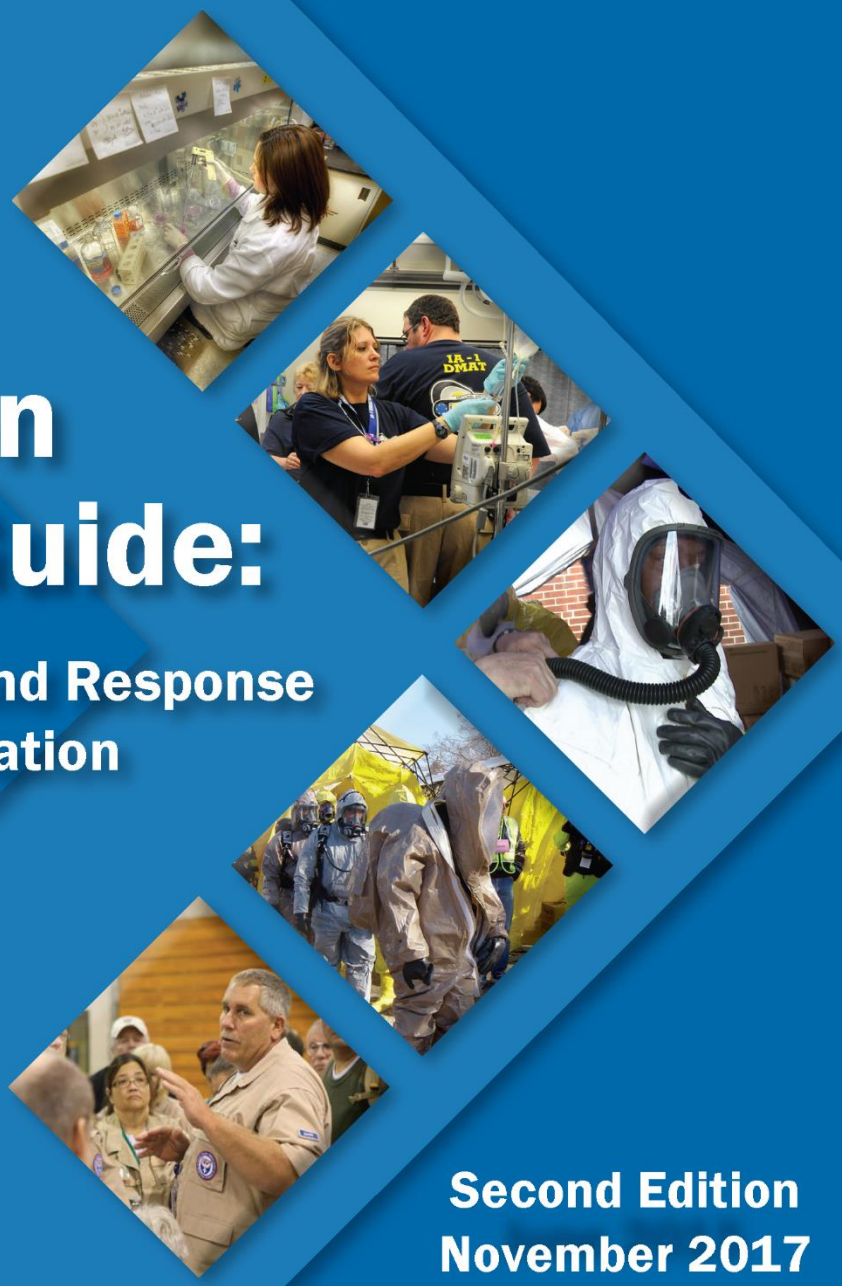
A Decision Makers Guide:

Medical Planning and Response for a Nuclear Detonation



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Foreword

A Decision Maker's Guide:
Medical Planning and Response for a Nuclear Detonation

Successful detonation of an improvised nuclear device (IND) would be a catastrophic event, causing an unprecedented number of injuries and lives lost, as well as economic, political, and social disruption. However, an effective medical response and an infrastructure prepared to protect itself from fallout could save tens of thousands of lives. Since 2001, all levels of government, academic institutions, and professional organizations have done significant work to enhance our ability to prepare for and respond to a nuclear detonation. The following manual is intended to simplify and translate the necessary protective actions and medical response modalities in order to make them more accessible and easier to translate into practice. The approach of this manual is to provide a common baseline application for various allied response disciplines (to include senior operational responders, emergency managers, public health advisors, and municipal, State, and Federal executives and elected officials). This manual will enhance mutual understanding of the basics of nuclear response.

PURPOSE

This Manual will assist preparedness efforts and decision making by providing readily accessible information that quickly describes critical scientific and medical aspects of a nuclear incident as well as the response organization and resources anticipated to be required or available during a response. It is intended to offer a checklist of decision-provoking questions and reference guide for essential information to assist with the development of appropriate actions in response to a nuclear detonation. The subject matter includes basic principles about radiation, measurement, health effects, protective actions, critical public messaging, response strategies, medical management and countermeasures, and preparedness for a nuclear detonation.

AUDIENCE

The Manual is intended for use by planners, administrators, emergency managers, government officials, and other upper-level policy and decision-makers in Federal, State, local, tribal, and territorial public health and health-sector agencies and institutions. As an informational resource and practical tool, the guide presents essential background information that provides the "why" behind the critical issues and decisions that must be made in the complex response to the medical and public health consequences of a nuclear detonation. This

manual is not intended to provide granular, encyclopedic content or instruction. Each "Section" is a rapid resource for awareness and understanding of key concepts and immediate concerns. Detailed reference information is accessible through the linked "Guide" reference sources. The summaries found in the Manual Sections and the associated details found in the Guides are essential to understanding an integrated systems approach to medical response that includes all municipal, state and federal responders, managers and key decision-makers.

The Manual is a companion to the journal manuscript published in 2012. PubMed: Medical Planning and Response for a Nuclear Detonation: a Practical Guide

USING THE MANUAL

Structure and Use of the Manual

The Manual consists of 13 Sections that provide evidence-based summaries of key information in a format of one-to-two pages. Each Section is linked to specific Guide(s) that provide the reader additional details explanation, and references. In each phase of an IND response, certain information and operations will be more important. The Sections and Guides are organized to present information in an order intended to align with anticipated IND response phases. Key points are selected and addressed to guide preparedness theories and crisis decisions.

By design, the reader has the flexibility to access any Section independently to acquire specific information as required by preparedness or response activities. The intent is for the user to be *able to quickly and effectively key in on the most important information*. In each Section, key points are offered to answer decision-based questions for fast specific information acquisition.

Navigating the Manual

There are 3 options for navigating the Manual.

1. Immediate Leader's Briefs !!! FOR IMMEDIATE DECISION SUPPORT !!!

In the immediate minutes to hours after a nuclear detonation, leaders will require prioritized background information to enhance their understanding prior to decisions that are based on actual incident information. While the Dynamic Navigation focuses on the operational timeframes for implementation, the questions that lead to decisions and actions are predictable and must be answered in the first few hours after the incident. To help focus leaders in the first few hours, questions and Manual Sections have been prioritized for when they should be read to best inform decisions over the next few days.

1. **Read in 0-4 hours – For immediate decisions and actions**
    a. RADIATION BASICS
    b. INITIAL PUBLIC PROTECTION – SHELTER AND ORDERLY EVACUATION
    c. ESSENTIAL MESSAGING AND COMMUNICATION

2. **Read in 4-24 hours – For planning actions 2 to 7 days**
    a. ORGANIZING THE RESPONSE
    b. FEDERAL, STATE, LOCAL AND INTERNATIONAL RESPONSE CAPABILITIES
3. **Read in 24+ hours – For planning actions 7 days to months**
    a. RESPONDER TRAINING AND EDUCATION
    b. DECONTAMINATION AND COMMUNITY RECEPTION CENTERS
    c. EXPOSURE ASSESSMENT AND HEALTH EFFECTS
    d. TRIAGE AND TREATMENT
    e. MEDICAL COUNTERMEASURES

2. Dynamic Navigation **!!! USE THIS METHOD FOR EMERGENCY OPERATIONS !!!**

The Dynamic Navigation feature allows the user of the Manual to access information that will answer key questions in the order they are anticipated to arise. The answers are intended to inform crucial decisions or actions and are drawn from a number of Regional planning activities, exercises, key planning resources, and national policy. Users can either proceed through the questions/answers by phase or they can dynamically access critical information through the questions as the situation requires.

3. Table of Contents Navigation

The Table of Contents is organized to help the reader quickly access the specific information being sought. The reader can proceed through preparedness resources, education, and resilience concepts leading to larger public health topics, the organization of a catastrophic medical response, medical management and medical countermeasures.

Appendices include additional details, referenced in the appropriate chapter. A list of acronyms used is at the end of the Guide.

Acknowledgments:

The preparation of this Guide would not have been possible without the generosity of the authors for their time and knowledge. Dr. Ann Norwood provided extraordinary assistance and expertize in the organization or the project and in the preparation of the publication in Biosecurity and Bioterror. RADM (Ret.) Ann Knebel provided expertise and guidance in the organization of the project.

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Dynamic Navigation

Phase 1:

0 – 48 hours
Post Detonation

Radiation Basics, Initial Public Protection, & Communication

Phase 2:

48 – 72 hours
Post Detonation

Response Organization & Capabilities

Phase 3:

72+ hours
Post Detonation

Patient Care & Treatment Guidance

Phase 1: 0 – 48 hours Post Detonation
Radiation Basics, Initial Public Protection, & Communication

RADIATION BASICS

How do people get exposed to radiation?

What are the effects of radiation exposure?

What is nuclear fallout?

How quickly does nuclear fallout dissipate?

What are the protective exposure levels for radiation exposure?

How do people limit their radiation exposure?

INITIAL PUBLIC PROTECTION – SHELTER AND ORDERLY EVACUATION

Should we distribute and dispense Potassium iodide (KI)?

Who is responsible for decontamination of casualties?

Why is shelter from nuclear fallout important?

What type of indoor shelter is best?

Why is a safe room important?

How should people choose a safe room?

What supplies and how many supplies should people keep for emergencies?

How do people keep a safe room ready?

ESSENTIAL MESSAGING AND COMMUNICATION

What lifesaving measures actions are need to be communicated after an IND?

What messages should be developed for the public?

What are the recommended channels of transmitting messages?

What challenges may arise when developing a message for the public?

How can people psychologically prepare for a nuclear detonation?

Phase 2: 48 – 72 hours Post Detonation
Response Organization & Capabilities

ORGANIZING THE RESPONSE

What is the National Incident Management System (NIMS)?

What is the purpose of the Incident Command System (ICS)?

How is the National Response Framework (NRF) structured?

How does FEMA coordinate emergency response effort?

What are the responsibilities of DHHS through ESF #8?

What are the general priorities for the response to an IND detonation?

What will the landscape look like after an IND detonation?

How should the response be organized based on the effects from the blast?

What is the RTR system?

How does the RTR system overlay with the physical damage?

Will all areas near the detonation be contaminated with radiation?

How will an IND affect the ability to get resources into the damaged areas?

FEDERAL, STATE, LOCAL AND INTERNATIONAL RESPONSE CAPABILITIES

What are the major issues that will need to be addressed after an IND incident?

What type of injuries will casualties experience?

What is the best way to use the resources available after an IND detonation?

How do we prepare for the scarcity of resources after an IND?

How will the lack of resources affect patient care?

What are Crisis Standards of Care?

Phase 2: 48 – 72 hours Post Detonation – cont'd
Response Organization & Capabilities

What resources have been developed to assist with the public health and medical response to an IND?

