Study on Potential Alternative Approach to Fire Death Reduction

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ABSTRACT

The reduction of residential fire deaths is attained not only by popularization of fire protection measures such as smoke detectors and residential sprinklers, but also by many other efforts such as improvement of fire safety of appliances and furniture used in homes, popularization of fire-resistive houses, and fire safety education of the public. This paper explores a potential approach to fire death reduction by examining the factors that affect fire incidence and fire death rates, using statistical analysis of trends by age group, types of home structure, and causes of fires based on the database of fire incident reports and fire death reports in Japan. As a result, it was found that the popularization of safer heating appliances and fire-resistive houses and/or fireproof wooden houses provides us a good prospect for reducing fire deaths in the future as a potential alternative approach besides fire protection systems. Also, the declining trend in fire death rate of older people seen in recent years will help reduce the estimated future number of fire deaths.

KEYWORDS : Residential Fire, Fire Death, Fire Death Rate, Fire Risk Analysis

INTRODUCTION

The number of fire deaths in homes in Japan has been quite constant for the 15-year period from 1980 to 1994 (see Figure 1), while that in the U.S. has declined substantially by one-third, or 34 %, in the same period [1]. The popularization of smoke detectors in homes and the introduction of upholstered furniture and mattresses with less flammability in the U.S. market, as well as the decreasing population of smokers, are often referred to as reasons for this decrease of fire deaths in the U.S. [for example, 2,3]. In Japan, the Fire and Disaster Management Agency (formerly called as the Fire Defense Agency) has conducted many programs to reduce fire deaths, including promoting the development of residential fire protection systems and promoting fire safety education of the public. Beginning in 1990, many of these programs have been organized in a campaign called "Promotion of Fire Protection in Homes". However, there has not been so much substantial progress in terms of popularization of fire protection systems such as smoke detectors or residential sprinklers so far in Japan.

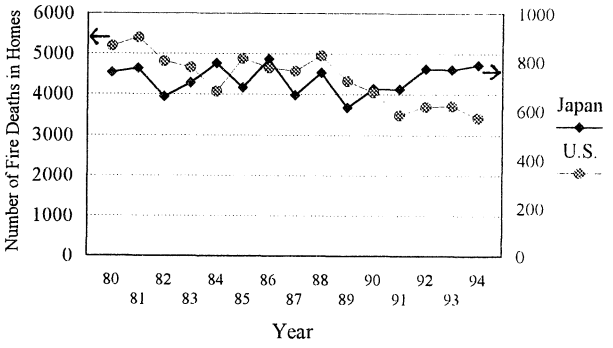

FIGURE 1. Trend in Number of Fire Deaths in Homes.
* U.S. Data is from the literature [1].
** Japan's Data : Without incendiary fires and suicides.

On the other hand, Japan is facing the problem of a rapidly aging society. In the absence of improvements in Japanese home fire protection, this increase in the size and share of the high-fire-risk aged population in the 15-year period of 1980-1994 would have meant an increase in the total number of fire deaths. However, as seen in Figure 1, there has been no increasing trend. Therefore, in this sense, the actual trend, while constant and not declining, is not discouraging or reasons for pessimism, but rather suggests that there must be some factors that have helped reduce the expected increase of fire deaths during the period. This paper explores a potential approach to fire death reduction by examining the factors that affect fire incidence and fire death rates, using statistical analysis of trends by age group, structure type of homes, and causes of fires based on the database of fire incident reports and fire death reports in Japan.

COMPARISON BETWEEN FORECAST TREND AND REAL TREND IN NUMBER OF FIRE DEATHS

Figure 2 shows the forecast trend of number of structure fire deaths and its breakdown by age group based on the average fire death rates by age group during 1983-1987 and the predicted trend of population by age group relative to the baseline year of 1985 [4]. The shares of number of fire deaths for "75 and older" and "65-74" are expected to grow steadily during the period from 1985 to 2020, while the share for "64 and younger" is instead expected to decline. Then, Figure 3 shows the comparison between the forecast trend and the real trend in number of fire deaths during the 10-year period from 1985 to 1994. As seen in this figure, the real number of fire deaths has been consistently below the forecast except in 1986 and quite constant. Here, the question is what is the reason for this gap.

