

ANALYSIS OF EFFECTIVENESS OF RESIDENTIAL FIRE MEASURE BY TYPE OF HOUSES AND ATTRIBUTES OF RESIDENTS

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ABSTRACT

The total death toll due to residential fires rose to 1223 in Japan 2005, which became an increase of 185 compared with the previous year, and became the worst after 1979¹. In addition, as is the case² in the U.S.A. and the U.K., the fire death rates for the elderly population in Japan (per 100,000 population) are very high specially among the groups over 75 yrs in comparison to other age groups. There is a strong concern that there will be an increase in residential fire fatalities, and in particular an increase in the risk of residential fires involving the elderly. The authors have been studying in order to consider preferable measures to reduce the risk of the residential fire fatality in aged society through the analysis of the tendency to past residential fires by using statistical approach. This time, the authors analyzed the effect of the fire prevention measures according to the type of houses and attributes of residents.

KEYWORDS: Residential Fire, Residential fire measure, Fire statistics, Type of houses, Attributes of residents

INTRODUCTION

Every year in Japan, over 900 people lose their lives in residential fires accounting for approximately 90% of all fatalities in structure fires. In addition, as is the case 1) in the U.S.A. and the U.K., the fire death rates for the elderly population in Japan (per 100,000 population) are very high specially among the groups over 75 yrs in comparison to other age groups. Also, our country is an aged society with the elderly over 65 yrs accounting for 18% of the total population. Furthermore, with the impact of increasing life expectancy and a decreasing birth rate, our aging society is expected to progress further, with estimates that by 2015 more than one in four citizens will be aged over 65.

There is a strong concern that there will be an increase in residential fire fatalities, and in particular an increase in the risk of residential fires involving the elderly. Thus, in regard to the objective to lower the number of fire deaths, saving vulnerable people such as the elderly from residential fires is becoming a most important issue in fire prevention.

PURPOSE AND METHOD OF THE STUDY

In this study, first we quantitatively analyze how much risk the vulnerable people such as the elderly have in residential fires. On the basis of these analyses, we then examine the availability of various measures that would reduce residential fire fatalities in high-risk groups. For this purpose, two main kinds of data sources were used in the analysis. The one is the national database of fire incident reports and fire fatality reports collected by the Fire and Disaster Management Agency, the Ministry of

General Affairs. The other sources are the housing survey data 2) such as population by age group, households by number of family members, dwellings by type of structure, and so forth.

As described in the research framework in Fig. 1, to investigate into residential fires, we analyze and clarify the problems from the following three aspects.

- (1) Fire outbreak and subsequent fire development
- (2) Causes of fire fatalities
- (3) Conditions of houses and family structures where fires and/or fire fatalities occurred

As for the aspect (1), the factors featuring a fire are the ignition source, the place where the fire began, the time of outbreak, the first item ignited, and the ultimate casualties. Regarding the aspect (2), the causes of fire fatalities include the direct and indirect causes of death, the age and physical condition of the victims, deceased, the location of victims in relationship to a fire origin, and the level of consciousness at a fire e.g. “sleeping or not” and/or “drunken or not”. For the aspects (3), the condition of houses and family structures are thought to give the background of the fire outbreak and the incidence of fatalities, for example, the type of dwellings (single house or apartments), the construction type, and the age of dwellings. In light of the framework, we initially analyze the tendency of the types of dwellings where the aged people or vulnerable people are likely to live in as well as any problem areas by analyzing housing survey data. In the meantime, there is the possibility that the patterns of residential fires and fire fatalities are changed in comparison to the past due to the secular changes in number of households, aging of residents, replacement of cooking appliances and heating equipment, and renovations. Following the results of statistical analysis, by processing the data of fatal fires together with the conditions of houses and fire protection measures, we carry out an analysis of the fatal fire incidence by dwelling types, and examine the effectiveness of fire alarm system in reducing fire deaths.

