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Paper:

Organizational Structure and Institutions for Disaster Prevention: Research on the 1995 Great Hanshin-Awaji Earthquake in Kobe City

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Based on the author's work experiences at the Kobe City fire department, this study examines the deaths directly and indirectly caused by earthquakes based on an examination of the firefighting, rescue, and emergency care operations that took place following the Great Hanshin-Awaji Earthquake. In particular, this study examines the ways in which the voluntary disaster-prevention organizations as well as the public services institutions, including the fire and police departments, have incorporated the lessons learned from previous disaster experiences. This approach is based on an observation of the operations conducted in Kobe City, and presents a framework aimed toward protecting lives from future earthquake disasters.

Keywords: Great Hanshin-Awaji Earthquake, Kobe City, regional assistance system, disaster-prevention welfare community

1. Introduction

It is widely considered that there is a high probability that the Japanese archipelago has entered an active earthquake period since the Great East Japan Earthquake in 2011. The Central Disaster Management Council has announced that it is very likely that Nankai megathrust earthquakes, including strong earthquakes directly affecting the Tokyo metropolitan area, will occur in the next thirty years and cause devastating damage [1]. Based on this recognition, municipalities around Japan are modifying buildings to be earthquakeresistant, and are undertaking anti-tsunami measures such as strengthening coastal protection facilities. Furthermore, to improve disasterresponse capabilities against earthquakes, a nationwide assistance system has been established for disaster-response services including prefecture-wide emergency fire response teams composed of firefighting brigades. Meanwhile, the organizational rate of voluntary disaster-prevention organizations initiated and organized by residents has risen drastically, from 43.1% in 1995 to 74.2% in 2010 [2]. In addition, public and private sectors are both undertaking disaster preparedness and mitigation measures, so that disaster preparedness training conducted by municipalities has come to include not only conventional demonstration-type disaster training, conducted under a prepared training scenario, but also on-paper training diagrams. Further, local communities have hosted training programs in which residents can learn about disasters in a game-playing context. However, do these approaches really result in reducing the number of earthquake victims and protecting lives? Article 1 of the Disaster Countermeasures Basic Act proclaims the purpose of "protecting . . . the life and limb of the citizens and their property." In this way, the greatest purpose of disaster preparedness is to protect human lives.

As a fire department personnel of Kobe City, one of the authors of this study was engaged in the function of protecting human lives at disaster sites following the Great Hanshin-Awaji Earthquake. Therefore, this paper examines the undertakings to protect lives from earthquakes and other disasters from the standpoint of a fire department worker. The Great Hanshin-Awaji Earthquake resulted in 6,434 deaths. In Section 2, we examine the reality of the deaths, considering when, where, and how these deaths occurred in order to consider why these casualties were caused and how we can reduce the number of deaths. Further, Section 2 discusses what actions must be taken to this end on the part of firefighting and other public services and residents. In Sections 3 and 4, we examine what kinds of operations have been carried out by public services and local communities or residents, respectively, in the two decades since the Great Hanshin-Awaji Earthquake in order to improve disaster preparedness capabilities. Finally, in Section 5, we offer an evaluation of the present situation and point out areas that require future improvement.

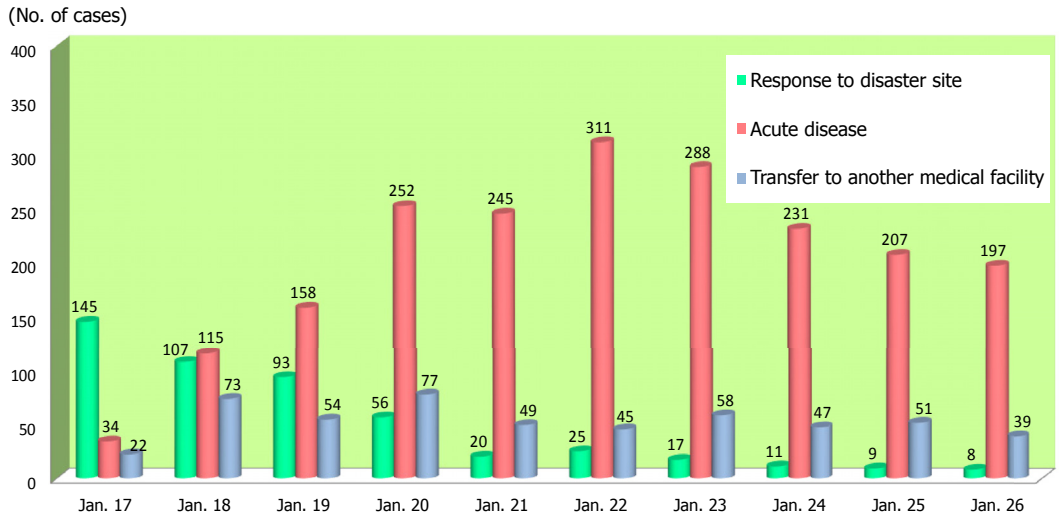

Fig. 1. Daily ambulance responses following the Great Hanshin-Awaji Earthquake.

2. Examination of the Great Hanshin-Awaji Earthquake

The Great Hanshin-Awaji Earthquake, which occurred at 5:46 a.m. on January 17, 1995, resulted in 122,566 buildings located within Kobe City to be partially or completed destroyed, and 4,751 lives were lost [3]. If the deaths are examined from the standpoint of the chronological change in the demand for disaster response, 3,908 deaths were directly caused by the collapse of houses or fires due to the earthquake, and were concentrated in the acute phase (the 72-hour period immediately following the earthquake). The remaining 663 deaths occurred in the semi-acute phase (from day four to three weeks following the earthquake), mostly consisting of elderly people who were forced to evacuate their damaged houses and died due to the spread of influenza, or due to the increase of diseases resulting from stress or deterioration of the living environment. For such deaths associated with the semi-acute phase, these are referred to as earthquake-related deaths. Deaths have also occurred among the aged and others living in temporary and reconstruction housing due to the earthquake disaster, and such earthquake-related deaths have occurred over a long period [4].

Figure 1 [5] is a graph of the number of ambulance responses by the Kobe City fire department over a ten-day period beginning on the day of the earthquake. The majority of cases for the four-day period immediately following the earthquake consisted of injuries caused by being caught in collapsed houses and similar problems requiring surgical attention. Then, from the second day onward, ambulance requests increased for the transport of patients from one medical facility to another, and for patients affected by acute cases at evacuation centers, which were housing approximately 200,000 people [5]. The ambulance requests from evacuation centers continued for a lengthy period, displaying a similar trend to the chronological changes in medical demand. In this section, we examine why the deaths due to the Great Hanshin-Awaji Earthquake occurred, whether they can be prevented, and what should be done to this end by dividing the post-earthquake period into the acute and semi-acute phases.

2.1. Acute Phase

According to a survey by the Office of the Medical Examiner, Hyogo Prefecture, the causes of the 3,651 deaths resulting from the Great Hanshin-Awaji Earthquake consisted of the following categories: 53.9% asphyxiation, 12.5% crushing death, 12.2% death from fire and burns, and 8.4% bruises and crush wounds; in addition, 86.6% of the deaths took place in the victims' own houses [6]. Based on this, we can estimate that the major causes of direct deaths involve fires, the collapse of houses, and external injuries. The important measures required to prevent deaths directly caused by earthquakes are to improve the earthquake resistance of buildings and implement fire prevention measures in advance. In addition, following the earthquake disaster, it is necessary to execute firefighting operations, rescue victims from collapsed buildings, and administer first aid and medical treatment to the injured and sick in a suitable and timely manner. Following, we examine the factors that resulted in the increase of damages from the standpoint of fire services by dividing these into the particular categories of firefighting operations, emergency (ambulance) services, and rescue operations. Further, we discuss the measures necessary to prevent the extending of damages following a disaster.

2.1.1. Firefighting Operations

The first five minutes following an initial building fire to a flashover constitutes the initial firefighting stage, during which the fire can be extinguished using fire extinguishers and/or buckets of water. If the fire can be extinguished during this stage, the building can still be used. The Fire Service Act states that it is mandatory to undertake firefighting activities for those associated with the

Table 1. Relation of number of pumper groups to number of fires and burned areas.