Figure 4 shows the trend of population by age group and Figure 5 shows the trend of number of fire deaths by age group. From Figure 4, the proportion of population falling in the two age groups constituting the aged, "65-74" and "75 and older", is increasing steadily, while the proportion for young children "4 and younger" is decreasing for this period. However, the trend in the proportion of fire deaths for the aged, shown in Figure 5, does not reflect this increasing trend, especially after 1985. Then, Figure 6 shows the trend of fire death rate

(number of fire deaths per million population per year) by age group for the period from 1980 to 1994. The fire death rate for the age group "0-64" has been constant around 3.5, which is usually less than one-tenth of that of "75 and older". However, the higher fire death rates for the two age groups making up the aged have been declining significantly, in contrast to the "0-64" age group. The decline has been 45% for the "65-74" age group, from 21.4 in 1980 to 11.8 in 1994, and 32% for the "75 and older" age group, from 55.6 to 38.0. A similar declining trend in fire death rate is also seen in the U.S., but it appears for all age groups evenly [5].

Since fire death rates have declined only for age groups constituting the aged in Japan, this must be explained by some age-related factors. Although the exact reason is unclear at present, the author thinks that improvement in recent years of health conditions and/or living conditions of older people, as part of the progress in the social care system for these age groups, would be a possible reason for this declining trend. For example, a smaller proportion of the aged population now has physical impairments sufficient to affect their evacuation capability in case of fire.

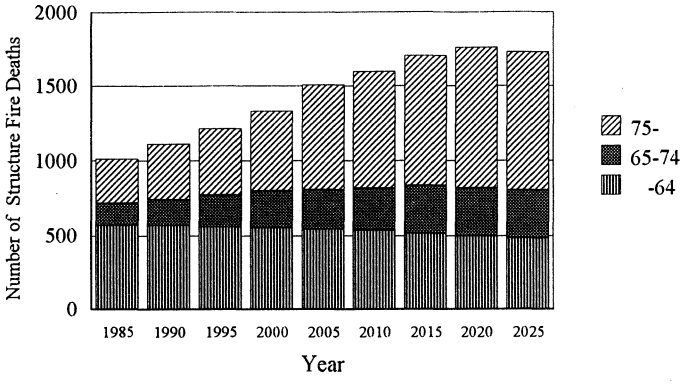

FIGURE 2. Forecast Trend in Number of Structure Fire Deaths by Age Group.
* Without incendiary fires and suicides.

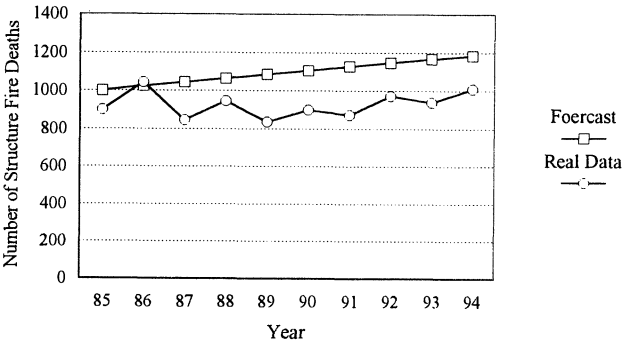

FIGURE 3. Comparison between The Forecast Value and The Real Data for Number of Structure Fire Deaths. * Without incendiary fires and suicides.

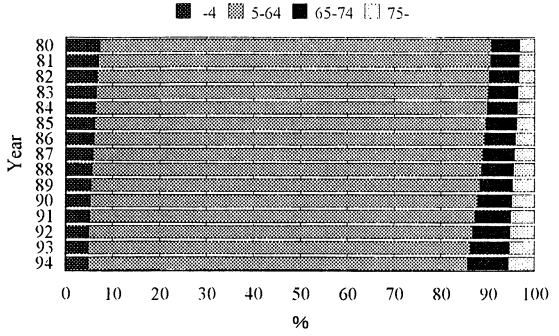

FIGURE 4. Trend in Population by Age Group.
* Source : Vital Statistics of Japan 1994, Ministry of Health and Welfare.

