FIREWORKS

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Acknowledgements

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We are also grateful to the U.S. Fire Administration for its work in developing, coordinating, and maintaining NFIRS. And we appreciate the important work done by the U.S. Consumer Product Safety Commission to develop, maintain, and support analysis of the National Electronic Injury Surveillance System (NEISS) and the National Center for Health Statistics and the National Safety Council for maintenance and analysis of the U.S. death certificate data base.

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Executive Summary

In 2003, 9,300 fireworks-related were treated in a hospital emergency room. The trend in fireworks-related injuries has been up and down since 1996, with a net increase as of 2003. An unusually large number of injuries occurred in 2000, with most of the difference associated with New Year's celebrations of the last year of the millennium. Injuries were higher in 1984-1995 than in recent years but lower in the mid-1970s and earlier.

In 2002, there were 3,000 reported structure or vehicle fires started by fireworks. This was the fourth consecutive year in which the total increased. These fires resulted in no reported civilian deaths, 60 civilian injuries, and $29 million in direct property damage.

In 1997-2001, 8 people per year were killed in fires started by fireworks, while 7 people per year were killed directly by fireworks.

In 2003, 100 people were killed in a Rhode Island nightclub fire ignited by the indoor use of pyrotechnics in a small, crowded room with wall linings that promoted rapid flame spread. The facility had no sprinkler protection.

As in most years, the majority of victims of fireworks injuries in 2003 were under age 20. The highest injury rates were for children aged 5 to 9, whose relative risk compared to other age groups has been increasing in recent years. Males accounted for nearly three-fourths (72%) of fireworks injuries.

In 2003, five out of six (84%) emergency room fireworks injuries involved fireworks that Federal regulations permit consumers to use.

The risk of fire death relative to exposure shows fireworks as the most risky consumer product.

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Size of the Fireworks Problem

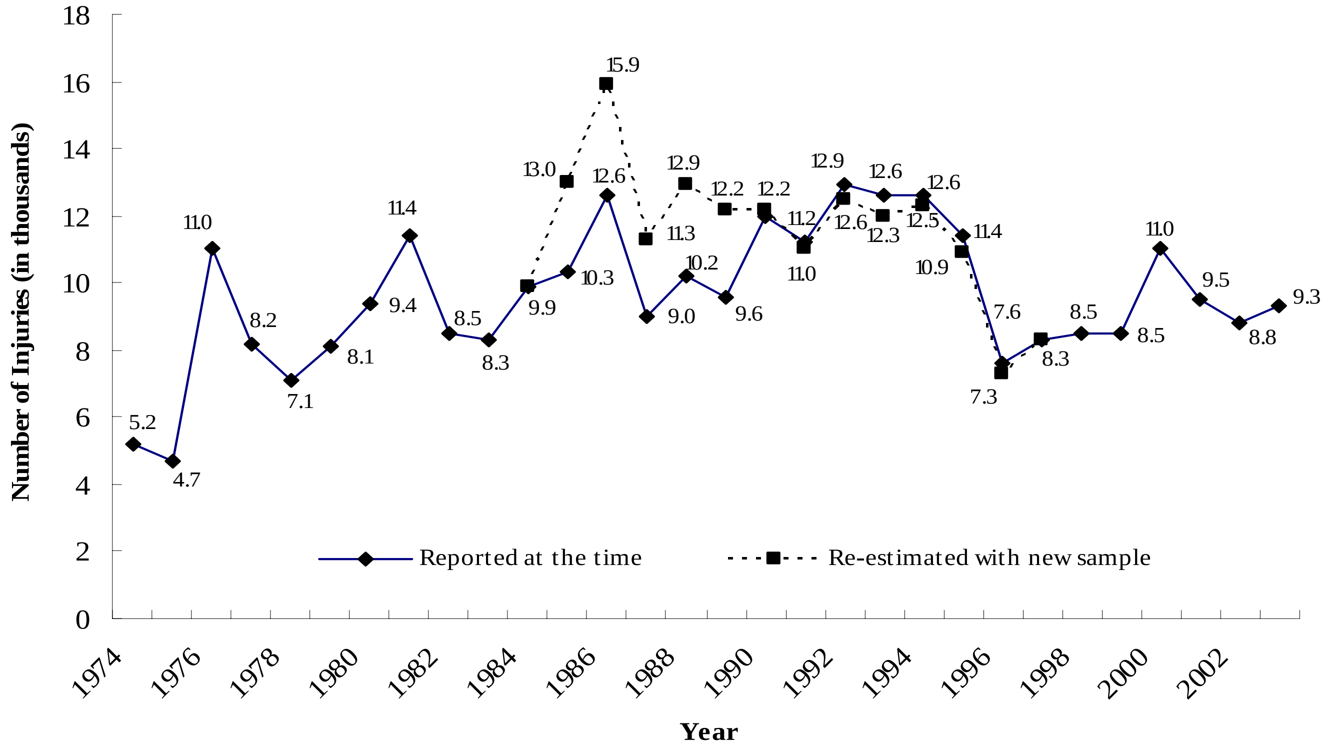
In 2003, 9,300 fireworks-related injuries were treated in a hospital emergency room. The trend in fireworks-related injuries has been up and down since 1996, with a net increase as of 2003. An unusually large number of injuries occurred in 2000, with most of the difference associated with New Year's celebrations of the last year of the millennium. Injuries were higher in 1984-1995 than in recent years but lower in the mid-1970s and earlier. (See Figure 1.)

