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THE FUKUSHIMA RADIOLOGICAL EMERGENCY AND CHALLENGES IDENTIFIED FOR FUTURE PUBLIC HEALTH RESPONSES

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Abstract

On 11 March 2011, northern Japan was rocked by first a magnitude 9.0 earthquake off the eastern coast and then an ensuing tsunami. The Fukushima Daiichi Nuclear Power Plant complex was hit by these twin disasters, and a cascade of events was initiated that led to radionuclide releases causing widespread radioactive contamination of residential areas, agricultural land, and coastal waters. Radioactive material from Japan was subsequently transmitted to locations around the globe, including the U.S. The levels of radioactive material that arrived in the U.S. were never large enough to be a concern for health effects, but the presence of this material in the environment was enough to create a public health emergency in the U.S. The radiation safety and public health communities in the U.S. are identifying challenges they faced in responding to this incident. This paper discusses three of those challenges: (1) The growing shortage of trained radiation subject matter experts in the field of environmental transport and dosimetry of radionuclides; (2) the need to begin expressing all radiation-related quantities in terms of the International System of Units; and (3) the need to define when a radiation dose is or is not one of “public health concern.” This list represents only a small subset of the list of challenges being identified by public health agencies that responded to the Fukushima incident. However, these three challenges are fundamental to any radiological emergency response. Addressing them will have a significant positive impact on how the U.S. responds to the next radiological emergency.

Keywords

operational topics; emergencies; radiological; emergency planning; public information

INTRODUCTION

On 11 March 2011, northern Japan was rocked by first a magnitude 9.0 earthquake centered 130 miles off the eastern coast and then an ensuing tsunami. These natural incidents caused

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widespread death and destruction in Japan. Approximately 15,000 people are confirmed dead and another 5,000 are still missing as a result of this disaster.

One location hit by these twin disasters was the Fukushima Daiichi Nuclear Power Plant complex. The destruction at this site initiated a cascade of events that led to multiple reactors overheating, core meltdown, and radionuclide releases resulting in widespread radioactive contamination of residential areas, agricultural land, and coastal waters. Thousands of Japanese citizens were evacuated from around the Fukushima site during early days of the crisis, and as of this writing, many of those people have not yet been allowed to return to their homes. To date, there have been no confirmed deaths as a result of the radioactive releases from the Fukushima reactors, but the public health and medical community in Japan will be dealing with this incident for many years to come.

As events unfolded at Fukushima, the U.S. public health community was concerned on many fronts. First, there was the desire to offer aid to the people of Japan as they faced the combined crises in their midst. There are also many U.S. citizens living and visiting in Japan at any given time, including U.S. military personnel, and their safety was a major concern. Then as the radioactive material continued to be released from Fukushima, there was concern for people living further from Japan. Prevailing winds, passengers returning home from Japan, and cargo vessels all had the potential to transport radioactive material from Japan to locations around the globe, including the U.S. The levels of radioactive material that arrived in the U.S. from Japan were never large enough to be a concern for health effects, but the very presence of this material in the environment was enough to raise concerns for safety in the minds of many people. The public health community had to respond to these concerns, and as a result, Fukushima became a public health emergency in the U.S.

For several weeks, state, local, and federal public health officials worked long hours to respond to this incident. Over the past few months, these agencies have been preparing their after-action reports, identifying those things that went well and those challenges that need addressing before the next radiological emergency occurs. The purpose of this paper is not to catalog all of these challenges but to raise some key, overriding issues that need to be considered as the health physics community deliberates on its role in preparing for future emergencies involving the release of radioactive material to the environment.

KEY CHALLENGES

Experienced personnel

In 2008, the Health Physics Society issued a Position Statement entitled the “Human Capital Crisis in Radiation Safety” (HPS 2008). This paper presents the case that because of declining graduation rates in health physics and related fields and the aging of the current work force, there will be a shortfall of sufficiently trained and educated radiation protection professionals in the years ahead. The Fukushima incident illustrated the wisdom of this statement.

During the U.S. response to the Fukushima incident, I had the opportunity to represent the Centers for Disease Control and Prevention (CDC) as a liaison to the National Security Staff (NSS). One of the key tools I took with me to that position was my electronic contact information. I quickly discovered that one way I could assist NSS staff in the response was providing contact information for people across the federal government agencies that are experienced in environmental dose assessment and practiced in emergency preparedness and response. Unfortunately, what made this task most achievable is that there are actually very few people across the interagency that fit these criteria.

For example, the Advisory Team for Environment, Food and Health (Advisory Team) is an interagency group that is tasked under the National Response Framework Nuclear/ Radiological Incident Annex (DHS 2008) with providing advice to decision makers with regard to protective actions they should consider. This team is composed of representatives from CDC, the Food and Drug and Administration (FDA), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Agriculture (USDA), and other federal agencies as needed for a given response. The Advisory Team established a bridge line communication early in the Fukushima response, and it remained active throughout the incident.

