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How to Reduce Fire Fatalities in Residential Occupancies on the Way to a Rapidly Aging Society?

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ABSTRACT

Everybody may be vulnerable to fires depending on the time, place, and circumstances. Fire statistics show that the occurrence of fire death depends not only on the severity of a fire itself, but also largely on the conditions of occupants such as physical functions, the environment around occupants, and the type of facility where the fire occurs. The review of fire safety from the viewpoint of vulnerable populations does not simply mean additional special attention and care only to high risk groups, but instead it means significant review of fire safety design and systems for all people from a more universal standpoint. Therefore, in order to examine the strategies of a fire death-reduction program, it is very important to set appropriate targets of research and development as well as policies for fire safety measures suitable for the relevant high-risk groups considering the type of vulnerable person, the type of fire, and the type of building in residential occupancies. Solutions will require strenuous multilateral effort and flexibility.

Keywords: Vulnerable population, aging society, fire fatalities, residential fire

INTRODUCTION

The care of vulnerable people from fires has been a concern in fire safety over the last few decades not only within fire research/engineering groups but also in collaboration with other expert groups on the environment and safety for people with disabilities[1)2)]. Progressive measures have been introduced such as "*Area of Refuge*" for mobility-impaired people as described in the BS Code of Practice for a means of escape for disabled people and/or in ADA Accessible Guidelines. Barrier-free evacuation as well as improvement in accessibility of disabled people in general buildings is becoming more important as society ages[3)]. In addition, the idea of using elevators in fire evacuation for people who have difficulty to use stairs emerged[4)] in the 1980s and led to discussion in the Symposium on Elevators and Fire in 1991[5)], and became more realistic especially after the WTC events of 2001. On the other hand, several statistical analyses[6)-11)] of actual fires show that fire deaths are most likely to occur in residential occupancies and most of those victims are disaster-vulnerable people such as the elderly accounting for a greater part of all fatalities in structure fires. In recent decades, therefore, the care to vulnerable people in residential occupancies has become an important strategic issue to reduce fire fatalities from a broader perspective[12)-16)].

The issues for care of vulnerable populations to fires are in a huge variety of ways. And, one revolutionary idea alone is not able to solve these diverse problems all at once, but instead strenuous efforts are to be required multilaterally for solving the problems. In order to reduce fire fatalities substantially, we need a comprehensive approach by the efforts linked with not only "hard science" such as fire safety engineering but also other various branch of knowledge like ergonomics, psychology, and sociology as pointed by Shileds and Prolux[2)]. In this frame of reference, the author would like to attempt to describe a perspective over the issues in reducing fire fatalities of vulnerable populations especially in residential occupancies on the way to a rapidly aging society in this paper.

SOCIAL IMPACTS ON THE CARE OF VULNERABLE POPULATIONS TO FIRE

As key factors to enhance the momentum for improving the care of vulnerable populations to fire, the author can point up the following social impacts such as a highly aging society, growing demand of barrier-free design or universal design, the WTC events of September 11th in 2001, and the diffusion of innovation to fire safety measures.

Figure 1 shows the transition of the population ratio of people aged 65 and older in Japan and other developed countries from 1950 to 2050. The graph shows the incredibly rapid increase in the ratio of people aged 65 and older in the past half-century as well as the predicated continued growth for the next 50 years, which is particularly significant in Japan where one third of the total population will be 65 and older by 2035. In a rapidly aging society, the size of the vulnerable population increases because elderly people find it more difficult to cope with the mental and physical strains caused by fire. This is particularly the case for people aged 75 and older. The increasingly large number of elderly people in society in the near future will undoubtedly lead to a rapid increase in fire fatalities, as the per capita fatality rates increase steeply with age in Japan as in other countries such as the U.K., and the U.S.[6)7)].

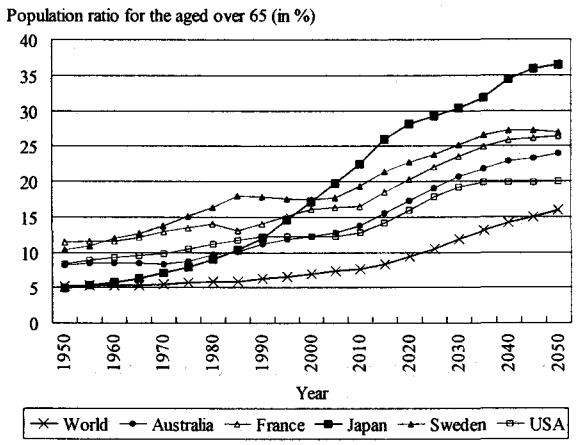

Figure 1 Transition of Population Ratio of People aged 65 and Older from 1950 to 2050[16)].