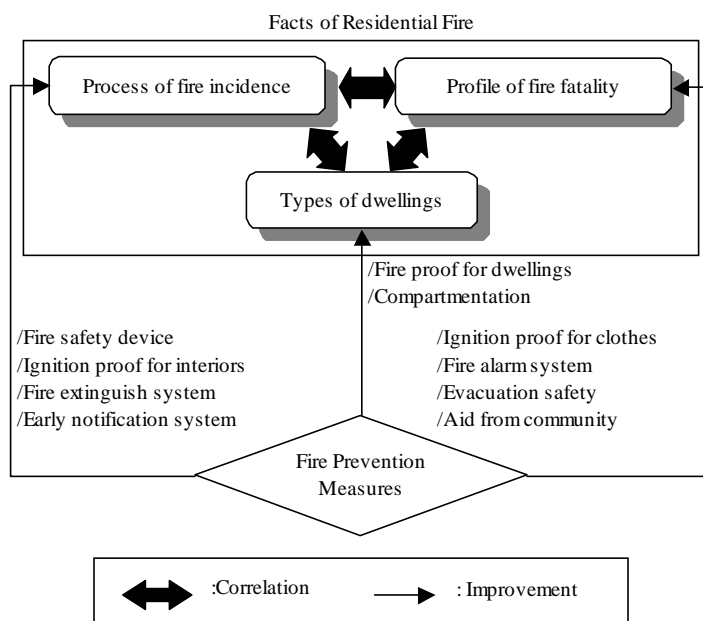


FIGURE 1. Framework of this study

RESULTS AND DISCUSSION

The Trends in Residential Fire Incidence and Fatalities

As shown in Table 1, for the average number of fires per year, fires from wooden single houses

account for approximately 70% of the total residential fires, an extremely high amount. Meanwhile, with regard to fire incidence per 10,000 dwelling units, the values of fire-resistive apartments are 1.82 as general fire incidence and 0.05 as with fatalities, stand out as being very small, less than half of those of other dwelling types.

As shown in Table 2-(1), with regard to fire fatalities, there are 650 victims in wooden single houses, accounting for approximately 77.6% of all fatalities due to residential fires. On one hand, as shown in Table 2-(2), 66.2% of residents in Japan live in wooden single houses. Looking at the fatalities rate per 100,000 people per year in Table 2-(3), the rate for wooden single houses is 0.83. Among the fire fatality rates by structure and dwelling type, the rate of wooden apartments is extremely high, at 1.54. It is approximately twice as much as the rate of wooden single houses. Looking at the breakdown of fire fatality rate according to age groups in Table 2-(3), the rate of wooden apartments is the highest in every age group. Especially, in the group of 65-74, it indicates 5.36, which is 5.8 times as much as that in fire-resistive apartments. As shown in the table, in every age group, fire fatality rates have more than a few degree of variation by structure and dwelling type.

To compare with the fire-resistive apartment, wooden apartment has quite high fire incidence and also high fatal fire incidence. There seems to be two reasons for this higher incidence of fires and fatal fires in wooden apartments. One is a higher potential of fire spread between units of dwelling because of weak fire separation. The other is that there are likely to be more single households in the wooden apartments, and so the delay in recognizing fire is easy to occur. On the other hand, the reason for the low incidence of fires and fires with fatalities in fire-resistive apartments is naturally its lower risk of fire spread. But, there is also another important reason such that fire-resistive apartments are relatively newer than wooden dwellings in Japan. This must be relating to new and safer devices for daily life used in fire-resistive apartments, such as heating equipments and cooking appliances etc. While fire incidents and fatalities happened in wooden apartments account less than 10% among the total, it is important to take into account the provisions to reduce the gap of fire incidence and fire fatality rates by structure and dwelling type.

TABLE 1. Breakdown of residential fire incidence (average of 1995-2001)

Dwelling Type	Structure	Number of Fire Incidents (Average of 1995-2001)				Number of Dwellings (10,000 units)	Fire Incidence (Per 10,000 units per year)	
		All	(%)	With Fatalities	(%)		All	With Fatalities
Single House	Wooden	10,651	(70.0)	589	(77.2)	2,493	4.27	0.24
	Fire-resistive	914	(6.0)	35	(4.6)	217	4.21	0.16
Apartment	Wooden	1,219	(8.0)	69	(9.0)	324	3.76	0.21
	Fire-resistive	2,431	(16.0)	70	(9.2)	1,336	1.82	0.05
Total		15,215	(100.0)	763	(100.0)	4,370	3.48	0.17

Note 1: Number of fire incidents is referred from the national database of fire incident reports (excluding incendiary fires).

