REVIEW ARTICLE

House fire injury prevention update. Part II. A review of the effectiveness of preventive interventions

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Abstract

Objective—To evaluate and summarize the house fire injury prevention literature.

Methods—MEDLINE (1983 to March 1997) was searched by keyword: fire, burn, etiology, cause, prevention, epidemiology, and smoke detector/alarm. ERIC (1966 to March 1997) and PSYCLIT (1974 to June 1997) were searched by keyword: as above, and safety, skills, education, and training. Other sources included references of retrieved publications, review articles, and books; *Injury Prevention* hand search; government documents; and internet sources. Sources relevant to residential fire injury prevention were selected, evaluated, and summarized.

Results—Forty three publications were selected for review, including seven randomized controlled trials, nine quasi-experiments, two natural experiments, 21 prospective cohort studies, two cross sectional surveys, one case report, and one program evaluation. These studies examined the following types of interventions: school (9), preschool (1), and community based educational programs (5); fire response training programs for children (7), blind adolescents (2), and mentally retarded adults (5) and children (1); office based counseling (4); home inspection programs (3); smoke detector giveaway campaigns (5); and smoke detector legislation (1).

Conclusions—This review of house fire prevention interventions underscores the importance of program evaluation. There is a need for more rigorous evaluation of educational programs, particularly those targeted at schools. An evidence based, coordinated approach to house fire injury prevention is critical, given current financial constraints and the potential for program overload for communities and schools.

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Numerous house fire prevention initiatives have been introduced in many communities around the world in an attempt to reduce house fire morbidity and mortality. These measures have included education and training of children, parents, and certain high risk populations such as the elderly, in both school and community based programs¹⁻⁴; promotion of smoke detectors and sprinkler systems for home use, as well as smoke detector legislation⁵⁻⁷; introduction of flame retardant fabrics and clothing, and related industry standards and regulations⁸⁻⁹; and recent innovations such as the development of the so-called "fire safe" cigarette.¹⁰⁻¹⁵ However, the effectiveness of many of these methods in reducing house fire injuries and deaths is unknown. Educational programs in particular are widespread, but their relative effectiveness has not been established. Of the many available programs, in which should a community or a school invest time and financial resources? The literature lacks a summary of this diverse research; therefore this review was initiated to evaluate and summarize the evidence for house fire injury prevention interventions.

Methods

LITERATURE REVIEW

The literature review methods are described in part I of this series.¹⁶

DATA ANALYSIS

All publications evaluating an intervention that could reduce house fire death or injury were included. For example, an educational program teaching children to "stop, drop, and roll" would be included, because this skill could be applied to fires at home as well as to fires in other locations. The following data were abstracted from each publication: study period; location of study, including country and type of population examined, such as school, city, county, state, or country; study design and unit of analysis, such as individual, or household; subject and data sources; sample size for each study group; and relevant results. Study designs were classified using principles outlined by Abramson.¹⁷

For ease of comparison, study data were organized by outcome category and then by

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type of intervention. Outcome categories included house fire morbidity and mortality, smoke detector use and function, fire and burn prevention knowledge, and fire and burn prevention behaviors. Types of interventions were determined by the scope of the retrieved publications, and included categories such as educational programs, smoke detector giveaway campaigns, and office based counseling. Within each outcome category, studies were grouped by type of intervention, and then by level of evidence, in descending order of strength: randomized controlled trial, quasiexperiment, natural experiment, cohort, cross sectional survey, and case report. After ranking by level of evidence, studies were then ordered by degree of validity, from most valid to least valid, as previously described. The final ranking of studies is reflected in the order in which the studies appear in the tables.

Results

Forty three publications were selected for review, including seven randomized controlled trials, nine quasiexperiments, two natural experiments, 21 prospective cohort studies, two cross sectional surveys, one case report, and one program evaluation. These studies examined the following types of interventions: school (9), preschool (1), and community based educational programs (5); fire response training programs for children (7), blind adolescents (2), mentally retarded adults (5) and children (1); office based counseling (4); home inspection programs (3); smoke detector giveaway campaigns (5); and smoke detector legislation (1).