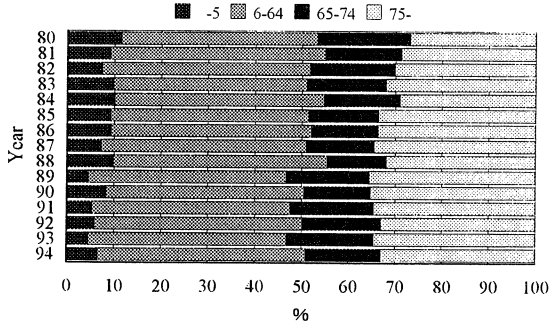

FIGURE 5. Trend in Number of Residential Fire Deaths by Age Group.
* Without incendiary fires and suicides.

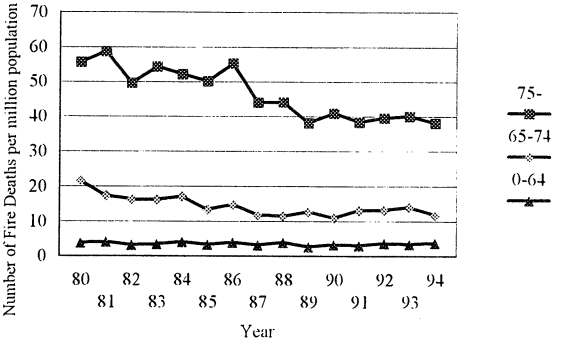

FIGURE 6. Trend in Residential Fire Death Rate by Age Group.
* Without incendiary fires and suicides.

Specifically, the trend in recorded physical condition of victims age 75 and older from 1982 to 1994 shows a declining proportion recorded as "Bedridden", while the proportion of "Normal" has slightly increased (see Figure 7). As the fire death rate of "Bedridden" is 41 times higher than the total average and the fire death rate of "Normal" aged people who are 75 and older is 8 times higher than the total average [6], the above-mentioned proportional change in Figure 7 must reflect a change in the proportion of the total aged population quantifying as "Bedridden". In addition to the above example, which shows only the data among fire fatalities, the data on physical condition of aged people who are 65 and older for the total population in Tokyo [7] also shows that the physical condition of aged people in terms of walking capability has been slightly improved for the period from 1980 to 1995, as seen in Table 1. For example, in this period, the percentages in three categories of people with reduced walking capability -- "Walk step by step", "Walk with help", and "Cannot walk", which includes "Bedridden" -- have all been declining.

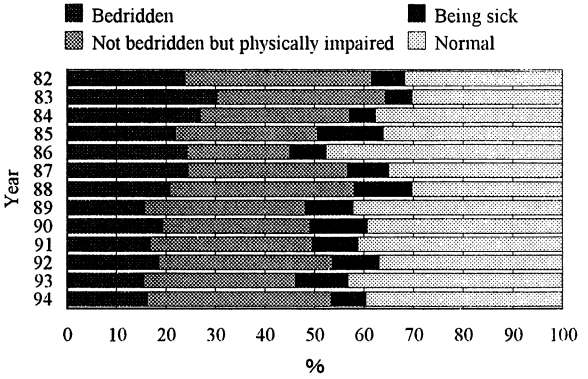

FIGURE 7. Trend in Proportion by Victims' Physical Condition Among Residential Fire Fatalities Who are 75 and older.
* Without incendiary fires and suicides.

TABLE 1. The Trend of Proportion by Walking Capability of Aged People Who are 65 and over.

	Walk normally (%)	Walk slowly (%)	Walk step by step (%)	Walk with help (%)	Cannot walk (%)	Total (%)
1980	81.8	11.7	3.0	1.9	1.5	100.0
1985	84.7	10.6	1.9	1.7	1.2	100.0
1990	85.8	10.2	1.1	1.7	1.1	100.0
1995	84.9	11.3	1.3	1.5	1.0	100.0

*Source of Data: Report on Living Condition of Aged People, Tokyo Metropolitan Government.
**Totals may not equal sums because of rounding error.

