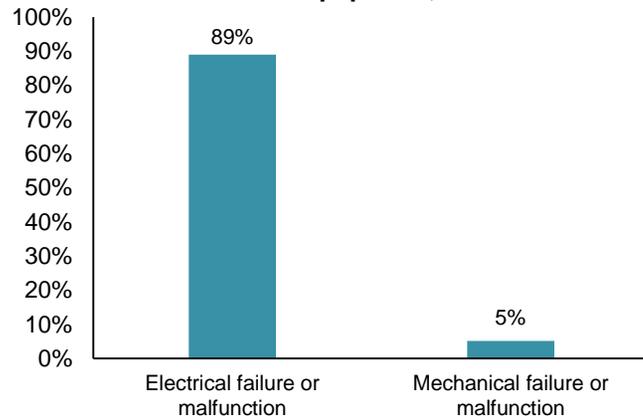


Figure 14. Factors Contributing to the Ignition of Home Fires Involving Lamps, Bulbs, or Lighting, 2012-2016

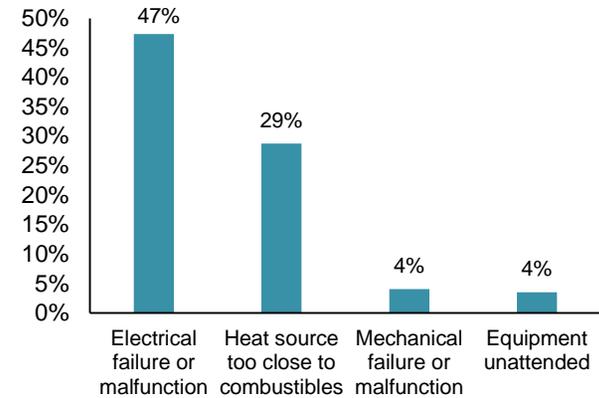


Figure 15. Factors Contributing to the Ignition of Home Fires Involving Cords or Plugs, 2012-2016

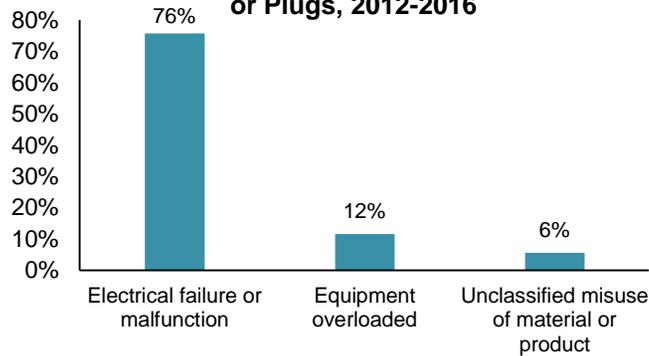
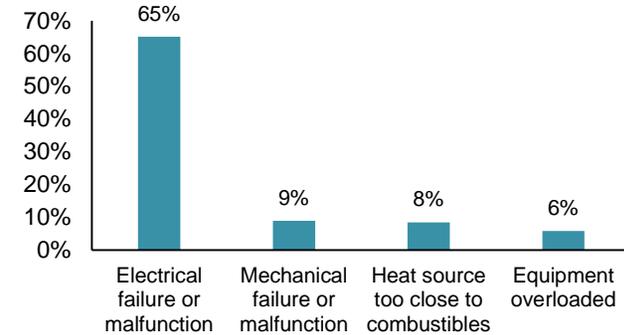


Figure 16. Factors Contributing to the Ignition of Home Fires Involving Transformers and Power Supplies 2012-2016

