Descriptive Epidemiology of Unintentional Residential Fire Injuries in King County, WA, 1984 and 1985

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Synopsis

Although most studies have concentrated on fatal residential fire injuries, which are a leading cause of fatal injuries in the United States, few investigators have examined in detail nonfatal injuries as a consequence of residential fires. This population-based study used the Washington State Fire Incident Reporting System to assess the incidence and descriptive epidemiology of fatal and nonfatal burns or respiratory tract damage resulting from unintentional residential fires.

For the 2-year period 1984–85 in King County, WA, the mortality rate due to injury in a residential fire was 0.7 per 100,000 per year, and the incidence of nonfatal injuries was 5.6 per 100,000 per year. Of 17 fatalities, 59 percent of the deaths occurred at the scene of the fire. Of 128 persons with nonfatal injuries, 19 percent were hospitalized; although the 55 percent seen as outpatients and the 26 percent treated by the fire department or paramedics at the fire scene usually had minor injuries, they would not have been captured if only traditional data sources had been employed.

Those injured averaged 2.8 days of restricted activity, but the range was from less than 1 day to 1 year. Injuries were more common in the households with a low socioeconomic status and among nonwhites, especially American Indians. Variation in incidence by age, sex, and source of ignition for deaths and nonfatal injuries suggests appropriate targets for future fire injury prevention programs.

EACH YEAR in the United States about 5,000 deaths, or about 2 deaths per 100,000 population, occur as a result of fires in buildings, making these events the fourth leading cause of fatal injuries (*1*). In addition, approximately 28,000 nonfatal civilian fire injuries (excluding firefighters) occur annually in the United States (*2*). Even though most fire injuries (fatal and nonfatal) occur in homes, studies of injuries specifically occurring in this setting have concentrated mainly on fatal injuries attributed to burns or smoke inhalation in unintentional fires (*3–5*).

Previous studies of nonfatal fire injuries have consisted primarily of information about case series of hospitalized burn patients without regard to where the injury occurred, such as the home, work, vehicle, institutions, and outdoors (*6–12*). Studies of hospitalized patients often include data on burns of all types—flame, scalds, contact, and chemical. However, only 3 to 11 percent were due to house fires (*9–12*). These proportions, combined with the number of injuries occurring in residential fires, suggest that a large number of nonfatal residential fire injuries, particularly the less serious burns, would be missed if only hospital surveillance data were included. Few studies have been population-based (*12–14*), have examined patients not requiring hospital care (*14–16*), or have included other

injuries, such as smoke inhalation or mechanical trauma. The majority of fire injuries are due to either burns or smoke inhalation (*17*).

While estimates of nonfatal fire injuries derived from fire departments' reports include all types of injuries sustained in a fire, information about these injuries consists primarily of information about the fire with little detail about the injured person. One study used fire department records to identify victims who were later treated in either hospitals or emergency rooms (*18*). Fire agency reports also have included fires caused by arson and fires in various types of buildings.

The purpose of this population-based study was to provide descriptive information about fatal and nonfatal burns and respiratory tract damage that occurred in unintentional residential fires requiring fire department assistance in King County, WA, during a 2-year period. From this information we hoped to (*a*) determine the degree to which previous estimates have underestimated the incidence of house fire injury because injuries not treated in hospitals were excluded, (*b*) identify high-risk groups to whom prevention efforts might be targeted, and (*c*) provide fire injury incidence data specifically for the residential setting where most burn and inhalation injuries occur and where prevention strategies depend on specific risk factors such as building codes, smoke detectors, cooking, and smoking.

Table 1. Age-specific incidence rates of fatal and nonfatal injury in residential fires, King County, WA, 1984–85[1]

Age (years)	Fatal		Nonfatal		Total	
	Number	Rate[2]	Number	Rate[2]	Number	Rate[2]
Less than 5	5	2.9	3	1.7	8	4.6
5–19	1	0.2	23	4.4	24	4.6
20–44	3	0.3	75	6.4	78	6.6
45–64	3	0.6	15	2.9	18	3.5
65 and older	5	1.6	12	3.9	17	5.6
All age groups	17	0.6	128	4.8	145	5.4

[1] Chi-square for fatalities compared with nonfatalities by age was 31.5 with 4 degrees of freedom, $P<0.001$.
[2] Rate per 100,000 population per year using 1985 King County population (22).

