Healthy Homes Issues:

Injury Hazards

June 2012

U.S. Department of Housing and Urban Development
Office of Healthy Homes and Lead Hazard Control

HEALTHYHOMES
Healthy Families | Healthy Children

Healthy Homes Issues:
Injury Hazards

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Preface

In 1998, Congress appropriated funds and directed the U.S. Department of Housing and Urban Development (HUD) to "develop and implement a program of research and demonstration projects that would address multiple housing-related problems affecting the health of children." In response, HUD solicited the advice of experts in several disciplines and developed a preliminary plan for the Healthy Homes Initiative (HHI). The primary goal of the HHI is to protect children from housing conditions that are responsible for multiple diseases and injuries. As part of this initiative, HUD has prepared a series of papers to provide background information to HHI grantees and others who are interested in the relationship between housing and health. This background paper focuses on residential injury and provides a brief overview of the current status of knowledge on:

- The extent and nature of injury hazards in the home;
- Assessment methods for injury hazards in the home;
- Mitigation methods for injury hazards in the home; and
- Research needs in the field of residential injury.

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Summary and Relevance to Healthy Homes Programs

The primary goal of the HHI is to protect children from housing conditions that are responsible for multiple diseases and injuries. As part of this initiative, HUD has prepared a series of papers to provide background information to HHI grantees and others who are interested in the relationship between housing and health. This background paper focuses on residential injury and provides a brief overview of the current status of knowledge on:

- The extent and nature of injury hazards in the home;
- Assessment methods for injury hazards in the home;
- Mitigation methods for injury hazards in the home; and
- Research needs in the field of residential injury.

Residential injuries are a significant problem, resulting in thousands of deaths and millions of hospital emergency department visits each year.

- The National Safety Council (NSC) estimated that in 2008, home-related unintentional injury deaths comprised about 46% of all injury-related deaths (or 54,500 deaths), only surpassed in magnitude by motor vehicle-related deaths.
- Data from the National Hospital Ambulatory Medical Care Survey show that injury of U.S. children in the home is the cause of 4.01 million emergency department visits and more than 70,000 hospitalizations each year.

Major causes of unintentional injury in the home include: poisoning, falls, fire and smoke, drowning, suffocation, and firearms.

- The most common causes of unintentional injuries and deaths in the home vary for different age groups.
    - The overall death rate due to residential injury is highest among people 75 years and older.
    - The death rate due to residential injury is highest in children younger than 1 year and among 1 to 4 year olds compared with older children.
- The risk of injury has also been shown to vary substantially with race; for example, black children were over 1.5 times more likely to die from injuries than white children, based on 1982-2002 data from the CDC's National Vital Statistics System.

Generally, the links between hazards in the home and major housing-related injuries have been well established. Measures to control injury in the home may be active (e.g., supervision of a child) or passive (e.g., changing the environment), and may require single or repetitive actions. Modifying the home environment is often more feasible, and is generally considered more effective, than attempting to influence individual behavior. Important injury prevention activities for healthy homes programs include:

- Improve injury surveillance and reporting;
- Increase public and individual education and outreach, e.g., teaching the Heimlich maneuver to reduce choking deaths;
- Make safety devices available and encouraging their use and maintenance, e.g., grab bars in bathrooms and smoke alarms;
- Support technological improvements to reduce hazards; and
- Develop legislation and regulation, including enforcement of hazard reduction laws.

Education of parents has been shown to be effective on the individual level in a variety of settings such as physicians' offices, clinics, or hospitals. In-home programs may reduce injury risk through initial home hazard inspections, customized interventions and resident education, and follow-up hazard inspections.

Methods of assessment of residential injury hazards include home safety questionnaires and home inspections.

Residential Hazards: Injury Hazards

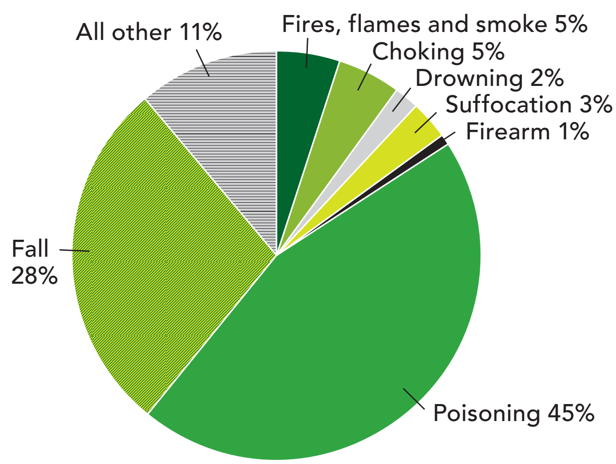
1.0 Overview of the Problem

The primary goal of the HHI is to protect children from housing conditions that are responsible for multiple diseases and injuries. Compelling evidence exists that supports the significance of injuries, many of which are preventable, as a primary result of housing-related hazards:

- Home injuries result in thousands of deaths each year.
  - The CDC estimates that there is one death every 3 minutes from injury in the U.S. (CDC/IPC, 2011). The National Safety Council estimates there is one death every 42 seconds as a result of injury events in the home (NSC, 2010).
  - Unintentional injuries are among the leading causes of death. It is the fifth leading cause of death in the U.S. among individuals of all ages, exceeded only by heart disease, cancer, stroke, and pulmonary disease. Among individuals aged 1 to 44 years, injuries are the most common cause of death (CDC/WISQARS, 2011).
  - Of all unintentional injury deaths, injuries in the home are the second leading cause, only surpassed by motor vehicle related deaths. The NSC estimates that in 2008, home-related injuries comprised about 46% of all injury-related deaths, amounting to approximately 54,500 deaths (NSC, 2010).
- Home injuries result in millions of hospital emergency department (ED) visits each year.
  - Disabling injuries occur more frequently in the home than in the workplace and motor-vehicle related accidents combined. Injuries in the home were estimated to be responsible for 13.1 million disabling injuries in 2008 (NSC, 2010).
  - According to the CDC, home and recreation-related injuries affect people of all ages, from infants to older adults, and account for about a third of all injury-related emergency department visits (CDC/IPC, 2011).
- Home injuries have a profound economic impact.
  - The economic impact of fatal and nonfatal unintentional injuries in the U.S. totaled an estimated $701.9 billion in 2008. Of the total costs, $182.3 billion are attributed to unintentional injuries in the home, including $116.9 billion attributed to wage and productivity losses, $41.2 billion to medical expenses, $9.8 billion for home and public insurance administrative expenses, and $4.9 billion in employer costs (NSC, 2010).

Figure 1 shows the major categories of unintentional injury death estimates in the home in 2008.

Figure 1. Principal Types of Home Unintentional-Injury Deaths[1], United States, 2008.



[1]Percent values reported in the figure are out of an estimated total of 54,500 home injury fatalities in 2008. These values are NSC 2005 revised estimates, which are based on analysis of 2005 National Vital Statistics System Mortality data from the CDC's National Center for Health Statistics (NCHS). NSC analysis of NCHS data includes a disaggregation of home-related injuries from all other injuries using the "place of occurrence" code, or, when the "place of occurrence" code was missing, through the application of a 2-way split methodology (see NSC, 2010 Technical Appendix).

Age. The most common causes of unintentional injuries and deaths in the home vary for different age groups (Agran et al., 2003). For example, as shown in Table 1, suffocation was the leading cause of death (due to home injury) for children four years of age and younger, while the primary cause of unintentional injury-related death in the home for individuals over 75 years was falling (NSC, 2011). Runyan et al. (2005b), using data from the National Vital Statistics System (NVSS) to calculate average annual rates for unintentional home injury deaths in the U.S. for different age groups (95% confidence intervals from 1992 to 1999), similarly found that residential fire/burn deaths, inhalation/suffocation, and drowning were the most important injury issues for young children.

Table 1 provides additional detail on the NSC death estimates due to unintentional injuries in the home, by major category of injury and age group.

Figure 2 shows death rates, by age group, for unintentional injuries in the home. Although death rates for those over 75 are the highest, they also represent the smallest proportion of the population (NSC, 2010; CDC/NCHS, 2000; U.S. Census Bureau, 2000). Nagaraja et al. (2005) investigated injury death rates for different age groups of children and adolescents (younger than 20 years of age) from 1985 to 1997, using data from the National Death Index and the U.S. Census. The authors found that the death rate due to residential injury was highest in

Table 1. Estimated Number of Deaths in the U.S. Due to Unintentional Injury in the Home, by Injury Type and Age Group, 2008.[1]

Injury Type	Age group							
	0–4	5–14	15–24	25–44	45–64	65–74	75+	All Ages
Poisoning[2]	60	90	2,500	11,100	10,300	600	450	25,100
Falls	70	20	60	350	1,900	1,800	11,100	15,300
Fires, flames and smoke	190	180	160	270	700	450	750	2,700
Choking (suffocation by ingestion)	90	10	50	150	550	350	1,300	2,500
Drowning[3]	260	40	40	120	170	90	180	900
Suffocation (mechanical)	1,000	60	80	140	250	20	50	1,600
Firearms	10	20	140	140	100	60	30	500
All other home[4]	550	80	70	200	950	450	3,600	5,900
All home	**2,200**	**500**	**3,100**	**12,500**	**14,900**	**3,800**	**17,500**	**54,500**

[Adapted from NSC, 2010. Source data: National Center for Health Statistics and state vital statistics departments.]

