The 1987 Forest Fire Disaster in California: Assessment of Emergency Room Visits

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ABSTRACT. During a 5-d period that commenced on August 30, 1987, dry lightning strikes ignited more than 1 500 fires that destroyed in excess of 600 000 acres of California forests. To evaluate the public health impact of the smoke on the general population, all hospital emergency rooms located in the six counties most severely affected by smoke or fire were surveyed. Selected hospital information was abstracted for a 2½-wk period during the fires and during two reference periods. During the period of major forest fire activity, visits of persons with asthma and chronic obstructive pulmonary disease increased in number (observed/expected ratios of 1.4 and 1.3, respectively), as did visits of persons with sinusitis, upper respiratory infections, and laryngitis. A few patients with acute respiratory or eye irritation also visited the emergency rooms. Even recognizing the limited sensitivity of emergency room surveys, the overall public health impact was relatively modest. The increased respiratory moribidity detected in this survey, however, supports the notion that persons with pre-existing respiratory disease represent a sensitive subpopulation, who should be targeted for purposes of public health intervention when exposure to forest fire smoke is likely.

DURING a 5-d period starting on August 30, 1987, 4 520 documented dry lightning strikes ignited more than 1 500 fires in the western United States, mainly in the sparsely populated forests of California.[1] Strong winds accompanied by low humidity resulted in the most severe fire disaster recorded on National Forest lands since 1929. At one point, 22 500 people were battling the fires. Seven firefighters were killed, and approximately 15 000 residents were evacuated. The fires consumed more than 600 000 acres, which is five times the average number of acres burned each year in the entire United States.[1]

Each year, forest fires in North America generate millions of tons of respirable particulates; carbon

Table 1.—Air Monitoring Data from Four California Counties, 1987

Date	*Lassen County*		*Shasta County*	*Siskiyou County*		*Tuolumne County*
	Susanville	18 miles from Susanville	Redding	Yreka	Happy Camp	Chinese station
	PM10*	TSP†	TSP	TSP	TSP	PM10
8/19	30	154	46	60	NA	36
8/25	21	68	29	41	NA	39
8/31	57	119	58	73	NA	68
9/2	NA‡	NA	NA	NA	NA	237
9/6	71	335	71	1 096	NA	79
9/7	NA	NA	NA	NA	2 253	87
9/8	NA	NA	NA	NA	4 158	104
9/12	45	174	56	389	578	49
9/18	26	78	60	226	1 568	NA

Source: These data were provided by the California Air Pollution Control Districts and the California Air Resources Board.
* Suspended particulates less than 10 μ, in $\mu g/m^3$.
† Total suspended particulates, in $\mu g/m^3$.
‡ Data not available.

monoxide (CO); nitrogen oxides; and hydrocarbons, including a variety of acid aerosols, aldehydes, and other respiratory irritants.[2] Concentrations of particulate matter in ambient air measured in several California counties during the fire period are displayed in Table 1. In some locations, particulate concentrations were markedly elevated, especially in parts of Siskiyou County, where visibility was reduced to 10% of normal for several days. In other counties, e.g., Humboldt County coast, there was no appreciable deviation from typical values.

These fires posed potential health hazards to the general population primarily from the huge amounts of smoke. Air monitoring data obtained by the California Air Resources Board and local air pollution control districts prompted the state Department of Health Services and county health officers to issue advisories urging residents (particularly young children, the elderly, and persons with cardiac or respiratory illnesses) either to evacuate or remain indoors and limit physical activity.

A survey was conducted in Northern California to evaluate selected health impacts of these forest fires.

Methods

Visits to all hospital emergency rooms (ERs) in the six California counties most affected by the smoke or the fires were surveyed. Tuolumne County was selected for a pilot study because of the initial severity of forest fires there. The protocol was then slightly modified and extended to ERs of all hospitals ($N = 15$) in five additional counties: (1) Trinity, (2) Siskiyou, (3) Lassen, (4) Shasta, and (5) Humboldt. These counties were selected on the basis of number of acres burned, population size, and proximity of population centers relative to the fires.

Emergency room log books were reviewed and abstracted (a) for a 2½-wk period, which commenced on the first day of the major forest fires (August 30–September 15, 1987) and (b) for two reference periods (September 1–September 15, 1986; and August 15–August 29, 1987). The reference periods were chosen to adjust for seasonal and annual trends. Although the first continued after September 15, the initial 2½-wk period was selected because significant public health impacts should have been apparent within this time period, when the fires in several counties reached their greatest intensity.

