CDC Grand Rounds: Radiological and Nuclear Preparedness

Radiological and nuclear disasters are infrequent, but when they occur, they result in large and demonstrable health burdens. Several scenarios can result in the public's exposure to radiation. For example, radiation sources used in health care or other industries can be lost or misused. Incidents in the nuclear power industry, such as those at Chernobyl and Three Mile Island, require significant public health response. In addition, radiological terrorism can involve the use of a radiological dispersal device (RDD) or an improvised nuclear device (IND). State and local health agencies are expected to perform essential public health functions in response to any of these emergencies (*1,2*) (Box 1).

Recent events illustrate that the public health sector will be essential in a radiological or nuclear response. For example, in August 2004, the day before the Republican National Convention, the New York City Department of Health and Mental Health (DOHMH) responded to a radiation incident at a mid-town Manhattan post office. A radiation source failed to retract into its protective shielding, resulting in dangerously high radiation levels near the radiation source. Police and fire departments evacuated the building and closed off nearby streets. The DOHMH response included conducting extensive environmental surveys outside and throughout the building, assisting with shielding the source, conducting press conferences, providing approximately 2,000 copies of fact sheets to residents in nearby buildings, and conducting dose estimates for the contractor and postal service employees. It took over 24 hours to remove the radiation source safely. The public's maximal risk for exposure was less than that received from a single chest radiograph because of their distance from the radiation source.

This is another in a series of occasional MMWR reports titled CDC Grand Rounds. These reports are based on grand rounds presentations at CDC on high-profile issues in public health science, practice, and policy. Information about CDC Grand Rounds is available at http://www.cdc.gov/about/grand-rounds.

BOX 1. Spectrum of potential public health roles in a radiological or nuclear emergency*

- Identify radiological agent or cause.
- Determine radiological exposure and contamination.
- Provide medical and public guidance on radiological-protective actions and medical management.
- Conduct environmental and human surveillance for potential radiological contamination or exposure.
- Conduct epidemiologic investigations, if needed.
- Conduct radiological monitoring and screening (environment and persons).
- Conduct radiological sampling and laboratory testing.
- Coordinate requests, receipt, and distribution of Strategic National Stockpile, if needed.
- Undertake mitigation and recovery.

* Additional information available at http://www.bt.cdc.gov/radiation/glossary.asp.

When Aleksander Litvinenko died in London in 2006 from poisoning with the radioisotope polonium-210, public health agencies in the United States were affected. Polonium was spread to many places in London, potentially contaminating thousands of persons, including foreign visitors. In the United Kingdom, approximately 8,000 persons contacted public health authorities, and citizens from 52 countries potentially were involved, including 160 U.S. citizens. Approximately 20 U.S. state and local public health agencies worked with CDC to notify involved citizens and to coordinate laboratory testing.

These events demonstrate that 1) radiological incidents can happen at any time and any place, 2) state and local health agencies are involved in response and communication concerning health effects of radiation, 3) communication needs arise even when there is no public risk, 4) responses require coordination with multiple agencies, and 5) planning requires multiagency input.

Current Capability of States and Localities

State and local capabilities to respond effectively to radiological or nuclear incidents vary greatly: 31 states with commercial nuclear power plants are required to have detailed response plans and drills, but only for designated zones around their power plants. Some major metropolitan areas that are considered high-probability terrorist targets (e.g., Los Angeles and New York City) have done extensive planning. Other regions have made modest planning efforts. Each state has one or more radiation control programs. In 35 states, these programs are in the state public health department; in the other states, this expertise is elsewhere, often in state environmental departments.

Enhancing Overall Public Health Capacity for Response

Public health authorities at all levels must understand the extent of their responsibilities in radiological emergencies, and they must prioritize emergency planning appropriately. Enhancing public health expertise on radiological agents is paramount for appropriate planning, drilling, and responding to radiological and nuclear incidents (Box 1).

The pre-event phase of planning includes 1) identifying preexisting radiation sources to establish a baseline, 2) developing and coordinating multiagency response plans, and 3) conducting training and exercises. These actions require strong alliances among public health entities, radiation control programs, subject matter experts, and emergency response agencies.

