REVIEW ARTICLE

# House fire injury prevention update. Part I. A review of risk factors for fatal and non-fatal house fire injury

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**Abstract**

***Objective*—To summarize house fire injury risk factor data, using relative risk estimation as a uniform method of comparison.**

***Methods*—Residential fire risk factor studies were identified as follows: MEDLINE (1983 to March 1997) was searched using the keywords fire*/burn*, with etiology/cause*, prevention, epidemiology, and smoke detector* or alarm*. ERIC (1966 to March 1997) and PSYCLIT (1974 to June 1997) were searched by the above keywords, as well as safety, skills, education, and training. Other sources included: references of retrieved publications, review articles, and injury prevention books; *Injury Prevention* journal hand search; government documents; and internet sources. When not provided by the authors, relative risk (RR), odds ratio, and standardized mortality ratios were calculated, to enhance comparison between studies.**

***Results*—Fifteen relevant articles were retrieved, including two case-control studies. Non-modifiable risk factors included young age (RR 1.8–7.5), old age (RR 2.6–3.6), male gender (RR 1.4–2.9), non-white race (RR 1.3–15.0), low income (RR 3.4), disability (RR 2.5–6.5), and late night/early morning occurrence (RR 4.1). Modifiable risk factors included place of residence (RR 2.1–4.2), type of residence (RR 1.7–10.5), smoking (RR 1.5 to 7.7), and alcohol use (RR 0.7–7.5). Mobile homes and homes with fewer safety features, such as a smoke detector or a telephone, presented a higher risk of fatal injury.**

***Conclusions*—Risk factor data should be used to assist in the development, targeting, and evaluation of preventive strategies. Development of a series of quantitative systematic reviews could synthesize existing data in areas such as house fire injury prevention.**

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Keywords: fire prevention; epidemiology; smoke detectors; residential fires

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Although many households in the developed world have a smoke detector, with some households having two or more,[1] there is a lack of awareness that house fire injury and death remain a major public health issue. A recent international comparative analysis of injury mortality data documented fires and burns as the third leading cause of injury mortality for children 1 to 14 years of age in eight of the 11 countries studied.[2] However, fire fighting services are being downsized and restructured in many regions, subject to financial constraints, and funds dedicated to fire prevention are increasingly limited.[3] Many rural and remote communities are served by volunteer fire fighters who do not have a mandate for fire prevention. Therefore it has become essential to decisively target campaigns to those at highest risk for fire injury, and to select for implementation only high quality programs known to be effective in reducing injuries and deaths. Unfortunately, the information required to choose appropriate and cost effective interventions is not easily accessible or well summarized, due to the broad range of disciplines with an interest in fire prevention involved in program development and assessment.

This two part review of the literature addresses two questions essential for the development of cost effective house fire injury prevention programs. First, *what factors are associated with house fire deaths and injuries?* Risk factors identified in the literature include non-modifiable variables, such as gender, age, and race; and modifiable variables, such as smoking, alcohol, and certain housing characteristics. The relative significance of these factors is not known, however, because published studies vary in design and in the extent and manner of data reporting, making direct comparison between them difficult. Therefore, a summary of house fire injury risk factor studies is presented in this paper using relative risk (RR) estimation as a uniform method of comparison.

The second paper in this series addresses the question of prevention: *How can we prevent house fire deaths and injuries?* Numerous measures have been introduced in many communities, including educational programs,[4–7] smoke detector based programs,[8–10] improvement of

standards and regulations,[11 12] and industry innovations such as the "fire-safe" cigarette.[13–18] However, the effectiveness of these methods in reducing house fire injuries and deaths has not been established. Therefore, a summary of house fire injury intervention studies will be presented in the second paper in this series.