TREND IN NUMBER OF HOMES AND ASSOCIATED FIRES AND FIRE DEATHS BY STRUCTURE TYPE

The incidence of fire deaths might be expected to be associated with the home structure type, in view of the latter's clear association with potential for fire spread. Fires in ordinary wooden homes or apartments are more likely to spread beyond a room of fire origin than fires in other structure types, such as fire-resistive structures or fireproof wooden structures, due to the relatively weak performance of associated compartmentation. Table 2 shows the fire incidence in terms of number of fires per million homes, the fire death rate in terms of number of fire deaths per 1000 fires, and the fire death rate in terms of number of fire deaths per million homes, by home structure type, respectively. These fire incidence and fire death rates clearly differ by home structure type. For example, the fire incidence of "Wood/Single" homes is three times as high as that of "Fireproof Wood/Single" homes and four times higher than that of "Fire-resistive/Single" homes. (Note: Here, the term of "Single" homes stands for one- and two-family dwellings.)

A similar tendency by home structure type is seen in the fire incidence for apartments. The fire death rate in terms of number of fire deaths per 1000 fires also shows the difference along with home structure type, although the gap among the structure types is smaller than that of fire incidence. The larger gap in the fire death rate by home structure type in terms of number of fire deaths per million homes is the result of the product of fires per million homes and fire deaths per 1000 fires.

The reason why fire incidence differs by home structure type is not so clear at present, but it seems that "Wood/Single" homes are relatively older and/or in poorer condition than other home structure types, resulting in a greater chance of fire ignition and/or larger fires that are more likely to be reported to fire stations.

By the way, since ordinary wooden homes have been steadily replaced by fire-resistive homes or fireproof wooden homes in Japan, the proportion of homes by structure type has been considerably changed, even though total number of homes has increased (see Figure 8). This trend of proportional change in number of homes by structure type must affect the number of fires and fire deaths associated with fire incidence and fire death rate by structure type.

TABLE 2. Fires and Fire Deaths per Million Homes by Home Structure Type for 1990-1993.

	Fires per Million Homes	Fire Deaths per 1000 fires	Fire Deaths per Million Homes
Wood/Single	630.4	58.5	36.9
Fireproof wood/Single	210.4	40.3	8.5
Fire-resistive/Single	153.1	40.8	6.3
Wood/Apt.	673.0	60.9	41.0
Fireproof wood/Apt.	388.2	41.4	16.1
Fire-resistive/Apt.	197.3	25.1	4.9

*The data in above table is the yearly average of total fires for 1990-1993.

**Without incendiary fires and suicides.

Figure 9 shows the trend in number of fires by home structure type in the 14 year period from 1980 to 1993. (Note: The data in 1994 is excluded because the definition of structure type in a fire incident report was changed in 1994.) The total number of fires has steadily declined by 17 % from 16,878 in 1980 to 13,974 in 1993. Only fires from "Fire-resistive/ Apartments" have increased, and by a substantial 57 %, while fires from other home structure types have been mostly declining or at least constant in the period. The declining trends in total number of fires and, even more importantly, in fires involving homes with wooden structures, which have especially high rates of fire deaths per 1000 fires, would contribute to a reduction in the number of fire deaths much greater than any increase in fire deaths due to the increased number of fires in fire-resistive homes.

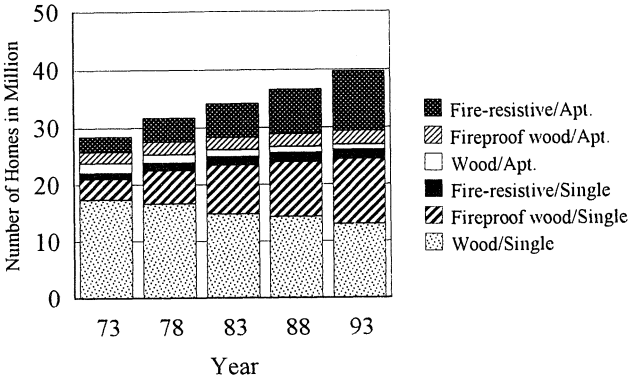

FIGURE 8. Trend in Number of Homes by Structure Type.
* Source of the data for numbers of house units: Housing of Japan, Statistics Bureau, Management and Coordination Agency.

