Identification of the Demand for Blood Products in Disaster Areas, Supply/Transportation Situations, and Responses

Mitsugu Kida,
Director of Supply Division, JRC Iwate Blood Center

I now report on how the six blood centers in the Tohoku region provided blood services to the disaster areas of the Great East Japan Earthquake (Figure 1).

I. Damage in the Iwate prefecture

Both the Great East Japan Earthquake and the Great Hanshin-Awaji Earthquake recorded the similar intensity level in each blood center, 6 Upper and 7, but the magnitudes of the two were different. The former had a magnitude of 9.0 and the latter 7.3.

Damage to buildings was not so serious because the maximal seismic intensity in Iwate was 6 Upper compared with the Hanshin-Awaji Great Earthquake (scale 7 and directly beneath) in 1995. However the loss due to the tsunami was enormous. In that sense the scale of the disaster was greater than that of the Hanshin-Awaji Earthquake (Figure 2).

Comparison between the Great East Japan Earthquake and the Great Hanshin-Awaji Earthquake

- The Great East Japan Earthquake (March 11, 2011)
  Intensity: level 6 Upper
  Magnitude: 9.0
  Number of people killed: 15,782
  Number of people missing: 4,086

- The Great Hanshin-Awaji Earthquake (January 17, 1995)
  Intensity: level 7
  Magnitude: 7.3
  Number of people killed: 6,434
  Number of people missing: 3
People died or were missing in large areas ranging from Aomori Prefecture to Chiba Prefecture, totaling 19,868 (Figure 3).

Of the 34 municipalities in Iwate Prefecture, 12 (35%) in coastal regions suffered catastrophic damage from the tsunami, with many people drowned and missing. In Miyagi and Fukushima Prefectures, damage was also devastating. These were the areas closest to the epicenter of the earthquake, which was deep off the coast along a line stretching south from Iwate down to Fukushima (Figure 4).

In Otsuchi-cho, located about 30 km south of Miyako City in Iwate Prefecture, the town office was washed away by tsunami waves, and 1,614 people including the town mayor, more than 10% of the town’s population, were killed or missing. The prefectural Otsuchi Hospital was damaged severely and it has been inoperable since then (Figure 5, Figure 6).

On the day of the earthquake, personnel of our blood collection teams were working in three bloodmobiles in Iwate Prefecture. Of the three bloodmobiles, one was on the coast of Miyako area, but it happened that the donation site was on a hill about 3 km away from the seashore, and the team survived.

II. Problems in distribution and transportation of blood products

There are ten medical institutions serving as stockpiling bases of blood products in Iwate Prefecture, and fortunately, these institutions on the coast were not severely damaged. The prefectural Otsuchi Hospital, prefectural Yamada Hospital, and prefectural Takata Hospital, however, suffered destructive damage (Figure 7).

As for damage to the Iwate Blood Center, the power went out across the facility immediately after the earthquake. We did not have enough heavy fuel oil A at that time, and so we tried to obtain dry ice and ice to prepare for emergency. Heavy fuel oil A was replenished through arrangements made by the emergency response headquarters of the prefecture the day after the quake, and any negative impact was averted. Power was restored on the evening of the day after the earthquake, and the heating system continued to function. Also, the water supply was restored. It was difficult, however, to obtain fuel for emergency vehicles. The emergency response headquarters helped us to secure the fuel.

We tried to maintain supply to medical institutions by assigning the members of the distribution division to a 12-hour shift schedule since we could no longer rely on the delivery consignment company immediately after the earthquake. In addition, we doubled the stockpile at medical institutions on the coast, and were able to meet the demand for blood products from them and other medical institutions nearby. We obtained passes for emergency vehicles at the time of disasters from the emergency response headquarters, and were able to use expressways to go to and from the disaster areas on the coast (Figure 8).
Telephone services were cut off after the earthquake, and emergency priority phone lines and satellite telephones could not be used at some medical institutions because they had not maintained them. Therefore, it was difficult for us to have close contact with some other organizations. However, thanks to a certain cellular phone service provider with many base stations and emergency priority phone lines in the disaster area, we were able to maintain some contact and receive orders (Figure 9).

III. Support from across Japan

To cover the shortage of blood production in the Tohoku region, supply lines throughout Japan were controlled at the Tokyo Metropolitan Blood Center to optimize supply-and-demand in the disaster-hit prefectures. Blood products were sent to Aomori and Akita by air, to Miyagi and Iwate by land, and to Yamagata by land from Miyagi. This enabled smooth distribution of blood products for transfusion to medical institutions in Iwate, although blood collection was suspended until the middle of April in Iwate, Miyagi, and Fukushima Prefectures (Figure 10-15).

The average number of units of red blood-cell products sent from the blood centers across Japan to the three prefectures of Iwate, Miyagi, and Fukushima was 764 units across Japan to the three prefectures of Iwate, Miyagi, and Fukushima was 764 units per day (4.2% of the mean total products per day across Japan), amounting to 29,796 units for a total of 39 days from April 7 to May 15, 2011 inclusive. The mean number of units of platelet products sent was 15,500 per day (6.6% of that mentioned above), totaling 883,500 units over a total of 57 days.

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Total supply of blood products sent to the Tohoku region after the earthquake, from April to the end of August, was as follows: 195,331 units of red blood-cell products, 81,092 units of plasma products, and 252,991 units of platelet products. It is entirely due to the wide-area supply and demand management system that this was possible.

The graph compares the number of units...
of red blood-cell products supplied to the Miyagi Blood Center before and after the earthquake (Figure 14).

This graph (Figure 15) compares changes in units of red blood-cell products in stock nationwide from March to April in 2010 and 2011. The blue dashed line represents the products in stock in 2010, and the red line represents those in 2011. We resumed blood collection activities from April 19, and thanks to kind consideration from people all over Japan, the volume of red blood-cell products in stock in 2011 exceeded that in 2010.

IV. Future challenges

1. In order to ensure means of communication at the time of disasters, we need to secure the number of lines for disaster priority telephone lines and ensure that satellite telephones are available.