However, if we consider the rapidly aging society together with the increasing accessibility of vulnerable populations to general buildings, fire safety plans must be based on the assumptions that there may be a large number of potentially vulnerable people even in general buildings. Therefore, we should now explicitly raise the issue that truly good barrier-free designs and good accessibility cannot be realized without the assurance of egressibility. And, this raises the problem of either harmonizing accessibility and good egressibility from the viewpoint of building design and fire safety planning or resolving these two aspects independently.

Until recent days, building occupants has long been told that they should escape to the ground level or a floor of refuge by the stairs, but not by elevators in emergencies such as fires. However, in fact in a number of past fires, not a few people used elevators for their evacuation. On the other hand, the number of people with difficulty in using stairs has increased annually even in high-rise buildings such as apartments, since the proportion of elderly people in the total population has been rapidly increasing and the accessibility of disabled people has also recently improved. Therefore, the potential demand for elevator use in evacuation has been growing recently especially after the WTC events of September 11th of 2001, while evacuation using elevators in case of fire is still a

controversial issue, because the safe operation of regular elevators is not always secured during evacuation in a fire. However, the event of the WTC has apparently impacted the pertinent organizations and individuals including governments, code officials, elevator industries, building companies, designers, and experts in the safety and welfare of disabled people as well as researchers/engineers in fire safety over the use of elevators in fires. This is not simply for people who have mobility impairment but for anyone who needs to leave a building quickly in an emergency.

By the way, the renovation in technologies such as computer science, information technology, and artificial intelligence has been enormously significant in recent years. However, it does not seem that the field of fire safety engineering has not been so blessed with these technical innovations to compare with other engineering fields. Of course, as it is needless to say that the most important thing is the efficiency or cost/effectiveness of measures for fire prevention and protection, so the above indication is not a so essential problem in nature. Easiness in use, popularization, familiarity, and so forth are preferable to sophistication of equipment or technology used for fire safety. Nevertheless, as there should be much capacity in application of technical innovations to fire safety field, we need further efforts to incorporate development and outcomes of the advanced technology into fire safety engineering.

WHICH POPULATIONS ARE VULNERABLE TO FIRE?

When we refer to vulnerable populations to fire, we typically imagine wheelchair users in public buildings such as assemblies, office buildings, and so on. And, in most cases, special care is given to the specifications of design guides and/or requirements in regulations relating to the evacuation safety of public buildings accessible to vulnerable people. However, is this enough for the fire safety of vulnerable populations? The answer is obviously "NO". Although some vulnerable people may be or work in such buildings, most of them are not there, but they live in their own home everyday.

Therefore, we should imagine that there are many other cases where people fall into vulnerable populations in a fire at any rate. For example, Figure 2 shows the statistical data of fire fatalities by physical condition and by type of occupancy of fires in Japan. From this figure, we can easily understand that the majority of fire fatalities occur in residential homes and also there are a disproportionately large number of fire fatalities that fall into one of categories of vulnerable populations, if considering the real proportions of these categories in the mother population. Also, we realize there is much variety in vulnerable populations ranging from the bedridden to the people in tentatively sick or injured. From this standpoint, we should think that vulnerable populations encompass a wide variety of people with physical and mental limitations such as physically handicap, sight-impairment, hearing-impairment, mental disability, pregnancy, infancy, etc. Tentative impairment like being injured or sick and the language barrier in different countries are also to be included as one of categories of vulnerable populations in some sense. At the same time, fire safety measures and devices to help these vulnerable people naturally change according to the type of each category of vulnerable people to fires.

This thought demonstrates that everybody may be vulnerable to fires depending on the time, place, and circumstances. Also, the facts in fire statistics[7] tell us that the occurrence of fire death depends not only on the severity of a fire itself, but also largely depends on the conditions of occupants such as physical functions, environments around occupants, and the type of facility where a fire occurs. The fire safety measures from the viewpoint of vulnerable populations do not simply mean additional special attentions and the care only to these high risk groups. But, it takes on significant review of fire safety design and systems for all the people from a more universal standpoint, which is especially true in Japan where elderly people will account for one fourth of the total population in the near future.