[1]NSC analysis of NCHS data includes a disaggregation of home-related injuries from all other injuries using the "place of occurrence" code, or, when the "place of occurrence" code is missing, through the application of a 2-way split methodology (see NSC, 2010 Technical Appendix).

[2]Includes deaths from drugs, medicines, other solid and liquid substances, and gases and vapors. Excludes poisonings from spoiled foods, salmonella, etc., which are classified as disease deaths.

[3]Includes drowning of persons in or on home premises such as in swimming pools and bathtubs. Excludes drowning in floods and other cataclysms.

[4]Includes deaths in the home and on home premises to occupants, guests, and trespassers. Also included hired household workers but excludes other persons working on home premises.

children younger than 1 year and 1 to 4 years compared with older children. Children are especially at risk for injuries because they are changing developmentally, they often exhibit risk-taking behavior, and they depend on adults for protection.

Race and economic status. The risk of injury has also been shown to vary substantially with race and economic status. For example, death rates for all types of unintentional injury combined are highest for Native Americans, relative to white, black, and Asian ethnic groups (CDC/WISQARS, 2011). From 1980 to 1986, the death rate from fires and burns for individuals with per capita income of less than $6,000 was approximately four times the death rate from fires and burns for individuals with per capita income of over $14,000 (Baker et al., 1992). Among children and adolescents younger than 20 years of age, Nagaraja et al. (2005) found that black children were two times more likely to die from residential injuries than white children, based on 1985–1997 data from the National Death Index. Data on children's blood-lead concentrations from the National Health and Nutrition Examination Survey (NHANES) show that among children aged 1–5 years, the geometric mean blood-lead level was significantly higher for non-Hispanic blacks (2.8 µg/dL), compared with Mexican Americans (1.9 µg/dL) and non-Hispanic whites (1.8 µg/dL).

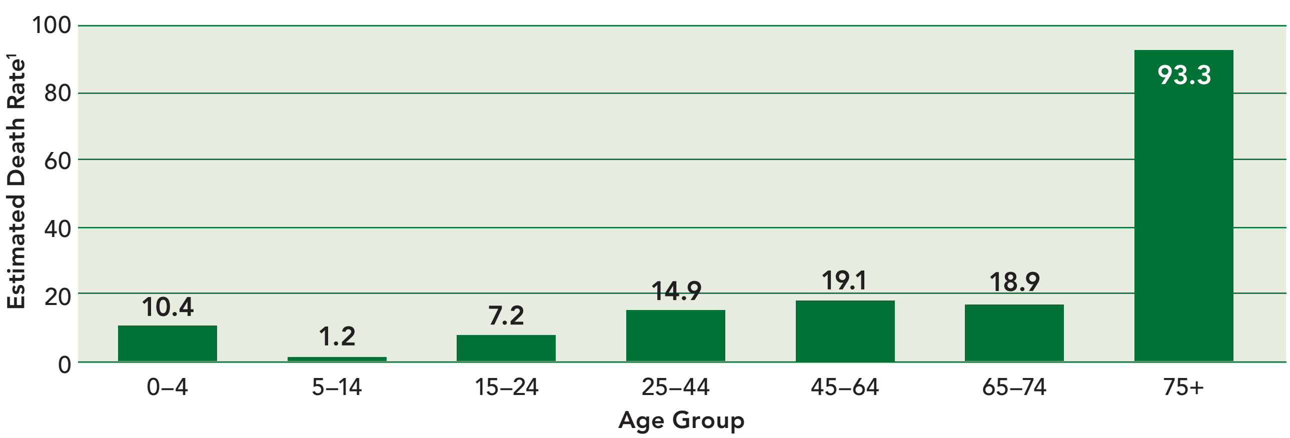
Injuries and Minority Populations

Different types of injuries may also disproportionately affect certain minority populations (CDC, 2011). For example, death rates due to residential fire for blacks were more than twice the rate for whites in 2002 (CDC/WISQARS, 2011). The risk of injury for young children may be linked to sociodemographic factors such as age and education of mother, with those of lower socioeconomic status typically being at greater risk of injury (Dowd, 1999; Scholer et al., 1999). In 1997, black children ages 0 to 14 were three times as likely to die in a house fire as white children (CDC, 2011). In a seven-year study of childhood falls from windows, the incidence of falls in urban areas was four times that of surrounding non-urban areas, and black children were three times more likely to fall than non-black children (Stone et al., 2000).

2.0 Extent and Nature of Residential Hazards with Injury

Generally, the linkages between hazard risk in the home and major housing-related injuries, including burns and other fire-related injuries, falls, suffocation, drowning, and poisoning are well established.

Figure 2. Estimated Death Rates Due to All Home Injuries, By Age Group, 2008.[1]



[Adapted from NSC, 2010. Source data: CDC/NCHS (2008) National Vital Statistics System Mortality data, divided by the population estimate for a given age group from the U.S. Census Bureau.]

[1]Deaths rates were calculated as the estimated number of deaths per 100,000 population in each age group.

2.1 Falls

In 2007, falls were the leading cause of nonfatal injuries for all age groups except those 15–24 years old (CDC/WISQARS, 2011). Falls are the most common cause of nonfatal injury and the leading cause of injury mortality among older Americans (NSC, 2010).

Injuries and Older Adults

For adults 65 years old or older, it has been estimated that 50–60 percent of fatal falls happen at home, versus 30 percent in public places and 10 percent in health care institutions (NSC, 2011; CDC, 2011). Among those, age 50 and up, falls are the most common cause of nonfatal injuries; in 2003, 2.7 million adults age 50 and up were injured from falls (CDC, 2011). By 2020, the cost of fall injuries for people age 65 and older is expected to reach $32.4 billion (NSC, 2002b).

Although falls are an infrequent cause of death during childhood, falls are a major cause of nonfatal injury in children (NSC, 2010). Each year, more than 3 million children are treated in emergency departments for injuries from falls (although not limited to home falls), with more than 40% occurring among infants, toddlers, and preschoolers (CDC, 2002). In 2003, more than 1.8 million children under age 4 were nonfatally injured and falls were the leading cause (CDC/WISQARS, 2011). In residential settings, falls for children are commonly associated with children's furniture (e.g., cribs, changing tables, highchairs, strollers), play on fire escapes, high porches, balconies, or around windows, playgrounds, and trampolines (NSC, 2009).

The Home Safety Council also reported the types of falls in the home for the entire population recorded in 1992–1998: 17.4% are tripping or falling down steps; 5.8% are falls on same level from slipping, tripping, or stumbling; 3.8% are falls from one level to another not on stairs; 3.7% are falls from or out of a building or structure; 3.2% are falls from a ladder; 3.2% are falls from a bed, and the remaining 66.7% are listed as "other" or miscellaneous (HSC, 2004).

The residential hazards associated with falls are:

Adults 65+

- Lack of handrails on stairs;
- Lack of grab bars and non-slip surfaces in the bathroom;
- Climbing or reaching high cabinets or shelves without using a sturdy stepstool with handrails;
- Presence of electrical or telephone cords in walkway;
- Tripping or slipping hazards such as objects on the floor, shag carpeting, lack of non-slip backing on rugs and other unsecured flooring, grease or liquid on the floors, waxed flooring, icy sidewalks and outdoor steps; and
- Behavior (e.g., lack of strengthening and coordination exercises in older adults).

Children

- Lack of safety gates to block stairways and other areas dangerous for children;
- Lack of window guards or stops for windows accessible to children;
- Structural defects in the home (e.g., uneven floors);
- Insufficient lighting on stairs and in other areas;
- Tripping hazards such as toys and objects on the floor or stairs, lack of non-slip backing on rugs and other unsecured flooring;
- Lack of non-slip surfaces in the bathroom;
- Use of unsafe infant walkers (i.e., those with translational motion); and
- Behavior (e.g., lack of supervision of children, not securely strapping children in high chairs, not moving cribs away from windows, etc.).

2.2 Poisoning

In the context of residential injuries, discussion of poisonings in this paper is primarily focused on poisonings that would result in acute health effects. Discussion of lead poisoning, although not often acute in nature, is also included due to its importance in residential environments.

In 2006, there were an estimated 28,000 deaths from unintentional poisonings in the home (NSC, 2010). The Home Safety Council reports that the vast majority of deaths from unintentional poisonings occur in middle-aged adults (HSC, 2004).

In 2009, 2,479,355 human poisoning exposures were reported to the National Poison Data System operated by the American Association of Poison Control Centers (Bronstein, 2010). Common causes of unintentional poisonings include drugs (local anesthetics, barbiturates, narcotics, cocaine, and other unspecified substances), carbon monoxide (CO), cleaning products, solvents, plants, and agricultural pesticides and herbicides. Nearly half (48%) of the unintentional poisoning deaths reported in 2006 were attributable to narcotic and hallucinogenic (including many illegal) drugs (NSC, 2010).

Exposure to medicines and toxic substances (solids and liquids) is common among the pediatric population, though the death rate due to this exposure is generally low (Dowd, 1999). The most common cause of poisoning by gases and vapors is CO (NSC, 2010). Lead poisoning is an important concern that disproportionately affects children, nonwhites, and the poor (USEPA, 1998a).

The primary residential hazards associated with unintentional poisonings are:

- Behavior (e.g., not locking up dangerous substances, improper use of products, warming a car in an attached garage, accidental or improper drug ingestion);
- Exposure to lead-based paint (e.g., dust from sanding lead-based paint, peeling paint chips);
- Lack of child-proof storage for toxic substances;
- Improperly or inadequately vented combustion appliances such as gas furnaces;
- fireplaces, wood-burning stoves, and other combustion appliances; and
- Lack of CO alarms.