Note 2: Number of dwellings is referred from the housing survey data in 1998).

Fires and Fire Fatalities by Major Fire Causes

Fig. 2 is a graph showing the fire incidence by major causes of fire and by dwelling type. As shown in Fig. 2-(1), with regard to all fire incidents, “Cooking appliances” is the highest among the five major causes of fire, followed by “Cigarettes, matches, lighters” (hereafter referred to as “Cigarettes etc.”) in most dwelling types excepting in wooden apartments. Meanwhile, as shown in Fig. 2-(2), with regard to the causes of fire with fatalities, fire incidence of “Cigarettes etc.” is the highest among the causes in every dwelling type. Furthermore, fire incidence of “Heating equipments” is also high in every dwelling type excluding fire-resistive apartment. Fire incidence with fatality by “Heating

equipments” in wooden single house is approximately 8 times as large as that in fire-resistive apartment and approximately 2 times as large as fire incidence with fatality by “Cigarettes etc.” in fire-resistive apartment. One of the reasons for the increasing fire incidence with fatalities by “Heating equipments” in wooden single houses might be that older-style heating equipment such as kerosene heaters are still in use due to the construction age of these dwellings.

Fire fatality rates also differ according to age group even in fires with the same cause, and it is not uncommon to see such evidence as the risk of fatality being more than five times as much in the age group over 75 as the group under 64. It is thought that because those in the age group over 75 have a lower physical ability compared with the younger groups, even if the cause of the fire is the same, it is more likely that they will not be able to take the appropriate response, thus leading to death.

It was shown in Table 2-(3) that the fire fatality rate in wooden apartments was higher than other dwelling types. It is important to consider fire safety measures suitable to actual conditions of dwelling type.

TABLE 2. Breakdown of residential fire fatalities and fire fatality rate by dwelling type and structure and by age group

(1) Breakdown of residential fire fatalities (average of 1995-2001)

Dwelling Type	Structure	Number of Fire Fatalities (Average of 1995-2001)					Total (%)
		Under 14	15-64	65-74	Over 75		
Single House	Wooden	37	218	123	272	650	(77.6)
	Fire-resistive	4	13	7	13	37	(4.4)
Apartment	Wooden	4	43	15	14	76	(9.1)
	Fire-resistive	12	38	11	14	75	(8.9)
Total		57	312	156	313	838	(100.0)

Note 1: Number of fire fatalities is referred from the national database of fire fatality reports (excluding incendiary fires and suicides).

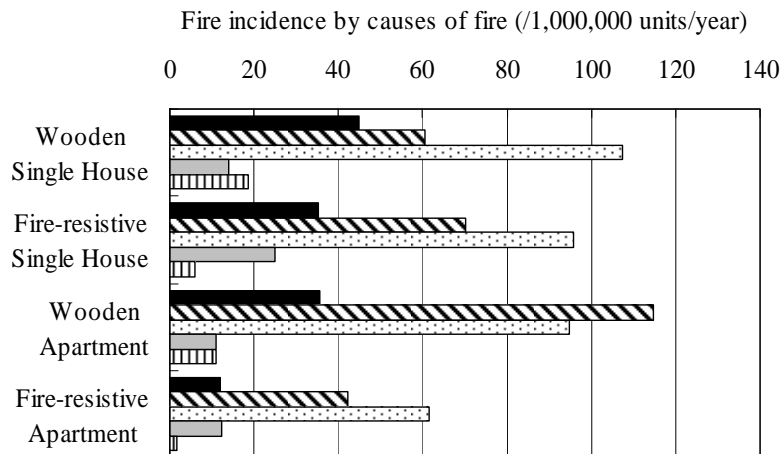
Note 2: Excluding unknown data of dwelling type and age group.

