Case Report ■

Great Earthquakes and Medical Information Systems, with Special Reference to Telecommunications

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Abstract The Hanshin-Awaji earthquake in January 1995 caused the greatest number of deaths and injuries in Japan since World War II. Various weaknesses of modern information systems were exposed during and after the earthquake.

The authors carried out a questionnaire survey to investigate the current state of hospital information and to examine the kinds of information needed immediately after an earthquake. The survey results show that information about the ability to admit new patients and the availability of medical supplies is necessary immediately after such a disaster. These results will be useful for planning countermeasures against this kind of disaster.

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About four years have passed since the Hanshin-Awaji earthquake occurred in January 1995. The affected areas have not yet completely recovered from the serious damage caused by that disaster.

Immediately after the earthquake, a number of problems related to medical care became apparent. These problems have not yet been fully resolved. In the present study, we carried out a questionnaire survey to investigate how medical information systems in the areas affected by the earthquake worked and what difficulties were faced following this earthquake, to identify problems with current medical information systems and to seek ways of resolving these problems.

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Subject and Methods

Eighty hospitals located in and around the Hanshin and Awaji districts of Hyogo Prefecture were selected, according to a hospital size. Each hospital had more than 50 beds and more than three clinics.

A questionnaire survey was sent to the 80 hospitals, and responses were collected from 52 of them. The questionnaire included, among others, items about the severity of damage sustained by hospital buildings, the time needed for electrical power to be restored after the earthquake, and the time needed for the water supply to become normalized. The severity of damage is summarized in Figures 1 and 2 and in Table 1.

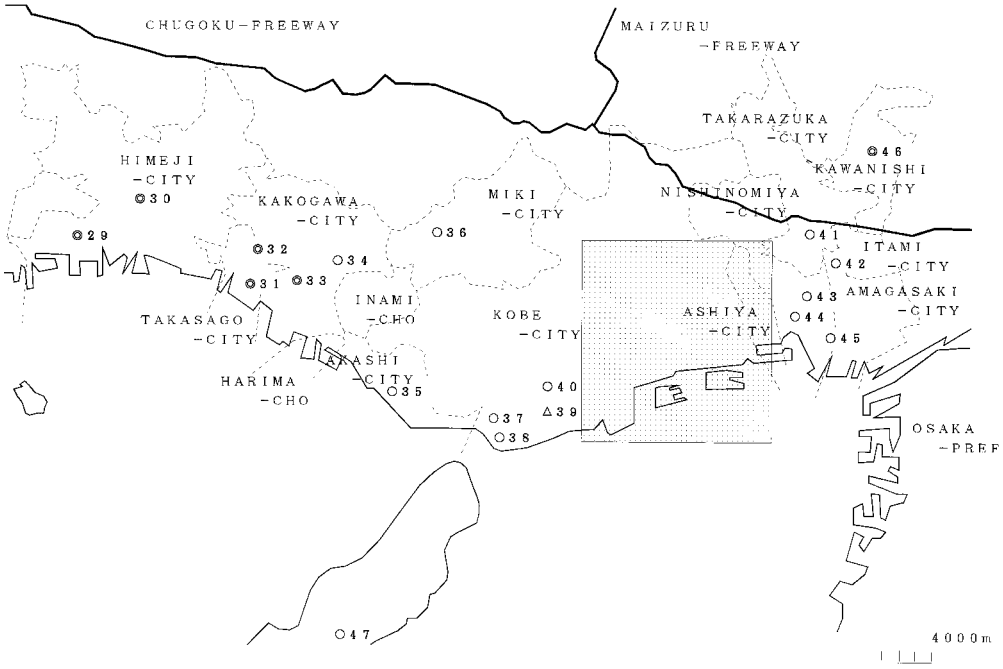

Figure 1 The location of hospitals in the area where the Hanshin-Awaji earthquake occurred in January 1995. The extent of damage to each hospital is indicated by the following symbols: open triangle, half destruction; open circle, partial destruction; double circle, no destruction (hospital intact). An enlargement of the shaded area is shown in Figure 2.