Which U.S. Government agencies could provide assistance during a radiological disaster?

What Federal partners will be involved in the response?

What is the role of the region/state surrounding the affected area?

Which international agencies could provide assistance during a radiological disaster?

What are the Protective Action Guides (PAGs) for the U.S. and where can they be found?

How can planning help create resilient communities?

Who should be involved in whole of community planning?

Phase 3: 72+ hours Post Detonation
Patient Care & Treatment Guidance

RESPONDER TRAINING AND EDUCATION

What key topics should first responders/first receivers know when managing patients after a radiation mass casualty emergency?

What online education/training is available to help fill in radiation emergency training and information gaps?

What onsite radiation emergency training is available?

DECONTAMINATION AND COMMUNITY RECEPTION CENTERS

How will those affected by a radiation or nuclear incident be assessed and monitored for radiation exposure and/or contamination?

What is the best method for decontamination?

How and where are mass decontaminations planned to occur?

What is a Community Reception Center (CRC)?

Who is responsible for staffing a community reception center?

EXPOSURE ASSESSMENT AND HEALTH EFFECTS

What is the background radiation dose for Americans each year?

What is the annual occupational dose limit for U.S. workers?

What are the symptoms of the late health effects of radiation exposure?

What dose of radiation exposure would result in little to no early or acute health effects?

How does radiation exposure effect an individual's lifetime cancer risk?

How is the amount of radiation exposure determined?

What are the health effects of large doses of radiation?

What doses of radiation exposure are medically treatable?

Phase 3: 72+ hours Post Detonation
Patient Care & Treatment Guidance

TRIAGE AND TREATMENT

What are the priorities for triage and treatment of affected individuals?

Will the largest amount of exposure be from internal exposure or external exposure?

What is the acute radiation syndrome?

How should those with the acute radiation syndrome be treated medically?

Who can help with treatment of patients with the acute radiation syndrome?

Where can I get more information for medical providers and responders?

How many people are likely to have been affected by the actual radiation?

MEDICAL COUNTERMEASURES

Which federal agency manages the Strategic National Stockpile?

How are Emergency Use Authorizations invoked to use drugs in the SNS?

Which federal agency is directly involved with the approval and use of internationally supplied drugs?

How do you treat mass casualties during a scarce resource setting?

After a radiation disaster, how are “off label” drugs managed?

What injuries are expected after radiological and nuclear incidents?

What is the most accurate method of obtaining radiation dose assessments?

What medical countermeasures are currently available for radiation exposure after a nuclear detonation?

What federal agencies are involved with MCM research and product development?

Manual

Just-in-Time Summary Information

Section 1: Shelter the Population for 24 Hours, then Orderly Evacuation

Nuclear Fallout Protection in a Nutshell – What to Do, What Not to Do, and Why

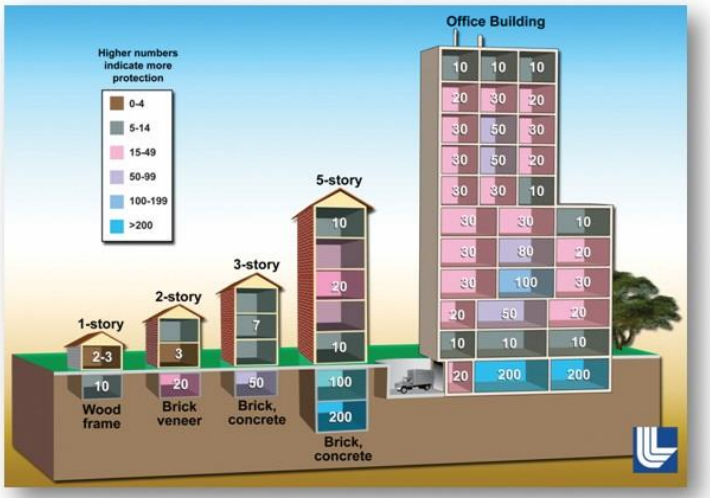
DECISION MAKING CONSIDERATIONS:

- How do people get exposed to radiation?
- What are the effects of radiation exposure?
- What is nuclear fallout?
- How quickly does nuclear fallout dissipate?
- What are the protective exposure levels for radiation exposure?
- How do people limit their radiation exposure?
- What type of indoor shelter is best?

KEY INFORMATION:

- The single immediate action that will save the most lives following a nuclear explosion is to **take shelter in the nearest and most protective building or structure and listen for instructions from authorities**. (See Figure 1, below, for estimated building protection factors).
- Most people should have at least 10 minutes before fallout arrives to reach shelter. **People should not remain outside or use vehicles for shelter.**
- Below ground is best, if that option is available, but the center of a structure is acceptable.
- Shelter for 12-24 hours until more information is available.
- Shelters such as houses with basements, large multi-story structures, and underground parking garages or tunnels, can generally reduce doses from fallout by a factor of 10 or more. These structures would generally provide adequate shelter.
- There is no protective clothing or gear that will prevent exposure to all types of radiation.

Figure 1: Fallout Protection Factors for Various Structures. Image is courtesy of Lawrence Livermore National Laboratory. The larger the PF number the greater the protection. For example, a PF of 10 indicates 1/10th the exposure compared to no protection and a PF of 100 means 1/100 (1%).



NEED TO KNOW:

What is nuclear fallout? - Fallout basics

Radiation from a nuclear explosion falls into 2 categories:

1. **Initial nuclear radiation** (prompt radiation and neutron activation), which originates from the explosive event and the early fireball
2. **Residual radiation, which** is largely associated with fallout.

Both prompt and fallout radiation can cause health effects and the severity **increases as the dose increases** (discussed in the section on Acute Radiation Syndrome in this manual).

The **exposure pathway** of greatest concern up to several days after the incident is **external irradiation from groundshine, not ingested or inhaled radiation. Nonetheless, external decontamination is important as soon as it is feasible.**

How long does the acute danger from fallout last? In the first hour, fallout dose rates in the hundreds of Roentgens per hour (R/hour) should be expected, and may be 1000 R/hour (10 Gy/h) or higher in localized areas.

Figure 2: Radiation dose rate decreases over time. After approximately 24 hours (and in most cases 12 hours) even the highest early dose rates have diminished to the point where exposures may be incurred without suffering acute radiation effects. **(**Source: Armed Forces Radiobiology Research Institute's Medical Effects of Ionizing Radiation Course on CD-ROM (1999))

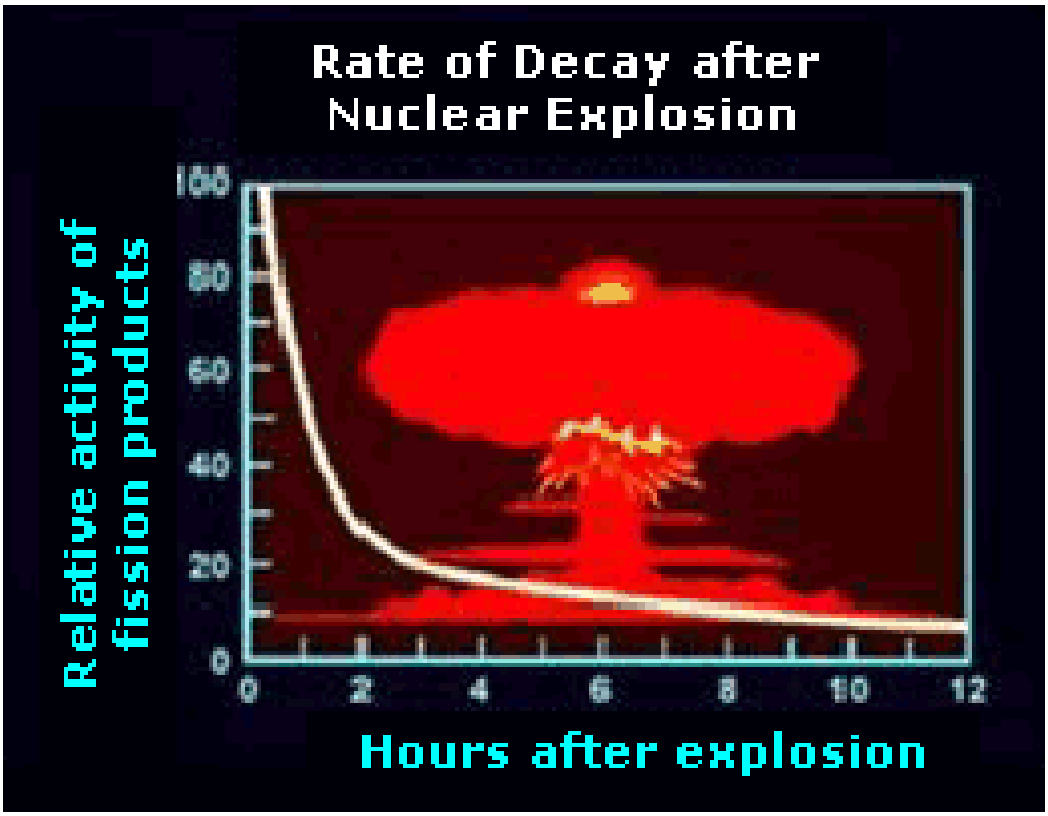


Table 1. Example dose rate decay from early fallout as a function of time after a nuclear explosion
(adapted from Glasstone, United States Department of Defense, Third edition, page 394, 1977)

Time (hours)	Dose Rate (R/h)
1	1,000
1.5	610
2	400
3	230
5	130
6	100
10	63
15	40
24	23
36	15
48 (2 days)	10
72 (3 days)	6.2
100 (~ 4days)	4.0
200 (~ 8 days)	1.7
400 (~ 17 days)	0.69
600 (~ 25 days)	0.40
800 (~ 33 days)	0.31
1,000 (~ 42 days)	0.24

For more details, see Guide 3 about:

- Nuclear fallout basics
- Fallout protection offered by normal structures
- The importance of shelter and evacuation timing

Section 2: What Do We Communicate to People and How Do We Do It?

Communicating About a Nuclear Detonation

DECISION MAKING CONSIDERATIONS:

- What messages should be developed for the public?
- What lifesaving measures actions are need to be communicated after an IND?
- What challenges may arise when developing a message for the public?
- What are the recommended channels of transmitting massages?

KEY INFORMATION:

- **An expert spokesperson should be available to discuss radiation and risk at a sophisticated level and be able to explain and/or counter partial or incorrect information that may be in the media.**
- **Pre-scripted messages are available for use in an emergency.**
- **See CDC -** CDC Radiation Emergencies webpage
- **See FEMA -** FEMA IND Communications Guidance

Initial Shelter and Evacuation Message (Source: CDC)

Get Inside

In a radiation emergency you may be asked to get inside a building and take shelter for a period of time.

- This action is called "sheltering in place."
- Get to the middle of the building or a basement, away from doors and windows.
- Bring pets inside.

Stay Inside

Staying inside will reduce your exposure to radiation.

- Close and lock windows and doors.
- Take a shower or wipe exposed parts of your body with a damp cloth.
- Drink bottled water and eat food in sealed containers.

Stay Tuned

Emergency officials are trained to respond to disaster situations and will provide specific actions to help keep people safe.

- Use radios, televisions, computers, mobile devices, and other tools to get the latest information.
- Emergency officials will provide information on where to go to get screened for contamination.

NEED TO KNOW:

One of the most effective life-saving activities after an IND incident will be to inform the population of when and how to protect themselves from fallout and when and how to subsequently evacuate. Messages prepared, tested, and practiced in advance are fundamental to conveying clear, consistent information and instructions during an emergency.

