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Review

Chinese Public Health Response to Accident at Fukushima Daiichi Nuclear Power Plant

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On March 11, 2011, a powerful magnitude 9 earthquake caused a substantial tsunami off the northeastern coast of Japan which had a disastrous impact upon the Fukushima Daiichi nuclear power plant, which was to attract worldwide attention. The Chinese Center for Medical Response to Radiation Emergency (National Institute for Radiological Protection, Chinese Center for Disease Control and Prevention (CDC)) carried out the public health response to Fukushima Daiichi accident and had excellent results due to appropriate organization, a timely response, accurate analysis and judgment, decisive support and scientific decision-making and recommendations. The public health response covered risk communication, the measurement of food, drinking water, and monitoring body surface contamination. The response was a field trial of the preparedness of the response system to a nuclear accident and a capacity test on the surveillance and monitoring of public health in China. The response also revealed some problems in the preparedness of the response system to a nuclear accident.

Key words: Fukushima, nuclear accident, risk communication, monitoring of food and water

1. Introduction

At 14:46 (Tokyo time) on March 11, 2011, a massive magnitude 9.0 earthquake occurred off the coast. This caused a tsunami which struck the northeastern coast of Japan, resulting in 15,843 deaths, 469 people missing and immense property damage. A tsunami approximately 15-meters high caused the submergence of the cooling system and a hydrogen explosion at four units at Fukushima Daiichi Nuclear Power Plant, causing the release of large amounts of radioactive isotopes equivalent to $(3.7\text{-}6.3) \times 10^{17}$ Bq ^{131}I. On April 12, the Ministry of Economy, Trade and Industry (METI) declared this event to be a major accident, Level 7, as described in the International Nuclear and Radiological Event Scale User's Manual (INES). This accident also triggered the release into the hydrosphere of 520 tons of high level radioactive waste water and 1.15 tons of low level radioactive waste water. As instructed by Japanese Government and Fukushima Prefecture, an evacuation was launched at 20:00 on April 11, 2011. A total of 210,000 residents within 20 km of the plant site were evacuated. On April 15, the residents within 20-30 km zone were required to shelter as appropriate. On the night of April 18, a decision was made to evacuate all of 1100 patients hospitalized in the 20-30 km zone. On April 25, the residents who were instructed to stay inside their houses within 20-20 km zone voluntarily evacuated. In other

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adjacent areas, some residents also voluntarily evacuated. Even in the more remote areas some residents evacuated. The huge amount of radioactive material released resulted in contamination of the air and surface water in a vast area. The radioactivity level increased significantly. On the 9th day after the accident occurred, radioactive contamination was detected in drinking water, vegetables and milk in the vicinity of Fukushima site and continued to extend to up to 600 km away from the plant. Food and drinking water produced locally was banned from the market and consumption because the radioactivity levels were in excess of the relevant interim limits. As of early May, imports of vegetables and other food produced in the 12 local counties in Japan were prohibited by other countries.

The public health response to the Fukushima Daiichi Nuclear Power Plant accident by the Chinese Center for Medical Response to Radiation Emergency & National Institute for Radiological Protection, China CDC was excellent due to appropriate organization, a timely response, accurate analysis and judgment, decisive support and scientific decision-making and recommendations.

