Chapter 6

Interventions to Prevent Residential Fire Injury

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6.1. EPIDEMIOLOGY OF RESIDENTIAL FIRES IN THE UNITED STATES

The National Fire Protection Association (NFPA) reported 402,000 residential fires in 2003, resulting in 3,165 deaths and incurring $6,074,000,000 in property damage (Karter, 2004). This represented an increase of 17.4% in residential fire deaths compared to 2002, although the overall number of fires and property losses did not increase. Residential fire deaths have been declining steadily since the late 1970s, with a relative plateau since the early 1990s. Smoking materials are the leading cause of fatal residential fires (20%), with 40% of smoking-related fire victims being older than 65 years of age (Hall, 2004). Cooking is the leading cause of residential fires and nonfatal injuries (Hall, 2005). Despite 96% smoke alarm prevalence for U.S. homes with a telephone in 2004, 40% of residential fires still occur in homes without a smoke alarm, and among homes with alarms, 25% are not functioning at the time of the fire. In 1999–2001, an average of 70% of residential fire deaths resulted from fires in homes with either no smoke alarms or in which no smoke alarm sounded (Ahrens, 2004). Nearly every high-risk group for residential fire fatality is less likely to install smoke alarms, including the poor, seniors, heavy drinkers, households with less than high school education, and those in rural areas and in the Southern United States (Ahrens, 2004; Hall, 1985; Hall, 1994).

In 2002, for all ages combined, fires and burns were the 6th leading cause of unintentional injury mortality, and the 14th leading cause of nonfatal injury (Centers for Disease Control and Prevention [CDC], 2005). Approximately 6% of people with residential fire-related injuries are hospitalized, with slightly more than half being admitted for carbon monoxide poisoning and the remainder for burns (CDC, 2003). Children and older adults have the highest rates of fire-related mortality and hospitalization (DiGuiseppi, Edwards, Godward, Roberts, & Wade, 2000). Fires and burns are the 5th leading cause of injury mortality among children younger than 15 years of age and the 10th leading cause of injury-related emergency department visits, with a ratio of 198 emergency department visits for every death (Ballesteros, Schieber, Gilchrist, Holmgreen, & Annest, 2003). For children 1–4 years of age, fires and burns are the 6th leading cause of death and result in almost 63,000 emergency department visits (CDC, 2005). Fatal fire injuries among children are often (30–60%) due to playing with fire, and playing with fire is the leading cause of fatal residential fire injuries for preschool children (Hall, 2003; Istre, McCoy, Carlin, & McClain, 2002; Shai & Lupinacci, 2003).

A number of other risk factors for fatal residential fires have been identified. Mortality rates are significantly higher for American Indian/Alaskan Native and black/African American populations (2.1 and 3.0 per 100,000 in 1998 vs. 1.2 per 100,000 for the total population) (U.S. Department of Health and Human Services [DHHS], 2000). Other risk factors include personal and household factors, such as income, educational level, rural residence, physical and mental disability, smoking, impairment by drugs or alcohol, and male gender, and housing-related factors, such as home ownership, lack of a telephone, housing age, and housing type (e.g., mobile/manufactured home) (Warda, Tenenbein, & Moffatt, 1999a).

6.2. HISTORY OF PREVENTION EFFORTS

Heat detectors for use in residential structures were introduced in 1921 and represented the first available technology for the early notification of fire. Underwriters Laboratories (UL) approved a single-station residential smoke detector in the 1960s, which was followed in 1970 by the now widespread single-station battery-powered smoke alarm. Early recommendations demanded installation of both smoke and heat detectors, at substantial expense to the homeowner. By 1974, research supported the effectiveness of smoke detectors in isolation, and the NFPA eliminated the requirement for an additional heat detecting system (Hall, 1985).

Fire prevention efforts at the national level have a lengthy history. In May 1947, the President's Fire Prevention Conference brought together 2000 leaders including President Harry Truman and representatives from industry, government, the military, higher education, and the fire service. Reports of this event detail an approach not unlike the current one, with a call for multilevel multisectoral interventions, including education, enforcement, and engineering measures (Federal Works Agency, 1947). Further evidence of an organized approach to burn prevention was apparent in the late 1960s and early 1970s. The American Burn Association was founded in 1967 and initially focused on patient care, teaching, and research. In 1972, the association expanded its activities to include public education and added *Prevention* to its name. The U.S. Fire Administration was established in 1974, when Congress passed the Federal Fire Prevention and Control Act, with the mandate to reduce deaths and property loss due to fire through surveillance, education, research, and training (Silverstein & Lack, 1987).

Fire prevention has been acknowledged as a public health priority for several decades. The 1990 health promotion objectives for the nation relating to injury prevention included increasing functioning smoke alarm prevalence to 75% for residential units from baseline rates of 50% in 1980 and 67% in 1982. Subsequently, *Healthy People 2010* injury prevention objectives included two objectives related to residential fire injuries: (1) reduce residential fire deaths to a target level of 0.2 deaths per 100,000 population in 2010 from a 1998 baseline of 1.2 per 100,000 and (2) increase functioning residential smoke alarms from a 1998 baseline of 87% of residences having a functioning smoke alarm on every floor to 100% in 2010 (USDHHS, 2000).

The U.S. Fire Administration, Consumer Product Safety Commission (CPSC), Centers for Disease Control and Prevention (CDC), and other organizations have recently established the goal of eliminating residential fire deaths by 2020 (CDC, 2003). As part of this effort, the CDC has funded smoke alarm installation programs and fire safety education programs in high-risk communities since 1998 and has targeted residential fires as a research priority. The CDC Injury Research Agenda includes the following priorities related to the prevention of residential fire injuries: evaluation of strategies to increase smoke alarm and sprinkler use; identification of behavioral factors that influence safe escape from fires; identification of strategies that improve the ability of high-risk individuals to detect and escape fires; and developing an interdisciplinary research program pertaining to evacuation in mass trauma events, including environmental and human factors, human reaction to fire, and fire risk perception (CDC, 2002).

6.3. CHAPTER ORGANIZATION

This chapter summarizes interventions of relevance to the prevention of fires and fire-related injuries. Three broad groups of interventions are summarized: products (e.g., smoke alarms, sprinklers), environmental interventions (residential design and household equipment factors that reduce the risk of fire injury), and behavioral interventions (strategies to increase smoke alarm use and function). Behavioral strategies are divided into three levels according to the group targeted for behavior change: the individual (e.g., education in clinical settings, schools, and the community), the community (e.g., smoke alarm legislation), and multilevel interventions. Risk factors and interventions are then summarized by vulnerable population. For each intervention type, the level of evidence is noted (effective, promising, insufficient evidence, no evidence, harmful).

6.4. REVIEW OF INTERVENTIONS BY LEVEL OF EVIDENCE

6.4.1. Intervention Types

6.4.1.1. Products

6.4.1.1.1. Smoke Alarms (Effective Strategy). There are three types of smoke alarms: ionization alarms, photoelectric alarms, and combination types. Photoelectric alarms respond more rapidly than ionization types, have fewer nuisance alarms, and therefore lower disconnection rates. Despite this, ionization alarms remain the most popular ones in U.S. homes (90%). In 1993 most smoke alarms were battery powered (72%), with the remainder being hard-wired to the home's electrical system (23%), portable units powered by an electrical outlet (2%), and hard-wired with battery backup (2%). Hard-wired systems are much more common in new construction, apartments, and manufactured homes, reflecting current fire and building codes and legislation. Although field testing has not confirmed greater effectiveness of hard-wired systems, these systems do not depend on batteries and are statistically much less prone to power source interruptions; therefore, hard-wired interconnected alarms are recommended over battery-powered systems and are now required in many jurisdictions for new construction. Wireless technology is being explored as a means to interconnect existing single-station battery-powered smoke alarms, thereby sounding all alarms if one is activated (Ahrens, 2004).