INTERVENTION STUDIES MEASURING FIRE AND BURN PREVENTION KNOWLEDGE

The 14 intervention studies measuring fire and burn prevention knowledge are summarized in table 1. These interventions include numerous school based educational efforts, with both long term^{4 18 19} and short term²⁰⁻²⁵ programming and evaluation components; a preschool educational program²⁶; community based educational programs for seniors²² and new residents of public housing²⁷; a fire response training program for mentally retarded adults²⁸; and pediatric office based counseling.²⁹ Short term outcome evaluation and lack of rigorous evaluation limit the majority of these studies.

Three studies of large scale school based educational interventions have been reported. The most recent study examined a program for elementary students introduced by the New Zealand Fire Service.^{18 19} Firefighters taught and demonstrated fire safety concepts, with a different module for each of three levels of primary students. Although baseline knowledge level was high, there was some improvement in children's knowledge after the program had been in place three years. Involvement by schools in the program was variable, however, with 20%–70% of schools reporting participation in all three components between 1992 and 1995. This may have limited the effectiveness of the program.

Project Burn Prevention examined an eight month educational program introduced in 22 public elementary schools and three high schools in an urban community.³ Three grade levels were targeted: kindergarten and grade 1, grades 2 and 3, and grades 10 to 12. Post-test scores were significantly higher in the intervention community than in a similar control community. The only other study of a large scale school based educational intervention examined the effectiveness of the Learn Not To Burn (LNTB) curriculum in grade 3 and 4 students.⁴ This study used a random sample of schools stratified by location in the state, urban-rural status, and LNTB participation status. Students were pre-tested and post-tested using the standardized LNTB test. Pre-test and post-test scores did not differ between children attending schools using the LNTB curriculum and those attending schools with other fire safety programs or with no established program.

A number of studies have examined smaller scale educational efforts, such as puppet shows²⁰ and short multimedia educational presentations.²¹⁻²⁵ Though well received by their audiences, long term maintenance of knowledge and skills is limited with a single intervention, and the majority of these studies did not test knowledge retention beyond two weeks. These programs, however, could be integrated into larger scale projects.

A successful community based training program targeted heads of households who were new tenants in housing projects administered by the Memphis Housing Authority (MHA).²⁷ Although smoke detectors were located in every residence, a 1992 baseline spot check of 325 units revealed that 92% had been vandalized or were otherwise inoperable. The training program consisted of a lecture and video with MHA footage and a dramatization of a child being carried out of a smoke filled building by a firefighter. After the presentation, each trainee signed a commitment sheet that indicated at least three fire safety behaviors they would try to achieve, and each was given a large card with five key fire safety behaviors to display in their home as a reminder. The training sessions were very well received by new residents. Pre-tests and post-tests demonstrated significant increases in knowledge, and trainee households had a lower incidence of fires than untrained households (see tables 1 and 2).

Many of these studies are directly relevant to the development of school based educational programs. They highlight a number of issues that would be of interest to program developers, such as specific program successes, and difficulties encountered in implementation. Several studies used age appropriate tests, for example, picture tests for younger grades,^{3 22} and many of the projects demonstrated imaginative and multidisciplinary approaches. A number of weaknesses limit these studies, however: questionnaires were rarely validated; pre-tests and post-tests were not administered in a controlled manner^{4 18 19 21-25}; most studies administered post-tests too soon after the

