U.S. Department of Housing and Urban Development

Healthy Homes Issues: Injury Hazards

HEALTHY HOMES INITIATIVE (HHI) BACKGROUND INFORMATION
Version 3
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U.S. Department of Housing and Urban Development (HUD)
Office of Healthy Homes and Lead Hazard Control
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Prepared by:

Peter Ashley, DrPH, U.S. Department of Housing and Urban Development (HUD)
Jack Anderson, Healthy Housing Solutions
John R. Menkedick, Battelle
Jessica Sanford, Battelle
Maureen A. Wooton, Battelle

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Kevin Fearn, Senior Statistical Associate
Research & Statistics Department
National Safety Council

Murray L. Katcher, MD, PhD
Department of Pediatrics, Department of Family Medicine
University of Wisconsin Medical School

Kieran J. Phelan, MD, MSc (version 3)
Assistant Professor of Pediatrics
Children's Hospital Medical Center
Cincinnati, OH

Julie Gilchrist, MD
Karin A. Mack, Ph.D. (version 3)
Sarah J. Olson, MS, CHES
Judy Stevens, PhD
Division of Unintentional Injury Prevention
National Center for Injury Prevention and Control
Centers for Disease Control and Prevention

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.

Please send all comments to:

Peter Ashley, DrPH, at: Peter_J._Ashley@hud.gov
or
Emily Williams, M.S., at: Emily_E._Williams@hud.gov

U.S. Department of Housing and Urban Development (HUD)
Office of Healthy Homes and Lead Hazard Control
Fax: 202-755-1000

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Executive Summary

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 2003, home-related injury deaths comprised about 33% of all injury-related deaths (or 33,100 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 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 two times more likely to die from residential injuries than white children, based on 1985-1997 data from the National Death Index.

Generally, the linkages between hazards in the home and major housing-related injuries are 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 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.

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. Home visitation 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.

Healthy Homes Issues: Injury Hazards

1.0 OVERVIEW OF THE PROBLEM

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 National Safety Council (NSC) estimates that there is one death every 16 minutes and one injury every 4 seconds in the U.S. as a result of injury events in the home (NSC, 2004).
  - Unintentional injuries are among the leading causes of death (and are the leading cause of preventable, premature death). They are 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, 2002).
  - 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 2003, home-related injuries comprised about 33% of all injury-related deaths, amounting to approximately 33,100 deaths (NSC, 2004).

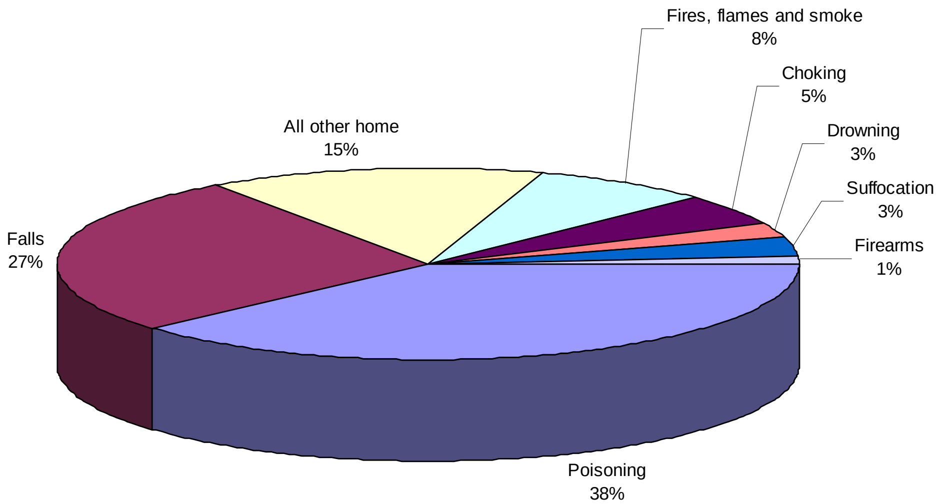
- Home injuries result in millions of hospital emergency department (ED) visits each year.
  - Disabling injuries occur more frequently in the home than in the workplace and motor-vehicle related accidents combined. Injuries in the home were estimated to be responsible for 7.9 million disabling injuries in 2003 (NSC, 2004).
  - According to the 1999 National Hospital Ambulatory Care Survey, over 29% of the 37.6 million ED visits because of injury in 1999 were as a result of injuries that occurred in the home (McCaig and Burt, 2001).
  - Combining nonfatal injury data from the National Health Interview Survey, National Ambulatory Medical Care Survey, and National Hospital Ambulatory Medical Care Surveys for Outpatient and Emergency Departments (1998-1999), it was estimated that in 1998, there were more than 12 million unintentional home injuries (across all age groups) requiring some form of medical attention. Falls were the most common injury among all age groups, and injury rates were highest among the oldest and youngest age groups (Runyan et al., 2005a).
  - The predominant location of injury for U.S. children is the home, accounting for 4.01 million ED visits and more than 70,000 hospitalizations each year (based on analysis of data on ED visits from the National Hospital Ambulatory Medical Care Survey) (Phelan et al., 2005).