Current recommendations for smoke alarm placement and number are based on sleeping location and home design; there should be one detector on each level of the home and close to each sleeping area. Detectors should be installed, maintained, and tested according to the manufacturer's instructions and should be replaced at least every 10 years. Batteries should be replaced at least annually (Ahrens, 2004; Reisinger, 1980).

The National Fire Incident Reporting System (NFIRS) has been used to estimate the effectiveness of smoke alarms. Residential fire mortality rates in homes with smoke alarms are 40–50% lower than those in homes not equipped with functioning detectors; this estimate has been consistent since it was first calculated using 1979 NFIRS data (Hall, 1985; Hall, 1994). A recent National Institute of Standards and Technology (NIST) Fire Research Division study reports extensive testing of current residential smoke alarm technologies in a controlled laboratory setting and in a series of real-scale tests conducted in two residential structures. These studies affirmed that both ionization and photoelectric smoke alarms consistently provide time for occupants to escape from most residential fires. Consistent with prior findings, ionization-type alarms provided somewhat better responses to flaming fires than photoelectric alarms, and photoelectric alarms provided considerably faster response to smoldering fires than ionization type alarms. Notably, the escape times documented in these studies (3 minutes) were considerably shorter than those reported in previous similar studies (17 minutes). The addition of a smoke alarm in the bedroom increased escape times significantly, particularly for smoldering fires (Bukowski et al., 2004).

The National Smoke Detector Project Survey conducted in 1993 found that up to 20% of installed smoke alarms are nonoperational. A number of studies have evaluated the performance of smoke alarms in real fires. The most common reason for nonoperational alarms are malfunctions, dead batteries, removed batteries, and disconnection, commonly due to frequent false alarms. In a 1983 study, in fires that produced enough smoke to cause activation, smoke alarms did not properly sound due to dead or missing batteries and other power source problems (69%), incorrect installation (12%), and incorrect location (11%) (Hall, 1994). Disconnection is a significant issue and has contributed to numerous fatal fires. Disabling of alarms occurs frequently in response to nuisance alarms, largely related to cooking. Despite educational efforts and research to reduce nuisance alarms, the current disconnection rate remains high. The National Smoke Detector Project recommended measures to reduce nuisance alarms, including adjusting the installation location, switching to the photoelectric type of detector, and decreasing sensitivity through routine maintenance and replacement after 10 years. Sensitivity drift due to age may increase nuisance alarms or decrease the detection of real fires (Hall, 1994).

Extended-life lithium batteries have been promoted in recent years to address the issue of battery replacement. These batteries are typically advertised as lasting 10 years. Numerous complaints have been documented regarding these batteries, due to premature low battery chirping. The CPSC investigated these complaints and determined that a grease sealing process used during a limited time period in 1998–1999 allowed moisture into the batteries. This problem appears to have been resolved; however, there are no data documenting improved effectiveness over standard batteries (Ahrens, 2004; Lee, 2002). In a randomized controlled trial examining which type of smoke alarm is most likely to remain functional in inner city housing, alarms with lithium batteries were significantly more likely to be functional at follow-up; however, a significant portion were not working after 15 months (Rowland et al., 2002).

The CPSC recently conducted a literature review concerning the audibility of smoke alarm signals to older adults and sleeping children. The authors concluded that current smoke alarms do not reliably wake children younger than 16 years of age or seniors who are hearing impaired. Interconnected alarms could enhance audibility, particularly for units installed in bedrooms. Further research is recommended regarding potential technical solutions, such as alternative audible or visible (strobe light) cues, and/or training and education to improve waking responses (Lee, Midgett, & White, 2004).

6.4.1.1.2. Child Resistant Lighters (Effective Strategy). In 1994, the CPSC introduced a safety standard for cigarette lighters (16 CFR Part 1210) that requires disposable or novelty lighters to have a child-resistant mechanism that makes them difficult for children younger than 5 years to operate. This standard does not pertain to "multipurpose lighters" used for barbeques and fireplaces because they are covered by a different standard. Lighter manufacturers are required to test their products using panels of children between 42 and 51 months of age, and 85% of these children must not be able to operate them within a defined time limit (Smith, Greene, & Singh, 2002).

The effectiveness of the CPSC standard was estimated by comparing the incidence of fires caused by children younger than 5 years playing with lighters for 1997–1999 (poststandard) to similar data for 1985–1987 (prestandard). There was a 58% reduction in these fires after the introduction of the standard (Odds ratio [OR]: 0.42; 95% confidence interval [CI]: 0.23–0.62). It was estimated that the child-resistant standard prevented 3300 fires, 100 deaths, 660 injuries, and $52.5 million in property losses in 1998 (Smith et al., 2002).

As part of another study, two groups of children 40–60 months of age were given conventional and child-resistant lighters. The children were given 5 minutes to attempt to operate the lighter; if the child could not ignite it, the administrator showed them how to use it and allowed another 5 minutes. Researchers found that 62% were unable to operate the conventional lighter after the second 5 minutes compared to 95% that were still unable to operate the child-resistant one. The child-resistant feature lowered caregivers' risk perceptions related to the lighter and reduced precautionary behaviors; however, the authors concluded that these effects would not significantly affect the effectiveness of the child-resistant feature in terms of fire-related injuries (Viscusi & Cavallo, 1994).

6.4.1.1.3. Residential Sprinklers (Insufficient Evidence). Residential sprinkler systems are designed to automatically discharge to extinguish fires, giving the occupant time to escape. Sprinkler systems have been available for more than 100 years, but residential systems were not practical until 1978 when technical advancements made them five times faster in response to fires (American Medical Association Council on Scientific Affairs, 1987). More quick-response heads that are now available react as quickly as 35 seconds. Industrial or commercial sprinkler systems have been evaluated by full-scale fire tests and have increased survivor rates, reduced multiple losses, and significantly reduced property losses (one fifth compared to unsprinklered buildings). It has been estimated that while smoke detectors reduce home fire fatalities by about 50%, a residential sprinkler system could reduce home fire fatalities by an additional 30% (Rohr, 2003). In 1999, only 3.4% of fires in one- and two-family dwellings occurred in homes with sprinkler systems (Rohr, 2003). One of the major deterrents to installation of sprinkler systems is the cost, estimated at greater than 20 times that of a smoke alarm system (Hall, 1985). A number of demonstration projects have been conducted to reduce installation costs, simplify installation, and investigate infrastructure and code alternatives and incentives for installation of these systems.

6.4.1.1.4. Fire-Safe Cigarette (Promising Strategy). "Fire-safe" cigarettes are designed to demonstrate a reduced propensity for igniting household materials such as furniture and mattresses and self-extinguish when they are not being smoked. Burn rates of cigarettes are determined by multiple factors, including the circumference of the cigarette, packing density of the tobacco, porosity of the paper, and presence of a filter. Other factors that play a major role are the addition of accelerants such as citrate and phosphate that maintain continuous burning when the cigarette is not inhaled (Botkin, 1988; Chapman & Balmain, 2004).