Lead Based Paint. Despite dramatic reductions in blood-lead levels over the past 15 years, lead poisoning continues to be a significant health risk for young children. Based on results from the American Healthy Homes Survey (HUD, 2011), it is estimated that approximately 35 percent of housing units (37.1 million) in the United States contain lead-based paint. It is further estimated that 3.6 million homes with children less than 6 years of age have one or more lead-based paint hazards (i.e., deteriorated lead-based paint, lead-contaminated dust, or lead-contaminated soil).

Results from CDC's National Health and Nutrition Examination Survey (NHANES) show that the national geometric mean blood-lead concentration of all children aged 1–5 years decreased from 2.7 µg/dL in the 1991–1994 survey period to 1.9 µg/dL in 1999–2002 (CDC/MMWR, 2005a). More recently, Dixon, et al. (2009) analyzed data from NHANES 1999–2004 and reported a geometric mean blood lead level of 2.0 µg/dL in children age 12–60 months.

As blood lead levels have dropped over the years, recent analyses have examined the relationship between relatively low blood lead concentrations (<10 µg/dL) and cognitive functioning in a representative samples of U.S. children and adolescents, and have found evidence that suggests that deficits in cognitive and academic skills associated with lead exposure have no threshold (NTP, 2012;Lanphear et al., 2000; Canfield et al., 2003; Bellinger et al, 2003).

However, the magnitude of the effect and the shape of the dose response relationship at blood lead levels less than 10 µg/dL are still uncertain.

While children under the age of six historically have been considered at risk for lead poisoning, perhaps the greatest risk and most severe injury occurs in children under the age of two because these are critical years in the development of the child and because young children engage in crawling and mouthing behaviors that provide a higher exposure to lead-based paint dust and paint chips (USEPA, 1998a). Many of the highest risk children, those already economically, nutritionally, and educationally disadvantaged live in older, deteriorating housing where routine maintenance and upkeep may have been deferred due to the financial constraints of the property owner. Current research shows that even subtle deterioration of largely intact lead-based paint on interior building components can create a significant hazard in household dust. This leaded dust is often accessible to young children through routes of ingestion based on normal activity patterns such as hand-to-mouth activities. Even moderate childhood lead poisoning can cause permanent injuries including cognitive impairments that are likely to affect development, educational potential, and subsequent ability to function as an adult (CDC, 1997). In addition, acute lead poisoning injuries to children have been well documented, most notably in instances involving sanding or stripping of lead-based paint or visible deterioration of lead-based painted residential building components combined with children who exhibit pica tendencies. Such instances can result in severe lead poisoning cases that require immediate medical intervention to prevent devastating health consequences, including seizures, coma, and death (CDC, 1997).

EPA's Dust-Lead Hazard Standards

The U.S. Environmental Protection Agency has identified hazardous levels of lead in house dust. The dust-lead hazard standards, based on wipe sampling, are: 40 µg/ft2 for smooth or carpeted floors and 250 µg/ft2 for interior window sills (USEPA, 2001). The standards should be compared to a surface-specific weighted average of the dust wipes (i.e., determined separately for floors and window sills). The EPA regulation also established hazard levels for bare residential soil. In play areas, lead-contaminated soil is defined as soil with a lead concentration of 400 parts per million (ppm) or greater. In the rest of the yard the hazard level is defined as an average soil-lead level of 1,200 ppm or greater in bare soil.

Carbon Monoxide and Other Indoor Air Toxics. In indoor environments, potentially toxic substances may be present as airborne gases or particulates. These substances include nitrogen oxides, sulfur oxides, CO, radon, environmental tobacco smoke (ETS) (secondhand smoke), formaldehyde, and volatile organic compounds (VOCs). For most indoor air pollutants, the majority of concern with typical exposures centers on long-term risk for disease. However, more immediate injury-like effects, such as respiratory distress, asthma exacerbation or developmental or neurotoxic effects (especially in sensitive individuals or those who incur high exposures), have also been linked to chemical exposures in indoor environments (Becher et al., 1996; Garrett et al., 1998). For example, survivors of CO poisoning may also have long-term neurological effects such as personality changes, memory deficits, impaired judgment, poor concentration, and other intellectual impairments (USEPA, 2000a).

CO poisoning is the most common cause of acute poisoning by inhaled gases in residential situations (CPSC, 2004). In the home, major potential sources of CO (as well as other combustion products such as nitrogen and sulfur oxides, VOCs, and particulates) include: tobacco smoke; malfunctioning or inadequately vented gas, oil, or wood burning appliances (e.g., water heaters, furnaces, gas dryers, fireplaces and woodstoves); malfunctioning or improperly operated unvented appliances designed to be used indoors (e.g., kerosene heaters, unvented space heaters, ranges and ovens); and indoor or confined-space use of combustion devices that should not be used indoors (e.g., charcoal/gas grills or hibachis, gasoline-powered generators and tools, gasoline-powered vehicles started or left idling in attached garages). Other residential hazards associated with CO poisoning include: housing design (e.g., lack of proper ventilation in attached garages and conditions which create backdrafting); lack of maintenance and yearly professional inspection of gas, oil, or wood burning appliances and their vent systems; lack of CO alarms; and behavior (e.g., misuse of heating and combustion appliances, cigarette smoking). In multifamily residential buildings, infiltration of secondhand tobacco smoke between units can cause significant exposure to tobacco smoke in the homes of non-smokers, as well as in the common areas of the buildings (Kreav, et al. (2009).

Although the number of fatal CO poisonings has generally been declining since the 1980's, there are still hundreds of unintentional deaths per year in the U.S. from CO, with many of these deaths occurring at home (CPSC, 2004). In addition to CO poisoning fatalities, it is estimated that thousands more go to hospital emergency rooms for treatment of non-fatal CO poisoning each year (Hampson, 2000). It is not uncommon for CO incidents involving one or more fatalities to also result in one or more non-fatal CO poisoning injuries.

See *Healthy Homes Initiative (HHI) Background Information: Carbon Monoxide* for additional information (HUD, 2011a).

2.3 Burns and Fire-Related Injuries

Roughly eight out of ten fire deaths in the U.S. occur in the home (Hall, 1997; Karter, 2005). The National Fire Protection Associations (NFPA) estimates that in 2004, U.S. fire departments responded to 410,500 residential fires (representing 78% of all structure fires), which resulted in $5,948,000,000 of property loss (Karter, 2005). Home fires caused 14,175 (80%) of all civilian fire injuries and 3,190 (82%) of all civilian fire deaths in 2004. Of these deaths, 510 occurred in apartment fires and 2,680 in one- and two-family dwellings. Smoke inhalation accounts for the largest percent of home fire injuries overall; about half of all victims were asleep when the fire occurred (Hall, 1997). Two of every five fatal fire victims never wake up before being injured (Hall, 2005).

Groups at increased risk of fire-related injuries and deaths include young children and the elderly (ages 0 to 4 and 75 and older), blacks, Native Americans, poor Americans, persons in rural areas, those living in manufactured homes and substandard housing (CDC, 2003a; NSC, 2010).

Children under age 5 are 74% more likely to die in a home fire than the all-ages average and adults age 65 or over are more than twice as likely to die (Hall, 2005). A study of fire victims in Shreveport, LA in 1999–2004 found that 67% were in neighborhoods with more than 45% of the residents living below the poverty line with 81% being black (Crawford, 2004). Problems in home wiring, like arcing and sparking, are associated with more than 40,000 home fires annually that claim over 350 lives and cause 1,400 injuries (CPSC, 1999b). Young children and the elderly may have difficulty escaping from burning buildings, even in cases where a smoke alarm may be sounding. According to U.S. Fire Administration estimates on leading activities of children prior to fire injury, in 2002 approximately 55% of children who were killed by fire in residential structures were asleep at the time of the fire (USFA, 2005). Twenty-six percent were trying to escape when they died, 9% acted irrationally, and 9% were classified as unable or "too young to act," which implies that the child did not understand what was happening around him or her and probably did not take meaningful action to escape the fire. For those children injured, 35% were trying to escape, 27% were asleep, and 16% were attempting to control the fire (USFA, 2005).

Fire-associated death rates relative to the entire population are also higher for certain minority populations. For example, blacks and Native Americans die at more than twice the rate of whites from residential fires (USDHHS, 2000). The higher rates of injury deaths caused by fires for minorities is consistent with the higher overall rates of home-related injuries associated with poverty or lower levels of education (e.g., due to substandard housing and lack of building code enforcement) (Schwarz et al., 1993). Because education and income levels are correlated, it is difficult to separate the relative importance of these factors in contributing to an increased risk of residential injury (Federal Emergency Management Agency, 1997).

The USFA investigated causes of residential fires resulting in child casualties. Based on analysis of 2002 data from the National Fire Incident Reporting System (NFIRS), the National Center for Health Statistics (NCHS), and U.S. Census Bureau data, 1,930 children age 14 or younger were injured and 560 were killed in residential fires. For all residential fatalities, USFA found that the leading cause of fatal residential fires was arson (22%), followed by smoking (21%) and open flame (15%). For residential structure fires that resulted in one or more child fatalities, the leading causes were arson (30%), followed by open flame fires (28%) and heating fires (17%) (USFA, 2005).

The leading cause of all fires that caused injuries in the home in 2002 was cooking (29%). For fires that resulted in injuries to one or more children, however, the leading fire cause was open flame (25%), followed by arson (21%) and cooking fires (20%) (USFA, 2005).