2. In order to secure fuel for emergency blood-delivery vehicles, etc., we need to provide the necessary facilities and information to ensure there is fuel available for the vehicles to travel to remote or inaccessible medical institutions.

3. In order to share information on available roads for transportation, we need to provide appropriate information on detours.

4. In order to secure fuel for emergency power systems, increasing the capacity of fuel tanks or ensuring sufficient amount of fuel is required.

5. Considering other preparations necessary for possible disasters, more effort needs to be put into securing a stable supply of blood products for transfusion, by means of the wide-area management system (Figure 16).

V. Conclusion

We must make every effort to achieve a "stable supply of safe blood products," which is the basic principle of our blood services, and learn the lesson from this experience and make further improvements.

The Great East Japan Earthquake, with its epicenter off the coast of Sanriku, occurred at 2:46 p.m. on March 11, 2011 and recorded a magnitude of 9.0, the largest ever recorded in Japan. The earthquake caused huge tsunami waves with run-up heights of as high as 40.5 m that inflicted devastating damage on the coastal areas of the Tohoku and Kanto districts. Approximately 20,000 people died or went missing, more than 270,000 buildings were completely or partially destroyed, the number of evacuees was more than 400,000 at its peak, electricity was cut off to over 8 million households, and more than 2.2 million houses were without water. The Fukushima Daiichi Nuclear Station of Tokyo Electric Power Company hit by the earthquake and tsunami, lost all electric power, was unable to cool its nuclear reactors, and discharged a large amount of radioactive material, which resulted in a serious nuclear accident. This accident forced the residents around the plant, especially the Hama-dori area where the plant is located, to evacuate and live as refugees for a long time. In addition, some thermal power plants were damaged causing a serious electricity shortage in the Tohoku and Kanto areas.

The intensity levels recorded at blood centers in the Tohoku Area were 4 at Aomori and Yamagata blood centers, 5 Upper at Iwate, Akita, and Fukushima blood centers, and 6 Upper at Miyagi Blood Center. Aftershocks occurred in Miyagi Prefecture 1,045 times, the highest of all areas, from March 11 to August 30 (Figure 1).
I. Blood collection at the time of the earthquake

Blood donation was being conducted at 11 of 15 donation rooms and blood centers, and at 17 bloodmobiles in six prefectures in the Tohoku region at the time of the earthquake. There were donation sites within 3 km of the seashore in Miyako City, Tagajo City, Minamisoma City, and Iwaki City (Figure 2).

At 2:46 p.m., when the earthquake occurred, blood was being collected from 44 donors at 20 of the 28 collection sites mentioned above. Of these 44 donors, 19 had the needle removed while the site was shaking, and 25 were held still while the site was shaking and had the needle removed after the shaking stopped. At a donation room, the room was in complete darkness due to power outage, and the needle was removed in the light of a flashlight. A bed toppled down while a donor was lying on it at a donation room, and one donor was frozen to the spot with horror and crying in the darkness. A member crouched down with the entrance of the toilet. The door was open but the donor could not move without the aid of a person who was crying. A member of the blood collection team piggy-backed the donor to the blood collection team to the toilet in another donation room. Fortunately, no donor was injured. Blood collection was completely discontinued immediately after the earthquake (Figure 3).

Blood collection was being conducted at four sites in the coastal areas, and at three of the four sites the tsunami warning was heard on the radio of the bloodmobile. Only two sites could contact the blood center immediately after the earthquake. Blood donation was completely discontinued immediately after the earthquake, and the bloodmobile left the site at 3:00 p.m. in Iwaki, and 3:10 in Tagajo, both before the flooding. The jack to immobilize bloodmobiles during donation were bent and the bloodmobile left the site at 3:00 p.m. in Iwaki, and 3:10 in Tagajo, both before the flooding. The jack to immobilize bloodmobiles during donation were bent and were not packed into the box correctly in three of the four bloodmobiles.

Not only in coastal areas but also in the city areas around Sendai and Fukushima, the automatic hydraulic jacks of the bloodmobiles did not work, and the vehicles could not move. In Sendai the blood collection team was picked up by a car from the blood center and went back to the blood center, and in Fukushima the team walked back to the blood center because they were nearby (Figure 4).

Blood donation site in Miyako City was located in an inland area, and the team had to go through the urban district in order to go back to the blood center. Tsunami waves of 8.5 m or higher reached beneath the district at 15:26, 40 minutes after the earthquake. The team left the site at 17:48 after the tsunami subsided and drove over muddy roads back to the Iwate Blood Center (Figure 5).

The jack of the bloodmobile in Tagajo City could not be put away into the box due to the earthquake. The team broke the jack by force to move the vehicle. They usually took a coastal route, part of which was a toll road, but they heard the tsunami warning on the radio and took another route through inland areas. They left the site in Tagajo City at 3:10 p.m., and tsunami waves reached there 30 minutes later at around 3:40 p.m. If they had taken the usual route, they might have been engulfed by the tsunami waves. They survived because of their decision to change their return route (Figure 6).

The team in Minamisoma City stopped blood collection when the earthquake hit. The automatic jack of the bloodmobile did not work normally, but they found a workaround solution and were able to leave the site at 4:00 p.m. Tsunami waves had already reached land, but they survived because the donation site was slightly outside the border of the area inundated by the tsunami (Figure 7).
The donation site in Iwaki City was 2.4 km from the seashore. The automatic jack of the bloodmobile did not work normally, but it worked half way. Thus, the team could leave the site promptly (Figure 8).

All blood centers in Tohoku Region discontinued blood donations on March 12, the day after the earthquake. From the following day, on March 13, Aomori, Akita, and Yamagata blood centers resumed blood collection. Miyagi, Fukushima, and Iwate blood centers started receiving donated blood via the Tokyo Metropolitan Blood Center, sent from Blood Centers across Japan, on April 18; the Miyagi Blood Center played a central role for receiving these blood products (Figure 9).

