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Medical Response to a Radiologic/Nuclear Event: Integrated Plan From the Office of the Assistant Secretary for Preparedness and Response, Department of Health and Human Services

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The end of the Cold War led to a reduced concern for a major nuclear event. However, the current threats from terrorism make a radiologic (dispersal or use of radioactive material) or nuclear (improvised nuclear device) event a possibility. The specter and enormousness of the catastrophe resulting from a state-sponsored nuclear attack and a sense of nihilism about the effectiveness of a response were such that there had been limited civilian medical response planning. Although the consequences of a radiologic dispersal device are substantial, and the detonation of a modest-sized (10 kiloton) improvised nuclear device is catastrophic, it is both possible and imperative that a medical response be planned. To meet this need, the Office of the Assistant Secretary for Preparedness and Response in the Department of Health and Human Services, in collaboration within government and with nongovernment partners, has developed a scientifically based comprehensive planning framework and Web-based "just-in-time" medical response information called Radiation Event Medical Management (available at http://www.remm.nlm.gov). The response plan includes (1) underpinnings from basic radiation biology, (2) tailored medical responses, (3) delivery of medical countermeasures for postevent mitigation and treatment, (4) referral to expert centers for acute treatment, and (5) long-term follow-up. Although continuing to evolve and increase in scope and capacity, current response planning is sufficiently mature that planners and responders should be aware of the basic premises, tools, and resources available. An effective response will require coordination, communication, and cooperation at an unprecedented level. The logic behind and components of this response are presented to allow for active collaboration among emergency planners and responders and federal, state, local, and tribal governments. [Ann Emerg Med. 2009; 53:213-222.]

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INTRODUCTION

Success depends upon previous preparation, and without such preparation there is sure to be failure.
—Confucius[1]

I am prepared for the worst but hope for the best.
—Benjamin Disraeli, First Earl of Beaconsfield[2]

The post–September 11 era raises concerns of terrorists using:

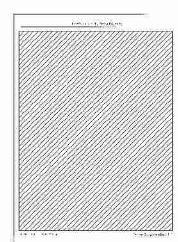
A radiologic device for which radioactive material is the source of radiation

- a radiologic dispersal device involves radioactive material dispersed by explosive or nonexplosive means that cause exposure through external and internal contamination
- a radiologic exposure device in which an intact hidden radioactive source exposes the public.

A nuclear device, which includes a nuclear detonation and subsequent spread of fallout

- an improvised nuclear device is the detonation of a nuclear bomb.

For planning purposes and not necessarily based on the likelihood of a specific threat, the National Planning Scenario document[3] has a 10 kiloton (10-kt) improvised



nuclear device as scenario 1 and a cesium chloride radiologic dispersal device as scenario 11. A 10-kt improvised nuclear device would be somewhat lower in terms of kilotons than the nuclear weapons used at the end of World War II. State-sponsored nuclear weapons are much larger in the megaton range. Given the major differences in the events, those active in response planning distinguish radiologic and nuclear events, often using the name "rad/nuc" when both are considered, but for simplicity, this article will combine them into "radiation event." Casualty estimates for a radiation event, which depend heavily on many factors, including location, time of day, type and size of device, weather conditions, and others, could number from the hundreds to thousands from a radiologic dispersal device[4] to hundreds of thousands from an improvised nuclear device.

Clearly, these are catastrophic events. Even if they are of very low probability, the Office of the Assistant Secretary for Preparedness and Response in the Department of Health and Human Services is developing a comprehensive plan of public health and medical response. As reflected in the quotations from both Confucius[1] and Disraeli,[2] the Office of the Assistant Secretary for Preparedness and Response vision statement is "A nation prepared to prevent, respond to and reduce the adverse health effects of public health emergencies and disasters."[5] The general plans for radiation event response have much in common with the "all hazards" mass casualty responses[6] and the development of medical countermeasures for radiation injury will have spinoffs for cancer treatment. Therefore, efforts and investments of the Department of Health and Human Services have potential benefits for society and health not limited to terrorism response.