## Methods

### LITERATURE REVIEW

*Database search:* MEDLINE (1983 to March 1997 via SilverPlatter 3.1) was searched using the keywords fire* or burn*, and etiology or cause*, prevention, epidemiology, as well as smoke detector* or alarm*. (Note: searching with the asterisk allows retrieval of records containing the search word, such as plurals, for example burn* would also retrieve burns.) The educational database ERIC (1966 to March 1997 via SilverPlatter 3.1) and the psychological literature database PSYCLIT (1974 to June 1997 via SilverPlatter 3.1) were searched using the keywords fire* or burn*, and prevention, safety, skills, education or training, as well as smoke detector* or alarm*. Abstracts and titles were reviewed, and relevant publications were marked for retrieval. Only English language and human studies were retrieved. Relevant letters, editorials, and review articles were also retrieved to review their reference lists. For sources not available locally, abstracts were examined, and all potentially pertinent publications were ordered, when possible, through an interlibrary loan service.

In addition to the database searches, the following sources were accessed, to capture potential missed references: *reference lists* of retrieved publications as well as fire and injury prevention books and chapters; *hand search* of original articles published in *Injury Prevention*; *government documents* (USA and Canada only) indexed on the electronic catalogue at the University of Manitoba; *internet sources:* fire and burn prevention sites, safety and general injury prevention sites, as well as statistical and government sites with online research databases, such as CDC Wonder. The latter were explored for both completed and ongoing studies.

Risk factor studies were included in this review if house fire victim data were provided. Most studies examining alcohol as a risk factor were excluded, as an extensive review has been published on this subject[19]; studies published subsequent to the publication of this review were included. The following data were abstracted from each publication: study period in years; 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 data were tabulated for ease of comparison, ranking within each category by strength of evidence, according to study design and validity.

Study validity was assessed using the guidelines of the Cochrane Collaboration: "In the context of a systematic review, the validity of a study is the extent to which its design and conduct are likely to prevent systematic errors, or bias".[20] Each study was examined by one investigator (LW) and rated as adequate (A), unclear (B), or inadequate (C) with respect to the extent it minimized each of four sources of bias: selection bias, performance bias, attrition bias, and detection bias. This allowed later ranking of studies in descending order of validity.

*Selection bias* arises when systematic differences are produced by the method of assigning subjects to the groups being compared. It is minimized in a randomized controlled trial by true randomization and concealing assignment until allocation is complete, and in cohort and case-control studies by control for confounders, defined here as the use of statistical methods such as regression analysis, or matching.

*Performance bias* arises when there are systematic differences in the way the comparison groups are treated, other than the intervention being studied. It is minimized by blinding subjects and providers in randomized controlled trials, blinding providers and subjects when possible in cohort studies, and by measuring outcomes in all groups in an objective and similar manner in cohort and case-control studies.

*Attrition bias* arises when systematic differences between groups are created due to the loss of subjects from one or both groups. It is minimized in all types of studies by completeness of follow up, defined here as withdrawals of less than 20%.

*Detection bias* arises when systematic differences between the groups are created due to the measurement of the outcome(s). It is minimized in randomized controlled trials and cohort studies by blinding outcome assessors and using objective outcomes, and in case-control studies by using valid case definitions.

### DATA ANALYSIS

For ease of comparison, data were organized by risk factor category, and within each category, studies were ordered by level of evidence in descending order of strength: case-control, cohort, cross sectional survey. After ranking by level of evidence, studies were then ordered by degree of validity, from most valid to least valid, as discussed above.

When not provided by the authors, RR (for cross sectional surveys), odds ratio (OR; for case-control studies), standardized mortality ratios (SMR; when mortality rates were provided) and/or standardized incidence ratios (SIR; when injury rates were provided) were calculated, in order to quantify the risk associated with reported variables and to enhance comparison between studies. For studies where these calculations were not possible due to insufficient data, simple mortality ratios (MR) were reported. The 95% confidence intervals for RR, SMR, and SIR were calculated using Confidence Interval Analysis Version 1.1. Bonferroni correction for multiple compari-