- Home injuries have a profound economic impact.
  - The economic impact of fatal and nonfatal unintentional injuries in the U.S. totaled an estimated $607.7 billion in 2003. Of the total costs, $135.1 billion are attributed to unintentional injuries in the home, including $84.3 billion attributed to wage and productivity losses, $33.5 billion to medical expenses,

$6.0 billion for home and public insurance administrative expenses, and $5.0 billion in employer costs (NSC, 2004).

Although no sharp distinctions exist between injury and disease, injuries are usually perceived almost immediately after contact with the causal agent (Baker et al., 1992). Figure 1 shows the major categories of unintentional injury death estimates in the home in 2002.

Figure 1. Principal Types of Home Unintentional-Injury Deaths[1], United States, 2002.



[Adapted from NSC, 2005. Source data: CDC/NCHS (2002) National Vital Statistics System Mortality data]
[1] Percent values reported in the figure are out of an estimated total of 36,200 home injury fatalities in 2002 (not including 200 deaths that occurred in motor vehicles at residences). 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, 2004 Technical Appendix).

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, in 2002 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, 2005). 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.

Table 1. Estimated [1] Number of Deaths in the U.S. Due to Unintentional Injury in the Home, by Injury Type and Age Group, 2002.

Injury Type	Age group							
	0-4	5-14	15-24	25-44	45-64	65-74	75+	All Ages
Poisoning [2]	50	30	1,330	7,170	4,720	230	370	13,900
Falls	40	10	50	320	1,180	1,360	6,740	9,700
Fires, flames and smoke	250	230	160	510	680	350	620	2,800
Choking (suffocation by ingestion)	120	20	20	170	350	280	940	1,900
Drowning [3]	340	60	40	160	120	60	120	900
Suffocation (mechanical)	590	60	70	170	130	30	50	1,100
Firearms	10	30	140	170	90	30	30	500
All other home [4]	100	60	90	330	830	660	3,330	5,400
All home [5]	1,500	500	1,900	9,000	8,100	3,000	12,200	36,200 [5]

[Adapted from NSC, 2005. Source data: CDC/NCHS (2002) National Vital Statistics System Mortality data]

[1] These values indicate National Safety Council (NSC) 2005 revised estimates based on analysis of 2002 injury data from the 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 is missing, through the application of a 2-way split methodology (see NSC, 2004 Technical Appendix).

[2] Includes deaths from drugs, medicines, mushrooms, and shellfish, as well as commonly recognized poisons in solid, liquid, gas, and vapor form.