How to get the message out - communication channels by target audience

In a nuclear denotation, every available information outlet, including social media, must be used to gather information about the health and safety issues the community and responders face; to provide guidance to affected populations; and to address health, economic, safety and other concerns of people across the country and throughout the world.

Table 1. Communication Channels by Target Audience - Communication channels can and should be approached with partners who can amplify the message and serve as force-multipliers for emergency responders.

Location of Target	Suggested Communication Channels
Damage Zones	Short-wave and regular radio Public announcement (PA) systems Flyers Siren warning systems Door-to-door Monitor social media for situational awareness
Dangerous Fallout Zone	Short-wave and regular radio NOAA weather radio Public announcement (PA) systems Siren warning systems Electronic billboards Flyers 911 systems Monitor social media for situational awareness
Surrounding Area	Radio Television Newspapers Text messaging systems Electronic and hard-copy billboards Social media Websites Flyers
National and International Communities	Social media Television Newspaper Magazines Websites

Recommendations for composing messages

- Write short, concise, and simple messages
- Use directive and authoritative language
- Provide prioritized instructions and directions in each message
- Provide information for a variety of environments
- Create a message to encourage people not to leave their homes to check on loved ones in schools, daycares, and elder-care facilities
- Avoid or define unknown terms and phrases
- Help people understand the radiation threat, by putting the levels being detected in the context of radiation we live with every day. **See Figure 1 in Guide 12 for an example.**

[Note: Some individuals may find the comparisons to be minimizing their concerns]

Challenges to consider when developing a message – Experiences from the Fukushima incident

- Confusion exists due to varying radiation units (Sievert, rem, Roentgen) and various prefixes (centi-, milli-) that are unfamiliar.
- Simple assurances are not sufficient and may even be detrimental or insulting to some.
- Long term radiation risk can be challenging to explain.
- Comparison with more routine sources of radiation was variably received (e.g., airplane flight).
- Differing recommendations can be a cause of confusion among the public, and partial or incorrect information can add to stress.
- Patience is critical and repetition of information is necessary, especially as more data become available.

For more details, see Guide 12 about:

- Communicating About Protective Actions And Radiation
- Communications Infrastructure
- Communication Channels
- Challenges to Preparedness and Opportunities for Planning

Section 3: Promoting Individual Resilience following an IND

Preparing the Home for Sheltering in Place Following a Nuclear Detonation

DECISION MAKING CONSIDERATIONS:

- How can people psychologically prepare for a nuclear detonation?
- Why is shelter from nuclear fallout important?
- Why is a safe room important?
- How should people choose a safe room?
- What supplies and how many supplies should people keep for emergencies?
- How do people keep a safe room ready?

KEY INFORMATION:

- **One of the most important aspects to saving the most lives following a nuclear detonation is for people to limit exposure to radioactive fallout that will come from the cloud traveling away from ground zero.**
- **The safest room in a home or business is a basement or a room with as few windows as possible.**

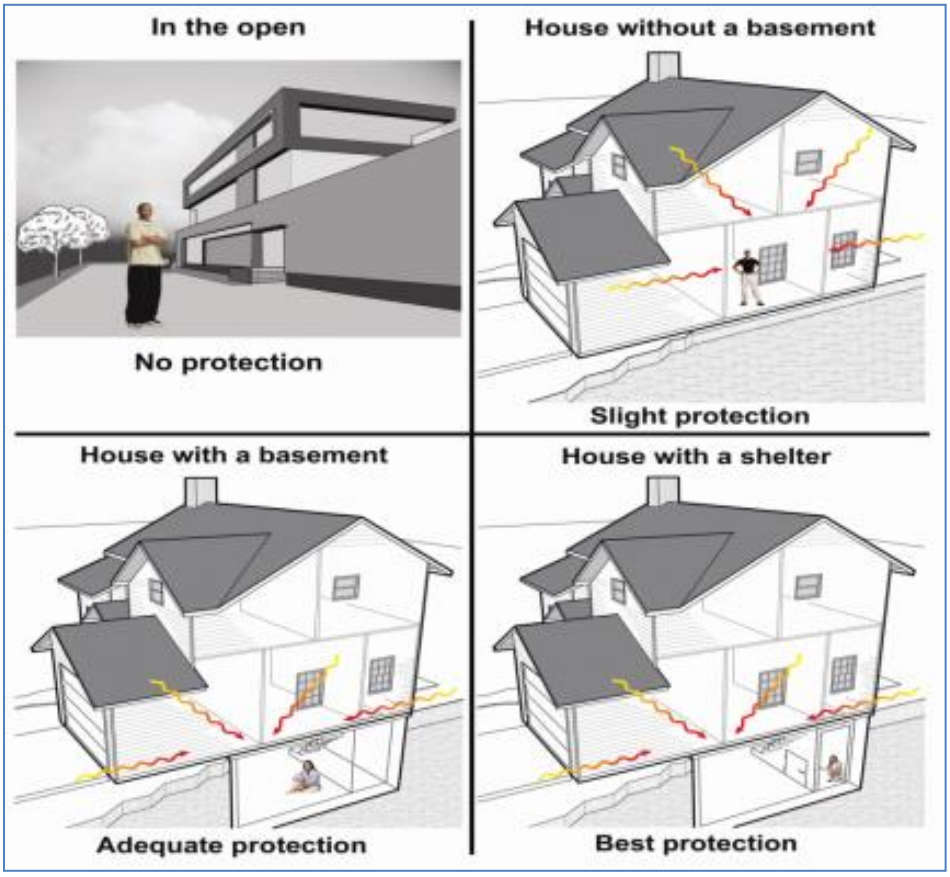


Image Courtesy of Lawrence Livermore Laboratories

NEED TO KNOW:

What can an individual do? – Preparedness at home

Every American family should prepare their home for the possibility of disaster. This is especially important for a nuclear detonation. A "shelter in place" order should be issued to reduce exposure of the population to radiation.

Individual and family preparedness can aid the response to a radiological incident by decreasing the likelihood of injury and exposure, reducing the sense of panic and the pressure on the overall response so responders can focus on the injured.

To find out more about preparedness and resilience - CDC Radiation Preparedness and Shelter webpage.

Important topics include:

1. **Psychological preparation** - acknowledging that there is the possibility that a nuclear explosion can happen and that there are protective actions one can take to reduce serious injury

2. How to choose a **safe room**– Selecting a proper safe room saves lives

3. Recommended **emergency supplies**

4. How to **maintain the safe room**

5. There will be areas of physical destruction with no radiation and also areas of fallout without physical damage so it is important to listen to information and follow instructions.

For more details, see Guide 4 about:

- Protective Actions: Shelter and Evacuation
- What to Do - Choosing, Preparing, and Maintaining a Safe Room in the Home

Section 4: Coordination of Local, State, and Federal Responses

The Federal Response Structure and Plans: NRF, NIMS, ESFs and Directives

Involving the Community: Operationalizing a Playbook, Engaging Regional Emergency Coordinators, and Considering Ethical Issues

DECISION MAKING CONSIDERATIONS:

- What is the National Incident Management System (NIMS)?
- What is the purpose of the Incident Command System (ICS)?
- How does FEMA coordinate emergency response efforts?
- How is the National Response Framework (NRF) structured?
- What are the responsibilities of DHHS through ESF#8?
- What resources have been developed to assist with the public health and medical response to an IND?

NEED TO KNOW:

Federal response structure

Management of a response: National Incident Management System (NIMS)

NIMS outlines the management structure for the response to a specific emergency, large or small, by establishing unified concepts, terminology, and procedures. It is a template that allows first responders (e.g., police, firefighters, or emergency planners) from various jurisdictions (local, state, tribal, government and non-government organizations) to effectively work together during a response. FEMA NIMS website

The NIMS concepts are built upon an organizational structure called the **Incident Command System (ICS)**. ICS is used for a broad spectrum of emergencies, from small to complex incidents, both natural and manmade, including acts of catastrophic terrorism. The ICS structure was designed for use by federal, state, local, and non-government organizations while managing incidents.

Geographic organization of the response: FEMA regions

States are divided into 10 regions, which enable FEMA to better coordinate emergency response efforts (Figure 1). Each region contains a Regional Response Coordination Center (RRCC) that serves as the main Federal coordination center. After an incident a Joint Field Office (JFO) is established locally to act as a temporary multiagency coordination center.

Figure 1. FEMA Regions (Region IX includes American Samoa, Commonwealth of the Northern Mariana Islands, Republic of the Marshall Islands and Federated States of Micronesia)

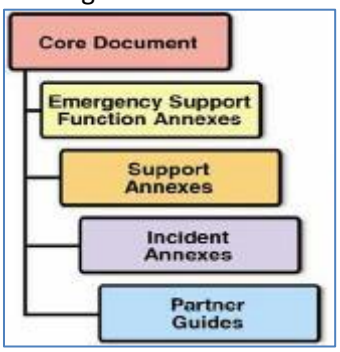
Response Plans

National Response Plans

National Response Framework (NRF)

The NRF and its list of annexes fully explain the principles that guide national response, roles and responsibilities, response actions, response organizations, and planning requirements to achieve an effective national response to any incident that occurs. A visual structure of the NRF is shown below in Figure 2.

Figure 2. Structure of the National Response Framework. These components are nonspecific and applicable to all hazard incidents and emergency and non-emergency situations to ensure all municipalities develop similar response structures in an effort to integrate response across all levels of government.



Emergency Support Functions

Contained in the NRF are 15 Emergency Support Function (ESF) Annexes. These annexes list the Emergency Support Functions and the capabilities, roles, and responsibilities each agency or group provides during response operations. . **For a table of the 15 ESFs, their scope, and coordinating and primary agencies see Guide 10, Table 1.**

Table 1. Tasks of the Department of Health and Human Services (DHHS) fall under ESF #8

Emergency Support Function	Scope
ESF# 8- Public Health and Medical Services	▪ Public health ▪ Medical ▪ Mental health services ▪ Mass fatality management

DHHS responsibilities through ESF #8 include:

1. Coordinate population monitoring
2. Coordinate and/or conduct certain laboratory analyses (radiobioassay)
3. Provide guidance and technical assistance for
    - Medical management of casualties
    - Population decontamination
    - Internal contamination monitoring
4. Provide medical countermeasures from the Strategic National Stockpile (SNS)
5. Coordinate fatality management
6. Coordinate training for providers
7. Provide medical surge

Nuclear/Radiological Incident Annex

The Nuclear/Radiological Incident Annex (NRIA) to the NRF addresses the unique responsibilities and coordination requirements for the scope of potential accidental or deliberate releases of radiological material or a nuclear detonation. Agency roles, responsibilities, and authorities are specifically described for each type of incident. Additionally, an integrated concept of operations and unique organization, notification, and activation processes and specialized incident-related actions are discussed. In 2015 a revised Nuclear Radiological Annex will be published, updated the previous 2008 version.

ESF #8 – Improvised Nuclear Device Playbook (IND Playbook)

This playbook, authored by Office of Emergency Management, ASPR, for use by DHHS, outlines key measures and options to aid the DHHS Secretary in making essential decisions and directing the DHHS response to a radiological attack. The IND Playbook provides specific linkages between DHHS and ESF #8 response capabilities (e.g., medical and public health coordination, guidance and technical assistance, patient movement, deployable assets and teams) and the overall planned federal response as it is outlined in the NRF guidance.