Because of the complexity of a comprehensive medical response, it has taken time to assemble components from the Department of Health and Human Services agencies and response partners to design the approach and have the plans vetted by experts in civilian medical care and planning. A coordinated US government response is being shaped through basic research, interagency meetings, multiagency partnerships, and a variety of exercises. The Department of Health and Human Services and other agencies are working with nonfederal responder constituents in this regard. The purpose of this article is to present to the general public and medical responders the overall concepts and structure behind the Department of Health and Human Services Radiation Event Medical Response Plan. Although gaps remain that we are working to fill, we will demonstrate the progress that has already been made and describe a number of components that are being actively developed. Because any radiation event can have a spectrum of victims, including those with external exposure resulting in the acute radiation syndromes (defined below) or internal contamination with a range of radionuclides, the medical response plan must be flexible, as well as cover any type of radiation event.

Table. Emergency support functions.[7]

Emergency Support Function No.	Type
1	Transportation
2	Communications
3	Public works and engineering
4	Firefighting
5	Emergency management
6	Mass care, housing, and human services
7	Resource support
8	Public health and medical services
9	Urban search and rescue
10	Oil and hazardous materials response
11	Agriculture and natural resources
12	Energy
13	Public safety and security
14	Long-term community recovery and mitigation
15	External affairs

How the Medical Response Fits Within the General Response

In devising the Radiation Event Medical Response Plan, the initial effort was to understand how the medical response fits into the overall national response and to develop a framework that could be used for response planning. An initial challenge was to transform the responsibilities of the Department of Health and Human Services and the other agencies stipulated in a number of lengthy documents into an action plan. Although there are various ways to organize and present the information, the chain of medical response uses an algorithm-based flow-diagram approach so that a logical stepwise response plan can be formulated. At present, there are 15 emergency support functions that cover the federal response activities (Table), each having a primary agency and supporting agencies. Emergency support function #8, Public Health and Medical Services,[7] is led by the Department of Health and Human Services. The Radiological Incident Annex of the National Response Plan[8] and emergency support function #8 were used to develop the chain of medical response diagram (Figure 1). How the agencies interact with the Department of Health and Human Services can be understood by walking through this chain of medical response stepwise. (The National Response Framework[9] is in preparation and under discussion and may replace the National Response Plan. The framework is in essence an update of the plan, which has evolved according to experience. Furthermore, the term "framework" is thought by the Department of Homeland Security to be a better descriptor than was the term "plan").

Chain of Medical Response

A radiation event (Figure 1, Box 1) could occur that would be obvious in real time, as in the case of an improvised nuclear device or explosive radiologic dispersal device. On the other hand, recognition would be difficult or delayed if the radiologic dispersal device involved contamination of the environment or food supply or if a radiologic exposure device were placed in a

