The Great East Japan Earthquake: Research and actions of Japan Medical Association Research Institute

JMAJ 55(5): 368–374, 2012

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Overview of the 2011 Great East Japan Earthquake and Comparison With the 1995 Great Hanshin-Awaji Earthquake

The Great East Japan Earthquake struck on March 11, 2011, with a magnitude of 9 and maximum seismic intensity of 7. In particular, this earthquake was characterized by the size of the fault, measuring approximately 450 km in length and 200 km in width, which moved over an extremely broad area, shifting 24 m east-southeast, and had an upthrust of 3 m.[1,2]

Tsunamis frequently occur off the coast of the Sanriku region, with three occurring approximately every 100 years. In addition, the tsunami following the 1955 Chile earthquake reached the Pacific coast of Japan, including the Sanriku region.

Maximum tsunami height following the Great East Japan Earthquake was 40.5 m, while another very large, high tsunami measuring 38.2 m has also occurred in the past.

A major reason why the 2011 tsunami in Japan caused so much damage was that, despite initial tsunami warning forecasts of waves measuring around 3 m to 6 m, after around 30 minutes Miyagi Prefecture was struck by 10 m waves, and after around 45 minutes Iwate Prefecture and Fukushima Prefecture were also struck by 10 m waves, and thus there was a huge time delay in the tsunami reaching its maximum height.

Shown in **Table 1** is a comparison of the characteristics of the 1995 Great Hanshin-Awaji Earthquake and the 2011 Great East Japan Earthquake.[3–6] The 1995 Earthquake occurred along an active fault, and such earthquakes are said to occur at intervals of between a thousand years and several tens of thousands of years. In comparison, ocean-trench plate earthquakes are said to occur at intervals of several decades to several hundreds of years.

In the 1995 Earthquake, damage was caused mainly by the collapse of buildings and fires, whereas in the 2011 Earthquake the main causes of damage were the tsunami and the nuclear power plant accident.

The main causes of death in the 1995 Earthquake were crushing and asphyxiation, whereas the main cause of death in the 2011 Earthquake was drowning.

With regard to the number of evacuees, following the 1995 Earthquake the number of residents staying at shelters gradually decreased, whereas in the case of the 2011 Earthquake, an extremely high number of residents are still living at shelters.

Survey Research by JMARI Regarding Recovery and Reconstruction Following the Great East Japan Earthquake

Japan Medical Association Research Institute (JMARI) ordinarily closes research theme submissions at the end of February, but since the Great East Japan Earthquake occurred on

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This article is based on the presentation made at JMA Symposium on Health Policy "Disaster Medicine and Medical Associations" held on March 11, 2012.

Table 1 Comparison of the 1995 Great Hanshin-Awaji Earthquake and the 2011 Great East Japan Earthquake

		1995 Great Hanshin-Awaji Earthquake	2011 Great East Japan Earthquake
1	Date of occurrence	January 17, 1995	March 11, 2011
2	Time of occurrence	5:46:52	14:46
3	Hypocenter (epicenter)	In the Akashi Strait, off the northern end of Awaji Island (Epicentral earthquake)	Off the Sanriku coast (Earthquake occurring a distance from land)
4	Hypocenter depth	16 km	24 km
5	Magnitude	7.3	9.0
6	Maximum seismic intensity	7 (Awaji Island)	7 (Kurihara City, Miyagi Prefecture)
7	Type of earthquake	Earthquake occurring along an active fault (occurs at intervals of one thousand to several tens of thousands of years)	Ocean trench earthquake (occurs at intervals of several decades to several centuries)
8	Affected areas	Urban areas	Mainly agricultural and fishing areas
9	Main damage	Collapsed buildings, fires	Giant tsunami, Fukushima Dai-ichi/Daini Nuclear Power Plants accident
10	Number of deaths	6,474	15,843 (as of December 22, 2011)
11	Main causes of death	Crushing, asphyxiation	Drowning
12	Number of missing persons	3	3,469 (as of December 22, 2011)
13	Number of injuries	43,792	5,890 (as of December 22, 2011)
14	Number of evacuees (Immediately following the disaster to 4 months after the disaster)	307,022 (one week after the disaster)–35,280 (4 months after the disaster)	102,648 (March 15, 2011)–138,620 (July 28, 2011)
15	Dwelling damage (total destruction)	104,906	127,091 (as of December 22, 2011)
16	Dwelling damage (partial destruction)	144,274	230,896 (as of December 22, 2011)