II. Production services

1 Until the earthquake occurred

[Examination department]

In the morning of the day of the earthquake, they started examination of 835 blood units collected in six prefectures in Tohoku region the day before the earthquake. They finished the first steps of the examination including blood typing at around 0:30 p.m. and infection testing with a fully automated chemiluminescence enzyme immunoassay analyzer CL4800 (CL4800 hereinafter) at 2:40 p.m., 6 minutes before the earthquake. They had finished biochemical tests for 827 units except for the remaining 8 units by the time the earthquake occurred. All of employees escaped out of the building because of the long-lasting heavy shake when the earthquake hit.

[Preparation department]

In the morning they separated and prepared 267 units of whole blood collected in the three prefectures of Iwate, Yamagata, and Miyagi the day before, and in the afternoon they started treatments of blood preparation with radiation and processes to make blood products. They finished producing 379 units of red blood-cell products. The earthquake occurred while irradiation was continuing. All employees immediately escaped out of the building.

2 Aftershocks on the day of the main shock

There were many aftershocks (Figure 10). In Sendai, aftershocks occurred nearly every 3 minutes from 2:46 p.m. when the main shock hit until around 4:30 p.m. Aftershocks were strong until around 3:30 p.m. Two of them were scale 4 intensity, eight were scale 3, and four were scale 2, in addition to the main shock which was scale 6 Lower. A few employees of each department went into the building to check the damage at 4:40 p.m. when aftershocks were less frequent. Aftershocks continued throughout the day.

3 Damage in the workrooms

[Examination department]

Things fell on the floor and scattered everywhere (Figure 11). The whole CL4800 system was shifted from its true position, and a leg of the jack to immobilize its centrifuge unit was broken (Figure 13). As for the fully automated blood analyzer PK7300 (PK7300 hereinafter), the motor to push out the plate did not work correctly, and the front cover was open with the wash fluid tank sticking out, so that both CL4800 and PK7300 were unusable for some time.
As for the automated clinical analyzer LABOSPECT 008 (LABOSPECT hereinafter), which has its own internal power supply, it had no apparent problem, although the connection to the CL4800 and the rack for carrying samples were not in their true positions (Figure 14).

[Preparation department]

Amongst the large devices, a platelet bag shaker toppled down, and the breaker of one X-ray blood irradiator was wrecked. Another X-ray blood irradiator in operation was turned off and the drawer was open. Thirteen units of damaged products were handled as impairment loss (Figure 16).

On the day of the earthquake we were able to secure a power supply from a private electric generator, but the water supply was cut off and the supply of city gas we had used for air conditioners was turned off. Since the examination division was on the third floor and the preparation division on the second floor of Miyagi Blood Center, we checked the pipework above the ceiling of the second floor and found that one pipe used for the disposal of infectious medical waste was damaged and leaking (Figure 17).

4 Actions taken after the earthquake

[Examination department]

LABOSPECT continued to be supplied with electricity from its own power supply and was apparently undamaged, as mentioned above. Validation of this with tests of the control blood serum confirmed that LABOSPECT was able to continue its biochemical testing. After the biochemical testing, we turned off the testing apparatus at 9:00 p.m. We contacted the Blood Service Headquarters, reported the situation of the day, and told them that it would be impossible to conduct testing from the next day on.

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**Handling of whole blood received on the day of the earthquake**

*The Miyagi Blood Center resumed tests on April 29 when the Miyagi Blood Center had to transport the samples to Osaka Blood Center, so late that they could not join the cargo which travelled to Osaka. They went to Saitama Blood Center for examination via Yamagata Blood Center and then Niigata Blood Center. Thus, all the samples collected in the six prefectures in Tohoku on March 11 underwent examination (Figure 20).*

**5 Actions taken toward restoration**

Amongst infrastructures and lifelines, the supply of city gas we used for air conditioners was restored on March 27, 16 days after the earthquake (Figure 23, Figure 24).

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**Examination and production of the blood collected in areas under our jurisdiction until the Miyagi Blood Center resumed production services**

<table>
<thead>
<tr>
<th>Preparation services were concentrated</th>
<th>Whole blood</th>
<th>Samples for serological tests</th>
<th>Samples for NAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Preparation department]</td>
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<tr>
<td><strong>Yamagata Blood Center</strong></td>
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<td></td>
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<tr>
<td>Samples for serological tests</td>
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<td></td>
<td></td>
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<tr>
<td>Whole blood</td>
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<tr>
<td>[Preparation department]</td>
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<tr>
<td><strong>Niigata Blood Center</strong></td>
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<td></td>
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<tr>
<td>Samples for serological tests</td>
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<tr>
<td><strong>Saitama Blood Center</strong></td>
<td></td>
<td></td>
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<tr>
<td>Samples for serological tests</td>
<td></td>
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<tr>
<td><strong>Tokyo Metropolitan Blood Center</strong></td>
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<tr>
<td>Samples for serological tests</td>
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<tr>
<td><strong>Akita Blood Center</strong></td>
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<td>Samples for serological tests</td>
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<tr>
<td><strong>Aomori Blood Center</strong></td>
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<td>Samples for serological tests</td>
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<tr>
<td>*** and Akita Blood Center**</td>
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<tr>
<td>Samples for serological tests</td>
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</tbody>
</table>

* The Miyagi Blood Center resumed tests on April 29 when the Tohoku Super Express service from Aomori was resumed.