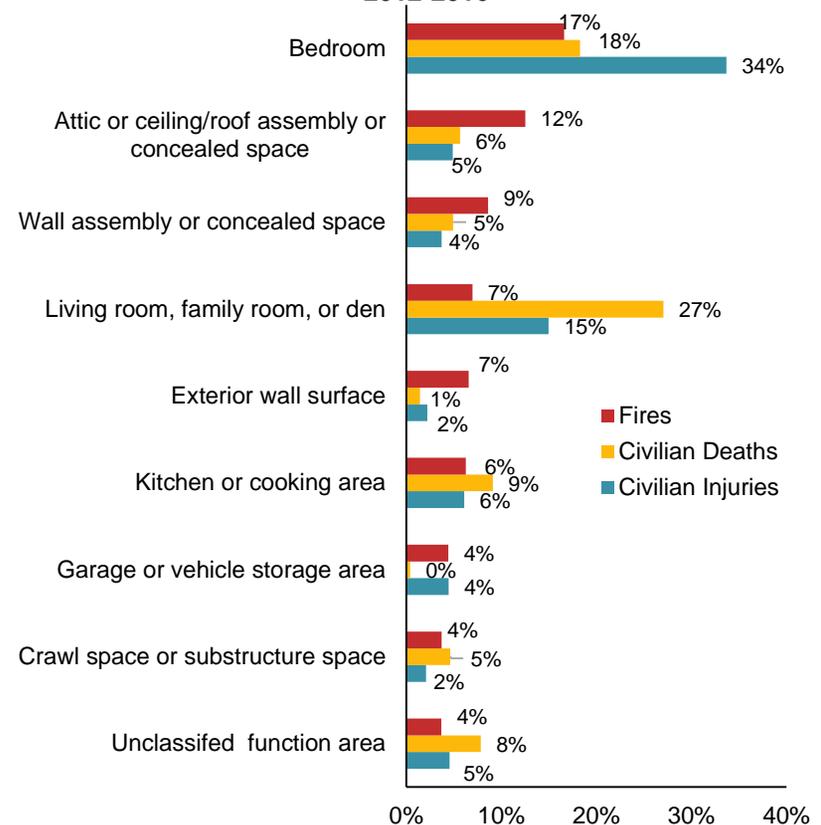


AREA OF ORIGIN IN HOME FIRES INVOLVING ELECTRICAL DISTRIBUTION OR LIGHTING EQUIPMENT

Almost one in five home fires (17%) involving electrical distribution or lighting equipment originated in a bedroom, with another 12% originating in an attic or ceiling/roof assembly or concealed space. Fires originating in a living room, family room, or den accounted for a disproportionately large share of civilian deaths, while those originating in a bedroom accounted for a disproportionately large share of civilian injuries. Fires originating in concealed spaces, such as attics or ceiling roof assemblies, wall assemblies, and crawl spaces, were also common.

Although the bedroom is the leading area of origin for overall electrical distribution and lighting equipment home fires, there are some differences by type of equipment. Figure 18 shows that fires involving wiring and related equipment, which accounts for the great majority of these fires (67%), are most likely to originate in the attic or ceiling/roof assembly or concealed space (16% of total), followed by bedrooms (13%), and wall assemblies or concealed spaces (12%). Hence, over two of five (42%) of the wiring and related equipment fires originate in areas where they are unlikely to be immediately detected.

Figure 17. Area of Origin in Home Fires Involving Electrical Distribution or Lighting Equipment 2012-2016



The bedroom is the leading area of origin in home fires involving lamps, bulbs, or lighting, cords or plugs, and transformers and power supplies. As Figure 19 shows, lamp, bulb, and lighting fires can also originate in areas that may not be readily detected, including attics or ceiling/roof assemblies or concealed spaces, exterior wall surfaces, ceilings/floor assemblies or concealed spaces, and exterior balconies.

Figure 18. Area of Origin in Home Fires Involving Wiring and Related Equipment, 2012-2016