In 2002, there were 3,000 reported structure or vehicle fires started by fireworks. This was the fourth consecutive year in which the total increased. These fires resulted in no reported civilian deaths, 60 civilian injuries, and $29 million in direct property damage. (See Table 1.) Each year, most fireworks-related fires begin in outdoor brush or refuse, but most of the loss occurs in fires with structures involved. These fires can start with outdoor use of fireworks, as when a bottle rocket, launched outside, lands on a roof or other location not easily accessed, where it can ignite combustibles before anyone can retrieve it. Because cause information is no longer required for outdoor refuse fires, statistics for outdoor refuse fires by cause cannot be calculated and so no outdoor-fire statistics are shown here.

In 1997-2001, an estimated 8 people per year were killed in reported fires started by fireworks, while 7 people per year were killed directly by fireworks.
Deaths involving fireworks are identified from two data sources, which may partially or largely overlap, because fireworks can kill directly and also start fires. (See Table 2.) The period of 1997-2001 is the latest 5-year period for which there is official data from death certificates. In both data bases, the death toll varies substantially from year to year, making trend analysis meaningless. As Figure 1 and Table 1 demonstrate, most non-fatal injuries due to fireworks do not occur in the context of a reported fire. For both fatal and non-fatal injuries, it is clear that fireworks can injure directly via a traumatic injury or indirectly via a fire injury from a fire initiated by the fireworks. As for non-fatal injuries, the available statistics also omit injuries that are treated in doctor's offices or are untreated.

In 2003, 100 people were killed in a Rhode Island nightclub fire ignited by the indoor use of pyrotechnics in a small, crowded room with wall linings that promoted rapid flame spread. The facility had no sprinkler protection.

Figure 1.
Fireworks-Related Injuries Reported to Hospital Emergency Rooms



Source: CPSC's NEISS

Table 1. Fires and Losses Associated With Fireworks, 1980-2002
Fires Reported to U.S. Fire Departments

A. Fires

Year	Home Structures	Other Residential Structures	Nonresidential Structures	Total Structures	Vehicles
1980	2,900	100	1,100	4,000	500
1981	2,800	100	1,300	4,200	500
1982	1,700	100	1,000	2,700	500
1983	1,400	100	800	2,300	500
1984	2,400	100	1,200	3,700	1,000
1985	2,600	100	1,500	4,100	900
1986	2,300	100	1,200	3,600	1,000
1987	1,900	100	1,100	3,100	800
1988	2,300	100	1,400	3,700	900
1989	1,700	100	900	2,700	800
1990	1,600	100	800	2,500	800
1991	1,600	100	900	2,600	900
1992	1,400	0	900	2,300	700
1993	1,300	0	800	2,100	800
1994	1,300	0	900	2,200	700
1995	1,100	0	700	1,900	700
1996	1,100	0	600	1,700	600
1997	1,000	0	700	1,700	500
1998	800	0	500	1,400	500
1999	1,000	0	700	1,700	500
2000	1,000	0	600	1,700	600
2001	1,200	100	700	2,000	700
2002	1,300	100	800	2,200	800

Note: These 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. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest hundred, civilian deaths are expressed to the nearest one, civilian injuries are expressed to the nearest ten, and property damage is rounded to the nearest million dollars. Figures reflect a proportional share of fires with heat source unknown. Inflation adjustment to 2002 dollars is done using the consumer price index.

Source: NFIRS and NFPA survey.

Table 1. Fires and Losses Associated With Fireworks, 1980-2002 Fires Reported to U.S. Fire Departments (Continued)

B. Civilian Deaths

Year	Home Structures	Other Residential Structures	Nonresidential Structures	Total Structures	Vehicles
1980	0	0	0	0	0
1981	0	0	0	0	0
1982	0	0	0	0	0
1983	0	0	0	0	0
1984	3	0	0	3	0
1985	8	0	0	8	3
1986	4	0	0	4	0
1987	4	0	3	7	0
1988	20	0	0	20	0
1989	4	0	0	4	0
1990	3	0	0	3	0
1991	0	0	0	0	2
1992	0	0	0	0	0
1993	0	0	0	0	0
1994	12	0	0	12	0
1995	0	0	0	0	0
1996	9	0	18*	27	0
1997	0	0	0	0	0
1998	0	0	0	0	0
1999	5	0	6	12	0
2000	27	0	0	27	0
2001	0	0	0	0	0
2002	0	0	0	0	0

*Inflated by statistical projection of one Ohio fire with nine deaths.

Note: These 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. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest hundred, civilian deaths are expressed to the nearest one, civilian injuries are expressed to the nearest ten, and property damage is rounded to the nearest million dollars. Figures reflect a proportional share of fires with heat source unknown. Inflation adjustment to 2002 dollars is done using the consumer price index.

Source: NFIRS and NFPA survey.

Table 1. Fires and Losses Associated With Fireworks, 1980-2002 Fires Reported to U.S. Fire Departments (Continued)

C. Civilian Injuries

Year	Home Structures	Other Residential Structures	Nonresidential Structures	Total Structures	Vehicles
1980	30	10	0	30	0
1981	30	0	20	50	0
1982	10	0	20	30	0
1983	50	0	0	50	0
1984	40	0	10	50	10
1985	70	10	10	80	30
1986	50	10	50	100	0
1987	50	10	10	70	0
1988	40	0	20	50	20
1989	50	0	0	50	20
1990	30	10	10	50	0
1991	50	10	10	70	10
1992	40	0	10	50	10
1993	20	0	20	40	0
1994	90	0	10	100	10
1995	50	0	0	50	0
1996	20	0	20	40	0
1997	20	0	10	30	20
1998	10	0	0	10	10
1999	10	0	10	20	10
2000	10	0	10	20	0
2001	30	0	10	50	10
2002	40	10	0	50	10

Note: These 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. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest hundred, civilian deaths are expressed to the nearest one, civilian injuries are expressed to the nearest ten, and property damage is rounded to the nearest million dollars. Figures reflect a proportional share of fires with heat source unknown. Inflation adjustment to 2002 dollars is done using the consumer price index.

Source: NFIRS and NFPA survey.