Legislative efforts to develop fire-safe cigarettes began in the 1920s, as a method to prevent forest fires (Barillo, Brigham, Kayden, Heck, & McManus, 2000). In 1979, the American Burn Association endorsed the first national campaign for fire-safe cigarettes. The 1984 Cigarette Safety Act (PL98-567) established a technical study group to examine the feasibility of the development of fire-safe cigarettes. In 1987 this group released their report, which stated that it was technically feasible to produce a cigarette with low propensity for ignition of other items. Subsequently, a Fire-Safe Cigarette Act was passed in 1990, which mandated the development of a test method and other studies. The final report of these activities was presented to Congress in 1993, and in February 1994, the late Congressman Joseph Moakley sponsored a bill that would have required the CPSC to issue a safety standard for cigarettes. This bill did not pass; however, legislative efforts continue. American Society for Testing and Materials (ASTM) recently introduced a test method for measuring cigarette ignition, and fire-safe cigarette legislation was recently passed in New York State and Canada, requiring manufacturers to publicize or limit ignition strength (Chapman & Balmain, 2004; Hall, 2004); but presently, not enough time has elapsed since the passage of these laws to determine if they have been effective. Preliminary results from the state of New York appear promising.

6.4.1.1.5. Ignition-Resistant Household Materials (Promising Strategy). Mattresses, bedding, and upholstered furniture are the items most commonly ignited in smoking-related home fires and in fires resulting from children playing with fire (Hall, 2003, 2004). Mattresses sold in the United States after 1971 are required to be resistant to ignition by a dropped cigarette (Clarke & Birky, 1981). It has been suggested that continued investigation regarding the ignition resistance and burning properties of household materials could further reduce the risk of injury and death for these types of fires, particularly for smoking-related fires (Hall, 2004).

6.4.1.1.6. Environmental Interventions (Insufficient Evidence). Building design, construction materials and quality, and household furnishings and equipment can contribute to residential fire risk and injury. Hard-wired interconnected smoke alarms, sprinkler systems, and well-planned routes for egress can reduce the risk of a fatal fire, while exposed heating sources, faulty wiring, poorly maintained appliances and fixtures, and substandard cooking facilities are potential fire hazards (Krieger & Higgins, 2002; Neutra & McFarland, 1972).

Heating equipment is the second leading cause of residential fires (Ahrens, 2003). Home heating equipment includes central heating units, portable and fixed space heaters, fireplaces, chimneys, and hot-water heaters. These fires typically involve poorly installed, poorly maintained, or misused heating equipment. Electrical distribution equipment fires are the leading cause of property damage (Ahrens, 2003). This equipment includes wiring; transformers; meters or meter boxes; switches, receptacles, and outlets; light fixtures; cords and plugs; and lamps and light bulbs. "Open flame, ember or torch" is the second leading cause of home fire injuries (Ahrens, 2003). This category includes cutting, welding, or other torches; matches, lighters, and candles not associated with intentional or child-play fires; open fires; and embers. Candles were the leading cause in this category of home fires for 1999. While these household equipment and other home environment fire risks are well characterized, prevention strategies have not been well evaluated. A Cochrane review of modification of the home environment to reduce injuries concluded that there is insufficient evidence to determine the effectiveness of these types of interventions (Lyons et al., 2003). However, fire-prevention education materials and campaigns often cite the need to modify environments to reduce these hazards, yet evidence is insufficient to determine if this works. The effectiveness of educational and behavioral change strategies are discussed in the next section.

6.4.1.2. Behavioral Interventions

Behavioral aspects of residential fire injury and its prevention are not well documented in current research literature. Some of these behaviors relate to routine practices, such as safe cooking behaviors and space heater placement, and are considered primary prevention, which can avert a fire. Other behaviors are considered secondary prevention and reflect decision making or action taken during a fire, which can eliminate or reduce fire-related injuries. Other characteristics of a human behavior approach to fire safety deal with principles of applied behavioral analysis, evacuation modeling, factors affecting perception of fire risk, visual access, residential design concepts, and human performance criteria needed for fire safety engineering (University of Ulster, 2001, 2004).

An understanding of health behavior theory may contribute to new or improved interventions, such as smoke alarm distribution and maintenance campaigns, and fire escape planning and practice (Thompson, Waterman, & Sleet, 2004). A set of key factors to predict and explain behavior change affecting many health problems has been determined, including three that are considered necessary and sufficient—intentions, environmental barriers, and skills—and five that can influence strength and direction of intentions or act directly to influence behavior—outcome expectancies, social norms, self-standards, emotional reactions, and self-efficacy (Fishbein et al., 2001). These eight factors can be applied to the behavior of testing the functionality of a residential smoke alarm.

As described by Gielen and Sleet (2003), if a home owner forms a strong positive intention (i.e., a commitment to test the smoke alarm every month), encounters no environmental barriers to accessing the smoke alarm (i.e., the alarm is reachable by household ladder), and has the skills necessary to successfully test the alarm, then we would expect routine alarm maintenance. Maintenance would be even more likely if the home owner believes that it is useful to do the testing, understands that it is the right thing to do in the neighborhood, expects that conducting smoke alarm maintenance is part of being a responsible home owner, overall feels positively about doing the testing (i.e., the satisfaction of knowing the smoke alarm is operational outweighs the time and effort involved in the testing), and finds it feasible to conduct the testing activities under conditions that could include other competing household or family demands. The more that is known from theory about factors influencing specific fire-related behavior and behavior change, the more likely it is that behavioral-intervention programs will succeed (Thompson et al., 2004). To date, few injury prevention programs have used health behavior theory as a framework for prevention (Trifiletti, Gielen, Sleet, & Hopkins, 2005).

6.4.1.2.1. Individual Education and Counseling (Insufficient Evidence). A systematic review of controlled trials of interventions to promote smoke alarms estimates that counseling and educational interventions had nonsignificant effects on the likelihood of owning an alarm (OR: 1.26; 95% CI: 0.87–1.81) or having a functioning alarm (OR: 1.19; 95% CI: 0.85–1.66) (DiGuiseppi & Higgins, 2000). Providing smoke alarm counseling as part of routine well-child care had more significant effects on smoke alarm ownership (OR: 1.93; 95% CI: 1.04–3.58) but not functionality (OR: 1.72; 95% CI: 0.78–3.78). However, these published interventions were not based on behavioral theory and did not study the interventions' effects on fire-related injuries. Educational interventions in other settings were not as effective, demonstrating no effect or modest positive, statistically nonsignificant effects on smoke alarm ownership and function; these included education in prenatal classes, discharge teaching for children hospitalized in a burn unit, and mass media and community-based injury prevention education. A more recent study documented significantly higher working smoke alarm rates in households receiving a health visitor delivered safety consultation based on evidence-based educational principles and including free safety devices fitted for the family free of charge (OR: 1.83; 95% CI: 1.33–2.52 at 12 months; OR: 1.67; 95% CI: 1.21–2.32 at 24 months). These and other improved safety practices were not associated with a reduction in injury rates (Watson et al., 2005).

6.4.1.2.2. Community/Societal Interventions, Including Legislation (Promising Strategy). The effectiveness of smoke alarm legislation was examined in a study of smoke alarm use in a county with a retrofit law requiring a smoke alarm in all homes regardless of age, compared to a county with legislation applying only to new construction. Just 5 years after the retrofit law was introduced, homes in the county with the retrofit law were less likely to have no operational alarms (17% vs. 30%) or to have no detector (6% vs. 16%) when compared to the control county. Fatal fires and fire deaths decreased to a greater extent in the retrofit county than the control county for the 6-year periods before and after the law was introduced (McLoughlin, Marchone, Hanger, German, & Baker, 1985).