		Number of pumper teams (a)	Number of fires (b)	a/b	Average burned area (m^2)	Fire hydrant	Number of fire-prevention water tank
Higashinada Ward		5	9	0.56	2,626	Inoperable	38
Nada Ward		4	13	0.31	3,940	Inoperable	100
Chuo Ward	Fukiai District	3	2	1.5	1,247	Inoperable	147
	Ikuta District	5	1	5.0	149	Operable	
	Suijo District	2	0	0	0	Operable	
Hyogo Ward		6	9	0.67	13,259	Inoperable	104
Kita Ward		6	0	0	0	Operable	259
Nagata Ward		6	12	0.5	24,500	Inoperable	93
Suma Ward		4	4	1.0	7,801	Inoperable	129
Tarumi Ward		5	0	0	0	Inoperable	77
Nishi Ward		4	1	4.0	77	Inoperable	356
Total		50	51	0.98	10,237	Operable	1303

*To deal with the multiple fires, the ambulance teams and other personnel switched to reserve vehicles to increase the number of pumper teams from 36 to 50.

building in which the fire originates, and to cooperate in firefighting activities for those in the vicinity of the site of the fire.

In the fully-developed fire stage, the risk of the fire spreading to adjacent buildings is drastically increased in urban areas. The Guidelines for Maintenance of Fire Service Strength (Notification No.1, Fire and Disaster Management Agency, 2000) states that the resilience of the fire service should be maintained with the goal of "controlling a fire that originates in an exclusive-residence detached house so that it remains an isolated fire of a single building." To attain this goal of containing the fire as a single-building fire and preventing it from spreading, it is necessary to keep the time between dispatch to water-spraying to within 6.5 minutes (within 8 minutes after a 119 emergency call is received) [7]. Accordingly, fire services in Japan have been maintaining their capabilities with the goal of preventing the spread of a fire from the building in which it originated to adjacent buildings. The Kobe City fire department has deployed pumper trucks at fire stations based on these guidelines, requiring the dispatch of four pumper teams whenever a building fire occurs as well as requiring the dispatch of an additional four teams (totaling eight teams) in the case of a "blazing fire," which poses the possibility of spreading. In this manner, large-scale fires are prevented through containment based on the constant maintenance of superior fire service abilities.

The number of fires in Kobe City from January 17–27 in 1995 caused by the Great Hanshin-Awaji Earthquake totaled 175, resulting in a total area of 819,108 m^2 to be burned. Of this area, 63% resulted directly from multiple fires (51 building fires) that started between 5:46 a.m. and 6:00 a.m. on January 17. **Table 1** presents the number of pumper teams in relation to the affected areas, compiled from data obtained by one of the authors during his work duties.

If we make a comparison by administrative district, the fires in the jurisdictions of the Ikuta fire department in Chuo and Nishi wards, in which the average number of pumper teams per fire was four or above (Kobe City's standard deployment for building fires), were contained as single-building fires. However, the fires in Fukiai District of Chuo Ward, in addition to those in Higashinada, Nada, Hyogo, Nagata, and Suma wards, in which the average number of pumper teams per fire was one or less, experienced large-scale fires with an average of 1,247–24,500 m^2 burned areas. The average burned areas in Hyogo, Nagata, and Suma wards were greater than those in the other areas because these locations posed high risks of fire spreading due to a concentration of old wooden dwellings in Hyogo and Nagata wards, and further due to the presence of many synthetic leather shoe factories in Nagata and Suma wards. **Table 1** shows that the probability that fires will grow into large-scale fires is greater in areas with a high risk of fire spreading unless multiple pumper teams are deployed in the early stages of a fire.

Unless firefighting operations are not undertaken in the early stages, the fire will spread from building to building in a short time. At this stage, the fire will begin spreading via flying sparks, intensive radiation heat emanating from large blazes, strong winds, and torrents of fire, making it extremely difficult to bring the fire under control. In some situations, fire whirlwinds may occur, and area residents may be victimized. In the fire that occurred at Mikuradori, Nagata Ward, at 5:47 a.m. on January 17, an area of about 1,000 m^2 was ablaze by the time the firefighting brigade arrived, which was 23 minutes after the fire had started. The fire had grown into a large-scale fire in the short period of just 24 minutes, and continued to spread even with the deployment of reinforcement pumper teams for 13 hours and 14 minutes until it was extinguished at 7:00 p.m. The resulting burned area was 25,509 m^2 in total [8].

Reinforcements from other cities included one team from Mita City that arrived at 11:10 a.m., and ten teams from Osaka City that arrived at 1:10 p.m., followed by

numerous additional teams so that 182 reinforcement pumper teams in total had arrived by 24:00 on January 17. The burned area caused by building fires on that date was 799,000 m^2, or about 7,800 m^2 per fire, while that from the 18th to the 26th, during which time there were sufficient reinforcement pumper teams, drastically fell to about 300 m^2 per fire [9–11]. Based on these findings, the major reason for the spreading of fires on the 17th was due to the lack of deployable pumper teams relative to the number of fire occurrences, although there were other factors as well such as the fact that fire hydrants became unusable as a result of the earthquake, as well as the long time required for the firefighting brigades to arrive at the scene of the fire due to collapsed buildings. As a measure to advance the rapid mutual support systems among fire services within Japanese prefectures, Emergency Fire Response Teams (EFRTs) have been established and are maintained within a nationwide support system.

2.1.2. Emergency Services

When the oxygen supply is cut off from the brain due to cardiac arrest, consciousness will be lost in several seconds and brain damage will result in 3–5 minutes [12]. Thus, early basic life support (cardiopulmonary resuscitation including the use of an Automated External Defibrillator (AED)), advanced life support (e.g., drug administration), and hospital treatment (intensive care following the recovery of cardiopulmonary functions) are essential to save a patient suffering from cardiopulmonary arrest. Meanwhile, the key to avoiding preventable deaths caused by external injury among severely injured patients is to administer surgery, hemostasis, or other treatment within an hour of receiving injury.

For this reason, Kobe City has promoted knowledge on cardiopulmonary resuscitation and other first aid techniques among its residents. In addition, the city has upgraded ambulance teams including the training of emergency lifesaving technicians, and made efforts to reduce the time of arrival to disaster sites. Further, Kobe City has implemented a system of requesting physicians at emergency sites and established ambulances with physicians with the goal of improving the lifesaving rate of severely injured patients.

Following the Great Hanshin-Awaji Earthquake, the ambulance teams of Kobe City were unable to carry out regular ambulance duties because they were recruited for firefighting and other necessary operations. Therefore, many injured and sick persons were transported to hospitals by residents. Meanwhile, the medical facilities, whose functions were reduced because of the earthquake, were unable to provide adequate treatment to the patients, whose numbers greatly exceeded that of the normal volume. It has been reported that there were 500 cases whose disasterrelated deaths may have been prevented if regular emergency medical care had been provided [13]. Based on this earthquake experience, EFRTs and Disaster Medical Assistance Teams (DMATs) have been established as part of a nationwide support system of ambulance and medical teams.

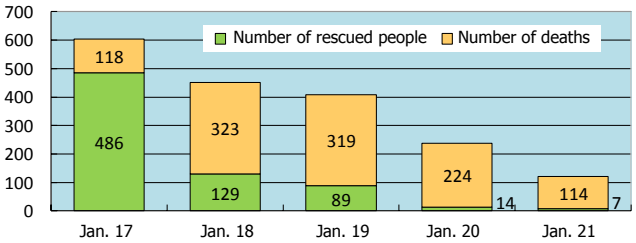

Fig. 2. Daily numbers of rescued people in the Great Hanshin-Awaji Earthquake.

2.1.3. Rescue Operations

At the time of the earthquake, the Kobe fire department had on standby three exclusive rescue teams and eight teams consisting of rescue and pumper units, making up a total of eleven teams in order to rapidly carry out rescue operations. Following the Great Hanshin-Awaji Earthquake, however, these teams were unable to deal with the cases of victims who were buried alive, whose numbers greatly exceeded the rescue capacity of the Kobe City fire department. Rescue teams from other cities and units of the Japan Self-Defense Forces (JSDF) worked in conjunction with the police and fire departments to conduct an organized joint rescue operation on January 18, and also initiated a search operation on the 20th to investigate all collapsed dwellings. Such operations are especially necessary in cases where crush syndrome may be a risk. Crush syndrome occurs when a person is pinned down by an excessive force for over two hours. Sustaining such an injury becomes lifethreatening when this state continues for over four hours.