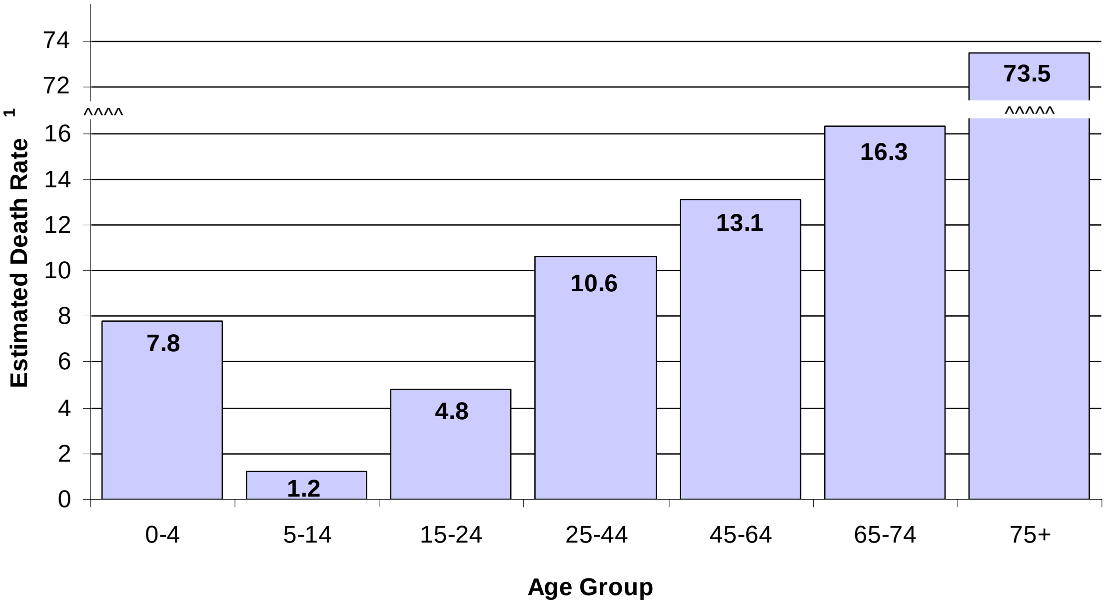
[3] Although a comparison for the 2002 estimates has not yet been calculated, a comparison of NCS 1998 estimates with the 1998 NCHS National Mortality Data compiled using the WONDER database (http://wonder.cdc.gov/) suggested that previous NSC estimates for residential drowning may be low. This same disparity may also exist in the 2002 data estimates.

[4] Includes electrocution, burns from hot liquids and steam, explosions, and excessive heat and cold.

[5] The total estimated number of residential injury fatalities in 2002 does not include 200 deaths that occurred in motor vehicles at residences.

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 only about a third of the total injury deaths across all ages (NSC, 2004; 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 children younger than 1 year and 1 to 4 years compared with older children. Children are especially at risk for residential injuries because they are changing developmentally, they often exhibit risk-taking behavior, and they depend on adults for protection and training in negotiating residential hazards (Katcher).

Figure 2. Estimated Death Rates[1] Due to All Home Injuries, By Age Group, 2002.



[1] Deaths rates were calculated as the estimated number of deaths per 100,000 population in each age group. [Adapted from NSC, 2005. Source data: CDC/NCHS (2002) National Vital Statistics System Mortality data, divided by the population estimate for a given age group from the U.S. Census Bureau (2000), multiplied by 100,000.] [Death Rate = (deaths / population) * 100,000]

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 (Baker et al., 1992 (analysis of data from 1980-1986); CDC/WISQARS, 2002). 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).

Different types of injuries may also disproportionately affect certain minority populations (USDHHS, 1990). For example, death rates due to residential fire for African Americans were more than twice the rate for whites in 2002 (CDC/WISQARS, 2002). The risk of injury for young children may be linked to sociodemographic factors such as age and education of mother, and the quality and maintenance of housing, with those of lower socioeconomic status typically being at greater risk of injury (Dowswell et al., 1996; Glik et al., 1993; Santer and Stocking, 1991; 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 (Katcher; USDHHS, 2000). 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 ASSOCIATED 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.

2.1 Falls

In 2004, falls were the leading cause of nonfatal injuries for all age groups except those 15-24 years old (CDC/WISQARS, 2004). Falls are the most common cause of nonfatal injury and the leading cause of injury mortality among older Americans (NSC, 2004).