The staff of the U.S. Embassy in Tokyo sought assistance in providing U.S. citizens in Japan with sound health and safety information and protective action guidance as the Fukushima incident unfolded. The Embassy was in close contact with officials in Washington, but there was a strong desire to have some health and radiation experts in Tokyo for direct assistance to Embassy staff. Consideration was given to asking the Advisory Team to deploy to Tokyo, but that idea was abandoned when some of the agencies that constitute the Advisory Team were unable to identify a sufficient number of radiation experts to satisfy their agency-specific domestic needs, participate in the U.S.-based Advisory Team, and still deploy staff to Tokyo. The Department of Health and Human Services deployed a medical team to the embassy that included a representative from FDA, and the USDA sent a staff person to Japan in the early summer. However, the Advisory Team never formally deployed to Tokyo for this incident.

State and local public health agencies also faced similar shortages of experienced personnel. In the face of overall budget cuts and a general decline in environmental monitoring activities around nuclear sites such as U.S. Department of Energy nuclear weapons facilities, state and local radiation experts are more likely to be employed in regulatory enforcement rather than activities related to environmental dosimetry.

There are experienced personnel working for contractors who can and were employed to augment state, local, and federal employees during an emergency such as Fukushima. For example, the CDC Emergency Operation Center engaged a number of contractors during this response. However, this pool of experts too is limited. Furthermore, many of the radiation subject matter experts who were used in this incident are reaching the age of retirement, and there is no group of younger staff being trained to take their place (HPS 2004).

The observations made here are certainly not a surprise to readers of this journal. Furthermore, there are no quick and easy solutions to this problem looming just over the horizon. Nevertheless, I think it is important to take note of the current status of radiation experts available to respond to radiological emergencies. Twenty-five years elapsed between the Chernobyl and Fukushima incidents. Many of us have been involved in the response and follow-up studies to the Chernobyl incident, and that knowledge and experience aided in our response to the Fukushima incident. The health physics community needs to consider how we can develop a body of knowledge and experience from the Fukushima incident that will allow the next generation of radiation experts to effectively respond should another major radiological incident occur.

Radiation units

The radiation monitoring data and dose assessment information that became available from Japan during the Fukushima incident was, of course, presented exclusively in the International System of Units (SI); i.e., becquerel (Bq) and sievert (Sv). Many U.S. guidance and informational documents are primarily in traditional units; i.e., curie (Ci) and rem. This dichotomy required that measurements and projections had to be translated constantly among systems. These translational efforts required time and resources, and while generally straightforward, they introduce unnecessary opportunities for numerical errors in the decision-making process. This unit difference also complicated communications between radiation subject matter experts, other professionals involved in the response, and members of the general public.

SI radiation units have been used around the world for many years, but the U.S. has never fully adopted them. This journal has a long-standing policy that requires the use of SI units for all quantities presented in its publications. At its meeting in West Palm Beach, FL, on 26 June 2011, the Health Physics Society (HPS) Board of Directors adopted the position that “SI units should be used exclusively when expressing radiological quantities.” A formal Position Statement in support of this statement is currently being drafted.

Not all health physicists believe that SI units should be used, and they will disagree with the position that the HPS Board of Directors is taking. However, the fact that traditional units are generally considered obsolete outside of the U.S. makes it imperative that we quickly and fully adopt SI units for all of our guidance and communication materials related to radiation and its safety. This will remove one potential source of error and confusion in the event of another radiation incident of the magnitude and world-wide impact of Fukushima.

Radiation doses of public health concern

As the incident at Fukushima unfolded, some of the radioactive material released from that site was carried into the upper levels of the atmosphere where it became entrained in the general atmospheric circulatory pattern. As a result, this material was carried away from Japan and around the world, generally moving in a west-to-east direction. Over time, this material was slowly removed from the atmosphere by gravitational and other processes, resulting in fallout deposition of small amounts of material on surfaces around the globe.

Such global fallout had arisen from the Chernobyl reactor incident in 1986 (Richmond et al. 1988) and from atmospheric nuclear bomb testing (Bouville et al. 2002).

For 50 y, the EPA has continuously monitored environmental trends in radiation levels throughout the U.S. using a system called RadNet (U.S. EPA 2011a). This network of fixed and deployable instruments monitors ambient air, drinking water, precipitation, and pasteurized milk for radionuclides. EPA regularly posts near-real-time results from its monitoring program on the Internet for the public to view.

During the height of the Fukushima incident, EPA accelerated and increased its sampling frequency and analysis. The purpose of this program was to ascertain whether harmful levels of radiation were reaching the U.S. from Japan and to keep the public informed about all radiation levels measured. EPA found that all of its monitoring results were so low as to be "below a level of public health concern" (U.S. EPA 2011b). This designation is based on levels that are less than 1% of the EPA Protective Action Guides (PAG) (U.S. EPA 1992).[†]

As noted above, another route by which radioactive fallout from the Fukushima incident could be carried to the U.S is by cargo ships. The Pipeline and Hazardous Materials Safety Administration (PHMSA) of the U.S. Department of Transportation is responsible for setting acceptable levels of radioactive contamination on cargo containers allowed to enter the U.S. (U.S. DOT 1990). PHMSA determined that the legal limit for contamination of beta and gamma emitting radionuclides is 0.4 Bq cm^{-2} but that it could potentially relax enforcement to 4.0 Bq cm^{-2} for this special emergency situation. This was an important decision because if the limit were 4 Bq cm^{-2}, U.S. Customs and Border Protection could monitor cargo containers using instruments routinely used for other purposes. However, if the limit were 0.4 Bq cm^{-2}, laboratory analyses of surface swipes would have been necessary, and the process would have required additional time to complete screening of all cargo containers entering the U.S. from Japan. This could have potentially shut down commerce between the U.S. and Japan.