Examining a record of rescue operations (**Fig. 2** [5]) following the Great Hanshin-Awaji Earthquake compiled by the writers of this report, the survival rate of rescued people was 80.5% on the 17th (when the earthquake initially occurred), 28.5% on the 18th, 21.8% on the 19th, 5.9% on the 20th, and 5.8% on the 21st. These rates illustrate that the rescue survival rate dropped drastically after the first 24 hours, and fell to a single-digit figure after 72 hours. Therefore, rescue operations that search collapsed dwellings must be initiated as soon as possible (within 72 hours at most) following the initial disaster. To this end, a nationwide support system has been established for the fire services, police departments, and the JSDF.

2.1.4. Activities of Organizations Following the Great Hanshin-Awaji Earthquake

2.1.4.1. Voluntary Disaster-prevention Organizations within Kobe City

While detailed studies have been carried out by the Japan Association of Fire Science and Engineering and other groups on the firefighting and rescue activities conducted by citizens following the Great Hanshin-Awaji Earthquake, relatively little documentation has been done on the activities of the Committees to Promote Voluntary Disaster-Prevention, which were voluntary disaster-

Table 2. Activities of Committees to Promote Voluntary Disaster-Prevention following the Great Hanshin-Awaji Earthquake; prepared by writer from documentation compiled by Kobe City.

		Higashinada	Nada	Chuo	Hyogo	Nagata	Suma	Tarumi	Total
Number of responses by committees (total number of committees)		4(11)	13(13)	12(18)	10(16)	14(17)	10(19)	19(24)	82(118)
Disaster type and activity within the committee's district	Fire (firefighting operation)	1(1)	6(5)	2(1)	3(1)	9(5)	3(2)	0(0)	24(15)
	Building collapse (rescue operation)	2(1)	8(5)	5(2)	1(1)	8(6)	4(2)	1(0)	29(17)
Activities conducted by committee or residents' associations as a unit	Firefighting operation	1	4	1	0	6	1	0	13
	Rescue operation	0	2	1	0	0	1	0	4
	Check on safety of residents and safety measures	1	0	1	1	2	1	2	8
	Patrolling and related activities	0	1	5	3	3	3	3	18
	Livelihood support in evacuation centers and other facilities	1	9	5	4	2	4	15	40
Activities carried out by neighborhoods and individuals	Firefighting operation	0	3	0	1	0	1	0	5
	Rescue operation	1	4	1	1	6	2	0	15
	Check on safety of residents and safety measures	0	0	0	0	1	0	1	2
	Patrolling and related activities	1	0	0	0	1	1	0	3
	Livelihood support in evacuation centers and other facilities	0	2	1	0	0	1	0	4

prevention organizations of Kobe City. In this section, we discuss the activities of the Committee to Promote Voluntary Disaster-Prevention based on data collected by one of the writers who was in charge of the paperwork when the Committees were established.

The Kobe City fire department began promoting the establishment of the Committees to Promote Voluntary Disaster-Prevention in 1985 in order to vitalize voluntary disaster-prevention activities by residents. The Committees to Promote Voluntary Disaster-Prevention each covered a jurisdiction roughly equivalent to an elementary school district and was made up of the president of the neighborhood association, president of the women's association, committee member of the women's association charged with disaster prevention and safety, district welfare commissioner, PTA president, fire protection managers of apartment complexes, and fire department personnel, where each member was expected to make use of his or her special function (for instance, the welfare commissioner is charged with measures for the aged, while the PTA's role is to consider measures to protect the safety of children) with the goal of improving the disaster-prevention capacity of the local community.

In 1993, 168 districts were established within the city. The numbers of formed districts according to wards were 11 in Higashinada Ward (covering 83.9% of households), 13 in Nada ward (75.5% of households), 18 in Chuo ward (31.6%), 16 in Hyogo ward (56.1%), 16 in Nagata ward (40.6%), 24 in Tarumi ward (43.3%), 29 in Kita ward (54.7%), and 21 in Nishi ward (16.1%). The activities of the Committees to Promote Voluntary Disaster-Prevention in FY 1993 consisted of fire prevention workshops (50), firefighting training (43), and training on making phone calls to the fire department (11), many involving training and workshops on fires. Thus, the objective of the activities of the Committees to Promote Voluntary Disaster-Prevention were to improve the fire prevention capacity of the local community, and there was no consideration of earthquakes.

2.1.4.2. Committees to Promote Voluntary Disaster-Prevention

Table 2 presents a summary of the activities of 82 districts (from a total of 118) among the Committees to Promote Voluntary Disaster-Prevention in Higashinada, Nada, Chuo, Hyogo, Nagata, Suma, and Tarumi wards, obtained in response to a survey on the committees' activities conducted in August 1995 by the Kobe City fire department. The section "Disaster type and activity within the committee's district" presents the number of fires (or collapsed buildings) within the district and the number of firefighting operations (or rescue operations) undertaken according to administrative jurisdictions. The sections "Activities conducted by committee or residents' association as a unit" and "Activities carried out by neighborhoods and individuals" present the respective activities according to administrative jurisdictions.

Among the firefighting operations undertaken in the committees' jurisdictions, thirteen were by committees or residents' associations acting as a unit, which greatly exceeded the five cases undertaken by neighborhoods and individuals. The firefighting operations were conducted using such methods as fire extinguishers, bucket brigades, and small power pumps. Firefighting operations that in-

volve bucket brigades or the operation of small power pumps require a group effort under a leader, which can explain why many of the operations were undertaken by the committees or residents' associations acting as a unit.

Next, we examine the effects of the firefighting operations undertaken by the Committees to Promote Voluntary Disaster-Prevention following the earthquake using **Tables 1** and **2** as references. The committees in Nada Ward, where the greatest number of fires occurred, undertook firefighting operations in five of the six districts that had fires. Meanwhile, there were thirteen fires immediately following the earthquake, while there were four pumper teams within Nada Ward. Four fires were being fought by pumper teams from the early stages of the fire, while nine fires were not dealt with. We were able to confirm that residents had engaged in firefighting operations in five of these nine unaddressed fires. The fire in the town of Nagata was extinguished by the residents' bucket brigade alone. As a result, although Nada Ward had the lowest number of pumper teams per fire (0.31), the average burned area, including the town of Rokko (burned area: 29,160 m^2), totaled 3,940 m^2, which is relatively low.

In Nagata Ward, the committees or residents' associations acting as units engaged in firefighting operations in five districts. In three cases, large-scale fires were prevented from spreading, likely due to the organized team effort. As we have seen, the committees in Nada and Nagata wards actively undertook firefighting operations, which were effective to some degree. In the other wards, however, the committees did not actively engage in firefighting operations, demonstrating the urgent need to establish voluntary disaster-prevention organizations capable of undertaking effective firefighting operations.

With respect to rescue operations, according to a survey by the Japan Association of Fire Science and Engineering [14], 34.9% escaped on their own, 62.6% were rescued by family members, neighbors, or passersby, and 1.7% were rescued by rescue teams, indicating that over 90% escaped from collapsed dwellings by themselves or through mutual help. There were 15 cases in which rescue operations were undertaken by neighbors or individuals (see **Table 2**), which greatly exceeds the four cases by committees or residents' associations acting as units. This shows that rescue operations undertaken by local residents do not constitute activities prepared in advance by the committees or residents' associations, but rather are rescue activities carried out by neighbors and individuals who witness disaster victims. On the other hand, a case in which boarding students of the Kobe University of Mercantile Marine organized rescue teams to rescue about 100 people shows the effectiveness of an organized rescue operation, and demonstrates the validity of organized rescue operations undertaken by voluntary disaster-prevention organizations.

Among the activities of the Committees to Promote Voluntary Disaster-Prevention following the earthquake, there were 40 cases of livelihood support in evacuation centers and other facilities. These made up about 48.2% of the committees' activities, indicating their active engagement. Meanwhile, there were only four such cases undertaken by neighborhoods and individuals. As the operations of evaluation centers should reflect residents' views, the activities undertaken by the committees proved suitable based on these findings.