Smoke alarm requirements differ considerably by state. By 1999, seven states did not have smoke alarm legislation, and the remainder of states had varying requirements; the dwellings affected include all residences in some states and in others, various combinations of one- and two-family dwellings, multiple-occupancy dwellings, mobile homes, and rental properties (ISCAIP Smoke Detector Legislation Collaborators, 1999). The type and number of detectors required range considerably, as well as the referenced codes (e.g., NFPA 72—the National Fire Alarm Code, Uniform Building Code).

6.4.1.3. Multilevel

6.4.1.3.1. Community-Based Campaigns (Insufficient Evidence). A recent Cochrane review examined community-based interventions for the prevention of burns and scalds in children 0–14 years of age (Turner, Spinks, McClure, & Nixon, 2004). Eligible interventions were coordinated, multi-strategy initiatives, and controlled community trials were included that reported changes in medically attended injuries. Of 32 studies, 3 met criteria for inclusion (Guyer et al., 1989; MacKay & Rothman, 1982; Ytterstad, Smith, & Coggan, 1998; Ytterstad & Sogaard, 1995). Project Burn Prevention was an educational campaign delivered through mass media, schools, and community organizations and was implemented in two Boston communities from October 1977 to May 1978 (MacKay & Rothman, 1982). The Massachusetts Statewide Childhood Injury Prevention Program (SCIPP) was an injury prevention educational intervention, with burn prevention being one of five target project areas; it was implemented in nine cities between September 1980 and June 1982. SCIPP implemented the Project Burn Prevention curricula through schools, libraries, police and fire authorities, and day-care facilities (Guyer et al., 1989). The Harstad Injury Prevention Study used the Safe Communities method and targeted burns and scalds in children younger than 5 years of age. Multiple community agencies and businesses delivered burn-prevention education using a variety of methods, ranging from individual counseling to local media involvement (Ytterstad & Sogaard, 1995).

Burn injury rates decreased in the Harstad study; however, in this study residential fires was not a focus of the intervention, but rather scalds and contact burns (Ytterstad & Sogaard, 1995). Neither of the other two studies documented significant reductions in burn injuries. Project Burn Prevention may have been limited by its short duration (8 months) (MacKay & Rothman, 1982). The SCIPP program may have been limited by the lack of penetration of its burn-prevention component (Guyer et al., 1989).

6.4.1.3.2. Smoke Alarm Installation (Effective Strategy) and Distribution (Promising Strategy). Another Cochrane review examined interventions for promoting smoke alarm ownership and function (DiGuiseppi & Higgins, 2000, 2001). This review included four published nonrandomized trials with multilevel components (Guyer et al., 1989; MacKay & Rothman, 1982; Mallonee et al., 1996; Schwarz, Grisso, Miles, Holmes, & Sutton, 1993). Two of these studies were described earlier. The Oklahoma City Smoke Alarm Project targeted households in an area with the highest rate of residential fires in the city, and distributed free smoke alarms and related information to residents. By 6 years after the project was implemented, fire-related injury rates had decreased 81% in the target area and only 7% in the remainder of the city. Part of this reduction may have been due to regression to the mean, as the target area had the highest rate at baseline. At 48 months, 46% of the alarms were still installed and functioning (Mallonee, 2000). A subsequent cost-effectiveness analysis documented that the program was cost effective both from a societal and a health care system perspective (Haddix, Mallonee, Waxweiler, & Douglas, 2001). Another smoke alarm giveaway program targetted urban African American households; this campaign increased functional smoke alarm use among the intervention group (96% vs. 77%) and also demonstrated a significant reduction in fire-related injuries in the intervention but not the control group (Schwarz et al., 1993). A more recent cluster randomized controlled trial targeting rental housing in a poor urban population did not reduce fires, hospitalizations, deaths, or alarm installation rates. Few of the alarms had been installed or maintained, suggesting that some distribution campaigns require installation assistance to ensure compliance (DiGuiseppi et al., 2002; Harvey et al., 2004).

Comparisons of the effectiveness of different distribution methods have been reported by several studies. For the Oklahoma City Smoke Alarm Project, the authors describe a comparison of smoke alarm distribution methods and document that direct distribution to homes was the most effective and cost-efficient method, compared to notification by mail, flyer, or public notices alerting residents that fire alarms were available at local fire stations. Contamination of the distribution groups limits this analysis because the distribution methods were assigned by ZIP code, and promotional materials were distributed widely through schools, the media, and community groups (Douglas, Mallonee, & Istre, 1998).

Another study examined two methods—direct distribution/installation and vouchers for free smoke alarms—in high-risk households in five states. Within each state, geographic areas were identified (areas, cities, counties), and comparable areas were randomly assigned to the two methods. All homes were canvassed, and households without any smoke alarms were eligible for randomization. Follow-up home visits at 6–12 months documented 89.8% in the installation group had functioning alarms compared to 65% in the voucher group (OR: 4.82; 95% CI: 3.97–5.85; $p < .0001$). Almost half of the voucher group did not redeem the voucher (Harvey et al., 2004). Another study revealed a positive economy of scale: as the number of smoke alarms installed went up, the costs per alarm went down; for every 1% increase in, smoke alarm installation, the cost per alarm decreased by $1.36 (Parmer, Corso, & Ballesteros, 2005).

One study evaluated the long-term functional status of smoke alarms distributed to high-risk households (Shults et al., 1998). Households were randomly selected for home visits to assess smoke alarms that were distributed 3–4 years earlier, for three different smoke alarm giveaway programs (Minnesota, North Carolina, Oklahoma). The proportion of homes with at least one functioning alarm ranged from 58% to 73%, with the majority (76%) of nonfunctioning alarms due to missing batteries or disconnection. In a more recent randomized controlled trial, almost half of the distributed alarms were not functioning at 15 months (Rowland et al., 2002).

6.4.2. Target Populations

Most smoke alarm distribution studies have targeted “high-risk” households, variably defined as communities or households with at least one risk factor, including increased rates of residential fires or fire-related injury/death or low prevalence of smoke alarm use, households with at least one young child or older adult, low-income areas, and high proportion of rental units. These studies are summarized above, as are other studies that specifically target children and their families. Data regarding other vulnerable populations are presented in this section.

6.4.2.1. Rural Communities

Rural homes are more likely to lack smoke alarms, and often have multiple risk factors for smoke alarm nonuse and residential fire death (Ahrens, 2004; Forjuoh, Coben, Dearwater, & Weiss, 1997). Although smoke alarm distribution initiatives in rural communities are described in the literature, their effectiveness in terms of reductions in fires, injuries, and deaths are not known. Uncontrolled follow-up studies of targetted smoke alarm distribution campaigns have demonstrated significant increases in functioning smoke alarms. One such study documented an increase from 58.6% to 89.9% at 1-year follow-up. In this study, dead or missing batteries and disabled alarms accounted for approximately 50% of nonfunctioning alarms and could be addressed by installation of alarms with long-life batteries (Jones, Thompson, & Davis, 2001).