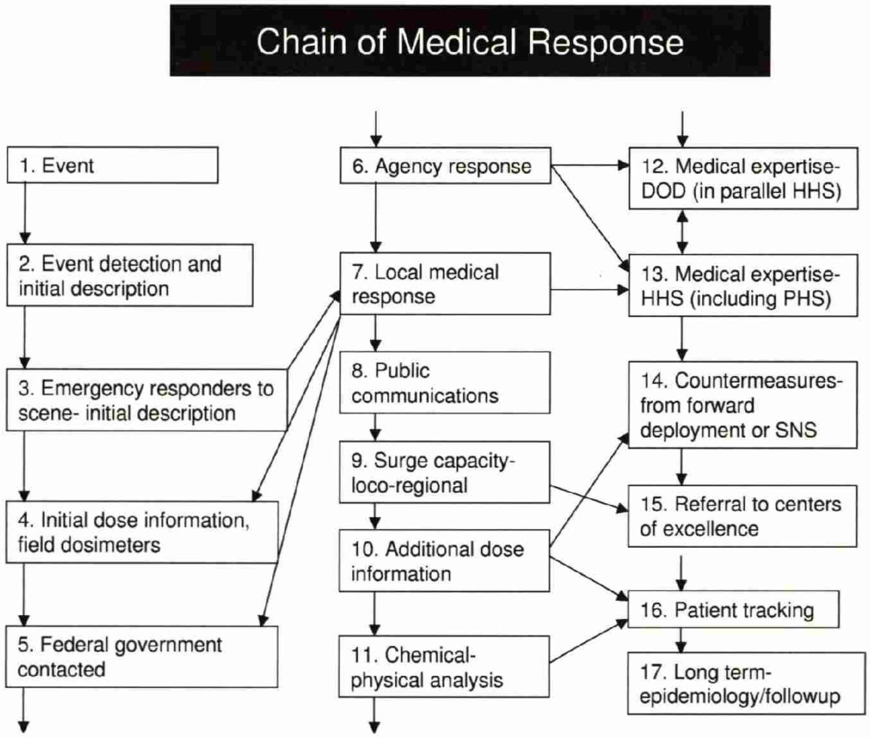


Figure 1. Chain of medical response. This algorithm-based flow diagram illustrates the relationship between the various components in a medical response to a radiation event. Each box represents a step often involving other federal agency partners and local responders. In an event, the response will not be entirely linear because one step may lead to more than 1 subsequent step. The need to anticipate who is responsible for the various steps and how to ensure appropriate communication and coordination among the various participants informs the construction of the concept of operations.

public place. The latter scenarios may well be discovered by astute emergency or primary care physicians and nurses who recognize signs and symptoms of radiation injury or who realize they are seeing a constellation of signs and symptoms out of the ordinary. Once the event is detected (Figure 1, Boxes 2 and 3) there will be additional information about the event, including radiation dose and, if relevant, identification of a radionuclide (Figure 1, Box 4). The state and federal governments will be contacted (Figure 1, Box 5) and event-appropriate agency responses initiated (Figure 1, Box 6). This will include the Department of Justice for criminal investigation, as well as the Department of Health and Human Services, Department of Energy and its consultative group Radiation Emergency Assistance Center/Training Site,[10] Department of Homeland Security, and the Environmental Protection Agency. The local medical response (Figure 1, Box 7) and emergency specialists are central in that they may not only detect the event but also be heavily involved afterward (Figure 1, Box 3) and may well be the ones to alert state health officials, who will alert federal health agencies. Medical care takes precedent over forensic examination but attribution is key to deterrence and response.

Government communications to the public must be timely, accurate, and coordinated among the various responding agencies (Figure 1, Box 8). The Department of Health and Human Services has scripted messages that can be tailored for the situation. Clearly, conflict among "experts" could be disruptive or even damaging, especially if there is contradictory information on orders to the public, such as sheltering in place and evacuation. Coordination among the responsible local, regional, state, and tribal officials with the federal government is essential. Examples of messages are available from the Centers for Disease Control and Prevention (CDC)[11] and which are available through the Radiation Event Medical Management Web site[12,13] described in detail below.

In the face of a very large event or if local resources are incapacitated or exhausted, the event may be declared an incident of national significance ("high-impact events that require an extensive and well-coordinated multi-agency response to save lives, minimize damage and provide the basis for long-term community and economic recovery"[14]). In other settings in which an incident of national significance is not declared, the Secretary of the Department of Health and Human Services may declare a public health emergency. Depending on the size of the event, medical surge capacity (Figure 1, Box 9) will be needed that will likely involve regional partners and, in the case of an improvised nuclear device, an entire national response, including various Department of Health and Human Services components, as well as the emergency support function #8 partners such as the National Disaster Medical System,[15] Department of Veterans Affairs, Department of Defense, and US Public Health Service Commissioned Corps either immediately or as the situation evolves. Voluntary networks of medical centers of excellence (Figure 1, Box 15) are being established to coordinate expert patient care.

The medical management of the overall event will depend on the type of event (radiologic dispersal device, radiologic exposure device, improvised nuclear device), the measurement of the radiation dose by health and environmental physicists (Figure 1, Box 10), and on an individual victim's biodosimetry, which uses CBC count change, lymphocyte cytogenetics, or other radiation-related signatures to measure a person's radiation exposure. For a radiologic dispersal device, chemical-physical identification of the radionuclide is necessary, called radiation bioassay (Figure 1, Box 11). Medical expertise will be available largely from Department of Health and Human Services (Figure 1, Box 13), with support from the Department of Defense. Subject matter experts will also be available from the Department of Energy, Environmental Protection Agency, and the Nuclear Regulatory Commission. The Department of Health and Human Services is responsible for coordination of public health and medical response. Although the Department of Defense is an essential partner, its primary mission of defense may limit their availability for the civilian response (Figure 1, Box 12). The appropriate medical countermeasures will be dispensed (Figure 1, Box 14), and referral to centers of excellence will be made as needed for acute medical management (Figure 1, Box 15).