Table 1. Fires and Losses Associated With Fireworks, 1980-2002 Fires Reported to U.S. Fire Departments (Continued)

D. Direct Property Damage (in Millions)

Year	Home Structures	Other Residential Structures	Nonresidential Structures	Total Structures	Total Structures in 2002 Dollars	Vehicles
1980	$12	$0	$3	$15	$32	$0
1981	$12	$0	$6	$18	$35	$0
1982	$9	$0	$2	$11	$20	$0
1983	$7	$0	$5	$12	$21	$0
1984	$19	$0	$6	$25	$42	$2
1985	$22	$1	$7	$30	$50	$1
1986	$24	$0	$29	$53	$88	$2
1987	$17	$0	$7	$24	$38	$1
1988	$22	$0	$14	$37	$56	$1
1989	$56	$0	$3	$59	$86	$1
1990	$22	$1	$4	$26	$36	$2
1991	$17	$0	$5	$21	$28	$2
1992	$13	$0	$16	$29	$38	$1
1993	$12	$0	$6	$19	$23	$1
1994	$10	$0	$8	$18	$21	$2
1995	$21	$1	$9	$30	$36	$2
1996	$12	$0	$7	$19	$22	$1
1997	$13	$0	$8	$21	$24	$1
1998	$9	$0	$3	$12	$13	$1
1999	$12	$0	$3	$15	$17	$1
2000	$13	$0	$12	$25	$26	$2
2001	$17	$0	$11	$28	$29	$3
2002	$18	$0	$8	$26	$26	$2

Note: These 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. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Fires are rounded to the nearest hundred, civilian deaths are expressed to the nearest one, civilian injuries are expressed to the nearest ten, and property damage is rounded to the nearest million dollars. Figures reflect a proportional share of fires with heat source unknown. Inflation adjustment to 2002 dollars is done using the consumer price index.
Source: NFIRS and NFPA survey.

Table 2. Deaths Associated With Fireworks Incidents, 1980-2003

Year	Estimated Civilian Deaths in Structure or Vehicle Fires Reported to U.S. Fire Departments	Recorded on U.S. Death Certificates
1980	0	10
1981	0	4
1982	0	5
1983	0	13
1984	3	7
1985	11	11
1986	4	8
1987	7	5
1988	20	4
1989	4	5
1990	3	5
1991	2	4
1992	0	2
1993	0	10
1994	12	4
1995	0	2
1996	27*	9
1997	0	8
1998	0	9
1999	12	7
2000	27	5
2001	0	6
2002	0	4***
2003	**	4***

*Inflated by statistical projection of one Ohio fire with nine deaths.

**Not yet available.

*** Death certificate figures for 2002 and 2003 are preliminary based on reports to the U.S. Consumer Product Safety Commission and exclude fireworks-caused fires, most notable the Station fire in 2003.

Note: In any year, the figures in these two columns may partially overlap if fireworks that directly kill also ignite a reported fire.

Sources: For death certificate tallies, *Injury Facts*, Chicago (1985-1992) and Itasca, IL (1993-2004): National Safety Council, 1985-2004. For national estimates of fire deaths, NFIRS and NFPA survey.

Characteristics of Fireworks Injuries

More than one-third (38%) of 2003 emergency room fireworks injuries were to the head, and half (51%) were to extremities.
Injuries to extremities were primarily to hand or finger (26% of total injuries). (See Figure 2.) One-fifth (20%) of injuries were to the eye, and one-sixth (17%) were to other parts of the head or face. A 1998 study of all Canadian fireworks injuries ever reported to the Canadian Hospitals Injury Reporting and Prevention Program found a large share of injuries occurred while the victim was holding the fireworks device, and the U.S. injury patterns are at least consistent with that pattern. (See Health Canada, "Injuries associated with … fireworks," at http://www.hc-sc.gc.ca.)

Nearly two-thirds (63%) of 2003 fireworks injuries were burns.
Contusions and lacerations were second (18%). (See Figure 3.) Contusions and lacerations were equal in number to burns when the injury was to any part of the head or face, including the eye.

Highest risks of fireworks injury are to school-age children.
As in most years, the majority of victims of fireworks injuries in 2003 were under age 20. (See Figure 4.) The highest injury rates were for children aged 5 to 9, whose relative risk compared to other age groups has been increasing in recent years. (See Figure 5.) Males accounted for nearly three-fourths (72%) of fireworks injuries.

Similar patterns in fireworks injuries were found in the Health Canada study cited above. The highest rates in that study were for the 10 to 14 and 15 to 19 age groups, followed closely by the 5 to 9 age groups. A Greek study (K. Vassilia, P. Eleni, and T. Dimitrios, "Fireworks-related childhood injuries in Greece: A national problem," *Burns*, Vol. 30, No. 2, 2004, pp. 151-153*)* found that young female victims were usually bystanders, while young male victims were usually involved in igniting fireworks.

In 2003, five out of six (84%) emergency room fireworks injuries involved fireworks that Federal regulations permit consumers to use.
Federal law permits public use of what are now referred to as "consumer fireworks" (formerly known as "common" or Class C fireworks), which are defined as "any small fireworks device designed primarily to produce visible effects by combustion" that comply with specific construction, chemical composition, and labeling regulations. These include a 50-mg maximum limit of explosive composition for ground devices and a 130-mg maximum limit of explosive composition for aerial devices. (See Figure 6.)

Some states further restrict the public's access to fireworks. The following seven states have banned access by the public to all fireworks – Arizona, Delaware, Georgia, Massachusetts, New Jersey, New York, and Rhode Island.