Lack of a working smoke alarm, living in manufactured (mobile) homes (particularly those built before 1976 when building codes changed), and impairment by alcohol or drugs also increase the likelihood of death in cases of residential fire (Marshall et al., 1998; CDC, 2003a, Hall, 2005).

According to data from the National Center for Injury Prevention and Control, approximately half of home fire deaths occur in homes without smoke alarms. Alcohol use is involved in approximately 40 percent of deaths associated with residential fires (Runyan et al., 2005b).

Home electrical fires in the U.S. claim approximately 700 lives per year and injure 3,000 more. Some of these fires are caused by electrical system failures and appliance defects, but many more are caused by the misuse and poor maintenance of electrical appliances, incorrectly installed wiring, and overloaded circuits and extension cords. Home electrical wiring causes twice as many fires as electrical appliances. In a typical year, home electrical problems account for an estimated 90,000 fires and $700 million in property losses (USFA, 2003).

Burns also commonly occur from contact with hot foods and liquids (scalds), objects, or electricity. In 1997, an estimated 12,400 scald burns were sustained by children, nearly a quarter of which were caused by hot tap water (Schieber et al., 2000). Most scald burns occur as a result of contact with hot food and drink or tap water and most deaths related to scalds occur primarily in children younger than 4 years old (NSKC, 2001). Burns as a result of scalding by hot tap water are generally more severe than other scalds, and occur most frequently in the bathtub or shower, but may also occur in the kitchen or bathroom sink. Most victims of scald burns from tap water are younger than 5 years, although other high-risk groups include the elderly and those with physical or mental disabilities.

The primary residential hazards associated with burns and fire-related injuries are:

- Lack of functional smoke alarms near or inside bedrooms and on every floor of the house;
- Lack of fire extinguishers;
- Lack of Arc Fault Circuit Interrupters (AFCIs);
- Lack of anti-scald devices for shower heads and faucets and water heater thermostats set above 120°F;
- Lack of safety plug covers to prevent electric burns; and
- Behavior (e.g., smoking inside the home; not establishing and practicing fire escape routes and procedures; not preventing children's access to matches and lighters; leaving burning candles unattended; storing flammable liquids under unsafe conditions; not turning pot handles to back of the stove and leaving hot foods and liquids near the edges of tables or counters; and not testing bath water).

2.4 Electrocution

Information on electrocutions is sparse and even less readily available for those in the home. The National Safety Council does not separate this information in their compilation of residential injury statistics, so electrocutions are incorporated in the "other" category (NSC, 2010). A CPSC report, citing National Center for Health Statistics data from the U.S. Census Bureau, found that total electrocutions has decreased over the years, from 670 in 1990 to 400 in 2000 (CPSC, 2004a). During this same period, they also found that the estimated number of electrocutions related to consumer products decreased from 270 to 150. The greatest numbers of electrocutions were associated with small appliances, followed closely by power tools and then damaged or exposed wiring (CPSC, 2004a).

The primary residential hazards associated with electrocution include:

- Lack of safety plugs to cover electrical outlets;
- Lack of ground fault circuit interrupters in bathrooms, kitchens, and other rooms with water or dampness;
- Lack of professional inspection of wiring, especially in older homes; and
- Behavior (e.g., not keeping electrical appliances out of the reach of children and away from water).

2.5 Choking

Choking includes injury or deaths from unintentional ingestion or inhalation of objects or food resulting in the internal obstruction of the respiratory passages. Death rates due to choking are highest for individuals older than age 75, followed by children aged 4 years and younger (NSC, 2010). In 2006, choking was the fifth leading cause of unintentional injury deaths among children under 15 and the third leading cause for adults over 75 (NSC, 2010). The Home Safety Council estimated that between 1992–1999, 496 children (aged 15 years and younger) died on average each year from unintentional injury due to suffocation/choking (HSC, 2004). For 1998, the breakdown of suffocation/choking injury deaths was as follows: 34.2% (375) died from inhalation or ingestion of food that obstructed the airway, 22.6% (248) died from accidental mechanical suffocation by other specified means, 18.5% (203) died from accidental mechanical suffocation (e.g., parent fell asleep on top of child and child suffocated), 14.6% (160) died from accidental mechanical suffocation by unspecified means, and 7.5% (82) died from inhalation or ingestion of an object causing obstruction. The Home Safety Council also compiled records of emergency department and physician visits due to inhalation/suffocation injuries in 1999 and reported that these were minimal. This is likely due to the nature of suffocation and inhalation (choking). If a fatal injury is prevented, further care is often not sought.

Foods that most commonly cause choking deaths are hot dogs and other chunks of meat, grapes, apples, nuts, popcorn, watermelon seeds, raw carrots, and candy. Objects that are commonly choked on by children are parts of toys, batteries, coins, jewelry, office supplies, balloons, rubber balls, and marbles.

The primary residential hazards associated with choking are:

- Behavior (e.g., not keeping common choking objects away from children, not serving appropriate sized food to young children and the elderly);
- Lack of education for the elderly on common causes of choking; and
- Lack of training in the Heimlich maneuver and CPR.

2.6 Drowning

The NSC estimated that in 2008, approximately 900 drowning deaths (across all ages) occurred in or on home premises, with drowning death being defined as death within 24 hours after an immersion event (NSC, 2010). Of these, 260 were estimated to be children between the ages of 0 and 14.

> Drowning is the second leading cause of injury death among children aged 1–14, surpassed only by motor vehicle accidents (CDC/WISQARS, 2011).

The Home Safety Council reports the following breakdown of drowning/submersion deaths in 1998: 45.1% (373) died from other accidental drowning or submersion, including swimming pools, 33.1% (273) died from accidental drowning in bathtub, 17.6% (158) died from unspecified accidental drowning or submersion, 4.2% (35) died from accidental drowning while engaged in sport or recreational activity, excluding swimming pools, and 0.1% (1) died from accidental drowning while engaged in swimming or diving for purpose other than recreation (e.g., rescue attempt, pool repair) (HSC, 2004). The CPSC (2008) reports 769 pool-related submersion fatalities of children under age 5 during 2002–2004. The CPSC also reports that there were 359 non-pool home drowning incidents involving children under the age of 5 in the years 2002–2004 that were related to products located in and around the home. The products included bathtubs, 5-gallon buckets, spas or hot tubs, toilets, and other water-holding products. The most frequent cause of these drowning deaths was submersion in bathtubs, causing 71% of the deaths in children under 5. Of these, over 80% were under the age of 2, amounting to almost half of all the fatalities. The level of child supervision is known in most of the incidents, and in many of them the child was reported to have been left unsupervised in the bathtub (CPSC, 2008).

Non-Fatal Submersion Injuries

For every drowning death, it is estimated that roughly four significant non-fatal submersion injuries occur (Baker et al., 1992). However, the Home Safety Council reports that the number and rate of emergency department and physician visits due to near-drowning injuries in 1999 were minimal. If a fatal drowning injury is prevented, further care may often not be sought. Data did not include information about near-drownings that result in hospitalization (HSC, 2004). These data are supported by the Web-based Injury Statistics Query and Reporting System (WISQARSTM) database information, showing that unintentional drownings are among the top three causes of death for those aged 0–24 years; however, unintentional drownings are not even listed in the top ten causes of non-fatal injuries (CDC/WISQARS, 2011). Because medical follow-up is not required as often for near-drowning injuries as it would be for burns or other types of injuries, the frequency of non-fatal submersion injuries is difficult to estimate.

The places and ways in which children drown are related to the developmental stage of the child (Agran et al., 2003). Children under one year most often drown in bathtubs, 5-gallon buckets, and toilets, and among children ages 1–4, most drownings occur in residential swimming pools (CDC, 2003b). Alcohol use is involved in about 25% to 50% of adolescent and adult deaths associated with water recreation (CDC, 2003b). According to U.S. Consumer Product Safety Commission (CPSC) estimates in 1994, an estimated 50 deaths and 130 emergency room visits are related to bucket drowning each year (NSC, 1994). Since 1980, CPSC has reports of more than 700 deaths in spas and hot tubs (CPSC, 2003b).

> According to the CPSC (CDC, 2000), about 60 percent fewer drownings occur in swimming pools (in ground) with four-sided isolation fencing, compared with pools without four-sided fencing.

Regardless of exact numbers, all estimates support the conclusion that residential drowning hazards, particularly in children under 14, are of serious concern. The primary residential hazards associated with drowning are:

- Access to 5-gallon buckets and other buckets containing liquids by young children;
- Behavior (e.g., lack of supervision of young children in the bathroom or around water);
- Lack of childproof fencing or safety covers around residential swimming pools, hot tubs, and spas;
- Lack of rescue equipment by pools; and
- Lack of training in CPR.

2.7 Suffocation and Strangulation

Mechanical suffocation includes injury or death resulting from external smothering by bedding, thin plastic materials, or confinement in closed spaces. Mechanical strangulation is also an external event in which the airway is obstructed by hanging from furniture, drawstring cords on clothing, or entanglement in noose-like loops of rope, cords, clothing, or bedding. In the past suffocation and strangulation most commonly occurred from cribs with slats spaced greater than 2-3/8 inches, mattresses that were not fit well for crib size, drawstrings, and dangling cords from window blinds (Baker et al., 1992). Death rates due to mechanical suffocation and strangulation are highest for children aged 0 to 4 years, with 1,000 deaths reported in 2008 (NSC, 2010). Parental behavior also plays a role. From 1981 to 1998, the CPSC has reports of nearly 200 children, most less than 4 years old, who have strangled to death after becoming entangled in window covering pull-cords. The younger children, who died, usually between 8 and 23 months of age, were often in cribs that were placed near the window cords (CPSC, 1998).