2.1.5. Semi-Acute Phase

In Kobe City following the Great Hanshin-Awaji Earthquake, needy residents whose houses were burned collapsed rushed to evacuation centers; by January 24, 263,899 people retreated to 589 evacuation centers [15]. Many victims who were unable to be admitted to evacuation centers lived in tents in parks. The number of acute diseases increased drastically due to the poor living conditions and stress, and there was a period in which the requests for ambulances from evacuation centers to the Kobe City fire department increased to two to three times that of the normal rate. According to the reports of ambulance teams, many of the ambulance requests from the evacuation centers involved elderly people whose chronic diseases were aggravated, who had contracted pneumonia or influenza, or who had become debilitated or dehydrated. Such problems led to a great amount of earthquake-related deaths, which occurred during the semi-acute phase and continued until after the chronic phase. The Great East Japan Earthquake has also resulted in many earthquake-related deaths [16]. To prevent against such death, medical measures are needed to prevent the aggravation of chronic diseases, as well as earthquake-related diseases caused by the deterioration of the living environment. In addition, such measures should aim to protect the elderly in evacuation centers.

According to the activities carried out among the Committees to Promote Voluntary Disaster-Prevention following the Great Hanshin-Awaji Earthquake, 40 districts (about half of the committees) provided livelihood support in evacuation centers and other facilities (see **Table 2**). This indicates the need to encourage voluntary disaster-prevention organizations to support victims in evacuation centers who are in need of support. Meanwhile, the Japanese government has also pointed out the need to strengthen systems involving the coordination of various parties, such as local voluntary disaster-prevention organizations, welfare commissioners, children's social workers, care facility operators, and volunteers.

3. Improvement of Public Services

3.1. Improvement of Rescue Rates

Efforts to improve the lifesaving rates of those who experience cardiopulmonary arrest and severe injuries have been implemented in Kobe City. Specifically, Kobe City has adopted systems to dispatch physicians to disaster sites, including a training program for emergencysite physicians and the placement of physicians in ambulances. Further, the city has amplified the capabilities

of ambulance teams through instilling an emergency lifesaving technician system.

3.1.1. Dispatch of Physicians to Disaster Sites

Kobe City has adopted a system of requesting physicians to emergency sites and deploying ambulances with physicians ("doctor cars"). The request system was institutionalized by Kobe City in 1973, where the ambulance team requests the dispatch of physicians to sites of traffic accidents and other incidences that involve lengthy rescue operations. Although there were about 100 requests per year during the early years of its operation, the number of requests has dwindled drastically since the deployment of ambulances with physicians.

The deployment of ambulances with physicians began in Kobe City in July 1997 at the Kobe City Medical Center General Hospital in collaboration with the Kobe City fire department. The system was also adopted by the Hyogo Emergency Medical Center in September 2003. Under this system, the ambulance consists of a physician, nurse, and ambulance workers. As a rule, such ambulances are dispatched for life-threatening emergencies, including those that involve a large number of injured persons, those that require a long time to rescue victims, and those that involve severely injured or sick patients.

According to the Fire and Disaster Management Agency, there were 26,661 cases in 2014 in which physicians were dispatched to emergency sites based on the "emergency-site physician request system," in which the fire services request physicians to be dispatched by ambulances. Of these, 13,270 cases (49.8%) involved acute diseases [17]. This dispatch system was a major factor that enabled the smooth coordination between physicians and ambulance teams in the derailment accident of the JR Fukuchiyama line that occurred in May 2005.

According to a report [18] by the committee to investigate the deployment of ambulances with physicians of the Kinki Emergency Medicine Study Group, the benefits of deploying ambulances manned with physicians include the following: "reduction of length of time for commencement of definitive treatments," "expected improvement of the lifesaving rate," and "usefulness in providing on-site support after disasters." Thus, the normal deployment rate of ambulances with physicians contributes to the medical treatment of a patient before he or she is admitted to a hospital. Further, the deployment rate can be appropriately extended to assist the activities of DMATs following major disasters.

3.1.2. Emergency Lifesaving Technician System

In 1970, the Seattle Fire Department adopted a paramedic system in 1970 that enabled ambulance workers to carry out life support measures such as defibrillation, intratracheal intubation, and drug administration. As a result, the lifesaving rate among those who had suffered from cardiopulmonary arrest rose drastically. Following this successful example, Japan enacted the "Emergency Lifesaving Technician" law in August 1991. In accordance with this law, Kobe City began deploying ambulance teams that included emergency lifesaving technicians in July 1992. By 2011, emergency lifesaving technicians were included in 94.3% of the ambulance teams in Japan [19].

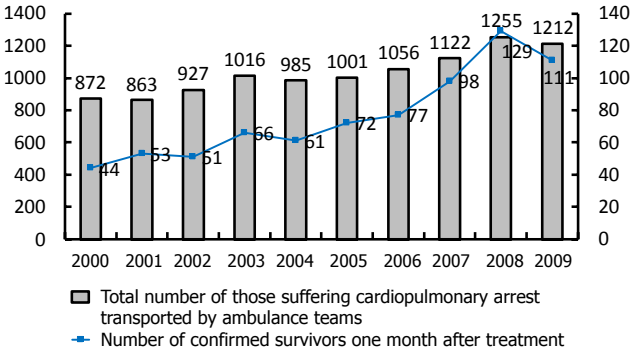

Fig. 3. Trend of life support treatment by emergency lifesaving technicians.

The qualification of an emergency lifesaving technician can be obtained by passing a national exam after enrolling in an established medical education course. Under a physician's instruction (both at the disaster site and during emergency transportation to a hospital or clinic), the emergency lifesaving technician is allowed to carry out the following life support treatments:

- Defibrillation using a semiautomatic defibrillator
- Transfusion of drugs designated by the Minister of Health, Labour and Welfare in order to secure an intravenous line
- Maintenance of the airway using devices designated by the Minister of Health, Labour and Welfare

Figure 3 [20] shows the trends from 2000–2009 in the number of one-month survivors among those who suffered cardiopulmonary arrest and received life support treatments by emergency lifesaving technicians working for the Kobe City fire department. As the range of life support treatments expanded to include defibrillation without a physician's instruction in 2003, intratracheal intubation in 2004, and the administration of epinephrine in 2006, the number of one-month survivors increased, indicating an increased lifesaving effect. Furthermore, beginning in April 2015, emergency lifesaving technicians will be allowed to 1) measure blood sugar levels and administer glucose, and 2) secure intravenous lines and administer transfusion to patients before they have had a cardiopulmonary arrest. These measures are expected to result in further improvement of the lifesaving rate. In particular, the latter measure is expected to improve the prognosis of those suffering from crush syndrome as a result of earthquakes and other disasters.

Table 3. Time to reach disaster sites under the regional firefighting support system (compiled by writer).

	Great Hanshin-Awaji Earthquake	Toyooka flooding	JR Fukuchiyama line derailment accident	Great East Japan Earthquake
Date and time of occurrence	5:46, Jan. 17, 1995	23:45, Oct. 20, 2004	9:18, Apr. 25, 2005	14:46, Mar. 11, 2011
Emergency Fire Response Teams	7 hours 20 minutes (Osaka City)	14 hours 55 minutes (Osaka Prefecture team)	66 minutes (Osaka Prefecture team)	14 hours 46 minutes (Akita Prefecture team)
Reinforcement from fire departments within Hyogo Prefecture	5 hours 20 minutes (Mita City)	8 hours 01 minute (Hyogo Prefecture team)	77 minutes (Hyogo Prefecture team)	5 hours 44 minutes (Morioka District fire department)

3.2. Improvement of Regional Support Systems for Public Services

The scale of damage caused by the Great Hanshin-Awaji Earthquake greatly exceeded the disasterresponse capacity of Kobe City. Therefore, the city received support from about 210,000 public employees (the cumulative total from January 17 to November 1, 1995) from other cities and working in various fields (including firefighting, water supply, environment, healthcare, and building inspection) during the stages of disaster response and reconstruction [21]. Nationwide support systems for various fields have been established to respond to large-scale disasters such as earthquakes. In this section, we examine the regional support system for the JSDF, fire services, police services, and medical services, which are related to firefighting, ambulance, and rescue operations.