"Safe and sane" fireworks caused more injuries than illegal fireworks, especially to preschool children.
"Safe and sane" fireworks include devices such as sparklers, fountains, snakes, party poppers, and ground spinners. Six states permit sale of sparklers and some other devices

of comparable strength – Illinois, Iowa, Maine, Ohio, Pennsylvania, and Vermont. As a promotional technique, the fireworks allowed under rules of this type have been labeled “safe and sane” fireworks by their advocates. Laws based on this approach allow considerable private use of fireworks, but exclude any explosive type devices that lift off the ground that are allowed under Federal law.

In 2003, sparklers, fountains, and novelties alone accounted for one-fourth (24%) of emergency-room fireworks injuries, including the majority of injuries to pre-school children (ages 4 and under) where the type of fireworks device was specified. And even sparklers can start very large fires, e.g.:

> A fire started in the bedroom of a first-floor apartment when a lit sparkler ignited a combustible bed skirt. The apartment’s resident had placed the sparkler in a cupcake for her 10-year-old daughter’s birthday. After sparks ignited the bed skirt, flames spread to bedding and other combustibles. The occupants detected the fire before smoke alarms could operate and escaped.
>
> Flames heavily damaged the bedroom of origin and other rooms in the apartment, while the structural steel elements sustained significant heat damage. Smoke extensively damaged the first floor and spread to the upper floors through a construction deficiency around a vertical ventilation shaft. Water damaged the lower floors. Damages were estimated at $1.6 million.*

“Safe and sane” fireworks are neither. When things go wrong with fireworks, they typically go very wrong very fast, far faster than any fire protection provisions can reliably respond. And fireworks are a classic attractive nuisance for children. If children are present to watch, they will be tempted to touch. Children can move too fast and be badly hurt too quickly if they are close to fireworks, as they inevitably are at home fireworks displays.

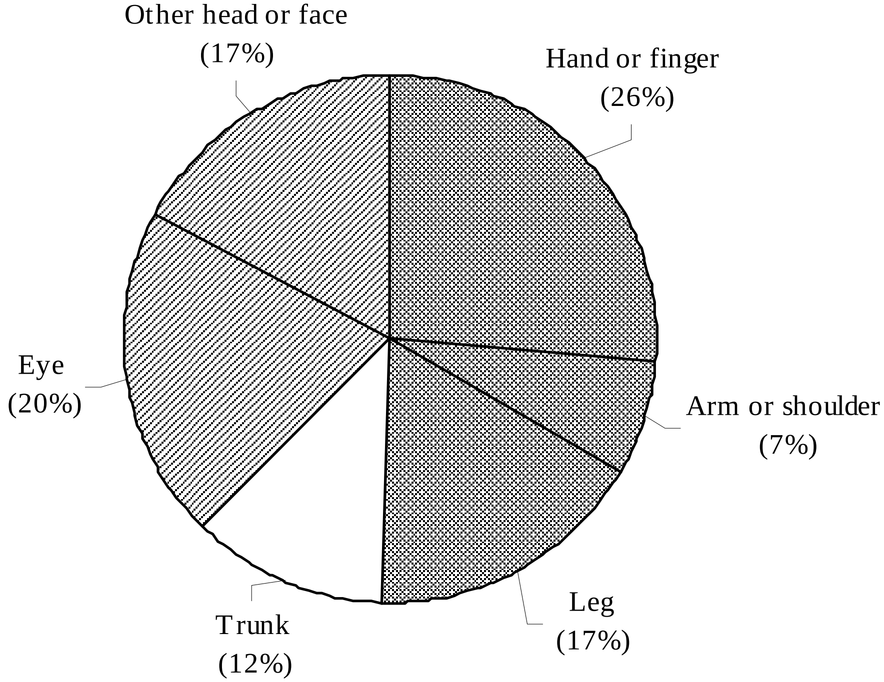
State laws to restrict fireworks use by the public are very difficult to enforce.
The other 37 states and the District of Columbia imposed no restrictions beyond the Federal requirements. This patchwork approach meant that people determined to acquire fireworks though living in a state that prohibits them can often cross a state border to buy fireworks, thereby violating a state law that is difficult to enforce. Every year, for example, people from Massachusetts drive into neighboring New Hampshire – a trip of at most a couple of hours – and buy fireworks from rows of retail stands set up near the border for the convenience of the scofflaw trade.

It is possible that limited laws, such as the current Federal law, are actually more difficult to enforce than a broader law would be, because the existence of some legal fireworks for the public encourages a climate of acceptance and creates a distribution network, both of which make it easier for amateurs to obtain illegal fireworks.

*Adapted from Kenneth J. Tremblay, “Firewatch,” *NFPA Journal*, March/April 1997, p. 21.

Since at least 1910, NFPA has crusaded to stop the dangerous private use of fireworks, which as noted accounts for nearly all of the injuries from fireworks in most years. Many states still permit untrained citizens to purchase and use fireworks – objects designed to explode, throw off showers of hot sparks, or reach surface temperatures as high as 1,200°F. The thousands of serious injuries and extensive property loss nearly all arise from this misguided activity, rather than the only acceptably safe way to enjoy fireworks, which is in public fireworks displays conducted in accordance with NFPA 1123, *Code for Fireworks Display*. Anything else is a violation of IFMA's (International Fire Marshals Association's) *Model Fireworks Law*, which reflects NFPA's zero-tolerance policy for consumer use of fireworks.