The primary residential hazards associated with suffocation and strangulation are:

- Lack of a safe sleep environment for children;
- Lack of safety lids on storage chests;
- Behavior (e.g., not tying up window blind cords, not keeping plastic bags away from children, lack of supervision of children); and
- Lack of CPR training.

2.8 Firearms

Firearm injuries were the sixth leading cause of unintentional injury death for children aged 10–14 in 2002, and deaths due to this cause in 2002 for ages 0–24 totaled 270, although this number was not restricted to only home injuries (CDC/WISQARS, 2011). The 15–24 year old and 65–74 age groups have the highest death rate for home firearm injuries (NSC, 2010). In addition, it is estimated that 2.6 serious nonfatal firearm injuries occur for every death from firearms (Dowd, 1999). Surveys of various sociodemographic groups have shown that guns are readily available to children and adolescents. For example, 42 percent of seventh and tenth graders surveyed in Boston and Milwaukee reported having easy access to guns, and 17 percent admitted to carrying a concealed weapon (Dowd, 1999). In 2004, the Home Safety Council collected survey information regarding home firearm safety (HSC, 2004). Among homes with firearms (31%), 46% reported keeping them in a lockbox or locked cabinet, and 28% reported using gun locks. Only 49% of gun-owning homes where young children live or visit reported storing all of their guns in locked locations, and only 32% reported using gun locks. Although gun locks were used more commonly in the homes of young children than in the population overall, 39% of gun-owner respondents with young children living or visiting the home reported that none of their guns were stored in locked locations.

In addition, children are often permitted to play with air guns (BB and pellet guns), despite the fact that they can inflict injury (Dowd, 1999). Bhattacharyya et al. (1998, as cited in Dowd, 1999) studied air gun-related injuries over a period of several years at one hospital and found that half of 42 patients admitted for air-gun related injuries required surgical intervention and 16 had a long-term disability as a result of their injury.

3.0 Methods Used to Assess and Mitigate the Hazards Associated with Injury

Injuries, like disease, are predictable from epidemiological data (i.e., examination of a host, agent, and environmental risk factors) and are preventable (USDHHS, 1990). Measures to control injury may be active (e.g. supervision of a child), or passive (e.g., changing the environment), and may require single or repetitive actions. Modifying man-made systems or products is often more feasible, and is generally considered more effective, than altering individual behavior (Baker et al., 1992). The most effective prevention strategies involve the provision of passive protection through a single one-time action (such as turning down the water heater thermostat to prevent tap water scalds).

Important components of an injury prevention program include:

- Injury surveillance and reporting;
- Public and individual education and outreach;
- Making safety devices available and encouraging their use and maintenance;
- Technological improvements to reduce hazards; and
- Legislation and regulation, including enforcement of hazard reduction laws.

Laws and Legislation Promote Safety Behaviors

Laws and legislation are among the most effective mechanisms for adopting safety behaviors for large segments of the population (Schieber et al., 2000). For example, mortality of children younger than five years from unintentional poisoning by oral prescription drugs decreased abruptly when the Poison Prevention Packaging Act first became effective in 1972, then decreased an additional 45 percent between 1974 and 1992 (Schieber et al., 2000). However, the legislative process can be slow, and enforcement can be difficult.

Education of parents has been shown to be effective on the individual level in a variety of clinical settings such as physicians' offices, clinics, emergency departments, or hospitals (DiGuiseppi and Roberts, 2000). Doctors are well situated to offer advice on home safety as well as options for low-income families to obtain safety features such as stair gates and electrical outlet plugs (Lowry, 1990). Pediatricians may also have a greater impact in promoting home safety by gaining the support of a wider community (e.g., local health departments) to make injury prevention a priority (Gallagher et al., 1985).

Some research also suggests that certain injury prevention programs may require supplemental education in a home setting. For example, DiGuiseppi and Roberts (2000) reviewed studies evaluating the effects of educational interventions in a clinical setting to counsel families on childproofing their homes. Overall, evidence suggested that clinical counseling had little effect on most home safety practices designed to childproof the home (DiGuiseppi and Roberts, 2000). Gallagher et al. (1985) successfully demonstrated a reduction in household hazards by combining safety counseling and the installation of safety devices with normal housing code enforcement. Home visitation, including resident education, is generally an effective means to assess and address multiple injuries hazards in the home. Home visitation programs may reduce injury risk through initial home hazard inspections, customized interventions and resident education, and follow-up hazard inspections. Home visits for injury could be combined with other interventions (e.g., public health nurse visits, weatherization visits, etc.).

Regarding assessment of residential injury hazards, methods include home safety questionnaires and home inspections. In a randomized study on the validity of self-reported responses to questions about home safety, Hatfield et al. (2005) compared questionnaires answered by Head Start families to home inspections (n=259). The authors found that self-reported use of safety devices and practices by parents of preschool aged children was generally reliable. Answers about the presence or absence of certain safety devices (e.g., CO detectors) were generally more accurate than those about safety practices (e.g., safe medicine storage). Reliability increased when the interview was conducted in the home, although the authors hypothesized that this may have been because parents were more prepared to answer the survey questions because they had previously agreed to a home visit for solely that purpose. In addition, the parents receiving the interview at home had been told they would receive help injury proofing their homes, which may have provided additional motivation to report unsafe conditions. In a similar study, Robertson et al. (2005) evaluated the validity of parents' self-reported home safety practices concerning smoke detectors, bike helmets, car seats, and water heater temperature. The results suggest that parent self report practice of certain injury prevention behaviors (owning a car seat, hot water temperatures) is reliable, whereas self reports on other practices (working smoke detectors, properly fitting bike helmets) may be overstated.

Table 2 provides an overview of selected major actions and strategies, as well as their effectiveness and estimated cost, for reducing risks for specific injury categories. Table 2 frames information needs related to cost and effectiveness of major injury intervention methods.

3.1 Falls

A number of measures can be taken to prevent residential injuries caused by falls. Safety devices such as grab bars and non-slip surfaces can be installed in bathrooms. To protect children, safety gates can be used to block stairs and dangerous areas. CPSC recommends that permanent window guards be affixed for use in windows on the 7th floor and above and that guards allowing for escape in case of fire or other emergency be used on windows for the 6th floor and below. CPSC also recommends the use of window stops installed so that the window opens no more than 4 inches as an alternative (CPSC, 2000a). NSC (2009) makes a number or recommendations to keep children safe from home falls: keep furniture or anything

Table 2. Selected Major Injury Prevention Methods, Grouped by Cause of Injury

Category	Effectiveness Assessment	Estimated Cost[1]
Falls		
Safety devices in bathrooms (e.g. grab bars, non slip surfaces)	Assumed [2]	Low/Medium
Safety gates to block dangerous areas	Assumed [2]	Low
Window guards	Assumed [2]	Medium
Repair of structural defects (e.g., unsafe stairs)	Assumed [2]	Medium/High
Education & behavior modification (e.g., supervising children, child-proofing homes, exercises to improve strength/balance/flexibility, review of medications)	Unknown	Low
Poisoning		
Carbon monoxide alarms	Unknown [3, 4]	Low/Medium
Correction of improper ventilation systems for gas and wood burning appliances	Assumed [2]	High
Inspection of gas burning appliances	Assumed [2]	Low
Lead hazard mitigation (e.g., addressing peeling paint, conducting specialized cleaning for lead dust, covering bare soil in yards, proper painting and renovation work practices)	Studied [5], quantified as effective	Medium toHigh
Safety locks for cabinets and other secure storage	Assumed [2]	Low
Education & behavior modification (e.g., buying less toxic consumer products, not warming car in an attached garage, locking up dangerous substances)	Unknown	Low
Deaths Associated with Fire and Non-Fire Burns		
Smoke alarms	Studied [4], quantified as effective	Low
Fire extinguishers	Assumed [2]	Low/Medium
Home sprinklers	Studied [4], quantified as effective	High
Anti-scald devices for showers and sinks	Assumed [2]	Low
Safety covers for outlets	Assumed [2]	Low
Ground circuit interrupters	Assumed [2]	Low/Medium
Education & behavior modification (e.g., setting water heater thermostats low, not smoking in home, using childproof lighters, wearing flame retardant sleepwear, practicing fire escape routes, placing space heaters way from flammable materials)	Unknown	Low
Choking		
Education & behavior modification (keeping dangerous objects away from children, Heimlich maneuver and CPR training, education on size of toy parts and food)	Unknown	Low
Drowning		
Education & behavior modification (e.g., supervising young children around water, training in water survival, safely storing 5 gallon buckets, CPR training)	Unknown	Low
Fencing around pools and hot tubs	Studied [4], quantified as effective	Medium
Suffocation and Strangulation		
Storage chest safety lids	Assumed [2]	Low
Safe sleep environments for children (e.g., cribs with slats less than 2 3/8 in. apart, well-fitting mattresses)	Assumed [2]	Medium
Education & behavior modification (e.g., tying up window cords, keeping plastic bags away from children, CPR training)	Unknown	Low

Table 2. Selected Major Injury Prevention Methods, Grouped by Cause of Injury

Category	Effectiveness Assessment	Estimated Cost[1]
Firearms		
Education & behavior (e.g., remove guns from children's environment, store guns unloaded and lock up ammunition separately)	Unknown	Low
Trigger locks	Unknown	Low

[1]*Estimated costs, for the purposes of this report, are categorized as follows: high=more than \$500; medium=\$50–500, low=less than \$50.*

[2]*No data were identified at the time of this report preparation.*

[3]*Research on the performance of CO alarms is ongoing. The Consumer Products Safety Commission (CPSC) currently considers CO alarms that meet UL 2034 or IAS 6-96 standards as important as smoke alarms in home safety.*

[4]*See discussions below.*

[5]*See Galke et al., 2001; USEPA, 1998b.*

children can climb away from windows; secure area rugs to keep them from causing people to slip and fall; keep stairs clear; don't leave babies alone on beds, changing tables, or sofas; and never leave a child unattended in the bathtub.

