Articles

Immediate Health Effects of an Urban Wildfire

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To document the immediate health effects of the urban wildfire that swept through parts of Alameda County, California, on October 20 and 21, 1991, we conducted a retrospective review of emergency department and coroner's records. Nine hospitals (6 local and 3 outlying) were surveyed for the week beginning October 20, 1991. Coroner's reports were reviewed for 25 identified fire-related deaths. A total of 241 fire-related emergency encounters, including 44 inpatient admissions, were recorded for 227 persons. Nearly a fourth of emergency department patients were seen for work-related injuries, more than half of which occurred among professional firefighters. Smoke-related disorders constituted more than half of all emergency department cases; of these, 61% had documented bronchospasm. Major trauma and burns contributed 1% and 4% of principal diagnoses, respectively; these were exceeded in number by corneal abrasions (13%), other medical problems (8%), and minor trauma (7%), among other diagnoses. All coroner's cases involved extensive burns, many with documented smoke inhalation injury. While the Oakland-Berkeley fire storm resulted in a high case-fatality ratio among major burn cases (25/31), those who survived the initial fire storm did well clinically. Among emergency department patients, medical (particularly smoke-related) disorders outnumbered traumatic presentations by a ratio of more than 2 to 1.

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On Sunday, October 20, 1991, a grass fire in the Oakland-Berkeley hills of northern California that was believed to have been extinguished on the previous day flared into one of the largest urban fires in US history. The fire was fueled by dry vegetation resulting from five consecutive years of drought and was fanned by unusually hot and dry northeasterly winds. Over the course of the next two days, more than 1,600 acres of hilly residential land burned, destroying or damaging approximately 3,800 dwelling units, killing 23 civilians and 2 public safety workers, and sending scores of persons to area emergency departments.[1] A smoke and ash plume rose to between 1,800 and 5,000 ft altitude and extended over at least 30 miles (Bay Area Air Quality Management District, oral communication, October 1991).

More than 1,500 firefighting personnel from 244 local, 4 military, and 2 state agencies fought the blaze over a three-day period.[1] Local police and public safety officers evacuated residents and controlled traffic and crowds. Emergency medical services were provided by at least nine area hospitals. In this article we summarize the immediate health effects of the fire—through the first week after the fire—as ascertained from emergency department records and coroner's reports.

Methods

Cases were researched at six local (Oakland and Berkeley) and three outlying hospitals. The latter were selected because of either their inpatient burn units or their regional trauma center status (Table 1). Study personnel reviewed emergency department logs and medical records for patients registered between 11 AM on Sunday, October 20, and 11:59 PM on Saturday, October 26. Our initial case search was aided by lists of fire-related cases compiled by emergency department administrators during the first two days of the fire. In addition, several diagnostic types were selected for review from the emergency department logs, including all trauma, burns, chest pain, respiratory disorders, smoke inhalation, conjunctivitis, corneal abrasions, mental health problems, and problems placing chronically ill patients. Criteria for inclusion in the study were treatment in an emergency department during the described time frame plus documentation in the medical record that, in the opinion of the treating physician, the fire was a causal, precipitating, or exacerbating factor for the presenting complaint. The locations of the fire and of the hospitals surveyed are shown in Figure 1.

We reviewed records using a standardized abstraction form. Data abstracted included demographics (age, sex,

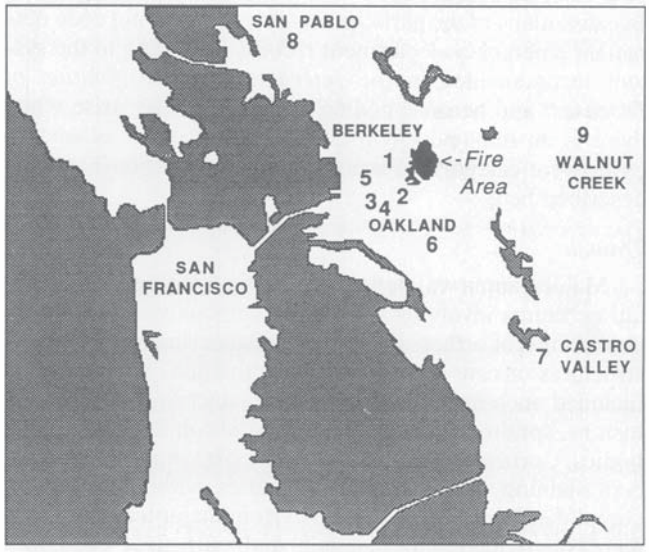

Figure 1.—General fire area and locations of hospitals surveyed are shown on this map of the Bay Area. (See Table 1 for key to hospitals.)