Essential to any event is the ability to identify and track patients throughout the course of the event and potentially for a much longer time thereafter (Figure 1, Box 16). The number of people tracked will depend on the event type and the victim's wishes because they have the right to refuse to be included in the postevent surveillance cohort. For those who need to be tracked long term, epidemiology and follow-up protocols appropriate for the event are needed (Figure 1, Box 17). The 60-year data from the atomic bomb survivors, which includes both radiation-induced cancer and other organ dysfunction,[16-18] and the long-term epidemiology studies from Chernobyl[19,20] have been extremely informative in preparing risk assessments for radiation-induced cancer and other noncancer illnesses. According to this experience, follow-up protocols and registries are being developed by the CDC and the National Cancer Institute Division of Cancer Epidemiology and Genetics. These agencies have experience in limited size events, but a national plan is not yet available.

Concept of Operations

The details of a response plan, including the goals of the different phases of response, the time course of the response, who will do what task, means of communications and coordination, and the required resources, are included in the concept of operations. The National Incident Management System[21] was established to standardize incident response management and terminology nationwide. The response algorithms in this article, along with many underlying details, are used to develop the concept of operations. Given the major difference between a nuclear blast and a radiation dispersal or exposure device, the concept of operations for each is different and constantly evolves as more functions are created, improved capabilities are developed, and exercises are conducted from which on-the-ground experience provides feedback. For example, the complexity of the response to an improvised nuclear device recognizes the severe degradation in infrastructure and the importance of being realistic in terms of the response process, responder availability, timelines for implementation of planned steps, supply and resource limitations, the need for clear communications, and the sharing of resources throughout the United States and, when possible, with international partners. Indeed, it is the reality of the concept of operations and the time elapsed before victims will be reached for an improvised nuclear device that limits the use of potential medical countermeasures. Even with forward deployment of resources, it will likely be many hours to days until most victims are reached. The planning and preparations being done have the goal of caring for every person in the best possible way despite the enormousness of the event.

Medical Response

Many aspects of the response to a radiation event are common to other mass casualties, including trauma, burns, bleeding, infection, psychological stress, and factoring in underlying medical conditions. Radiation events have the added issues of decontamination and of the whole-body effects of radiation that can produce bone marrow failure, immunosuppression, radiation burns, and internal organ damage. The window of opportunity for specialized medical countermeasures is limited. Thus, the additional breadth of expertise required for a comprehensive medical response to a radiation event ranges from knowledge of basic physics and radiation biology to combined injury to detailed on-site response planning and operations. Although the response must be appropriate for the event and there is a broad range of possible radiation events, response steps are planned and scripted as much as possible.

Although components of this response are in various states of development, Figure 2 is a conceptual diagram of how the Department of Health and Human Services views the breadth of expertise required for comprehensive medical response to a radiation event. The shaded boxes include the need and the open boxes indicate the action item.

Acute Radiation Syndrome

The unique aspects of radiation injury are based on the relationship between dose and specific organ injury. The acute radiation syndrome, often called radiation sickness, has a symptom sequence postexposure of prodrome, latency, and