In the initial hours of an event, environmental characterization is critical for identifying persons and places likely to be contaminated and for driving protective actions. The capabilities of the Integrated Modeling and Atmospheric Assessment Center* can help initially to define the contaminated areas (via atmospheric plume modeling), identify potential evacuation routes, and assist with initial protective action guidance, such as recommendations for sheltering in place versus evacuation. Real-time environmental monitoring data should be used to verify the atmospheric modeling results and guide decision-making as quickly as such monitoring data become available.

During the hours to days after an event begins, besides the ongoing environmental monitoring, public health response elements fall under the rubric of population monitoring, which draws upon public health surveillance, epidemiology, laboratory analyses of biologic samples, and health physics. Some states can handle events involving a small number of casualties, such as an industrial incident, but all states are likely to face major challenges in dealing with a large mass-casualty event, such as detonation of an RDD or an IND. In these events, persons might be contaminated both on the body (external contamination) and in the body (internal contamination). An IND event also will expose thousands of persons to strong gamma rays without external or internal contamination. External radioactive contamination can be assessed with readily available radiation survey meters. Internal contamination by strong gamma emitters can be detected by whole body counters, radiation meters, or bioassays. Internal contamination by most alpha and beta emitters requires a urine bioassay. Additionally, medical countermeasures might be required for either internal contamination (such as Prussian blue) or external high-dose exposure (such as filgrastim) or both (*3*), and it will be the responsibility of public health authorities to provide access to the Strategic National Stockpile and recommendations on medical countermeasure use.

CDC has developed a guidance document to help state and local authorities evaluate their emergency response plans and prioritize allocation of existing resources. CDC and state and local partners are developing data collection and reporting tools for epidemiology, surveillance, and registry needs, as well as developing guidance for using readily available handheld instruments for internal monitoring (*4*).

Public health issues to be addressed during the recovery phase (days to months after the event begins) and clean-up process require engagement of many stakeholders. These issues include 1) safe management and identification of human remains (*5*), 2) complete identification of types and levels of contamination present (i.e., chemical, biologic, and radioactive), 3) the intended use of the restored area (e.g., residential, school, industrial, or tourism), 4) selection of the remedial action most cost-effective and acceptable to the community, and 5) establishment of a post-event acceptable level of residual radioactivity based on a pre-event background level of radioactivity.

Throughout all phases of a radiological or nuclear event, public health authorities must ensure the safety and health of the potentially large number of emergency responders, health-care workers, and recovery workers involved in the response. Many of these workers will have very little experience in radiological

* Additional information available at https://imaacweb.llnl.gov/web.

and nuclear safety and health. Responders should be trained to recognize the acute health effects of high-dose radiation, the long-term risk for cancer that can result from low-dose radiation, and the protective principles of time, distance, and shielding (*3*). Because personal protective equipment (PPE) does not protect responders from external gamma radiation exposure, responders must rely instead on monitoring equipment to alert them to such exposures and help gauge the appropriate time and distance allowed for work near a radiation source. PPE can, however, protect the responder from internal or external radionuclide contamination. The need for such equipment will vary, depending on the type of radiological or nuclear event. CDC's National Institute for Occupational Safety and Health (NIOSH) and other organizations have prepared guidance in the selection of appropriate PPE for radioactive environments (*6*).

Finally, at all times, public health authorities must provide the public with information on how to protect themselves. The communication needs during any radiological event, regardless of size, should not be underestimated.

Enhancing Laboratory Expertise and Capacity for Response

According to recent surveys by the Association of Public Health Laboratories and the Conference of Radiation Control Program Directors, state public health laboratories currently have no rapid methods for analyzing clinical samples (*7*). Such bioassays are critical for 1) defining baseline contamination, 2) identifying persons with post-event internal contamination, 3) estimating radiation dose, 4) directing short- and long-term medical care, and 5) supporting epidemiologic assessments. In response to this shortage, CDC is developing rapid urine bioassays to detect 22 radionuclides; these bioassays will include both traditional radiation counting technologies and mass spectrometry analytical methods (Box 2).[†] To develope the needed surge capacity, a Laboratory Response Network (Radiological) at 10 or more state public health laboratories needs to be established once resources become available. The effort should include equipment, personnel, supplies, training, technology transfer, and ongoing performance evaluation.