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**Production on the day of the earthquake**

<table>
<thead>
<tr>
<th>9:00</th>
<th>12:30</th>
<th>13:30</th>
<th>14:46</th>
</tr>
</thead>
<tbody>
<tr>
<td>Started</td>
<td>Finished</td>
<td>Separation and preparation</td>
<td>Whole blood for separation and preparation at Iwate, Yamagata, and Miyagi Blood Centers</td>
</tr>
<tr>
<td>Whole blood collection</td>
<td>Number of bottles</td>
<td>Type of blood collection</td>
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<tr>
<td>200</td>
<td>400</td>
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<tr>
<td>PPP</td>
<td>PPP</td>
<td>PPP</td>
<td></td>
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<tr>
<td>Total</td>
<td>267</td>
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</tbody>
</table>

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**Actions taken to resume production services**

- **Lifelines**
  - Electricity 3/11(1day)
  - Water 3/21(1day)
  - City gas 3/30(1day)
- **Building and facilities**
  - Repaired the pipework for disposal of infectious medical waste. 3/14(3day)
  - Inspected the treatment unit for disposal of infectious medical waste. 3/14(3day)
- **Contractors**
  - Cleaning 4/4(24day)
  - Collected infectious medical waste. 3/13(2day)

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**It was decided that the samples brought to Miyagi Blood Center should be examined at Osaka Blood Center, and they were carried to Yamagata Airport by an employee of Miyagi Blood Center. The flight, however, did not accept any cargo due to a change of aircraft. Therefore, the samples had to be delivered by land. They arrived in the Osaka Blood Center at 3:30 a.m. on March 13. Other samples from 12 donors were brought to the Miyagi Blood Center so late that they could not join the cargo which travelled to Osaka. They went to Saitama Blood Center for examination via Yamagata Blood Center and then Niigata Blood Center. Thus, all the samples collected in the six prefectures in Tohoku on March 11 underwent examination (Figure 20).**

Handling of the blood collected in the Tohoku region on and after March 13 was divided as follows until the Miyagi Blood Center resumed manufacturing: For the blood collected at Yamagata Blood Center, manufacturing services were carried out at Niigata Blood Center, with materials and samples being sent from Yamagata Blood Center to Niigata Blood Center. Serological tests were conducted at Saitama Blood Center. NAT was conducted at Tokyo Metropolitan Blood Center by sending the samples for NAT to Tokyo. On the other hand, for the blood collected at Aomori and Akita blood centers, samples were sent to Tokyo and underwent serological tests and NAT there (Figure 21).

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**[Preparation department]**

The whole blood collected in Miyagi, Yamagata, and Iwate was brought in much later than scheduled. Whole blood in 177 units was separated by 2 employees from 1:00 midnight to 7:00 in the morning. Platelets collected by apheresis were prepared on March 12, irradiated on March 13, and made into products on March 13 and 14 (Figure 22). The blood collected at Akita and Aomori blood centers on March 11 was separated, prepared, and made into products at Miyagi Blood Center.
Problems in Securing Donors and Supplying Blood Products during the Nuclear Disaster

Toshiya Ichinowatari,
Deputy Director of Management Division, JRC Fukushima Blood Center

I. Introduction
As a result of the unprecedented earthquake and the subsequent nuclear accident, Fukushima Prefecture was devastated. The effect is still immeasurable. It seems that it will take a long time to deal with the effects of the nuclear accident. Under these circumstances, I report on the securing of donors and the supply of blood products in the area (Figure 1).

II. Post-disaster situation and measures taken

Japan issued the first “declaration of a nuclear emergency” right after the nuclear power station was hit by a tsunami on March 11. The effects of the accident caused increasing damage as time went by. The area within a 20 km radius of the Fukushima Daiichi Nuclear Station of the Tokyo Electric Power Company was designated as an “evacuation zone,” and an area within a radius of 20 to 30 km an “emergency evacuation preparation zone” (Figure 2).

Repair, inspection, and validation of testing apparatus was completed on April 4, 24 days after the earthquake. As for preparation apparatus, the measurement of dose distribution and leakage radiation of X-ray blood irradiators was completed on April 5, 25 days after the earthquake, and inspection of the large centrifuge unit was completed on the same day. On April 7 when we were about to resume manufacturing services, an aftershock of level 6-lower occurred. Therefore, we had to repeat the inspection of the apparatus and confirm that it all functioned normally. We resumed manufacturing services on April 12 after re-inspecting the apparatus and the pipework (Figure 25, Figure 26).

We would like to thank you for your assistance and cooperation after the earthquake. We are extremely grateful.
We immediately closed the Haranomachi Supply Station, the facility closest to the nuclear station, and decided to provide blood products to medical institutions using “takeout blood” from the Fukushima Blood Center (Figure 3). Blood donation had to be suspended immediately after the accident. Blood collection services at Fukushima Blood Center and the other permanent facilities were resumed on April 18, and the activities of bloodmobiles resumed on May 1. The employees engaged in the services dealing with the disaster all had “direct-reading personal dosimeters” to prepare for any unexpected accident (Figures 4-6).

III. Trends in supply and demand of blood products for transfusion

Under the wide-area supply and demand management system established immediately after the earthquake, we successfully provided blood products to medical institutions with support from blood centers in other prefectures (Figure 7). In March, the receipt of blood products for transfusion under this system amounted to 10,649 units, 53.4% of the total of 19,960 units that were distributed. Trends in supply and demand of blood products changed after the earthquake. Even now, seven months after the occurrence, demand for blood products (red blood cell products, platelet products and plasma products) has not reached 90% of the demand during the same month in the previous year. This demonstrates the extent of the damage to medical institutions (Figures 8, Figure 9).
IV. Blood donation during the disaster and future forecast

The administrative functions of eight municipalities in the Hama-dori area of the evacuation zone and the emergency evacuation preparation zone were moved to other prefectures, and approximately 137,000 people in Fukushima Prefecture were forced to evacuate (Report of the Fire and Disaster Management Agency, the Ministry of Internal Affairs and Communications dated March 16, 2011). Part of another town and a whole village were also newly designated as an “emergency evacuation preparation zone,” and there was concern about increasing damage. This greatly affected the securing of donors after the earthquake (Figure 10). In particular, whole blood donation at bloodmobiles was significantly affected. Figure 11 shows the changes in the quantity of donated blood by site in the first half of the fiscal year from 2008 to fiscal year 2011. The “Share Blood in the Spirit of Love Campaign” had usually been conducted in cooperation with thirteen cities in Fukushima Prefecture, but the campaign was discontinued at some sites or conducted on a smaller scale this year, which resulted in 19.7% year over year reduction in donated blood. A site that had usually been used for the campaign had become an evacuation shelter and the campaign could not be conducted there. In general, a trend toward reduction was seen (Figure 11). The quantity of donated blood during the first half of the current fiscal year (April to September 2011) was 44,829 units. Although this amount exceeded the target goal of 42,417 units (which had been revised from the initial goal after the earthquake) by 5.7 percentage points, the achievement rate of the initial goal was only 66.6% (Figure 12).