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TABLE 1.—*Characteristics of Hospitals Surveyed, With Number and Types of Initial Visits*

No.	Hospital	City in California	Type*	Licensed Beds, No.	Relevant Areas of Specialty	Total Initial Visits, No.	Emergency Department Only, No.	Admissions and Transfers, No.
1	Alta Bates-Herrick†	Berkeley	1	469	Inpatient burn unit	61	51	10
2	Kaiser Foundation	Oakland	2	300	--	46	39	7
3	Merritt-Peralta	Oakland	1	260	--	36	27	9
4	Providence	Oakland	1	238	--	35	30	5
5	Oakland Children's	Oakland	1	205	Pediatric trauma center	19	13	6
6	Highland General†	Oakland	3	300	Regional trauma center	16	12	4
7	Eden†	Castro Valley	1	238	Regional trauma center, inpatient burn unit	9	8	1
8	Brookside†	San Pablo	4	246	Inpatient burn unit	3	3	0
9	John Muir	Walnut Creek	1	317	Regional trauma center	2	2	0
	Total					227	185	42

*Hospital types: 1 = private, nonprofit; 2 = health maintenance organization; 3 = public, governmental; 4 = public, district.
†These hospitals are participants in an ongoing study of smoke inhalation victims sponsored by the Federal Emergency Management Agency-US Fire Administration and the International Association of Fire Fighters-Burn Foundation.

race, and residence location); date, time, and mode of arrival in emergency department; type of visit (emergency department only, inpatient admission, or transfer); work-relatedness of injury (with occupation and employer if appropriate); chief complaint, discharge diagnosis, and type and severity of injuries and medical complaints. For persons identified from medical records as exposed to smoke, the initial carboxyhemoglobin level was recorded, if available. For fatalities, cause and circumstances of death, description of injuries, and results of toxicologic analyses were obtained from the Alameda County Coroner's Office. Data were entered and analyzed using Epi-Info, Version 5.01b (Centers for Disease Control, Atlanta, Georgia).

Hospital cases were classified for study purposes based on the principal discharge diagnosis (for those admitted as inpatients) or the first condition listed in the diagnosis section of the emergency department record (for those treated as outpatients), except when an obvious competing diagnosis of greater severity influenced the level of emergency care. Because many of the participating hospitals did not code outpatient emergency department records according to the system recommended in the *International Classification of Diseases*[2] and because coding ambiguities may arise when there is an imputed environmental agent, such as smoke, cases were categorized according to the functional scheme described here.

Trauma

Major trauma was defined as life-threatening or incapacitating trauma involving the central nervous system, thorax, or abdomen or orthopedic trauma endangering neurovascular structures or causing risk of exsanguination. Minor trauma included uncomplicated lacerations, puncture wounds, contusions, sprains, strains, abrasions, and conjunctival foreign bodies. Corneal abrasions were defined by abnormal fluorescein staining of the cornea. Fractures without secondary complications were distinguished from major trauma. Burns were subdivided into inpatient and outpatient categories based on severity.

Smoke-Related Disorders

Irritative reactions to smoke included smoke-related headache, conjunctivitis, nasopharyngitis, sinusitis, tracheitis, acute bronchitis without wheezing, and nonspecific

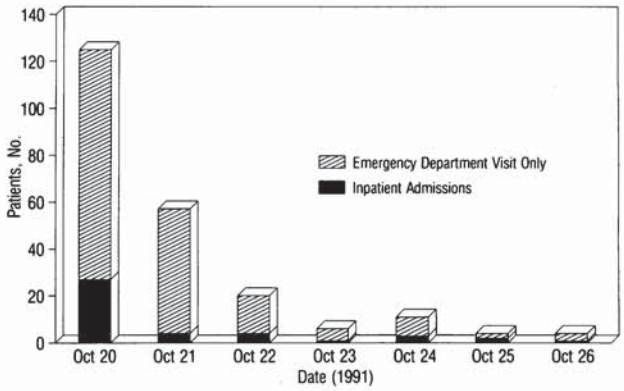

Figure 2.—The graph correlates initial emergency department visits and inpatient admissions, by day, for the period October 20 to 26, 1991.