(2) Breakdown of housing survey data 9) (in 1998)

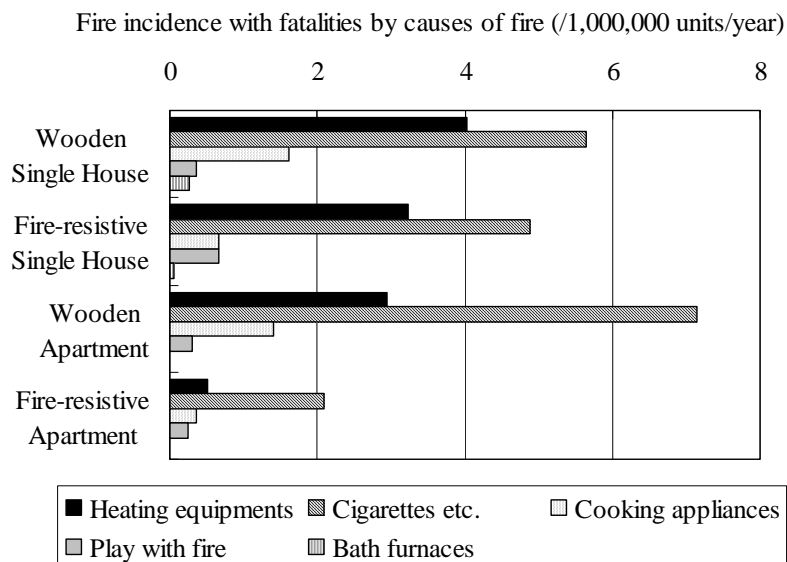
Dwelling Type	Structure	Household Memberships (100,000 people)					Total (%)
		Under 14	15-64	65-74	Over 75		
Single House	Wooden	107.8	520.4	96.6	62.8	787.6	(66.2)
	Fire-resistive	11.7	48.3	6.7	3.9	70.5	(5.9)
Apartment	Wooden	6.5	38.5	2.8	1.6	49.4	(4.1)
	Fire-resistive	55.1	210.5	11.8	5.7	283.1	(23.8)
Total		181.1	817.7	117.8	74.0	1190.6	(100.0)

(3) Breakdown of residential fire fatality rate

Dwelling Type	Structure	Fire Fatality Rate (Per 100,000 people per year)				
		Under 14	15-64	65-74	Over75	Total
Single House	Wooden	0.34	0.42	1.27	4.33	0.83
	Fire-resistive	0.34	0.27	1.04	3.33	0.52
Apartment	Wooden	0.62	1.12	5.36	8.75	1.54
	Fire-resistive	0.22	0.18	0.93	2.46	0.26
Total		0.31	0.38	1.32	4.23	0.70