State and Local Response Plans

Each state and locality should have their own plans/playbook for responding to an IND. FEMA has published the ***Comprehensive Preparedness Guide 101*** (CPG 101) that describes ways to align community planning with the broader response should that community become overwhelmed and require additional assistance. FEMA CPG 101 document

To assist state and local medical planners in their IND response planning and ensure that those plans link and integrate with the anticipated federal response, ASPR developed the ***State and Local Planners Playbook for Medical Response to a Nuclear Detonation (State and Local Planners Playbook)***. ASPR State and Local Planner's Playbook for IND

ASPR State and Local Planners Playbook for Medical Response
DHHS has developed a *State and local Planners Playbook* as an adjunct to the ESF #8 *IND Playbook* to assist with the integration of state and local IND response planning. The *State and local Planners Playbook* uses action steps to guide emergency management leaders from pre-incident to tasks 96 hours after the incident and can either be downloaded or an interactive web-version can be used.

Ensuring ethical planning for an IND detonation

After an IND detonation, resources are likely to become limited until resupply can occur. Medical decision making under chaotic circumstances will be a difficult issue. Discussion and consensus building prior to a nuclear event is essential to ensuring public health officials and disaster response professionals understand the interests and preferences of various communities related to the utilization of scarce medical resources. These discussions can be useful in providing immediate direction for local hospitals regarding clinician training and dissemination of information to the public.

For more details, see Guide 10 about:
- The Federal Response Structure
- Federal Response Plans

For more details, see Guide 11 about:
- Ways to Involve the Community
- Using the ASPR State and Local Planners Playbook
- Coordinating with ASPR Regional Personnel
- Important Ethical Considerations

Section 5: International Resources

International Agencies, Networks, and Radiation Safety Guidance

Section 5

DECISION MAKING CONSIDERATIONS:

- Which U.S. Government agencies could provide assistance during a radiological disaster?
- Which international agencies could provide assistance during a radiological disaster?
- What are the Protective Action Guides (PAGs) for the U.S. and where can they be found?

KEY INFORMATION:

- Any atmospheric release of radiation will be an international issue.
- Sensitive radiation detectors are present around the world. The lowest levels that can be detected are well below an amount that requires any protective actions for the public because there is little or no human health risk (acute or chronic).
- Individual countries set their own protective action guidelines (PAGs). Minor differences in the dose and in radiation units used in these guidelines can produce confusion among countries, decision-makers and the public.
- For the U.S. Protective Action Guidelines (PAGs), see Guide 14 or EPA PAG Webpage
- The U.S. Government has been working with international governments and agencies to prepare for a possible nuclear or radiological incident.
- Governmental, national and International agencies can provide assistance in the event of a nuclear or radiological incident.

NEED TO KNOW:

Who has DHHS been working with internationally?

Under the umbrella of the United Nations, the World Health Organization (WHO) and International Atomic Energy Agency (IAEA) develop recommendations for planning and preparedness and assist with networks that have expertise and laboratory capability for biodosimetry and medical response.

1. **International Atomic Energy Agency (IAEA), United Nations** IAEA webpage
    a. Emergency Notification and Assistance Technical Operations Manual (ENATOM)
        i. Defines the roles and responsibilities of the IAEA, State Parties, and the IAEA Member States for being prepared for responding to nuclear accidents and radiological emergencies.
    b. Response and Assistance Network (RANET) RANET webpage
        i. Promotes emergency preparedness and provides assistance and advice among IAEA Member States. Can also provide biodosimetry assistance. From the U.S. REAC/TS is currently the only deployable response team

that supports RANET, but the size of their response team is relatively small. REAC/TS webpage

2. **World Health Organization (WHO), United Nations**
    a. Radiation Emergency Medical Preparedness and Assistance Network (REMPAN) REMPAN webpage
        i. Provides emergency medical support for radiation exposed individuals.
    b. WHO BioDoseNet BioDoseNet webpage
        i. Provides a network of biodosimetry laboratories to support management and decision-making in cases of large radiation emergency events.
    c. MULTIBIODOSE MULTIBIODOSE webpage
        i. Consortium developed and validated several biodosimetry assays as tools for rapid biological dose assessment in a mass casualty event. The assays were harmonized in such a way that in an emergency situation they can be run in parallel in a network of European laboratories. A dedicated MBD statistical software tool was developed that allows collation of results obtained with the different assays.

3. **Global Health Security Initiative (GHSI)** GHSI webpage
    a. An informal, international partnership whose purpose is to strengthen health preparedness and response globally to threats of CBRN terrorism and pandemic influenza.

What U.S. agencies can provide assistance?

1. Radiation Emergency Assistance Center/Training Site (REAC/TS) - REAC/TS webpage
2. U.S. Agency for International Assistance (USAID), Office of the United States Foreign Disaster Assistance (OFDA), Disaster Assistance Response Team (DART) - USAID webpage
3. Department of Health and Human Services (HHS), Office of the Assistant Secretary for Preparedness and Response (ASPR) - ASPR webpage
4. Center for Disease Control and Prevention (CDC), Radiation Studies Branch - CDC Radiation Emergency webpage

For more details, see Guide 14 about:
- Potential International Collaborations
- International Assistance Provided by the United States

Section 6: Key Response Planning Concepts for Planning an IND Response

Response, Resources, and Resilience: Preparedness and Planning for a Nuclear Detonation

DECISION MAKING CONSIDERATIONS:

- What are the major issues that will need to be addressed after an IND incident?
- How can planning help create resilient communities?
- Who should be involved in whole of community planning?
- What Federal partners will be involved in the response?

KEY INFORMATION:

- Preparedness efforts should focus on all-hazard issues to ensure that the command, control, coordination, and communications elements of an effective response are as robust and well-practiced as possible within a community.
- Checklists containing required action items and essential information and planning guidance can be found in the State and Local Planners Guide from ASPR and the National Planning Guidance for an IND Response prepared by OSTP (see links below).
- The ultimate goal of resilience is to systematically integrate into the overall community structure realistic risk reduction that is achieved through good baseline health status, strengthened institutions and capacities, and programmatically implemented preparedness, response, and recovery plans.

1. State and Local Planner's Playbook
   ASPR State and Local Planners Playbook for IND

2. National Planning Guidance
   National Planning Guidance for an IND

NEED TO KNOW:

Planning for the medical and public health issues resulting from an IND

Effectively planning for the public health and medical response to a major disaster is critical for saving lives and offering care to as many people as possible. The resources to support a medical response should be understood and augmented to the degree possible given economic and other constraints prior to an incident.

After an IND incident, the following issues will need to be addressed:

- Massive "Key Infrastructure" damage
- Multiple system failures, including command and communications and possible loss of major systems or emergency operations centers
- Contingencies for overwhelmed responder agencies and organizations
- Integration of a regional, federal and perhaps international response
- Medical resource deficits

- Patient movement within and out of the affected area
- Resource availability, scarcity, and ethical distribution of resources

Creating resilient communities through effective planning

Community resilience is an essential element needed to recovery from a disaster. Coordination, communication, education, cooperation, and collaboration among the broad spectrum of government, academia, the private sector, and in particular the general public, creates communities that will be empowered to endure after a catastrophic and traumatic incident. Local planning is most effective when it is integrated across the tiers of response to include the federal tier.

Federal response resources

A nuclear detonation will bring an unprecedented number of federal agencies to the jurisdiction. Understanding the resources available and the chains of command, as well as anticipating where and how to coordinate efforts is essential. Some of the key players would likely be:

- DHS and FEMA
- Department of Defense (DoD)
- U.S. Department of Energy (DOE)
- Nuclear Regulatory Commission (NRC)
- DOJ and Federal Bureau of Investigation (FBI)
- DOT and FAA
- U.S. Department of Health and Human Services (DHHS or HHS)
- U.S. Department of Veteran's Administration (VA)

The specific roles of each agency can be found in the Available Resources section of this manual at the end of the guides.

For more details, see Guide 2 about:
- Creating Resilient Communities Through Planning

Section 7: Medical Response Concerns for an IND

Response, Resources, and Resilience: Response to a Nuclear Detonation

DECISION MAKING CONSIDERATIONS:

- What are the general priorities for the response to an IND detonation?
- What will the landscape look like after an IND detonation?
- How should the response be organized based on the effects from the blast?
- What is the RTR system?
- How does the RTR system overlay with the physical damage?
- Will all areas near the detonation be contaminated with radiation?
- What type of injuries will casualties experience?
  What is the role of the region/state surrounding the affected area?

KEY INFORMATION:

- For a detailed response plan including phased action steps, please see the IND playbook or State and Local Planners Playbook for Medical Response to a Nuclear Detonation.
- The RTR system (Radiation TRiage, TReatment, and TRansport) overlays functional response capabilities on the physical damage response zones.
- There can be major zones where there is physical injury without radiation (upwind glass breakage injuries, consequences of flash-blindness) and others where there is radiation exposure with limited or no physical damage to the infrastructure (fallout areas).
- A nuclear detonation will bring an unprecedented number of federal agencies to the jurisdiction. The overall response will be handled at the local level with support from state and regional partners.

NEED TO KNOW:

Scope of the problem

After an IND incident, there will be:

- Key Infrastructure damage
- Multiple system failures, including command and communications and possible loss of major systems or emergency operations center locations
- Overwhelmed responder agencies and organizations
- Integration of an unparalleled regional, federal, and perhaps international response
- Medical resource deficits
- Required patient movement within and out of the affected area
- Resource scarcity

Organization of the response based on the effects of the blast

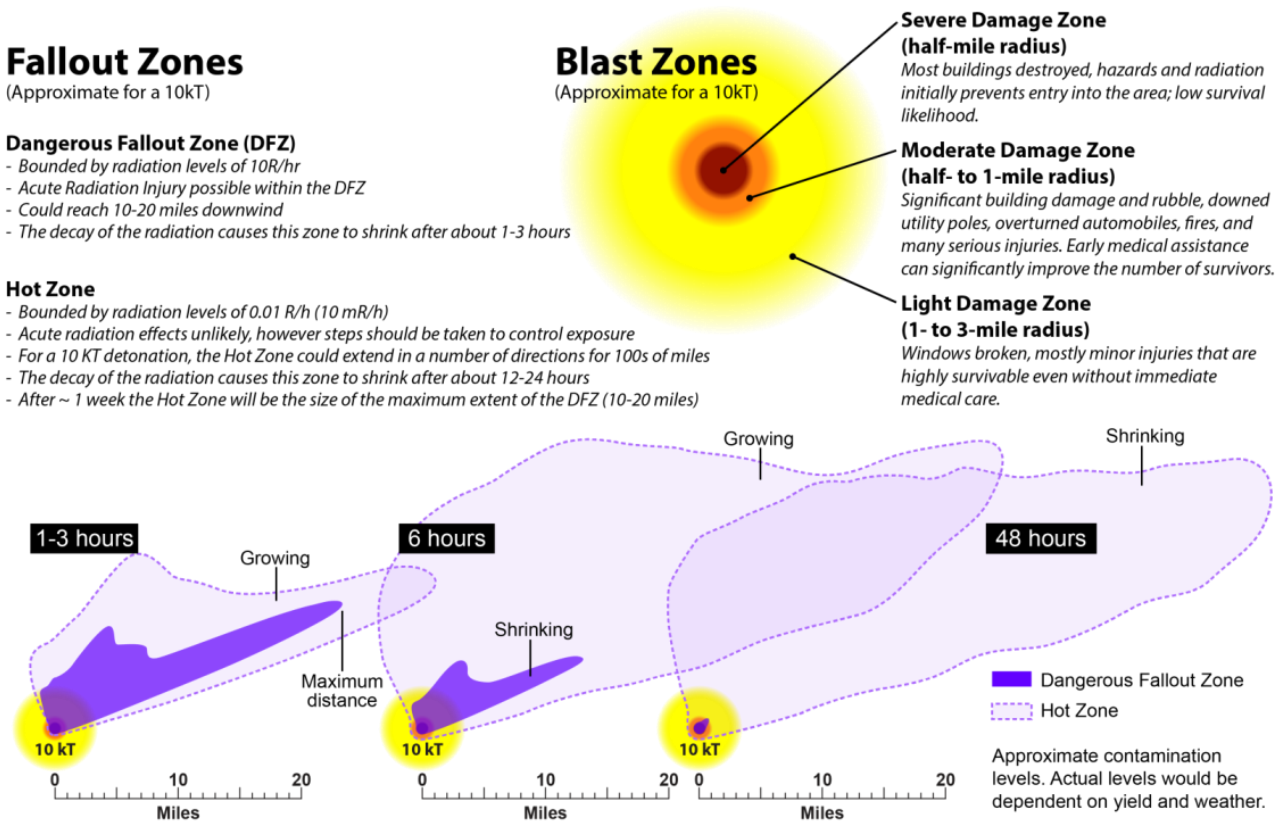
The destruction from a nuclear detonation produces both physical damage and radiation exposure. While the blast, heat, and radiation zones are fairly co-incident close in, there can be

major zones where there is physical injury without radiation (upwind glass breakage injuries, consequences of flash-blindness) and others where there is radiation with limited or no physical damage to the infrastructure (fallout areas). The planned response after a nuclear detonation is organized around and within the damage zones (Table 1 and Figure 1, below):