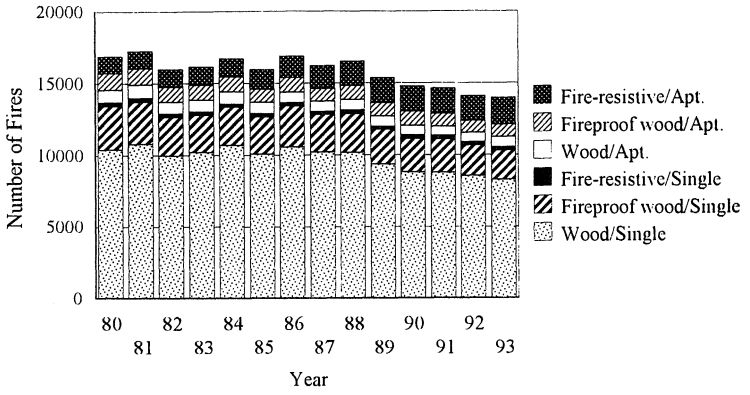

FIGURE 9. Trend in Number of Residential Fires by Home Structure Type.
* Without incendiary fires.

Figure 10 shows the trend in number of fire deaths by home structure type in the same period from 1980 to 1993. As stated earlier in this paper, the total number of fire deaths in this period has shown a constant trend, even if random variability has produced a zigzag change in death tolls from year to year. This constant trend in number of fire deaths therefore does not show the reduction in fire deaths effect from changes in the mix of home structure types and from the fire incidence by type of home structure, because these effects have been offset by the increase in the aged proportion of the population living in homes in this period. However, it is still true that the fire death toll is much lower than it would have been without the favorable effect of changes in the proportional shares of homes by structure type and in the fire incidence rate by home structure type. And since the share of homes by structure type is almost certain to continue to change in the same favorable direction, we can forecast with confidence that this will help reduce potential future fire deaths as well.

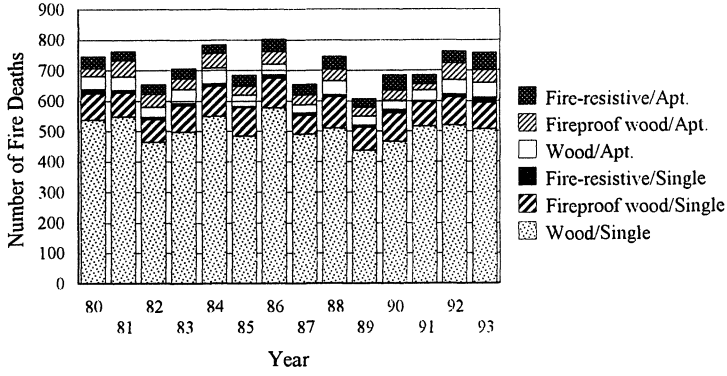

FIGURE 10. Trend in Number of Fire Deaths by Home Structure Type.
* Without incendiary fires and suicides.

TREND IN CAUSES OF FIRES AND FIRE DEATHS

Fire cause is one of the important items when we think of approaches for reducing fires and fire deaths. Figure 11 shows the trend in number of residential fires by cause in the 15 year-period from 1980 to 1994. We can see declining trends for the three causes of "Bath furnace", "Playing", and "Heating". Of these three causes, "Bath furnace" fire shows the most significant decrease, by 80 % from 2977 in 1980 to 608 in 1994, followed by the decrease in "Playing" (46%) and then by the decrease in "Heating" (26%). By contrast, the number of fires caused by "Tobacco or Matches" has been quite constant, while the fires caused by "Cooking" apparatuses show a somewhat different trend, beginning with a sharp increase during 1980 to 1988 before shifting to a declining trend from 1988 to 1994.