Table 1 Intervention studies measuring burn and fire prevention knowledge

Intervention	Country (population)	Study period	Study design	Subjects	Data sources	Outcomes measured	Results (control group or before)	Results (intervention group or after)	Reference
Education programs: school based	USA (state: cities)	1977–8	E-quasi	Communities exposed to intensive school education programs Control: similar community	Pre- and post-tests (picture or multiple choice)	Mastery (80% correct)	Grade K–1: 18%	70%	3
	USA (state: schools)	1989–90	E-quasi	Grade 3–4 students with exposure to the LNTB curriculum; control: no curriculum	Pre- and post-tests+K22 (written)	Test scores (mean)	Grade 2–3: 20% Grade 10–12: 1%–2% 90.58	87–9% 10% 90.75	4
	New Zealand (country: schools)	1992–95	Cohort, prospective	Elementary schoolchildren ages 8–9, n=1014 in 1992, n=1089 in 1995. No control group	Pre- and post-tests (written)	Correct responses (5 %s)	70%–93%	64%–92%	19
	USA (town: school)		Cohort, prospective	Grade 3–6 students (n=67). No control group	Pre- and post-test (written)	Correct responses (9 %s)	Grade 3: 19%–78%	45%–82%	25
Education programs: preschool	USA (city: class)		Cohort, prospective	Grade 8 students. No control group	Pre- and post-tests (written)	Test scores (F test)	Grade 4: 31%–81% Grade 5: 22%–87% Grade 6: 33%–89% 2.19	35%–88% 40%–100% 33%–100% 2.09	24
	USA (city: classes)		Cohort, prospective	Elementary schoolchildren (n=16, 1035 children). No control group	Pre- and post-tests (picture or multiple choice)	Test scores (all correct)	0%–46%	25%–96%	22
	USA (city: schools)		Cohort, prospective	Grade 4–5 students. No control group	Pre- and post-tests (written)	Improvement (%) Test scores (mean)	66.30%	11%–57% 79.90%	23
	USA (city: schools)	1986	Cohort, prospective	Elementary schoolchildren (n=3, 811 children). No control group	Pre- and post-tests (written)	Test scores (all correct)	1%	61%	21
Education programs: preschool	USA (city: classes)	1986	Cohort, prospective	Grade 3 groups at 2 elementary schools. No control group	Pre- and post-tests (crossword puzzle)	Improvement (%) Test scores	66%	60% 94%	20
	USA (city: daycares)		E-quasi	Preschool children (immediate education) Control: preschool children (delayed education)	Pre- and post-tests (verbal)	Change in test score (max=96)	Age 3: 9.95 Age 4: 12.06	30.25 22.04	26
	USA (city)	1994–5	Cohort, prospective	Head of all new families moving into public housing. Control group: other residents	Pre- and post-tests (written)	Test scores (max=8)	Age 5: 7.32 4.2	20.84 6.9	27
	USA (state: seniors' groups)		Cohort, prospective	Senior citizen groups (n=29, 1265 seniors). No control group	Pre- and post tests (questionnaire, bingo game)	Test scores (all correct)	0%–22%	43%–100%	22
Fire response training	New Zealand (city: group homes)	1985	Cohort, prospective	Mild-mod mentally retarded adults. No control group	Pre- and post-test (written)	Improvement (%) Test scores (mean)	18.6	40%–100% 26	28
Office counseling, SD coupon	USA (city: clinic)		E-RCT	Group well child care couples (n=29, control: n=26)	Pre- and post-tests (written)	Test scores (mean)	18.58	20.28	29

Notes: E-quasi = quasieperimental design; E-RCT = randomized controlled study; LNTB = Learn Not To Burn; SD = smoke detector.