smoke inhalation without wheezing. Bronchospastic reactions to smoke included acute exacerbations of asthma and chronic obstructive pulmonary disease, asthmatic bronchitis, bronchospasm, and reactive airways disease, in each case with the auscultatory finding of wheezing documented in the medical record.

Other Medical, Psychiatric, and Social Service Problems

Medication refills was a category limited to patients without acute symptoms. Other medical problems included chest pain, nontraumatic chest wall pain, and gastrointestinal, skin, and other nontraumatic disorders. Mental health problems, including acute exacerbations of underlying psychiatric disorders and acute situational stress or grief reactions, were also seen. The final category was evacuation or placement difficulties, referring to displaced persons with chronic medical conditions rendering referral to shelters inappropriate.

Results

Emergency Department Visits and Hospital Admissions

A total of 241 emergency department visits were documented for 227 persons, with 44 inpatient admissions. Of the admissions, 42 occurred at the time of the initial visit and 2 on follow-up evaluation. The number of initial emergency

department visits and inpatient admissions by hospital are shown in Table 1, and their timing is shown in Figure 2. The numbers follow a roughly inverse relationship to the distance of each hospital from the fire zone.

The demographic characteristics of patients seen in local emergency departments and of coroner's cases are shown in Table 2. Overall, there was a predominance of male to female patients, although this excess was largely limited to those injured in the course of employment. Residents of Oakland and Berkeley together contributed 72% of emergency department visits. Table 3 gives the occupational status of patients. Almost 25% of all cases were work related; among these, roughly half were among professional firefighters, and the rest were nearly evenly split between volunteer firefighters and people of other occupations.

The diagnoses of patients treated in emergency facilities are categorized in Table 4. The leading diagnostic categories were bronchospastic reactions to smoke (31%), irritative reactions to smoke (20%), corneal abrasions (13%), other medical problems (8%), and minor trauma (7%). It is interesting to note that almost half of the corneal abrasions and more than 25% of the irritative reactions to smoke occurred among professional and volunteer firefighters, who together constituted only 18% of all patients seen. On the other hand, no firefighters were seen in the emergency department with a principal diagnosis of burns, and only two were seen with bronchospastic reactions to smoke.

The Oakland Fire Department (the employer with the largest number of fire-related injuries) contracts with an outpatient physician group to treat nonemergency work-related injuries; such outpatient care was available beginning with the second day of the fire. It is therefore likely that our case search significantly underestimated the number of minor injuries among local professional firefighters (Capt. William Salters, oral communication, November 1991). Similarly, many persons injured nonoccupationally may have sought care in nonemergency outpatient settings and thus would not be reported here.

Major Trauma

Three cases were ultimately classified as major trauma; one patient was treated at the regional trauma center closest to the fire area (hospital 6), one at the pediatric trauma center (hospital 5), and one at a hospital not designated as a trauma center (hospital 2). Another three patients were treated either as trauma team cases or trauma consultations at hospital 6; after examining discharge diagnoses, two of these cases were classified here as minor trauma and the last as an inpatient

TABLE 2.—*Characteristics of Emergency Department Patients and Direct Fire Fatalities*

Characteristic	Patients (n=227)	Fire Fatalities (n=25)*
Age		
Range	3 mo-97 yr	18-85 yr
Mean	38.7 yr	54.6 yr
Sex	*No. Male/Female*	
All patients	140/87	11/14
Patients with non-work-related conditions	90/83	9/14
Patients with work-related conditions	50/4	2/0
City of Residence	*No. (%)*	*No. (%)*
Oakland	120 (53)	17 (68)
Berkeley	44 (19)	5 (20)
Other	63 (28)	3 (12)
Total	227 (100)	25 (100)

*An additional indirect fire-related fatality is documented in the text.

