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THE COST OF FIRE AND WHY LIFE WAS LOST[1]

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ABSTRACT

Life and property losses from accidental fires in the United States are examined with particular emphasis on life safety. An effort is made to validate data by comparing results from different investigators and to reappraise suggested means of reducing losses. The greatest monetary loss per fire occurs with industrial buildings, so greatest emphasis on protection has been for these structures. However, the far greater number of residential fires, even with lower unit costs per fire, results in total fire costs for residences being greater. In addition, most fatalities are from residential fires. It is concluded that there is need for improved fire investigation and fact analysis; reliable fire detectors and alarms; education for designers and the public; and research to define areas and circumstances in which combustibles may be safely used.

Keywords: Fire prevention, fire losses, fire safety, National Fire Protection Association, costs.

INTRODUCTION

The full extent of losses caused by accidental fires in the United States or elsewhere will probably never be known. Too many intangibles are involved to permit an accurate assessment of fire damage, including the cost of down time and lost customers, the value of human lives permanently lost or disabled, and the cost of extensive medical care. Estimates of these values, plus known property losses, are sufficient, however, to support the activities of many individuals and organizations and to have convinced Congress that a national policy and program on fire safety is required.

In its 1973 report to the President, the National Commission on Fire Prevention and Control suggested that fire losses could be reduced by 5% a year with a 50% reduction attainable in 14 years (NAT. Com. Fire. Prev. Cont. 1973). Realization of that objective would mean direct annual savings of close to $1¾ billion in property values, 6,000 lives, and nearly 60,000 injuries. Most fire protection engineers would agree that even greater savings could result from safe building design, construction, and maintenance if individuals applied known principles of fire safety in their daily lives. This paper will examine available information concerning fire losses, the more significant causative factors, and the implementation of more effective fire prevention efforts.

SOURCES OF INFORMATION

The information presented herein is based largely on data published by the National Fire Protection Association in the Fire Protection Handbook (1976) and the bimonthly Fire Journal, and annual reports of the Oregon Office of the State Fire Marshall (1971–1975). Oregon was the only state where comprehensive statistical information on fires was available to the author. Reference is made also to an analysis of one- and two-family dwelling fires in Los Angeles and Seattle conducted in 1968 by the Southwest Research Institute (Sw. R. I.) (Pryor and Yuill 1969).

Locating background material on fire prevention can be a frustrating experience. First, there is a lack of data based on sound investigation of fires. Most fire departments are reluctant to train and assign personnel for such work when they frequently are short-handed for fire fighting. Coordinated efforts on the part of the National

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TABLE 1. *Average annual U.S. fire losses for 1971 through 1975*

Type fire	Av. No./Yr.	Av. Loss/Yr.
Buildings	1,133,420	$2,783,250,000
Transportation	589,260	372,152,000
Forest, crops	144,060	176,680,000
Grass, rubbish	986,680	21,000,000
Total	2,853,420	$3,353,082,000

TABLE 2. *U.S. monetary losses per fire by occupancy based on 1971–1975 estimates*

Occupancy Classification	Av. No. of Fires per Year	Av. Cost per Fire
Public assembly	38,340	$ 4200
Educational	27,360	3945
Institutional	24,550	1217
Residential	809,480	1370
Mercantile	78,680	4955
Basic industry	6,780	12046
Manufacturing	44,220	10288
Storage	69,320	5442
Other bldgs.	34,780	1762
All buildings	1,133,420	2439

Fire Protection Association, the National Fire Prevention and Control Administration, and the Fire Research Center of the National Bureau of Standards will hopefully correct this situation (Clarke and Ottoson 1976).

Even when information is available, a common definition of terms and a common format for presentation of data are frequently lacking. So statistical comparisons are difficult, if even possible. An extreme example is found in the National Household Fire Survey conducted by the Census Bureau (Nat. Fire Prev. Cont. Admin. 1975). The information provided was based on any fire (smoke or flame) observed during the preceding year by the householder. The results are hardly comparable to similar data based on actual fire department response where a serious or potentially serious fire is in progress. In the former case, for instance, no loss figure was given in over one-half of the cases analyzed.

Because of space limitations, the National Fire Protection Association Handbook combines sleeping, dining, and kitchen areas under "function areas," while the Oregon State Fire Marshall's Office report lists each separately. Since such information is recorded on punch cards, more detailed data can be retrieved if necessary. Such differences make specific analyses difficult without access to computer facilities.

The validity of published data has occasionally been questioned. Despite problems such as those cited, some interesting and often surprisingly close correlations have been found. This study compared data from many investigators located in various areas of the U.S. and working under different circumstances. These similarities are given here in various tables where applicable.

THE NUMBER AND COST OF FIRES

The magnitude of the problem is indicate by the figures in Table 1. These data are from "Fires and Fire Losses Classified," published annually by NFPA in the Fire Journal (1972–1976). They are estimates based on data submitted by fire departments projected to the national level. This is the equivalent of more than 7,800 reported fires a day and a daily loss of nearly $10 million.