Table 2 Intervention studies measuring fire and burn prevention behaviors

Intervention	Country (population)	Study design	Subjects (intervention group)	Subjects (control group)	Data sources	Outcomes measured	Results (control group or before)	Results (intervention group or after)	Reference
Fire response training	USA (city: school)	E-RCT	External method (passive) n=16, v self instruction (active) n=16	n=16	Direct behavioral assessment	Fire situation responses		Both methods effective; self>external	31
Schoolchildren	USA (city: school)	E-RCT	Elaborative (n=16) or behavioral rehearsal (n=16)	n=14	Direct behavioral assessment	Fire situation responses	4% increase in specific skills	96-8% increase in specific skills	34
	USA (city: school)	E-RCT	Grade 2-4 students: with/without rationale and behavioral or verbal practice (n=15,15)	Grade 2-4 students: with/without rationale and behavioral or verbal practice (n=15,15)	Direct behavioral assessment	Fire situation responses	Near 0% correct	95% correct	33
	USA (town: school)	E-RCT	Grade 2-4 students: with/without rationale and behavioral or verbal practice (n=15,15)	Grade 2 and 3 students: with/without fire safety session (n=12,12)	Direct behavioral assessment	Fire situation responses	11% (both control groups) Near 0	Fear reduction group 98%; fire safety group 96% 5-6	30
	USA (city: school)	E-quasi	Grade 3-4 students (n=8)	Multiple baseline assessments	Direct behavioral assessment	Fire situation responses (mean score, max=6)	4.5% correct	74.4% correct	36
	USA (city: class)	Cohort, prospective	Grade 3 children (n=5)	Multiple baseline assessments	Direct behavioral assessment	Fire situation responses	0.23	2.73	35
Preschool children	USA (city: classes)	Cohort, prospective	Preschool children	Multiple baseline assessments	Direct behavioral assessment	Fire situation responses (mean score, max=4)	Near 0% correct	3 of 4 subjects: 100% mastery, and 82%-100% at 4 months	32
Blind adolescents	USA (city: school)	Cohort, prospective	Blind adolescents (n=4)	Multiple baseline assessments	Direct behavioral assessment	Fire situation responses	45% correct	100% correct	37
	USA (city: school)	Cohort, prospective	Blind adolescents (n=8)	Multiple baseline assessments	Direct behavioral assessment	Fire situation responses	Near 0% correct	72% correct	41
Mentally retarded children	USA (city: group home)	Cohort, prospective	Moderate to severely mentally retarded children (n=4)	Multiple baseline assessments	Direct behavioral assessment	Fire situation responses	Zero at baseline	100% mastery, and 74-100% at 5-8 month follow up	42
Mentally retarded adults	USA	Cohort, prospective	Mentally retarded adults	Multiple baseline assessments	Direct behavioral assessment	Fire situation responses	Near 0% correct	Most achieved mastery, maintained for 6-18 weeks	28
	New Zealand (city: group homes)	Cohort, prospective	Mild to moderate mentally retarded adults	Multiple baseline assessments	Direct behavioral assessment	Fire situation responses	85 seconds 57%	24 seconds 7%	43
	USA (city: group home)	Cohort, prospective	Profoundly mentally retarded adults in group home (n=10)	No control group	Direct behavioral assessment	Safe exit (mean time) Safe exit (physical prompts required)	0	49%	39
	USA (city: institution)	Cohort, prospective	Institutionalized mentally retarded adults	No control group	Direct behavioral assessment	Safe exit (timed)	5-7 minutes	<1 minute	41
	USA (city: institution)	Case report	Blind male adult with Down's syndrome	No control group	Direct behavioral assessment	Safe exit (timed)	9	7	45
Office counselling	USA (city: clinic)	E-RCT	Parents of 6 month old children attending well child clinic (n=85)	Parents of 6 month old children attending well child clinic (n=86)	Home inspection	Matches accessible (%)	3.7	3.6	44
With free safety devices	USA (city: clinic)	E-RCT	Mothers with preschool children attending a clinic	Mothers with preschool children attending a clinic	Home inspection	Matches/lighters lying around the house	One fire for every 780 renter months	One fire for every 4312 renter months	27
Education programs	USA (city)	Cohort, prospective	Head of all new families moving into public housing	Existing residents, untrained	Fire reports	Incidence of fires	47%-84%	46%-95%	19
	New Zealand (country: schools)	Cohort, prospective	Subset of 62 (1992) and 100 (1995) children for skill demonstration	No control group	Direct behavioral assessment	Mastery of fire situation responses (3 situations)			

Notes: E-quasi = quasisexperimental design; E-RCT = randomized controlled study.

intervention, often less than one week, with no subsequent follow up²⁰⁻²⁵; most studies used convenience samples, with no control for confounding variables²⁰⁻²⁵; and few used a control group for comparison.

INTERVENTION STUDIES MEASURING FIRE PREVENTION AND RESPONSE BEHAVIORS

The 19 studies examining fire prevention and response behaviors are summarized in table 2. These studies included training programs for high risk populations, including children,³⁰⁻³⁶ blind adolescents,³⁷⁻³⁸ and mentally retarded children and adults²⁸⁻³⁹⁻⁴³; a school based educational program¹⁸⁻¹⁹; and a community based training program for new public housing residents.²⁷ Included in this series of studies are two randomized controlled trials examining the effectiveness of counseling mothers to reduce household hazards, such as exposed matches and lighters.⁴⁴⁻⁴⁵ This is a group of well designed, carefully controlled studies, the majority of which were found in the psychology literature. The four randomized controlled trials involving schoolchildren were of equal validity, each having adequately addressed the four types of bias.