Table 1. Physical Damage Zones

Damage Zone Name	Description
Severe Damage (SD) Zone	Extensive infrastructure damage and few survivors
Moderate Damage (MD) zone	Passable, with variable to no levels of radiation that if present decrease over time
Light Damage (LD) zone	Passable, with little or no radiation other than where fallout areas overlap the LD zone
Dangerous Fallout (DF) zone	Area with a dose rate of 10 R/h or greater – may overlap the above zones. (The DF zone shrinks rapidly as exposure from fallout decays).
A perimeter 10mR/h (0.01 R/h) or greater	Location where time and dose for people working in that zone are monitored. This is outside the DF zone

Figure 1. Damage and Fallout Zones Defined (Source: National Planning Guidance)



Section 7

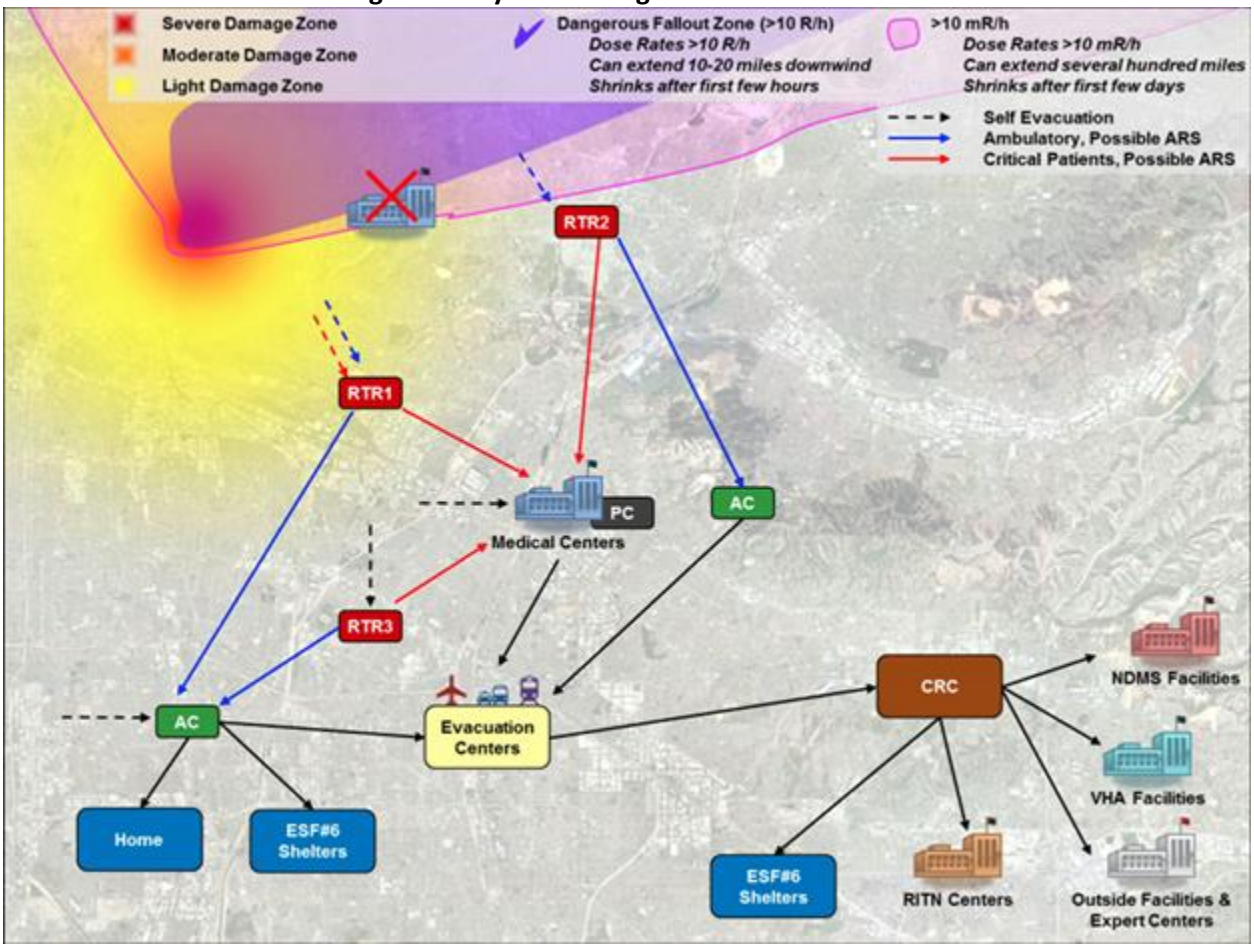
The RTR system

The RTR system (Radiation TRiage, TReatment, and TRansport) overlays a functional response structure on the physical damage response zones. The labeling of RTR sites is based on their geographic location in respect to the site of the initial blast and the fallout pattern. The definitions of the Damage Zones are in Table 1 and Figure 1, above, RTR in Table 2 and Figure 2, below)

Table 2. The RTR Functional Response System (Radiation TRiage, TReatment, and TRansport) helps organize the response.

RTR Site Type	Specific Functions
Spontaneously forming RTR sites (casualty collection points)	• RTR1 – at or near **major physical damage** with **radiation present** • RTR2 – **no or limited physical damage** and **radiation present**, likely near the DF zone • RTR3 – **no or limited damage** and **NO radiation**
Pre-designated sites (assembly centers & healthcare facilities)	• Medical Care (MC) sites, including alternative medical care sites • Assembly centers (AC), some of which may be co-located near MC sites for people who do not require medical care • Evacuation centers (EC)

Figure 2. Physical Damage and RTR Zones.



General priorities for medical response to an IND detonation

- Situational awareness and establishment of command and control
- Patient triage based on physical injury first and then radiation assessment
- Emergency care of patients takes precedence over their radiation decontamination
    - Removal of clothing removes >90% of superficial contamination
- Psychological and behavioral medical care for responders and casualties
- Transport of patients and responders into and out of the damaged area will be difficult
    - Back-fill of personnel and supplies will be required
    - May require creative solutions (4-wheel drive vehicles, buses, etc.)

Regional/State Response

The role of the surrounding region is to support, and when needed assume responsibility for absent command and control mechanisms.

- Command and control in the absence of local mechanisms
- Proactive emergency declaration for state and federal resources
- Assist with the surge in acute medical care needs at locations outside the damaged area
- Support from emergency management assistance compacts (EMACs) may be uncertain due to the magnitude of the crisis
- Regional staging areas may be used for the response
- Activities may change as resources are limited and then supplied from the outside

Federal Response

A nuclear detonation will bring an unprecedented number of federal agencies to the jurisdiction. Some of the key players would likely be those below based on cause of nuclear material):

- Federal Bureau of Investigation (FBI) - FBI WMD webpage
- Federal Emergency Management Agency (FEMA) - FEMA Nuclear Blast Preparedness webpage
- U.S. Department of Energy (DOE) - DOE Radiation Response webpage
- Nuclear Regulatory Commission (NRC) - NRC Radiation Response webpage
- U.S. Department of Health and Human Services (HHS) - ASPR HHS Medical Response Resources webpage
- Department of Defense (DOD) - DoD JTFCS Response webpage
- U.S. Department of Veteran's Administration (VA) - VA Medical Emergency Radiological Response Team webpage

The specific roles of each agency can be found in the Available Resources section of this manual located at the end of the guides.

For more details, see Guide 2 about:

- Response Organization – Damage Zones and a Functional Response System

Section 8: Solutions to Scarce Resource Availability after an IND

Response, Resources, and Resilience: Resource Scarcity after a Nuclear Detonation

DECISION MAKING CONSIDERATIONS:

- How will an IND affect the ability to get resources into the damaged areas?
- What is the best way to use the resources available after an IND detonation?
- How do we prepare for the scarcity of resources after an IND?
- What are Crisis Standards of Care?
- How will the lack of resources affect patient care?

KEY INFORMATION:

Strategies for Scarce Resource Situations

- **Prepare** – stock disaster supplies and increase inventory of commonly needed items such as tetanus vaccines, laceration trays, narcotic analgesics, dressings, etc.
- **Substitute** – use a clinically equivalent item or staff position
- **Adapt** – use items or technologies to provide sufficient care (transport ventilators or anesthesia machines instead of full-featured ventilators), use staff with similar or congruent skill-sets (specialty surgeons assisting with trauma surgeries), or adapt locations of care (performing surgical procedures outside of the operating room)
- **Conserve** – use less of a resource by lowering dosage or changing utilization practices if possible
- **Reuse** – after appropriate disinfection and sterilization, reuse supplies
- **Reallocate** – prioritize a therapy in scarce supply so that it is only given to those with a higher chance of benefit or greater need

NEED TO KNOW:

Preparing for resource scarcity after an IND incident

Resource scarcity is the lack of sufficient resources to meet medical needs — space, staff, and supplies (stuff). The gap between need and available resources will vary by type of resource, location of need, and the time following detonation. Thus, the scarce resource setting will differ in location and over time and consequently the standards of care will vary.

Effect of diminishing resources on patient care

- Scarce resources will not be limited to pharmaceuticals and medical supplies and there will be increased demand for medical space, staff, and other related services and they will not be replenished at the normal rate.
- Triage priority for patients may differ from when conventional resource levels are available.
- Palliative treatment of patients should not change, but more patients may require this type of care and the supply of medications for this course of treatment must be investigated early in the incident.
- Strategies to provide the best care in a non-ideal situation should be used.
- As resources arrive, patients will be re-triaged. Some receiving palliative care may then receive more aggressive medical management as conditions change

Although the scarce resource setting is likely to vary based on physical location and time since the event, strategies for dealing with even transient scarcity are necessary.

Table 1. Resource Availability for Nuclear Detonation and Institute of Medicine Standards of Care – Early after the detonation and close to the site, resources are scarce, yet moving away from the site and with time, resource availability improves. Arrows indicate increasing scarcity and development to crisis standards of care (→→→) and return to conventional standards of care as time and distance increase (←←←).