Buildings by far represent the greater part of fire losses both in the number of fires and the values represented. Within this group, the average fire loss in industrial establishments is more than double that of the next highest occupancy category —storage (Table 2). It is significant to note that the residential category is next to the lowest in average unit value. This may explain why the residential group, having over three-fourths of the building fires and

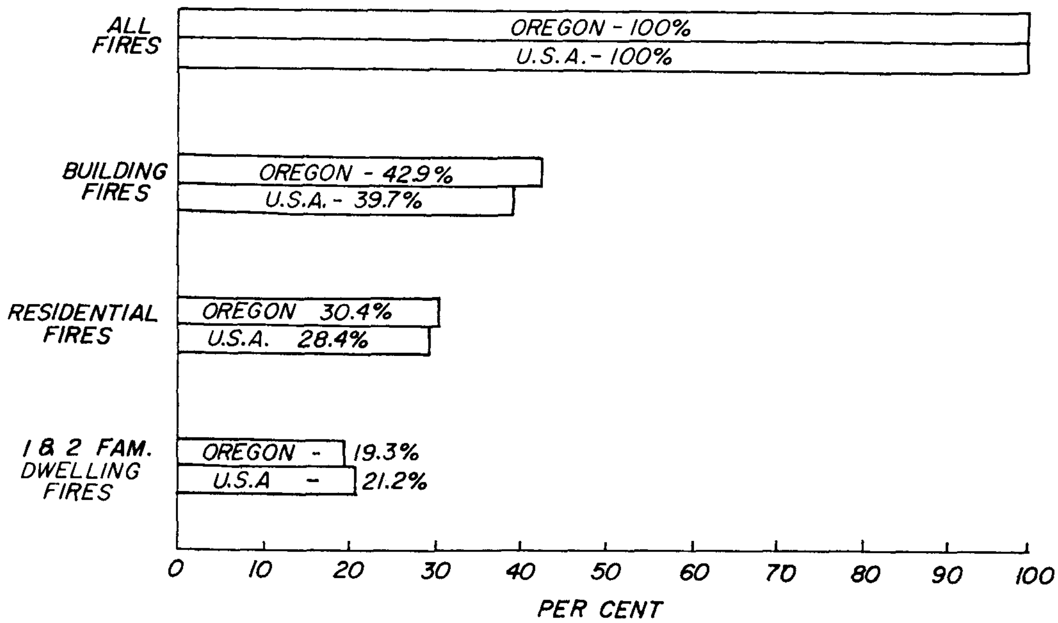

FIG. 1. U.S. and Oregon fires by occupancy for 1971 through 1975.

more than one-half of the fire fatalities, has received comparatively little attention in the overall fire protection program.

Within the residential grouping, one- and two-family dwellings predominate, as shown in Fig. 1. Here, by way of comparison, data from the state of Oregon, the only state with readily available statistical data,

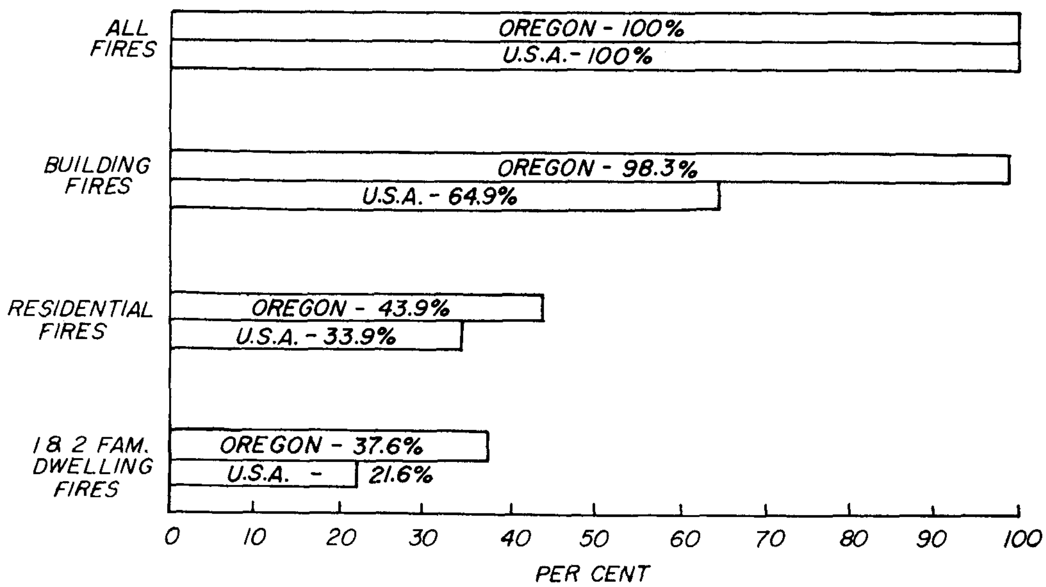

FIG. 2. Relative costs of U.S. and Oregon fires for 1971 through 1975.