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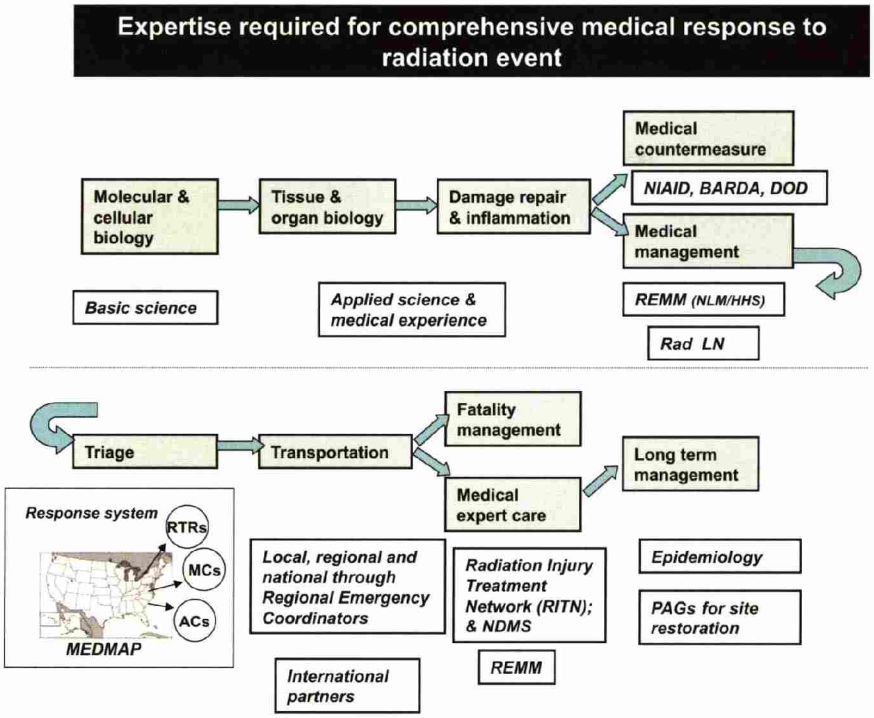

Figure 2. Expertise require for comprehensive medical response to a radiation event. The optimal medical response requires a broad range of expertise, ongoing process improvement, and basic and technologic research and development. It begins with basic biological knowledge of radiation response to molecules, cells, and tissues through medical management and response planning/operations to long-term follow-up for exposed victims. The shaded boxes include the various steps and the open boxes below them include the programs in place or in the process of further development to address the various needs. *RTR*, Radiation (triage, treatment and transport); *MC*, medical centers; *AC*, assembly centers.

clinical manifestations. The latency period during which the person can look and feel good can last for a few weeks despite what ultimately may be relatively severe clinical manifestations, including bone marrow suppression or failure.[22] The understanding of the mechanisms of radiation damage, as well as organ system injury, damage repair, and inflammation, is necessary to develop optimal medical management and medical countermeasures. This requires expertise in basic and applied radiation science and clinical experience. The emergency medical response community will deal with a range of problems, including physical trauma, burns, visual problems (flash blindness and retinal burns), psychological issues, and combined injury that includes physical trauma, blast and burn injuries, and radiation exposure. Detailed discussion of medical management is beyond the scope of his article and is covered elsewhere.[12,13,23-30]

Medical countermeasures and management guidelines. In the setting of a radiation incident, the term "medical countermeasure" is used for drugs designed to counter the specific threat.[31] For many years, investigators and clinicians in radiation oncology and in the Department of Defense have sought to develop radiation protectors that can reduce radiation injury if given before exposure.[32] For cancer treatment, a radioprotector would be timed appropriately to avoid protecting the tumor. For military personnel in a battlefield, it might be possible to self-administer a medical countermeasure in the few minutes postdetonation but before exposure to fallout. However, because a terrorist event is not predictable, agents are needed for postexposure administration. It may be possible to use a mitigator after exposure to reduce the severity of the ensuing radiation injury. This would not only reduce the medical consequences for the victim but also the ultimate medical resource requirement. Characteristics of the medical countermeasures that must be appropriate for the terrorism scenario include route of administration, stability, ease of use, and window of efficacy. Victims not reached early on with migitators will need treatment, and some drugs such as hematopoietic growth factors may serve to both mitigate and treat.

Faced with the need for practitioner access to complex medical response options for an event that has a low probability of occurring, the Office of the Assistant Secretary for Preparedness and Response partnered with the National Library of Medicine to produce Web-based medical guidelines called

Radiation Event Medical Management.[12,13] Radiation Event Medical Management provides just-in-time algorithms and information specifically for medical caregivers and is continuously updated as new information becomes available. Radiation Event Medical Management can be accessed on the Web and is downloadable as a zip (WinZip, WinZip Computing, Mansfield, CT) file so that the information is available in the event of a power outage. A personal digital assistant version will be available within the next year, and possible extension of the Radiation Event Medical Management concept to other terrorism or mass casualty situations is under discussion.