Poor vision increases the risk of falling. At least once a year, seniors should have an eye doctor check their vision and correct it as much as possible. Psychoactive medications such as tranquilizers, sleeping pills, and antianxiety drugs can make a person more likely to fall (Ray and Griffin, 1990). Having a doctor or pharmacist review prescription and over-the-counter medicines can reduce side effects and interactions. Muscle weakness, gait, and balance problems increase the risk of falling (Graafmans et al., 1996). Exercise is an effective prevention strategy to improve leg strength and balance (Rand 2003).

The most effective fall intervention strategy for the elderly is a comprehensive clinical assessment combined with individualized fall risk reduction and patient follow-up (Rand 2003). Environmental risk factors in and around the home (i.e., tripping hazards, lack of stair railings, or poor lighting) can increase fall risk (Northridge et al. 1995; Gill et al. 1999). Home safety can be improved by installing handrails on both sides of stairs; installing grab bars next to the toilet and in the tub or shower; removing tripping hazards such as throw rugs and clutter; and using nonslip mats in the bathtub and on shower floors.

3.2 Poisoning

Mitigation methods vary for different types of unintentional poisonings in the home. For poisonings by solids and liquids, preventive measures include mitigating lead hazards, installing safety locks on cabinets, locking up medicines and dangerous substances, buying less toxic consumer products, taking medicines as prescribed. The most common methods of preventing poisonings by gases and vapors (e.g., combustion gases) are professional qualified annual inspection and maintenance of gas and wood burning appliances, the correction of improper ventilation systems for these appliances, including the checking of chimneys, flues, vent pipes for blockage, separation, or any other form of deterioration that might cause leakage into home, installation of CO alarms near all sleeping areas (CPSC, 1999a; CPSC, 2002b), and education on hazardous behaviors, such as warming a vehicle in an attached garage.

Lead-Based Paint. Recent analyses suggest that homes that comply with current federal standards for lead in paint and house dust may nonetheless put children at risk. Dixon et al. (2009) analyzed NHANES 1999–2004 data and found that floor dust lead levels in older homes below current federal standards are sometimes associated with elevated blood levels in children, and recommended keeping dust lead levels in older homes on floors and windowsills as low as possible to protect children (Gaitens et al., 2009).

Carbon Monoxide Alarms. Along with regular inspection of combustion appliances, properly working CO alarms can provide home occupants with warning when indoor CO levels reach dangerous levels. The U.S. CPSC recommends that consumers purchase home alarms that meet specifications established by Underwriters Laboratories (UL) 2034 standard for CO detectors/alarms, "Single and Multiple Station Carbon Monoxide Detectors" (UL, 2008), or the Canadian Standards Association CAN/CSA 6.19-01 (CAN, 1999), or the previous International Approval Services IAS 6-96. All three organizations are well respected standards developers and their standards are equally acceptable to the CPSC staff.

CPSC recommends that all homes have one CO alarm that meets the requirements of UL 2034, IAS 6-96, or CAN 6-19-01 installed in the hallway near every separate sleeping area of the home. CO alarms should be installed according to the manufacturer's instructions (e.g., alarms should not be covered by furniture or draperies). For earlier warning, some gas utilities (e.g., Baltimore Gas & Electric in Maryland) recommend installing additional CO alarms in and any area with a fireplace, furnace or fuel-burning appliance, or in an attached garage .

3.3 Burns and Fire-Related Injuries

Many devices can be used to prevent burns and deaths associated with fire. These include: smoke alarms, fire extinguishers, home sprinklers, escape ladders, anti-scald devices for showers and sinks, safety covers for outlets, and arc fault circuit interrupters (AFCIs). Other prevention strategies require altering individual behavior, for example: not leaving children unsupervised, not smoking in the home, not leaving burning candles unattended, especially in the presence of children or near combustibles such as bedding or furniture, using childproof lighters, wearing flame retardant sleepwear, practicing fire escape routes, placing space heaters away from flammable materials, and setting water heater thermostats low.

Smoke Alarms. The presence of a functioning smoke alarm has proven to be effective in reducing mortality from residential fires (Dowd, 1999). According to the National Fire Protection Association (NSC, 2000), homes with smoke alarms usually have a death rate from fires that is 45 to 50% lower than the rate for homes that have no alarms. In one- and two-family dwellings, only 16% of fire deaths during 1988–1997 resulted from fires where a smoke alarm sounded, although 39% of apartment fire deaths occurred under these conditions.

Non-Functioning Smoke Alarms

According to the U.S. Consumer Product Safety Commission (NSC, 2000), of the homes containing at least one smoke alarm, one of every five had no functioning alarm. The CPSC also found that 25% of all U.S. households had no smoke alarms or only non-functioning smoke alarms. In two-thirds of the home fires in which a child was injured or killed, no working smoke alarm was found (NSKC, 2001). Causes for non-functioning smoke alarms include: a disconnected power source, a dead or missing battery, improper installation, or improper placement of the alarm. One of the largest reasons for disconnected or missing power sources in alarms is the frequency of nuisance alarms (NSC, 2000). Smoke alarms should be tested monthly and batteries replaced twice a year (Dowd, 1999).

The effectiveness of smoke alarms is also influenced by their number and placement in the home. At least one smoke alarm should be installed on every floor of the home, including the basement, and outside each sleeping area. Because smoke rises, alarms should be mounted high on walls or ceilings, away from windows, doors, or forced-air registers where drafts could interfere with their operation. The direct distribution of smoke alarms to homes has been found to be more effective and cost efficient in reducing deaths due to residential fires than other public education methods such as distributing brochures about smoke alarm giveaways (Dowd, 1999). However, research also indicates that poor maintenance can often limit these programs in the longer-term, and therefore, giveaway programs are more effective when followed by maintenance and inspection programs, especially in certain high-risk areas (Warda et al., 1999). A study in Baltimore demonstrated that 92 percent of households receiving free smoke alarms (upon request) had installed them (Gallagher et al., 1985). A project in Oklahoma City showed that the distribution of smoke alarms, combined with large-scale education, was effective in reducing injuries and deaths due to residential fires. Over a four-year period, the annualized fire-injury rate per 100,000 population in the target area declined by 80 percent while the rate in the rest of the city rose by 8 percent. Similarly, the injury rate per 100 residential fires declined 74 percent in the target area and increased 32 percent in the rest of Oklahoma City (Mallonee et al., 1996). Distribution of hard-wired or long-lasting (10-year) lithium battery-powered smoke alarms may also help to make smoke alarm giveaways more effective in the long term.

Fire Extinguishers.

Fire extinguishers can be used to put out small fires in the home. However, extinguishers must be checked periodically to ensure they are properly charged, and occupants must be trained on how to use a fire extinguisher effectively. Only adults should handle fire extinguishers. Most importantly, residents should understand that most portable extinguishers empty in 8 to 10 seconds and that they should evacuate if the fire is not extinguished immediately.

Arc Fault Circuit Interrupters (AFCI).

CPSC reports that a new safety device for homes, called an arc fault circuit interrupter or AFCI, can provide added protection from electrical fires. AFCIs work by responding to early arcing and sparking conditions in home wiring to prohibit or reduce potential electrical fires from happening. The National Electrical Code, a widely-adopted model code for electrical wiring, has required AFCIs for bedroom circuits in all new residential construction since January 2002. AFCIs may be added to new and existing homes for fire protection, but installation should be performed by a qualified electrician because it involves work within electrical panel boxes that are electrically alive, even with the main circuit breakers turned off (CPSC, 1999).

Home Sprinklers.

The installation of home fire sprinklers is advocated by both the U.S. Fire Administration (USFA) and the National Fire Protection Association (NFPA), but is often overlooked as an effective strategy for preventing deaths in house fires. Conley and Fahy (1994) estimate that the chances of dying in a fire when sprinklers are present may be one- to two-thirds lower than the chances of dying in a fire in which sprinklers are not present. Kay and Baker (2000) estimate that while smoke alarms can reduce the fire death rate by 50%, sprinklers alone can reduce deaths by about 70% and the combination by 80%. Fire sprinklers can effectively extinguish residential fires and save lives without human action. This protection is especially beneficial for those who cannot escape easily without help, such as children, the elderly, the disabled or intoxicated persons.