3.2.1. Current State of the Regional Support System

The regional support systems for the fire, police, and medical services were not wellestablished when the Great Hanshin-Awaji Earthquake struck. Meanwhile, responding to a request made by the governor of Hyogo Prefecture at 10:00 am on January 17, 1995, the JSDF were fully mobilized by the afternoon of the same day. Based on a recognition of the inadequate response to the earthquake, nationwide support systems were established by various services. For the fire services, an EFRT system was established in June 1995, which authorized the Commissioner of the Fire and Disaster Management Agency to request or instruct prefectural governors to dispatch municipal fire departments. The system was legislated when the Fire Organization Act was revised in June 2000. As of January 2014, 4,600 teams from fire departments around Japan have been registered and are kept on standby at all times. In addition, mutual support among the fire departments within each prefecture has also been strengthened.

With regard to the police services, the Interprefectural Emergency Rescue Units (IERUs) were established in June 1995 within prefectural police stations all over Japan. IERUs are formed by a national total of 4,700 officers (2,600 in civil disturbance units, 1,500 in traffic control units, 600 in detective units). IERUs from around Japan are dispatched to disaster sites when the public safety commission of the disaster-stricken prefecture makes a request for assistance via the national or district police departments.

In order to facilitate the rapid dispatch of the JSDF to disaster sites, the Disaster Countermeasures Basic Act and the Self-Defense Forces Act were revised. These revisions incorporated changes based on past experiences of the Great Hanshin-Awaji Earthquake, and included the expansion of the authority of municipalities to make requests for the dispatch of the JSDF, and the simplification of the dispatch request process. The JSDF have set up a system enabling them to dispatch the personnel, aircraft, and/or naval vessels necessary for initial mobilization roughly within an hour of the initial request [21].

With regard to medical services, Disaster Medical Assistance Teams (DMATs) were established in April 2005 by the Ministry of Health, Labour and Welfare. A DMAT is defined as a highly mobile, trained medical team capable of mobilizing within 48 hours following the occurrence of a disaster. Engaging whenever a request is made by the disaster-stricken prefecture, these teams engage in the regional transportation of patients from disaster areas to areas of safety. Further, DMATs support medical activities within disaster-stricken areas over a range of three days to one week.

3.2.2. Examination of Regional Support Systems

In this section, we examine the regional support systems for the JSDF, fire services, police services, and medical services in cases of disasters experienced since the Great Hanshin-Awaji Earthquake.

3.2.2.1. Time of Arrival to Disaster Sites

We examined the times required by reinforcement firefighting teams as well as that of EFRTs to arrive at different disaster sites (see **Table 3**). The disasters considered are the Great Hanshin-Awaji Earthquake, the Toyooka City flood caused by Typhoon 23, the JR Fukuchiyama line derailment accident, and the Great East Japan Earthquake (ultra-wide-region disaster). The times to reach the disaster sites were computed by subtracting the time of disaster occurrence from the time the first team arrived at the site. For the Toyooka flood, the point at which the Maruyama River levee broke was used as the initial time and date of the occurrence of the disaster. Meanwhile, for the Great East Japan Earthquake, the time it took for support to arrive in Miyako City was used as the time to reach the disaster site. As shown in **Table 3**, the time to reach the site is affected by the type of disaster. In

Table 4. Rescue operations by fire services, police units, and the JSDF following the Great East Japan Earthquake.

	Dispatched period	Number of dispatched personnel	Daily maximum	Number of rescued people
Emergency Fire Response Teams	March 11–June 6, 2011	104,093 (27,544 teams)	6,835 (1,870 teams)	5,064 (18%)
Interprefectural Emergency Rescue Units	March 11–June 20, 2011	389,000	approx. 4,800	3,749 (13%)
Japan Self-Defense Forces	March 11–August 31, 2011	approx. 10,580,000	approx. 107,000	19,286 (69%)

*Total number of rescued people: 28,099
Source: March 15, 2012, report by the Fire and Disaster Management Agency

the case of the JR Fukuchiyama line derailment accident, both the EFRT (66 mins.) and reinforcement firefighting team from Hyogo Prefecture (77 mins.) arrived at the disaster site in a short time, because the local accident had no effect on the road passage conditions.

In the case of the Toyooka flood, both the EFRT (14 hrs. 55 mins.) and reinforcement firefighting team from Hyogo Prefecture (8 hrs. 01 min.) took a long time to arrive as heavy rainfall made it difficult for the fire trucks to travel. In the Great East Japan Earthquake, the Akita Prefecture team (an EFRT) took a long time to arrive at the disaster site due to the long distance to Miyako City, Iwate Prefecture. However, the Morioka District fire department, which was dispatched based on the intraprefectural mutual support agreement, arrived at Miyako City in the relatively short time of 5 hours 44 minutes. Based on this information, although the regional support system (including EFRTs) has been strengthened, we see that the times to reach disaster sites in the natural disaster cases of the Toyooka flooding and the Great East Japan Earthquake were not reduced in comparison to that of the Great Hanshin-Awaji Earthquake.

3.2.2.2. Emergency Rescue and Disaster Medicine

Table 4 presents the numbers of personnel dispatched by the fire services, police departments, and JSDF, as well as the corresponding number of people rescued following the Great East Japan Earthquake. The performance of the JSDF stands out as they rescued 19,286 persons, which constitute 69% of the total number of those rescued. This is the result of the strenuous efforts made by the JSDF in which they dispatched a cumulative total of approximately 10,580,000 members, or a daily maximum of approximately 107,000 members. The EFRTs and the police IERUs rescued 5,064 and 3,749 persons, respectively, which are also noteworthy considering the harsh conditions. In particular, the police services have greatly upgraded their equipment and rescue skills by establishing the IERUs, which specialize in rescue operations. While rescue operations in traffic accidents and other incidences during normal times are carried out by the fire services alone, **Table 4** shows that the police and JSDF play major roles in the event of large-scale disasters.

The DMATs were deployed immediately following the Great East Japan Earthquake. From March 11 to 22, 2011, about 340 teams consisting of 1,500 physicians, nurses, and other workers converged to Iwate, Miyagi, Fukushima, and Ibaraki prefectures, where they undertook, in coordination with the JSDF, the wide-area medical transportation of severe patients to areas outside the disaster areas. This service was enabled by running special care units (SCUs) or administering treatment during air transport. On March 13 and 14, 240 patients in medical facilities within the disaster-stricken areas were transported by JSDF aircraft to areas outside the disaster zone by making use of SCUs established at airports. This was the first time that wide-area medical transport was carried out on a major scale in Japan, and represented a major advance in comparison to the response to the Great Hanshin-Awaji Earthquake.

3.2.2.3. Firefighting Operations

To contain a fire as a single-building fire, the pumper team must begin spraying water within eight minutes after the building fire starts. Experience from the Great Hanshin-Awaji Earthquake demonstrates that large-scale fires, covering areas of several tens of thousands to several hundreds of thousands of square meters, will result if water spraying is delayed. Thus, when a fire that exceeds the area's firefighting capacity occurs, the damage must be minimized by strengthening firefighting capabilities to a level that exceeds the scale of the fire as soon as possible. Yet, if we compare the times for the fire services to reach disaster sites following the Great Hanshin-Awaji Earthquake and the Great East Japan Earthquake, we find that the reinforcement firefighting teams within the prefecture as well as the EFRTs took longer in the latter case. Therefore, currently it is not possible to arrive during the early firefighting stages in cases where multiple fires occur immediately after an earthquake. If an earthquake with a scale comparable to that of the Great Hanshin-Awaji Earthquake were to occur in a major city, it is highly possible that multiple fires will occur. However, it is difficult to reduce the time to reach disaster sites due to many physical factors, such as the long distance to the disaster-stricken areas.

Our analysis shows that the response capacities for rescue and ambulance operations have much improved due to the drastic strengthening of regional support systems involving the JSDF, DMATs, and police and fire ser-

Table 5. Categories of citizens' lifesaving technician course.