*Table 1 Non-modifiable risk factors for fatal and non-fatal house fire injury*

| *Risk factor group* | *Risk factors (referent group)* | *RR or equivalent* | *95% Confidence interval* | *Measure of RR* | *Groups compared (type of injury)* | *Reference* |
|---|---|---|---|---|---|---|
| Age | | | | | | |
| | Young age (average) | 2.0 (0–4 years) | | MR | Fatal | 29* |
| | Young age (5–64 years) | 3.2 (0–4 years) | 3.0 to 3.4 | SMR | Fatal | 38* |
| | Young age (5+ years) | 2.6 (0–4 years) | 1.8 to 3.6 | SMR | Fatal | 30* |
| | Young age (5+ years) | 1.8 (0–4 years) | 1.2 to 2.7 | SMR | Fatal | 31* |
| | Young age (10–14 years) | 7.5 (0–4 years) | 5.4 to 10.1 | SMR | Fatal | 34* |
| | Young age (females 5–14 years) | 2.9 (females 0–4 years) | 1.1 to 6.2 | SMR | Fatal | 37* |
| | Old age (5–64 years) | 3.6 (65+ years) | 3.4 to 3.8 | SMR | Fatal | 38* |
| | Old age (total) | 2.6 (>80 years) | 1.1 to 5.1 | SMR | Fatal | 30* |
| Gender | | | | | | |
| | Male | 1.4 | | MR | Fatal | 29* |
| | Male | 2.9 | | MR | Fatal | 35* |
| | Male | 1.7 | 1.7 to 1.8 | SMR | Fatal | 36* |
| | Male | 1.7 (adjusted for age) | 1.0 to 1.9 | SMR | Both | 23 |
| | Male (white female) | 2.0 (white male) | 1.5 to 2.6 | SMR | Fatal | 31* |
| Race | | | | | | |
| | Black (white) | 2.0 | | MR | Fatal | 29* |
| | Black (white) | 2.2 | 1.0 to 12.8 | RR | Both | 23 |
| | Black (white) | 3.2 | 3.0 to 3.4 | SMR | Fatal | 36* |
| | American Indian (white) | 4.4 | 1.5 to 12.8 | RR | Both | 23 |
| | American Indian (white) | 2.0 | 1.3 to 3.0 | SMR | Fatal | 35* |
| | Native (non-native) | 5.3 | 3.7 to 7.3 | SMR | Fatal | 30* |
| | Native (non-native) | 4.5 | 3.5 to 5.5 | SMR | Fatal | 33 |
| | Native,male (non-native, male) | 4.1 | 3.1 to 5.1 | SMR | Fatal | 33 |
| | Native,female (non-native, female) | 5.2 | 3.4 to 5.5 | SMR | Fatal | 33 |
| | Native (non-native, 0–1 years) | 3.4 (native, 0–1 years) | 1.2 to 7.3 | SIR | Non-fatal | 33 |
| | Native (non-native, 1–4 years) | 5.6 (native, 1–4 years) | 3.8 to 7.9 | SIR | Non-fatal | 33 |
| | Native (non-native, 5–14 years) | 4.8 (native, 5–14 years) | 2.6 to 7.2 | SIR | Non-fatal | 33 |
| | Native (non-native, 15–64 years) | 3.6 (native, 15–64 years) | 2.5 to 5.2 | SIR | Non-fatal | 33 |
| | Native (non-native, 65+ years) | 11.7 (native, 65+ years) | 4.1 to 29.2 | SIR | Non-fatal | 33 |
| | Native (non-native) | 4.5 | 3.6 to 5.5 | SIR | Non-fatal | 33 |
| | Hispanic (white, non-Hispanic) | 1.3 | 1.0 to 1.6 | SMR | Fatal | 35* |
| | Non-white males (white males) | 2.5 | 1.9 to 3.3 | SMR | Fatal | 31* |
| | Non-white females (white females) | 4.1 | 3.0 to 5.4 | SMR | Fatal | 31* |
| | Non-white (male, white, 0-4 years) | 7.5 (male, non-white, 0–4 years) | 1.6 to 21.9 | SMR | Fatal | 37* |
| | Non-white (female, white, 0–24 years) | 4.4 (female, non-white, 0–24 years) | 1.2 to 11.4 | SMR | Fatal | 37* |
| | Non-white (female, white, 0–4 years) | 15.0 (female, non-white, 0–4 years) | 3.1 to 43.8 | SMR | Fatal | 37* |
| Other | | | | | | |
| | Lower income (two highest quintiles) | 3.4 (two lowest quintiles) | | MR | Fatal | 29* |
| | Time of fire (6am–9:59 pm) | 4.1 (10:00 pm–05:59 am) | 2.7 to 6.2 | OR | Fatal *v* non-fatal | 22 |
| | Young, old, disabled, impaired (none) | 6.5 (<5 or >64, impaired or disabled) | 4.2 to 10.0 | OR | Fatal *v* non-fatal | 22 |
| | Disabled person present (none) | 2.5 | 1.5 to 4.4 | OR | Fatal *v* non-fatal | 22 |
| Residence | | | | | | |
| | Rural residence (urban) | 2.1 | 1.7 to 2.5 | SMR | Fatal | 30* |
| | Rural residence (urban) | 2.2 | | MR | Fatal | 35* |
| | South USA (west USA) | 2.1 | 2.0 to 2.2 | SMR | Fatal | 36* |
| | Central urban (rest of city) | 4.2 | 2.6 to 6.9 | SIR | Both | 8 |