We are now trying to make a yearly forecast on the collection and distribution of blood based on the results so far. We forecast a 10.9% reduction in distribution and a 24.2% reduction in collection. The ratio of collection to distribution is forecasted to be 89.6%, falling short of the initially planned 105.2%. It is very unlikely that the collected blood will reach the quantity required for supply in Fukushima prefecture (Figure 13).

As mentioned earlier, we are under unprecedented and difficult circumstances including the invisible and largely unquantifiable obstacle of “nuclear disaster.” We may be able to return to the starting point of blood donation services only when appropriate measures against radiation contamination etc. are taken as necessary, and people can recover their livelihood. We must take steady steps to secure donors by seeking as many ways as possible to return to the pre-earthquake situation (Figure 14, Figure 15).

V. Our services and the action taken during the nuclear disaster (related to Figures 5 and 6)

A number of blood centers are similarly located to us (i.e. with the presence of a nuclear station within the center’s jurisdiction) in Japan. In this section, I describe our services and the actions taken from the time when the disaster occurred up to the present and hope that what we have done will assist in the consideration of appropriate measures in the future.

Depending on the groundless “myth of safety,” we did not have any risk management policy in place to prepare for a nuclear disaster. The disaster occurred in these circumstances, and we have to admit that many of our counter-measures were one step behind. First, the off-site center was closed and became inactive, because it was located 15 km west of the Fukushima Daiichi Nuclear Station, and was therefore within the 20 km emergency evacuation zone declared on March 14, 2011. Therefore, we contacted the Blood Services Headquarters and received instructions from them thereafter. The Blood Service Headquarters lent us direct-reading personal dosimeters on March 15, and the employees in the supply division began to take a long time and much effort to resume blood donation activities while living one’s life with peace of mind.

Planned number of units to be distributed and collected before and after the earthquake (as of October 1, 2011)

<table>
<thead>
<tr>
<th>Month</th>
<th>Forecasted number of units to be collected:</th>
<th>Forecasted number of units to be distributed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 2010</td>
<td>87,769 units</td>
<td>121,740 units</td>
</tr>
<tr>
<td>April 2011</td>
<td>44,829 units</td>
<td>66,795 units</td>
</tr>
</tbody>
</table>

Demand for blood products for transfusion

Some medical institutions were forced to close or downscale significantly, and many doctors and nurses are leaving their jobs. We cannot expect that the supply of blood products will return to the previous level.

Blood donation activities while living one’s life with peace of mind

It is said that the nuclear disaster does not immediately damage health, except in the controlled areas (the evacuation zone, etc.) and certain other areas. A “Prefectural People’s Health Management Survey” is being conducted, and areas with a certain level of radiation are uninhabitable until “decontamination” is conducted. It will take a long time and much effort to resume blood donation activities while living one’s life with peace of mind.

Challenges in securing donors

Long-term decrease in the number of donors due to the earthquake (and nuclear accident)

- Many people lost their livelihood due to the earthquake (and nuclear disaster) and had to evacuate to other areas in- and outside Fukushima Prefecture.
- The administrative functions of nine municipalities had to be moved.
- Difficulty in cooperating with blood donation
- Blood donations from employees of nuclear stations became impossible. (There were 1,222 employees who donated 2,263 units of blood in FY 2010)
carry them on the same day while they conducted services in accordance with the Guidelines for Risk Management of Blood Services, Chapter 8: Radiation Accident. Five dosimeters were lent as shown in Figure 6. Two of them were used by the distribution division of Iwaki Blood Center, two were used at the Fukushima Blood Center, and the last one at the Koriyama Supply Station.

In the guidelines there are instructions that ① an employee should carry a “direct-reading personal dosimeter” while conducting services in response to requests from medical institutions located in an area where an evacuation order or instructions to stay indoors is issued, ② an employee should ask the Self Defense Force etc. to deliver blood products and hand the products over to them if the delivery vehicle enters the 30 km zone, and ③ the employee should promptly discontinue the service and escape to a safe place if the integrating dosimeter reading exceeds 20 mSv.

We continued to use the dosimeters until March 18, but they never sounded an alarm. The doses were not recorded during the period. We understood that 20 mSv was reasonable as a reference value for the following reasons. The “20 mSv” was common to two values, namely, the lower limit in the emergency phase (20 to 100 mSv/year) and the upper limit for the restoration phase after the conclusion of an accident (1 to 20 mSv/year) in the recommendations issued by the International Commission on Radiological Protection (ICRP) in 2007. Article 4 of the Ordinance on Prevention of Ionizing Radiation Hazards (Ordinance No. 5 of the Ministry of Health, Labor, and Welfare) also specifies that an effective dose limit for a radiation worker should be 100 mSv or less over 5 years, and it can therefore be assumed that the permissible limit for 1 year is 20 mSv. The Disaster Response Committee of our blood center decided to use radiation dosimeter badges that had been used in the production division and measure the personal exposure dose of the employees of other divisions as well to verify the safety. We distributed the badges to 47 employees of the blood collection division on March 18. We distributed more badges to the employees of the blood collection division on March 22. The number of employees with a badge was 65 in total (46.8% of all employees). The badges were used for measurement until June 30. The maximum value of external exposure measured during the period was 800 μSv. However, the measurement limit or the cut-off value of the badge was 100μSv, which is relatively higher than other devices, which meant doses lower than that might not be measured or not be accumulated. We therefore introduced electric personal dosimeters from May 19 onwards.