Therefore, in order to examine the strategies of fire death-reduction programs, it is very important to set appropriate targets of research and development as well as policies of fire safety measures according to corresponding high risk groups in consideration of the type of vulnerable populations,

type of buildings and facilities where they may become involved in a fire. In addition to fire safety measures, the circumstances and living conditions of vulnerable people and/or elderly people as well as their daily care and emergency assistance in evacuation by their family members or bystanders must be improved in order to mitigate fire deaths and related fire risk. As described in further detail below, to discuss the key issues and policies for improving fire safety of vulnerable populations to fires, it is appropriate to look into the facts and issues from the following two aspects:
(1) How to reduce the risk of fires and fatalities in residential occupancies, and
(2) How to improve the barrier-free environment in general buildings for fire safety and evacuation.

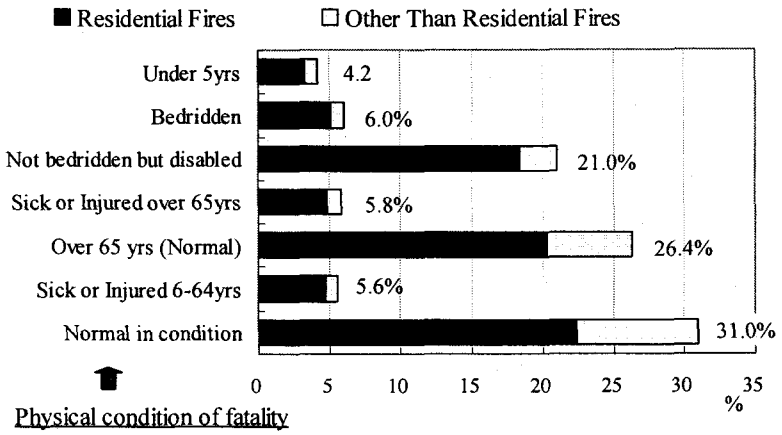

Figure 2 Physical Conditions of Fatalities at the Time of a Fire by Type of Occupancy in Japan.
*Source of Data: Fire Fatality Data of the Fire and Disaster Management Agency for 1995 - 2001.

KEY ISSUES AND POLICIES FOR IMPROVING FIRE SAFETY FOR VULNERABLE POPULATIONS IN RESIDENTIAL OCCUPANCIES

The reduction of residential fire deaths is attained not only by popularization of fire protection equipment such as smoke detectors and/or residential sprinklers, but also by many other efforts such as improvement in fire safety of appliances and furniture used in homes, popularization of fire-resistant houses, and fire safety education of the public and care personnel for vulnerable people as indicated in Figure 3. The author believes that mitigating the incidence of fire ignitions is an effective and fundamental approach to reduce future fire deaths besides fire protection equipment such as residential smoke detectors. Therefore, when considering appropriate measures to reduce potential fire fatalities in the future, the integrated efforts are inevitably necessary not only to improve direct fire safety measures like fire protection equipment, but also to upgrade other overall safety matters such as creating the proper housing environment in terms of fire-resistant homes, safer fire appliances and living conditions, and the establishment of cooperative systems involving neighbours and other people living nearby the elderly.

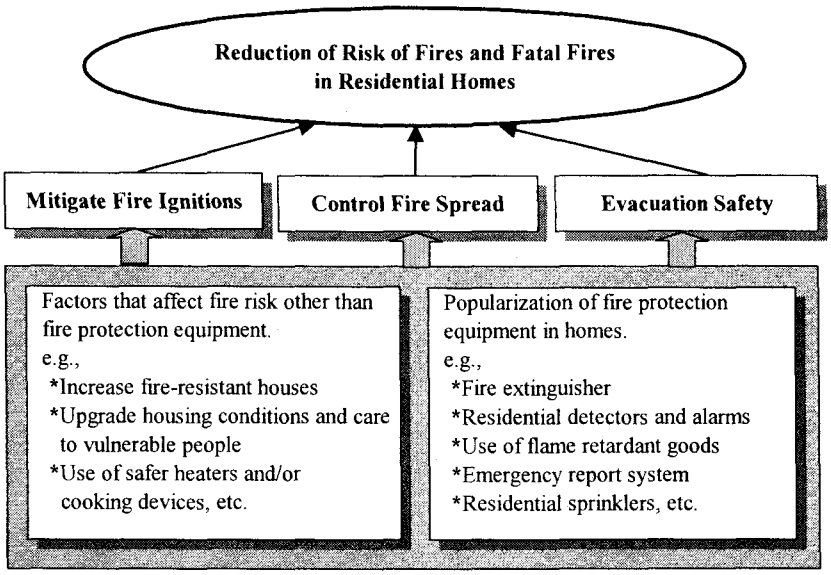

Figure 3 Approaches for Reducing Risk of Residential Fires and Fatal Fires.