Before finalizing their decision, PHMSA asked CDC if a residual contamination level of 4.0 Bq cm^{-2} could result in a radiation dose to a member of the public that would be of "public health concern." Using a dose assessment method based on ANSI/HPS Standard N13.12 (ANSI 1999), CDC estimated that at this level of residual contamination, a member of the public was unlikely to get a dose in excess of 40 μSv y^{-1} from ^{90}Sr or ^{137}Cs and a dose in excess of 4 μSv y^{-1} from ^{131}I.[‡] The average annual ubiquitous background exposure to people in the U.S. is 3,100 μSv y^{-1} (NCRP 2009). Based on this analysis, CDC concluded that "the radiation dose a member of the public is likely to receive from a cargo container contaminated at a level of 4 Bq cm^{-2} would be indistinguishable from natural background."[§] The National Institute for Occupational Safety and Health and EPA performed similar analyses for workers and the environment, respectively, and came to the same conclusion.

[†]Personal communication, Wieder J, U.S. Environmental Protection Agency, May 2011.

[‡,†]Miller CW, Whitcomb RC, Smith JM. Monitoring potentially contaminated cargo from Japan: when is a dose of "public health concern?" Presented at the Fifty-Sixth Annual Meeting of the Health Physics Society, Palm Beach, Florida, 2011. Unpublished.

[§]Portier, CJ. Letter to R. Reed and J. Porcari, 7 April 2011.

As a result, PHMSA decided not to enforce noncompliance for contamination levels below 4 Bq cm^{-2} for these radionuclides and this incident.

For emergency situations, what is a radiation dose or a concentration of a radionuclide in an environmental media that is of "public health concern?" During the Fukushima incident, both public health decision makers and members of the public were eager to know the answer to that question. In the two examples presented here, one federal agency (EPA) chose a definition based on a small fraction of a PAG, while another (CDC) effectively used a definition based on a small percentage of the average annual ubiquitous background exposure to people in the U.S. However, there is no official public health definition of what is a level of radiation dose or concentration that is a "public health concern."

When is a radiation dose high enough to be a "public health concern?" This, of course, is a question that the radiation safety community has been trying to answer for decades. Over 20 y of working with the public on radiation issues strongly indicates to me that many, if not most, members of the public have answered this question for themselves: Any amount of radiation that is not of direct benefit to me will result in harm to me or my children. The National Academy of Sciences has most recently concluded that use of the linear no-threshold (LNT) hypothesis to describe the relationship between radiation dose and the risk of developing cancer in humans is consistent with current scientific evidence (NRCNA 2006). The public believes that this is a fact, not a hypothesis. If we, the radiation safety and public health communities, agree with this statement, then any dose above background could be considered a dose of "public health concern." Of course, the proper use of the LNT hypothesis is subject to considerable discussion (Siegel and Stabin 2012).

EPA chose to use a small fraction of the PAG in the Fukushima incident as a level of no "public health concern." Was that an appropriate use of this phrase? The Health Physics Society has issued a position statement that below a dose of 50–100 mSv, the "risks of health effects are either too small to be observed or are nonexistent" (HPS 2010). Is this a place to begin defining a dose of no "public health concern" for emergency response purposes?

Clearly, this question is not going to be answered easily or quickly. However, if the radiation safety and public health communities can begin moving forward on addressing this issue, the impact on future radiation incidents similar in nature to Fukushima would be significant. Despite the lack of measureable health effects on U.S. citizens from the Fukushima fallout, this incident may have become a public health emergency in the U.S. largely because the issue of what is a dose of "public health concern" has not been effectively addressed.

CONCLUSION

The Fukushima Daiichi nuclear reactor complex incident of March 2011 was a terrible occurrence for the people of Japan. The radiation safety and public health communities in the U.S. do have an opportunity, however, to identify and begin dealing with challenges they faced in responding to this incident. This paper discusses three of those challenges:

1. The growing shortage of trained radiation subject matter experts in the field of environmental transport and dosimetry of radionuclides, especially as it relates to emergency preparedness and response;
2. The need to begin expressing all radiation-related quantities in terms of the International System of Units; and
3. The need to define when a radiation dose is or is not one of "public health concern."

These challenges represent only a small subset of the complete list of challenges being identified by the state, local, and federal public health agencies that responded to the Fukushima incident. However, these three challenges are fundamental to any radiological emergency response. Addressing them will have a significant positive impact on how we respond to the next radiation emergency that may occur.

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