At each ER, the logs were reviewed for each day during the study and for reference periods, and the total number of visits and numbers of visits related to injuries and respiratory and nonrespiratory conditions were abstracted. Information was collected from ER records (nonhospitalized cases) and from admission files (hospitalized cases) for all patients who visited the ER for one of the following reasons: noninfectious respiratory illness, including emphysema, chronic bronchitis, asthma, acute pulmonary edema, lower respiratory distress, or other malignant condition; infectious diseases of the upper respiratory tract; eye irritation; and other conditions that could be directly related to the forest fires, e.g., panic and/or anxiety reactions. Additional information was abstracted only for patients who visited the Tuolumne County ERs and whose diagnoses included sore throat, headache, coronary disease, otitis, bee sting reaction, and psychological problems. Information abstracted from all ERs included age; date and time of first visit to the ER for the condition of interest; date of any subsequent visits related to the same condition; city, county, and state of residence; the diagnosis and any pre-existing condition; history of exposure to smoke from the forest fires; and disposition.

An ER visit for asthma was defined as "a visit for which the principal physician diagnosis was asthma." To account for differences in terminology among hospitals, this asthma category included asthmatic bron-

chitis, bronchial hyperreactivity, status asthmaticus, wheezing bronchitis, and bronchospasm.

Data were obtained only from abstracting existing information without additional patient interviews. All ER visits that involved occupational exposures (i.e., firefighters) were excluded from this analysis.

Data were analyzed using the SAS statistical package developed by the Statistical Analysis System Institute.[3] For the six counties, we calculated—collectively and individually—expected numbers of visits for each medical condition of interest during the period of the forest fires as follows: ER visits and admissions for a specific medical condition during the reference periods were multiplied by the ratio of the total number of visits (for all conditions) during the period of the forest fires to the total number of visits during the two reference periods. We then calculated an observed/expected ratio for each medical condition of interest and assessed its statistical significance using the Poisson distribution. However, when a given medical condition existed in fewer than 10 cases for the reference periods and the period of the forest fires, then expected numbers were not calculated. Minor differences among small numbers might have resulted in a misleading observed/expected ratio or might have increased the likelihood of Type I and Type II errors.

Results

All 15 hospitals that were solicited agreed to participate. In Figure 1, the daily number of visits to ERs in all hospitals, from August 15–September 15, 1987, is displayed for all hospitals combined. The number of visits for respiratory conditions increased as of September 1.

Results related to specific medical conditions are presented in Figure 2. When all data from the ERs surveyed were combined, significantly more patients were treated for asthma (observed/expected ratio [O/E] = 1.4) and chronic obstructive pulmonary disease (COPD) (O/E = 1.3) than would be expected during the period of the forest fires. This increase was also observed in our review of data from each county (with the exception of COPD patients in Humboldt County). Among persons who visited an ER for asthma, 65% who came during the reference periods had a pre-existing history of asthma, compared with 63% during the period of the forest fires. The comparable percentages for persons with COPD were 59% and 56%, respectively. There