Table 2. Source of fire ignition in fatal and nonfatal residential injuries and fires, King County, WA, 1984–85

Ignition[1]	Fatal		Nonfatal		Total	
	Number injured	Percent	Number injured	Percent	Number injured	Percent
Cooking	1	6	43	35	44	32
Smoking	11	65	29	24	40	29
Heating	3	18	20	16	23	17
Other[2]	2	12	30	25	32	23
Total[3]	17	[4]101	122	100	139	[4]101

[1] Comparing fatal and nonfatal by source of ignition: number of injured chi-square = 13.8 with 3 degrees of freedom, $P=0.003$.
[2] 8 appliances, 7 wiring, 5 electric blanket, 4 candle, 3 light bulb, 5 miscellaneous.
[3] Source of ignition was unknown in 6 fires with single injuries.
[4] Percentages do not add to 100 because of rounding.

Methods

Setting. King County, located in western Washington adjacent to Puget Sound, is predominantly an urban area. Its population of 1.3 million people makes it the most populous county in the State with a total of 29 municipalities, including the city of Seattle. The county is served by 22 general medical hospitals and 45 fire departments. Harborview Medical Center, the regional trauma and burn center, is located in Seattle and is the referral hospital for the majority of severe injuries and burns. When a fire department is called to a fire, a paramedic unit is also dispatched to the fire scene. All deaths caused by injuries, including fire deaths, are autopsied by the King County Medical Examiner's Office.

Study design. Persons injured due to unintentional residential fires in King County from January 1984 through December 1985 were identified using the Washington Fire Incident Reporting System (WAFIRS). This study was part of a case-control study conducted to evaluate behavioral and environmental risk factors of injuries occurring in residential fires. To maximize ascertainment of fatalities, death certificates for the county were also reviewed. Only two deaths were identified that were not reported to WAFIRS; one had been reported by the fire department, but it was not recorded at the State level. One additional nonfatal injury was identified when all fire departments that did not participate in the reporting system were contacted. These departments served only 1.6 percent of the county's population.

An injury victim was a person (other than a firefighter) who sustained a burn or respiratory tract damage as a consequence of an unintentional fire as identified by the fire department or paramedics at the scene. A qualifying residence was any one- or two-family dwelling, apartment, condominium, or townhouse. An injury household was any household that had at least one person injured as defined previously. Because this investigation was

Table 3. Percent of body surface area burned among residential fire victims, by place where last treated, King County, WA, 1984–85

Category	Died at scene (N=8)	Hospital		Out-patient[1] (N=35)	Fire department (N=17)
		Died (N=7)	Survived (N=17)		
Range	25–81	3–96	0.1–21	0.1–50	0.1–6
Median	45.5	43.4	6.7	1.7	0.9
Mean	54.6	48.1	8.4	3.0	1.5
Standard deviation	22.0	35.4	7.0	8.2	1.5

[1] Emergency room or physician in clinic.

part of a case-control study in which control households were selected by random digit dialing (*19*), detailed data on injuries and the home environment were gathered only for households with a telephone.

Of the 154 households fitting the above criteria, 21 households (14 percent) did not have a telephone. Although all 154 households were used to calculate overall incidence and mortality rates, all other results reported in our study were confined to the 133 injury households with a telephone. Of the 133 households, 3 percent (4 households) were lost to followup and 5 percent (6 households) refused. In the 123 eligible households, 145 persons were identified with burns or respiratory tract damage. All interviews were conducted between March 1986 and February 1987.

Demographic information and details about the injury and the fire were collected during a telephone interview with the injured adult, with the parent if the injured person was less than 18 years old, or with the next-of-kin if the victim had died. If the preferred respondent could not be found, a proxy respondent was selected using a predetermined protocol, giving priority to those present during the fire, familiar with the fire, or related to the injured. Autopsy data were collected on the cause of death.

Place of treatment was used as a gauge of injury severity: died at the scene of the fire, hospitalized, treated in an emergency room or by a physician in a clinic, or treated by the fire department or paramedics at the scene of the fire. Since patients may have received treatment at more than one source, they were classified by the last place where they were treated.