The largest school based study was the New Zealand Fire Service program,¹⁹ in which a subset of children were tested by demonstration of response to three fire situations: clothes on fire, room full of smoke, and telephoning for help. This study documented a significant increase in skills in two of the three situations following the program.

There are a number of rigorous small scale studies involving training of children and other high risk populations in fire response behaviors. These studies are characterized by small group (for example four children) or individualized intensive training, and rehearsal of correct behavioral responses to a variety of fire stimuli, using a standardized simulated bedroom or actual sleeping areas.³⁰⁻³⁶⁻⁴¹ In one study, passive (external instruction) and active (self instruction) methods of training were equally effective. Both methods used behavioral rehearsal with active participation by the children.³¹ A number of follow up studies further explored these findings. In one of these, behavioral practice was only slightly more effective than verbal practice in skill acquisition, although all subjects were trained and tested with behavioral scenarios.³³

Several studies have examined methods to reduce children's fear of fire, with the hypothesis that performance should be improved with fear reduction. Elaborative rehearsal, in which students are taught the rationale behind fire procedures during practice sessions, was more effective than simple behavioral rehearsal in reducing children's fear of fire.³⁴ Students taught the rationale behind fire procedures also retained their skills longer than control students,³³ but both techniques were equally effective in teaching fire situation responses.³⁴ A later study used self instructional methods and added fear reduction techniques to one of two experimental groups. Although both experimental groups demonstrated significantly

superior behavioral responses than two control groups immediately after the training period, the fear reduction group retained these skills longer.³⁰ Even in these intensive training programs, however, loss of skills was marked over time.³⁰⁻³¹⁻³³

Several studies of mentally retarded children and adults have documented mastery of safe fire exit and self extinguishing procedures in mildly to profoundly affected individuals using a one-to-one or small group approach and behavior modification techniques.²⁸⁻³⁹⁻⁴³ Maintenance of skills was variable, with good retention at 3-8 months. However these studies consistently document the importance of follow up testing and supplementary training.²⁸⁻³⁹⁻⁴¹⁻⁴²

Office based educational programs for mothers using individualized and interactive approaches have been variably successful in reducing fire and other hazards in the home. One such intervention did not reduce the number of household hazards observed by a home visitor,⁴⁴ but another similar intervention resulted in a modest reduction.⁴⁵

This group of studies is superior to the previous group, due to improved study design and rigor. They document the effectiveness of active participation in learning specific behavioral responses to a variety of fire situations. These life saving skills are directly applicable to real fire situations children might encounter. Although responses to actual situations cannot be tested, many of these studies tested children in simulated and actual bedrooms. These training methods would be more difficult to implement in larger groups, such as classrooms, due to time and cost restraints.

INTERVENTION STUDIES MEASURING SMOKE DETECTOR USE AND FUNCTION

The 10 intervention studies measuring smoke detector use and function are summarized in table 3. These studies represent a wide range of interventions: home inspection with educational intervention⁴⁶⁻⁴⁸; screening of home care patient households with provision of smoke detector when required⁴⁹; pediatric office based counseling²⁹⁻⁴⁵⁻⁵⁰; city-wide⁵¹ and targeted⁵ smoke detector giveaway programs; and smoke detector legislation.⁵² This group of studies includes six randomized or quasiexperimental designs, and many rated above average in terms of study validity.

Several urban smoke detector giveaway campaigns have been successful in encouraging the installation of smoke detectors, particularly in high risk urban areas.⁵⁻⁵¹ In one program, follow up home inspections at 4-9 months demonstrated that 81% of homes having received a smoke detector had an installed and operational detector at follow up.⁵¹ Although there are also a number of giveaway programs underway in rural areas of the United States, their outcomes have not been published (www.cdc.gov/ncipc/res-opps/firecop2.htm).