Category	Content (hours of instruction)
Citizens' Lifesaving Technician Course	
Introductory lifesaving course	Cardiopulmonary resuscitation including AED (1.5 hrs.)
Regular lifesaving course I	Cardiopulmonary resuscitation including AED (3 hrs.)
Regular lifesaving course II	Above course I with exam (4 hrs.)
Children's treatment course	First aid treatment of infants and children (3 hrs.)
Treatment of injuries course	Hemostatic dressing, splinting methods
Advanced course	In addition to the above contents, instructions on posture management and conveyance of sick or injured person (8 hrs.)
Emergency Care Instructor Course	Instruction on advanced first aid procedures and instructional skills (24 hrs.)

vices. Meanwhile, although the establishment of EFRTs has made it possible for the fire services to organize nationwide response, there is a high probability that these teams will not be able to arrive at fire sites in time to carry out effective firefighting operations in the event of earthquakes and other wide-area disasters. This is assumed based on the length of time required for such teams to arrive to disaster areas. When multiple fires have occurred following a wide-area disaster, the writers feel that it would be best if rescue and ambulance operations were carried out by police units, the JSDF, and DMATs, while the fire department of the disaster-stricken area and reinforcement firefighting teams within the prefecture should deploy pumper teams in addition to other groups assigned to ambulance and rescue operations, since fire departments can arrive in a relatively short time. Thus, a system is desirable in which firefighting operations are executed by the fire services, while ambulance and rescue operations are carried out by police units, JSDF, and DMATs in the initial deployment to address multiple fires following an earthquake.

4. Improving Residents' Capacity

4.1. System of Citizens' Lifesaving Technician Course

4.1.1. Outline of Citizens' Lifesaving Technician Course

Based on the success of the aforementioned Seattle case, in addition to the deployment of ambulance teams including emergency lifesaving technicians, the Fire and Disaster Management Agency issued the "Implementation guidelines to promote activities to spread and educate first aid procedures" in March 1993 (notification by the Deputy Commissioner, Fire and Disaster Management Agency). These guidelines were issued in order to spread knowledge on cardiopulmonary resuscitation among Japanese citizens. In response, with one of the present writers serving a central role, Kobe City initiated a lifesaving technician course to train citizens on lifesaving and first aid procedures in April 1993. The citizens' lifesaving technician course instructs on cardiopulmonary resuscitation, hemostatic dressings, and splinting procedures, and the content aims to enable those who complete the course to deal not only with acute sickness and accident-related injuries, but also disaster victims (see **Table 5** [23]).

At the same time, Kobe City initiated an emergency care instructor course to train instructors for the citizens' lifesaving technician course. Following the example of Seattle in which citizen volunteers served as instructors, this system allows citizens who have become certified as emergency care instructors to serve as instructors in the course. As a result, a group of citizens who have become certified as emergency care instructors has contributed to the further training of citizens to become lifesaving technicians.

The goal of this training is to produce one technician in each household, so that the probability will be high that there will be at least one trained technician nearby when a person collapses from an illness or injury at any location within Kobe City. Although the number of trainees was about 10,000 per year in the initial stages, it drastically rose to 18,000 in 1995, when the Great Hanshin-Awaji Earthquake occurred, and has continued to rise so that there were over 500,000 trained lifesaving technicians as of July 2013. It is expected that the emergency care capacity of the citizen technicians will be a major force in the event of major disasters such as a Nankai megathrust earthquake.

4.1.2. Effect of Citizen Lifesaving Technicians

Table 6 [23] summarizes the number of one-month survivors of cardiopulmonary arrest who were transported by ambulance teams of the Kobe fire department in 2014. The one-month survival rate was 15.7% when there was a witness present for patients who suffered from cardiopulmonary arrest. Meanwhile, the one-month survival rate was 2.5% when there was no witness, showing a large gap between the two cases. The one-month survival rate is higher when there is a witness because the ambulance arrives much quicker. Among those who suffered from cardiogenic cardiopulmonary arrest, those who received first aid treatment (e.g., artificial respiration, chest compression, defibrillation using an AED) by a citizen while waiting for the ambulance team had an 18.5% one-month survival rate as compared to 14.5% among those who did

Table 6. Effect of first aid treatment administered by citizens in Kobe City, 2013.

State at time of cardiopulmonary arrest			Number conveyed	Number of one-month survivors	One-month survival rate (%)
Witness present	Cardiogenic	Received first aid	146	27	18.5
		Did not receive first aid	145	21	14.5
	Not cardiogenic		200	23	11.5
	Witnessed by ambulance team or fire-fighting team		107	23	21.5
No witness present			809	20	2.5
Total			1407	114	8.1

not receive such first aid treatments by a citizen. Thus, the first aid treatment provided by citizens had the effect of increasing the survival rate by about 1.3 times.

When a person experiences severe arrhythmia that can lead to cardiac arrest, the chances of survival are higher the sooner that the defibrillation is administered. For this reason, it became acceptable in Japan for common citizens to use AEDs as of July 2004. In response, in April 2005, Kobe City instituted "town corner emergency stations," a system of facilities that have AEDs established on their premises (there are 2,033 stations as of March 2015). According to data compiled by the writer in his line of duty, there were 90 cases in which citizens administered defibrillation with an AED between April 2005 and December 2014. Of these, normal heart rhythm was restored in 42% of cases (38 persons), with a one-month survival rate of 37% (33 persons), demonstrating the lifesaving effect. As the number of trained citizen lifesaving technicians continues to grow, we can expect the lifesaving rate of those who suffer from cardiopulmonary arrest to improve in the future.

4.2. Disaster-Prevention Welfare Community

4.2.1. History of Disaster-Prevention Welfare Community

Following the Great Hanshin-Awaji Earthquake, it was not possible to appropriately respond to the multiple fires that occurred, or to the victims who were buried alive under collapsed buildings, given the limited disasterresponse capacity of fire services and other public services. Meanwhile, citizens demonstrated their resourcefulness by engaging in self-help and mutual-support efforts to fight fires, rescue victims, and provide emergency care. Based on this reaction of citizens, the Kobe City fire department conducted a reevaluation of voluntary disaster-prevention organizations based on the views of citizens and experts.

The main views expressed were as follows: 1) Since firefighting activities were carried out by neighborhood associations acting as units, while emergency-aid and rescue activities were effective when carried out by neighborhoods and individuals, the organizational setup should be such that firefighting and rescue activities are based on units of neighborhood associations (consensus view among citizens, experts, and fire department personnel); 2) Since individual neighborhood associations constitute small-scale organizations, which lack venues available for meetings or training as well as active members due to aging and the declining daytime population, there is a need to coordinate activities with other neighborhood associations in the vicinity; 3) There is a need to coordinate disaster prevention and welfare, as the elderly are especially prone to suffer from fires and be transported by ambulance, and further represented a disproportionately high rate of victims in the Great Hanshin-Awaji Earthquake.

Based on these views, it was decided to abolish the voluntary disaster-prevention promotion committees, and instead include disaster prevention among the activities of the Fureai Community-Building Committees, which had been engaged in welfare activities since 1995 to establish "disaster-prevention welfare communities." In FY 2008, these communities were established in 191 districts in Kobe City.

4.2.2. Organization of Disaster-Prevention Welfare Communities

As shown in **Fig. 4**, the organization of disaster-prevention welfare communities consists of the "headquarters" or caretaker committee, roughly covering the area of an elementary school district and composed of member organizations of the "Fureai Community-Building Committees." These member organizations include such groups as neighborhood associations, women's associations, and various committees. The organization of such communities also involves "blocks" made up of individual neighborhood associations.

The general roles of the headquarters or caretaker committee are to engage in information exchange among member organizations, draw up plans for livelihood support in evacuation centers for those requiring special help, draft operation plans for evacuation centers, and conduct comprehensive training for the disaster-prevention welfare community. Following a disaster, the roles of the headquarters are to collate disaster-related information, support and coordinate activities among the blocks, coordinate support for those requiring special help in evacuation centers, and operate evacuation centers.