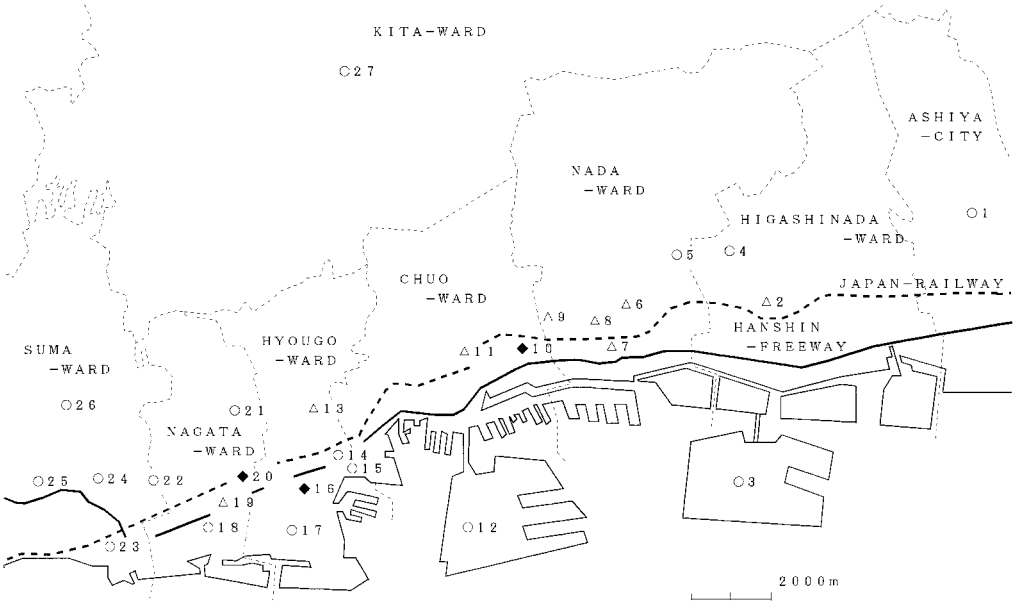

Figure 2 Enlargement of the shaded area shown in Figure 1, showing the location and extent of damage of hospitals in Kobe City and Ashiya City, the area hardest hit by the Hanshin-Awaji earthquake. The extent of damage to each hospital is indicated by the following symbols: solid diamond, complete destruction; open triangle, half destruction; open circle, partial destruction; double circle, no destruction (hospital intact).

Complete to half destruction of hospital buildings was the usual case in the areas hardest hit by the tremor, which had a magnitude of 7.2 on the Richter scale. The number of hospitals that were only partially damaged or remained intact increased with distance from the most severely affected area. In some hospitals electrical power was not restored until January 26, nine days after the earthquake. The water supply was not normalized until early April, more than two months after the earthquake, in the most delayed case.

We used the destruction of buildings and disruption of the electrical and water supplies to estimate the severity of damages, because building safety was crucial to accommodating patients, various machines in each hospital depended on the electrical supply, and the water supply was important as a lifeline and was