Fazzini, Perkins, & Grossman (2000) studied the problem of nuisance alarms in a cohort study conducted in four small villages in Alaska. They compared the false alarm rate between households with ionization and photoelectric types of detectors. Both groups were similar with respect to square footage, household income, family size, and alarm location (distance from cooking source). At 6 months after the detectors were installed, surveys were conducted to determine false alarm and detector disconnection rates. Significant rates of false alarms were documented for ionization detectors (92% vs. 11% for photoelectric) and high rates of disconnection were found in the same group (19% vs. 4%). Of note, these homes were small, and the nuisance alarms were predominantly related to frying foods. The authors conclude that photoelectric alarms may result in higher long-term functioning smoke alarm rates for small homes (<1000 square feet) or those with high rates of nuisance alarms. However, in a subsequent study, ionization alarms were significantly more likely to be functional at follow-up (Rowland et al., 2002).

6.4.2.2. Homebound and Older Adults

Between 1997 and 2001, a total of 11 “sentinel events” were reported to the Joint Commission on Accreditation of Healthcare Organizations related to home-care patients who were seriously (4) or fatally (7) injured in residential fires (Joint Commission on Accreditation of Healthcare Organizations [JCAHO], 2001). Risk factors identified in these cases included living alone, lack of a functional smoke alarm, cognitive impairment, a history of smoking while using oxygen, and flammable clothing. These cases were analyzed for root causes that contributed to these fires, which included patient care processes, caregivers, the environment of care, and communication factors. Risk-reduction strategies arising from these analyses include development of home safety assessment processes, including obtaining and testing smoke alarms; providing smoking-cessation information and terminating home-care services for noncompliance; and staff training with respect to care of smokers and home-care fire safety. In-depth fire safety assessments of geriatric home-care clients have documented significant personal and environmental risk factors for fire injury (physical impairment, poor fire safety knowledge and equipment, apathy) (Stiles, Bratcher, Ramsbottom-Lucier, & Hunter, 2001). A home safety checklist for homebound adults has been developed for home visitors and other caregivers, but has not been evaluated (Weese, 1995); home safety risk-assessment tools have been developed for home-care professionals but have not been validated (Stiles et al., 2001; Tanner, 2003).

6.4.2.3. Persons with Disabilities and Older Adults

Individuals with disabilities, including many older adults, are at an increased risk of fire-related death; this may be related to limited mobility; sensory or cognitive impairment that prevents awareness of a fire or an alarm; or inability to develop, alter, or complete an escape plan (Gaebler-Spira & Thornton, 2002). In an analysis of victims and survivors of the same residential fires, persons with physical or cognitive disabilities had a 4-fold increased risk of death (OR: 4.18; 95% CI: 1.33–13.11) (Marshall et al., 1998). In this study, the presence of a potential rescuer (unimpaired adult) reduced the risk of death by half, and the presence of a smoke alarm reduced the risk of death by 60%. The risk of death for persons with disabilities (vision, hearing, mobility, mental status) was documented as a 2.5-fold increase compared to nondisabled persons in a previous case-control study by the same authors (OR: 2.5; 95% CI: 1.5–4.4) (Runyan, Bangdiwala, Linzer, Sacks, & Butts, 1992).

Several studies of mildly to profoundly mentally disabled children and adults have documented mastery of safe exit in individual or small group training sessions using behavior-modification techniques (Haney & Jones, 1982; Holburn & Dougher, 1985; Jones & Thornton, 1987; Katz & Singh, 1986; Rae & Roll, 1985; Rowe & Kedesdy, 1988). Maintenance of skills was variable, with good retention at 3–8 months. These studies consistently document the importance of follow-up testing and reinforcement. Two studies examined cognitive-behavioral training to teach blind, mildly mentally disabled adolescents the necessary fire evacuation skills to escape a nighttime fire in their dormitory. In the first study, individuals were trained to respond to four different scenarios. In the second study, group training was used with a single scenario. Both individual and group training were effective in teaching the correct sequence of behaviors (100% mastery), with high levels of maintenance of these skills at 3–4 months (Jones, Sisson, & Van Hasselt, 1984; Jones, Van Hasselt, & Sisson, 1984).

6.4.2.4. Children

Studies that evaluate the effectiveness of fire safety education and smoke alarm counseling in various settings (e.g., primary care, prenatal classes, parenting classes, injured children, community-based programs) and targeted caregivers of young children are summarized in the above sections. Studies that evaluate interventions targeting children themselves include educational programs and fire-response training at schools and day cares and are summarized in detail elsewhere (Warda, Tenenbein, & Moffatt, 1999b). Some of these educational programs documented modest increases in fire safety knowledge but most were limited by short-term outcome evaluation and lack of rigorous evaluation methods. Of note, the single published study of the Learn Not to Burn (LNTB) curriculum documented that pretest and posttest scores among grade 3 and 4 students did not differ between LNTB schools and schools with other fire safety programs or no fire safety program (Grant, Turney, Bartlett, Winbon, & Peterson, 1992). One large school-based program implemented by the New Zealand Fire Service documented a significant increase in correct behavioral responses to two of three simulated fire situations (Dunn & Renwick, 1995). Several small randomized controlled trials have evaluated small group and one-on-one intensive training in fire response behaviors using simulated bedrooms or actual sleeping areas. Several groups of grade 2–4 students successfully mastered these skills; however, loss of skills over time was considerable (Jones & Haney, 1983; Jones, Ollendick, McLaughlin & Williams, 1989; Jones, Kazdin, & Haney, 1981; Hillman, Jones, & Farmer, 1986).

Infants and children generally require more sleep, have longer stages of deep sleep, and are more difficult to arouse from sleep than adults. There has been growing concern regarding the extent to which children will awaken to a smoke detector alarm in the standard hallway location. In response to this concern, a study was conducted using 20 individuals 6–17 years old and 16 adults 30–59 years old (Bruck, 1999). A smoke alarm stand was placed such that the decibel reading at the pillow of each participants was 60 dBA ± 3 dBA. It was found that 85% of the children slept through the 3-minute alarm, whereas 100% of the adults reliably awoke. Based on these findings, the author recommends that interconnected detectors and alarms be installed in residential settings so that adults can be awoken if a fire occurs in or near children's bedrooms.

Inadequate supervision is a significant risk factor for injury death among children, including residential fire death (Rimsza, Schackner, Bowen, & Marshall, 2002; Landen, Bauer, & Kohn, 2003) Families with previous involvement with child protection services are at higher risk of injury death and hospitalization, including burn injuries. In a retrospective burn center study, 17.6% of admissions were related to abuse or neglect, 36% had been investigated for abuse or neglect, and 12% had lost custody of other children (Hultman et al., 1998). In a similar study of 507 consecutive admissions to a pediatric burn unit, 14% of families were referred to child protection services with suspected or confirmed child abuse or neglect (Andronicus, Oates, Peat, Spalding, & Martin, 1998) A 12-month study of patients treated in a pediatric emergency department documented 431 patients with burn injuries, of which 84 (19.5%) were suspected of being abused or neglected (Rosenberg & Marino, 1989). These case series are primarily scalds and contact burns; however, caregiver neglect has also been documented for residential fire injuries and flame injuries related to playing with lighters and matches; for flame injuries, cases of neglect include children left alone and children supervised by intoxicated adults. Prevention program staff might benefit from communicating with child protection services, to further understand families at risk and to ensure that fire safety and education regarding active supervision are incorporated in home visiting and other early intervention programs.