Each team of employees, mainly from the operations, blood collection, and medical information divisions who spent a lot of time outdoors, carried the new device while they were engaged in services. The teams recorded the dose value of the day when they came back to the blood center, and the monthly accumulated dose for each employee was obtained by adding up the differences between the readings on the day and the day before. This value was used as an index of health management. The accumulated dose was measured for 120 employees from May 19, 2011 to February 29, 2012 (86.3% of the employees carried the electric personal dosimeters). The maximum accumulated personal dose recorded was 474 μSv. Although the period from March 18, 2011 to June 30, 2011 (when radiation dosimeter badges were used) partly overlapped with the period from May 19, 2011 to February 29, 2012 (when electric personal dosimeters were used), the maximum accumulated dose over about 11 months (from the start of measurement with dosimeters up to the present [February 29, 2012]) was 952 μSv. However, the measurements were not taken during the period from the evening on March 15 to March 17. During that period high doses might have been measured due to a hydrogen explosion at Unit 3 of Fukushima Daiichi Nuclear Station. All employees also did not carry dosimeters from the beginning as mentioned earlier. The accumulated dose for each employee was managed collectively at the administrative division as personal information. Of course, changes in the value for each employee must continue to be closely observed from now on as well.

For your reference, the latest averages (average of the last week of February 2012 [February 23 to 29]) of the environmental radioactivity in seven areas of Fukushima Prefecture are as follows.

- Fukushima City: 0.71 μSv/h (normal value: 0.04 μSv/h);
- Koriyama City: 0.60 μSv/h (normal value: 0.04-0.06 μSv/h);
- Shirakawa City: 0.31 μSv/h (normal value: 0.04-0.05 μSv/h);
- Aizuwakamatsu City: 0.11 μSv/h (normal value: 0.04-0.05 μSv/h);
- Minamiaizu-machi: 0.07 μSv/h (normal value: 0.02-0.04 μSv/h);
- Minamisoma City: 0.37 μSv/h (normal value: 0.05 μSv/h);
- Taira, Iwaki City: 0.17 μSv/h (normal value: 0.05-0.06 μSv/h).

(Source: Fukushima Prefecture radiation map)
Sixteen years have passed since the Great Hanshin-Awaji Earthquake occurred (Figure 1).

It was a huge earthquake with a magnitude of 7.3 directly beneath a major city that hit the urban areas directly and recorded intensity level 7 (Figures 2 to 4).

Comparing the Great Hanshin-Awaji Earthquake with the Great East Japan Earthquake, there are differences in the types of damage and fatality. Numbers of casualties and buildings completely or partially burned show that more people were injured due to collapsed buildings, etc. in the former, while more people were killed or missing and more buildings were completely or partially destroyed due to the tsunami, rather than shaking, in the latter (Figures 5 to 7).

### Outline of the earthquakes

**Great Hanshin-Awaji Earthquake**
- Date: Tuesday, January 17, 1995 at 5:46 a.m.
- Epicenter: Northern part of Awaji Island
- Magnitude: M 7.3
- Seismic intensity: 7 at some places between Osaka and Kobe, and on Awaji Island
- Type: Inland (urban area) earthquake directly beneath a city
- Disaster area: Hyogo, Osaka, and Kyoto prefectures

**Great East Japan Earthquake**
- Date: Friday, March 11, 2011 at 2:46 p.m.
- Epicenter: Off the Sanriku coast on the Pacific
- Magnitude: M9.0
- Seismic intensity: 7 (Kurihara City, Miyagi Prefecture)
- Type: Trench-type, reverse-fault earthquake
- Disaster area: Very large area from the Tohoku to the Kanto district
- Secondary disaster: Huge tsunami, Nuclear station accident

### Damage

#### Great Hanshin-Awaji Earthquake (as of October 5, 2011)
- **Dead**: 6,434 (1)
- **Missing**: 3
- **Injured**: 43,792 (8)
- **Houses completely or partially burned**: 7,483
- **Houses completely or partially destroyed**: 249,180 (38)
- **Evacuees**: 316,678 (43)
- **Total amount of damage**: Approximately 10 trillion yen

#### Great East Japan Earthquake (as of October 6, 2011)
- **Dead**: 15,821
- **Missing**: 3,929
- **Injured**: 5,940
- **Houses completely or partially burned**: 298,408
- **Houses completely or partially destroyed**: 278
- **Evacuees**: More than 400,000
- **Total amount of damage**: Approximately 16-25 trillion yen

Numbers in parentheses indicate affected employees.

### Heavily damaged areas

As for us, one part-time doctor died and eight employees were slightly injured, thirty eight houses were completely or partially destroyed, and 14 employees were forced to evacuate and live at shelters for the staff of the Hyogo Blood Center (Figure 8, Figure 9).

The building of the blood center was 16 years old. Damage to the building structure was not great, but the damage inside the building was considerable. Things were scattered everywhere and many pieces of apparatus had fallen down and were damaged. In particular, a platelet bag shaker in the preparation division toppled down and the content of the platelet bag splashed out. A blood-delivery vehicle also dropped down from an underground multi-story parking garage (Figure 10, Figure 11).

### Employees affected by the earthquake

<table>
<thead>
<tr>
<th>Details</th>
<th>Great Hanshin-Awaji Earthquake</th>
<th>Great East Japan Earthquake (as of October 5, 2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead</td>
<td>6,434 (1)</td>
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</tr>
<tr>
<td>Missing</td>
<td>3</td>
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</tr>
<tr>
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</tr>
<tr>
<td>House completely or partially burned</td>
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<tr>
<td>Evacuees</td>
<td>316,678 (43)</td>
<td>More than 400,000</td>
</tr>
</tbody>
</table>

### Damage to our facilities and equipment

- **Underground garage**: Distribution vehicle dropped down from a two-story parking structure
- **Office**: Building that housed the Sannomiya Donation Room
- **Testing room**: 4th floor was flattened.
San Plaza Donation Room, located in Sannomiya, the central part of Kobe City, could not be used because the building housing the donation room was crushed at the 4th floor, though the damage of the 2nd floor was much less. The other 2 donation rooms were not badly damaged, only apparatuses were slightly damaged and things were scattered across the rooms (Figure 10, Figure 11).