TABLE 3.—*Occupational Status of Emergency Department Patients*

Work Status of Admitting Condition	Patients, No. (%)	Patients, No. (%)	Patients, No. (%)
Not work related	173 (76)	--	--
Work related	54 (24)	--	--
Firefighters	--	40 (74)	--
Professional	--	--	28 (70)
Volunteer	--	--	12 (30)
Police officers	--	4 (7)	--
Other	--	10 (19)	--
Total	227 (100)	54 (100)	40 (100)

TABLE 4.—*Principal Diagnoses of Patients Seen in Emergency Settings, With Occupational Status*

Diagnostic Category	Number of Cases: Emergency Department Only	Number of Cases: Admissions	Number of Cases: Total (%)	Firefighters (Professional and Volunteer), No.	Other Occupations, No.	Non-occupational, No.
Bronchospastic reactions to smoke	54	17	71 (31)	2	1	68
Irritative reactions to smoke	42	4	46 (20)	12	3	31
Corneal abrasions	29	0	29 (13)	13	4	12
Other medical problems	17	2	19 (8)	4	2	13
Minor trauma	14	1	15 (7)	6	3	6
Evacuation or placement	4	9	13 (6)	--	--	13
Mental health problems	11	0	11 (5)	1	0	10
Fractures (simple)	5	3	8 (4)	2	0	6
Burns (inpatient)	0	6	6 (3)	0	0	6
Medication refill	4	0	4 (2)	--	--	4
Major trauma (other than burns)	1*	2	3 (1)	0	1	2
Burns (outpatient)	2	0	2 (1)	0	0	2
Total	183	44†	227 (100)‡	40	14	173

*One patient was unable to be resuscitated in the emergency department. †Includes 2 admissions from follow-up (non-initial) visits. ‡Percentages may not total correctly because of rounding.

burn. A total of 54 ambulance transports were documented from hospital records.

Burns

Seven people had minor burns not requiring admission, with severity ranging from punctate blisters on the eyelids to second-degree burns over 5% of the upper extremities. Burns were the principal diagnosis for only two outpatients. Only one professional and one volunteer firefighter were noted to have burns, in neither case as the principal diagnosis.

Six patients with burns were treated in hospital. The range of body surface area involvement among inpatients was 12% to 43% (mean 24%). The burns were predominantly second degree in depth, although two inpatients had third-degree burns of minor extent and a third had widespread, deep second-degree burns. One patient had a serious inhalation injury with transient myoglobinuric renal failure.

Qualitatively, some unusual burn patterns were noted. Among the inpatients, burns were usually patchy in distribution, reflecting the fact that flaming debris had struck the patients. In addition, the finding of confluent areas of deep second-degree burns with lines of burn demarcation at the edges of clothing and intact body hair suggested that radiant (infrared) heat may have conveyed a substantial part of the thermal injury. Cinders were apparently responsible for the punctate distribution of burns in some outpatients.

Smoke-Related Disorders

Overall, bronchospastic and irritative reactions to smoke constituted more than half of the emergency department visits related to the fire, with bronchospastic reactions alone constituting nearly a third of all cases. Among the 71 patients with bronchospasm related to smoke, 16 were admitted as inpatients on their first day of treatment, 1 was admitted on a follow-up visit, and 4 had several outpatient visits during the week after the fire. Approximately two thirds of these patients (n = 47; mean age 24 years) had a history of asthma documented on the chart, and another 11% (n = 8; mean age 66 years) had a history of chronic obstructive pulmonary disease. The remaining 23% with bronchospasm and no history of asthma or chronic obstructive pulmonary disease were intermediate in age (n = 16; mean age 33 years). At the single pediatric hospital in the study area, bronchospastic reactions to smoke constituted nearly 85% of fire-related visits and all of the inpatient admissions, the highest proportion among any of the study hospitals. Bronchospastic reactions to smoke led to most of the inpatient admissions after the first day of the fire and the only admissions after day 2 following the fire.