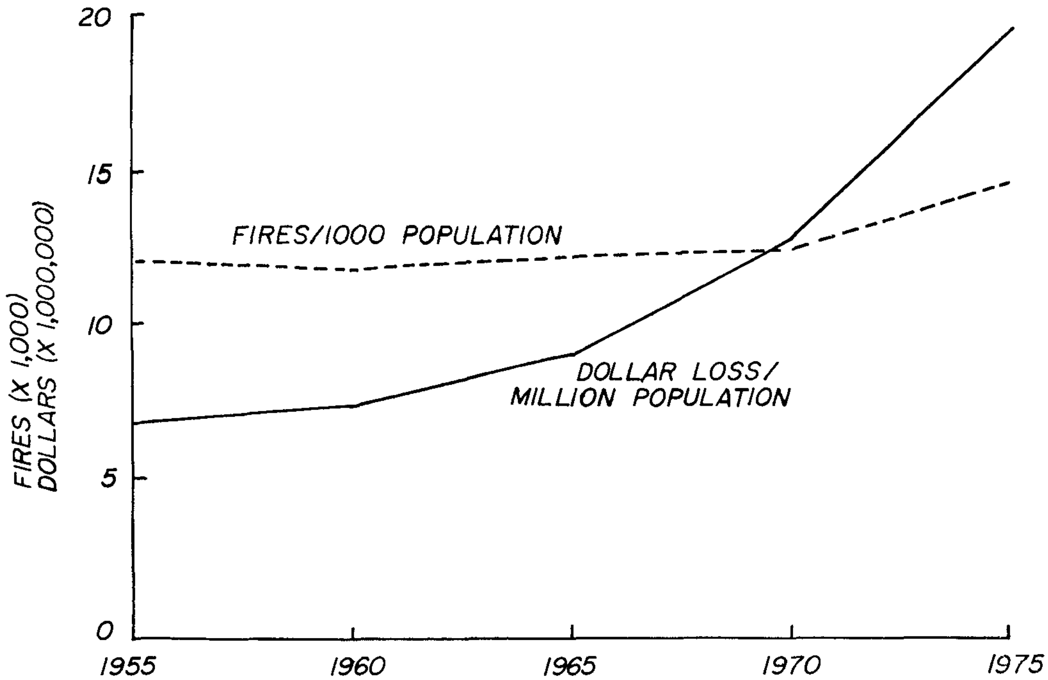

FIG. 3. Trends in numbers and annual direct costs of U.S. fires.

are also shown. Both sources cover the period 1971 through 1975. In each case, more than 70% of building fires were in residential occupancies and over 60% of residential fires were in one- and two-family dwellings.

In regard to cost, there is less agreement between the two sets of data, as shown in Fig. 2. Close to half of the monetary losses attributable to building fires were represented by residential fires with 64% of U.S. but 86% of Oregon residential fire losses in one- and two-family dwellings. The latter figure undoubtedly reflects a heavier concentration of industrial and commercial property values in other parts of the country.

There is a secondary cost factor involved in dwelling fires that should not be overlooked. Even though the number of such fires represents only about 20% of all fires and the unit loss is relatively low, the number of homes at risk is high. Thus, municipalities must provide fire protection, and this is a costly service in terms of men, equipment, and buildings.

The long-range trend in fires and losses is of interest in view of the national objective of a 50% reduction in fire losses (Fig. 3). Because of changes in dollar value, the number of fires is generally considered to be the more reliable index. The chart shows a relatively stable situation with an increase in the last 5-year period. This indicates that the number of fires is increasing at a slightly faster rate than growth in population.

FIRE CASUALTIES AND THEIR COSTS

The value of buildings damaged or destroyed through fire and indirect losses is only part of the total cost of fire. There is the annual toll of deaths and injuries, the value of which is even more difficult to assess than the dollar value of the direct and indirect property losses caused by fire. The best estimates available indicate that