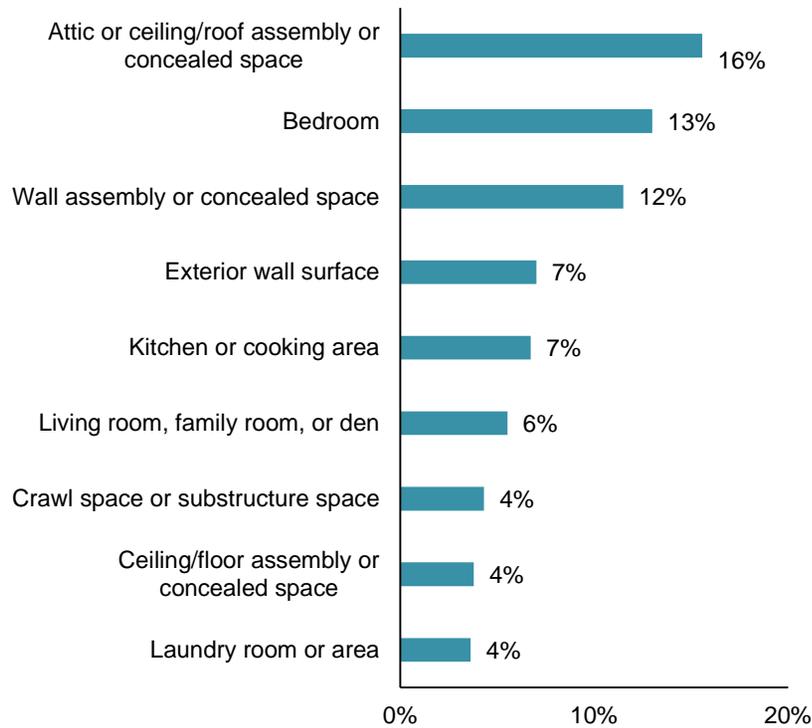


Figure 20 indicates that fires involving cords and plugs are less likely to originate in concealed areas, with nearly half of the fires originating in either the bedroom, living room, family room, or den.

Of home fires involving electrical distribution or lighting equipment that originated in a garage or vehicle storage area, the largest share were those involving transformers and power cords, as shown in Figure 21.

Figure 19. Area of Origin in Home Fires Involving Lamps, Bulbs, or Lighting 2012-2016