The spectrum of nonbronchospastic irritative effects from smoke ranged from mild conjunctivitis to tracheobronchitis. Of the 46 patients in this diagnostic group, 4 were admitted as inpatients, 3 with a diagnosis of smoke inhalation and 1 with a smoke-related exacerbation of preexisting fibrotic lung disease; among the patients with smoke inhalation were two professional firefighters. Only one of the four inpatients had acute abnormalities on the admission chest radiograph. The average carboxyhemoglobin level among the 3 inpatient smoke inhalation cases was 0.054 (5.4%), compared with 0.033 (3.3%) among the 17 outpatients with irritative reactions to smoke who were sampled. Some of the patients in this category may have had bronchospasm without wheezing. Conditions such as "cough-equivalent asthma," however, could not be detected in our retrospective study because the participating emergency departments do not administer pulmonary function tests on a consistent basis.

Other Medical and Mental Health Problems

Among the 19 cases classified with other medical problems were the following principal diagnoses, in order of descending frequency: suspected anginal symptoms, chest pain of unknown cause, poison oak (rhus) dermatitis, nontraumatic chest wall pain, gastroenteritis (possibly from donated prepared food), dehydration, esophageal spasm, dyspepsia, peptic ulcer disease, and loss of control of diabetes mellitus. Most of the 11 mental health visits were related to situational stress.

Evacuation or Placement Difficulties

The average age of patients evaluated for placement (n = 13) was 87 years, with a range of 71 to 97 years. Documented preexisting debilitating medical conditions in this group included stable chronic obstructive pulmonary disease, dementia, stroke, and congestive heart failure. Nine of these patients were admitted, including two who were transferred to skilled nursing facilities. One hospital opened up a ward for several days to accommodate chronically ill and elderly patients displaced by the fire.

Carboxyhemoglobin Levels

Carboxyhemoglobin (COHb) levels were determined for 43 people (11 professional firefighters, 5 volunteer firefighters, and 27 civilians) on arrival at the emergency department. All hospitals determined COHb levels by differential spectrophotometry, although the specific manufacturer and model of instruments varied from hospital to hospital. The range of COHb values was from 0.000 to 0.091 (0.0% to 9.1%), with a mean of 0.033 (3.3%). The distributions of COHb values for firefighters and civilians are shown in Figure 3; COHb levels among the 16 professional and volunteer firefighters averaged 0.051 (5.1%) versus 0.023 (2.3%) among the 27 civilians.

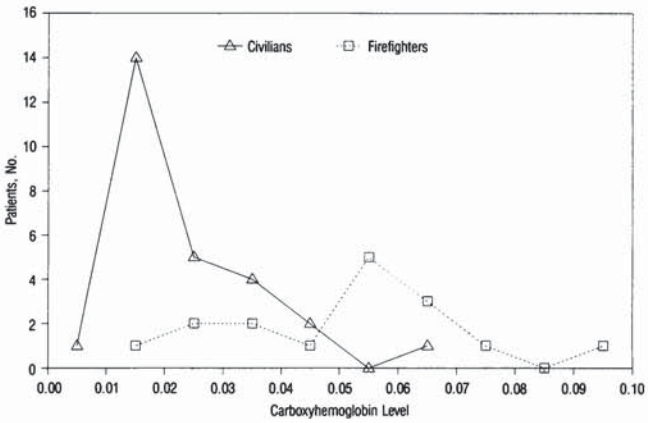

Figure 3.—Measurements of carboxyhemoglobin levels were obtained on 27 civilians and 16 firefighters (11 professionals and 5 volunteers).

Fatalities

The official coroner's count of fire-related deaths was 25, including 23 civilians and 2 public safety personnel. In contrast to emergency department cases, there was a predominance of female over male fatalities. Those who died were,

on the average, older, reflecting the relatively settled demographics of the remote hillside areas (Table 2). The residential distribution of deaths was roughly similar to that of emergency department cases, with Oakland and Berkeley together being the location of 88% of the deaths. Included in our tally is a traffic death that occurred away from the fire site but that was clearly related to traffic diversion around the fire area.

All coroner's cases involved extensive burns, with or without documented smoke inhalation injury. The coroner's office also noted specific traumatic injuries in some cases. Given the rapidity with which the fire moved, the high temperatures involved, and the consequent destruction of physical evidence, it was impossible for the coroner's office to attribute specific underlying or contributory causes of death or to reconstruct premortem events in most cases.