(1) All fire incidents

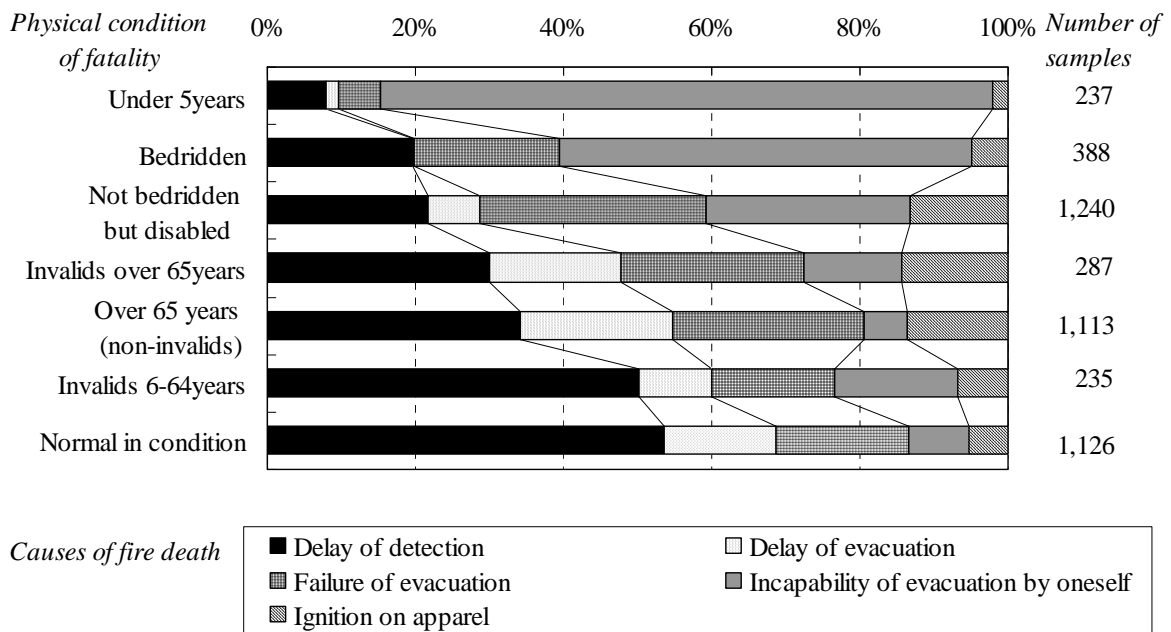


(2) Fire incidents with fatalities

FIGURE 2. Fire incidence by major causes of fire and by dwelling type (excluding others/unknown)

The Causes of Fire Death According to Physical Condition of Victims

Fig. 3 shows the breakdown by causes of fire death for different fatality groups that are divided into by



their physical conditions at a fire. In the categories of “Under 5 years” and “Bedridden”, more than 50 to 80% of total causes of fire death fall into “Incapability of evacuation by oneself”. The sum ratio of “delay of detection” and “delay of evacuation” becomes larger as the group of physical condition of fatalities is shifting from harder physical conditions such as “Under 5 years” and “Bedridden” to less hard conditions as “Normal in condition”. In the groups of “Disabled” and “Over 65 years”, the cause of “Ignition on apparel” accounts for 13 to 14% of the causes of fire death. These results demonstrate that appropriate fire protection measures should be considered according to the features of different types of high-risk groups. In Fig. 4, the half of residential fire fatalities is one person at time of ignition. The rate of “Absence of family at time of ignition” is large (about 20%) in wooden single house and the rate of “live-alone” is large (about 60%) in wooden apartment.

FIGURE 3. Causes of fire death by type of physical condition.

Data: The national database of fire fatality reports 1995-2001 in Japan (excluding incendiary fire)