*RR estimate (MR, SMR, SIR) using study data.

sons was not performed, as the data were considered hypothesis generating rather than testing.

## Results

A total of 15 relevant articles were retrieved. Two were case-control studies[21 22] and the remainder were cross sectional surveys. The two case-control studies rated equally well with respect to study validity, both having adequately adopted measures to reduce the four types of bias. Of the cross sectional surveys, only three reported confidence intervals, and only one adjusted for age when analyzing gender as a risk factor.[23]

### NON-MODIFIABLE RISK FACTORS

A summary of the RR estimates for non-modifiable risk factors, including gender, age, and race, is found in table 1. Young children and the elderly were at higher risk for fatal house fire injury, with RR equivalents ranging from 1.8 to 7.5. Males were also at higher risk for house fire injury, both fatal and non-fatal, with RR equivalents between 1.4 and 2.0. Race was a significant risk factor for all non-white populations, for both fatal and non-fatal injury, for both genders, and across all age groups. The direction of risk was consistent across all studies for age, gender, and race. None of the confidence intervals included one, and few intervals approached one. Other significant non-modifiable risk factors identified were low income, disability, and late night/early morning occurrence.

Place of residence is in theory a modifiable risk factor, however, for practical purposes, it will be considered as a non-modifiable risk factor, recognizing that its unmeasured correlates, such as type of heating, may in fact be modifiable. In summary, residents of rural areas, central urban areas, and regions of the southern USA were at higher risk for house fire death, with RR equivalents ranging from 2.1 to 4.2.