Incident demand/resource imbalance increases early and close →→→
Risk of morbidity/mortality to patients increases with scarcity →→→
←←← **Recovery – Increasing resources with time and distance**

Resource	Conventional	Contingency	Crisis
Space	Usual patient care space fully utilized	Patient care areas re-purposed (PACU, monitored units for ICU-level care)	Facility damaged/unsafe or non-patient care areas (classrooms, etc.) used for patient care
Staff	Usual staff called in and utilized	Staff extension (brief deferrals of non-emergent service, supervision of broader group of patients, change in responsibilities, documentation, etc.)	Trained staff unavailable or unable to adequately care for volume of patients even with extension techniques
Supplies	Cached and usual supplies used	Conservation, adaptation, and substitution of supplies with occasional re-use of select supplies	Critical supplies lacking, possible re-allocation of life- sustaining resources
Standard of care	Usual care	Functionally equivalent care	Crisis standards of care

Usual operating conditions **Austere operating conditions**

(Adapted from IOM Crisis Standards of Care: A Systems Framework for Catastrophic Disaster Response - Access the IOM Crisis Standards of Care document

For more details, see Guide 2 about:

- Scarce Resource Allocation

Section 9: Training Medical Responders and Those That Support Them

The Increasing Role of Technology in Educating Responders and Planners about Mass Casualty Radiation Emergencies

DECISION MAKING CONSIDERATIONS:

- What key topics should first responders/first receivers know when managing patients after a radiation mass casualty emergency?
- What online education/training is available to help fill in radiation emergency training and information gaps?
- What onsite radiation emergency training is available?

NEED TO KNOW:

Importance of radiation knowledge for those involved in the response community

First responders, first receivers, and planners for radiation mass casualty emergencies need to acquire and maintain radiation-specific knowledge and skills over and above what they know from training for "all hazard" emergencies. However, there is no universal agreement about the exact nature of the potential core radiation curriculum for the various types of responders. Additionally, few emergency or healthcare personnel have ever responded to or practiced for any type of radiation mass casualty emergency in formal drills or exercises and reluctance to train for and respond to radiation mass casualty emergencies has been reported.

Most health care responders with direct patient care responsibilities should learn at least the basics about the following:

1. The types of radiation emergencies that might occur
2. How responses to "small" and "large" incidents differ
3. Health Physics (what is radiation)
4. The difference between exposure and contamination
5. How to diagnose and manage the Acute Radiation Syndrome (ARS)
6. How to diagnose and manage external and internal contamination
7. Principles, practices, and regulations of radiation safety including the proper use of personal protective equipment
8. The basics of the potential long-term effects of radiation exposure

Medical education and training

Onsite

- **Armed Forces Radiobiology Research Institute (AFFRI)** at the Uniformed Services University of the Health Sciences, Bethesda, MD. AFFRI Training Resources
- **Radiation Emergency Assistance Center and Training Site (REAC/TS)** at the Oak Ridge Institute for Science and Education (ORISE), Oak Ridge, TN. REAC/TS Training Resources

Online

- **Radiation Emergency Medical Management (REMM)** provides just in-time information, vetted background material, and clinical tools for responders. Training opportunities from a variety of sources are also aggregated. REMM Training Resources
- **The Centers for Disease Control and Prevention CDC** focuses on radiation-related public health issues. Training opportunities are also provided. CDC Training Resources
- **Office of the Assistant Secretary for Preparedness and Response (ASPR)** focuses on integrating radiation issues into all-hazard preparedness and response. ASPR webpage

For more details, see Guide 13 about:

- Formulating the Problem: Information Gap
- Approaching the Solution: Education and Training
- Radiation vs. All Hazards
- Suggested Approaches

Section 10: How Do We Assess an Individual's Exposure? Who Needs Treatment Now? Why?

Population Monitoring After a Nuclear Detonation

DECISION MAKING CONSIDERATIONS:

- How will those affected by a radiation or nuclear incident be assessed and monitored for radiation exposure and/or contamination?
- Who is responsible for decontamination of casualties?
- What is the best method for decontamination?
- How and where are mass decontaminations planned to occur?
- What is a Community Reception Center (CRC)?
- Who is responsible for staffing a community reception center?

KEY INFORMATION:

- Radiation exposure (Acute Radiation Syndrome) is a greater threat to the population than radiation contamination.
- The National Response Framework* states that decontamination of possibly affected victims is the responsibility of state, tribal, and local governments. Self-decontamination is necessary given the magnitude of the incident. Currently, the planned response includes using Community Reception Centers (CRC) or other ad hoc facilities so that healthcare professionals can focus on those needing medical care.
- Management of serious injury takes precedence over radiological decontamination. Radioactive contamination is not immediately life threatening.
- In most cases, external decontamination of skin and clothing can be self-performed (i.e., showering or washing with water and changing into clean clothes) if straightforward instructions are provided.
- Based on experience from the Chernobyl and Fukushima, stress-related illness may affect a large portion of the population.

*National Response Framework (NRF), FEMA NRF webpage

NEED TO KNOW:

Following any large scale radiation disaster, the evacuated, sheltered, or otherwise affected members of the public will require monitoring for dose from exposure as well as external and/or internal contamination, and decontamination, if indicated. In addition, the potentially-affected individuals should be identified so that acute injuries can be detected and epidemiologic data can be collected. Affected individuals may need dose reconstruction (from exposure, including biodosimetry), bioassay to detect internal contamination, medical treatment for physical and radiation injuries, and inclusion into long-term health and medical

monitoring programs and registries. All these actions are part of patient assessment and population monitoring.

Purpose of patient assessment and population monitoring

1. **Identifies individuals who are in immediate danger and require medical stabilization**. Near the incident site, this monitoring is accomplished as part of the medical triage process.
    a. Management of serious physical injury takes precedence over radiological decontamination.
    b. Radioactive contamination is not immediately life threatening, whereas high dose from exposure may be.

2. **Prevents and mitigates acute radiation syndrome and acute local radiation injury through radiation detection and removal of contamination.** In most cases, external decontamination of skin and clothing can be self-performed (i.e., showering or washing with water and changing into clean clothes) if straightforward instructions are provided.

3. **Reduces the potential burden on hospitals and maximizes scarce medical resources.** Casualties who do not need immediate medical attention can be reassured and given further evacuation or shelter information thereby preventing these individuals from drawing on scarce medical resources. Based on experience from the Chernobyl incident, stress-related illness is another anticipated outcome for the affected population.

Planned organization of patient assessment and population monitoring

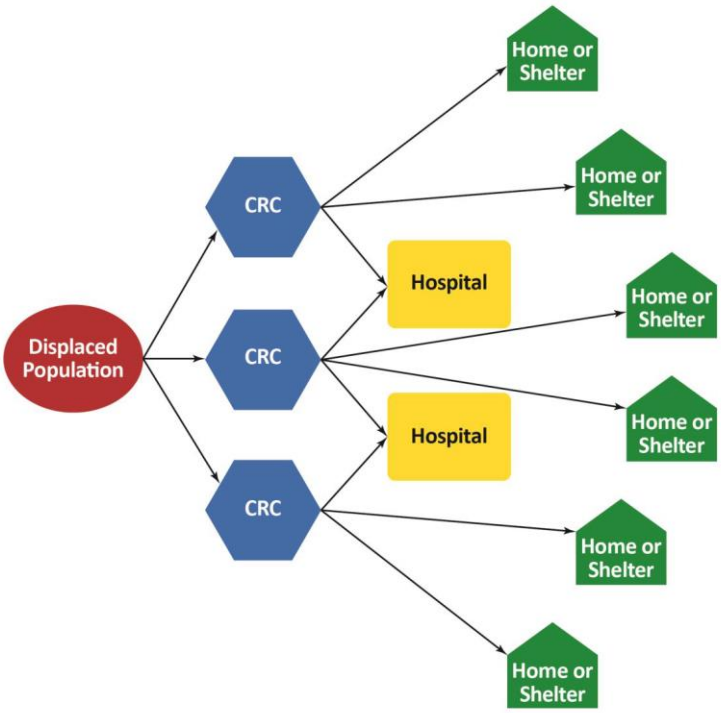
The National Response Framework states that decontamination of possibly affected victims is the responsibility of state, tribal, and local governments. Currently, the planned response includes using **Community Reception Centers (CRC)** to provide patient monitoring services. CRCs are modeled closely after points of dispensing (POD) sites. The processes used for population monitoring and decontamination should remain flexible and scalable. (This is work in progress).

Community Receptions Centers are opened within 24 to 48 hours after a radiation emergency (or sooner if resources are available) in locations outside the affected areas.
The basic services offered at a CRC may vary by locale and may include:

- Screening people for radioactive contamination
- Assisting people with washing or decontamination
- Collecting epidemiologic data and registering people for long-term follow up
- Prioritizing individuals for further care

Staffing of CRCs is provided by local government employees as well as organized volunteers and requires trained radiation protection personnel who can operate radiation detection equipment, interpret the screening results, and assist with decontamination.

Figure 1. Schematic Illustration of how a Community Reception Center Fits into a Planned Response. Community Reception Centers are set up in unaffected host communities away from the impacted area to provide population monitoring services before people move on to temporary housing. Each CRC can serve multiple public shelters.



For more details on the staffing and equipment requirements of a CRC, please see Guide 5 or the CDC website CDC Community Reception Center webpage.

For more details, see Guide 5 about:

- Population Monitoring After a Nuclear Detonation
- Collection of Data for Tracking and Health Studies
- Community Reception Center Guidance and Resources

Section 11: What are the Health Risks from This Type of Radiation Exposure?

Health Risks from Exposure to Radiation: The Basics

DECISION MAKING CONSIDERATIONS:

- What is the background radiation dose for Americans each year?
- What is the annual occupational dose limit for U.S. workers?
- What are the symptoms of the late health effects of radiation exposure?
- What dose of radiation exposure would result in little to no early or acute health effects?
- How does radiation exposure impact an individual's lifetime cancer risk?

KEY INFORMATION:

For additional health effects based on dose of radiation exposure see Sections 12 and 14.

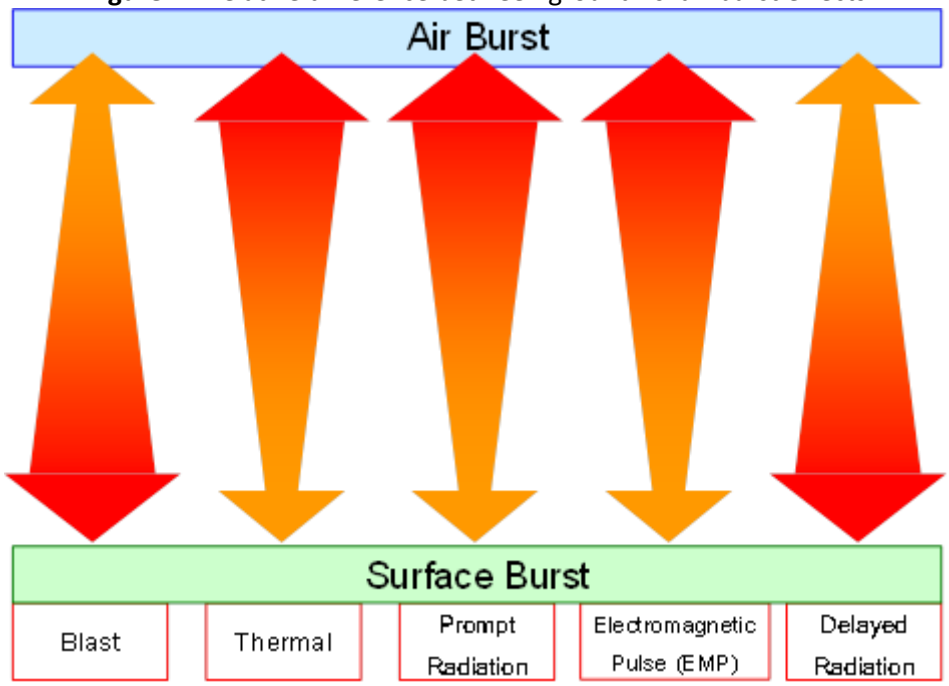
- In general, a given dose of radiation over a short time period results in more serious acute health effects than the same dose over a prolonged period of time. Also, the higher the dose, the greater the acute adverse effect
- **Early effects** — The severity of the injury is directly related to the amount of the dose, the dose rate, host factors, and the organ that receives the dose. Some organs are more sensitive than others to acute radiation injury, especially bone marrow, gastrointestinal tract, skin and lung. Early effects:
  - Occur minutes to days after exposure; sooner after higher dose.
  - Can be life threatening in the short-term
  - Are called "deterministic" effects.
- **Late effects** — The likelihood of occurrence (probability or chance) is related to exposure dose. Late effects:
  - Include radiation-induced cancer and damage to organ systems
  - Typically occur several years to decades after exposure
  - Are called "stochastic" effects
- **For long-term cancer risk:**
  - The **increase in frequency** (over baseline) of developing cancer **is related** to the radiation dose and certain host factors.
  - The **severity** of radiation-induced cancer **is NOT related** to the radiation dose.
  - Radiation-induced cancers are medically similar to the same conditions that develop in persons who develop cancer but who never received radiation.