Table 1 ■

Damage to and Recovery of Hospitals Affected by the Hanshin-Awaji Earthquake

Area	No. of Hospital Buildings by Extent of Destruction				Power restored*	Water restored*
	Intact	Partial	Half	Complete		
Kawanishi City	1				Within 30 min	Within 30 min
Itami City		1			10:00 AM, Jan 17	Jan 31
Takarazuka City		1			8:00 AM, Jan 17	Jan 18
Nishinomiya City		3			Noon, Jan 18	Feb 25
Ashiya City		1			7:00 AM, Jan 17	Jan 28
Kobe City:						
Higashinada Ward		1	1		2:00 AM, Jan 18	Feb 11
Nada Ward		1	4		10:00 AM, Jan 26	Mar 10
Chuo Ward		1	1	1	2:00 AM, Jan 20	Jan. 28
Hyougo Ward		2	1	1	3:00 PM, Jan 20	Feb. 13
Nagata Ward		4	1	2	10:00 PM, Jan 21	Mar 22
Suma Ward		5	1		7:00 PM, Jan 21	Early Apr
Tarumi Ward		2			9:00 AM, Jan 17	Jan 23
Kita Ward		3			10:00 AM, Jan 17	Soon
Nishi Ward		2			9:00 AM, Jan 17	Jan 20
Akashi City		1			9:00 AM, Jan 17	Jan 19
Sumoto City		1			Within 30 min	Within 30 min
Miki City		3			7:00 AM, Jan 17	Soon
Nishiwaki City		1			Within 30 min	Within 30 min
Kakogawa City	2	1			Within 30 min	Within 30 min
Takasago City	1				Within 30 min	Within 30 min
Himeji City	2	1			Within 30 min	Within 30 min
Total	6	33	9	4		

*The earthquake took place at 5:47 AM on January 17, 1995. The times given for restoration of power supply and water supply are representative (longest) times.

necessary for developing x-ray film, dialyzing patients with renal diseases, and cooling power generators.

In our analysis of the questionnaire, we divided the hospitals into three groups, according to the severity of damage: severely damaged hospitals (28 hospitals that were half destroyed or worse or in which the water supply was not normalized before March 1995); moderately damaged hospitals (eight hospitals whose water supply was cut off for some time after the earthquake and whose electrical supply was off for six hours or more); and slightly damaged hospitals (16 hospitals that resumed their ordinary services within 30 minutes after the earthquake).

Results

Hardware Damage

Some central processing units (CPUs) and computer storage discs crashed or were otherwise severely damaged during the earthquake. Most of these could not be used again. Those CPUs and discs that were merely dislocated by the earthquake were able to be used again later. Even among the severely damaged hospitals, a relatively high percentage of hospitals sustained no damage to their CPUs and storage discs. These results indicate that medium and large computers and their related equipment resist earthquakes better than one might expect (Table 2).[1,2]

In all three groups, the computers in many hospitals were out of use until the electrical supply was restored. In some hospitals, computer use was supported by the hospital's own electrical generators before the commercial electrical supply was restored. In hospitals with computerized ordering systems, these systems were not functional even though the hospital information system was in use, because the order-receiving sections of the hospitals (e.g., the central laboratory and radiology section) were not yet able to resume services (Table 3).

Effects on Medical Care

Of the 50 hospitals that responded to a question about disaster manuals, 46 (92 percent) reported that they had no disaster manual. This clearly indicates that risk control in the hospitals was inadequate.[3]

On the day the earthquake hit the Hanshin-Awaji area, all 52 hospitals that responded to our survey provided outpatient care. Those hospitals in the earth-

Table 2 ■

Damage to Central Processing Units (CPUs) and Computer Storage Disks in 52 Hospitals

		Severely Damaged Hospitals	Moderately Damaged Hospitals	Slightly Damaged Hospitals
CPU	Destroyed or crashed	3 (0)	0	0
	Dislocated	13 (13)	3 (3)	0
	No damage	12 (12)	5 (5)	16 (16)
Discs	Destroyed or crashed	3 (1)	0	0
	Dislocated	13 (12)	3 (3)	0
	No damage	12 (12)	3 (5)	16 (16)

NOTE: The number of hospitals where CPUs or discs could still be used after the earthquake is shown in parentheses.

quake-devastated areas were probably flooded with many outpatients. The time needed for outpatient care in the severely damaged hospitals to become normalized was, on average, 8.5 days. This suggests that hospitals will be able to resume ordinary outpatient care about one week after a major earthquake.