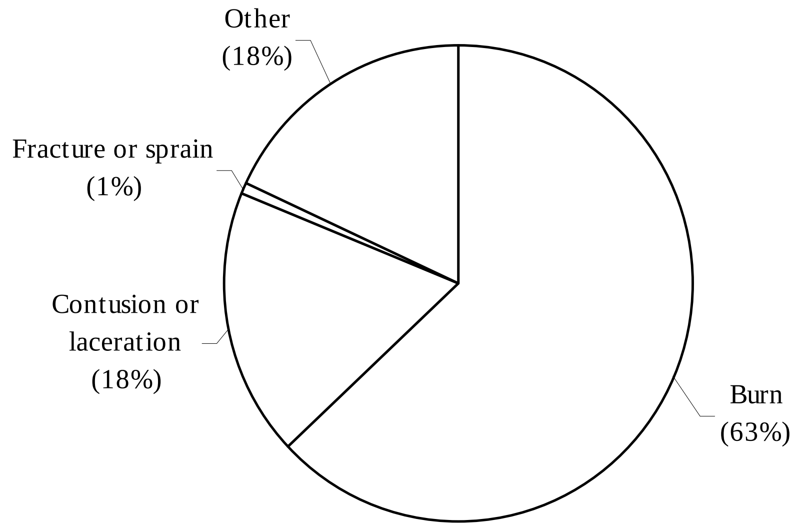
Figure 2.
2003 Fireworks-Related Injuries*
by Part of Body Injured



Source: CPSC's NEISS

*Based on injuries during the month around July 4.

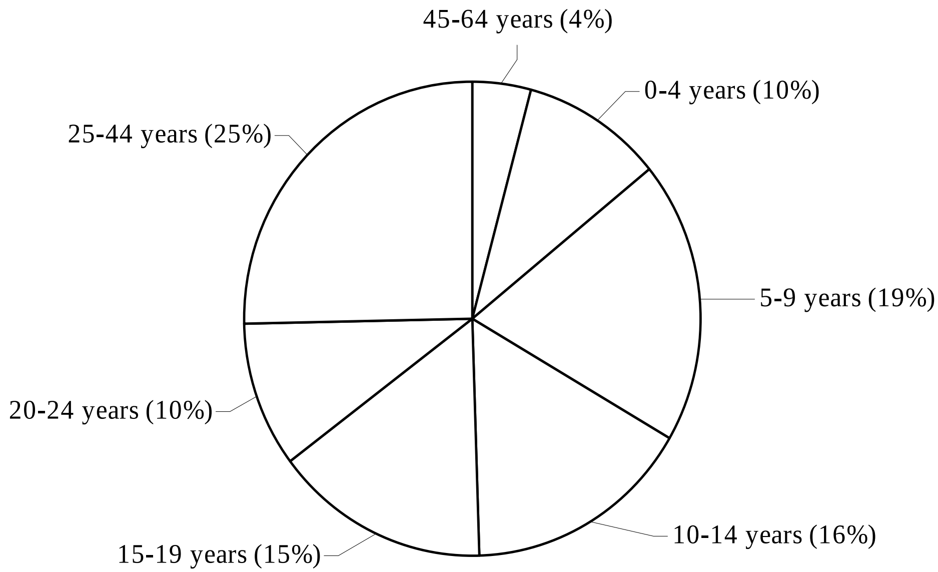
Figure 3.
2003 Fireworks-Related Injuries*
by Type of Injury



Source: CPSC's NEISS

*Based on injuries during the month around July 4.

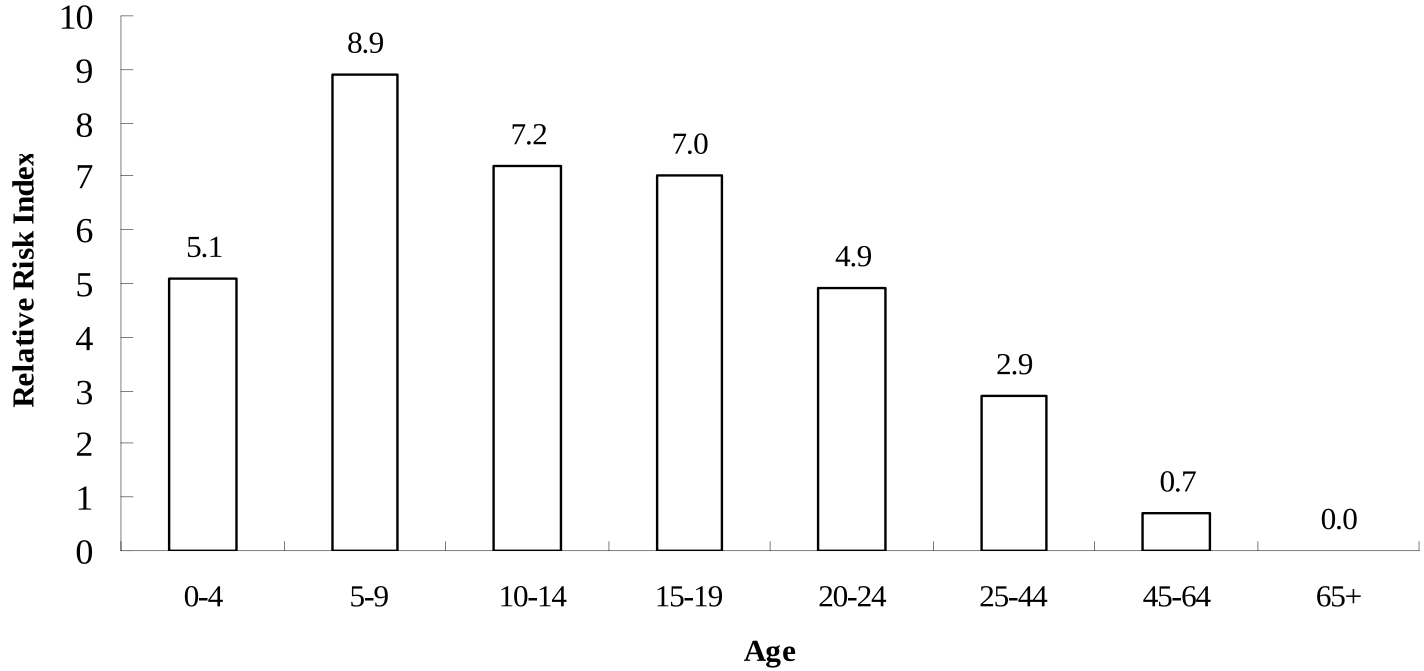
Figure 4.
2003 Fireworks-Related Injuries*
by Age of Victim



Source: CPSC's NEISS

*Based on injuries during the month around July 4.