The forensic toxicology protocol for the County of Alameda Sheriff's Office involves determining COHb, cyanide, and ethanol blood levels for all cases of death by burns or smoke inhalation for which suitable specimens are available (Paul Herrmann, MD, oral communication, December 12, 1991). The COHb levels (n = 16) ranged from 0.02 to 0.51 (2% to 51%), with a mean of 0.14 (14%). Measured cyanide levels (n = 18) ranged from nondetectable (less than 6 μmol per liter [< 0.15 μg per ml]) to 60 μmol per liter (1.56 μg per ml), with a mean of 9.8 μmol per liter (0.26 μg per ml). Only 2 of 16 blood specimens had ethanol levels in the detectable range: 4.3 and 34.7 mmol per liter (20 and 160 mg per dl).

Discussion

Trauma

Major trauma (other than burns) was relatively rare, involving motor vehicle accidents in two cases and a fall from a roof in the third. One motor vehicle accident was related to a motorist running a stop sign while fleeing the fire; the victim was on a motorcycle and was wearing a helmet. The other was related to the diversion of traffic on a freeway that traverses the fire area; the victim was an unrestrained passenger. Both of these cases involved head injuries, in one case being fatal. Five of the nine documented fractures involved the lower extremities, and the predominant mechanisms of injury were falling, jumping, and running on uneven ground. The pattern of minor trauma was unremarkable under the circumstances.

Fatalities and Burns

The high case-fatality ratio among major burn patients (25/31) was attributable to the rapid spread of the fire and the impeded escape in many areas; many residents were overtaken by flames as they attempted to flee. On the other hand, those who survived their initial burn injuries did well. Whereas some residents were trapped in their homes, others fell victim to traffic bottlenecks exacerbated by narrow hillside roads. In one stretch of road, for example, 11 people perished. Inspection of the area later revealed that the 13-ft-wide road (half the minimum national standard width) had become obstructed by fleeing vehicles (M. Taylor and B. Wallace, "Charing Cross Bottleneck Was Big Killer," *San Francisco Chronicle,* November 2, 1991, p A14). In addition to area residents, two public safety officers (one firefighter and one police officer) died while attempting to lead civilians to safety.

The burn injuries among survivors were treated roughly equally on an inpatient and outpatient basis. As noted earlier, many of the burns displayed either a patchy quality (related to exposure to flaming debris) or a pattern related to radiant heat. The effectiveness of the "turnout coat" worn by firefighters against both of these hazards was attested to by the virtual absence of burns documented among firefighters.

Smoke-Related Disorders

The intensity and duration of smoke exposure ranged from mild and transient (among residents of surrounding areas) to intense and prolonged (among firefighters and some residents of the fire area). Although obvious risk factors for a bronchospastic response to smoke include antecedent asthma and chronic lung disease, some persons may wheeze for the first time after smoke exposure.[3,4] Reports of bronchospasm among residents some distance from the fire are consistent with published reports on the exacerbation of asthma by particulate air pollution.[5-7] Observations of particulate-triggered asthma have recently been extended to include smoke from forest fires[8] and from an urban warehouse fire (Michael Lipsett, MD, unpublished data, January 1991), with 40% to 60% increases in the number of local emergency department visits for asthma being typical during large fires.

Occupational Health Issues

Urban (structural) firefighters have been noted to be at high risk for smoke inhalation, burns, and falls.[9] Combustion products posing acute inhalation hazards in structural fires include simple asphyxiants (such as carbon dioxide and oxygen-deficient atmospheres), cellular asphyxiants (carbon monoxide and hydrogen cyanide), and various irritants (including nitrogen oxides, particulate matter, organic acids, aldehydes, and chlorine compounds).[10] Wildlands firefighters, by contrast, have been noted to be at lower risk of developing carbon monoxide intoxication than their urban counterparts.[11] Structural firefighters have been shown to be at risk for transient respiratory impairment, with cross-shift changes in forced expiratory volume in 1 second, forced expiratory flow in the midexpiratory phase, and nonspecific bronchial reactivity[12-14]; similar changes have been demonstrated in wildlands firefighters on a cross-seasonal basis.[15]