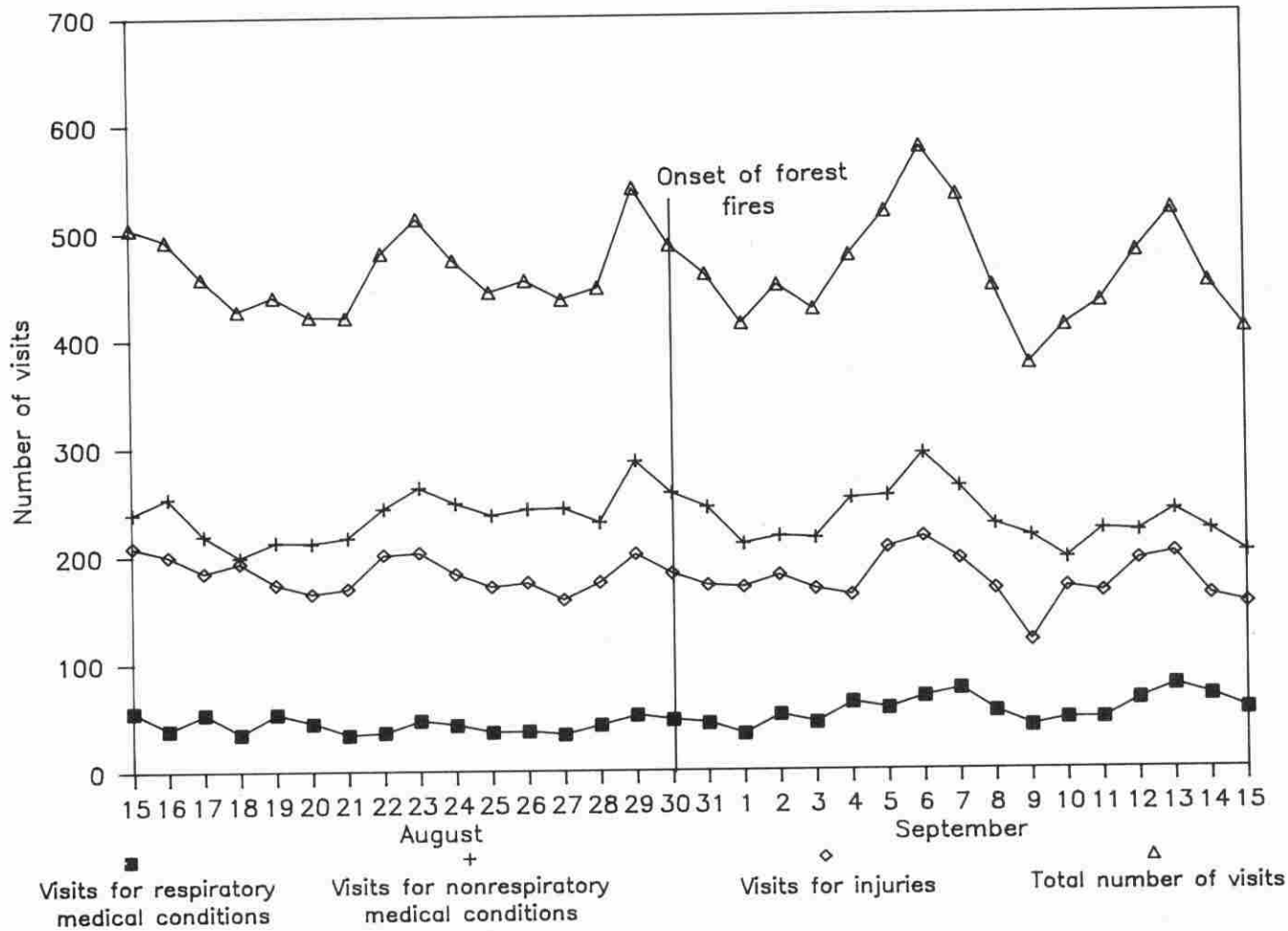

Fig. 1. Daily number of visits, August 15–September 15, 1987, to emergency rooms in Shasta, Siskiyou, Humboldt, Tuolomne, Lassen, and Trinity Counties, California.