Figure 5.
Risk of 2003 Fireworks-Related Injury*
by Age of Victim

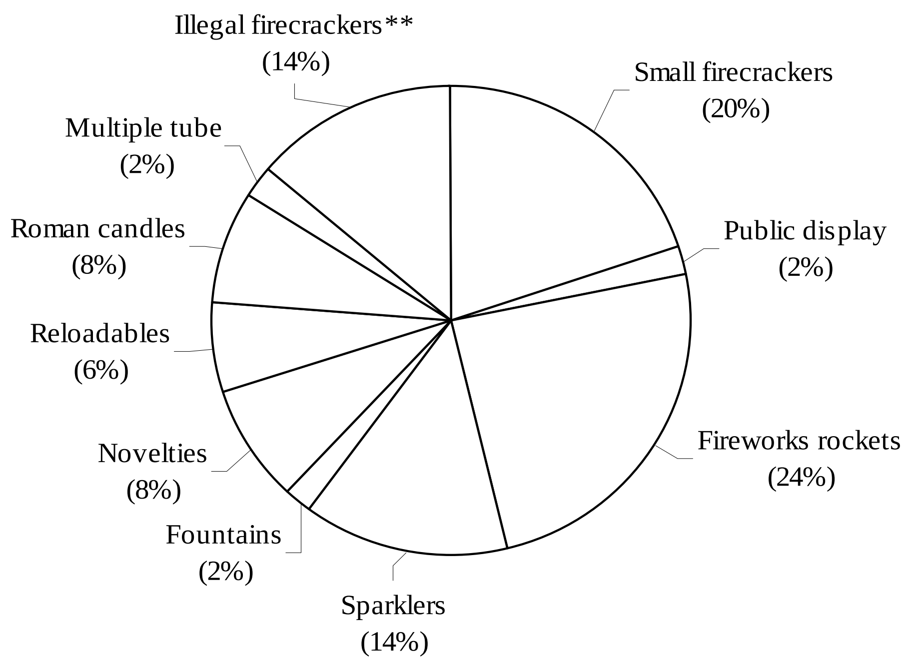


*Based on injuries during the month around July 4.

Source: CPSC's NEISS

Note: Relative risk index is injuries per million population for the age group divided by injuries per million population for all ages combined.

Figure 6.
2003 Fireworks-Related Injuries* by Type of Fireworks
(Unknowns Allocated)



Source: CPSC's NEISS

*Based on injuries during the month around July 4.
**Illegal under Federal law.

Risks of Private Fireworks Use

The risks of fireworks are typically encountered for only a few days each year. On the July 4 Independence Day holiday in a typical year, fireworks are the leading cause of reported fire, accounting for more outdoor fires in the U.S. than all other causes of outdoor fires combined. (This characterization, based on patterns in late 1990s data, has not been reconfirmed with more current data, because NFIRS Version 5.0 does not require cause reporting for outdoor trash fires.) But because most exposure to the risk of fireworks is limited to a few days around July 4, the actual toll of loss is relatively small, and so the risk may not impress itself upon the average person. Some areas may also see heightened fireworks use around New Year's Day, Chinese New Year, or Mardi Gras.

The same is true in some other countries. In the United Kingdom, a tradition exists for fireworks use on November 5, sometimes called "Bonfire Night," a date very near Halloween (October 31). In Canada, fireworks injuries peak on Halloween, Victoria Day (a Monday in late May), and Canada Day (July 1). Many countries see heightened fireworks use around Chinese New Year (late January or early February). Greeks see a jump in usage and injuries on Greek Orthodox Easter. But relatively few countries (China and Mexico may be among the exceptions) see substantial fireworks use year-round.

The risk of fire death relative to exposure shows fireworks as the most risky consumer product.
Risk estimates relative to exposure time are very rough, but even an estimate designed to give fireworks the benefit of the doubt supports the above conclusion.

Take, for example, cigarettes, the product associated with the largest number of fire deaths per year and the only other product likely to have the highest risk of fire deaths relative to exposure time. Recent figures indicate 425-435 billion cigarettes are smoked per year by a smoking population that constitutes about one-fourth of the adult population, who themselves constitute three-fourths of the total population of roughly 280 million people. This translates into roughly 28 cigarettes per smoker per day and 52.5 million smokers. Assuming it takes at least 5 minutes on average to smoke a cigarette, this translates into just over 2 hours per day of exposure to the fire risks associated with a lit cigarette. The latest death toll from fires started by lit tobacco products, nearly all of which are cigarettes, is about 800. The risk is therefore estimated as (800 deaths)/(2 hours/day x 365 days)/(52.5 million smokers) = 2.1 deaths per hundred million person-hours of exposure.

Now, consider fireworks. Recent figures indicate 120-130 million pounds of fireworks are used per year. Fireworks are typically used by households, so we assume that, on average, 2.6 people (the average size of a household) are exposed in any use of fireworks. A pound of fireworks will translate into a varying number of devices, depending on the type of device, but assume that on average a pound of fireworks burns for no more than 20 minutes. (The longer the time, the longer the estimated exposure time, and so the lower the estimated risk.) In 1997-2001, fires started by fireworks averaged 7 deaths a year. (See tables later in this report.) The risk is therefore estimated as (7 deaths)/(2.6 people/exposure x 1/3 exposure-hour/pound x 130 million pounds) = 6.2 deaths per hundred million person-hours of exposure.