The NSC estimated that approximately 9,700 deaths due to falls in a residential setting occurred in 2002, with nearly 70 percent of these occurring in the over 75 age group (NSC, 2005). Approximately 50-60 percent of all residential injury deaths for those aged 65 and older are estimated to be due to falls (NSC, 2005; NSC, 2002b). For adults 65 years old or older, it has been estimated that 60 percent of fatal falls happen at home (versus 30 percent in public places and 10 percent in health care institutions) (CDC, 2000a). By 2020, the cost of fall injuries for people age 65 and older is expected to reach $32.4 billion (Englander et al., 1996 as cited in CDC, 2000a; NSC, 2002b).

Although falls are an infrequent cause of death during childhood, falls are a major cause of nonfatal injury in children (NSC, 2004). Each year, more than 3 million children are treated in emergency departments for injuries from falls, with more than 40% occurring among infants, toddlers, and preschoolers (CDC, 2000b; CDC, 2002). About half, or 1.5 million of these emergency department visits are for falls in the home (Phelan et al. 2005). In residential settings, falls for children are commonly associated with children's furniture (cribs, changing tables, highchairs, strollers), play on fire escapes, high porches, balconies, or around windows, playgrounds, and trampolines (NSC, 2002c). Research has also shown a marked increased risk of injury for outdoor play equipment greater than 1.5 meters (~ 5 ft.) in height (Chalmers et al., 1996 as cited in *Hazard*, 2001).

The Home Safety Council also reported the types of falls in the home for the entire population recorded in 1998: 17.2% are falls up or down steps; 6.1% are falls on same level from slipping, tripping, or stumbling; 3.6% are falls from one level to another not on stairs; 3.5% are falls from or out of a building or structure, and the remaining 63.4% listed as "other" (not classified or lacking information) (HSC, 2002).

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 or clutter 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,
- Behavior (e.g., lack of strengthening and coordination exercises in older adults), and
- Inadequate lighting.

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 and clutter 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 2002, there were an estimated 13,900 deaths from unintentional poisonings in the home (NSC, 2005). The Home Safety Council reports that the majority of deaths from unintentional poisonings occur in middle-aged adults (HSC, 2002). Approximately 2.4 million human poisoning exposure cases were reported in 2002 (NSC, 2004). Common causes of unintentional poisonings include drugs (including local anesthetics, barbiturates, narcotics, cocaine, and other unspecified substances), carbon monoxide, cleaning products, solvents, plants, and agricultural pesticides and herbicides. Nearly half (46%) of the unintentional poisoning deaths reported in 2001 were attributable to narcotic and hallucinogenic (including many illegal) drugs (NSC, 2004). It is possible that some proportion may be mis-classified and completed suicide attempts.

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 carbon monoxide (CO) (NSC, 2001). 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 carbon monoxide 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 National Survey of Lead and Allergens in Housing (Jacobs et al., 2002), it is estimated that approximately 40 percent of housing units (38 million) in the United States contain lead-based paint. It is further estimated that 25 percent of the nation's housing stock (24 million housing units) have one or more significant lead-based paint hazards (i.e., deteriorated lead-based paint, lead-contaminated dust, or lead-contaminated soil). 1.2 million housing units represented those posing the highest risk of lead poisoning because they housed low income families with children under six years of age (Jacobs et al., 2002).

The most recent 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). In addition, among children aged 1- 5 years from families with low income, the geometric mean blood-lead level also declined significantly, from 3.7 µg/dL in the 1991- 1994 survey to 2.5 µg/dL in 1999 - 2002 (CDC/MMWR, 2005a). However, some data indicate that many children still have blood-lead levels of concern. Analyses of data from 19 States participating in CDC's Childhood Blood-Lead Surveillance Program suggest that a high percentage (10.5% in 1996 and 7.6% in 1998) of children screened for lead poisoning are still being identified with elevated blood-lead levels above the threshold of 10 μg/dL (CDC, 2000c). Based on the NHANES 1999 - 2002 survey, an estimated 1.6% of children (310,000) aged 1-5 had elevated blood-lead levels (i.e., $\geq$10 μg/dL) (CDC/MMWR, 2005a). In addition, a higher percentage of non-Hispanic blacks and Mexican Americans had elevated blood-lead levels (1.4% and 1.5%, respectively) than non-Hispanic whites (0.5%) (CDC/MMWR, 2005a).