Meanwhile, the general roles of the blocks are to execute certain tasks such as conduct fire drills and patrol dangerous areas. Following a disaster, the blocks engage in disaster-response activities such as firefighting and res-

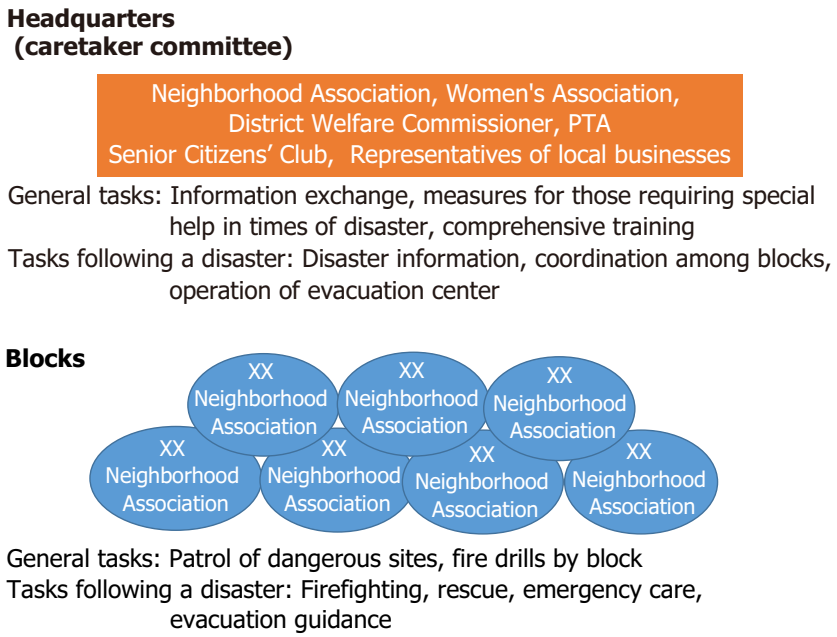

Fig. 4. Organization of disaster-prevention welfare community.

cue activities. The blocks are charged with carrying out the actual work in times of disaster. In this manner, it was made clear that the disasterresponse activities are to be undertaken by the neighborhood associations acting as units. This resolves the previous shortcomings of the voluntary pre-earthquake disaster-prevention committees where it was unclear as to what party was to carry out disasterresponse activities.

The community welfare centers (one per elementary school district), which have adequate facilities to serve as the home base for the "Fureai Community-Building Committees," were selected as the bases of activity. Thus, the disaster-prevention welfare community is an organization capable of reflecting the residents' collective opinion based on a committee structure. Further, this welfare community has a strengthened the disasterresponse capacity for firefighting and other activities due to its division into blocks, which are each composed of a single neighborhood association.

The voluntary disaster-prevention organizations in Japan can be divided into those based on units of neighborhood associations (94.1%), those based on units of elementary school districts (2.0%), and others (4.0%) (data as of April 1, 2010) [2]. This shows that those organizations composed of individual neighborhood associations make up the great majority, while the disaster-prevention welfare communities adopted by Kobe City, based on elementary school districts and made up of multiple local groups, are in the minority. Voluntary disaster-prevention organizations based on neighborhood associations have the merit that, due to their small scale, they are suitable for carrying out activities such as disaster-prevention training and undertaking actual activities such as firefighting and rescue. Meanwhile, those based on units of elementary school districts have the merit of being suitable for coordinating activities with various local groups or operating evacuation centers. For these reasons, the Fire and Disaster Management Agency is recommending that voluntary disaster-prevention organizations based on neighborhood associations set up "community safe and secure stations" [2]. Such stations should be based on elementary school districts, where activities are coordinated among the voluntary disaster-prevention organization, PTA, district welfare commissioner, women's association, and other parties. In FY 2008, there were 412 "community safe and secure stations" in operation.

4.2.3. Activities of the Disaster-Prevention Welfare Community

4.2.3.1. Typical Activities

There are two types of training for these communities: comprehensive training conducted by the headquarters, and block training conducted by each block. The comprehensive training covers an entire elementary school district and includes evacuation drills for those requiring special help following a disaster, as well as evacuation drills in preparation for tsunamis, training for evacuation center operation, and classes on disaster prevention for elementary school students and parents. The block training consists of training in handling fire extinguishers, small power pumps, and other equipment, and is aimed at raising the overall disasterresponse capacity. The numbers of training sessions (compiled by the writer) were 775 in FY 2009, 788 in FY 2010, 841 in FY 2011, and 896 in FY 2012. Therefore, an overall increase over the years is evidenced, indicating the high level of disaster readiness and awareness even 18 years after the Great Hanshin-Awaji Earthquake.

Taking advantage of the feature of disaster-prevention welfare communities as based on elementary school districts, these communities and elementary schools in Kobe

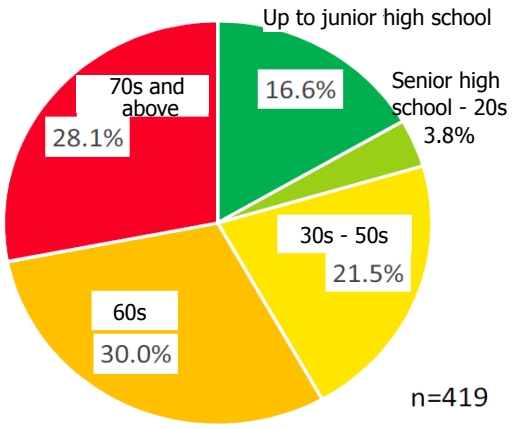

Fig. 5. Age composition of training participants ($N = 419$).

City collaborate to provide disaster-prevention education to school children, including the transmission of disaster experiences and disaster-prevention training. Furthermore, disaster-prevention junior teams targeting junior high school students have been formed in 17 disaster-prevention welfare communities. In these teams, students engage in activities to transmit the knowledge on disaster prevention from parent to child to grandchild based on the adults' experiences of disasters. Due to this collaboration between the communities and the elementary and junior high schools, the number of drill participants among parents has increased. In response to the prompt "on the age composition of participants in the comprehensive training" included in a questionnaire survey administered in 2012, it was found that junior high school students and younger made up 16.6%, while 21.5% was made up of those in their thirties to fifties. This indicates that elementary and junior high school students and their parents made up about 40% of the total (see **Fig. 5** [24]). On the other hand, participation by senior high school students and those up to their twenties was low (3.8%), indicating that participation by senior high school students and university students is an issue that must be addressed.

4.2.3.2. Activities Following Disasters

As shown in **Fig. 4**, the main duties of the headquarters following a disaster are to collect disaster information, facilitate information exchange among the committee members, coordinate among the blocks, and operate evacuation centers. Each of the blocks form an information unit, firefighting unit, rescue and emergency care unit, and evacuation guidance unit to carry out on-site activities such as checking on the safety of residents, firefighting, rescue and emergency care activities, and evacuation guidance, among other activities.

In actual disaster scenarios, the designated members are to gather at the site of the disaster preparedness storehouse and engage in disasterresponse activities such as firefighting, rescue and emergency care, and evacuation guidance. Later, these groups should take part in operating evacuation centers and assisting the elderly and others requiring special help. The disaster preparedness storehouses are set up in such locations as parks and elementary schools, and are used to store small power pumps, jacks, crowbars, saws, megaphones, and other supplies to equip for disaster preparedness. In addition, a system of assisting those requiring special help in times of disasters has been established and is operational in 32 districts as of September 2015.

When members of disaster-prevention welfare communities were questioned on the activities following disasters in the questionnaire survey mentioned above, 63.0% responded that they carry out rescue and emergency care duties, and 50.8% responded that they were capable of doing so. These results show the positive effect of the citizens' lifesaving technicians training. In addition, 39.6% responded that they take part in firefighting duties, while 34.8% responded that they were capable of doing so, reflecting that many citizens may regard firefighting activities to be difficult [24]. This indicates the necessity to reevaluate the local firefighting system, and to improve the quality and frequency of fire drills in the future.

5. Conclusion

In this study, we examined whether it was possible to reduce the number of deaths resulting from the Great Hanshin-Awaji Earthquake, and if so, what measures should have been taken. To this end, in Section 2 we identified particular issues by dividing the Great Hanshin-Awaji Earthquake into the acute and semi-acute phases. We then discussed in detail what type of undertakings should be adopted in the third and fourth sections. The findings of this study are presented in **Fig. 6**, which presents a framework for disaster response.

In order to minimize the damage caused by collapsed buildings and fires resulting from earthquakes, it is necessary to initiate disasterresponse activities within the time limit in which disaster response is possible. **Fig. 6** shows the chronological time limits for disaster response, along with the framework of disasterresponse organizations following normal and large-scale disasters. In this section, we examine whether it is possible for the disasterresponse organizations to undertake operations within that time limit, and clarify the issues that must be addressed to minimize the damage following large-scale disasters.