*Table 2 Modifiable risk factors for fatal and non-fatal house fire injury*

| *Risk factor group* | *Risk factors (referent group)* | *RR or equivalent* | *95% Confidence interval* | *Measure of RR* | *Groups compared (type of injury)* | *Reference* |
|---|---|---|---|---|---|---|
| Housing | | | | | | |
| | Rental property (owned) | 2.0 (rental) | 1.3 to 3.1 | OR | Fatal *v* non-fatal | 22 |
| | No telephone | 3.2 (none) | 2.0 to 3.1 | OR | Fatal *v* non-fatal | 22 |
| | No smoke detector | 3.4 (none) | 2.1 to 5.6 | OR | Fatal *v* non-fatal | 22 |
| | Age of house (< or =20 years) | 2.0 (> or =20 years) | 1.3 to 3.1 | OR | Fatal *v* non-fatal | 22 |
| | Number of exits (>2 exits) | 2.1 (< or =2 exits) | 1.3 to 3.4 | OR | Fatal *v* non-fatal | 22 |
| | Mobile home (other) | 1.7 | 1.1 to 2.6 | OR | Fatal *v* non-fatal | 22 |
| | Mobile home (single detached) | 9.0 | 6.4 to 12.2 | SMR | Fatal | 30* |
| | Mobile home (house or apartment) | 4.0 | | MR | Fatal | 34* |
| | No indoor plumbing (indoor plumbing) | 10.5 | | MR | Fatal | 34* |
| Smoking | | | | | | |
| | Smoker in household (No) | 4.8 (yes) | 3.0 to 7.8 | OR | Both *v* control | 21 |
| | Number of smokers in household (0) | 4.1 (1 smoker) | 2.4 to 7.1 | OR | Both *v* control | 21 |
| | | 6.3 (> or =2 smokers) | 3.3 to 12.2 | OR | Both *v* control | 21 |
| | Total cigarettes/day/household (0) | 1.5 (1–9/day)† | 0.6 to 4.2 | OR | Both *v* control | 21 |
| | | 6.6 (10–19/day)† | 2.5 to 17.5 | OR | Both *v* control | 21 |
| | | 3.6 (> or =20/day)† | 1.9 to 7.2 | OR | Both *v* control | 21 |
| | Smoking ignition source (other) | 7.7 (smoking) | 4.1 to 14.6 | OR | Fatal *v* non-fatal | 22 |
| Alcohol | | | | | | |
| | Average # drinks/occasion (1–2) | 0.7 (3–4 drinks)†‡ | 0.3 to 1.9 | OR | Both *v* control | 21 |
| | | 1.8 (> or =5 drinks)†‡ | 0.5 to 6.9 | OR | Both *v* control | 21 |
| | Impaired by drugs or alcohol (not) | 7.5 (impaired) | 4.5 to 12.2 | OR | Fatal *v* non-fatal | 22 |
| Other | | | | | | |
| | Home alone (not alone) | 2.2 | 1.5 to 3.3 | OR | Fatal *v* non-fatal | 22 |

*RR estimate (MR, SMR) using study data.
†Adjusted for income, education, # permanent household members, # males.
‡Adjusted for smoking.

*Table 3 Predictors of alcohol use in fatal and non-fatal residential fire injuries*

| *Reference* | *Measure of alcohol exposure* | *Risk factor (referent group)* | *RR estimate* | *95% Confidence interval* | *Comments* |
|---|---|---|---|---|---|
| 29 | BAC>0.1% | Ignition source (other source) | 2.75 (cigarette ignited)* | (0.73 to 10.3) | |
| 30 | BAC>0.8 g/l | Ignition source (other source) | 2.3 (smoking material)* | | |
| | | Race (non-aboriginal) | 2.6 (aboriginal)* | | $\chi^2$=12.6, p=0.0004 |
| | Mean BAC | Race (non-aboriginal) | 1.7 (aboriginal)* | | |
| 26 | BAC = 0 | Age (17–74 years) | 2.6 (>75 years)* | | $\chi^2$=84, p<0.005 |
| | History of alcoholism | Age (>75 years) | 5.7 (17–74 years)* | | |
| 31 | BAC>21 mmol/l | Ignition source (heating) | 2.2 (cooking)* | | |
| | | | 1.5 (smoking)* | | |
| 22 | Impairment | Ignition source (other) | 2.3 (heating) | (1.2 to 4.4) | Impairment of person at the fire, according to fire official |
| | | | 4.4 (smoking) | (1.8 to 10.5) | |

*RR estimated using study data.
BAC = blood alcohol concentration.

MODIFIABLE RISK FACTORS

A summary of the RR estimates for modifiable risk factors, including type of housing, smoking, and alcohol use is found in table 2. A number of significant housing variables were reported. Mobile homes and substandard homes were associated with the highest risk of fatal injury, with RR equivalents ranging from 1.7 to 10.5. Homes with fewer safety features, for example, lacking a smoke detector, telephone, or adequate number of exits also presented a higher risk of fatal injury. Smoking was a strong risk factor for fatal and non-fatal injury, as was alcohol. The relationship between alcohol use and other risk factors is summarized in table 3. Alcohol use was more likely in smoking and cooking related fires, and in victims who were aboriginal. Alcohol use was less likely among elderly victims.