6.5. DISCUSSION: IMPLICATIONS FOR PREVENTION

The causes of residential fires and key effective countermeasures (smoke alarms, fire-safe cigarettes) have been well described, with the remaining prevention gaps being widespread implementation of these measures. As with other injury issues, legislation could be instrumental in addressing these gaps. Such legislation could include mandatory compliance with NFPA's Life Safety Code for single- and two-family dwellings, lodging homes, and apartments; the current code requires functioning smoke alarms on every floor and outside every sleeping area, as well as inside bedrooms (excludes apartments). For new construction, interconnected hard-wired alarms are required, and for multistory dwellings greater than four floors, sprinkler systems are also required. As the proportion of nonfunctioning alarms remains significantly high, future efforts must address disconnection and power source (battery) issues; programs that facilitate routine battery replacement and installation of long-life battery alarms or hard-wired systems are potential prevention measures, and careful selection and placement of alarms can reduce false alarm rates and disconnection. Given the new information regarding short escape times afforded by current smoke alarm technology, smoke alarms should be installed inside the bedroom, as well on every level of the home, and interconnected systems should be encouraged. Smoke alarm distribution programs should encourage compliance with these recommendations and should provide education and install alarm units in a manner that reduces false alarm rates.

Federal-level fire-safe cigarette legislation and smoking cessation programs could also contribute significantly to a reduction in fatal residential fires. As the population ages, fires in the home-care setting may increase; the health care system should begin to integrate fire safety precautions in routine standards of care for home-care patients and should also monitor the frequency and patterns of fires in home-care systems.

6.6. RESEARCH GAPS

6.6.1. Intervention Type

A number of research gaps remain with respect to smoke alarm technology, including relative effectiveness and cost-effectiveness of long-life battery-powered alarms systems and hard-wired systems, smoke alarm audibility for children and older adults, relative effectiveness of interconnected alarm systems, and effective and efficient methods to increase functional smoke alarm prevalence in the highest-risk households. Finally, if new technology develops an acceptable smoke, heat, and carbon monoxide combination detector, consumer acceptance and nuisance alarm potential will all have to be carefully evaluated. Residential sprinkler effectiveness in real fires has not been demonstrated, and cost and installation barriers deserve exploration.

6.6.2. Target Audience

American Indian and Alaskan Native communities have significantly elevated residential fire mortality rates and have unique cultural, infrastructure, housing, and equipment (e.g., heating and cooking systems) challenges; effective prevention programs for these communities have not been established. Programs addressing the unique needs of older adults, particularly the frail and homebound elderly in home-care systems, have not been developed or evaluated. The potential for integration of fire-prevention countermeasures with health- and home-care services, such as home visitors, has not been explored. While intensive training methods for fire evacuation responses have been shown to be effective for individuals and small groups with mental and physical disabilities, these methods have not been adopted for more widespread training efforts, and the potential for application of these techniques to teach very young children fire evacuation responses could be further examined.

6.6.3. Methodological Problems in Existing Research

Smoke alarm promotion interventions in clinical and community settings should evaluate fire-related injury outcomes using more rigorous designs (e.g., randomized controlled trials, where feasible), ensuring adequate allocation concealment, blind outcome assessment, and adequate follow-up (DiGuiseppi & Higgins, 2000). Where different interventions are compared with one another, theory should be used to inform and guide the most promising ones. When a single intervention has produced null results, it doesn't mean all interventions in that class should be abandoned. The search for more useful methods of delivering interventions and methods for disseminating results of effective ones remain important research goals.

Cost-effectiveness and cost utility analyses of these interventions are also needed. The validity of self-report measures has been documented; telephone surveys may overestimate the presence of functioning smoke alarms by more than 20%, and should be interpreted with caution or validated with on-site measurements or verification by testing during a phone interview (Chen, Gielen, & McDonald, 2003; Douglas, Mallonee, & Istre, 1999).

6.7. CONCLUSIONS

The current research evidence regarding the prevention of residential fire injuries emphasizes the widespread adoption of effective measures, including long-life smoke alarms, child-resistant lighters, and smoke alarm installation programs. The best protection currently available is for interconnected hard-wired smoke alarm systems with detection units on every level, outside of every sleeping area, and in each bedroom. Further research regarding behavioral and engineering interventions to improve compliance with current prevention recommendations is warranted, as well as important research on improving fire escape planning, practice and evacuation behaviors. Coordination and integration of these efforts with other public health, social, and educational services, especially among vulnerable populations, may contribute to cost-effective and efficient implementation of these interventions and long-term maintenance of safer behaviors.

REFERENCES

Ahrens, M. (2003). *The U.S. fire problem overview report: Leading causes and other patterns and trends.* Quincy, MA: National Fire Protection Association.

Ahrens, M. (2004). *U.S. experience with smoke alarms and other fire detection/alarm equipment.* Quincy, MA: National Fire Protection Association.

American Medical Association Council on Scientific Affairs. (1987). Preventing death and injury from fires with automatic sprinklers and smoke detectors. *Connecticut Medicine, 51* (12), 811–814.

Andronicus, M., Oates, R. K., Peat, J., Spalding, S., & Martin, H. (1998). Non-accidental burns in children. *Burns, 24* (6), 552–558.

Ballesteros, M. F., Schieber, R. A., Gilchrist, J., Holmgreen, P., & Annest, J. L. (2003). Differential ranking of causes of fatal versus non-fatal injuries among U.S. children. *Injury Prevention, 9* (2), 173–176.

Barillo, D. J., Brigham, P. A., Kayden, D. A., Heck, R. T., & McManus, A. T. (2000). The fire-safe cigarette: A burn prevention tool. *Journal of Burn Care of Rehabilitation, 21* (2), 162–164.

Botkin, J. R. (1988). The fire-safe cigarette. *Journal of the American Medical Association, 260* (2), 226–229.

Bukowski, R. W., Peacock, R. D., Averill, J. D., Cleary, T. G., Bryner, N. P., Walton, W. D., Reneke, P. A., & Kuligowski, E. D. (2004). *Performance of home smoke alarms. Analysis of the response of several available technologies in residential fire settings* (NIST Technical Note 1455). Washington, DC: National Institute of Standards and Technology.

Bruck, D. (1999). Non-awakening in children in response to a smoke detector alarm. *Fire Safety Journal, 32*, 369–376.

Centers for Disease Control and Prevention. (2002). *CDC injury research agenda.* Atlanta, GA: National Center for Injury Prevention and Control.

Centers for Disease Control and Prevention. (2003). Nonfatal residential fire-related injuries treated in emergency departments—United States, 2001. *Morbidity & Mortality Weekly Report, 52* (38), 906–908.

Centers for Disease Control and Prevention, National Centers for Injury Prevention and Control. (2005). Web-based injury statistics query and reporting system (WISQARS). Retrieved April 18, 2005, from www.cdc.gov/ncipc/wisqars.

Chapman, S., & Balmain, A. (2004). Time to legislate for fire-safe cigarettes in Australia. *Medical Journal of Australia, 181* (6), 292–293.

Chen, L. H., Gielen, A. C., & McDonald, E. M. (2003). Validity of self reported home safety practices. *Injury Prevention, 9* (1), 73–75.

Clarke, F. B., & Birky, M. M. (1981). Fire safety in dwellings and public buildings. *Bulletin of the New York Academy of Medicine, 57* (10), 1047–1060.

DiGuiseppi, C., Edwards, P., Godward, C., Roberts, I., & Wade, A. (2000). Urban residential fire and flame injuries: A population based study. *Injury Prevention, 6* (4), 250–254.

DiGuiseppi, C., & Higgins, J. P. (2000). Systematic review of controlled trials of interventions to promote smoke alarms. *Archives of Disease in Childhood, 82* (5), 341–348.

DiGuiseppi, C., & Higgins, J. P. (2001). Interventions for promoting smoke alarm ownership and function (CD002246). *Cochrane Database of Systematic Reviews, 2* (2), 1–39.