A respiratory tract damage score (RTDS) was developed by summing up the number of respiratory signs or symptoms on a predefined list reported during the telephone interview. History of exposure to fire products in an enclosed space was also recorded. The RTDS was divided into two parts—thermal and nonthermal respiratory tract damage. Thermal respiratory tract damage was defined using Stone's criteria—flame burn to the face, singed nasal hair, and history in an enclosed space (*20*). Any person meeting two of Stone's three criteria was considered to have probable thermal respiratory tract damage; if all three criteria were met, the injury was considered a definite thermal respiratory tract damage. A score suggesting severity of nonthermal respiratory tract damage was computed as a sum of reported signs or symptoms implying possible mechanical, toxic, or systemic exposure. The signs or symptoms included cough, wheezing or hoarseness, dizziness, headache, pneumonia, unconsciousness, and other (eye irritations, dyspnea). Each contributed one point toward the score except unconsciousness, which was weighted as 3 points because it indicates more serious respiratory damage resulting in hypoxia.

Statistical analysis. Relative risks and 95 percent test-based confidence intervals were calculated using programs developed by Rothman and Boice for the Hewlett-Packard programmable calculator (*21*). Comparisons of proportions were done using chi-square analysis; for continuous variables a Student's two-tailed *t*-test was used.

Results

The overall mortality rate (including persons living in households without a telephone) for King County was 0.7 per 100,000 per year, and the incidence of nonfatal injuries was 5.6 per 100,000 per year. In all subsequent analyses, those households without telephones were excluded. Multiple burn or inhalation injuries occurred in 17 (14 percent) households. Of the 145 qualifying injured persons, 17 (12 percent) died; the remaining 128 had nonfatal injuries. All but eight (5 percent) injuries were sustained by permanent household members or guests. These eight included apartment managers, neighbors, or passersby attempting to help fight the fire.

Demographic characteristics. The age-specific rates demonstrate that the young and the elderly were at highest risk for fatal injury, while the highest incidence of nonfatal injuries was in the 20–44 age group (table 1). The relative risk for males compared with females, adjusted for age, was 1.7 (95 percent confidence interval, 1.0 to 1.9). Although differences in sex-specific rates by age group were

Table 4. Respiratory tract damage among residential fire victims, by place where last treated, King County, WA, 1984–85

Category	Died at scene		Hospital and died		Hospital and survived		Outpatient		Fire department	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Thermal—Stone's criteria (*20*):										
None	2	20	0	0	13	54	56	79	30	91
Probable	6	60	3	43	9	38	12	17	3	9
Definite	2	20	4	57	2	8	3	4	0	0
Nonthermal score:[1]										
0	2	20	1	14	6	25	32	45	12	36
1	0	0	0	0	6	25	12	17	14	42
2	0	0	0	0	2	8	12	17	0	0
≥3	8	80	6	86	10	42	15	21	7	21
Mean score	2.4		3.0		2.4		1.4		1.2	
Standard deviation	1.3		1.4		2.4		1.6		1.5	

[1] Sum of symptoms that indicate respiratory tract damage that consist of mechanical, physical, toxicity or systemic injury.

Table 5. Days of restricted activity and costs resulting from injuries among residential fire victims, by place where last treated, King County, WA, 1984–85

Category	Died at scene	Hospital		Outpatient[1]	Fire department
		Died	Survived		
Days of restricted activity:					
Range	(2)	(2)	0–365	0–90	0–30
Median	(2)	(2)	14.2	0.4	0.3
Mean	(2)	(2)	60.8	5.6	2.8
Standard deviation	(2)	(2)	89.2	12.7	6.4
Number of persons studied	(2)	(2)	22	65	30
Personal costs:[3]					
Range	(2)	$1,000–$6,000	$400–$41,500	$0–$7,000	$0–$850
Median	(2)	$4,000	$4,995	$3,999	$3
Mean	(2)	$3,667	$9,261	$712	$35
Standard deviation	(2)	$2,517	$11,729	$1,224	$158
Number of persons studied	(2)	3	17	45	29

[1] Emergency room or physician in clinic. [2] Costs not applicable or measurable.
[3] Sum of costs in dollars including medical expenses, loss of wages, and counseling. Based on subjects with known data.

not statistically significant, the data suggested that young boys (under 5 years) and elderly women (age 65 or older) were at the highest risk for fatality.