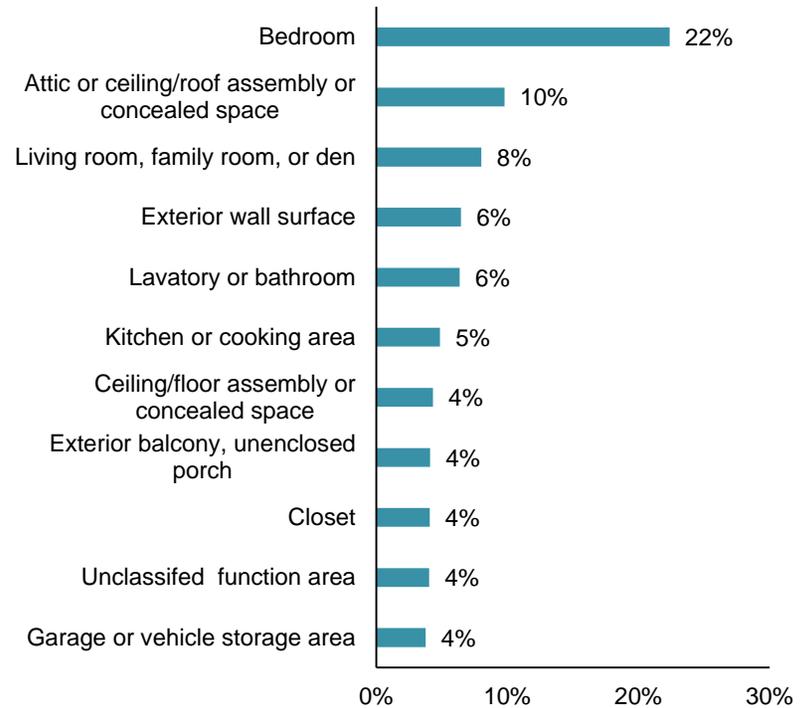


Figure 20. Area of Origin in Home Fires Involving Cords or Plugs, 2012-2016

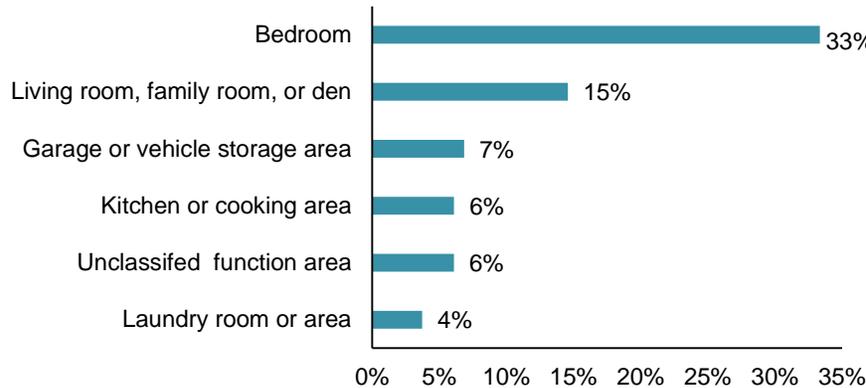
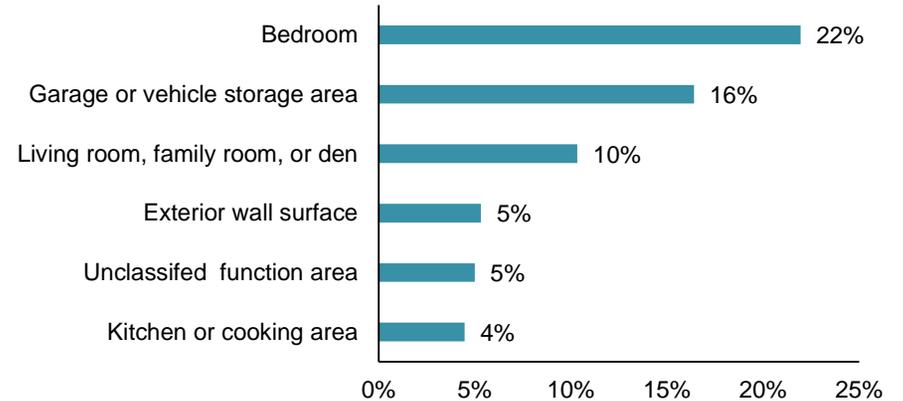


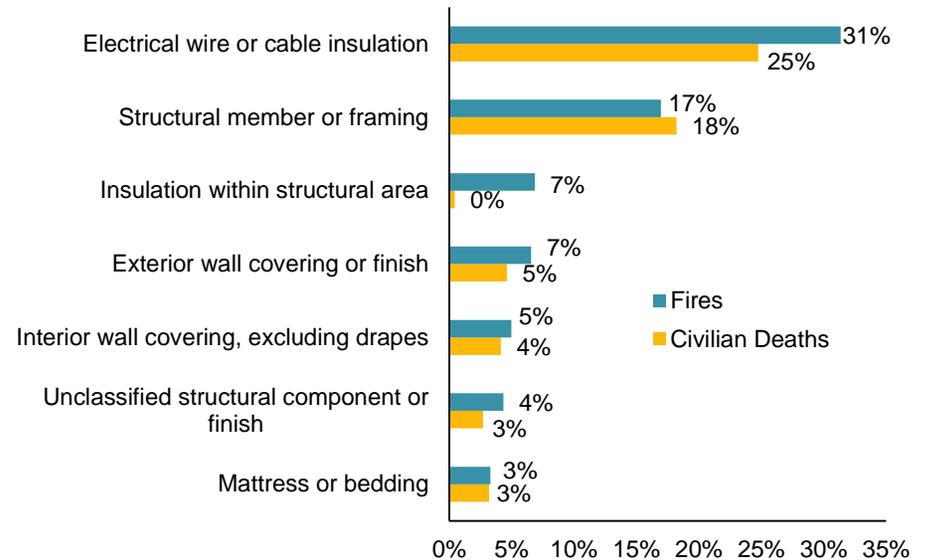
Figure 21. Area of Origin in Home Fires Involving Transformers and Power Supplies, 2012-2016



HOME FIRES INVOLVING ELECTRICAL DISTRIBUTION AND LIGHTING EQUIPMENT BY ITEM FIRST IGNITED

The item that first ignited in home fires involving electrical distribution and lighting equipment was electrical wire or cable insulation (31% of fires). Two of five fires (40%) involving electrical distribution and lighting equipment first ignited an item that was part of the building (i.e., structural member or framing, insulation within building area, exterior or interior wall cover or finish, unclassified structural component or finish). See Figure 22. This indicates the need to be attentive to hidden electrical hazards, including electrical distribution and lighting equipment that is installed close to combustible structural elements.