On the other hand, as shown in Figure 12, the trends in numbers of residential fire deaths by cause do not show so many clearly declining trends as seen in the number of fires in Figure 11 except for the cause of "Bath furnace". This lack of more decreasing trends might also be due to the offsetting effect of the increasing population share of the aged, as stated earlier.

However, the net declines in numbers of fires and fire deaths involving "Bath furnaces" and, less dramatically and steadily, "Heating" are noteworthy because they were targets of the fire deaths reduction program in Japan. This decrease was attributed to the popularization of safer appliances and the replacement of older ones by new ones. Here, the most typical example is the "Bath furnace" fire. The number of "Bath furnace" fires was so high in 1980 that they ranked a close second to the leading cause, which was "Cooking" fires. "Bath furnace" fires then declined by 80% during the 15-year period to become the lowest-ranking cause in 1994 (see Figure 11). This decrease was achieved through a regulation that required newly manufactured bathtub furnaces to be equipped with a device to prevent overheating. The decrease in "Heating" fires has similarly been achieved through the gradual popularization of safer heaters such as fan heaters and/or air conditioners, which have replaced older kerosene heaters and flame-exposed type of heaters. These equipment changes that reduced the chance of ignition must be one of the most fundamental and effective countermeasures to reduce the number of fires and fire deaths.

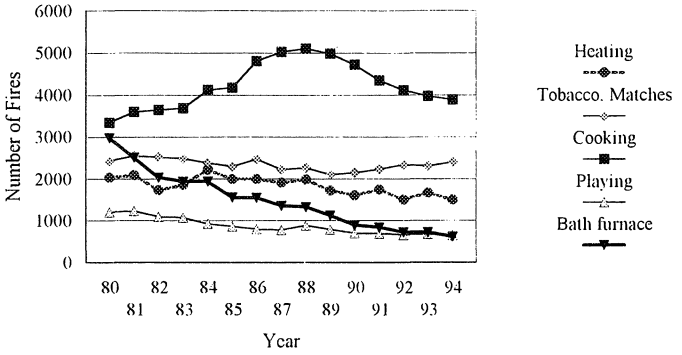

FIGURE 11. Trend in Number of Residential Fires by Cause of Fire.
* Without incendiary fires.

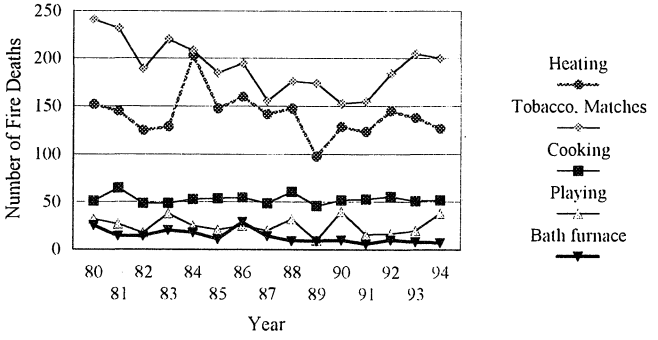

FIGURE 12. Trend in Number of Residential Fire Deaths by Cause of Fire.
* Without incendiary fires and suicides.

In terms of number of fire deaths per 1000 fires by cause, the causes of "Heating" and "Tobacco or Matches" show quite high fire death rates, averaging 82.7 and 78.2, respectively , during the period from 1990 to 1994, while the fire death rates for "Cooking" (12.6) and "Bath furnace" (10.7) are much smaller (see Table 3). From the viewpoint of effectiveness in reducing fire deaths by popularization of safer appliances related to the specific fire cause concerned, the fire death rate, defined as number of fire deaths per 1000 fires, is of course important. In this regard, the declining trend of "Bath furnace" fires may not impact so much upon the total number of fire deaths, because "Bath furnace" fires have never contributed a large share of fire deaths. On the other hand, the declining trend in the cause of "Heating" provides us a good prospect for reducing fire deaths in the future, as the number of fire deaths per 1000 fires due to "Heating" is quite high.