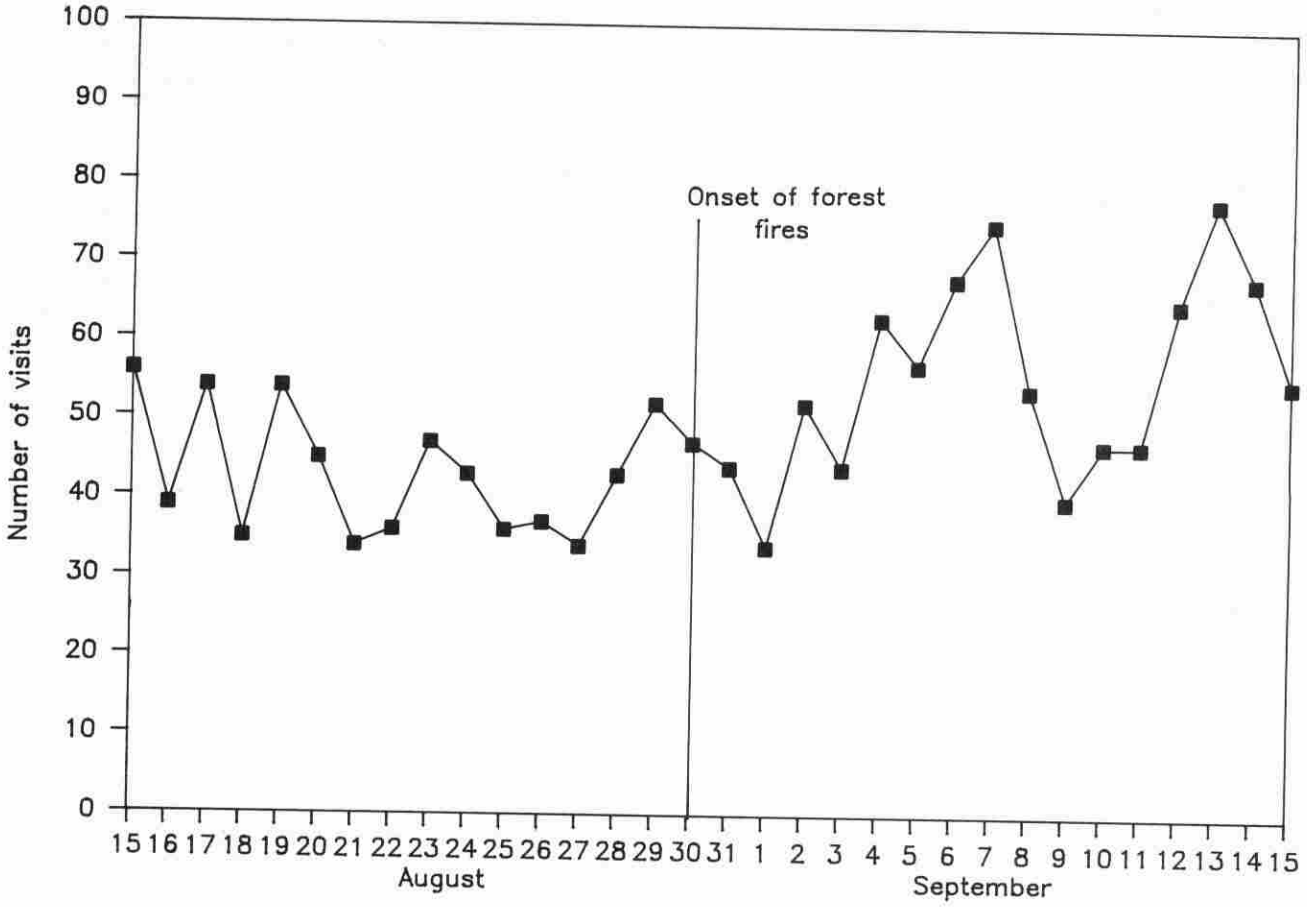

Fig. 2. Daily number of visits for respiratory medical conditions, August 15–September 15, 1987, to emergency rooms in Shasta, Siskiyou, Humboldt, Tuolomne, Lassen, and Trinity Counties, California.

was no increase in hospital admissions for asthma during the period of forest fires.

Among patients with other respiratory conditions, those with laryngitis showed the most consistent increase in ER visits (O/E from 1.6–2.2 for each county). Numbers of visits for nonrespiratory medical conditions, e.g., eye irritation (for all ERs, O/E = .9, p = .4) did not increase significantly during the period of the forest fires.

No statistically significant increased incidence in mental health problems was observed (O/E = 1.1, p = .4); headache (O/E = 1.6, p = .1); coronary problems (O/E = 1.2, p = .1); otitis (O/E = 1.2, p = .1); or bee sting reactions (O/E = .8, p = .4), which were surveyed only in Tuolumne County.

Discussion

Studies relating air pollution and ER visits are subject to the limitation that economic and behavioral factors influence the utilization of medical services. Nevertheless, ER visits are a valid indicator of acute respiratory morbidity.[4,5] However, people who attend ERs for illnesses of mild to moderate severity are not necessarily representative of the catchment area population. Various factors affect ER use, e.g., access to other medical care, availability of insurance, perceptions about the seriousness of illness or injury, and time of day. Therefore, the use of reference periods to try to adjust indirectly for some of these variables influencing ER utilization is important.

After combining statistics for all ERs, an increase was observed in visits for respiratory conditions from September 2 to September 15, 1987, but no increase in visits for nonrespiratory conditions was noted. Typical day-of-the-week variability with respect to the number of daily visits provides a partial explanation for the relative decrease in visits for respiratory conditions observed between September 7 and 12.

The health impact of forest fires on the general population was limited, except for increases in several respiratory conditions. During the period of forest fires, ER staff handled more visits than would have been expected by chance that were related to noninfectious respiratory conditions (particularly asthma or COPD).