(Source: Cabinet Office, Government of Japan.[3] National Policy Agency of Japan.[4] Headquarters for Emergency Disaster Response, Prime Minister of Japan and His Cabinet.[5] MEXT of Japan.[6])

March 11, research themes related to the disaster were quickly devised and submitted from April onwards.

First of all, JMARI carried out follow-up of Japan Medical Association Team (JMAT) activities; secondly, JMARI cooperated in projects related to damage compensation and reconstruction; and thirdly, JMARI conducted research concerning electricity demand and supply measures in response to the shutdown of the nuclear power plant and the effects of these measures. In addition to these three areas of research, JMARI is currently in the process of compiling a "Great East Japan Earthquake Fact Book."

Overview of the Fukushima Daiichi Nuclear Power Plant Accident and Issues

One cause of the nuclear power plant accident was that the tsunami wave reached around 10 m in height. Another major cause of the accident was in particular that the plant's external power supply was interrupted and that the emergency power supply did not function. When the power lines were toppled by the earthquake/tsunami, the plant's entire external power supply was lost. Moreover, because virtually all of the emergency diesel generators were located on the first basement level, all but one was lost.

Furthermore, the third cause of the accident is said to have been the fact that the containment vessel used in reactors No. 1 to 5 at the plant were the "Mark I" model, which falls into the oldest category of containment vessel used in Japan. These containment vessel have been identified as having three problems by such experts as the creators of the United States Department of Energy's reactor decommissioning handbook, the former head of safety at the

Table 2 Occurrence of hydrogen explosions due to reactor core meltdown at the Fukushima Daiichi Nuclear Power Plant

2011	Reactor No. 1	Reactor No. 2	Reactor No. 3	Reactor No. 4
March 11	14:46 The earthquake struck off the Pacific Coast of the Tohoku region (Mw 9.0) 15:27 The first waves of the tsunami reached the Tokyo Electric Co. Fukushima Daiichi Nuclear Power Plant			
March 11	Around 17:00 Fuel was exposed, after which meltdown of the reactor core began	—	—	—
March 12	15:36 Hydrogen explosion occurred	—	—	—
March 13	—	—	Around 8:00 Fuel was exposed, after which meltdown of the reactor core began	
March 14	—	Around 18:00 Fuel was exposed, after which meltdown of the reactor core began	11:01 Hydrogen explosion occurred	—
March 15	—	Around 6:00 to 6:10 A huge impact sound was heard (at virtually the same time, pressure in the pressure control room dropped to zero)	—	Around 6:00 to 6:10 A huge sound was heard (nuclear reactor building was damaged)

(Source: Headquarters for Emergency Disaster Response, Prime Minister of Japan and His Cabinet.[5] Tokyo Electric Power Company.[9])

United States Nuclear Regulatory Commission, researchers at nuclear power-related national government laboratories in the United States, and the former designers of Toshiba's containment building models.[7,8]

The Fragility of the "Mark I" Containment Vessel, Which the Earthquake Exposed

The first problem with the Mark I containment vessel is that the vessel capacity was reduced to one-tenth of that originally planned due to economic reasons. It is said that the too-small containment vessel intensified the seriousness of the accident.

The second problem that has been pointed out is that virtually no analysis of the safety of the Mark I model has been conducted in areas where earthquakes occur frequently.

The third problem is what is called the "suppression pool," which is thought to have been damaged in the disaster because it is extremely vulnerable to strong shaking such as in earthquakes.