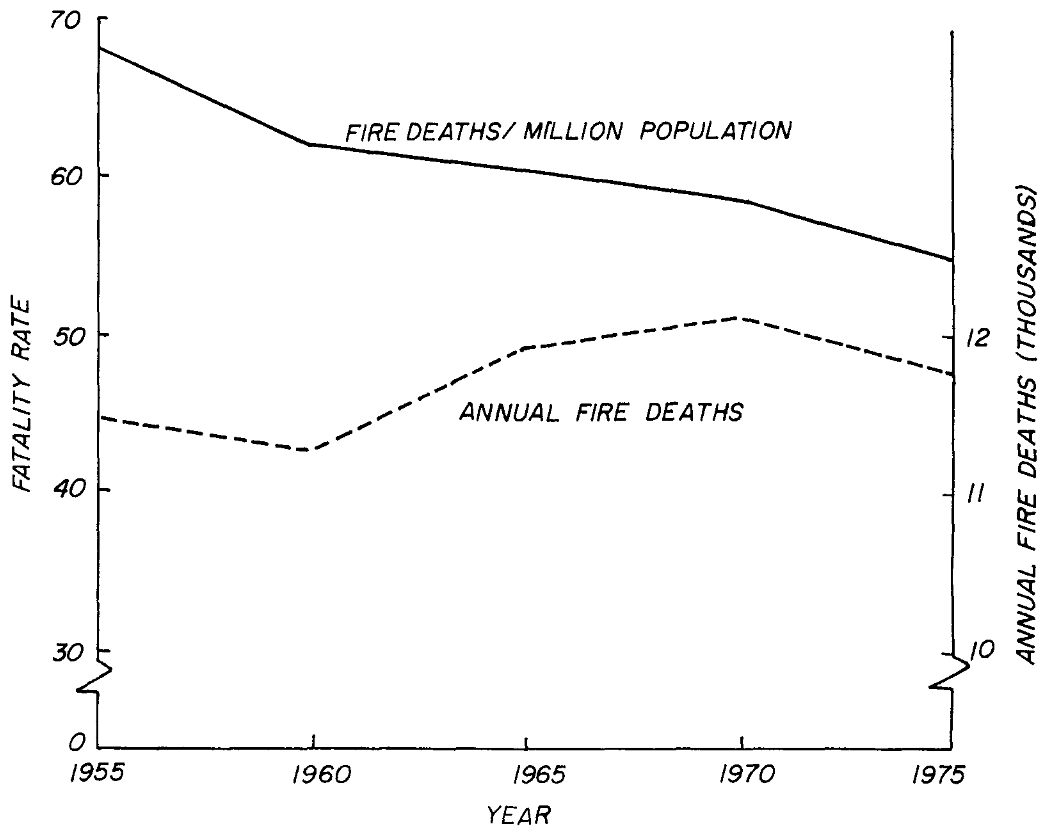

FIG. 4. Trends in numbers of U.S. fire fatalities.

some 12,000 persons die each year in or as the result of fires. Ten times that number suffer injuries sufficient to require hospitalization.

In studies on the economics of fire, the British have placed a value of 50,000 pounds—roughly $87,500—on a life lost in fire (Melinek 1972). Moreover, the National Commission on Fire Prevention and Control estimated the annual cost of burn treatment at $1 billion (1973). These figures exclude the cost of lost income while the victim is under treatment, insurance premiums and settlements, the undefinable cost of permanent scars, and the lingering, traumatic effects of the fire itself.

The estimated number of annual fire deaths has not varied greatly in the last 20 years, but the population of the United States has increased each year. Thus, the fire fatality rate has steadily declined as illustrated in Fig. 4. Although this represents some progress in this direction, the frustration facing those concerned with life safety in fires lies in the knowledge that most fire casualties, and in fact most fires could be avoided if known safety precautions were followed.

Injuries from fires are estimated to have averaged 118,000 a year for the last five years with a gradual increase to 131,000 in 1975 (Fig. 5). Fire injuries have more than kept pace with population growth, resulting in a widening gap between the number of injuries and the injury rate. One explanation for the difference between injury and fatality experience may be that excellent progress has been made in the treatment of

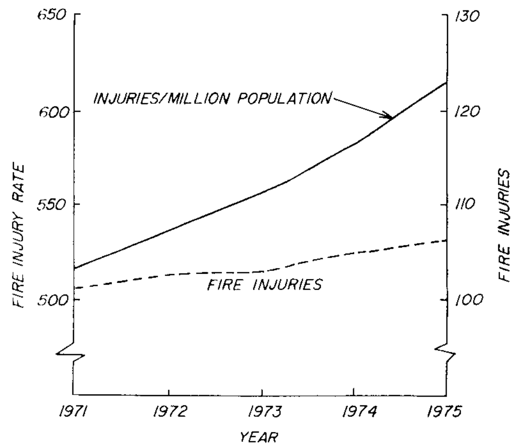

FIG. 5. Current trends in numbers of fire injuries.

fire casualties resulting in greatly improved chances for recovery.

Any consideration of fire casualties should note the hazards faced by fire fighters. NFPA reports that approximately one-half of the estimated annual fire injuries are suffered by firemen (1976), and the mortality rate of 90 deaths per 100,000 workers is reported to be the highest of any industrial group (Inter. Assn. Fire Fighters 1976).

FIRE FATALITIES—WHERE, WHEN, AND HOW

Millions of dollars and man-hours have been spent on the problem of the high-rise building fire. Actually, relatively few lives have been lost in such fires, probably not as many in a year as are lost in a week in small home fires. However, because of the large number of people living in high rises, the potential for extensive life loss is considered great. Figure 6 shows the proportion of structural fires involving fatalities to the total number of fatal fires, and the proportion of fatal structural fires attributed to residential occupancies and one- and two-family dwellings. These data are based on actual fire death reports submitted to the National Fire Protection Association over a 35-year period and published in the thirteenth edition of the Fire Protection Handbook (1969). Further analysis of these data reveals that 78.9% of all fatal residential fires and 76.2% of residential fire deaths were in one- and two-family dwellings.

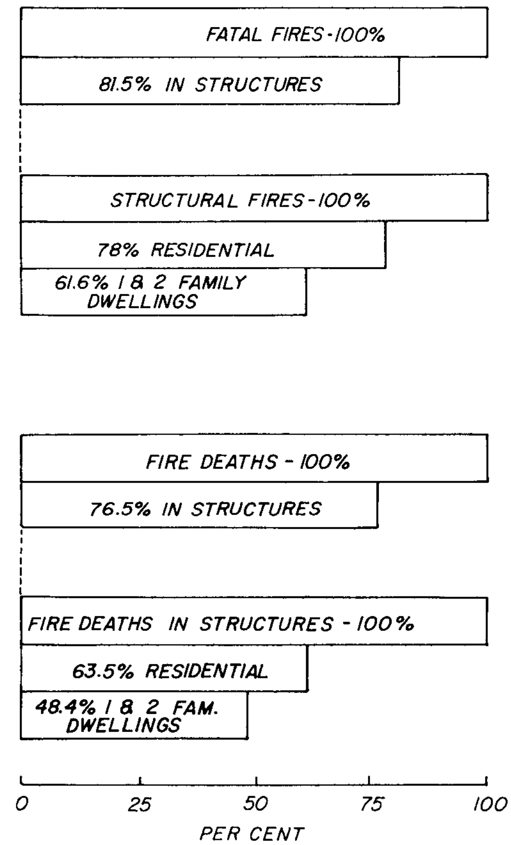

FIG. 6. Where most fatal fires occur (over a 35-year period).