Particulate readings at some locations were within the range for which respiratory symptoms could be expected, i.e., well in excess of state and federal air quality standards.[6,7] Because smoke, chemical irritants, and dust can provoke bronchoconstruction and airway obstruction, the increased visits related to asthma and COPD are not surprising.[8–10] Although no association between forest fire smoke and asthmatic attacks or COPD exacerbations had been published previously, health department officials prudently advised people who had pre-existing lung disease(s) to evacuate or

otherwise minimize their exposure. Exposure could be minimized by limiting time spent outside (smoke-related indoor air quality was assumed to be better than outdoor air quality) and limiting strenuous physical activity, which would increase exposure. People at higher risk (i.e., those with pre-existing cardiorespiratory disease or with potential age-related susceptibility, e.g., elderly persons or infants) may have left the exposed areas or limited their outside exposure, thereby decreasing the number of people at risk during the study period. Although this study protocol precluded evaluation of individuals' behavior and the effect of the health advisories on their behavior, our results indicate that these warnings were insufficient to prevent the occurence of some increased respiratory morbidity. Conversely, many ER visits for asthma and COPD were made by people who had no previous history of these illnesses, which suggests that misclassification of disease status may have occurred. Therefore, physicians may have overdiagnosed obstructive conditions or we may have inadvertently inflated the asthma category by including isolated episodes of bronchospasm, which also occurs among people without asthma and often accompanies smoke inhalation injuries.[11] The observation in this study of smaller increases in numbers of visits for respiratory conditions compared with other studies related to air pollution[6] may be explained by differences in smoke and particulate chemical composition, demographic characteristics, exposure patterns, diagnostic fashions, or ER practices.

Increases in sinusitis, laryngitis, and other respiratory noninfectious conditions were also found in the most severely affected counties (Table 2). There was no increase in the incidence of pneumonia or pharyngitis. This increased incidence of infectious respiratory conditions may be attributed to exposure to forest fire smoke constituents[12-16] or possibly to heightened perceptions of the severity of respiratory diseases.

Smoke exposures were not uniform within a county, from one county to another, or during the period of our survey. Air monitoring for particulates was infrequent and occurred at fixed locations that were often remote from much of the smoke to which the populations were exposed. Consequently, exposure could not be quantified reliably. Overall, Humboldt County residents were exposed to less smoke than residents of other counties, and ERs in that county were located further from fires and smoke. Not unexpectedly, no significant increase was observed for any noninfectious respiratory conditions in Humboldt County.

The only CO measurements were made near the fires, and the levels were relatively low, which suggests that CO exposure would not have been responsible for health problems among the general population. That CO-related symptoms, such as headache and coronary problems, were not increased in the hospitals surveyed in Tuolumne County is consistent with this hypothesis.

Conclusions

Considering the huge quantities of smoke to which people were potentially exposed, the short-term public health impact of California's forest fires appears to have been moderate. Because of the inherent limitations of emergency room surveys, we could not assess the full public health impact of the California fires. Nevertheless, an increased incidence of infectious and noninfectious respiratory illnesses was detected. The results of this study support the notion that persons with preexisting respiratory disease are susceptible to effects of smoke exposure, and public heatlh officials should direct interventions toward this subpopulation when exposure to forest fire smoke is likely.

It is recommended that public health officials establish an active community surveillance system during future fire disasters that involve exposures of population centers to forest fire smoke. Surveillance should focus on infectious and noninfectious respiratory illnesses. Authorities might benefit from collaboration with lung associations and pulmonary rehabilitation or-

Table 2.—Observed and Expected Numbers of Emergency Room Visits* for Respiratory Conditions (August 30–September 15, 1987; California)

	Number of observed visits	Number of expected visits	Observed/ expected	*p* value (1-tailed test)
Asthma	120	86.0	1.4	<.001
COPD	74	56.9	1.3	.02
Laryngitis	23	14.2	1.6	.02
Sinusitis	40	30.2	1.3	.05
Tonsillitis	53	56.3	0.9	.4
Pharyngitis	129	120.4	1.1	.2
Other upper respiratory infections	97	67.0	1.5	<.001
Bronchitis	134	113.3	1.2	.03
Pneumonia	29	27.9	1.0	.4

Note: Excluded from above were five visits identified as "cases of smoke inhalation" on the medical chart.
* Emergency room visits were made and studied in the following counties: In Humboldt, Lassen, Shasta, Siskiyou, Trinity, and Tuolumne.

ganizations. Authorities should also warn potentially smoke-exposed residents that asthma, chronic obstructive pulmonary disease, and respiratory infections might be exacerbated, and they should issue guidelines on limiting unnecessary exposure.

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Use of trade names is for identification only and does not constitute endorsement by the Public Health Service of the U.S. Department of Health and Human Services.

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