Currently, there are still 10 of the same Mark I model of nuclear reactors in nuclear power plants throughout Japan, excluding the Fukushima Dai-ichi Nuclear Power Plant: Higashidori in Aomori Prefecture (Tohoku Electric Power Co.), Onagawa in Miyagi Prefecture (Tohoku Electric Power Co.), Shiga in Ishikawa Prefecture (Hokuriku Electric Power Co.),Tsuruga in Fukui Prefecture (Japan Atomic Power Co.), Shimane in Shimane Prefecture (Chugoku Electric Power Co.), and Hamaoka in Shizuoka Prefecture (Chubu Electric Power Co.). That is to say, there are still at least 10 nuclear power plants in Japan installed with reactors with which particular care must be taken.

Data From the System for Prediction of Environmental Emergency Dose Information That Was Not Provided to Residents

The reasons that this accident caused severe damage are said to be first of all that a hole possibly opened in the suppression pool of the

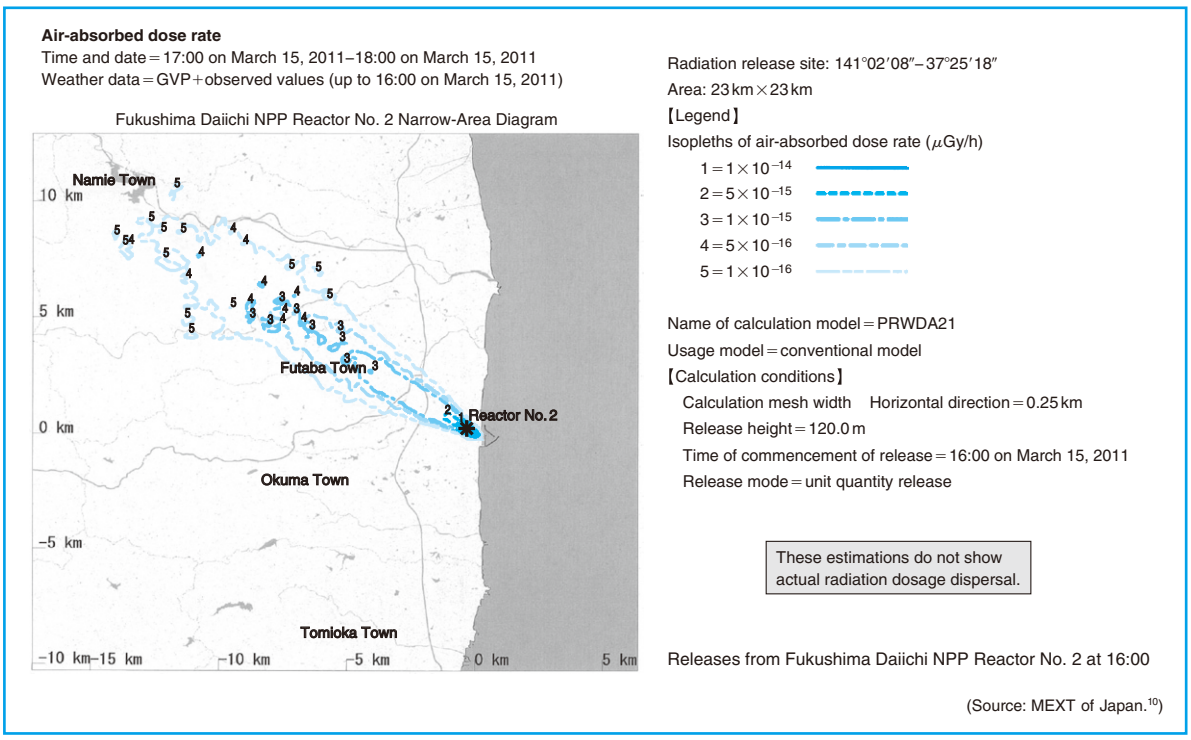

Fig. 1 Direction of the dispersal of the air-absorbed radiation dosage ratio (March 15) via System for Prediction of Environmental Emergency Dose Information (SPEEDI) that residents were not informed about

No. 2 reactor due to the explosions (suspected to have occurred) in the No. 2 and No. 4 reactors on March 15. It is also said that possibly the nuclear reactor building which stores spent nuclear fuel at the No. 4 reactor sustained damage, causing so-called radioactive substances to scatter (**Table 2**).[5,9]

Radiation levels peaked on March 15 and 16, with radiation doses near the front of the power plant rising to an extremely high 12 mSv/h.