A further check on the above data is found in the 1976 edition of the NFPA Handbook with comparative information for the last five years from Oregon (Office of the State Fire Marshall 1971–1975). Figure 7 again illustrates the heavy toll of lives in one- and two-family dwelling fires.

Many fire casualty studies have included an analysis of the time of day at which the fires and fatalities occurred. All highlight the higher incidence of fire deaths during late evening and early morning hours. The implication is that fires will not be detected as quickly and escape will be more difficult when people are asleep. Data from three studies are presented in Fig. 8.

Various studies have demonstrated no relationship between the number of fires and fire fatalities. Figure 9 shows the

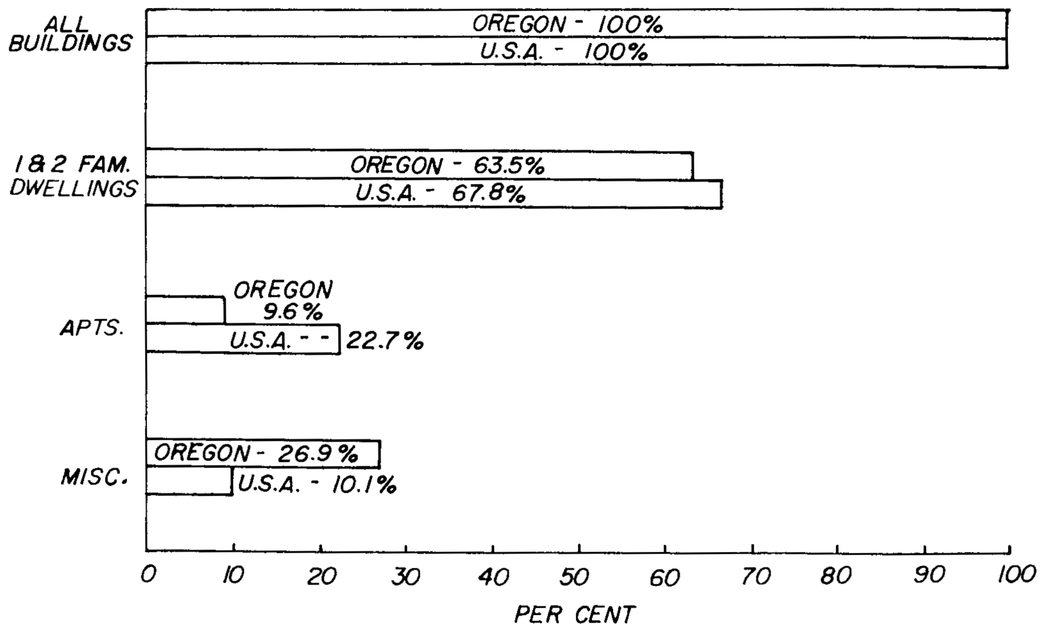

FIG. 7. U.S. and Oregon fatalities by type of occupancy for 1971 through 1975.

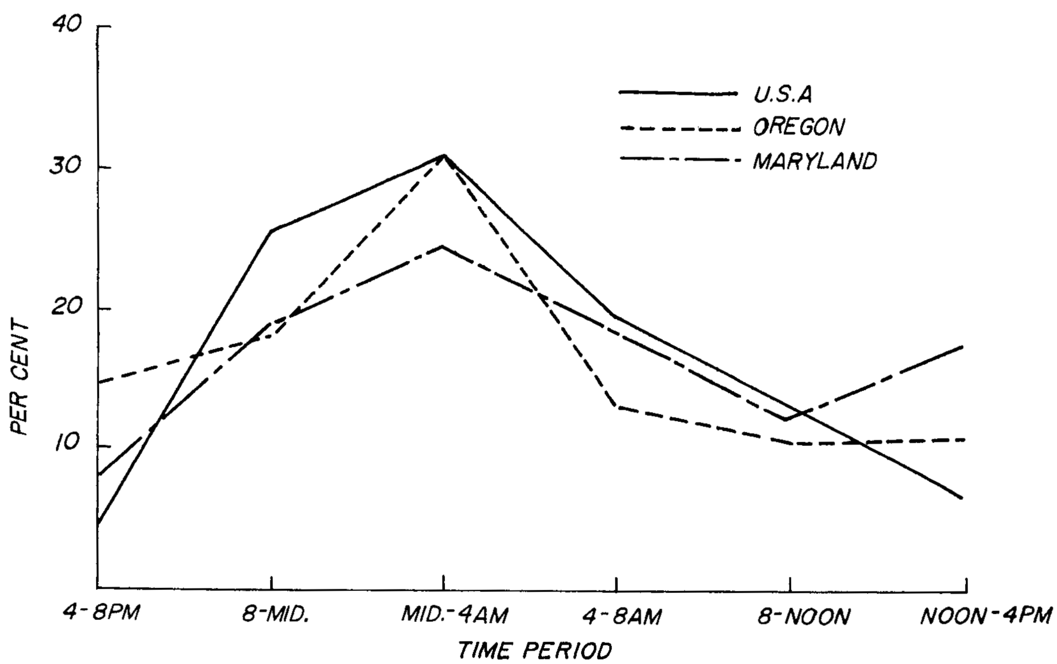

FIG. 8. When fatal fires occur during the day.