The crude incidence rate for whites was 4.9 per 100,000 population per year; for blacks, 10.9; for American Indians, 21.9; for Asians, 4.4; and for other races, 6.3. Since recent county population statistics for sex and age by race were not available, these rates were not adjusted for age and sex. Compared with the rate in whites, blacks had rates 2.2 times greater (95 percent confidence interval, 1.0 to 12.8); American Indians, 4.4 times greater (95 percent confidence interval, 1.5 to 12.8); and other races, 1.3 times greater (95 percent confidence interval, 0.2 to 9.6). Using annual household income as a measure of socioeconomic status, the median household income in the study group was $18,100 compared with a median estimate of $28,930 in 1987 for King County (*23*). Income data for the county were not available for 1984 or 1985.

Injuries resulting from fires ignited by smoking materials were more likely to have resulted in a fatality than injuries from fires ignited by other means (table 2).

Types of injury and treatment. According to the fire departments, 34.5 percent of the study group had burns only, 37.9 percent had respiratory tract damage only, and 27.6 percent had both. Six of the study group also reported other types of injuries: four sustained a wound or fracture, and two reported contusions. Eight (5.5 percent) also reported emotional problems or expenses related to counseling.

The proportion of persons receiving each category of care is shown in the figure. Of the 17

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deaths, 10 (59 percent) died at the scene of the fire and 7 (41 percent) in the hospital. Of those who died in the hospital, six died within 24 hours and one died 11 days after admission. The length of hospitalization for nonfatal injuries ranged from 24 hours to 90 days with a mean of 12 days. Approximately one-fourth of the injured persons received treatment only from the fire department or paramedics at the scene of the fire and were released.

Self-reported burns were reported by 84 (58 percent) of the 145 injured persons. All but 2 of the 17 who died sustained burns; 69 (54 percent) of those not fatally injured reported a burn. The average total percent of body surface area (BSA) burned documented by the last place where treatment was received is shown in table 3. Because it was felt that the classification of burns as first, second, and third degree could not accurately be determined by self-report, these figures include the total percent of BSA without regard to the degree of burn. The mean percent BSA burned was highest in those who died and decreased according to the setting where treatment was received.

Besides burn injury, persons also reported symptoms indicating respiratory tract damage. Of those who died, most had either definite or probable thermal respiratory damage according to Stone's criteria, as did 46 percent of those who were hospitalized and survived, 21 percent of those seen in the emergency room or by a physician in a clinic, and 9 percent treated only by the fire department (table 4). The mean score implying nonthermal respiratory tract damage (table 4) also indicates a gradient with the treatment received.

For those who survived, severity was also measured by the number of days a person had restricted activity. Although victims requiring hospitalization had on average more days of restricted activity (61 days), persons treated as outpatients and by the fire department did have significant morbidity, averaging 6 and 3 days, respectively (table 5).

Interviewees were queried about total expenses related to their injuries including medical bills (regardless of insurance coverage), nonprescription medical supplies, loss of wages (regardless if taken as sick leave), and counseling. As expected, costs were minimal for minor injuries treated by the fire department, but averaged more than $700 for outpatients and more than $9,000 for hospitalized survivors (table 5). Since these costs were available for only 69 percent of the 145 injured persons, total expenses are no doubt underestimated. Information was not available for the other 31 percent because next-of-kin did not know the costs, or survivors could not remember or did not know the cost as their insurance company paid the bill.

Autopsy reports. From an analysis of the autopsy reports, the main cause of death in 12 of 17 persons was inhalation of combustion products or respiratory tract damage; in 4, the primary cause of death was both inhalation and burns; and 1 died from complications of the burns. Although severe burns were also present in 75 percent of those who died due to inhalation, they were diagnosed at autopsy as probable postdeath burns.

Comments

If only the traditional data sources (death certificates and hospital records) had been used, only about 28 percent of the injuries that occurred would have been identified. Of the remaining 72 percent, 23 percent were treated only by the fire department or paramedics at the scene of the fire. These data provide reassurance that injuries not captured by data sources that were previously used appear to be relatively mild.

Because few (8 percent) persons refused to participate or were lost to followup, it is unlikely that results were biased due to nonresponders. Data on nonresponders were limited, but all had minor injuries, except for one hospitalized person. They were similar to responders in terms of age, race, and type of injury, but were more likely to be male or to refuse an interview if the injury had occurred in 1985 rather than 1984.