Who are the Victims of Residential Fires and Why?

The authors analysed of the trends and features of the incidence of fires and fatal fires[16], using the database of "Fire Fatality Reports" collected by the Fire and Disaster Management, which give details of many items of a fire itself and also physical conditions and situations of victims at a fire in order to clarify the risk of fatal fires in relation to various factors. The conditions of victims at a fire recorded in a fire fatality report include such items as "age", "sick or not", "bedridden or not", "disabled or not", referring to physical ability, "awake or asleep", "drunk or sober" referring to ability making decisions, "alone or not at the breakout of fire", "living alone or not" referring to the care condition of victims.

In Figure 4, we classified the types of fatalities into seven categories of physical conditions by combining the above items according to their reaction capability to a fire in order to identify effective fire protection measures corresponding to each type of fire fatality. The proportion of estimated reasons of fire death for each type of physical condition of victims based on the data in fire fatality reports is shown in this figure, which gives us a very informative picture on how they were involved in fires that resulted in death. The victims, who were bedridden, disabled physically, and aged under 5 were likely to be killed in residential fires mostly due to incapability and/or failure of evacuation that are much related to their less capability of evacuation. For victims who were disabled physically but not bedridden and aged over 65, a relatively large proportion also appears in the reasons of ignition on wearing apparel and/or delay of evacuation. By contrast, for the victims who are normal in physical condition and simply sick or injured of 6-64 yrs old, the share in the reasons mentioned above are relatively small, but the share in delay of detection instead is a major reason and higher than other types of fatalities. In addition, it should be paid attention that the majority of fire death cause for younger children, aged under 5 is the incapability of self-evacuation when they were unattended by parents or other family members at a fire caused by playing with fire. Figure 5 shows the breakdown of fire causes of fatal residential fires for each age group of victims. The share of the cause of "Heaters" increases as the age of victims is higher, and the share of the cause of "Heaters" is 20%, or one-fifth, for those aged 75 and older. This fact also demonstrates how effectively total fire deaths among elderly people can be reduced by mitigating fires caused by heating appliances.

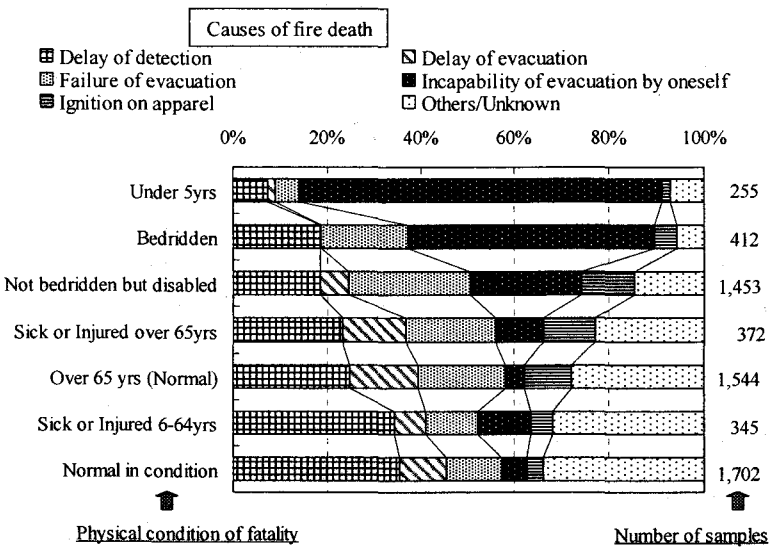

Figure 4 Causes of Fire Death by Type of Physical Condition in Residential Fires.
*Source of Data: Fire Fatality Data of the Fire and Disaster Management Agency for 1995 - 2001.