There is a major ongoing effort to develop medical countermeasures,[33-37] involving the National Institutes of Health through the National Institute of Allergy and Infectious Diseases,[34] the National Cancer Institute, the Armed Forces Radiobiology Research Institute, academia, and industry. The National Institute of Allergy and Infectious Diseases developed a cooperative research program called the Centers for Medical Countermeasures against Radiation,[35] the focus of which is to bring medical countermeasures and biodosimetry to clinical application. The medical countermeasures will come from products already in use in medical practice and from agents specifically developed for postexposure use. The major federal investment in medical countermeasure development will be through Biomedical Advanced Research and Development Authority, with a 2007 implementation plan recently developed.[36] Product development and acquisition must balance the need for sufficient capability, including surge capacity, using existing drugs and investment in superior future products.

The development and use of medical products for a nuclear event are complex, particularly because clinical trials of efficacy cannot be done, even for drugs that are in use for other indications such as oncology. To help solve this issue, the Food and Drug Administration (FDA) has the "animal rule" as a path to drug approval. Additionally, the FDA has a process of emergency use authorization[38] so that with approval by the commissioner of the FDA there can be off-label use of a drug during an emergency.

Biodosimetry. Medical triage and management of victims depend on an individual's exposure.[26] This will be ascertained by a combination of history (where was the person in relation to the epicenter); clinical assessment, including symptomatology (recognizing that many symptoms such as nausea and vomiting can be nonspecific); laboratory assessment (primarily CBC counts); and specialized biodosimetry laboratory tests that measure radiation exposure and bioassay analysis that assesses internal contamination. Biodosimetry includes assessment of chromosome injury (cytogenetics), molecular markers of radiation exposure, and other protein abnormalities resulting from radiation damage, many of which are only under development and 3 to 5 years away from clinical application.[22,34] Additionally, projects are in progress to automate the current technologies and develop high-throughput assays that when developed would make it possible to rapidly test many thousands of people. Clinically useful assays must be sufficiently standardized and quality controlled so that they can be used reliably in medical management. This usually requires approval by the Clinical Laboratory Improvement Amendments process.[39]

To address the need for biodosimetry, the Office of the Assistant Secretary for Preparedness and Response, along with multiagency partners, is considering the development of the Radiation Laboratory Network that could be similar in concept to the CDC Laboratory Response Network.[40] The various components for the Radiation Laboratory Network, biodosimetry and bioassay, exist only in a few laboratories at present. The Radiation Laboratory Network efforts include international partners to establish international standards, share new technology, and have increased surge capacity.

Triage and on-site treatment. Although triage algorithms exist for trauma, burns, and other events, there are no simple algorithms with which to make treatment decisions in a radiation mass casualty event. Military triage includes 4 categories, including minimal treatment for those with minor injury, immediate treatment and delayed treatment for those who need and can benefit from lifesaving intervention, and an expectant category for those with serious or multiple injuries and a poor chance of survival.[41] Although Radiation Event Medical Management[12,13] provides mass-casualty radiation-event medical guidelines, the potential for responder exposure to radiation, along with infrastructure destruction, may limit the ability of nearby responders to reach and assist victims quickly. In a major event, there will be resource limitations. To help address the use of scarce resources, the Office of the Assistant Secretary for Preparedness and Response collaborated with the Agency for Healthcare Research and Quality to prepare a monograph, "Mass Medical Care With Scarce Resources: A Community Planning Guide."[42]

A *functional response system* was developed specifically for a radiologic dispersal device and improvised nuclear device event management to guide deployment of resources and to direct victims and responders to the most appropriate locations. Indeed, it addresses more than medical triage as it relates to triage, treatment on site, and transportation, and it is different from the triage T1,2,3 medical triage system.[43] This response system can serve as a template for local emergency responders developing plans for their response to a nuclear incident.