The effect of legislation was examined in a study of smoke detector use in a county with a "retrofit" law requiring smoke detector in all homes regardless of the age of the home,

Table 3 Intervention studies measuring smoke detector use and function

Intervention	Country (population)	Study period	Study design	Subjects (intervention group)	Subjects (control group)	Data sources	Outcomes measured	Results (control group or before)	Results (intervention group or after)	Reference
Smoke detector giveaway	USA (city)	1987–90	E-quasi	Urban area with highest injury rates (n=10 100)	Remainder of the city	Inspection	One working SD (3 months)	61% (95% CI 58% to 64%)	51% (95% CI 50% to 52%) 45% (95% CI 41% to 49%) 81%	5
							One working SD (12 months)			
							One working SD (48 months)			
							One working SD (4–9 months)			
Office counselling	USA (city: hospital)	1982	Cohort, prospective	Households requesting a free smoke detector (n=3720)	No control group	Inspection	Number of homes screened	2400/year	85%	49
							Home care patients screened on initial assessment for SD			
With SD coupon	USA (city: clinic)	1981–2	E-RCT	Parents of 6 month old children attending well child clinic (n=85) Group well child care couples (n=29)	Parents of 6 month old children attending well child clinic (n=86) Group well child care couples (n=26)	Inspection	New SD installed	89%	“Significantly higher number” (p=0.03) 40%	29
							No SD			
							New SD			
							New SD			
Smoke detector legislation	USA (city: clinic)	1979	E-quasi	Consecutive well children (n=120)	Consecutive well children (n=120)	Inspection	One working SD (4–6 week)	45%	18% 82%	50
							New SD installed			
							One working SD			
							One working SD			
Home inspection program	USA (counties)	1983	E-natural	County with 5 year hx “retrofit” law	County without “retrofit” law	Inspection	No SD	16%	6% 4%	47
							No SD			
							No SD			
							No SD			
	USA (city: low income)	1989–90	E-quasi	Census tracts with highest burn injury rates (n=3004)	Similar census tracts	Inspection	No SD	>50%	“Little improvement” 6%	46
							No SD			
							No SD			
							No SD			
	USA (city: low income)	1981–2	Cohort, prospective	Households in an area of substandard housing (n=285)	No control group	Inspection	New, working SD at follow up			48
							Home care patients screened on initial assessment for SD			
							Parents of 6 month old children attending well child clinic (n=85) Group well child care couples (n=29)			
							Parents of 6 month old children attending well child clinic (n=86) Group well child care couples (n=26)			

Notes: E-quasi = quasiexperimental design; E-natural = natural experiment; E-RCT = randomized controlled study; SD = smoke detector.

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compared with a nearby county with legislation requiring smoke detectors in new homes only.⁵² Homes in the county with the “retrofit” law were less likely to have no operational detector (17% *v* 30%) and to have no detector at all (6% *v* 16%).

Two smaller scale studies deserve mention for their simplicity, success, and innovation. In one, a brief pediatric office counseling intervention, a one minute educational message, pamphlet, and an offer to purchase a smoke detector at cost was effective in encouraging its purchase and installation. Of the 55 families in the experimental group having no smoke detector at the office visit, 26 purchased one within six weeks, compared with none of the control group.⁵⁰ In the second, an innovative burn prevention program was developed for home care patients in which visiting nurses screened households for smoke detectors. Smoke detectors were provided when required, either free or at cost, and installation was verified by the visiting nurse.

The strengths of this group of studies include successful inspection of a large, random sample of households,^{5 51 52} documentation of smoke detector use by home inspection rather than self report,^{5 46 47 50–52} and documentation of smoke detector function by actual testing.^{5 47 50–52} Limitations of these studies include selection of a middle class or affluent sample,^{50 52} and use of non-random allocation.^{47 50}

INTERVENTION STUDIES MEASURING RESIDENTIAL FIRE INJURY

The four intervention studies measuring fatal and non-fatal house fire injury are summarized in table 4. This group of studies includes: targeted smoke detector giveaway campaigns^{5 53}; a large scale community based and school based educational campaign⁵⁴; and an analysis of burn morbidity and mortality trends coincident with community based burn prevention measures.⁵⁵

Studies of fire and burn prevention interventions have reported variable success in reducing fire injury. Residential fire injuries decreased in a high risk urban area after a large scale smoke detector giveaway campaign targeting this area. Fire injury rates decreased by 80% and injury rates per 100 fires decreased by 74% in the target area during a four year period after the campaign, whereas the corresponding rates increased slightly in the rest of the city.⁵ Neither the incidence nor the severity of burn injuries reduced during the 12 month period after Project Burn Prevention, a large scale burn prevention campaign with both school and community components.⁵⁴ (Note: McLoughlin *et al*⁵ and MacKay and Rothman⁵⁴ both describe Project Burn Prevention results.) Burn incidence reduced by 3% per year at a burn unit in Denmark over a 17 year period during which numerous burn prevention measures were initiated, including an extensive media campaign, and product and legislative changes.⁵⁵