On the day of the earthquake, the care of inpatients was maintained in 65 percent of the severely damaged hospitals; 30 percent of the hospitals in this group were unable to continue their previous inpatient care. The hospitals that were unable to continue providing inpatient care needed information to facilitate the smooth transfer of their inpatients or a smooth referral of patients requiring hospitalization to other facilities. However, this kind of communication was insufficient immediately after the earthquake.

Information Needed at the Disaster Site

Immediately after the earthquake, the severely damaged hospitals needed information about medical facilities that could accept patient transfers and referrals and information about means of transporting patients to such facilities, as well as other information (Table 4). The slightly damaged hospitals, which often accepted transfers or referrals, required information about the severity of the damage caused by the earthquake, details about the patients being transported to them, and other information. About seven days after the earthquake—i.e., when the patient transfer, referral, and transportation systems functioned well—the hospitals needed information about when their facilities and lifelines (e.g., water, electrical, and gas supplies) would be normalized. In other words, the types of information needed by the hospitals varied over time after the first shock of the earthquake.

Table 3 ■

Operation of Computers in 48 Hospitals after the Earthquake

	Severely Damaged Hospitals	Moderately Damaged Hospitals	Slightly Damaged Hospitals
Discontinued until electric supply restored	22	4	10
Continued by hospital's own generators	2	4	1
Discontinued but restored within 30 min	0	0	5

Receipt of Information

The severely damaged hospitals received information about the severity of damage caused by the earthquake 6.5 hours, on average, after the earthquake. They received this information primarily by means of battery-powered radios, because restoration of the electrical supply was delayed. Direct personal communication (hearsay) was also a source of information used by the hospitals.

Accuracy of Information

The severely and slightly damaged hospitals frequently pointed out that information provided by the mass media immediately after the earthquake included biased or incorrect statements (Table 5). Inaccurate information received by severely damaged hospitals included:

- Incorrect information about how to obtain daily necessities
- Little information related directly to people who suffered damage
- Erroneous reports of the destruction of hospitals that remained intact
- Incorrect information about the state of individual citizens
- Biased information about shelters

Table 4 ■

Information Needed on the Day of the Earthquake and on Subsequent Days

	Severely Damaged Hospitals	Moderately Damaged Hospitals	Slightly Damaged Hospitals
Immediately after the earthquake (Jan 17 and 18)	■ Where to transfer patients (13) ■ Means of transportation (6) ■ Severity of disaster (6) ■ Lifeline recovery schedule (4) ■ How to get supplies (3)	■ State of other hospitals (3) ■ How to get drugs (3) ■ Lifeline recovery schedule (3) ■ Severity of disaster (2) ■ Means of transportation	■ Severity of disaster (6) ■ Information needed to prepare for transferring patients (4) ■ Patient details (3) ■ State of other hospitals (3) ■ What to remove from hospital (3) ■ Employees' circumstances (1)
After the 3rd day (Jan 19)	■ Where to transfer patients (13) ■ Lifeline recovery schedule (7) ■ State and recovery schedule of transportation (4) ■ How to get supplies (3) ■ Severity of disaster (1)	■ Lifeline recovery schedule (3) ■ How to get supplies (2) ■ Where to transfer patients (1) ■ State of other hospitals (1)	■ Information needed to prepare for transferring patients (4) ■ State of other hospitals (3) ■ How to get drugs (3) ■ Lifeline recovery schedule (3)
After the 7th day (Jan 24)	■ Recovery schedule (7) ■ How to get supplies (4) ■ Where to transfer patients (3) ■ State and recovery schedule of transportation (2) ■ Information from administrative organs (1) ■ State of transferred patients (1) ■ How to transfer patients (1) ■ State of shelters (1) ■ News of volunteer helpers (1) ■ How to communicate the hospital's ability to accept patients (1)	■ Lifeline recovery schedule (1) ■ State of transportation (1) ■ State of other hospitals (1) ■ How to dispose of infectious wastes (1)	■ Information needed to prepare for transferring patients (details of patients) (3) ■ State of other hospitals (3) ■ How to get supplies (1) ■ Conditions near the residences of accepted patients (1) ■ Severity of disaster (1)

NOTE: The number of hospitals that indicated a need is shown in parentheses.