DiGuiseppi, C., Roberts, I., Wade, A., Sculpher, M., Edwards, P., Godward, C., Pan, H., Slater, S. (2002). Incidence of fires and related injuries after giving out free smoke alarms: Cluster randomised controlled trial. *British Medical Journal, 325* (7371), 995.

Douglas, M. R., Mallonee, S., & Istre, G. R. (1998). Comparison of community based smoke detector distribution methods in an urban community. *Injury Prevention, 4* (1), 28–32.

Douglas, M. R., Mallonee, S., & Istre, G. R. (1999). Estimating the proportion of homes with functioning smoke alarms: a comparison of telephone survey and household survey results. *American Journal of Public Health, 89* (7), 1112–1114.

Dunn, K., & Renwick, M. (1995). *Children's knowledge of fire safety stage 2: What standard 2 children know about fire safety and where they got that information from.* Wellington, New Zealand: New Zealand Council for Educational Research.

Fazzini, T. M., Perkins, R., & Grossman, D. (2000). Ionization and photoelectric smoke alarms in rural Alaskan homes. *Western Journal of Medicine, 173* (2), 89–92.

Federal Works Agency. (1947). *A guide to community organization for fire safety. President's Conference on Fire Prevention.* Washington, DC: Author.

Fishbein, M., Triandis, H., Kanfer, F. H., Becker, M., Middlestat, S. E., & Eichler, A. (2001). Factors influencing behavior and behavior change. In A. Baum, T. A. Tevenson, & J. E. Singer (Eds.), *Handbook of health psychology* (pp. 3–16). Mahwah, NJ: Erlbaum Associates.

Forjuoh, S. N., Coben, J. H., Dearwater, S. R., & Weiss, H. B. (1997). Identifying homes with inadequate smoke detector protection from residential fires in Pennsylvania. *Journal of Burn Care & Rehabilitation, 18* (1, Part 1), 86–91.

Gaebler-Spira, D., & Thornton, L. S. (2002). Injury prevention for children with disabilities. *Physical Medicine & Rehabilitation Clinics of North America, 13* (4), 891–906.

Gielen, A. C., & Sleet, D. (2003). Application of behavior-change theories and methods to injury prevention. *Epidemiologic Reviews, 25*, 65–76.

Grant, E., Turney, E., Bartlett, M., Winbon, C., & Peterson, H. D. (1992). Evaluation of a burn prevention program in a public school system. *Journal of Burn Care & Rehabilitation, 13*, 703–707.

Guyer, B., Gallagher, S. S., Chang, B. H., Azzara, C. V., Cupples, L. A., & Colton, T. (1989). Prevention of childhood injuries: Evaluation of the Statewide Childhood Injury Prevention Program (SCIPP). *American Journal of Public Health, 79* (11), 1521–1527.

Haddix, A. C., Mallonee, S., Waxweiler, R., & Douglas, M. R. (2001). Cost effectiveness analysis of a smoke alarm giveaway program in Oklahoma City, Oklahoma. *Injury Prevention, 7* (4), 276–281.

Hall, J. R. (1985). A decade of detectors: Measuring the effect. *Fire Journal* (September), *79*, 37–43, 78.

Hall, J. R. (2003). *Children playing with fire.* Quincy, MA: National Fire Protection Association.

Hall, J. R. (2004). *The smoking-material fire problem.* Quincy, MA: National Fire Protection Association.

Hall, J. R. (2005). *Home cooking fire patterns and trends.* Quincy, MA: National Fire Protection Association.

Hall, J. R. (1994). The U.S. experience with smoke detectors: Who has them? How well do they work? When don't they work? *National Fire Protection Association Journal, 88* (5), 36–46.

Haney, J., & Jones, R. (1982). Programming maintenance as a major component of a community-centered preventive effort: Escape from fire. *Behavior Therapy, 13*, 47–62.

Harvey, P. A., Aitken, M., Ryan, G. W., Demeter, L. A., Givens, J., Sundararaman, R., Goviette, S. (2004). Strategies to increase smoke alarm use in high-risk households. *Journal of Community Health, 29* (5), 375–385.

Hillman H., Jones R., & Farmer L. (1986). The acquisition and maintenance of fire emergency skills: Effects of rationale and behavioral practice. *Journal of Pediatric Psychology, 11*, 247–258.

Holburn, C., & Dougher, M. (1985). The fire-alarm game: Exit training using negative and positive reinforcement under varied stimulus conditions. *Journal of Visual Impairment & Blindness, 79*, 401–403.

Hultman, C. S., Priolo, D., Cairns, B. A., Grant, E. J., Peterson, H. D., & Meyer, A. A. (1998). Return to jeopardy: The fate of pediatric burn patients who are victims of abuse and neglect. *Journal of Burn Care & Rehabilitation, 19* (4), 367–376.

ISCAIP Smoke Detector Legislation Collaborators. (1999). International smoke detector legislation. *Injury Prevention, 5* (4), 254–255.

Istre, G. R., McCoy, M., Carlin, D. K., & McClain, J. (2002). Residential fire related deaths and injuries among children: Fireplay, smoke alarms, and prevention. *Injury Prevention, 8* (2), 128–132.

Joint Commission on Accreditation of Healthcare Organizations. (2001). Lessons learned: Fires in the home care setting. *Sentinel Event Alert, 17*, 1–3.

Jones, A. R., Thompson, C. J., & Davis, M. K. (2001). Smoke alarm ownership and installation: A comparison of a rural and a suburban community in Georgia. *Journal of Community Health, 26* (5), 307–329.

Jones, R. & Haney, J. (1983). *Refinement of a primary preventive approach to fire emergencies: A comparison of external and self-instruction strategies for training and maintaining fire emergency responding.* Pittsburgh, PA: University of Pittsburgh.

Jones, R., Kazdin, A., & Haney, J. (1981). Social validation and training of emergency fire safety skills for potential injury prevention and life saving. *Journal of Applied Behavior Analysis, 14*, 249–260.

Jones, R., Ollendick, T., McLaughlin, K., & Williams, C. E. (1989). Elaborative and behavioral rehearsal in the acquisition of fire emergency skills and the reduction of fear of fire. *Behavior Therapy, 20*, 93–101.

Jones, R., & Thornton, J. (1987). The acquisition and maintenance of emergency evacuation skills with mildly to moderately retarded adults in a community living arrangement. *Journal of Community Psychology, 15*, 205–215.

Jones, R. T., Sisson, L. A., & Van Hasselt, V. B. (1984). Emergency fire-safety skills for blind children and adolescents. Group training and generalization. *Behavior Modification, 8* (2), 267–286.

Jones, R. T., Van Hasselt, V. B., & Sisson, L. A. (1984). Emergency fire-safety skills. A study with blind adolescents. *Behavior Modification, 8* (1), 59–78.

Karter, M. J. (2004). *Fire loss in the United States during 2003.* Quincy, MA: National Fire Protection Association.

Katz, R. C., & Singh, N. N. (1986). Comprehensive fire-safety training for adult mentally retarded persons. *Journal of Mental Deficiency Research, 30* (part 1), 59–69.

Krieger, J., & Higgins, D. L. (2002). Housing and health: Time again for public health action. *American Journal of Public Health, 92* (5), 758–768.

Landen, M. G., Bauer, U., & Kohn, M. (2003). Inadequate supervision as a cause of injury deaths among young children in Alaska and Louisiana. *Pediatrics, 111* (2), 328–331.