These studies measured much needed injury related outcomes. Such studies are infrequently

Table 4 Intervention studies measuring fire related morbidity and mortality

Intervention	Country (population)	Study period	Study design	Subjects (intervention group)	Subjects (control group)	Data sources	Outcomes measured	Results (control group or before)	Results (intervention group or after)	Reference
Smoke detector giveaways	USA (county)	1987–90	E-quasi	Urban area with highest injury rates (n=10 100)	Remainder of the city	Hospital, fire, medical examiner, vital statistics reports, media	Incidence-density ratio, before <i>v</i> after	1.1 (95% CI 0.7 to 1.7)	0.2 (95% CI 0.1 to 0.4)	5
							Rate ratio of injury rate/100 fires before <i>v</i> after	1.3 (95% CI 0.9 to 2.0)	0.3 (95% CI 0.1 to 0.6)	
	USA (city)	1984–5	Program evaluation	Urban areas with substandard housing	No control group	Mortality data	Residential fire death	32 in 1984	16 in 1985	53
						Firefighter report of averted injury due to SD	Averted injury (# cases)	Unknown	65	
Education program	USA (cities)	1977–8	E-quasi	Communities exposed to intensive education programs	Similar communities	Hospital records	Incidence rate ratio, before <i>v</i> after	1.0 (95% CI 0.6 to 1.5)	School program 1.4 (95% CI 1.1 to 1.6)	54
Media campaign, product and legislation changes	Denmark (city: burn unit)	1968–84	E-natural	Burn unit referral area	No control group	Morbidity and mortality data	Burn injury incidence	Community program 0.8 (95% CI 0.5 to 1.1) Media campaign 1.2 (95% CI 0.8 to 1.7) 3% Decrease per year		55

Notes: E-quasi = quasi-experimental design; E-natural = natural experiment; SD = smoke detector.

found in the literature, due to cost and time constraints. These studies, however, are limited by a lack of rigor, including lack of control for confounders such as socioeconomic status,^{5 53 55} lack of a control group,^{5 53 55} and inadequate follow up.⁵³

Discussion

This summary of fire and burn prevention interventions highlights some of the successes and limitations of a wide variety of programs that have been implemented and evaluated over the past three decades. Although fire and burn prevention programs are widespread, and a large number of studies have been published that are relevant to program development, the literature lacks a summary of this diverse research. Due to the broad based search strategy used here, a number of effective programs were identified that would have been missed using traditional search methods.

The major limitation of this review pertains to the unavoidable issue of publication bias. However, all relevant data were reported, whether negative or positive, and other sources were used, including a search of research grant databases available on the internet. For practical reasons only English language studies were included, leaving the possibility of language bias. There was also a potential “database bias”, towards journals and disciplines indexed on the databases used.

The ranking of studies by design and validity may have been limited by its subjective nature, but a standardized method for indicating the relative strength of studies was desired. There is not a recognized, uniform method of measuring study validity. The method used here allowed a simple summary of how well key study design issues were addressed, and resulted in a rough ranking of studies.

It is unfortunate that only four of the 43 studies examined fire related morbidity and mortality as outcome measures. The results of these four studies were highly variable, due to their varying study design, data sources, and choice of outcome measure. Also contributing to this variability were a lack of control for confounders by some studies, lack of a control group, and inadequate follow up. The use of injury outcomes should be highlighted as a priority for future house fire prevention research.