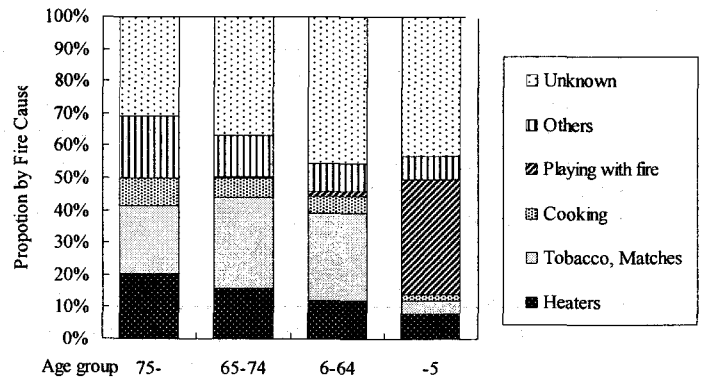

Figure 5 Breakdown by Fire Cause of Fatal Residential Fires by Age Group.
*Source of Data: Fire Fatality Data of the Fire and Disaster Management Agency for 1995 - 2001.

Effect of Residential Detectors in Reducing Fire Deaths in Homes

The number of fire deaths in the U.S. has been continuously decreasing during these two decades and was reduced almost by half in this period. As the reasons for this dramatic decrease of fire deaths, the diffusion of residential smoke detectors in homes and the introduction of upholstered furniture and mattresses with less flammability in the U.S. as well as the decreasing population of smokers are often referred to. And, the effect of residential smoke detectors in reducing fire deaths, when they were present and activated in comparison with the case that they were absent or failed to activate, was estimated as about 46% reduction in the report of NFPA[17], which is quite similar to the evidence such

as 56% reduction indicated in the report of Fire Statistics of U.K[18]. In Japan, although there has not been the diffusion of residential detectors in homes so far, there are sizable numbers of homes installed with ordinary fire alarm systems by fire regulation especially among apartment houses. Therefore, the authors tried to validate the evidence of the effect of existing fire alarm systems in Japanese homes on mitigating fire deaths based on the statistical analysis of the fire data of the Fire and Disaster Management Agency. As a result, the reduction ratio by the presence and activation of the fire alarm systems is ranging from 41% for fire-resistant apartment houses to 56% for wooden apartment houses[19], which is also very close to the estimates in the U.S. and the U.K. as introduced above. Further, since the Fire Service Law was amended in June 2004 to require the installation of residential detectors in all dwellings in Japan, we think it very important to conduct a follow-up study regarding the effect of residential detectors in reducing the risks of fire deaths and fire damage in the future.

By the way, in case of fire evacuation of the people who cannot self-escape such as bedridden or mobility impaired, it is absolutely essential to establish a system for transmitting the fire alarm to the family members, neighbours, and/or care personnel to ask assistance in evacuation in connection with the early detection of a fire. In Japan, we have an urgent notification system called as "*Emergency Reporting System*" as one of the measures of this purpose. In case of all sort of emergencies, which include not only fire incidents but also any other sorts of accidents such as sudden illness, they can access to the emergency operation center (mostly fire departments) automatically through the telephone of exclusive use by pressing the button in their pendants. The people in charge are to respond for 24 hours a day, and if situation requires or irresponsive case happens, the pre-registered nearby assistant is supposed to receive a message and fire crews also are supposed to turn out. In some systems, the buzzer outside the house sounds to alert neighbours to assist people who are disabled and in need of help.

Rapid Increase of Grey-types of Nursing Homes and Challenges in Fire Administration

In the context of regulation by Fire Service Law in Japan, buildings are classified according to the type of use and the type of occupant (as is in the case in many other countries.) However, so-called "grey-type" nursing homes, which are intermediate residential facilities between special elderly nursing homes and general apartments, have been proliferating in recent decades with a rapidly aging society in Japan. For example, the number of group homes for older people who are capable of supporting themselves in daily life has increased dramatically.

These facilities have problems from the viewpoint of fire safety, because many of them are converted from general apartments and were renovated to fit the new needs[20]. Since the regulations applicable to elderly nursing homes do not apply to these buildings, most of these grey-type of nursing homes have been supplied with no more fire protection than ordinary apartments. Code enforcement officials are aware of the potential risk of fires as well as the difficulty in evacuation and rescue when a fire occurs in these institutions. However, they find it difficult to classify these grey-type institutions for aged people because they have no standard policy to control this problem at present. Against this background, the technical committee set up in 2002 by the Fire and Disaster Management Agency of Japan has been evaluating this issue with a goal of establishing a revised method of regulating these intermediate residential facilities as either those equivalent to special elderly nursing homes or those equivalent to general apartments, depending upon their features such as the conditions of occupants and buildings. Also, the Fire and Disaster Management Agency recommends the application of residential sprinkler systems as an alternative means of other requirements by the Fire Service Law to these intermediate residential facilities[21].