2. Public health response in China

Organization, Food and Water Measurement, and Contamination Monitoring

Over the night of March 11, 2011 while the accident was occurring, the medical and public health emergency response was launched in China by the Chinese Center for Medical Response to Radiation Emergency (CCMRRE), namely National Institute for Radiological Protection, China CDC (NIRP/CDC), which included setting up the leading groups for coping with the Japan earthquake and the Fukushima accident, assembling international medical rescue teams, activating information collection, analysis and judgment on the accident, compiling special topic reports provided to the leaders of the Ministry of Health (MOH), and drafting the *Measurement of Radionuclides in Food and Drinking Water and Monitoring and Treatment of Radioactive Contamination to the Human Body Surface* to guide the response at the provincial level. The professional staff in radiological health agencies from 14 coastal or eastern provinces received emergency training on radioactivity monitoring for food and drinking water. As mandated by the MOH, an initiative to monitor radioactivity levels in food and drinking water was officially launched in several regions of China on March 26. The monitoring results were analyzed scientifically and provided to the MOH and the general public in a timely manner[1]. On March 28, the monitoring of radioactive contamination to the human body surface for the returnees from Japan was initiated, in which a total of 432 persons were monitored by 31 health agencies of 27 provinces or municipalities, with 3 people who has abnormal levels of radioactive contamination being treated appropriately[2].

Radionuclides released from the accident were scattered globally through atmospheric circulation. In China, aerosol monitoring was activated by the CDC. Trace amount of ^{131}I (0.102 Bq/m^3), as a single nuclide, was detected in air samples on March 25 at Beijing Monitoring Station in Beijing Center for Disease Control and Prevention, a subsidiary to the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO). ^{131}I concentration reached a peak between the 22nd and 29th days following the accidents occurrence and then fell back to normal levels on the 40th day[3]. Trace of ^{131}I, in the range of 10^{-4}-10^{-5} Bq/m^3, was detected in aerosol samples from Heilongjiang province among others by some local environmental protection agencies. After April 4 a succession of reports from the CDC and other agencies identified that, trace of ^{131}I had been detected in samples of spinach growing in various localities, the levels of which were consistent with those estimated by using a deposition model. By December 15, the measurement of radionuclides in food had been carried out in 22 provinces for 831 sort of food. Trace of ^{131}I was reportedly measured in vegetables in 12 provinces, with maximum of 3.1 Bq kg^{-1}. Usually, no ^{131}I will be detected in vegetables that have been washed so there was no danger to the public[4].

Risk communication

In contrast, when the Chernobyl accident occurred in April 1986, the monitoring results from the health agencies of China indicated that air, food and drinking water had suffered from severe radioactive contamination[5]. However, this situation was not broadly reported in the media, thus receiving less attention from the public at that time. Whereas this time there was an acute concern about the Fukushima accident, a full range of reports including live ones were made on the incident, covering both the Tohoku earthquake and the subsequent tsunami, on the China Central Television (CCTV) news channel and in other major media. Nuclear professional personnel and the general public witnessed these events. The general public in China has a fear of the possible health impacts resulting from a nuclear disaster occurring in a neighboring country. In order to address the concerns of the public and to provide them with accurate media guidance, the experts of the CDC conducted a wide variety of response activities, such as making scientific summaries, analysis and judgment on relevant information collected, determining whether health impacts had been presented to the public on a scientific assay basis, preparing accurate and key information points for communication to the

public through the media, accepting interviews by CCTV, the timely releasing of news on the MOH and the CDC websites, and publishing scientific information brochures. The experts at the CDC received not less than 150 interviews from more than 20 central and foreign news media outlets. These efforts greatly contributed to effective publicity, media communications and information issues, thus allaying the fears of the public and avoiding people's panic buying iodized salt, and as a result played an important role in maintaining social stability[6].

International communication

On October 18, 2011, a China-Japan-South Korea Workshop on Fukushima Accident was hosted by the International Cooperation Department, MOH. The representatives from these three countries presented their public health actions and their experiences gained in response to the accident respectively. Similar public health actions were carried out in South Korea and in the Taiwan regions of China. In South Korea, biological dose estimation was also done for the rescue personnel at Fukushima.