At that time, absolutely no data from the System for Prediction of Environmental Emergency Dose Information (SPEEDI) was provided to residents (**Fig. 1**).[10]

Chairman of Japan's Nuclear Safety Commission said that calculations of SPEEDI would have taken time and it would probably have been unhelpful for residents even if the data had been available. However, on March 15 the wind was blowing in a southerly direction during the day, moving clockwise so that by evening it was blowing inland in a northwesterly direction. If residents had known these changes over time, they could have foreseen that the wind would blow inland.

In addition, even though the chairman was saying that it was impossible to make calculations because the amount of radioactive substances being emitted at the accident site was unknown, it has been pointed out that it should have been possible to carry out simulations of how radioactive substances would disperse when one unit was entered. That absolutely none of this information was provided to residents was undoubtedly extremely problematic. This has been pointed out to have been an issue for the government's Investigation Committee on the Accident at the Fukushima Nuclear Power Stations of Tokyo Electric Power Company (TEPCO) to handle, as I am sure you all know from newspaper and other media reports.

Problems that later emerged were that no records were kept of meetings at nuclear emergency response headquarters and other responding organizations, and that despite the accident being a worst-case scenario, clearly this information was not disclosed to the general public. I believe that this was a huge problem.

Table 3 Recommendations made by the JMA Project Committee with regard to damage compensation and recovery/reconstruction, etc.

1. Recommendations regarding damage compensation for the Tokyo Electric Co. Fukushima Daiichi/Daini Nuclear Power Plant Disaster
   (1) Policy for nuclear damage compensation
   (2) Commencement of early compensation related to property
   (3) Improvement of compensation related to labor costs and decontamination
   (4) Improvement of compensation related to payment of retirement benefits
   (5) The termination time of damage compensation for business operations should not be determined early
   (6) Damage compensation payments should continue even after changes in zone designation.
2. Recommendations regarding recovery/reconstruction from the Tokyo Electric Co. Fukushima Daiichi/Daini Nuclear Power Plant Disaster
   (1) The government, which promoted the nuclear power policy as a national policy, should share responsibility.
   (2) Efforts should be focused to restore local communities to their pre-accident state.
   (3) A nuclear power second opinion system comprising nuclear energy experts without no conflict of interest should be prepared in order to ensure nuclear power plant safety and disclose information.
   (4) The national government should devise and legislate soft systems for local community regeneration.
   (5) The national government should establish a disaster assessment system that takes into consideration evacuation areas to which entry is not permitted.
   (6) A national center for safety and assurance should be established.
   (7) The national government should prepare places for evacuation residents to return or colonize to.
   (8) With the cooperation of municipal medical associations, temporary clinics through public-private partnership should be established and operated as part of efforts to create a safe living environment.
   (9) In order to reunite the divided Soso region community, the Jouban railway line and Jouban motorway need to be reconstructed and made available to the community toll-free.
3. Recommendations regarding the restoration of community healthcare services by Fukushima Prefecture
   (1) Formulate operational support measures to enable medical institutions in the disaster zone to endure.
   (2) Provide funding and facilities to secure human resources for community healthcare.
4. Recommendations regarding responses to disasters due to nuclear power plant accidents
   (1) Provide information about nuclear accidents in real time and evacuations, etc., from the standpoint of the general public and disaster zone residents.
   (2) As early as possible, realize measures for ensuring safety at the 54 nuclear power plants around the country and the safety of residents of areas near nuclear power plants.
   (3) Create a two-step implementation process for stockpiling and distributing potassium iodine.
   (4) As a member of the Central Disaster Prevention Council (Committee to Consider the Promotion of Disaster Prevention Countermeasures), proactively pursue measures to prevent and avoid disasters.
   (5) Recommendations regarding the ideal form of JMAT activities

Responses by the JMA and JMARI

As part of our work, we provided support to the Fukushima Medical Association in relation to seeking compensation for damages from the TEPCO. This support broadly took two forms: firstly, we negotiated with TEPCO for them to accept a simplified application system; and secondly, we made TEPCO remove the phrase "No objections or additional demands may be lodged" from agreements.