A. Radiation (triage, treatment, and transport) [RTR] sites will occur spontaneously and be determined during the event. There are 3 general RTR sites:

- RTR 1 sites will be in or just near the blast zone and have severely limited time for responders because of radiation exposure.
- RTR 2 sites will be along the plume where radiation dose will limit time for responders.

- RTR 3 sites will be sites with low radiation dose, at which victims will collect for transportation out.

There may be many RTR sites with responders calling in their location to the incident command center. Radiation dose will rapidly decrease over time so the location of RTR sites will be fluid.

B. Medical Care (MC) sites are those at which victims requiring immediate medical care will be directed and to which medical assets will be sent. These will include obvious health care facilities but also other focal points that will be predesignated to the extent possible. Because local facilities may be off line because of infrastructure damage and radiation or simply overwhelmed by numbers of casualties, medical care sites will involve regional facilities farther away from the epicenter and, indeed, an entire national network, for an improvised nuclear device.

C. Assembly Centers (AC) are collection points for displaced people and also for those needing minimal or delayed medical treatment. These may be natural collection points such as schools, public stadiums, convention centers, and highway rest stops.

The complexity of the response requires preidentification of the medical care and assembly center sites, including geographic location and type of facilities. This is being accomplished with the MEDMAP project, which is now being started to have a map and database available for the medical care sites and also for as many assembly center sites as can be preidentified. The information will be coordinated with regional, state, local, and tribal responders. The Department of Health and Human Services Regional Emergency Coordinators supported by Department of Health and Human Services for the 10 Department of Health and Human Services regions will help this effort, as well as with further coordination among Department of Health and Human Services and nonfederal partners.

Protective action guidelines. Draft Protective Action Guidelines[44] have been published to help determine dose limitations for individuals who may be involved in response activities. These are now being finalized according to public comments received. There are different suggested limits for workers in radiation industries compared with the general public and specific guidelines for a radiologic terrorism event. The determination of what is an "allowable" dose after an event for responders to recover victims, for individuals to recover their property, and for allowing reoccupation of the blast site will be determined in the local regional community, with appropriate expert consultation.[42]

Transportation. Transporting those in medical need and those displaced will be an enormous task, which includes bringing critically injured to immediate medical care, those at risk for delayed radiation injury to expert centers, and increasing local capacity to treat the severe casualties by transporting some hospitalized patients to other facilities to free up facilities. Initially, infrastructure will be severely disrupted in the event of an improvised nuclear device because of physical damage and the electromagnetic pulse. For a radiologic dispersal device, the infrastructure will be largely intact. Patient transportation for the first 24 to 72 hours postevent will be accomplished by local or regional resources. Transportation support from the federal government will be sourced from a combination of the Department of Transportation and the Department of Defense through their connection with the National Disaster Medical System.[15] It is anticipated that many of the injured will self-evacuate in private vehicles. Information as to available routes, routes and sites that are contaminated, and collection points will be issued by the local incident commander as the situation is defined during the initial hours.

Medical expert care. The US medical response system includes the local and regional hospitals, a network of hospitals in the National Disaster Medical System,[15] and the Department of Defense and the Veterans Administration system. Victims with multiple trauma, burns, and combined injury will be accommodated as best as possible in acute care hospitals. Given the similarity between cancer and hematology management and medical management of the acute radiation syndrome, the care of individuals with primary radiation injury will be assisted through the Radiation Injury Treatment Network,[45] which is a voluntary organization initiated by the National Marrow Donor Program.[46] The Radiation Injury Treatment Network, working with Department of Health and Human Services, is currently expanding this voluntary network to include National Cancer Institute Comprehensive Cancer Centers[47] and may be further expanded during the next few years. For individuals at risk for the acute radiation bone marrow syndrome, the medical management may be largely accomplished in an outpatient setting, as is done with cancer care. Thus, victims who are thought to be at risk according to their history and laboratory studies can be referred during the subsequent few weeks to Radiation Injury Treatment Network centers so that medical facilities near the event will not be overwhelmed. Although the National Marrow Donor Program is an integral part of the response network, the majority of radiation-only casualties will receive supportive care as used in hematology and oncology practice, including the hematologic growth factors as needed. Bone marrow transplantation per se is not envisioned to be used except in rare instances.