It took almost 18 hours for the electricity supply, 8 days for the water supply, 48 days for gas, and more than 15 hours for the telephone lines to be restored (Figure 12).

The whole blood products, red blood cell products, and plasma products in the blood center were spared from any damage because ice and dry ice were immediately supplied to the storage facilities and the contractor provided an emergency repair service for the refrigerating system. However, 1,000 units of platelet products were damaged because the platelet bag shakers toppled down and stopped functioning (Figure 13).

A total of 640 units of whole blood and red blood cell products and plasma products stored at medical institutions were damaged. There were about 2,900 medical institutions in Hyogo Prefecture at the time of the earthquake, and about 1,500 of them (about 51%) stopped functioning. Some buildings of them were completely or partially destroyed (Figure 14).

It is important to maintain the facilities and system for storing blood products and give the highest priority to blood supply as the initial response to the earthquake. We built a delivery system involving 53 employees (about 25%) who could come to the blood center on the day of the earthquake.

We supplied blood products by making a round, visiting major medical institutions because the telephone lines were cut. About 1,700 units were distributed to 56 hospitals, accounting for 65% of the blood products distributed on the day of the earthquake. We believe that this was a very important initial response (Figure 15).

Compared to the same period the previous year, about 67% of blood products were supplied during the 2-week period after the earthquake, and about 70% to 90% during the 2-month period (Figures 16-19).

**Impact on lifelines**

**Details**

<table>
<thead>
<tr>
<th>Electricity</th>
<th>Period during which the service was suspended and the situation</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>From January 17, at 5:46 to January 18, at 0:03</td>
<td>Power outage continued. Private power generator was started. Employees on duty reported the situation. 7:00-9:00</td>
<td>Employees who could commute arrived, and started visual observations and took initial measures. 9:00</td>
</tr>
</tbody>
</table>

**Water**

| From January 17, at 5:46 to January 18, at 0:03 | 8 days | 18 hrs 17 mins |

**Gas**

| From January 17, at 5:46 to January 18, at 0:03 | 48 days | 15 hrs 10 mins |

**Telephone lines**

| From January 17, at 5:46 to January 18, at 0:03 | 11:45 | 18 hrs 17 mins |

**Distribution service after the earthquake**

1. **Distribution service on the day of the earthquake**

   Medical institutions where we made a round of visits
   56 hospitals 72 deliveries 1,069 units
   Total deliveries on the day of the earthquake 107 deliveries 1,637 units

   (Results for January compared to the same month the previous year, 105.4% [before the earthquake], 98.9% [after the earthquake])

2. **Support from neighboring blood centers**

   Osaka Blood Center (Jan. 17-19) 7 deliveries 166 units
   Tokushima Blood Center (Jan. 17-28) 7 deliveries 108 units

**Damage to blood products (at medical institutions)**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Number of damaged products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole blood products</td>
<td>1 unit: 27 bottles, 27 units</td>
</tr>
<tr>
<td>Red blood cell products</td>
<td>2 units: 83 bottles, 166 units</td>
</tr>
<tr>
<td>Plasma products</td>
<td>1 unit: 99 bottles, 99 units</td>
</tr>
</tbody>
</table>

**Products in stock on the day of the earthquake**

- Plasma products: stock for about 4 days
- Red blood cell products: stock for about 1 month
- White blood products, red blood cell products, and plasma products were spared from damage because ice and dry ice were immediately supplied to the storage facilities.

**Figure 11**

Director general’s office

**Figure 12**

Impact on lifelines

**Figure 13**

Damage to blood products (at the blood center)

<table>
<thead>
<tr>
<th>Product name</th>
<th>Number of damaged products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platelet products</td>
<td>5 units: 24 bottles, 120 units</td>
</tr>
<tr>
<td></td>
<td>10 units: 45 bottles, 450 units</td>
</tr>
<tr>
<td></td>
<td>15 units: 25 bottles, 375 units</td>
</tr>
<tr>
<td></td>
<td>20 units: 9 bottles, 180 units</td>
</tr>
<tr>
<td>Total</td>
<td>103 bottles, 1,125 units</td>
</tr>
</tbody>
</table>

**Figure 14**

Catastrophic damage to Kobe City Medical Center West Hospital (370 beds)

**Figure 15**

Initial reaction immediately after the earthquake

**Figure 16**

Damage to blood products (at medical institutions)
As for blood collection activities, we reopened the Tsukaguchi Blood Donation Room in Amagasaki City and the Driver’s License Center Blood Donation Room 20 days after the earthquake, and they were manned mainly by employees living near the blood centers. Bloodmobiles were resumed 34 days after the earthquake. They were first dispatched to sites located in the northern part of our jurisdiction, where the damage was relatively small, and then gradually to other sites between Osaka and Kobe.

San Plaza Donation Room in Sanno-miya was moved to an adjacent building because the building that had housed the room had collapsed. It was reopened on August 10, which was 205 days after the earthquake.

We dispatched seven nurses to the Osaka Blood Center for two weeks because the number of donors visiting the center increased sharply (Figure 20).

To conclude, as the response to the earthquake, the most important thing was to store and supply blood products appropriately, and then to secure adequate manpower, provide appropriate maintenance and management of facilities and apparatuses, report to the Blood Service Headquarters, and co-operate with neighboring blood centers and JRC chapters, as well as recording any damage and dealing with the mass media.

It was entirely due to support from other blood centers across Japan that we could manage all of these tasks. We appreciate the importance of the Red Cross network (Figure 21, Figure 22).