In addition, the Japan Medical Association (JMA)'s Project Committee has made various recommendations (**Table 3**).

To mention several points from amongst these, one committee recommendation was that a national center for safety and assurance, which could provide information focusing on monitoring, be established, since we cannot know what could happen in the future.

The committee also recommended that the national government should take responsibility for the preparation of places to which residents can evacuate and then return or colonize to.

Another recommendation concerned the stockpiling and distribution of potassium iodine. No information about the actual venting of radioactive steam from the containment vessel was provided to local residents, either. In such situations, where residents do not know when

Table 4 Comparison of characteristics of information provision to residents with regard to the tsunami disaster and nuclear disaster following the Great East Japan Earthquake

	Occurrence of the Great East Japan Earthquake (Tohoku-Pacific Ocean Earthquake)	
	Large-scale tsunami disaster (visible disaster)	Nuclear accident involving nuclear reactor core meltdown, etc. (invisible disaster behind closed doors)
Provision of information to residents about disaster causes and location of origin	Information on the earthquake epicenter was provided to residents in a short period of time by earthquake/tsunami information provision systems.	No details of the accidents at the Tokyo Electric Power Co. Fukushima Daiichi/Daini NPP were disclosed for several days until information was released by the government and the hydrogen explosions occurred.
Provision of information to residents about the scale and details of the disaster	Information on the magnitude of the earthquake was provided to residents in a short period of time.	Information was released in small amounts by the government; the disaster was assessed as ranking 7 on the nuclear accident scale approximately one month after the event.
	The process of providing information included virtually no meetings or other impediments to speedy dissemination.	The process of providing information included an extremely large number of meetings and other impediments to speedy dissemination.
Provision of information necessary for evacuation to residents	Despite some confusion, information on the scale of the tsunami was provided to residents in a short period of time.	Virtually no residents of the area near the nuclear power plant were provided with information regarding actual radiation levels.
	The majority of residents were aware that evacuation from the tsunami generally meant escaping in the opposite direction to the ocean.	Virtually no residents of the area near the nuclear power plant were provided with information regarding the direction of dispersal of the air-absorbed dose rate via SPEEDI.
	The majority of residents were aware that evacuation from the tsunami generally meant seeking refuge on high ground.	Virtually no residents of the area near the nuclear power plant were provided with information regarding evacuation means with respect to radioactive substances.

they should take the potassium iodine preparations, not only government agencies but also organizations such as the medical association in local area should, I believe, stockpile potassium iodine.

In addition, I believe that the JMA and JMARI should proactively disclose and disseminate relevant knowledge that the president of the JMA acquires through participation in the Central Disaster Prevention Council "Committee to Consider the Promotion of Disaster Prevention Countermeasures," to which he has been appointed.

Information Becomes Extremely Important in the Case of Nuclear Disasters, Which Are Invisible Disasters

Based on inspections already carried out, I have summarized the characteristics of the nuclear power plant accident. Simply put, in comparison with the case of a tsunami, which causes visible damage, a nuclear accident occurs behind closed doors and causes invisible damage (**Table 4**).

Therefore, nuclear disasters are characterized by the fact that, as long as the government or operators of electric utilities provide information, the damage is unknown to residents, and it is precisely for this reason that information is extremely important.

Predicted Summer Electricity Supply Situation in the Case That Nuclear Power Plants Are Not Restarted

The repercussions of the nuclear power plant accident have spread nationwide with the problem of the supply of electricity growing tight in summer of 2012, Kansai Electric Power Co. is running short of capacity by 19%, TEPCO. by 13%, Shikoku Electric Power Co. by 11%, and Kyushu Electric Power Co. by 12%. These esti-

mates were based on the very hot summer of 2010 and years with very cold winters, and so this is thought that we can expect this much demand, and measures need to be taken to meet this demand (situation as of November 1, 2011).[11]

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