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 (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). For example, the CDC recently documented a fatal pediatric lead poisoning case in New Hampshire, in which a two-year old girl died from lead encephalopathy after short-term (less than three weeks) exposure to extremely high levels of lead from dust and deteriorated paint in an older apartment being rented by the family (CDC, 2001).

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 $\mu g/ft^2$ for smooth or carpeted floors and 250 $\mu g/ft^2$ 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, carbon monoxide (CO), radon, environmental tobacco smoke (secondhand smoke or ETS), 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).

Carbon monoxide poisoning is the most common cause of acute poisoning by inhaled gases in residential situations (NSC, 2000). 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). According to the U.S. CPSC staff, from 1999-2001, the total number of unintentional CO poisoning deaths associated with the use of consumer products under the jurisdiction of the CPSC, excluding those associated with fire or motor vehicles, averaged about 126 annually (CPSC, 2004). The majority (66%) of these deaths occurred in the home, with the most common source of CO emissions in the home being heating systems (54%).

Beyond CO fatalities associated with consumer products, many additional unintentional deaths occur each year as a result of CO poisoning from motor vehicle exhaust, including some deaths in homes from motor-vehicle exhaust infiltration into the living space from an attached garage. The National Highway Traffic Safety Administration (NHTSA) estimated that, between 1995 and 1997, the total number of unintentional CO poisoning fatalities from stationary motor vehicles in residential settings was 397 (126 in 1995, 149 in 1996, and 122 in 1997) (NHTSA, 2000)[1].

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). According to CPSC staff, it is not uncommon for CO incidents involving one or more fatalities to also result in one or more non-fatal CO poisoning injuries. During 2001-2003, an estimated 15,200 persons with confirmed or possible non-fire-related CO exposure were treated annually in hospital emergency departments, with most (64%) of the nonfatal CO exposures occurring at home (CDC/MMWR, 2005b).

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). There were some 50 reported cases of hyperbaric oxygen treatment for CO poisoning related to the use of portable generators after Hurricane Katrina in the Southeastern US (CDC/MMWR, 2005c). These cases likely only represent a fraction of the total cases of CO poisoning related to the use of generators following Hurricane Katrina. Because unvented gas cooking ranges/ovens are used intermittently for cooking purposes, it is not likely their use would result in substantial increases in CO over long periods of time, except possibly in households where gas ovens are used improperly as a primary or secondary source of heat (USEPA, 2000a). Carbon monoxide in the indoor environment from vented combustion appliances (furnaces, hot water heaters, and gas clothes dryers) is generally negligible unless the unit is malfunctioning (USEPA, 2000a). Other residential hazards associated with CO poisoning include: housing design (e.g., lack of

[1] NHTSA estimates based on analysis of National Center for Health Statistics (NCHS) 1995-1997 data.

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 carbon monoxide alarms; and behavior (e.g., warming the car engine in a closed garage, misuse of heating and combustion appliances, cigarette smoking).

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 died in one- and two-family dwellings. Smoke inhalation accounts for the largest percent of home fire injuries overall; about half of all victims are asleep when the fire occurs (Hall, 1997).

Groups at increased risk of fire-related injuries and deaths include young children and the elderly (ages 0 to 4 and 75 and older), African-Americans, Native Americans, poor Americans, persons in rural areas, and those living in manufactured homes or substandard housing (CDC, 2003b; NSC, 2000). 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, African Americans 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; Katcher; USDHHS, 1990). 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 (Runyan et al., 1992), and impairment by alcohol or drugs also increase the likelihood of death in cases of residential fire (Marshall et al., 1998; Runyan et al., 1992; CDC, 2003b). 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., 1992).

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. These three risk groups account for almost 90% of those burned by hot tap water (Katcher).