## Discussion

Quantitative summaries of injury prevention studies are uncommon. Even qualitative literature reviews are often hampered by an inability to compare study results due to differing methods and a lack of essential reported data. However, an assessment of risk is central to injury prevention research and practical program development, both in identifying the degree of risk experienced by certain populations and population subgroups, and in assessment of risk reduction due to interventions. RR estimation allows a uniform comparison of data and demands only a few simple mathematical steps. The end result is a summary of data in a user friendly format, in terms familiar to all; such an analysis is strengthened by its ease of application to public education, such as media messages. Newspaper articles, advertising campaigns, and even road signs often cite statistics using the familiar concept of risk in terms of RR.

The major limitation of this review pertains to the unavoidable issue of publication bias. However, all 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 database used; however, a subsequent search of educational and psychology databases, ERIC and PSYCLIT respectively, did not reveal additional sources. Finally, the RR estimation relied on published data, and therefore is sub-

ject to possible errors with respect to data accuracy and completeness of reporting.

Although an assessment of study validity is an important component of a literature review, actual ranking of these studies was not feasible, as most were not rigorous enough to rate. There has been much debate as to the optimal method of assessing study validity. Many scales and tools exist, however many have been criticized for being too complex.[20] The Cochrane method is appealing in its simplicity, and our application of this method allowed a summary of the degree to which key study design issues were addressed. Critics of the Cochrane method may argue it is too simple an approach, and that the ranking is too subjective in nature. Studies risk a poor rating (unclear or inadequate) if the published report did not satisfy the reviewer that validity criteria were met. This issue may be overcome by contacting authors for detail when required, however, this is an arduous and time consuming task. Finally, the Cochrane method is not as easily applied to many of the non-medical disciplines involved in injury prevention research. Nevertheless, the two case-control studies[21 22] offer the greatest strength of evidence, therefore their results should be weighted accordingly.

Knowledge of non-modifiable risk factors may assist fire prevention program developers in targeting interventions for those at highest risk. Young children are at higher risk for house fire death for a number of reasons: they may be more likely than older children to play with fire and then are developmentally unable to react appropriately and plan escape; they may be left unattended; or they may be supervised, and wake to the sounds of the smoke alarm, but are dependent upon others for escape.[24] Therefore the prevention of young childhood deaths involves several approaches, including keeping matches and lighters out of reach; introducing child resistant lighter legislation where it does not already exist; educating parents regarding the dangers of leaving children unattended; and offering smoke detectors to high risk new parents, either at the hospital or by a home visitor.

Similarly, the elderly are at higher risk for house fire death for a number of reasons: they are known to have a lower prevalence of smoke detectors[9 25]; they may be hearing impaired, and not hear the smoke alarm; they are often mobility impaired, slowing or completely preventing escape; and they may use older appliances, such as portable heaters or heating blankets, or live in older homes, introducing a higher risk of house fire.[26] Therefore prevention approaches in the elderly must be multifaceted: encouraging the purchase and maintenance of smoke detectors; selecting alarms with a louder signal, and placing the alarm closer to the sleeping area; selecting alarm systems with an alternative inaudible method of indicating smoke; planning escape assistance with household members or neighbours; and ensuring the safety of home appliances.