Figure 22. Item First Ignited in Home Fires Involving Electrical Distribution or Lighting Equipment 2012-2016



Methodology

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. 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.

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

The NFIRS data element of Factors Contributing to Ignition was used to identify and estimate electrical failures or malfunctions. In this field, the code "none" is treated as an unknown and allocated proportionally. Multiple entries are allowed in this field. Percentages are calculated on the total number of fires, not entries, resulting in sums greater than 100%. Any fire in which no factor contributing to ignition was entered was treated as unknown.

Entries in the "electrical failure, malfunction" category (factor contributing to ignition 30-39) were grouped together in this analysis.

This category includes:

31. Water-caused short circuit arc
32. Short-circuit arc from mechanical damage
33. Short-circuit arc from defective or worn insulation
34. Unspecified short circuit arc
35. Arc from faulty contact or broken connector, including broken power lines and loose connections
36. Arc or spark from operating equipment, switch, or electric fence
37. Fluorescent light ballast
30. Electrical failure or malfunction, other

NFIRS data element Equipment Involved in Ignition (EII) codes 200-263 were used to identify and estimate electrical distribution and lighting equipment as identified by NFIRS.

NFPA noticed that many fires in which EII was coded as None (NNN) have had other causal factors that indicated equipment was a factor or were completely unknown. To compensate, NFPA treats fires in which EII = NNN and heat source is not in the range of 40-99 as an additional unknown.

To allocate unknown data for EII, known data is multiplied by

$$\frac{\text{All fires}}{(\text{All fires} - \text{blank} - \text{undetermined} - [\text{fires in which EII} = \text{NNN and heat source} \in \{40-99\}])}$$

In addition, fires and losses associated with code EII 200, "electrical distribution, lighting, and power transfer, other," were allocated proportionally across specific kitchen and equipment codes EII codes, 211-263. Equipment that is totally unclassified (EII code 000) was not allocated further. Unfortunately, equipment that is truly different is erroneously assigned to other categories.

Because of the large number of specific EII codes, most have been grouped into more general categories.

Code Grouping	EII Code	NFIRS definition		
Fixed wiring and related equipment	210	Unclassified electrical wiring	236 Sodium or mercury vapor light fixture or lamp	
	211	Electrical power or utility line	237 Work or trouble light	
	212	Electrical service supply wires from utility	238 Light bulb	
	213	Electric meter or meter box	241 Nightlight	
	214	Wiring from meter box to circuit breaker	242 Decorative lights – line voltage	
	215	Panel board, switch board or circuit breaker board	243 Decorative or landscape lighting – low voltage	
	216	Electrical branch circuit	244 Sign	
	217	Outlet or receptacle		
	218	Wall switch		
	219	Ground fault interrupter		
			Cord or plug	260 Unclassified cord or plug
				261 Power cord or plug, detachable from appliance
				262 Power cord or plug- permanently attached
				263 Extension cord
Transformers and power supplies	221	Distribution-type transformer		
	222	Overcurrent, disconnect equipment		
	223	Low-voltage transformer		
	224	Generator		
	225	Inverter		
	226	Uninterrupted power supply (UPS)		
	227	Surge protector		
	228	Battery charger or rectifier		
	229	Battery (all types)		
Lamp, bulb or lighting	230	Unclassified lamp or lighting		
	231	Lamp-tabletop, floor or desk		
	232	Lantern or flashlight		
	233	Incandescent lighting fixture		
	234	Fluorescent light fixture or ballast		
	235	Halogen light fixture or lamp		

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

Acknowledgements

The National Fire Protection Association thanks all the fire departments and state fire authorities that participate in the National Fire Incident Reporting System (NFIRS) and the annual NFPA fire experience survey. These firefighters are the original sources of the detailed data that make this analysis possible. Their contributions allow us to estimate the size of the fire problem.

We are also grateful to the U.S. Fire Administration for its work in developing, coordinating, and maintaining NFIRS.

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