With respect to normal disasters, the increased probability of administering emergency care within the time limit for saving cardiopulmonary arrest victims due to the citizens' lifesaving technicians training, upgrading of ambulance teams, deployment of ambulances with physicians, and the optimum deployment of rescue teams have made it possible to provide emergency care within the appropriate time limit. This has resulted in a drastic reduction of preventable trauma deaths. With respect to fires, deaths related to burns resulting from large fires have not occurred since firefighting brigades have been optimally positioned to enable engagement in firefighting operations within the time limit for the prevention of fire spreading. This reduction in deaths resulting from large fires can be

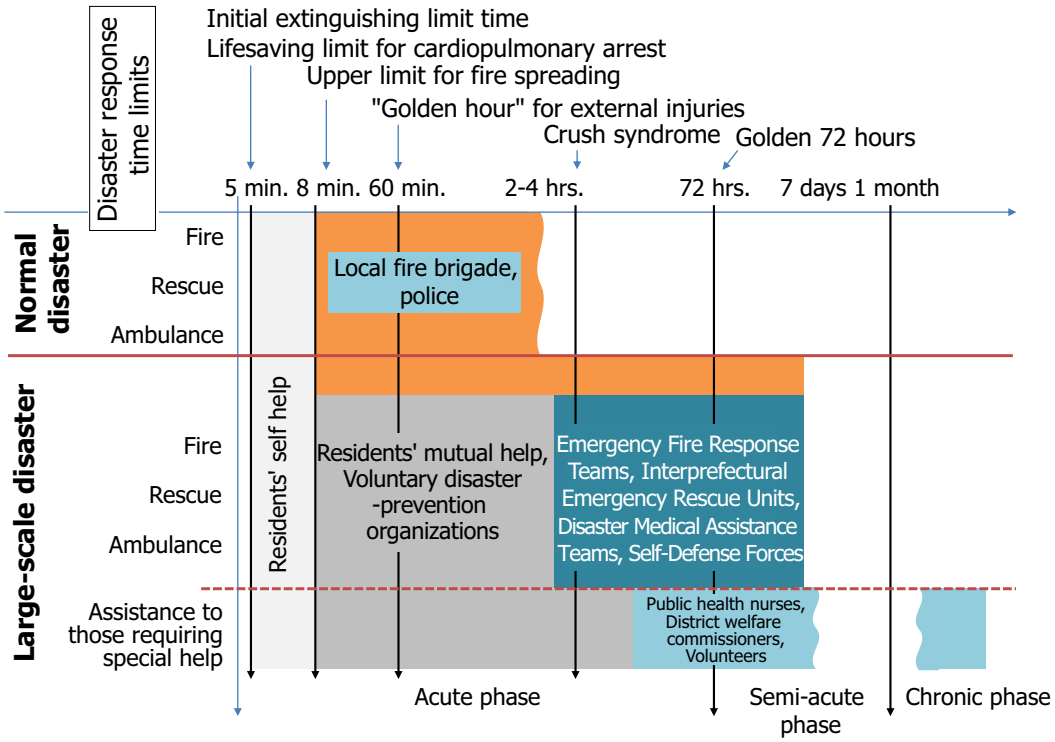

Fig. 6. Framework for protecting lives.

attributed to the high quality of disaster response occurring within the proper time limit by local residents, fire services, and police departments.

There were nearly 1,000 preventable trauma and burn deaths resulting from large fires following the Great Hanshin-Awaji Earthquake. This is largely due to the fact that the number of disaster occurrences exceeded the disasterresponse capacity of the local fire and police services; these departments were unable to respond within the appropriate time limit for disaster response. Based on this lesson, regional support systems for fire and other public services, in addition to voluntary disaster-prevention organizations, were established to fulfill the necessary disasterresponse capacity that could not be met by local fire and police services alone. Following, we shall examine the strengths and weaknesses of the regional support systems and voluntary disaster-prevention organizations from the standpoint of the time limits for disaster response (see **Fig. 6**).

With respect to the regional support systems for public services, based on the experiences and lessons from the Great Hanshin-Awaji Earthquake, the EFRTs and IERUs (including specialized rescue units) were established in June 1995, and DMATs began their operations in April 2005. Meanwhile, the disaster dispatch system of the JSDF was strengthened with the revision of the Disaster Countermeasures Basic Act, enabling them to dispatch the personnel and equipment necessary for initial mobilization approximately within an hour of the initial disaster. We shall examine the wide-area support operations of the various services following the Great East Japan Earthquake.

The rescue operations by the EFRTs, IERUs, and JSDF took place within the time limit for disaster response (up to 72 hours), and the personnel dispatched by these units in terms of daily maximums are approximately as follows: 6,835, 4,800, and 107,000, respectively. These numbers made up for the lack of manpower among the local fire and police services, and resulted in the rescue and survival of 28,286 persons. This was possible due to the high quality of the rescue operations, which were conducted within the time limit for disaster response. In addition, while it is difficult to evaluate emergency care following the Great East Japan Earthquake as nobody was severely injured due to few collapsed buildings, an SCU was established at the Fukushima Airport on the day following the earthquake (March 12, 2011), indicating that sufficient personnel and equipment were deployed at an early stage.

Since there have been no large-scale disasters resulting in multiple fires since the Great Hanshin-Awaji Earthquake, we refer to **Table 3** to examine the time for EFRTs and other units to arrive at disaster sites in previous large-scale disasters. We can see that the time limit to prevent fire spread was greatly exceeded. In particular, longer times were required in the Great East Japan Earthquake to arrive at the disaster site than in Great Hanshin-Awaji Earthquake. As matters stand, it is highly possible that once they occur, multiple fires will grow to become large fires on a scale similar to those following the Great Hanshin-Awaji Earthquake. Therefore, it is significant to reduce the time required by the EFRTs to arrive at disaster sites. However, it is physically difficult for even neighboring fire services to arrive within the time limit to prevent fire spread. Thus, measures to improve the firefighting

activities by voluntary disaster-prevention organizations should be considered.

Following, we examine the voluntary disaster-prevention organizations. As previously stated, Kobe City has established disaster-prevention welfare communities, based on a recognition of the effectiveness of the rescue operations by residents and firefighting activities undertaken by some of the voluntary disaster-prevention organizations following the Great Hanshin-Awaji Earthquake. As these communities cover the entire city, they are capable of engaging in disasterresponse activities within the proper time limit to effectively respond to disasters.

In the questionnaire survey regarding the disaster-prevention welfare communities, one-half responded that they were capable of carrying out rescue and emergency care activities, while only about 35% responded that they were capable of taking part in firefighting activities. Furthermore, participation in training by senior high school students and those up to their twenties was extremely low (3.8%). Meanwhile, a large number of citizens have undergone training to become citizen lifesaving technicians, which has resulted in a high emergency care capacity. Thus, the disaster-prevention welfare communities display a high disasterresponse capacity for emergency care and rescue activities, yet a low capacity for firefighting activities. Thus, increasing citizens' firefighting capacities is required.

Thus far, we have reviewed the disaster response in times of normal disasters and during large-scale disasters. To address preventable trauma and burn deaths due to fires in large-scale disasters, the regional support systems for public services and voluntary disaster-prevention organizations must be operating in the initial mobilization stage. We have shown that the support systems for emergency care and rescue have been strengthened to a level to avert most preventable disaster-caused deaths. However, we have also illustrated that, based on the current state of the regional support systems for public services and voluntary disaster-prevention organizations, it will be difficult to prevent large fires caused by an earthquake.

In the future, it is hoped that the systems for regional support among public services are further strengthened to enable their rapid dispatch to disaster areas, and further that the voluntary disaster-prevention organizations improve their firefighting capacity. However, it is quite difficult to drastically reduce the time required to reach disaster sites under the regional support system for public services, as this requires resolving physical obstacles such as traveling long distances. Therefore, the greatest resolutions that can be currently proposed in regards to large-scale disaster response are to raise the residents' awareness on firefighting techniques and activities, and to strengthen the fire response capacity of voluntary disaster-prevention organizations. We intend to examine the possibilities regarding firefighting activities undertaken by voluntary disaster-prevention organizations in future studies.

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