Lee, A. (2002). *Preliminary test results on lithium batteries used in residential smoke alarms.* Washington, DC: U.S. Consumer Product Safety Commission.

Lee, A., Midgett, J., & White, S. (2004). *A review of the sound effectiveness of residential smoke alarms.* Washington, DC: U.S. Consumer Product Safety Commission.

Lyons, R., Sander, L., Weightman, A., Patterson, J., Jones, S. L., Rolfe, B., Kemp, A., & Johansen, A. (2003). Modification of the home environment for the reduction of injuries (CD003600). *Cochrane Database Systematic Reviews, 4*, 1–33.

MacKay, A. M., & Rothman, K. J. (1982). The incidence and severity of burn injuries following Project Burn Prevention. *American Journal of Public Health, 72* (3), 248–252.

Mallonee, S. (2000). Evaluating injury prevention programs: The Oklahoma City Smoke Alarm Project. *The Future of Children*, *10* (1), 164–174.

Mallonee, S., Istre, G. R., Rosenberg, M., Reddish-Douglas, M., Jordan, F., Silverstein, P., Tunell, W. (1996). Surveillance and prevention of residential-fire injuries. *New England Journal of Medicine*, *335* (1), 27–31.

Marshall, S. W., Runyan, C. W., Bangdiwala, S. I., Linzer, M. A., Sacks, J. J., & Butts, J. D. (1998). Fatal residential fires: Who dies and who survives? *Joural of the American Medical Association*, *279* (20), 1633–1637.

McLoughlin, E., Marchone, M., Hanger, L., German, P. S., & Baker, S. P. (1985). Smoke detector legislation: Its effect on owner-occupied homes. *American Journal of Public Health*, *75* (8), 858–862.

Neutra, R., & McFarland, R. A. (1972). Accident epidemiology and the design of the residential environment. *Human Factors*, *14* (5), 405–420.

Parmer, J. E., Corso, P. S., Ballesteros, M. F. (2005). A cost analysis of a smoke alarm installation and fire safety education program. Unpublished data, National Center for Injury Prevention and Control, Atlanta, GA.

Rae, R., & Roll, D. (1985). Fire safety training with adults who are profoundly mentally retarded. *Mental Retardation*, *23* (1), 26–30.

Reisinger, K. S. (1980). Smoke detectors: Reducing deaths and injuries due to fire. *Pediatrics*, *65* (4), 718–724.

Rimsza M. E., Schackner R. A., Bowen K. A., & Marshall W. (2002). Can child deaths be prevented? The Arizona Child Fatality Review Program experience. *Pediatrics*, *110* (1, Part 1), e11.

Rohr, K. D. (2003). *U.S. experience with sprinklers*. Quincy, MA: National Fire Protection Association.

Rosenberg, N. M., & Marino, D. (1989). Frequency of suspected abuse/neglect in burn patients. *Pediatric Emergency Care*, *5* (4), 219–221.

Rowe, M., & Kedesdy, J. (1988). Fire evacuation skills training for institutionalized mentally retarded adults. *Behavioral Residential Treatment*, *3*, 101–118.

Rowland, D., DiGuiseppi, C., Roberts, I., Curtis, K., Roberts, H., Ginnelly, L., Sculpher, M., & Wade, A. (2002). Prevalence of working smoke alarms in local authority inner city housing: Randomised controlled trial. *British Medical Journal*, *325* (7371), 998–1001.

Runyan, C. W., Bangdiwala, S. I., Linzer, M. A., Sacks, J. J., & Butts, J. (1992). Risk factors for fatal residential fires. *New England Journal of Medicine*, *37* (12), 859–863.

Schwarz, D. F., Grisso, J. A., Miles, C., Holmes, J. H., & Sutton, R. L. (1993). An injury prevention program in an urban African-American community. *American Journal of Public Health*, *83* (5), 675–680.

Shai, D., & Lupinacci, P. (2003). Fire fatalities among children: An analysis across Philadelphia's census tracts. *Public Health Reports*, *118* (2), 115–126.

Shults, R. A., Sacks, J. J., Briske, L. A., Dickey, P. H., Kinde, M. R., Mallonee, S., & Douglas, M. R. (1998). Evaluation of three smoke detector promotion programs. *American Journal of Preventive Medicine*, *15* (3), 165–171.

Silverstein, P., & Lack, B. (1987). Fire prevention in the United States. Are the home fires still burning? *Surgical Clinics of North America*, *67* (1), 1–14.

Smith, L. E., Greene, M. A., & Singh, H. A. (2002). Study of the effectiveness of the U.S. safety standard for child resistant cigarette lighters. *Injury Prevention*, *8* (3), 192–196.

Stiles, N. J., Bratcher, D., Ramsbottom-Lucier, M., & Hunter, G. (2001). Evaluating fire safety in older persons through home visits. *Journal of the Kentucky Medical Association*, *99* (3), 105–110.

Tanner, E. K. (2003). Assessing home safety in homebound older adults. *Geriatric Nursing*, *24* (4), 250–254, 256.

Thompson, N. J., Waterman, M. B., & Sleet, D. A. (2004). Using behavioral science to improve fire escape behaviors in response to a smoke alarm. *Journal of Burn Care & Rehabilitation*, *45* (2), 179–188.

Trifiletti, L. B., Gielen, A. C., Sleet, D. A., & Hopkins, K. (2005). Behavioral and social sciences theories and models: Are they used in unintentional injury prevention research? *Health Education Research*, *20* (3), 298–307.

Turner, C., Spinks, A., McClure, R., & Nixon, J. (2004). Community-based interventions for the prevention of burns and scalds in children (CD004335). *Cochrane Database of Systematic Reviews*, *3*, 1–15.

United States Department of Health and Human Services. (2000). *Healthy people 2010. With understanding and improving health and objectives for improving health* (2nd ed., 2 vols.). Washington, DC: U.S. Government Printing Office.

University of Ulster. (2001). Second international symposium on human behavior in fire: Understanding human behavior for better fire safety design. Cambridge, MA.

University of Ulster. (2004). Third international symposium on human behavior in fire: Public fire safety—professionals in partnership. Belfast, UK. London: Interscience Communications.

Viscusi, W. K., & Cavallo, G. O. (1994). The effect of product safety regulation on safety precautions. *Risk Analysis*, *14* (6), 917–930.

Warda, L., Tenenbein, M., & Moffatt, M. E. K. (1999a). House fire injury prevention update. Part 1. A review of risk factors for fatal and non-fatal house fire injury. *Injury Prevention*, *5* (2), 145–150.

Warda, L., Tenenbein M., & Moffatt, M. E. K. (1999b). House fire injury prevention update. Part II. A review of the effectiveness of preventive interventions. *Injury Prevention*, *5* (3), 217–225.

Watson, M., Kendrick, D., Coupland, C., Woods, A., Futers, D., & Robinson, J. (2005). Providing child safety equipment to prevent injuries: Randomised controlled trial. *British Medical Journal*, *330* (7484), 178.

Weese, B. (1995). Fire and burn safety: Important issues for caregivers. *Caring*, *14* (9), 40–42, 44.

Ytterstad, B., Smith, G. S., & Coggan, C. A. (1998). Harstad injury prevention study: Prevention of burns in young children by community based intervention. *Injury Prevention*, *4* (3), 176–180.

Ytterstad, B., & Sogaard, A. J. (1995). The Harstad injury prevention study: Prevention of burns in small children by a community-based intervention. *Burns*, *21* (4), 259–266.