NEED TO KNOW:

Essential facts about radiation exposure following a nuclear detonation

1. The amount of prompt radiation released and fallout created will depend on the explosive yield (typically in Kilotons or KT) and whether it is a ground or air burst. A ground burst generates more fallout and less prompt radiation (See Figure 1, below)
2. Nuclear detonations expose people externally to x-rays/gamma rays and some neutrons.
3. There is more adverse health risk from external exposure than from internal exposure or contamination as the result of an IND.
4. Exposure to large doses of radiation over seconds is more dangerous than the same total exposure distributed over long periods of time (days, months, or years).
5. External and internal exposure from fallout particles can continue for years or decades, depending on clean-up and recovery.
6. Dangerous fallout, includes a large number of radioactive isotopes (over 200) that have half-lives (the time for the radioactive emissions to decrease by 50%) ranging from seconds to thousands of years.

Figure 1. Relative difference between ground vs. air burst effects



Radiation dose information and risk of ARS

For an IND incident where exposure would occur over a short time period:

- Doses below 1 Sv (100 rem) are associated with few, if any, early or acute effects, except nausea and vomiting but only at the high end of the range.
- Doses over 1 Sv (100 rem) in a short time period (a few minutes or less) would likely lead to vomiting and nausea.
- Moderate doses (1-2 Sv, 100-200 rem) combined with major physical trauma or burn ("combined injury") can be life threatening.
- Doses greater than 2 Sv (200 rem) but less than 8 Sv (800 rem) without other

trauma would produce significant "Acute Radiation Syndrome" (ARS) with damage to blood-forming tissues and gastrointestinal tract and would require intensive medical care to ensure survival, especially above 3.5 Sv (or 3500 mSv or 1000 times background).

- Those with doses of 7-10 Sv (700 – 1000 rem) would be at very high risk of radiation-related death within days of exposure. Intensive rescue efforts may be able to save some people.
- Radiation received over the entire body is worse than that received to only a portion of the body.

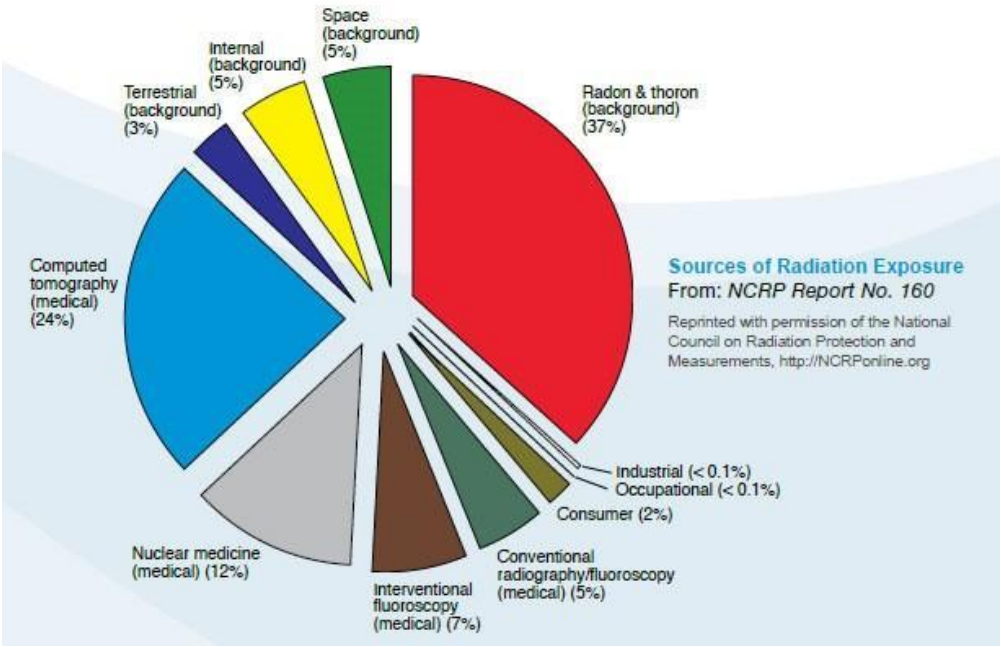
Comparison of the doses of radiation exposure from an IND to those from other sources

Everyday life exposes people to ionizing radiation from a variety of natural and manmade sources. Examples include radon gas, space radiation exposure during airplane flights, and medical exposures such as x-rays or CT scans.

- Background radiation doses for Americans are ~3 mSv/year (300 mrem/year).
- Medical procedures can increase the amount of radiation a person is exposed by tens of mSv (thousands of mrem). These include, CT scans, fluoroscopy, x-rays, etc.
- Annual occupational doses for radiation workers in the U.S. are permitted up to 50 mSv (5,000 mrem). This dose limit is considered highly protective and is about 8-times the typical dose received by Americans.
- The most common dose received by the A-bomb survivors was 5 to 10 mSv, or about equal to one or two years of exposure to natural background radiation.

Note: 1 milliSievert (mSv) = 1/1000 of a Sievert (Sv); abbreviation for millirem is mrem.

Figure 1. Sources and average proportions of annual radiation exposure.
Reprinted with permission of the National Council on Radiation Protection and Measurements, NCRP webpage



Section 11

Long-term cancer risk

- The **severity** of radiation-induced cancer **is NOT related** to the radiation dose.
- The **increase in frequency** (over baseline) of developing cancer **is related** to the radiation dose.
- Radiation-induced cancers are medically similar to the same conditions that develop in unexposed persons.

- The lifetime risk (chance) for Americans to develop cancer is approximately 40% (American Cancer Society)
    - Any increase in the cancer risk due to exposure to radiation will add to the 40% chance.
- There is no evidence for a radiation dose below which there is no risk of cancer development.
- For a dose of 10 mSv (1 rem), the increased lifetime risk of developing cancer would be approximately 0.8%. Thus, 10 mSv would increase the lifetime risk of developing cancer from approximately 40%to 40.8%.
    - A dose of 10 mSv is 2-3 times the annual background dose.
- The risk for developing many types of cancer is higher when radiation exposure occurs in childhood in part because late effects have longer time to develop and tissues may be more sensitive.
- Long-term cancer risk can continue for decades after exposure.

For more details, see Guide 9 about:
- Radiation Dose
- Radiation Risk after a Nuclear Detonation

Section 12: How to Care for Those with Acute Radiation Syndrome (ARS)

Acute Radiation Syndrome: Medical Guidance and National Response

DECISION MAKING CONSIDERATIONS:

- How is the amount of radiation exposure determined?
- Should we distribute and dispense Potassium iodide (KI)?
- What are the health effects of large doses of radiation?
- What doses of radiation exposure are medically treatable?
- What are the priorities for triage and treatment of affected individuals?
- Will the largest amount of exposure be from internal exposure or external exposure?
- What is the acute radiation syndrome?
- How should those with the acute radiation syndrome be treated medically?
- Who can help with treatment of patients with the acute radiation syndrome?
- Where can I get more information for medical providers and responders?
- How many people are likely to have been affected by the actual radiation?

KEY INFORMATION:

- Radiation injury depends on the dose received, dose rate, and the extent of the body exposed.
- In a nuclear detonation, external radiation exposure makes up most of the overall radiation exposure. There is little significant internal exposure (from ingestion or inhalation).
- **KI is not indicated and is not a priority in this emergency.** Radioiodine exposure is not a hazard for a nuclear detonation. KI is only necessary for a nuclear power plant release, not for nuclear detonation. Radioiodine uptake is by ingestion and inhalation – those are not hazards here as airborne radioiodine levels are extremely low and eating contaminated food can be avoided.
- As radiation dose from exposure increases, injury is more severe and manifests more quickly.
- Those with trauma (broken bones, bleeding, etc.) in addition to radiation exposure have a worse prognosis than those with radiation exposure only.
- Responders should not worry about possible contamination from critically injured patients that have not yet undergone thorough decontamination processes although the ambient radiation exposure rate will determine where responders can enter and how long they can stay.

NEED TO KNOW:

Health effects of acute doses of radiation

- As the dose from radiation exposure increases, injury is more severe and manifests more quickly
- Acute Radiation Syndrome (ARS), also known as radiation sickness, is a severe illness with a rapid onset caused by high doses of radiation delivered to the body over a short period of time.
- The unit for radiation dose absorbed by an individual is the rad or gray (Gy).
- Biological effects of radiation are in units of rem or sievert (Sv), which are often used interchangeably with rad or Gy. **See the scientific primer for more details, (Appendix A).**
- Serious radiation injury (ARS) typically begins at doses of approximately 2Gy, especially for those with combined injury
    - Combined injury- radiation plus physical trauma and/or burn can have a worse prognosis.
- Exposures of 2-10 Gy of ionizing radiation are treatable if acted upon promptly.

Methods for determining dose of exposure

- Estimates of dose from exposure can be determined by geographic, clinical, or laboratory means.
    - The dose from exposure can guide treatment and, therefore, the resources required for care.
    - Based on physical location of person, it may be possible to estimate exposure to some extent.

Priorities for treatment and organization of triage

- Ideally, triage centers would be organized around concentric rings, providing initial stabilization prior to transport to unaffected medical centers.
- It is recognized people may self-evacuate and not reach initial medical assessment until well beyond the zone in which the detonation occurred.
- Responders should focus on critical physical injuries from patients and less on radiation contamination and decontamination. Studies have shown that responders receive an insignificant amount of radiation exposure in this manner.
    - Ambient radiation exposure (R/h) will determine where responders will go. Ambient dose rate declines rapidly.
- Those with trauma (broken bones, bleeding, etc.) in addition to radiation exposure have a worse prognosis than those with radiation exposure only.
- Proper triage will help alleviate extra stress on medical care facilities from those who do not need immediate treatment. This can be done with medical history, information about the patient's geographic locations, and diagnostic clinical tools to assess dose.
- Behavioral health treatment will help promote individual resilience.
    - A large number of stress-related injuries were seen after the Chernobyl incident.
    - Relieving stress on responders requires attention.