Slightly damaged hospitals pointed out the following problems with information they received:

- Information about individual citizens that was not detailed enough
- Inadequate information about traffic
- An erroneous report that a hospital could accept patients for hemodialysis, causing a rush of patients there

Table 5 ■

Was Information from Mass Media Biased or Incorrect?

	Severely Damaged Hospitals	Moderately Damaged Hospitals	Slightly Damaged Hospitals
Biased or incorrect	9	1	6
Not biased	15	7	8
No answer	4	0	2

NOTE: See text for examples of biased and incorrect information reported by severely damaged and slightly damaged hospitals.

- Information confined to severely damaged areas and lack of information about the neighborhood of specific hospitals

Useful Means of Collecting and Dispatching Information

Immediately after the earthquake, ordinary telephone systems were difficult to use because they were overwhelmed by the extraordinarily large number of callers attempting to use the telephone. Under these circumstances, portable telephones, electronic mail, radios, walkie-talkies, and such were found to be useful (Table 6).

Table 6 ■

Means of Communication Found To Be Useful for Collecting or Dispatching Information after the Hanshin-Awaji Earthquake

Portable telephones (28)
Pay telephones (2)
E-mail (9)
Telephone line leased for exclusive use (1)
Wireless (6)
Motorbike (1)
Fax (4)
Local newsletter (1)
Means other than telephone (2)

NOTE: The number of hospitals that found each means useful is shown in parentheses.

Discussion

Traditional telephones were unusable immediately after the Hanshin-Awaji earthquake, as they had been immediately after previous major earthquakes.

Because of broken telephone wires, interrupted power supplies to telephone exchange equipment, and the attempts of many people to use the telephone to find out whether their relatives and friends were safe, the telephone lines were 50 times busier immediately after the earthquake than before it. Even the day after the earthquake, the telephone lines were still about 25 times busier than usual, despite the measures taken by the telephone company to rectify this situation (as reported by Nihon Telephone & Telegram).

It is difficult to see how to secure means of telecommunication for collecting information about referrals to accepting hospitals and usable means of patient transportation (i.e., the information many hospitals reported that they needed) under such circumstances.

The information provided by mass media, such as television and radio, is sometimes biased and incorrect. It is doubtful that these mass media can provide medical facilities with the information they actually need. It also seems unlikely that these media can serve as useful providers of information to medical facilities immediately after a major earthquake.

Some telephones in our hospital were ''priority telephones''—that is, their use was not restricted by the telephone company even though the use of ordinary telephones was restricted immediately after the earthquake. Even these priority telephones could not be used, however, if the telephone wires had been broken. But if priority telephone lines remain intact, it is possible to make communication links outside the hospital even though other telephone lines are overloaded. At least one priority telephone should be installed at each medical facility. There were four such telephones at the Kobe University Hospital. However, the people working in the hospital did not know clearly where these telephones were installed. For this reason, the priority telephones were not used during the telephone panic immediately after the earthquake. When a manual for coping with disasters is prepared, it is imperative to describe the utilization of priority telephones.[4]

Portable telephones did serve as a useful means of communication immediately after the earthquake. The number of portable telephone users has increased sharply in Japan during the past year. Before the earthquake, this number had been increasing gradually, but it was not very high at the time of the earthquake.

Immediately after the earthquake, portable telephones could be used easily. However, like ordinary telephones, portable telephones require some exchange equipment, so an increase in the number of portable telephones will make even their use difficult when many people attempt to use them at the same time.