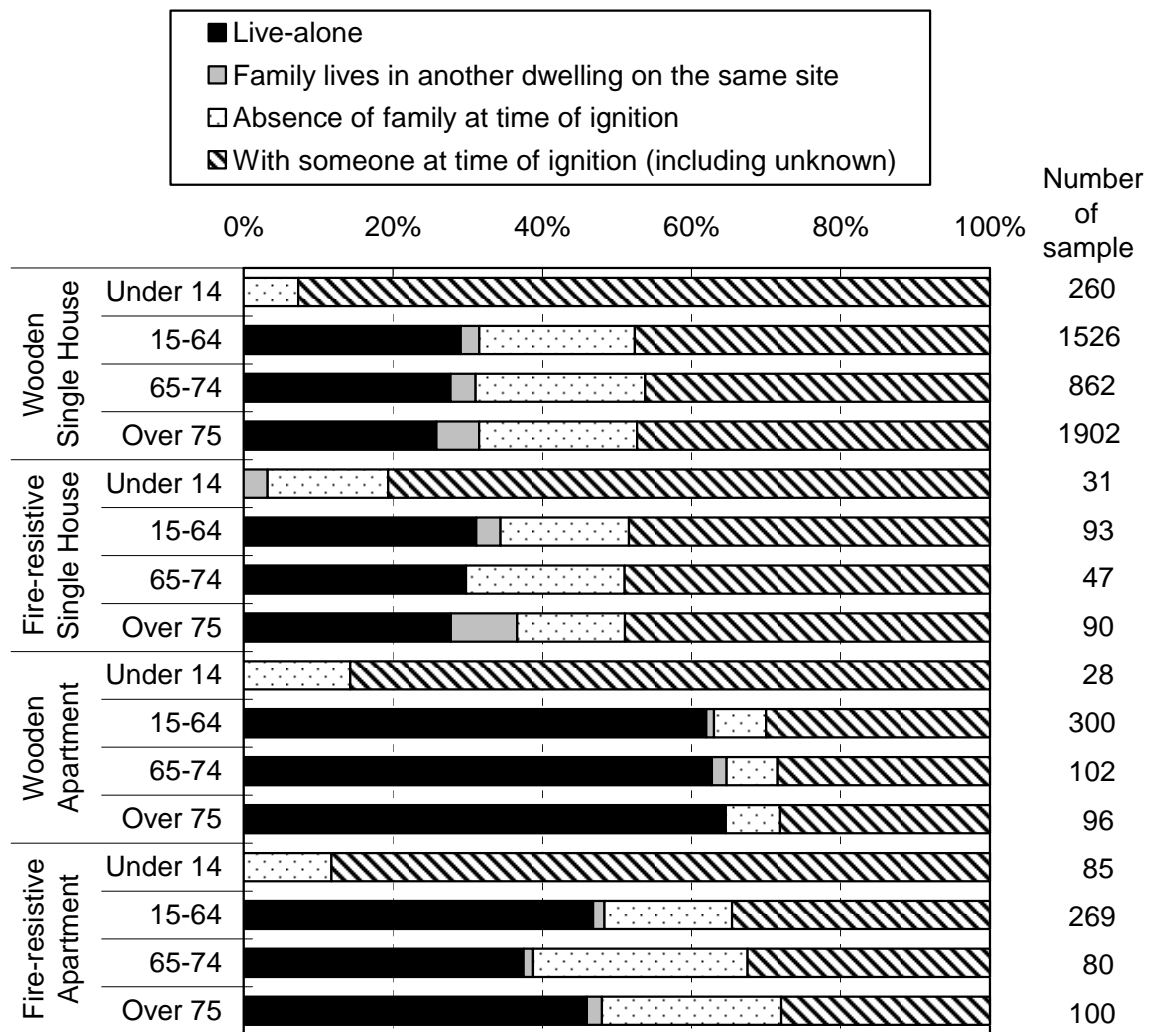


FIGURE 4. Situation of fire fatality at time of ignition by age group and dwelling type
The Effectiveness of Fire Alarm System for Reducing Residential Fire Fatalities

In this section, we investigate the popularity of fire protection equipment in homes such as the fire alarm system, based on the residential fire data from 1995-2001, and then introduce the results of the statistical analysis on the effectiveness of the fire alarm system in mitigating the risk of fire fatalities in residential occupancies. As shown in Table 3, the average diffusion rate of fire alarm system among the total dwellings in fire is 7.2% (being activated in 4.1% of the cases). The diffusion rates and activation rates of the fire alarm system in dwellings differs greatly by the type of dwelling. For example, in wooden single houses, the diffusion rate is very low at 0.7% (being activated in 0.1% of the cases), while the installation rate is comparatively high at 34.2% (being activated in 19.8% of the cases) in fire-resistive apartments, which are roughly three times higher than those in wooden apartments.

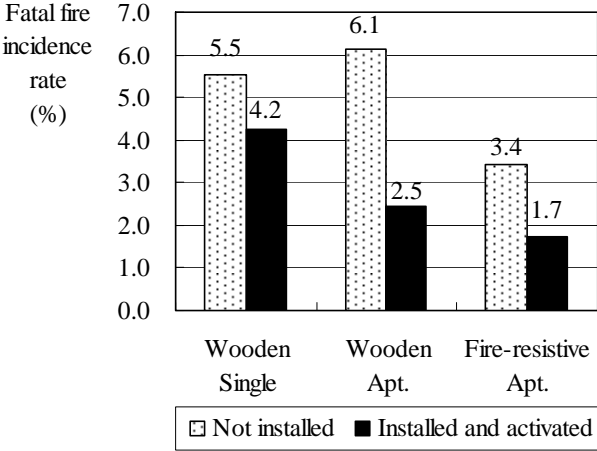
Among residential fire protection measures, fire alarm system is one of most popular equipment. Therefore, we examined the efficiency of fire alarm system on reducing the risk of fatal fire incidence by taking the factors of dwelling types and fire causes into consideration. As an example, Fig. 5 shows fatal fire incident rates by dwelling type and by conditions of installation/activation of fire alarm system and fire extinguisher at a fire. For fire-resistive apartments, in which the installation rate of fire alarms is the highest among the all dwelling types, the fatal fire incidence rate is 1.7% when fire alarm system was installed and activated at a fire, while the fatal fire incidence rate is 3.4% when fire alarm system was not installed. Thus, the reducing ratio of fatal fire incidence by fire alarm system for fire-resistive apartments can be estimated as 50% decrease to compare with the rate