The use of fire sprinkler technology as a prevention strategy may be diminished by misconceptions about fire sprinklers activating accidentally and causing extensive water damage. In practice, automatic sprinklers rarely go off by mistake, and each sprinkler head is independently activated by the heat of a fire as needed so that only sprinklers in the immediate area of flames will activate (USFA, 1997). With water discharge rates less than 30 gallons per minute, home sprinklers in fact reduce property loss as compared to damage caused by fire hoses discharging over 300 gallons per minute. Residential sprinklers listed by Underwriters Laboratories, are available (USFA, 1997). Misconceptions about the cost of home sprinklers may be another deterrent to their installation in new homes and housing units. Installation costs have been reduced through the use of plastic pipe to $1.00–$1.50 per square foot of finished floor space in new housing (USFA, 1997), about the same cost as installing carpet or upgrading cabinets. It is hoped that the cost will decrease as the use of home fire protection grows. It is also possible to retrofit existing homes with sprinkler systems. In addition,

USFA's National Residential Sprinkler Initiative

In a 2005 report that includes key strategies for fire safety initiatives targeted at the home, the NFPA recommended that wider use of residential sprinklers be aggressively pursued (Karter, 2005). In 2003, the USFA launched its National Residential Sprinkler Initiative to help implement policies that have an immediate National impact and to identify and strive to remove barriers inhibiting the acceptance and use of residential fire sprinklers to reduce life loss and injuries. The USFA strategy includes:

- Advocacy for sprinkler systems in dwelling units under Federal control or influence;
- Promotion of localized fire suppression in high fire-risk areas for retrofit applications;
- Development of partnerships for advocacy and informational support; and
- Support for continuing research and development.

the cost of installation can be recovered by significant reductions in insurance premiums.

Fire and Burn Education. Programs funded by the National Fire Protection Association and public fire departments help save lives by teaching the public how to prevent fires and how to react during fires. Fire prevention education includes lessons on potential home fire hazards (e.g., smoking in bed, poorly maintained furnaces and chimneys), how to "stop, drop, and roll," the use and maintenance of smoke alarms, the danger in leaving children unattended, keeping matches and lighters away from children, and developing a family escape plan that includes multiple escape routes with unblocked exits or quick-release devices (for bars and locks), fire drills, and a designated safe meeting place outside.

Thermostats in Water Heaters.

Since the late 1980s, water heater manufacturers have voluntarily agreed to preset all electric water-heater thermometers to 120°F (Dowd, 1999). However, because thermostats in water heaters can sometimes be inaccurate (especially in the case of older water heaters), parents are advised to measure hot water temperatures using a thermometer, and if necessary, lower the temperature so that it does not exceed 125°F to 130°F, where the likelihood of scald injury increases (Dowd, 1999; Schieber et al., 2000). Education regarding hot water temperature (especially with the provision of a free thermometer) has been shown to result in more than a twofold increase in the likelihood of lowering hot tap water temperature (DiGuiseppi and Roberts, 2000). However, residents of apartments may not have access to or control of their hot water settings (Doc4Kids Project, 1998).

3.4 Electrocution

The use of an inexpensive electrical device called a ground fault circuit interrupter (GFCI) installed in household branch circuits could work to prevent over two-thirds of the approximately 300 electrocutions each year in and around the home (CPSC, 2004b).

The use of an inexpensive electrical device called a ground fault circuit interrupter (GFCI) installed in household branch circuits could work to prevent over two-thirds of the approximately 300 electrocutions each year in and around the home (CPSC, 2004b). Installation of this device could also prevent thousands of burns and electric shock injuries each year. Electrocutions occur when electrical current escapes from an appliance and travels through the victim to the ground (e.g., when a person comes into contact with an electrical appliance while touching a grounded metal object or while submerged in water). If the GFCI senses any disruption in current, it turns off power to the affected circuit and prevents delivery of a lethal dose of electricity (CPSC, 2004b). Local building codes generally require the installation of GFCIs in rooms with water sources, such as kitchens and bathrooms. The use of GFCIs with power tools could prevent the approximately 20-30 associated electrocution deaths each year (CPSC, 2004c). CPSC also recommends the use of GFCIs for protection against hazards involving electrical circuits and underwater lighting circuits in and around pools, spas, and hot tubs (CPSC, 2004d).

3.5 Choking

Methods to prevent choking include keeping dangerous objects away from children and education on the Heimlich maneuver and CPR, the appropriate size of toy parts for small children and the appropriate size of food for small children and the elderly. Under the Child Safety Protection Act (CSPA) (effective January 1, 1995), any ball with a diameter of 1.75 inches (44.4mm) or less is banned in products that are manufactured in or imported into the United States for use by children younger than 3 years of age. For children three years or older, labeling of toys with small parts is required to indicate a potential choking hazard. The CDC generally suggests that any toy that is small enough to fit through a 1 ¼-inch circle or is smaller than 2 ¼ inches long is unsafe for children under 4 years old. Additional information on preventing choking among children is available at www.cpsc.gov and www.cdc.gov/ncipc/duip/spotlite/choking.htm.

3.6 Drowning

According to the U.S. Consumer Product Safety Commission, 60% fewer drownings occur in in-ground pools with four-sided isolation fencing as in-ground pools without four-sided fencing (CDC, 2000). Childproof fencing 4.5 to 5 feet high is recommended around swimming pools (Baker et al., 1992). The use of non-rigid pool covers in some cases is believed to have contributed to drownings, but the CPSC reports that properly secured, rigid safety covers on spas can reduce drownings, as can the use of power safety covers on pools when not in use (CPSC, 2002a). A CPSC study of pool drowning and submersion incidents involving young children found that approximately 75% of the victims were between 1 and 3 years old, two-thirds of the victims were boys, and most victims had been out of sight for five minutes or less (CPSC, 1998). Training in cardiopulmonary resuscitation (CPR) is strongly recommended for owners of swimming pools (Baker et al., 1992). Teaching older children to swim has also been associated with reduced risk of drowning (Dowswell et al., 1996), though swimming instruction in young children may lead to overconfidence in swimming ability, as can air-filled swimming aids such as "water wings" (CDC, 2000).

Importance of Supervising Children

A study of low-income urban families found that 89 percent of children aged 35 to 59 months and 6 percent of those younger than 3 years old sometimes bathed without adult supervision (Santer and Stocking, 1991). Prevention of drownings and near-drownings requires education concerning the importance of supervising children, particularly during bathing and while five-gallon buckets are in use. CPSC offers three free publications consumers can use to help prevent child drowning: "Safety Barrier Guidelines for Pools," "How to Plan for the Unexpected" and "Guidelines for Entrapment Hazards: Making Pools and Spas Safer." Copies of these publications can be obtained at CPSC's website at www.cpsc.gov.

3.7 Suffocation and Strangulation

Prevention of suffocation and strangulation requires safe sleep and play environments for children. Crib-related deaths used to be as high as 150 to 200 annually in the 1970's but have declined over the years to the current rate of approximately 30-35 deaths per year (CPSC, 2000b; CPSC, 2003a). The Consumer Product Safety Commission played a large part in the reduction of crib-related hazards when they published mandatory standards for full-size cribs in 1973 and non-full-size cribs in 1976, including requirements for side height, slat spacing, mattress fit, and other aspects of crib performance and construction. Parents can also further reduce suffocation hazards in young children by following CPSC guidelines to avoid placing babies to sleep on adult beds (CPSC, 2004e), soft bedding for babies (CPSC, 2004f), ill-fitting crib sheets (CPSC, 2004g), and improperly fitting crib mattresses (CPSC, 2004h).

Further reductions in suffocation and strangulations can be made by avoiding toy boxes and chests that do not have proper lid supports or ventilation (CPSC, 2004i), window covering cords with loops (CPSC, 2004j, CPSC, 2008, Paul and Bhadoria, 2010), plastic bags (CPSC, 2004k), and strings, cords, and necklaces on infants, (CPSC, 2004l). Children can strangle on window drapery and blind cords that can form a loop. Parents should use cordless blinds, or cut looped cords, install a safety tassel at the end of each pull cord, and use a tie-down device. Parents should also install inner cord stays to prevent strangulation and never place a child's crib or playpen within reach of a window blind. CPR training for parents and caregivers can also help reduce death by suffocation and strangulation.

3.8 Firearms

The American Academy of Pediatrics recommends removing guns from environments where children live and play as the best method of prevention of firearm injuries. Where this is not possible, it recommends that guns be stored unloaded and ammunition be locked and stored separately (Dowd, 1999). The American Academy of Pediatrics also is involved in a firearm injury prevention training project designed to provide pediatricians with the skills and resources necessary to reduce firearms injuries and deaths. A recent study found that parental compliance with various safety practices not related to firearms was not necessarily associated with safe firearm storage. Of the participants who followed other safety precautions (e.g., the use of child car restraints, keeping poisonous substances out of reach, annually changing smoke alarm batteries, capping electric sockets, and keeping the water heater temperature below 120 F), 56% said they had a handgun in the home, 27% reported an unlocked gun, 20% reported a loaded gun, and 7% reported a gun that was loaded and unlocked (Coyne-Beasley et al., 2002).

Child Access Prevention (CAP) laws or legal holdings that hold gun owners accountable for leaving a firearm easily accessible to a child (i.e., they generally require adults to either store loaded guns in a place that is reasonably inaccessible to children, or use a device to lock the gun) are currently in place in 19 states (Brady Campaign to Prevent Gun Violence, http://www.bradycampaign.org/facts/). In addition, some cities have enacted local CAP ordinances including Elgin and Aurora, Illinois; Houston, Texas; Wichita, Kansas; and Baltimore, Maryland (Brady Campaign). A study was performed that investigated the impact of child access prevention laws that hold the owner of an unsecured gun responsible for injuries inflicted with that gun as a result of a child gaining access to the gun. In the first 12 states to adopt such laws for at least 1 year from 1990 through 1994, a 23% reduction in the death rate of children from firearm accidents was found among children younger than 15 years (Cummings et al., 1997).