Because of the rapid aging of society, many developed countries have similar challenges associated with these types of intermediate residential facilities. Therefore, the best methods of fire prevention/protection in these types of occupancies should be explored. In addition, the impact of diminished abilities associated with aging, such as decreased walking ability, sense of vision and

hearing ability after people move into these grey-type facilities can necessitate changing how these buildings are regulated. The question is how this kind of change can and should be observed and by whom. These future issues impact not only fire safety, but also other associated areas such as barrier free design, social welfare, and housing environment, fire protection engineers should cope with these problems in collaboration with policy makers, researchers, and engineers in these other fields.

The Issue of Use of Elevators in Fire Evacuation

The use of elevators in fire evacuation as an alternative vertical route has been long discussed in a past few decades as mentioned earlier, but it has become a more realistic and urgent issue after the WTC events of September 11th. After this tragic event, the total evacuation in a high-rise building that used to be considered infeasible is now the demand of many occupants who work or live in high-rise buildings especially in North America, since they have feeling of risk aversion to an extreme event like the total collapse of a building as happened with the WTC twin tours. This momentum has been boosting up the need of elevator use in emergencies including fires not simply for the disabled people who cannot use the stairs but also able-bodied general people who wish to get out of a building as quickly as possible.

There are naturally many technical and systematic issues for the safe operation of elevators. It is necessary to instruct and educate the public and the relevant organisations regarding elevator use in fires in due course, if the basic policy is changed to allow the use of elevators in fires from the conventional concept of limiting elevator use in such emergencies. Nevertheless, if this ordinary means of movement can be used directly as an evacuation route for wheelchair users and other residents having difficulty to use stairs, elevators can be the most effective means for smooth evacuation for these vulnerable people.

On this subject, worth mentioning is the Workshop on the Use of Elevators in Fires and Other Emergencies that was held in Atlanta in March 2004, under the joint auspices of American Society of Mechanical Engineers (ASME), National Institute of Standards and Technology (NIST), International Code Council (ICC), National Fire Protection Association (NFPA), U.S. Access Board, and International Association of Fire Fighters (IAFF), in which the author participated. Due in part to the impact of the collapse of the World Trade Centre, the debate at the workshop was even more constructive and purposeful than on previous occasions. The two principal topics of the workshop were the use of elevators by fire-fighters as a means of access and the use of elevators by occupants as a means of escape during emergencies. It appeared that permitting the use of elevators for fire-fighter access in emergency situations had the support of the majority of delegates. Furthermore, despite some opinions from fire officials cautioning against a drastic change in the current policy, which prohibits the use of elevators as a means of escape, the pervasive opinion among delegates was that such a change could be supported in the future.

The significant feature of this workshop was its format that consists of the plenary presentations[for example 22)-25)] of six or seven papers on each topic and afterwards the intensive discussions by eleven groups, which delegates were divided into. Discussions centred on the technical conditions and the policy issues needed to enable the safe and efficient use of elevators in fire emergency for the two purposes described above.

CONCLUDING REMARKS

Fire safety for vulnerable people does not mean only caring for the high-risk groups. This paper reviews fire safety measures for vulnerable people from a more universal standpoint. In order to examine the strategies to reduce fire deaths of vulnerable people, which account for a major portion of fire fatalities, it is very important to set appropriate targets of research and development as well as policies of fire safety measures according to corresponding high risk groups in consideration of the type of vulnerable people, type of fire, and type of building or facility. For further discussion on the

key issues and policies for improving the fire safety of vulnerable populations, the following procedures and efforts are needed.

a) Analysis of the fire risk of vulnerable populations based on historical experiences and data.
b) Review of the basic research and the database on human behaviour such as walking speed, flow rate, distribution of occupants by type of their attributes and so forth.
c) Review of building codes, fire codes, and design guides.
d) Review of fire safety concepts, design methods, evacuation plan, and emergency management.
e) Research and development of fire safety measures and devices using new technologies that reflect the knowledge and research on the behavioural features of vulnerable populations.
f) Information exchange on suitable case examples of studies, facilities, designs, equipment, etc.

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