The high risk of house fire injury among various non-white populations, including black, American Indian, and Hispanic groups, is related to many other unmeasured socioeconomic factors. Smoke detector use is known to be lower in poor, rural, remote, and central urban areas and in non-white populations.[9 11 25 27] Mobile homes and substandard homes, more prevalent in these communities, are associated with a much higher risk of fire death. Methods of heating, such as wood stoves and kerosene, introduce additional risk. Interventions for these communities will vary according to the specific hazards present, and a baseline household survey may be necessary to define and quantify these hazards. Smoke detector promotion and maintenance programs are an essential part of prevention programs in these communities. However efforts must also include improvements in housing, disposal of hazardous materials, as well as programs addressing the issues of smoking and alcohol. Non-white children and the elderly are at particular risk, and the measures discussed above are of even greater importance for these individuals.

Smoking and alcohol use are often implicated in house fire deaths. The most common cause of fatal house fires is careless smoking, responsible for up to 65% of deaths.[23 28–30] Over half of victims tested for alcohol exceed the legal limit for driving,[29–31] although these data are of course subject to selection bias. An estimated 25% of deaths result from the combination of smoking while intoxicated. In one series of house fire fatalities, victims were legally impaired in 85% of cooking related, 60% of smoking related, and 39% of heating related house fires.[31] Dangerous smoking habits are common. In a survey of American Indian households, 25% had a member who smoked in bed and 38% had a member who drank alcohol and smoked at same time.[32] Interventions attempting to alter smoking and drinking habits are important, however passive interventions are more likely to succeed. The "fire-safe" cigarette was designed to reduce fires due to dropped cigarettes on furniture and mattresses, due to its reduced circumference, lower density tobacco, and its less porous, lower citrate paper. The American Fire Safe Cigarette Act of 1990 mandated the development of a standard test method to determine the ignition potential of cigarettes, essential for further legislative efforts. Industry has successfully prevented the application of this legislation.[13–18]

Fire prevention traditionally has been the responsibility of the fire service, with provision of programs by fire fighters. In recent years, as increasing financial pressures limit human resources available to dedicate to preventive services, new partnerships are being formed between fire services and other sectors such as health, education, and the corporate community. Professionals trained in public health and epidemiology can make a meaningful contribution to this area, by sharing experience with injury epidemiology and injury surveillance, as well as expertise in research design and program evaluation. Summarizing the available evidence in an approachable format is one of

the essential steps, both for program development and for evaluation. Furthermore, development and maintenance of a series of topic based quantitative and qualitative systematic reviews could synthesize existing data in areas such as house fire injury prevention, and would be a valuable resource.