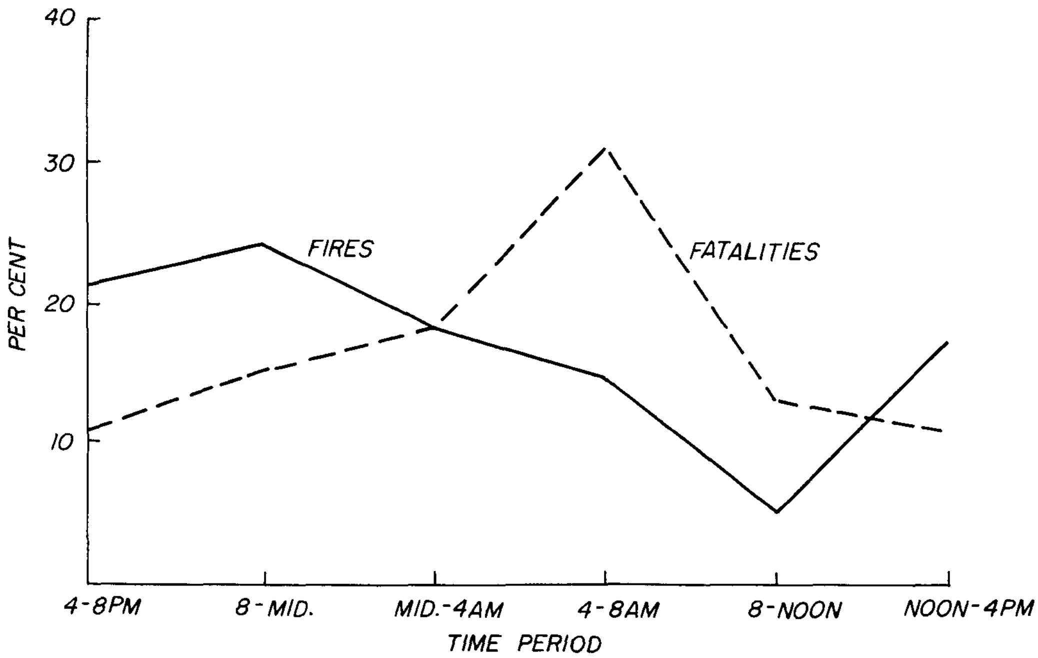

FIG. 9. Fatal vs. structural fires by time period (Oregon, 1971 through 1975).

period of day in which most building fires and fire deaths occur based on five years' experience in Oregon. Building fires peak in the noon to 4 a.m. period while fire deaths are highest in the midnight to 8 a.m. period.

Age, of course, is a factor in any analysis of fire fatalities. The very young (0 to 5 years of age) and the "over 65" group show the highest incidence of fire deaths when age groups are considered in five-year increments from birth to 65 or 70 and over. If, however, ages are divided into three general groups: those under 20, 20 to 65-year-olds, and those over 65, the middle-aged group, those best able to care for themselves, presumably are the most vulnerable (Fig. 10).

The Halpin et al. study (1975), which took place in Maryland, is a significant, in-depth effort to integrate circumstances surrounding fire deaths with results of autopsies performed on the deceased. Conducted by Johns Hopkins University, such a study ultimately should provide specific guidelines to the construction and maintenance of safer buildings. (A similar study has been initiated by the University of Utah for the state of Utah.)

Since most fires and fire deaths occur in the home, it is of interest to establish where and why fires start. Various investigators agree on this point. Because all seem to agree on definitions of living rooms, bedrooms, dining rooms, kitchens, and bathrooms, comparable data are available. Results of three independent investigations are presented in Table 3.

As might be expected, the highest incidence of fires occurs in those parts of the home subject to the longest periods of use. Other areas are not commonly defined and comparisons are difficult. However, these show a much lower fire incidence than those listed. In terms of fires and fire deaths, the areas listed in Table 3 show greatest promise of results for fire prevention efforts.

The broader categories listed in the 1976 NFPA Fire Protection Handbook represent a more general computer readout based on the NFPA coding system (Nat. Fire Prot. Assn. 1974b). It is hoped that this system