Implications for prevention

EDUCATING THE GENERAL PUBLIC

Although pamphlet distribution and poster production have become an accepted part of prevention campaigns, the effectiveness of these potentially expensive tools is unknown. Though the use of mass media information may be desirable, the cost of a truly “marketable” campaign is not practical for most injury prevention organizations. An extensive review of the effects of public communication programs on house fire prevention concluded that no rigorous evidence was available.¹ Project Burn Prevention, the most recent and rigorous of the studies examining a large scale

community based campaign using the media, was not effective in reducing burn injury. Nevertheless, the power of the media should not be underestimated; we know that children are highly influenced by television. When elementary schoolchildren in New Zealand were surveyed regarding the source of their fire safety knowledge, between 14% and 18% reported television as a source.¹⁹

SCHOOL BASED EDUCATION PROGRAMS

The review of school based education programs revealed a number of specific methods and components that might improve program effectiveness. Perhaps the most important finding was that programs using active participation by children in learning fire responses were more effective than those using passive methods. This observation is well known to experienced child educators; children enjoy the opportunity to participate, and to rehearse skills, such as “stop, drop, and roll”.²⁰⁻²² Similarly, when testing children, actual demonstration of skills is likely a more reliable marker of children’s real response in fire situations than providing correct answers on a written test.^{18, 19} Training these behavioral responses in small groups of children has resulted in high acquisition of skills in diverse populations, but even these intensive methods are associated with poor long term maintenance of skills.^{30, 31} The addition of fear reduction techniques and teaching the rationale supporting the use of correct fire response behaviors may significantly improve skill retention.^{30, 33} And finally, although small group and behavioral approaches are effective, the application of these techniques on a large scale is impractical. Therefore policy makers may encourage these efforts, but cannot be expected to mandate them.

Several authors noted the need for annual exposure to fire safety training.^{18, 19} Periodic repetition of material is required for maintenance of knowledge and skills; however, the format and content of each component or module of a fire and burn prevention program should be tailored according to group size, developmental level, cognitive ability, and actual fire or burn experience.²⁰⁻²² Reinforcement of standardized, hence familiar, fire safety messages could also be provided in the community, such as through the media, or at local fairs or exhibitions. Mascots, such as LNTB’s “Sparky”, are often used in school programs, and can be used for community based programs as well.

Several authors noted children’s positive responses to having figures of authority from the community teach fire safety skills. Three years after the introduction of a large scale firefighter taught program, significantly more children, particularly boys, reported learning fire safety knowledge from a firefighter than before the program.^{18, 19} Firefighters and burn unit nurses have been involved in numerous programs^{18, 19, 21}; this multidisciplinary approach should be encouraged in other school programs.

School based programs can be ineffective for a number of reasons. Schools may not be aware of the availability of resources. Even large scale programs described a problem with lack of exposure and consequent non-participation by schools.^{18, 19} Some programs are limited by schools choosing not to use the materials provided; others may not use them appropriately. The issue of potential “program overload” should be given careful consideration by injury prevention organizations. Schools may become overwhelmed by the large number of fragmented injury prevention modules, targeting not only fire safety, but also road safety, cycling safety, and head injury prevention.

OFFICE BASED COUNSELING

Office based counselling programs have documented variable success: one brief intervention was effective,³⁰ another more intensive intervention was less effective.⁴⁵ Few studies have examined this issue in detail, and a number of questions remain unanswered. It is not known which component of office based interventions is most effective. Is it the educational materials, personalized advice, or device incentives such as giveaways and coupons? Perhaps focusing effort on a single, simple message, such as purchasing and installing a smoke detector, may be most effective. Addressing multiple hazards may be overwhelming. Does the announced home visit, common to several studies, inspire last minute household adjustments? When should fire safety counselling be provided—at prenatal visits, well baby check-ups, or at any non-acute visit? These questions should be given careful consideration, and may lead to further research.

SMOKE DETECTOR GIVEAWAYS AND PROMOTIONS

Smoke detector giveaway programs are appealing, particularly for high risk urban areas, due to their documented success and relatively passive nature. Free smoke detectors provided door-to-door, with immediate assistance with installation, can improve their prevalence substantially. The issue of poor maintenance can limit such programs, however. Batteries are often removed or not replaced, detectors may be inactivated due to false alarms, and those in tenant housing may be vandalized.^{6, 56} Therefore, in certain high risk areas, giveaway programs must be followed by long term maintenance and inspection programs.

REGULATION AND LEGISLATION

Policy makers have played an important part in house fire prevention in many communities across the globe, by mandating smoke detector use in homes, strengthening building codes, improving sleepwear standards, and introducing the child resistant lighter. Some of these initiatives are limited, however, by a lack of enforcement at the community level. Therefore, a coordinated approach involving government, law enforcement, and dedicated community members will be necessary to ensure that fire prevention policy is effective.

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