The Oakland-Berkeley fire showed characteristics of both structural and wildlands fires. Similar to a wildlands fire, little of the firefighting took place in enclosed spaces—hence, the relatively low COHb levels observed in firefighters. At the same time, the prolonged firefighting hours and rugged terrain rendered impractical the respiratory protective gear often used in structural firefighting (the self-contained breathing apparatus). The combination of long and arduous work hours, dehydration, respiratory tract irritation, and low-level carbon monoxide exposure took its toll on many of the firefighters: 30% of firefighter emergency department cases had a principal diagnosis of irritative reaction to smoke, compared with only 18% of civilians. The issue of eye protection was highlighted by the relative prominence of corneal abrasions among firefighter casualties (33% of firefighters versus 7% of civilians).

Carboxyhemoglobin Levels

The observed COHb levels among emergency department patients were relatively low, consistent with the predominantly outdoor exposure conditions. The levels observed here, however, are in the same range as those noted

to shorten the time to angina in a treadmill study of patients with coronary artery disease (0.02 to 0.04, or 2% to 4%)[16] or to increase ventricular ectopy during exercise in a similar group (0.06, or 6%).[17] Among fire deaths, two of the observed COHb levels were potentially life threatening (>0.45) and a third potentially impairing (>0.25). Likewise, the cyanide levels of two who died were in the potentially lethal range (>40 μmol per liter). Although the coroner's office did not speculate on the question of incapacitation before death, it is interesting to view these toxicologic data in light of the recent literature on synergistic toxicity from carbon monoxide and hydrogen cyanide in fire smoke.[18,19]

Mental Health Needs

Probably more than any other health end point, mental health problems are underestimated by examining emergency department visits. The American Red Cross, which operated shelters with volunteer and professional staff, made more than 3,700 contacts for crisis counseling and mental health services (American Red Cross, *East Bay Hills Fire*, DR 590, November 25, 1991). At the University of California at Berkeley, counseling services and the employee assistance program performed active mental health outreach to many of the more than 500 faculty, staff members, and students who were displaced by the fire (Carol Hoffman, LCSW, oral communication, December 1991). The local children's art museum conducted art therapy workshops related to the fire, and a psychiatry grand rounds at a local hospital was devoted to the issue of posttraumatic stress disorder and the fire. Neighborhood support groups, dubbed "Phoenix Societies" after the mythical bird that emerges from its own ashes, sprang up in many fire-ravaged areas; block parties were organized to reestablish neighborhood ties and to honor professional and volunteer firefighters. As of the date of writing, Oakland's metropolitan newspaper still maintains a "fire bulletin board" announcing fire-related meetings and services, including counseling and support groups.

Lessons From the Fire—Prevention

Preventive measures suggested by our examination of the Oakland-Berkeley fire experience can be divided between public safety—fire prevention, evacuation, and emergency response—and public health interventions. In the latter category, the results of our study, like those of others before it,[8] suggest that health advisories should be targeted toward persons with asthma or chronic lung disease, warning them to either stay indoors or vacate areas affected by smoke. Patients taking asthma medications as needed should anticipate the difficulties that smoke will pose and adjust their medication regimens accordingly. Citizens of fire-prone areas should be made aware of the fact that heavy-duty occlusive clothing may provide some protection against radiant heat injuries in escape situations. Firefighters charged with fighting prolonged, smoky, outdoor fires should be encouraged to use protective eyewear and possibly air-purifying (cartridge) respirators when using self-contained breathing apparatus is impracticable.

In the public safety arena, two reports critiquing both advance planning and the emergency response were recently issued by the California Office of Emergency Services and the Federal Emergency Management Agency.[1,20] Among their recommendations were the following:

- Control flammable vegetation near homes;
- Require safer home construction materials (in particular, ban wooden roofs in high-fire-hazard areas);
- Widen streets or prohibit curbside parking in areas with narrow streets, or both;
- Improve communications protocols and equipment for emergency personnel;
- Upgrade and standardize emergency water delivery systems;
- Improve interagency disaster planning; and
- Establish viable evacuation plans for high-fire-risk areas.

Considering the history of major fires in this geographic area (1923, 1946, and 1970), future generations of Oakland-Berkeley hillside dwellers will undoubtedly judge the adequacy of the response to these recommendations.

Acknowledgment

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