Several potential limitations of this study, particularly with regard to nonfatalities, should be kept in mind in interpreting the results. The incidence of nonfatal injury may be underestimated for these reasons: incomplete ascertainment of residential fires, injuries not reported by the fire department,

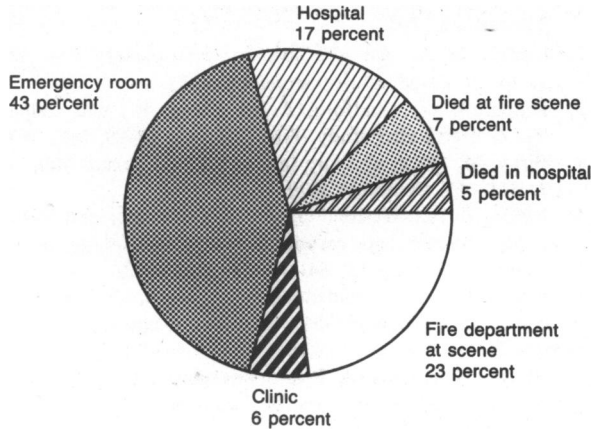
and exclusion of households without telephones for the later analysis. Although previous studies have shown that a large number of fires are not reported to the fire department, the definition of a fire in these surveys was broad. Most were cooking-related fires, and only 5.6 percent of the unreported fires resulted in an injury or illness, most of which were minor (*24,25*).

In addition to the 145 eligible injured persons reported by fire departments, another 12 injured persons were identified during the interviews who would have met the fire department's definition of an injury. None of these persons, however, reported burns and most of their injuries were minor. These nonreported injuries were excluded in the analysis because the number of possible unreported injuries in other households identified by WAFIRS as noninjury households was unknown.

Since this case series was part of a case-control study, injured persons in households without a telephone at the time of the fire were excluded from most of the analyses. Since 19 of these households had a telephone at the time the study was conducted, information collected during an interview suggested that these households were of lower socioeconomic status. Thus, the case series in this study might not be fully representative. This is further supported by the fact that 14 percent of the otherwise eligible households did not have a telephone compared with the estimated 3.9 percent of King County households (*26*).

Another limitation in this study may be that the RTDS was based on the interviewee's response, and some of the symptoms could be unrelated to fire combustion products. The RTDS may also be underestimated or inaccurate when proxy respondents were interviewed. In support of the RTDS, others have defined inhalation using a similarly derived score based on clinical signs and symptoms plus Stone's criteria (*27–29*). For the majority of cases (73 percent), the respondent was the injured person or the parent. Of the proxy respondents, 36 percent reported on adults who died. Overall, in only 12 percent of the cases was the respondent not present during the fire or not a relative. Even though more information was missing for those who died, suggesting that the RTDS for deaths was probably underestimated, the RTDS in this study did correspond with the gradation in treatment received. In addition, when self or parent reported information was compared with information collected from proxy respondents by the place where treatment was last received, significant differences were not observed. Thus, it is felt that the RTDS used in this study does offer a means of evaluating possible respiratory exposure to products of combustion.

Residential fire injuries of 145 persons classified by last place where treatment was received



As in previous studies of fatal fire injuries (*4,30,31*), autopsy data revealed that most died due to inhalation. Percent of body surface area burned, RTDS, days of restricted activity, and personal expenses all demonstrated a gradient of severity with the place where treatment was received.

At highest risk of fire injury were persons in low-income households and nonwhites, especially American Indians. The data also suggested that, for fatal injury, those at highest risk were young children and the elderly. For nonfatal injury, young adults were at highest risk.

In summary, the findings presented in this study describe in detail a population-based case series of fire injuries. The findings help identify high risk subsets of the population—for both fatal and nonfatal residential fire injury—who may be particularly appropriate targets for fire injury prevention programs. The data for the source of fire ignition suggest certain preventive measures. Because smoking is a common cause of fatal and nonfatal fire injuries, possible prevention strategies include education about the dangers of smoking in bed, the use of self-extinguishing cigarettes, and installation of smoke detectors, particularly in low-income housing. Legislation requiring detectors may also be effective in increasing their prevalence (*32*). To prevent cooking-related fire injuries, households need to be informed of the dangers of unattended cooking. In addition, the promotion of safety temperature controls on stove burners and the purchase of fire extinguishers may lead to a safer home environment.

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