[†] *Bioassays* are analytical technologies that detect the type and amount of radionuclides in a urine sample to determine the amount of internal radionuclide contamination that a person has received during a radiological or nuclear incident. *Traditional counting technologies* include liquid scintillation counting to detect alpha- and beta-emitting radionuclides, alpha spectrometry to detect alpha-emitting radionuclides, and gamma spectrometry to detect gamma-emitting radionuclides in urine. *Mass spectrometry technologies* detect the actual number of radionuclide atoms instead of the alpha, beta, or gamma emissions. Additional information, including a glossary of terms, is available at http://www.bt.cdc.gov/radiation/glossary.asp.

BOX 2. CDC radionuclide screen*

Step 1. Screen for the presence of any radionuclides:
- Identifies presence of alpha-, beta-, or gamma-emitting radionuclides.
- Results for the first 100 samples in 8 hours.
- Throughput: alpha or beta, 300 samples per day; gamma, 3,000 samples per day.

Step 2. Identify and quantify specific radionuclides:
- Goal: 22 radionuclides (current capability: eight radionuclides).
- Specific radionuclide assays.
- Throughput: 300 samples per day.

Sample requirement:
- 70 mL of urine (spot sample).
- All methods in accordance with Clinical Laboratory Improvement Amendments (CLIA) regulations.

* Additional information available at http://www.bt.cdc.gov/radiation/glossary.asp.

Ensuring Strong Partnerships in All Phases of Response

In an emergency setting, the public health system has the flexibility to reach from federal to state to local authorities to ensure that the health system response is integrated with a broader national response to an event (including responses related to transportation, commerce, agriculture, and the environment). National planners must develop broad partnerships to integrate radiological and nuclear preparedness into overall national preparedness, including 1) developing a national concept of operations (CONOPS) for post-event monitoring of exposed persons and validating that concept with stakeholders, 2) defining the resources needed to meet monitoring needs, and 3) using the CONOPS to drive interagency collaborations with partners, including the Federal Radiological Preparedness Coordinating Committee, the U.S.

Department of Defense, the U.S. Department of Energy, the U.S. Environmental Protection Agency, the Food and Drug Administration, and the U.S. Department of Agriculture.

Radiological preparedness activities can be funded through various mechanisms, including the U.S. Department of Homeland Security's Urban Areas Security Initiative Grants, CDC's Public Health Preparedness Grants, the U.S. Department of Health and Human Services' Health Preparedness Program, and professional organizations such as the Conference of Radiation Control Program Directors. Funding and planning resources also might be available from neighboring regional or state programs.

Finally, radiological response planning should be part of all-hazards preparedness. Real-life and exercise experience can be used to strengthen coordination and performance and to define gaps that can be filled through corrective actions.

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References

1. US Department of Homeland Security. National response framework, January 2008. Washington, DC: US Department of Homeland Security, Federal Emergency Management Agency; 2008. Available at http://www.fema.gov/pdf/emergency/nrf/nrf-core.pdf. Accessed September 9, 2010.
2. CDC. Radiation emergencies. Atlanta, GA: US Department of Health and Human Services, CDC; 2010. Available at http://emergency.cdc.gov/radiation. Accessed September 9, 2010.
3. National Institutes of Health, National Library of Medicine. Radiation Event Medical Management (REMM). Available at http://remm.nlm.gov. Accessed September 9, 2010.
4. CDC. Population monitoring in radiation emergencies: a guide for state and local public health planners. Atlanta, GA: US Department of Health and Human Services, CDC; 2007. Available at http://emergency.cdc.gov/radiation/pdf/population-monitoring-guide.pdf. Accessed September 9, 2010.
5. CDC. Guidelines for handling decedents contaminated with radioactive materials. Atlanta, GA: US Department of Health and Human Services, CDC; 2007. Available at http://emergency.cdc.gov/radiation/pdf/radiation-decedent-guidelines.pdf. Accessed September 9, 2010.
6. CDC. Attention emergency responders: guidance on emergency responder personal protective equipment (PPE) for response to CBRN terrorism incidents. Cincinnati, OH: US Department of Health and Human Services, CDC, National Institute for Occupational Safety and Health; 2008. Available at http://www.cdc.gov/niosh/docs/2008-132/pdfs/2008-132.pdf. Accessed September 9, 2010.
7. Association of Public Health Laboratories. 2009 APHL All-Hazards Laboratory Preparedness Survey data. Silver Spring, MD: Association of Public Health Laboratories; 2010. Available at http://www.aphl.org/aphlprograms/ep/ahr/documents/aphlallhazwhitepaperepr.pdf. Accessed September 14, 2010.