The cigarette calculation is probably high, because 5 minutes is a low-end estimate of smoking time per cigarette, particularly if one factors in the long smolder time of imperfectly extinguished cigarettes, which are a common scenario for fire. The fireworks calculation is probably low, because 20 minutes is a high-end estimate of the average burn time for a pound of fireworks, possibly high by a factor of two to four. Yet, even with these assumptions, the risk while fireworks are burning that a fire death will result is three times the corresponding risk when cigarettes are burning. The fireworks risk would be higher even if the lower average number of deaths directly caused by fireworks (i.e., excluding fire deaths like those at the Station night club) from 2002-2003 were used.

In recent years, the industry has asserted a risk-type argument based on the fact that fireworks consumption (in pounds) roughly doubled in the early to mid-1990s while hospital emergency-room injuries due to fireworks were declining. The above calculation shows the fallacy of this reasoning, which focuses on whether the risk is increasing or decreasing and not on how high the risk actually is.

The risks associated with fireworks are not limited to displays, public or private. Risks also exist wherever fireworks are manufactured, transported or stored. Most but not all such losses in recent decades have occurred in other countries, where fireworks activity is not controlled as tightly – or kept as separate from highly populated areas – as it tends to be in the U.S.

- In 1983, two separate massive fireworks explosion incidents in Mexico killed 34 and 21 people, respectively, the latter reportedly coming when a fireworks display flare ignited fireworks stored in the back room of a church. Fireworks displays are a traditional part of a religious festival called the feast of the Holy Cross.
- In 1996, nine people died in an Ohio fire when a customer ignited a fireworks device in the sales display area of a fireworks retail facility, and the resulting fire quickly spread to the entire store inventory. (See *NFPA Journal*, September/ October 1997, p. 52.)
- In 2000, 18-20 people were killed in the Netherlands when a residential fire spread to a fireworks warehouse located next to the neighborhood.
- In 2002, three separate incidents in India involved explosions at fireworks storage facilities, killing 14, 13, and 12 people, respectively. The first incident involved storage at an ordinary home, while the last incident involved storage in a straw-thatched warehouse where a short circuit ignited a fire that then led to an explosion when fire spread to fireworks.

Data Sources

Changes in NFIRS pose opportunities and challenges in describing and tracking the problem.
The statistics in this report are national estimates derived from the US Fire Administration's (USFA's) National Fire Incident Reporting System (NFIRS) in combination with NFPA's annual fire department survey. In Version 4.1, "fireworks" were usually understood to include two categories under form of heat of ignition – code 63 (fireworks) and code 64 (paper cap or party popper). In Version 5.0, these two groups of devices are combined into one – Heat Source code 54 (fireworks). Detailed information about NFIRS, including Version 4.1 and 5.0 codes and conversion tables, can be obtained from http://www.usfa.fema.gov/.

Data on injuries at hospital emergency rooms come from NEISS.
All fireworks-related injury statistics from hospital emergency rooms come from reports by the U.S. Consumer Product Safety Commission (CPSC) and private communications from Linda Smith and Michael Greene of the CPSC. Linda Smith also provided the rules for setting the range of fireworks injury estimates during the period from 1985 to 1989, reflecting the change in the sample, and in 1991 to 1996, reflecting the latest change in the sample. Reports referenced include Michael A. Greene and James Joholske, *2003 Fireworks Annual Report*; Michael A. Greene and Patrick M. Race, *1999 Fireworks Annual Report*; Michael A. Greene, *1998 Fireworks-Related Injuries*; Ron Monticone and Linda Smith, *1997 Fireworks-Related Injuries*; Sheila L. Kelly, *Fireworks Injuries, 1994*; Dr. Terry L. Kissinger, *Fireworks Injuries - Results of a 1992 NEISS Study*; Linda Smith and Sheila Kelly, *Fireworks Injuries, 1990*; Deborah Kale and Beatrice Harwood, *Fireworks Injuries - 1981*; and the May/June 1974 issue of *NEISS News*. All were published by CPSC.

Appendix A: How National Estimates Statistics Are Calculated

Estimates are made using the National Fire Incident Reporting System (NFIRS) of the Federal Emergency Management Agency's (FEMA's) United States Fire Administration (USFA), supplemented by the annual stratified random-sample survey of fire experience conducted by the National Fire Protection Association (NFPA), which is used for calibration.

Data Bases Used

NFIRS provides annual computerized data bases of fire incidents, with data classified according to a standard format based on the NFPA 901 Standard. Roughly three-fourths of all states have NFIRS coordinators, who receive fire incident data from participating fire departments and combine the data into a state data base. These data are then transmitted to FEMA/USFA. Participation by the states, and by local fire departments within participating states, is voluntary. NFIRS captures roughly one-third to one-half of all U.S. fires each year. More than one-third of all U.S. fire departments are listed as participants in NFIRS, although not all of these departments provide data every year.

The strength of NFIRS is that it provides the most detailed incident information of any national data base not limited to large fires. NFIRS is the only data base capable of addressing national patterns for fires of all sizes by specific property use and specific fire cause. (The NFPA survey separates fewer than 20 of the hundreds of property use categories defined by NFPA 901 and solicits no cause-related information except for incendiary and suspicious fires.) NFIRS also captures information on the avenues and extent of flame spread and smoke spread and on the performance of detectors and sprinklers.

The NFPA survey is based on a stratified random sample of roughly 3,000 U.S. fire departments (or just over one of every ten fire departments in the country). 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 by the NFPA 901 Standard; (2) the number of on-duty firefighter injuries, by type of duty and nature of illness; and (3) 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 NFPA survey begins with the NFPA Fire Service Inventory, a computerized file of about 30,000 U.S. fire departments, which is the most complete and thoroughly validated such listing in existence. The survey is stratified by size of population protected to reduce the uncertainty of the final estimate. Small rural communities protect fewer people per department and are less likely to respond to the survey, so a large 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.