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1 Statistics Canada. *Household facilities and equipment*. Ottawa, Canada: Statistics Canada, 1996.
2 Fingerhut LA, Cox CS, Warner M, *et al. International comparative analysis of injury mortality: findings from the ICE on injury statistics*. Advance data from vital and health statistics. No 303. Hyattsville, Maryland: National Center for Health Statistics. 1998.
3 Canadian Association of Fire Chiefs. *The Canadian fire chief*. Ottawa: Canadian Association of Fire Chiefs, Spring 1997.
4 Haskins J. *The effects of public communication programs on fire prevention in the home: a review.* Washington, DC: National Commission on Fire Prevention and Control, 1972.
5 McLoughlin E. Issues in evaluation of fire and burn prevention programs. *J Burn Care Rehabil* 1982;**3**:281–4.
6 McLoughlin E, Vince C, Lee A, *et al*. Project Burn Prevention: outcome and implications. *Am J Public Health* 1982;**72**:241–7.
7 Grant E. Evaluation of a burn prevention program in a public school system. *J Burn Care Rehabil* 1992;**13**:703–7.
8 Mallonee S, Istre GR, Rosenberg M, *et al*. Surveillance and prevention of residential-fire injuries. *N Engl J Med* 1996;**335**:27–31.
9 Hall J. A decade of detectors: measuring the effect. *Fire Journal* 1985:37–43, 78.
10 Hammond J. The status of statewide burn prevention legislation. *J Burn Care Rehabil* 1993;**14**:473–5.
11 Baker SP. *The injury fact book*. New York: Oxford University Press, 1992.
12 Stanwick RS. Clothing burns in Canadian children. *Can Med Assoc J* 1985;**132**:1143–9.
13 Botkin JR. The fire-safe cigarette. *JAMA* 1988;**260**:226–9.
14 McGuire A, Daynard RA. When cigarettes start fires: industry liability. *Trial* 1992;**28**:44–9.
15 Cope V. Where there's smoking... Attorneys allege tobacco-industry liability for cigarette fires. *Trial* 1988;**24**:42–7.
16 Teret S, DeFrancesco S. The cigarette safety bill: a case study in injury control advocacy. *J Public Health Policy* 1983;**4**:440–6.
17 DeFrancesco S, McGuire A. The fire-safe cigarette campaign. *J Public Health Policy* 1985;**6**:340–8.
18 Brigham P, McGuire A. Progress towards a fire-safe cigarette. *J Public Health Policy* 1995;**16**:433–9.
19 Howland J, Hingson R. Alcohol as a risk factor for injuries or death due to fires and burns: review of the literature. *Public Health Rep* 1987;**102**:475–83.
20 Mulrow CD, Oxman AD, eds. *Cochrane Collaboration handbook*. Oxford: The Cochrane Collaboration, 1997 (updated 1 March 1997).
21 Ballard JE, Koepsell TD, Rivara F. Association of smoking and alcohol drinking with residential fire injuries. *Am J Epidemiol* 1992;**135**:26–34.
22 Runyan CW, Bangdiwala SI, Linzer MA, *et al*. Risk factors for fatal residential fires. *N Engl J Med* 1992;**327**:859–63.
23 Ballard JE, Koepsell TD, Rivara FP, *et al*. Descriptive epidemiology of unintentional residential fire injuries in King County, WA, 1984 and 1985. *Public Health Rep* 1992;**107**: 402–8.
24 Squires T, Busuttil A. Can child fatalities in house fires be prevented? *Inj Prev* 1996;**2**:109–13.
25 Hall J. The US experience with smoke detectors: Who has them? How well do they work? When don't they work? *National Fire Protection Association Journal* 1994; September/October:36–46.
26 Elder AT, Squires T, Busuttil A. Fire fatalities in elderly people. *Age Ageing* 1996;**25**:214–6.
27 Hoffman R. Tracking 1990 objectives for injury prevention with 1985 NHIS findings. *Public Health Rep* 1986;**101**:581–6.
28 Barillo DJ, Goode R. Fire fatality study: demographics of fire victims. *Burns* 1996;**22**:85–8.
29 Mierley MC, Baker SP. Fatal house fires in an urban population. *JAMA* 1983;**249**:1466–8.
30 Chernichko L, Saunders LD, Tough S. Unintentional house fire deaths in Alberta 1985–1990: a population study. *Can J Public Health* 1993;**84**:317–20.
31 Patetta MJ, Cole TB. A population-based descriptive study of housefire deaths in North Carolina. *Am J Public Health* 1990;**80**:1116–7.
32 Mobley C, Sugarman JR, Deam C, *et al*. Prevalence of risk factors for residential fire and burn injuries in an American Indian community. *Public Health Rep* 1994;**109**:702–5.
33 Friesen B. Haddon's strategy for prevention: application to native house fires. *Cicumpolar Health* 1985;**84**:105–9.
34 Parker DJ, Sklar DP, Tandberg D, *et al*. Fire fatalities among New Mexico children. *Ann Emerg Med* 1993;**22**:517–22.
35 Deaths associated with fires, burns, and explosions—New Mexico, 1978–1983. *Morb Mortal Wkly Rep* 1985;**34**:623–5.
36 Gulaid J, Sattin R, Waxweiler R. Deaths from residential fires, 1978–1984. *Morb Mortal Wkly Rep* 1988;**37**(SS-1): 39–45.
37 O'Shea JS. House-fire and drowning deaths among children and young adults. *Am J Forensic Med Pathol* 1991;**12**:33–5.
38 Regional distribution of deaths from residential fires—United States, 1978–1984. *Morb Mortal Wkly Rep* 1987;**36**: 645–9.