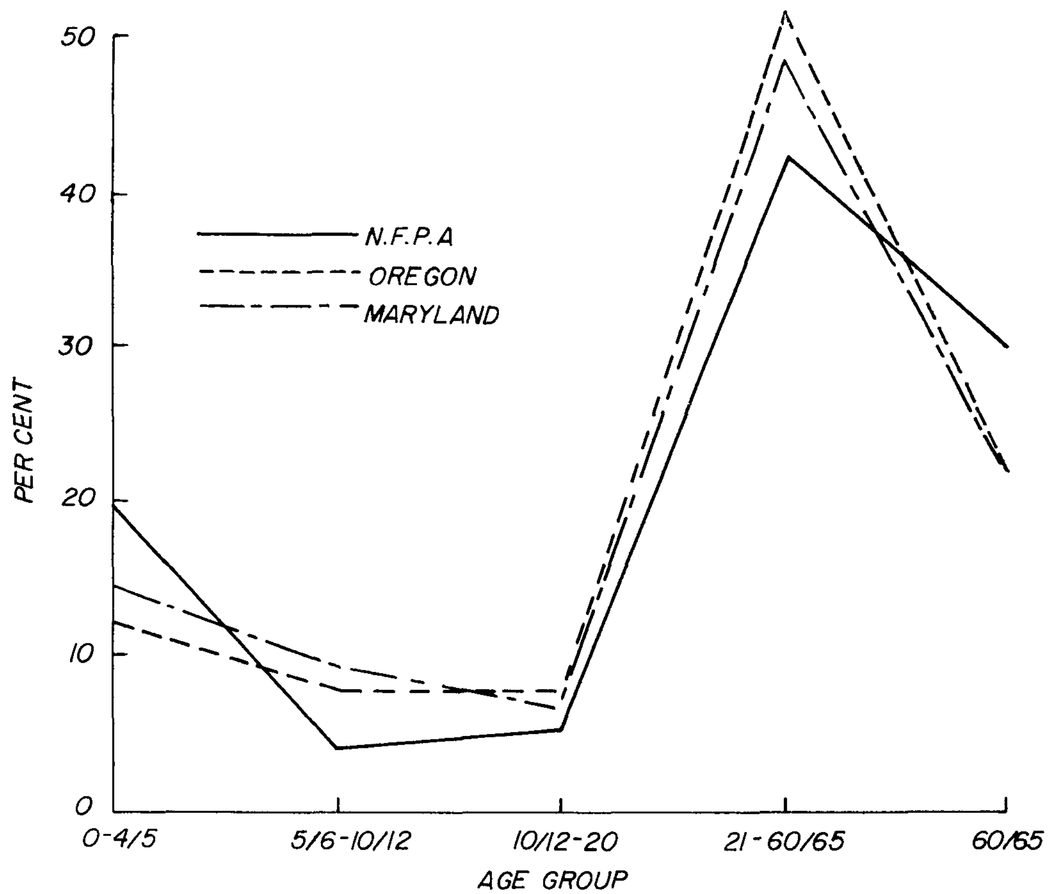

FIG. 10. Fire fatalities by age groups (data from Halpin et al. 1975).

will eventually be used throughout the country so that detailed and meaningful studies of fires can be made.

The 1969 Sw. R. I. study included a computer analysis of over 14,000 punchcard records of dwelling fires in Los Angeles and Seattle (Pryor and Yuill 1969). Information from this study listed in Table 3 can be separated as Table 4 to demonstrate differences between the two cities. This analysis was broken down even further to show fire causes in relation to living room, bedroom, and kitchen areas (Table 5).

Experience suggests that the disproportionate number of fires caused by "smoking" in the living room and bedroom should be attributed to a more basic cause—falling asleep while smoking. For example, the Maryland study (Halpin et al. 1975) found the combination of smoking and alcohol to be a significant factor in fire deaths. Recognizing the difficulty in attempting to change personal habits, official attention in many areas has been directed toward the marketing of fire-retardant mattresses, bed clothing, and furniture.

Until recently efforts to reduce fire losses have been initiated with little if any check on their effectiveness. The more sophisticated fire investigatons and fire records now being developed on a national scale should provide a measurement tool. This would make it possible to be selective in regulatory and other actions rather than to take a "shotgun" approach as has been done in the past.

TABLE 3. *Where most dwelling fires start*

Location	1976 NFPA F.P. Handbook[a]	Oregon (5 years)[b]	SwRI 1969 Study[c]
Living room	26.4%	29.2%	19.1%
Kitchen[d]	36.5%	22.0%	17.6%
Bedroom[d]	36.5%	14.2%	24.4%
Total	62.9%	65.4%	61.1%

[a] Nat. Fire Prot. Assn. 1976

[b] Off. State Fire Mar. 1971-1975

[c] Pryor and Yuill 1969.

[d] Note: These two items are combined under "Function Areas" in the 1976 Fire Protection Handbook.

The data presented in Table 5 are based on all fire records for dwellings during the period covered in Los Angeles and Seattle. An analysis of fatal dwelling fires for the same areas and time provides an interesting comparison with Oregon data (Table 6). Again, the similarity is noteworthy.

The standard format used in developing a national body of information on fires, NFPA 901, (Nat. Fire Prot. Assn. 1974b) includes the initial material ignited. Little information on this item has been published, but an analysis of the Oregon reports for the 1971–1975 (inclusive) period is listed in Table 7.

TABLE 4. *Where dwelling fires have started in Los Angeles and Seattle*

Location	Los Angeles percent	Seattle percent
Living room	19.1	18.9
Kitchen	17.8	16.8
Bedroom	26.1	18.9
Attach. gar.	5.3	1.8
Closets	4.2	2.7
Basement	1.1	11.7
Other	26.4	29.2
	100.0	100.0

TABLE 5. *Area of fire origin vs. cause (per cent of fires)*

Cause	Living Room percent	Bedroom percent	Kitchen percent
Smoking	54.7	52.0	8.9
Child./matches	5.0	14.5	3.0
Elect. app.	3.6	5.2	6.1
Heat./furnace	13.3	3.6	---
Elect. wiring	6.5	7.0	5.2
Incend./susp.	4.0	5.7	4.0
Cooking	---	---	57.4
Scattered	6.5	7.9	15.4

Clarke and Ottoson (1976) refer to fires of residential furnishings caused by smoking materials as being responsible for 27% of fire deaths. They found furniture to be the first item ignited in 36% of fires studied as against 6% for structural components, which approximates the Oregon figures cited in Table 7.