### Actions taken at the time of the earthquake

**Supply and demand control after the earthquake**

<table>
<thead>
<tr>
<th>Details</th>
<th>Number of supplies (units)</th>
<th>Year-over-year rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma products</td>
<td>6,384</td>
<td>115.8%</td>
</tr>
<tr>
<td>Whole blood, red</td>
<td>7,941</td>
<td>101.7%</td>
</tr>
<tr>
<td>blood cell products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Platelet products</td>
<td>5,586</td>
<td>102.3%</td>
</tr>
<tr>
<td>Plasma products</td>
<td>4,936</td>
<td>69.6%</td>
</tr>
<tr>
<td>Whole blood, red</td>
<td>8,682</td>
<td>100.3%</td>
</tr>
<tr>
<td>blood cell products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Platelet products</td>
<td>6,601</td>
<td>100.3%</td>
</tr>
<tr>
<td>Subtotal</td>
<td>21,141</td>
<td>105.4%</td>
</tr>
<tr>
<td>Total</td>
<td>38,775</td>
<td>83.5%</td>
</tr>
</tbody>
</table>

**Details**

- **Before the earthquake**
  - Plasma products: 6,384 units, 115.8% increase
  - Whole blood, red blood cell products: 7,941 units, 101.7% increase
  - Platelet products: 5,586 units, 102.3% increase

- **After the earthquake**
  - Plasma products: 4,936 units, 69.6% decrease
  - Whole blood, red blood cell products: 8,682 units, 100.3% increase
  - Platelet products: 6,601 units, 100.3% increase

**Number of deliveries**

- Total number of deliveries (emergency) 7,804 per day
- Average deliveries per day before the earthquake: 81/285
- Average deliveries per day after the earthquake: 91/23

**Maintenance and management of blood products and equipment**

- (1) Installed a temporary pump for the cooling tower (storage facility of blood products).
- (2) Contacted the Kansai Electric Power Company, the Waterworks Bureau, and contractors including apparatus manufacturers, and requested restoration.
- (3) Restored the unified system.
- (4) Asked the building contractor to confirm the damage to the equipment.
- (5) Examined the damage to buildings, equipment, and vehicles.

**Resumption of blood donations**

February 6 (Mon.) 20 days after the earthquake

Akashi Driver’s License Center, donation room

*Manly mainly by employees living near the rooms.

February 20 (Mon.) 34 days after the earthquake

BLOODMOBILES (dispatched 3 bloodmobiles on the day)

Dispatched to the sites in the north-western part of our jurisdiction in February, to other sites between Osaka and Kobe in March, and to the Awaji area in April. Achieved 90% of the target of dispatch.

August 10 (Thu.) 205 days after the earthquake

The San Plaza donation room in Sannomiya moved to an adjacent building and was reopened.

**Actions taken at the time of the earthquake**

- Contacted the Blood Service Headquarters, reported the situation, and received instructions.
- Coordinated with neighboring blood centers.
- Co-operated with others.
- Reported to the chapter and confirmed the situation.
- Confirmed the (personnel) support system as the Red Cross organization.
- Received the damage and damages taken.
- Co-operated with the prefectural chapter.
- Report to the Blood Service Headquarters, confirmed the situation.
- Contacted the Blood Service Headquarters, reported the damage, and received instructions.
- A temporary support system immediately after the earthquake
  - A temporary support system centered around the Osaka Blood Center because the damage at the Osaka Blood Center was unknown.
  - A support system for the Osaka Blood Center, centered around Tokyo Metropolitan Blood Center.
- Supply and demand control after that
  - Co-ordinated with other blood centers.
  - Co-ordinated with neighboring blood centers.
  - Co-ordinated with the prefectural chapter.
  - Co-ordinated with the prefectural chapter.
  - Co-ordinated with other blood centers.
Although we needed to make some improvements, first, we reviewed the role of emergency priority telephone lines and increased the lines to secure means of communication with medical institutions.

Secondly, we felt the need to prepare a disaster manual for each regional blood center, or indeed the entire nation. This need was met by the risk management guidelines provided by the Blood Service Headquarters. To secure manpower in the initial stage, we conducted emergency training to pass on instructions and call out the employees by area, but the problem was that we did not continue the effort. We are making efforts to raise awareness among the employees by having them participate in the training proactively and by promoting the registration of aid workers (Figure 23).

We also faced the important challenge of taking proactive measures to extend working spaces and prepare for prompt recovery from potential damage to one of the facilities. Hyogo Prefecture and the JRC Hyogo Chapter conceived the idea of establishing a joint facility as a disaster preparation base, and also made a plan to secure blood products and vehicles, evacuate the employees, secure the necessary manpower to deal with the emergency, and provide a facilities management system. It is also necessary to have our own back-up measures for the information system (Figure 24).
We, as members of a blood center that experienced the Great Hanshin-Awaji Earthquake, will continue to learn lessons by reflecting on our actions at the time of the disaster, utilizing our experience of restoration, and making the necessary improvements, while making further efforts to study disaster control and risk management (Figures 28-30).

Friday, August 19, 2011 Kobe Shimbun

Huge earthquake; epicenter, activity similar to that in the 9th century

"Nankai" and others may hit serially; experts warning

"West Japan is next"

Then, we as a blood center need to:
1. Establish an emergency response headquarters (to collect and share information) and contact and report to the JRC Headquarters, the blood service headquarters, and the prefectural chapter
2. Store blood products properly, and secure blood products (supply and demand control)
3. Provide a stable supply (means of transportation, routes) *Measures for remote islands and mountainous areas
4. Secure adequate manpower (firstly the personnel necessary for supply at a blood center in the affected area)
5. Establish a system to conduct blood donation activities (confirm the situation in the affected area and establish a support system by blood centers in other areas)
6. Receive aid materials such as water, ice, dry ice, gasoline, food, etc. through the network of neighboring blood centers and blood centers across Japan
7. Maintain and manage facilities and apparatuses, and
8. Stay on the alert for tsunami waves! (Especially at blood centers in coastal areas)

Consider necessary measures, prepare manuals and conduct trainings.

Tonankai / Nankai earthquake hits!

January 23, 2010
(15 years after the earthquake)
Opened "Shin-Nagata Tetsujin-mae Donation Room" in heavily hit Nagata-ku, Kobe City
Area of 310.1 m²
10 beds (8 beds for apheresis donation)