Understandably, wireless methods have served as useful means of telecommunication immediately after disasters like the Hanshin-Awaji earthquake. It is well known that the MCA wireless system was usable immediately after this earthquake. The control station for this wireless system was at the top of Rokko mountain, and it sustained little damage from the earthquake. Immediately after the earthquake, some employees of the MCA wireless system provider went up to the summit of Rokko mountain, carrying a power generator to handle possible interruption of the power supply to the control station. Although the control station remained almost intact during this earthquake, the possibility of its being destroyed by a major earthquake remains as long as it located on the ground.

The government of the Hyougo Prefecture had a functioning satellite telecommunication system, which used the Super-Bird B satellite. This system could not be used during the earthquake, however, because the power generator for it did not work as a result of damage caused by the earthquake to a water pipe leading from the water cooling tank. In addition, the antenna table for the system was broken, resulting in a shift of the direction of the parabola antenna. These problems made it impossible for this satellite telecommunication system to be used immediately after the earthquake.

Some projects for developing satellite telephone systems are now being undertaken, including the Inmarsat P, Odyssey, Iridium, and N-Star projects. When these systems are established, people will be able to communicate at any time, anywhere, with others at any location, using a portable satellite telephone. Such systems will contribute to establishing a disaster-resistant telecommunication network.[5]

Electronic mail, which was reported to be useful in collecting and dispatching information, served as a useful means of communication from the third day after the earthquake. Electronic mail can follow many alternative pathways and so works even if one pathway has been blocked. Furthermore, receivers of electronic mail can read the mail at any time, so their activities are not restricted by the medium as they would be, for example, by the need to wait for phone calls.[6] In addition, electronic mail can be sent to many receivers at one time. These features of electronic mail made it particularly useful for the exchange of information among volunteer helpers after the earthquake.

It seems necessary to designate several core hospitals to serve as hospital information centers in given districts and equip them with various telecommunication systems, such as preference telephones, satellite telephones, and electronic mail. Information can be pooled at these core hospitals after a disaster and then be made available to other hospitals in the same district. The core hospitals should be labeled ''first core hospital,'' ''second core hospital,'' and so on,[7] so that if the first core hospital were not functional, the second would be contacted, and if that hospital were also out of order, the third core hospital would take over. These core hospitals should also function as information centers during ordinary times, so that they are always prepared to take quick action in an emergency.

Only a small percentage of the surveyed hospitals had disaster manuals. All hospitals need to prepare such manuals and include sections on how to collect and treat essential information.

Conclusions

The results of our questionnaire survey about hospital information systems following the Hanshin-Awaji earthquake will be useful for planning countermeasures to be taken by hospitals against future earthquakes and other major disasters.

References ■

1. Naito M. Earthquake-caused damage of hospital information systems [in Japanese]. Jpn Congr Med Inform. 1995;15:32.
2. Ozaki T. The damage caused by Hanshin-Awaji great earthquake in medical information systems and the countermeasures taken [in Japanese]. Jpn J Med Inform. 1996;16:299–303.
3. Miyamoto M, Sako M, Kimura M. A survey of damage to information systems caused by the Great Hanshin-Awaji Earthquake [in Japanese]. Jpn J Med Inform. 1996;16:265–70.
4. Kimura M, Miyamoto M. Effects of the earthquake on information systems [in Japanese]. Jpn Congr Med Inform. 1995; 15:39–40.
5. Miyamoto M, Sako M. Telecommunication in great disaster. In: Takeshita H, Okuaki S, Kobayashi K, Aikawa N (eds). Emergency and Disaster Medicine in Great Earthquake [in Japanese]. Tokyo, Japan: Health Publishing, 1996.
6. Kimura M, Tani S, Miyamoto M. Crisis management of telecommunication methods at hospitals in large-scale disaster [in Japanese]. Jpn J Med Inform. 1996;16:255–63.
7. Miyamoto M, Sako M. Influence of the Great Hanshin-Awaji Earthquake on the medical information system at the Kobe University Hospital [in Japanese]. Jpn Congr Med Inform. 1995;15:33–4.