of homes with no presence of fire alarms. This decrease ratio of 50% is very close to 46% that is introduced as the reducing ratio of fatal fire incidence by fire alarm system in the U.S.A.³, where the number of residential fire deaths has been declining drastically during these two decades due to the popularization of residential smoke detectors. Through the evidence of actual fire incidence data in Japan, we can also recognize the significance of promoting the universal installation of residential fire alarms for the purpose of reducing residential fire deaths as has been done in the U.S.A.

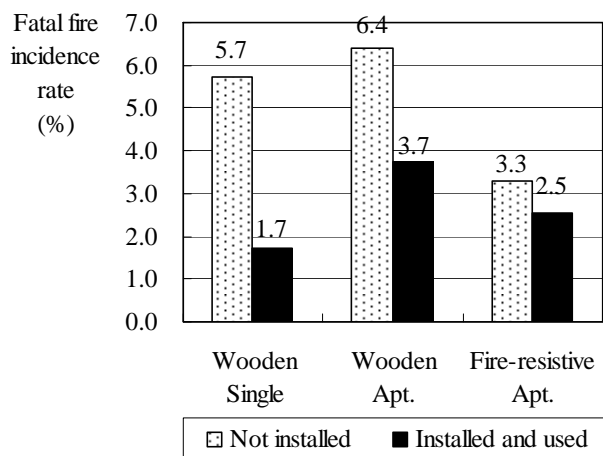
TABLE 3. Installation / activation rate of fire alarm system within homes that had fires (in %)

	Wooden Single House	Wooden Apartment	Fire-resistive Apartment	Average of all dwellings
Not installed	99.3	88.6	65.8	92.8
Installed	0.7	11.4	34.2	7.2
(Installed but not activated)	(0.6)	(3.8)	(14.4)	(3.1)
(Installed and activated)	(0.1)	(7.6)	(19.8)	(4.1)

Data: The national database of fire incident reports 1995-2001 in Japan. Total sample: 99,502(excluding incendiary fire).



(1) Fire alarm



(2) Fire extinguisher

FIGURE 5. Fatal fire incidence rate according to installation/activation of fire alarm system and fire extinguisher

Data: Average of 1995-2001 for residential fires.

Note: The term of “Single” home stands for one-and-two family dwellings, and “Apt.” stands for apartment

CONCLUSIONS

Using the fire data from 1995 to 2001 in Japan, we carried out the analyses of the risk in residential fires and fatalities in connection with factors of the type of dwellings, type of victims such as age groups and physical conditions at a fire, and the daily environmental conditions of victims that may affect the risk of fatal fires. We also examined the effectiveness of fire alarm systems as a residential fire prevention measure in mitigating fire deaths. The main results are as follows:

- 1) Fire deaths in wooden single houses account for 78% of the total fire death toll in all dwellings, and thus fire prevention measures can have the biggest impact in the wooden single houses. Since the highest proportion of fatalities in this dwelling type are made up of the elderly and physically disabled, it is necessary to investigate into fire safety measures suitable for these types of people as well.
- 2) In wooden apartments, the incidences of fires as well as fire fatalities per residence and per household are much higher than other dwelling types. Even if we look into the fire fatality rate in each age group of elderly, adults and children, these rates are higher than other dwelling types.
- 3) The influence of dwelling type is as strong as the vulnerability of occupants such as age group in Japan. It is important to consider fire safety measures suitable to the actual conditions of dwelling type in addition to consider physical condition of residents.
- 4) Fire alarm systems are highly effective in controlling fire fatality incidence caused by heating equipments and cigarettes. It is also obvious that fire alarm systems have a significant impact in terms of mitigating property loss and shortening the fire notification time (time taken to report the fire department).

We will continue our analysis and obtain a more precise data of the secular change of fire incidence and fire fatality rate, the location of victims relative to the fire origin, the relationship between the ignition sources and the materials first ignited by dwelling type and so forth.

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