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Preventing Death and Injury From Fires With Automatic Sprinklers and Smoke Detectors

Council on Scientific Affairs

Resolution 2 (Annual Meeting 1985), which was referred to the Board of Trustees, asked the American Medical Association to urge government officials to require all new residential and nonresidential buildings to be equipped with rapid-response automatic water sprinklers and smoke detectors and to require their installation in existing high-rise buildings within three years unless existing code requirements are more stringent. This response to the resolution is a summary of the literature up to June 1986.

(JAMA 1987;257:1618-1620)

ACCORDING to the Federal Emergency Management Agency,¹ the incidence of fires and of fire death rates per capita in the United States is among the highest in the industrialized world. The United States is second only to Canada in number of deaths caused by fire from 1965 to 1985.² Fire is responsible for the third largest number of accidental deaths and injuries; it causes 20 times more deaths per year than hurricanes, tornadoes, floods, and earthquakes together.³ From 1977 to 1983, civilian deaths averaged almost 7000 per year. This figure is comparable to the midair

crashes of two 747 jets each month.⁴

In 522 000 reported fires in 1981 involving one- and two-family residences, more than 4000 persons were killed and 34 000 were injured, including 20 000 firemen. There was over \$1.5 billion in property loss and nearly \$0.5 billion of indirect expenses for temporary shelter, absence from work, and legal, medical, and funeral services.⁵ Residential fires—most of which are caused by smoking, heating, cooking, and suspected arson—comprise only 25% of fires annually in the United States, but they are responsible for 76% of the deaths, 64% of the injuries, and 43% of the property loss.⁶

Statistics in 1983 for all types of fires were generally worse than in 1982; the numbers of fires, deaths, and injuries increased slightly more than 4%. The major causes of residential fires (heating and cooking) and the percentages of fire-related deaths, injuries, and dollar loss show little change from 1982 to 1983. Careless smoking caused the most fatalities (23.1% in 1983); these incidents usually occurred at night, and the smoker often had been drinking. Cook-

ing was blamed for the largest proportion of fire injuries (15.6%), while arson accounted for the largest economic loss.⁶

In 1984, property loss from fire totaled \$6.7 billion, an increase of 1.7% over 1983; this is an average loss of \$6947 per structure. The incidence of arson in 1984, on the other hand, decreased by 9.4%—to 110 500 structure fires—with a dramatic reduction (45%) in deaths associated with such fires (National Fire Protection Association, written communication, Aug 19, 1985).

Smoke and carbon monoxide (CO), rather than heat or flame, are generally responsible for fire-related deaths. Based on data obtained in Maryland from 1972 to 1977, CO alone caused 48% of the fatalities; CO combined with other factors (eg, the presence of hydrogen cyanide or heart disease) accounted for another 16%. Burns and heat were responsible for the remaining 36% (18% each).²

From the Council on Scientific Affairs, American Medical Association, Chicago.

Report G of the Council on Scientific Affairs, adopted by the House of Delegates of the American Medical Association at the 1986 Annual Meeting, in response to Resolution 2 at the 1985 Annual Meeting.

This report is not intended to be construed or to serve as a standard of medical care. Standards of medical care are determined on the basis of all of the facts and circumstances involved in an individual case and are subject to change as scientific knowledge and technology advance and patterns of practice evolve. This report reflects the views of the scientific literature as of June 1986.

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REPRODUCED AT GOVERNMENT EXPENSE

Residential fire risk in 1983 was shown to be greatest for individuals aged 0 to 9 years and 65 years and older. These are persons who may have to rely on others for mobility or direction in an emergency.⁶

The US Fire Administration has stated that "the US fire death rate is high because the number of fires is high."² Probably the best way to reduce the numbers of fires and fire-related deaths is to encourage widespread use of smoke detectors and sprinklers.²