FIRE STARTS VS. FIRE SPREAD

While structural components such as interior finishes, siding, and roof coverings appear to have a minor involvement in fire

TABLE 6. *Causes of fatal dwelling fires*

Cause	Oregon (5 years)[a] Percent	Los Angeles/Seattle (1969 SwRI study)[b] Percent
Smoking	32.1	28.6
Stove/heater	24.8	19.2
Electric sys.	6.9	13.1
Child./matches	1.9	10.0
Incen./susp.	10.1	6.5
Other	24.2	22.6
	100.0	100.0

[a] Nat. Fire Prot. Assn. 1976

[b] Pryor and Yuill 1969.

TABLE 7. *Initial material ignited (Oregon, Off. State Fire Marshall 1971 through 1975)*

Material	Percent of total
Furnishings[a]	39.3
Chimneys	15.6
Electric systems	14.7
Flammable liquids	8.5
Cooking materials	6.9
Structural	6.2
Wall/ceil. fin. - 3.9	
Roof coverings 2.3	
Miscellaneous	9.8
	100.0

[a] Includes furniture, curtains, drapes and loose combustibles.

starts, they are a most serious factor in fire spread. Once a chair, sofa, or bed ignites, the life of anyone in that room is jeopardized. If flames, heat, smoke, or gases spread to other parts of the structure, other lives in the building are threatened. Assuming that a fire gains enough headway to ignite wall and ceiling finishes or doors, or that a door has been left open, further spread is evidently a function of the combustibles outside the room of fire origin. NFPA staff analyzed 500 building fires, including 311 one- and two-family dwelling fires. The results showed key elements in fire spread and were presented in the 1969 edition of the Fire Protection Handbook (Nat. Fire Prot. Assn. 1969). Results are summarized in Table 8.

TABLE 8. *Firespread factors in 311 dwelling fires*

Factor	Percent of total[a]
Interior finish	54.6
Open stair/door	42.5
Flammable liquids and gases	25.0
Inadequate fire stopping	22.2
Furnishings	3.2

[a] Note: These figures are not additive - two or more may be present in any one fire.

TABLE 9. *Human factors in fire deaths (311 dwellings)*

Factor	Percent of Total
Asleep	38.0
Overcome by heat or smoke	34.8
Too young to act	24.4
Intoxicated or drugged	5.8
Bedridden or handicapped	7.7

In the same study, human factors were listed for the 311 dwelling fires. Here, two or more factors may also have been present in any one fire. Results are listed in Table 9. People who were asleep or overcome might have escaped had there been sufficient warning. On the other hand, as Christian pointed out relating structural characteristics of dwellings to fire deaths, the last three groups might not have been saved by an alarm (Christian 1974).

The term "overcome" is probably misused here as is the term "smoke inhalation" as used in connection with fire deaths. Intensive studies are underway in many countries to determine why people die in fires as a precedent to developing means of reducing fire deaths. More deaths are

TABLE 10. *General causes of fire deaths*

Cause of Death	NFPA 1976 Handbook[a]	Oregon (1971-1975)[b]
Fire gases, hypoxia	62.4%	67.4%
External burns	26.0%	29.1%
Other (heart, mechanical)	11.6%	3.5%

[a] Nat. Fire Prot. Assn. 1976

[b] Off. State Fire Mar. 1971-1975

caused by noxious fire gasses and oxygen deficiency than by external skin burns. Sufficient evidence has been produced to substantiate this point as indicated in Table 10. These data support the contention that thermally activated detection and alarm systems alone do not provide an adequate level of protection.

TOWARD MORE FIRE SAFE DWELLINGS

The national objective of a 50% reduction in fire losses is not an impossible achievement, but its accomplishment will not be simple or easy. While fire fighting and rescue services are essential, long-range benefits will be realized only after much greater emphasis on preventive measures. On the basis of such meager evidence as has been presented above, it is clear that the following recommendations are essential:

1. Current efforts to establish a broad base of accurate, uniform fire investigation and reporting are needed to implement effective and efficient programs.
2. With an adequate statistical background, the value of specific programs can be measured, thus avoiding the "shotgun" approach to fire safety.
3. Accelerated studies of fire-safe dwelling design are needed to reduce obstacles to escape in case of fire and to seek ways in which essential combustible materials can be used safely in construction and furnishings.
4. Home fire detection and early warning systems are obviously needed. Research is also needed to develop reliability in the types of equipment sold, since regulations in many areas have required their installation.
5. A more effective approach to reducing the vulnerability of furnishings to fire is needed. Public education is an essential element, while the development of fire-retardant textiles and furniture is another. However, both approaches are necessary.

The knowledge of how to make homes reasonably safe exists today, but how to impart this knowledge to the general public or how to develop the public's interest in personal fire safety has to be answered to achieve the established objective.

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