3.9 Effectiveness of Multi-facet Mitigation Strategies.

A study that tested the efficacy of installation of home safety measures effectively reduced modifiable medically attended injury in children. Even though there was no statistically significant difference in the rate of medically attended injuries between the intervention and control groups; 14.3 injuries (95% confidence interval [CI], 9.7–21.1 injuries) vs 20.8 injuries (95% CI, 14.4–29.9 injuries) per 100 child-years, respectively , injury hazards were reduced in the interventions homes at one and two years ($p<.004$). There was also a 70 percent reduction in the rate of modifiable medically attended injury. The study defined a medically attended injury as an injury that resulted in a call or a visit to a physician's office, urgent care or emergency room and a modifiable medically attended injury as a medically attended injury that can be prevented or its severity reduced due to the implementation of an intervention. For example installation of a stairway gate to prevent a child from rolling over the stairs and sustaining injuries requiring medical attention. The nested randomized controlled trial involved a total of 355 children who were assigned to either the intervention (181) or control (174) group. The mean age at intervention was 6.3 months. The interventions included multiple measures such as stair gates, cabinet locks and smoke detectors. Outcome measures were assessed by trained assistants using a validated survey tool (Phelan et. al. 2011).

Another study of the relation between several childproofing strategies and the risk of injuries to children in the home, compared hazards in the homes of children with and without injuries (LeBlanc, et al., 2006). The hazards found in the homes included baby walkers (21% of homes with infants), no functioning smoke alarm (17% of homes), and no fire extinguisher (51% of homes). Homes with children with injuries did not differ from homes without children with injuries in the mean proportion of home hazards. After controlling for siblings, maternal education and employment, researchers found that the two groups differed for 5 hazards: the presence of a baby walker (odds ratio [OR] 9.0), the presence of choking hazards within a child's reach (OR 2.0), no child-resistant lids in bathroom (OR 1.6), no smoke alarm (OR 3.2) and no functioning smoke alarm (OR 1.7). Thus, homes of children with injuries differed from those of children without injuries in the proportions of specific hazards for falls, choking, poisoning and burns, with a striking difference noted for the presence of a baby walker. In addition to counseling parents about specific hazards, researchers recommend that clinicians consider that the presence of some hazards may indicate an increased risk for home injuries beyond those directly related to the hazard found. Families with any home hazard may be candidates for interventions to childproof against other types of home hazards.

4.0 Current Research Needs and Information Gaps

Possible areas of consideration for future research include:

- Data on the effectiveness (and the duration of benefit) of community-based injury prevention strategies.
- Further data on the effectiveness of clinic- and home-based education programs, as well as public education campaigns. For example, is one strategy more effective than another? Are two in combination more effective? Does focusing on a single injury produce the most successful outcome, or can multiple injuries be addressed at once?
- Costs and benefits of reducing residential injury hazards.
- Identification and characterization of residential injury risk factors for different types of injuries.
- Better understanding of parental knowledge and practices and how they relate to childhood injury.
- Strategies to educate landlords, parents, and policymakers about the need for window guards, working smoke alarms, and locked storage space for hazardous substances, particularly in multiple-unit dwellings and public housing projects.
- Assessment of the potential for effective use of insurance benefits and penalties for not having a working smoke alarm in a rental property.
- Evaluation of the effectiveness of swimming instruction and risk-taking behavior among youth related to drowning injuries and death.
- The effectiveness of various types of exercise in preventing falls among the elderly.
- Assessment of the effectiveness of regulatory interventions in preventing firearm-related injuries and deaths (e.g., childproofing, magazine safeties and trigger locks, personalization, loaded-chamber indicators).
- Research on methods to increase residential smoke alarm installation purchase, installation, use and routine maintenance among high risk groups.
- Research on interventions to reduce childhood poisoning in and around the home.
- Research on the relationship between the impact of the level of child development and the risk of various injuries.
- A better understanding of the reasons behind gender, age, economic, cultural, and regional differences in death and injury rates, particularly in instances where a systematic trend could be investigated in an attempt to prevent such occurrences.
- Improved data collection on residential injury.
    - In an analysis of nonfatal injury data derived from the National Health Interview Survey,

National Ambulatory Medical Care Survey, and National Hospital Ambulatory Medical Care Surveys for Outpatient and Emergency Departments, Runyan et al. (2005a) found that there was inconsistency across data sets with regard to the presence of location information and definitions of the home environment, inclusion criteria, and the presence of external cause of injury and poisoning codes (E-codes). The authors suggest that data collection systems need to be improved so that location of injury data are routinely collected using consistent definitions so as to allow comparisons across data sets and over time.

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Appendix A. Additional Internet Resources

In addition to the references and links appearing in the reference list above, the following table provides selected links with additional information on injury and associated issues.

Sponsoring Organization/Topic	Internet Web Site Address
American Academy of Pediatrics— The Injury Prevention Program (TIPP)	http://www.aap.org/family/tippmain.htm
American Association of Poison Control Centers	http://www.aapcc.org/
American Public Health Association	http://www.apha.org/
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.	http://www.ashrae.org/
Boston Medical Center Doc4Kids Program	http://www.bmc.org/program/doc4kids/index.html (error–page cannot be found The main page http://www.bmc.org/program/ still has the program listed, but the link does not work)
Canada Mortgage and Housing Corporation (Healthy Housing & Sustainability Projects)	http://www.cmhc-schl.gc.ca/en/imquaf/hehosu/index.cfm
Carbon Monoxide Headquarters	http://www.coheadquarters.com/CO1.htm
CDC's Childhood Lead Poisoning Prevention Program	http://www.cdc.gov/nceh/lead/lead.htm
CDC's National Center for Injury Prevention and Control	http://www.cdc.gov/ncipc
CDC's Web-based Injury Statistics Query and Reporting System (WISQARS™)	http://www.cdc.gov/ncipc/wisqars/
CDC's Preventing Falls Among Seniors Page	http://www.cdc.gov/ncipc/duip/spotlite/falls.htm
CDC's Wide-ranging Online Data for Epidemiological Research (WONDER)	http://wonder.cdc.gov/
Center for Injury Research & Control, University of Pittsburgh	http://www.circl.pitt.edu/home/
Children's Environmental Health Network	http://www.cehn.org/
Children's Health Environmental Coalition Network	http://www.checnet.org
Children's Safety Network: National Injury and Violence Prevention Center	http://www.edc.org/HHD/csn/
Consumer Products Safety Commission (CPSC)	http://www.cpsc.gov/
Environmental Health Watch	http://www.ehw.org/
Gas Technology Institute (information on carbon monoxide)	http://www.gri.org/
Harborview Injury Prevention and Research Center	http://depts.washington.edu/hiprc/
Harvard Injury Control Research Center	http://www.hsph.harvard.edu/hicrc/index.html
Health House Project of the American Lung Association	http://www.healthhouse.org/
HUD's Healthy Homes for Healthy Children	http://www.hud.gov/consumer/hhhchild.cfm
HUD's Office of Healthy Homes and Lead Hazard Control	http://www.hud.gov/offices/lead/

Sponsoring Organization/Topic	Internet Web Site Address
Injury Control Resource Information Network (Center for Injury Research & Control)	http://www.injurycontrol.com/icrin/index.html
Injury Free Coalition for Kids	http://www.injuryfree.org/
The Injury Prevention Web (Internet Injury Prevention Resources)	http://www.injuryprevention.org/ (http://www.injuryprevention.org/links/links.htm)
Loews Home Safety Council	http://www.loweshomesafety.org/
Minnesota Department of Health Children's Environmental Health	http://www.health.state.mn.us/divs/eh/children/index.html
National Center for Lead Safe Housing	http://www.centerforhealthyhousing.org/
National Resource Center on Supportive Housing and Home Modification for the elderly	http://www.homemods.org/index.html
National Fire Protection Association	http://www.nfpa.org/
National SAFE KIDS Campaign	http://www.safekids.org
National Safety Council Environmental Health Center	http://www.nsc.org/ehc.htm
National Safety Council Home Safety	http://www.nsc.org/home/homesafe.htm
National Safety Council Indoor Air Program	http://www.nsc.org/ehc/indoor/iaq.htm
New Jersey Poison Information and Education System	http://www.njpies.org
NIH National Institute for Child Health and Human Development	http://www.nichd.nih.gov
Occupational Safety and Health Administration (information on carbon monoxide)	http://www.osha-slc.gov/SLTC/healthguidelines/carbonmonoxide/index.html
Poison Prevention Week Council	http://www.poisonprevention.org/index.html
SafeUSA Program of the CDC	http://www.cdc.gov/safeusa/
Safer Child, Inc.—Indoor Pollution and Home Safety	http://www.saferchild.org/indoor.htm
Society for Public Health Education	http://www.sophe.org/ui/index.html
The Johns Hopkins Center for Injury Research & Policy	http://www.jhsph.edu/Research/Centers/CIRP/
U.S. Consumer Product Safety Commission	http://cpsc.gov/
USDA—HUD Healthy Home Partnership	http://www.uwex.edu/healthyhome/
USEPA Indoor Air Quality Home Page	http://www.epa.gov/iaq/
USEPA Office of Children's Health Protection	http://yosemite.epa.gov/ochp/ochpweb.nsf/homepage
U.S. Fire Administration	http://www.usfa.fema.gov/
USFA National Residential Sprinkler Initiative	http://www.usfa.fema.gov/research/dsn/dsn_sprinkler.shtm http://www.usfa.fema.gov/safety/sprinklers/

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