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; inadequate vigilance related to intoxication (alcohol or drugs), 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, 2004). A recent 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, 2000). In 2001, choking was the fifth leading cause of unintentional injury deaths among children under 15 and the third leading cause for adults over 75 (NSC, 2004). The Home Safety Council estimates that for suffocation and inhalation deaths (includes both suffocation and choking) in 1998, 530 children and young adults (aged 24 years and younger) died from unintentional injury due to suffocation/inhalation (HSC, 2002). For 1998, the breakdown of suffocation/inhalation injury deaths is 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. Although it is commonly accepted that it takes approximately four minutes for irreversible central nervous system damage or death to occur following oxygen depletion, it is a much shorter time (often 1 to 2 minutes) until unconsciousness, loss of airway control, and laryngospasm (a closure of the larynx that blocks the flow of air to the lungs) to set in. Therefore, shorter periods of submersion or suffocation can ultimately lead to irreversible brain damage or death if those who find such an individual are unable or untrained to manage and airway and resuscitate an unconscious victim (Kieran J. Phelan, MD, personal communication).

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 2002, 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, 2004)[2]. Of these, 400 were estimated to be children between the ages of 0 and 14 (NSC, 2005). Drowning is the second leading cause of injury death among children aged 1-14, surpassed only by motor vehicle accidents (CDC/WISQARS, 2002).

The Home Safety Council reports the following breakdown of drowning/submersion deaths in 1998: 44.1% (381) died from other accidental drowning or submersion, including swimming pools, 32.8% (283) died from accidental drowning in bathtub, 18.3% (158) died from unspecified accidental drowning or submersion, 4.8% (41) 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, 2002). The CPSC reports that there were 459 non-pool home drowning incidents involving children under the age of 5 in the years 1996-1999 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 292 deaths in children under 5. Of these, 148 children were under the age of 2, amounting to almost half of all the fatalities. The level of child supervision is known in 231 of the 292 incidents, and in 222 of them the child was reported to have been left unsupervised in the bathtub (CPSC, 2002a) (see above discussion in section 2.5, “Choking” regarding the risk of death once unconsciousness sets in even though a child may have been left unsupervised for about a minute).

[2] Although a comparison for the 2002 estimates has not yet been calculated, a comparison of NCS 1998 estimates with the 1998 NCHS National Mortality Data compiled using the WONDER database (http://wonder.cdc.gov/) suggested that previous NSC estimates for residential drowning may be low. This same disparity may also exist in the 2002 data estimates. Although the NCHS WONDER database groups together injuries regardless of place of injury occurrence, a query based on the 1998 injury codes for “drowning in the bathtub” (E-code 910.4) and “other drowning” (E-code 910.8) (which is believed to primarily consist of drowning in residential swimming pools, but may also include drowning in industrial quenching tanks or other unspecified drownings), indicated that the number of residential drowning deaths in 1998 may have approached 2,600 (vs 1,000 in the NSC 1998 estimate).

For every drowning death, it is estimated that roughly four significant non-fatal submersion injuries occur (Katcher; 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, 2002). These data are supported by the WISQARS 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, 2002 and 2004). 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, 2003c). Alcohol use is involved in about 25% to 50% of adolescent and adult deaths associated with water recreation (CDC, 2003c). 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). According to the CPSC (see CDC, 2000a, “Drowning Prevention” factsheet), about 60 percent fewer drownings occur in swimming pools (in ground) with four-sided isolation fencing, compared with pools without four-sided fencing. Since 1980, CPSC has reports of more than 700 deaths in spas and hot tubs (CPSC, 2003b).