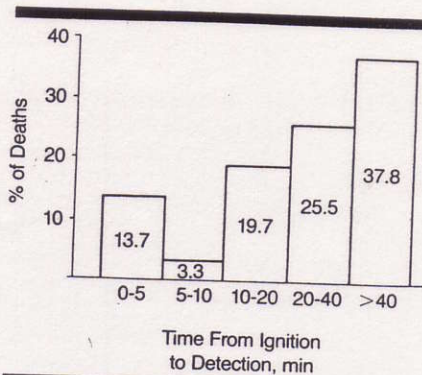
CONTROL MEASURES

Detectors

Detectors are of special benefit to sleeping persons and in fires caused by careless smoking. Undisputed evidence shows that they reduce fire death rates. Of three commonly used devices, one responds to heat, either a fixed temperature or a rate-of-rise in temperature, and the other two sense smoke or other particulate matter in the air by ionization or photoelectric means. A comparison of the two types of smoke detectors with the heat detector determined that smoke detectors provided a greater amount of escape time—at least two minutes, depending on whether the fire is flaming or smoldering, are minimal with respect to escape time and lifesaving potential.⁷

The first residential fire detectors, or heat detectors, were introduced in 1921. It was not until 1970 that the first battery-powered smoke detectors were marketed; although technologically acceptable, the devices were not affordable for the average home, based on the standards of the time.⁸ Although detectors now cost \$10 to \$50, a sizable number of families still cannot afford them and remain unprotected.¹

The chance of death in one- and two-family homes without smoke detectors is 2.5 times higher than those with detectors. For mobile homes, the comparable fatality rate is two to four times higher.⁹ Detectors do not have as dramatic an effect on injury rates in conventional homes as they do on death rates (4.5 injuries per 100 fires with detectors vs 4.8 without). The difference in injury rates is more pronounced when detectors are installed in mobile homes, being less than one third the rate when detectors were absent. However, detectors may significantly reduce the severity of injuries when the warning is early. Unfortunately, the margin of safety provided by an early warning may cause otherwise avoidable injuries to some persons when they attempt to extinguish the fire by themselves or to rescue other victims.¹



Percentage of deaths in residential one- and two-fatality fires by time from ignition to detection. Percentages were based on 873 deaths in 716 fires, and times were estimated by responding fire departments (reprinted with permission from Derry¹⁰; copyright 1979, National Fire Protection Association, Quincy, MA 02269).

The number of fatalities may be related to the long delay from ignition to detection and the subsequent arrival of the fire departments; approximately 26% of the fatalities occurred when the fires were detected 20 to 40 minutes after ignition, and almost 38% occurred when fires were detected more than 40 minutes after ignition (Figure).¹⁰ Children, the elderly, and those who cannot escape unaided appear to be a major proportion of the casualties even when they have been alerted by the alarm.²

Effective protection requires proper installation of an adequate number of detectors, with regular testing and maintenance thereafter. In one third of the instances in which the detectors did not function properly, particularly when they gave nuisance alarms, the cause was either improper location or mounting.⁸ More common is failure to test and maintain detectors. Some way should be found to emphasize the need for regular testing and maintenance and for the replacement of older detectors; periodic public messages and inspection by the local fire department could be effective measures.¹¹

Limited data indicate that smoke detectors alone could reduce the residential fire fatality rate by about 50%. If both detectors and residential sprinklers were used, the rate could be reduced as much as 73% for one- and two-family dwellings, mobile homes, and apartments. Approximately 20% to 30% of the deaths probably could not be prevented because of intimate exposure (eg, ignited clothing), shielded fire, or rapid fire development.⁹

Sprinklers

Automatic fire detectors are intended to give an early warning that allows occupants to escape or to defend them-

selves from the hazard. Automatic sprinklers, on the other hand, are meant to control or extinguish a developing fire so that occupants are better able to escape or do not need to escape.¹² Conventional water sprinkler systems have been in commercial/industrial use for more than 100 years. Accounts of their effectiveness in reducing fire losses of life and property are legion.¹

Residential sprinkler systems were not practical until 1978, when a sprinkler head that reacted five times faster than previous ones was developed. Sprinkler heads intended for residential systems are similar in principle and appearance to those used industrially since the 1800s. A fusible metal link keeps the valve closed until the heat of the fire softens the link, thereby releasing a distributed fountain of water that both wets and cools the fire area. The smaller sizes and lower ceilings of residential rooms, compared with industrial/commercial spaces, confine the hot gases and cause temperatures and carbon monoxide levels to rise faster, thereby necessitating more rapidly responding sprinklers.¹ The quick-response heads now available react in as little as 35 s.²

Once it is properly installed and maintained, the sprinkler system has a life of about 30 years and should require little upkeep, by either the homeowner or a contractor. Occasionally, one or more heads may have to be replaced due to dust, corrosion, or careless painting.⁵