Influence on the development of nuclear power plants

Over the past 25 years since the Chernobyl nuclear power plant accident, many countries have adjusted their energy policies and decided to continue the expansion of nuclear energy. The major accident that occurred at the second generation nuclear power plant at Fukushima has had a profoundly adverse influence, with the lessons worthy of being learned. On March 16, 2011, the State Council of China, convened the meeting of Standing Committee with a focus on the top priority of nuclear safety in developing nuclear power, by comprehensively scrutinizing the nuclear facilities in operation or under construction, by preparing a nuclear safety program as quickly as possible, by adjusting and improving the mid- and long-term nuclear power vision, and by suspending the construction licensing of nuclear power projects including those whose early preparatory work was already underway. On November 24, at the executive meeting of the State Council, China decided to restore normal construction but at a rational pace, and projects in the inland regions would be suspended. Germany and some other western countries decided to give up a nuclear energy program but a large number of countries expressed a desire to further draw lessons from the events at Fukushima and put safety in first place in the process of developing nuclear energy.

3. Discussion

In China, nuclear power plants are mostly sited in the economically developed southeastern coast, where there are important industrial and agricultural zones with a dense population. At present, in addition to operating the China Experimental Fast Reactor (CEFR) at the China Institute of Atomic Energy (CIAE), there are 15 nuclear units in operation at three nuclear power bases, which are Qinshan in Zhejiang Province, Daya Bay and Ling Ao in Guangdong Province and Tianwan in Jiangsu Province. Additionally, there are also 16 units under construction, and 20 units with pending construction licenses or in the early preparatory phase. By 2020, there will be about 50 operating nuclear units, if successfully completed, in 16 provinces or regions with a nuclear installed capacity of 70,000-80,000 MWe. By 2035, there will be about 140 nuclear units with a total nuclear capacity of 150,000 MWe.

China is also a country with a high frequency of earthquakes and other natural disasters. There are a large number of nuclear power plants and facilities operating in neighboring countries and regions. The nuclear power plants on the mainland of China are mostly second-generation plus reactors, which have already proven to be operationally safe. Whereas, those currently under construction on the mainland of China are third-generation reactors, which are safer in theory but there is a lack of accumulated operational data and experience. The Fukushima nuclear accident reminds us that safety is critical to the development of nuclear power. And there should be a clear awareness of design basis, plant emergency equipment performance in a disaster situation, an ability to compensate for nuclear accident damage, governmental liability and the permanent disposal of high level radioactive waste in response to an earthquake disaster at one site with multiple reactors.

China succeeded in coping with the accident at Fukushima Daiichi Nuclear Power Plant. This could be a valuable opportunity to implement an emergency exercise in the current situation of the ongoing vigorous expansion of nuclear power in China. It would also be a review of the preparedness of the response system to a nuclear accident and the capacity test on public health monitoring and surveillance in China. In respect of the medical response during a nuclear accident in China, special attention should be paid to the monitoring of regional hygiene and the resident health baseline in the surrounding areas of nuclear power plants. The basic information on nuclear power plants, event information and health monitoring information should be made available to the public in a timely manner. All of these actions should increase both public confidence and support. The operational manual on contamination monitoring should be easier and more convenient to use and should be revised in greater detail in pursuant of the existing laws, regulations and standards. The capacity of the radiological injury rescue bases should be strengthened

and training for professional personnel should be reinforced. A plan for health risk communication and psychological intervention during a nuclear accident should be developed. In the context of being fully aware of the importance, and sensitivity of monitoring radioactivity in food and drinking water in the event of a nuclear accident, the emergency monitoring capacity should be enhanced and the emergency intervention level in a nuclear accident situation should be developed both by reference to internationally endorsed standards and based on the dietary habits of China's residents. Biological and epidemiological studies should be carried out, and the health effects from chronic exposures at small doses should be reinforced. In addition, regional cooperation should be strengthened with the inclusion of shared assay techniques and information communication.

4. Conclusion

CCMRRE gained a lot of experience during the public health response to the Fukushima nuclear accident. This accident also tested the Chinese public health systems capability and medical response to a nuclear emergency. It tested the monitoring of food, drinking water and the importance of the collection of the resident health baseline in the surrounding areas of nuclear power plants, risk communication and psychological intervention. It indicated that the capacity of radiological injury rescue bases should be enhanced. Related operational manuals and standards should be developed.

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