To further enhance the pool of experts and resources for medical care, collaborative efforts are being developed with the American Burn Association, although a shortage of burn beds is a serious concern; suppliers of blood products; and professional medical societies, particularly the oncology, hematology, and radiology societies, for educational programs of their members. In response to the shortfall in the number of burn nurses available to provide surge capacity for the nation, the Department of Health and Human Services developed the burn nurse training program that was implemented in October 2005 in partnership with the American Burn Association. The Burn Asset Resource Tracking System[48] was initiated in 2005 as a reporting and tracking tool for use in a burn mass casualty event.

Fatality management. Depending on the size of the event and the circumstances, attention will be given as soon as is reasonably possible to those who are fatally injured. Planning is being done to ensure that the utmost respect and dignity are provided. In an improvised nuclear device event, many of the victims may be completely disintegrated by the blast and, therefore, never recovered; the difficulty of such a consequence is well understood. In a mass casualty event such as an improvised nuclear device, management of the deceased will be delayed for a few days so that efforts will be placed on saving lives and also allowing some decay in the fission products. The handling of decedents requires the use of personal protective equipment and guidance from health physicists about dose rate and appropriate steps of decontamination and storage for those with high levels of contamination. *Guidelines for Handling Decedents Contaminated With Radioactive Materials*[49] was published recently and is available on the CDC Web site and through Radiation Event Medical Management.

Long-term management. Long-term medical management will address physical injury from the event, delayed effects of acute radiation exposure, psychological trauma, and surveillance for the risk of radiation-induced cancer. There is generally a long latency period between radiation exposure and a radiation-induced cancer. An individual's lifetime risk depends on dose received and age at exposure. For the vast number of individuals in or around even an improvised nuclear device, the incremental risk of radiation-induced cancer above their underlying normal lifetime risk will be small to negligible.[18] In the atomic bomb survivors study of the Radiation Effects Research Foundation,[18] among almost 87,000 people with individual dose estimates, 5% of the solid cancer deaths and 0.8% of the noncancer deaths were associated with radiation exposure. History of victim location, coupled with physical dose information, will provide some measure of risk assessment. Some individuals may undergo a more formal evaluation, including biodosimetry cytogenetic assessment by their physicians in consultation with subject matter experts. Research is ongoing on postexposure countermeasures that might reduce the risk of radiation-induced cancers, but there is no proven mitigation therapy available.

Summary and Conclusions

Building from the Radiological Incident Annex of the National Response Plan,[8] the emergency support function #8,[7] Public Health and Medical Services, the Office of Preparedness and Emergency Operations in the Office of the Assistant Secretary for Preparedness and Response[5] (Department of Health and Human Services) has organized a framework for civilian medical response to a radiation event. The radiation event includes a radiation dispersal device, radiation exposure device or an improvised nuclear device. The response will require unprecedented cooperation among federal agencies, local/regional/state/tribal planners, health care providers, professional medical societies, and international partners. A just-in-time medical management system, Radiation Event Medical Management,[12,13] is available. Medical countermeasures to mitigate and treat radiation injury are available to some extent in the strategic national stockpile, with new agents being developed through research programs sponsored by the National Institute of Allergy and Infectious Diseases.[34] A unique system for triage, transportation, and on-site treatment (RTR, MC, and AC sites) has been developed, and work is ongoing to identify medical care sites throughout the United States. Necessary laboratory support network for bioassay (analyzing victims for contamination with radionuclides) and biodosimetry (assess exposure through cytogenetic abnormalities) is in the early stages of being established. The hospital surge capacity provided by the National Disaster Medical System[15] is being supplemented by the Radiation Injury Treatment Network,[45] a voluntary group of experts and expert centers in hematology and oncology to help manage the radiation toxicity.

Although progress is being made in all aspects of the radiation event response planning, much remains to be done involving a broad range of experts, including emergency responders, planners, radiation biologists, countermeasures experts, biodosimetry experts, physicists, health care providers, ethicists, policymakers, and many more. Although the consequence of a catastrophic radiation event may be unthinkable, we are endeavoring to be as well prepared as possible within the United States and with our international partners.[14]

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