Projecting NFIRS to National Estimates

To project NFIRS results to national estimates, one needs at least an estimate of the NFIRS fires as a fraction of the total so that the fraction can be inverted and used as a multiplier or scaling ratio to generate national estimates from NFIRS data. But NFIRS is a sample from a universe whose size cannot be inferred from NFIRS alone. Also, participation rates in NFIRS are not necessarily uniform across regions and sizes of community, both of which are factors correlated with frequency and severity of fires. This means NFIRS may be susceptible to systematic biases. No one at present can quantify the size of these deviations from the ideal, representative sample, so no one can say with confidence that they are or are not serious problems. But there is enough reason for concern so that a second data base - 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.

There are separate projection formulas for four major property classes (residential structures, non-residential structures, vehicles, and other) and for each measure of fire severity (fire incidents, civilian deaths, and civilian injuries, and direct property damage).

For example, the scaling ratio for 2002 civilian deaths in residential structures is equal to the total number of 2002 civilian deaths in residential structure fires reported to fire departments, according to the NFPA survey (2,695), divided by the total number of 2002 civilian deaths in residential structure fires reported to NFIRS (1,029). Therefore, the scaling ratio is 2,695/1,029 = 2.62.

The scaling ratios for civilian deaths and injuries and direct property damage are often significantly different from those for fire incidents. Except for fire service injuries, average severity per fire is generally higher for NFIRS than for the NFPA survey. Use of different scaling ratios for each measure of severity is equivalent to assuming that these differences are due either to NFIRS under-reporting of small fires, resulting in a higher-than-actual loss-per-fire ratio, or possible biases in the NFIRS sample representation by region or size of community, resulting in severity-per-fire ratios characteristic only of the oversampled regions or community sizes.

Note that this approach also means that the NFPA survey results for detailed property-use classes (e.g., fires in storage structures) may not match the national estimates of the same value.

Calculating National Estimates of Particular Types of Fires

Most analyses of interest involve the calculation of the estimated number of fires not only within a particular occupancy but also of a particular type. The types that are mostly frequently of interest are those defined by some ignition-cause characteristic. The six cause-related characteristics most commonly used to describe fires are: form of the heat that caused the ignition, equipment involved in ignition, form or type of material first ignited, the ignition factor that brought heat source and ignited material together, and area of origin. Other characteristics of interest are victim characteristics, such as ages of persons killed or injured in fire.

For any characteristic of interest in NFIRS, some reported fires have that characteristic unknown or not reported. If the unknowns are not taken into account, then the propensity to report or not report a characteristic may influence the results far more than the actual patterns on that characteristic. For example, suppose the number of fires remained the same for several consecutive years, but the percentage of fires with cause unreported steadily declined over those years. If the unknown-cause fires were ignored, it would appear as if fires due to every specific cause increased over time while total fires remained unchanged. This, of course, does not make sense.

Consequently, most national estimates analyses allocate unknowns. This is done by using scaling ratios defined by NFPA survey estimates of totals divided by only those NFIRS fires for which the dimension in question was known and reported. This approach is equivalent to assuming that the fires with unreported characteristics, if known, would show the same proportions as the fires with known characteristics. For example, it assumes that the fires with unknown ignition factor contain the same relative shares of child-playing fires, incendiary-cause fires, short circuit fires, and so forth, as are found in the fires where ignition factor was reported.

Rounding Errors

The possibility of rounding errors exists in all our calculations. One of the notes on each table indicates the extent of rounding for that table, e.g., deaths rounded to the nearest one, fires rounded to the nearest hundred, property damage rounded to the nearest hundred thousand dollars. In rounding to the nearest one, functional values of 0.5 or more are rounded up and functional values less than 0.5 are rounded down. For example, 2.5 would round to 3, and 3.4 would round to 3. In rounding to the nearest one, a stated estimate of 1 could be any number from 0.5 to 1.49, a roughly threefold range.

The impact of rounding is greatest when the stated number is small relative to the degree of rounding. As noted, rounding to the nearest one means that stated values of 1 may vary by a factor of three. Similarly, the cumulative impact of rounding error - the potential gap between the estimated total and the sum of the estimated values as rounded - is greatest when there are a large number of values and the total is small relative to the extent of rounding.

Suppose a table presented 5-year averages of estimated deaths by item first ignited, all rounded to the nearest one. Suppose there were a total of 30 deaths in the 5 years, so the total average would be 30/5 = 6.

In case 1, suppose 10 of the possible items first ignited each accounted for 3 deaths in 5 years. Then there would be 10 entries of 3/5 = 0.6, rounded to 1, and the sum would be 10, compared to the true total of 6.

In case 2, suppose 15 of the possible items first ignited each accounted for 2 deaths in 5 years. Then there would be 15 entries of 215 = 0.4, rounded to 0, and the sum would be 0, compared to the true total of 6.

Here is another example: Suppose there were an estimate of 7 deaths total in 1992 through 1996. The 5-year average would be 1.4, which would round to 1, the number we would show as the total. Each death would represent a 5-year average of 0.2.

If those 7 deaths split as 4 deaths in one category (e.g., smoking) and 3 deaths in a second category (e.g., heating), then we would show 4 x 0.2 = 0.8 deaths per year for smoking and 3 x 0.2 = 0.6 deaths per year for heating. Both would round to 1, there would be two entries of 1, and the sum would be 2, higher than the actual rounded total.

If those 7 deaths split as 1 death in each of 7 categories (quite possible since there are 12 major cause categories), then we would show 0.2 in each category, always rounding to 0, and the sum would be 0, lower than the actual rounded total. The more categories there are, the farther apart the sum and total can -- and often do -- get.

Note that percentages are calculated from unrounded values, and so it is quite possible to have a percentage entry of up to 100%, even if the rounded number entry is zero.