Figure 13 shows the breakdown of causes of residential fatal fires for each age group of victims. The share of the cause of "Heating" increases as the age of victims is higher, and the share of the cause of "Heating" is 24 %, or one-fourth, for those aged 75 and older. This fact also shows how effectively total fire deaths among the aged can be reduced by reductions in fire deaths caused by heating appliances.

TABLE 3. Number of Residential Fire Deaths per 1000 fires by Cause of Fire.

Causes	Number of fires	Number of fire deaths	Number of fire deaths per 1000 fires
Heating	1,605	136	84.7
Tobacco, Matches	2,290	179	78.2
Cooking	4,210	53	12.6
Playing	678	26	38.3
Bath furnace	749	8	10.7
Others	3,114	75	24.1
Unknown	1,808	264	146.0
Total	14,454	741	51.3

*The data is the yearly average of total fires of the 5-year period from 1990 to 1994.
**Without incendiary fires and suicides.

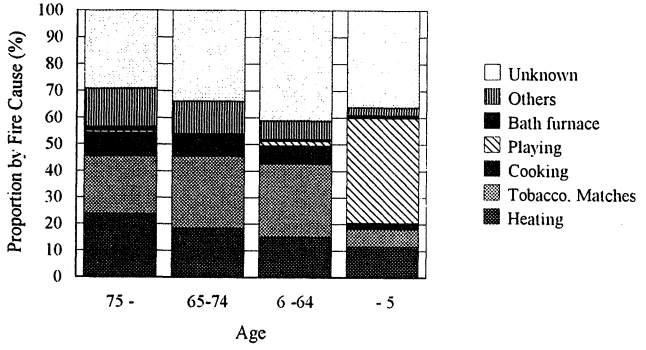

FIGURE 13. Breakdown by Cause of fire for Residential Fire Deaths by Age Group.
* Without incendiary fires and suicides.

CONCLUSION

The factors which have contributed to the fire death reduction in recent years in Japan were examined through statistical analyses on the trends in numbers of fires and fire deaths by age group, types of home structure, and causes of fires. The results are summarized as follows.

(1) The declining trend in fire causes such as "Heating" and "Bath furnace", which was attributed to the popularization of safer appliances, provides us a good prospect for reducing fire deaths in the future through a potential alternative strategy besides fire protection systems.

(2) We can forecast that the continuing trend of change in the proportional shares of homes by structure type, derived from replacing old wooden homes by fire-resistive structure or fireproof wooden structure homes, will also help reduce fire deaths in the future.

(3) As the fire death rates for "65-74" and "75 and older" have been substantially declining in recent years, this tendency will help offset the potential for increased future fire deaths due to rapid growth in the aged share of the population in Japan.

In conclusion, although the above factors are not directly associated with fire protection measures, the effectiveness of these factors in the reduction of fire deaths is noteworthy from the viewpoint of developing a potential alternative approach for preventing fire deaths, in addition to the popularization of smoke detectors and residential sprinklers in homes.

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REFERENCES

1. Karter, J., "Fire Loss in the United States in 1994", NFPA Journal, September/October pp. 93-100, 1995.
2. Conley, C.J. and Fahy, R.F., "Who Dies in Fires in the United States?", NFPA Journal, May/June pp. 99-106, 1995.
3. Hall, J. R, "The Other Way Cigarettes Kill", NFPA Journal, January/February pp. 58-62, 1998.
4. National Social Welfare Association, White Book on Aged People, 1992.
5. Hall, J. R., Patterns of Fire Casualties in Home Fires by Age and Sex, 1991-95, NFPA, January 1998.
6. Sekizawa, A., "Statistical Analysis on Fatalities Characteristics of Residential Fires", Proceedings of The Third International Symposium for Fire Safety Science, pp.475-784, July 1991.
7. Tokyo Metropolitan Government, Survey Report on Living Condition of Aged People, 1980 edition, 1985 edition, 1990 edition, 1995 edition.