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 (Katcher; Baker et al., 1992). Death rates due to mechanical suffocation and strangulation are highest for children aged 0 to 4 years, with 616 deaths reported in 2001 (NSC, 2004). 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, 2002). The 15-24 year old age group has the highest death rate for home firearm injuries (NSC, 2000). In addition, it is estimated that 2.6 serious nonfatal firearm injuries occur for every death from firearms (Annest et al., 1995 as cited in 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 (Bergstein et al., 1996 as cited in Dowd, 1999). More than 35 percent of parents presenting to suburban community pediatric practices across the US reported having a gun in the home that was not stored correctly. (Gun ownership was reported by 37% of 5233 respondent families: rifles (26%), handguns (17%), and powder firearm (32%). Thirteen percent of 823 handguns and 1% of 1327 rifles were reported both unlocked and loaded (Senturia et.al., 1994). In 2002, the Home Safety Council collected survey information regarding home firearm safety (HSC, 2002). 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. In 2001 the CPSC estimated that there were 10,241 BB/pellet-associated injuries treated in emergency departments. More than half (53%) involved children 5-14, and another 30% involved children and youths 15-24 (NSC, 2003).

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 a large proportion are preventable (Katcher; USDHHS, 1990). Measures to control injury may be active (e.g. supervision of a child or behavior change on the part of a care giver), or passive (e.g., changing the environment), and may require single or repetitive actions (Katcher). Modifying man-made systems or products is often more feasible, and is generally considered more effective, than altering individual behavior (Baker et al., 1992). Katcher, in a preliminary Healthy Homes Initiative Report on Unintentional Injury, cites the most effective prevention strategies as involving 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 and housing codes.

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). However, only a relatively small proportion of households with young children report receiving such counseling (Quinlan et al., 1998). 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 cited as an effective means to assess and address multiple injuries hazards in the home (Cohen et al., 1996 as cited in Katcher). Home visitation programs may reduce injury risk through initial home hazard inspections, customized interventions and resident education, parental social support, 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.

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 to High
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 (deaths)	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
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.

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). Outdoor play equipment should be less than five feet in height should be placed on a suitable (i.e., impact-absorbing) surface. Some measures involve modifying behavior or home structure. For the elderly, these include repairing unsafe stairs or other structural defects, improving strength/balance/flexibility through exercise, reviewing medications which could disrupt balance, wearing low-heeled non-slip sole shoes, and improving vision (e.g., through glasses or increased lighting). The elderly can also be protected from hip fractures through the use of hip protectors that consist of plastic shields or foam pads held in place by pockets in specialized undergarments (*Hazard*, 2001). For parents, these include supervising children, child-proofing homes, and repairing structural defects.

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 for of deterioration that might cause leakage into home, installation of carbon monoxide alarms near all sleeping areas (CPSC, 1999a; CPSC, 2002b), and education on hazardous behaviors, such as warming a vehicle in an attached garage.

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, 2001) or the Canadian Standards Association CAN/CSA 6.19-01, and 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].

3.3 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 (as cited in 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.

According to the U.S. Consumer Product Safety Commission (as cited in 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 (Douglas et al., 1998 as cited in 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, Rowland et al. 2002). Alarms with ionization smoke detectors and those with lithium powered or hard-wired to the home electrical supply are associated with a better chance of functioning at 15 months (Rowland et al. 2002). A study in Baltimore demonstrated that 92 percent of households receiving free

[3] BG&E Service Express newsletter, Dec 2000, "Protecting Yourself Against Carbon Monoxide Poisoning."

smoke alarms (upon request) had installed them (as cited in Gallagher et al., 1985). A project evaluation 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)[4] and the National Fire Protection Associations (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

[4] http://www.usfa.fema.gov/safety/sprinklers/

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

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[5] 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.

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. As of 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

[5] http://www.usfa.fema.gov/research/dsn/dsn_sprinkler.shtm

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/safeusa/home/choke.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, 2000a). Childproof fencing 4.5 to 5 feet high is recommended around swimming pools (Wintemute, 1990 as cited in 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, 2000a).

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 number 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, 2003d). 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), plastic bags (CPSC, 2004k), and strings, cords, and necklaces on infants, (CPSC, 2004l). 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).

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.
- Effectiveness testing as part of approval process for new home safety devices incorporating the measurement of injury events and outcomes in children.
- 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 policy makers 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.
- 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/
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/

Sponsoring Organization/Topic	Internet Web Site Address
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/