There is too little experience from which to gauge the reliability of residential sprinkler systems. However, industrial/commercial systems have a noteworthy record. It is also difficult to determine just how effective the new sprinklers may be in saving lives.¹ A series of full-scale fire tests to simulate the most common types of incidents that might cause residential deaths was conducted in 1979 and 1980. It was found that an individual could survive a fire in a room with sprinklers, because the fire would be extinguished before the concentration of combustion products became lethal.¹³⁻¹⁵ No multiple loss of life due to fire or smoke has taken place in fully sprinklered buildings, and property loss is placed at one fifth of that for unsprinklered buildings.²

In 1978, a typical installation was estimated to be about 1% to 2% of the average new home price of \$100 000 or about 2% to 4% of the cost of an existing home.¹ The 1980 revision of the National Fire Protection Association's (NFPA's) sprinkler systems code for one- and two-family dwellings (NFPA 13D) potentially made the home installation even more affordable. Piping now may

be interconnected with other domestic plumbing and plastic pipe can be used in place of metal. Retrofitting of existing homes also has been made simpler and more economical by the acceptance of polybutylene pipe instead of metal.⁵

A number of communities have adopted building ordinances making the installation of sprinklers in new homes compulsory. Building code "trade-offs" often are used as an incentive.¹⁶ High-rise buildings, defined by NFPA 101-1985 (Life Safety Code, pp 113, 151) as a building with six or more stories or with occupiable (*sic*) floors more than 23 m (75 ft) above the lowest level of fire department vehicle access, have a particular need for sprinkler systems. In several states, sprinklers must be installed in all new buildings above a certain height.²

There are still some serious obstacles that must be addressed before residential sprinkler systems become commonplace. Apart from the cost of installation, homeowners are most likely to be concerned about water damage during a fire or from accidental discharge. However, documented evidence shows that fire or smoke is far more destructive to property than the water released by the sprinklers. Also, each sprinkler head operates independently, and only those in the immediate fire area are apt to go off. Unscheduled leakage is expected to be no more frequent than from any other plumbing fixtures.¹

Other deterrents include manufacturers' and installers' concerns about litigation over injuries, deaths, or property damage when a system malfunc-

tions or does not provide adequate protection and spurious claims of water damage.¹

A reduction in insurance premiums, changes in building codes to allow less expensive construction practice and/or increased building density, favorable financing, and various tax credits and tax exemptions will help to persuade the homeowner to install a sprinkler system.⁵ Without such incentives, sprinkler systems cost more than 20 times as much as detectors to purchase, install, and maintain.⁹ A form of tax rebate, similar to the Internal Revenue Service's Energy Tax Credit, also has been proposed.¹⁷

CONCLUSIONS

Fires are one of the two leading causes of accidental death in the US home.

Smoke detectors can be one of the least expensive and most effective means of providing an early warning and escape from the hazard of fire as well as a means of reducing personal injury. However, detectors offer little protection to persons with impaired mobility, such as young children, the elderly, and the handicapped. Moreover, they cannot control or extinguish a developing fire and do little to reduce property loss. These functions are better performed by automatic sprinkler systems.

With improvements in technology and certain monetary concessions, ie, reduced insurance premiums, tax credits, and more favorable financing, sprinkler systems are becoming affordable

for a larger portion of the population.

Unfortunately, many people remain unprotected because they cannot afford either detectors or sprinklers.

RECOMMENDATIONS

The Council on Scientific Affairs recommends that the American Medical Association:

1. Cooperate in public education campaigns of federal and local governments and professional fire organizations to promote fire prevention and fire safety.
2. Encourage legislation that will require smoke detectors and will encourage rapid-response automatic sprinklers in all new residential and commercial buildings.
3. Encourage legislation that will require smoke detectors and rapid-response automatic sprinklers in all existing high-rise buildings (as defined in this report).
4. Encourage federal, state, and local taxing bodies and insurance carriers to grant appropriate monetary concessions to property owners as inducements to install automatic fire detection and suppression systems in new and existing structures.
5. Encourage manufacturers of fire detection and suppression equipment to develop and market products that are increasingly effective and less costly and thus more affordable to an even greater proportion of the US population.
6. Encourage local, state, and county medical associations and medical specialty societies to cooperate with the government.

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