Treatment of acutely irradiated casualties

1. Treatment of ARS is dependent on dose of radiation exposure and the length of time between exposure and medical intervention.
2. Exposure minimization (i.e., sheltering, shielding, and removal of contaminated clothing if they are in fallout) is the easiest way to limit exposure to radiation.
3. Supportive medical care should be used to mitigate the morbidity and mortality of radiation exposure (e.g., hydration, antibiotics, antiemetics, skin care).
4. Radiation medical countermeasures (MCMs), unlike supportive care, have the potential to alter the natural history of radiation exposure.
5. Patients with a high likelihood of exposure to > 2 Gy based on medical history, location, laboratory methods, or blood counts, should be given cytokines within 24 hours of exposure to ionizing radiation. **For more detailed information about cytokine use refer to Guide 8.**
6. Initial biodosimetry estimates dose received and this data is use to help guide physician who will use further data to determine overall treatment course.
7. Inhalation and ingestion of radioactive particles is less likely during an IND incident than during a RDD or nuclear power plant (NPP) release. During a NPP release, use of potassium iodide may be advised to reduce thyroid gland uptake of radioactive iodine. However, potassium iodide has a short time-window in which it is effective and is not relevant for IND.

Available Resources

For more detailed information, please see the "Available Resources" Section of this manual.

- RITN webpage
- "Just-in-time" and background information for medical providers and responders at the REMM Training website.

For more details, see Guide 6 about:

- RTR System – Radiation TRiage, TRansport, and TReatment
- Management of ARS
- Radiation Injury Treatment Network (RITN)
- Radiation Emergency Medical Management (REMM) web site

Section 13: Medical Countermeasure and Medical Supply Distribution for the Response to an IND

Strategic Framework for Providing Radiation Sickness Medical Countermeasures and Supplies in a Scarce Resources Setting: Local, Regional, and Federal Resources

DECISION MAKING CONSIDERATIONS:

- Which federal agency manages the Strategic National Stockpile?
- How are Emergency Use Authorizations invoked to use drugs in the SNS?
- Which federal agency is directly involved with the approval and use of internationally supplied drugs?
- How do you treat mass casualties during a scarce resource setting?
- After a radiation disaster, how are "off label" drugs managed?

KEY INFORMATION:

- People who have received a moderate radiation dose (~3-6 Gy) are most likely to benefit from medical intervention and should receive immediate attention in all resource settings.
- Repeated (iterative) triage is an essential component of the response, so that a person initially medically triaged into the "Delayed" or even "Expectant" categories could become "Immediate" over time.
- The Strategic National Stockpile (SNS) – see link below – a national repository of pharmaceuticals, medical supplies, and equipment can be deployed during a public health emergency for use by local/state/regional responders.

Strategic National Stockpile, CDC SNS information

NEED TO KNOW:

Available resources

Medical countermeasure supply

- In March 2015, the FDA approved Neupogen® (filgrastim), for the treatment myeloid suppression due to radiation exposure. This drug is typically used to improve the neutrophil (white cell) count in patients given cancer chemotherapy.
- There are several other drugs in routine use for the treatment of low neutrophil counts that may be effective medical countermeasures (MCMs) for ARS despite the lack of FDA approval for that indication. See REMM for more information - Detailed Cytokine Information on REMM
- In order to permit medical countermeasures (MCMs) to be used in an emergency for off-label indications, the FDA has established the **Emergency Use Authorization (EUA)**. FDA EUA information

    - While physicians routinely use prescription medications for "off-label" use in their daily practice, in a large scale emergency, there will be no or limited physician-patient relationship allowing off-label use to occur.
- Some medications and supplies that have dual utility (can be used for multiple hazards) can be found in the Strategic National Stockpile (SNS), managed by the CDC.

Strategic National Stockpile (SNS) and supply refreshment

In general, hospitals and medical facilities keep very low inventory of many drugs and use "just-in-time" inventory management systems.

- The SNS, managed by the CDC, is a national repository of pharmaceuticals, medical supplies, and equipment that can be deployed during a public health emergency for use by local/state/regional responders when they lack sufficient medical countermeasures and other supplies during the initial phase of a mass casualty incident.
    - SNS supplies can reach an affected area within 12-24 hours after the state government request for a federal decision to deploy SNS resources.
    - The SNS also has agreements with manufacturers to store some pharmaceuticals and supplies, called Vendor Managed Inventory (VMI), as part of their operational plan.
- Medical supplies or drugs could be obtained from international partners in special circumstances, although importing drugs is complicated and requires complex approval among governments as well as by the FDA.
- Manufacturer's production surge will likely occur either voluntarily in response to obvious need or by request of the local, state or federal government. This will likely take days to weeks.

Managing the MCM supply in a scarce resource environment

Scarcity of supplies, personnel and medical countermeasures is likely, at least initially, after a mass casualty disaster like a nuclear detonation. Plans are in place to assist with triage decision making during a scarce resource situation. More explanation and a visual illustration of managing triage categories can be found in detail in Guide 7.

For more details, see Guide 7 about:

- Providing MCMs in a Scarce Resources Setting
- Understanding Triage Categories Relative to Radiation Dose and Resource Availability
- Potential Sources for Medical Supplies

Section 14: Improving the Medical Countermeasure Supply

Radiation/Nuclear Medical Countermeasure Research and Product Development Efforts for Public Health Emergencies

DECISION MAKING CONSIDERATIONS:

- What injuries are expected after radiological and nuclear incidents?
- What is the most accurate method of obtaining radiation dose assessments?
- What medical countermeasures are currently available for radiation exposure after a nuclear detonation?
- What federal agencies are involved with MCM research and product development?

KEY INFORMATION:

- Radiation detectors/survey meters in the environment do not directly determine absorbed dose to any specific person, but can be used to estimate the exposure that a victim might have received in the area of the detector.
- The diagnosis of Acute Radiation Syndrome (ARS) is currently based on patient history, signs and symptoms (including time to the onset of vomiting), blood counts, and manual or semi-automated laboratory-based assays. Both laboratory and clinical assessment are critical to medical management of exposed individuals.
- For those medical treatments not approved by the FDA, an Emergency Use Authorization (EUA) may be issued that would allow unapproved medical products or unapproved uses of approved medical products to be used in an emergency when there are no adequate, approved and available alternatives.
- The U.S. has a Strategic National Stockpile (SNS), managed by the CDC, which has large quantities of medicine and medical supplies to protect the American public if there is a public health emergency (e.g. terrorist attack, flu outbreak, earthquake, etc.) severe enough to cause local supplies to run out.

NEED TO KNOW:

Medical response for radiological and nuclear incidents ,including a nuclear detonation, radiological dispersal device (RDD), radiological exposure device (RED), or nuclear power plant accident (NPP), involves supplies for treating trauma and burns; drugs for relief of nausea, pain, and infection; and medical countermeasures (MCMs) for radiation injury.

Radiation-related countermeasures in the Strategic National Stockpile (SNS)

- Decorporation agents used to remove internalize radionuclides
  - Indicated for Am-241, Cf-252, Co-60, Cm-244, Pu-238/239, Y-90
    - Calcium diethylenetriaminepentaacetate (Ca-DTPA)
    - Zinc diethylenetriaminepentaacetate (Zn-DTPA)
  - Indicated for Ce-137
    - Prussian blue
- Potassium iodide (KI) is currently not available from the SNS.

- Anti-neutropenia agents (myeloid cytokines)
    - Neupogen® (filgrastim: granulocyte colony-stimulating factor (G-CSF))
        - FDA-approved, "*Increase survival in patients acutely exposed to myelosuppressive doses of radiation (Hematopoietic Syndrome of Acute Radiation Syndrome).*"
    - Leukine® (sargramostim: granulocyte-macrophage colony-stimulating factor (GM-CSF))
        - FDA approved - In clinical use for various indications but NOT approved by the FDA for the specific indication of acute exposure to myelosuppressive doses of radiation.
- Supportive care
    - Various antimicrobials (antibiotics, antivirals, antifungals)
    - Infusion fluids
    - Anti-emetics

Diagnostics

For prompt and effective treatment of exposed individuals, first responders and medical teams will try to make accurate radiation dose assessments as well as careful clinical assessment.

The key diagnostic lab tests currently widely available include measuring lymphocyte blood counts and the dicentric chromosome assay. However, work is being done to improve the library of useful mass casualty lab tests.

- The primary U.S. coordinating dicentric chromosome assay lab approved for clinical use is at the Radiation Emergency Assessment Center/Teaching Site (REAC/TS in Oak Ridge, TN. REAC/TS Information on Dicentrics. Throughput is limited at that location, but they have surge plans in place to increase capacity via partner labs.
- Environmental radiation survey meters may be used to help estimate a dose that a victim located near the device could have received, but there are limitations on its accuracy for any individual.

Who is working on diagnostics and MCM development? – PHEMCE

The approaches to MCMs, including dose assessment capabilities, involve a continuum of activities from basic science to technology and drug development to preclinical and clinical assessment, all in a context of guidelines and review by the U.S. Food and Drug Administration (FDA). U.S. government agencies involved in MCM development and FDA approval are components of the U.S. Department of Health and Human Services and part of the PHEMCE (Public Health Emergency Medical Countermeasures Enterprise):

- Office of the Assistant Secretary for Preparedness and Response (ASPR)
    - Office of Policy and Planning (OPP)
    - Biomedical Advanced Research and Development Authority (BARDA)
- National Institutes of Health (NIH), particularly the National Institute of Allergy and Infectious Diseases (NIAID)
- Centers for Disease Control and Prevention (CDC)

For more details, see Guide 8 about:
- MCM Research and Product Development
- Diagnostics

Guides

Detailed Background Information

Guide 1: Preparing For and Responding to the Health and Medical Consequences of a Nuclear or Radiological Incident: Essential Concepts, Information, and Resources

Introduction

"Two decades after the end of the Cold War, we face a cruel irony of history—the risk of a nuclear confrontation between nations has gone down, but the risk of nuclear attack has gone up." — Remarks by President Obama at the Opening Plenary Session of the Nuclear Security Summit, April 13, 2010[1]

The successful detonation of a nuclear device on U.S. soil would be a catastrophic event, causing an unprecedented number of injuries and lives lost, as well as economic, political, and social disruption. However, an effective medical response and a public prepared to protect itself from fallout could save tens of thousands of lives. Since 2001, all levels of government, academic institutions, and professional organizations have done significant work to enhance our ability to prepare for and respond to a nuclear detonation. The following series of papers in this Guide distill and translate key pieces of that work on protective actions and medical response to make them more accessible and easier to translate into practice. In addition, policies to enhance our nation's ability to respond to a nuclear detonation are suggested.

For example, the Center for Biosecurity of UPMC's May 2011 conference, *Advancing U.S. Resilience to a Nuclear Catastrophe*[2], addressed 2 issues that complement the Guides that follow. One is the critical importance of a public prepared to take immediate shelter following a nuclear detonation. Despite recent research showing that sheltering is more effective than previously thought and should be the immediate default protective action, there has been little public discussion about how to counter the public's natural inclination to flee the area. To fill this gap, a new Center for Biosecurity project to help create radiation (rad) resilient cities was introduced.[3] The initiative provides an expert advisory consensus checklist for leaders of high risk cities to provide a path to enhanced fallout preparedness. The Center also presented a novel proposal for a public-private partnership to screen up to a million people for dangerous levels of radiation in just a few days.[4] Discussions with large commercial medical laboratories suggest that there is the capability to perform absolute lymphocyte counts (ALC), an indicator of radiation exposure, on a massive scale.

Systems-Based Approach

Preparation for a nuclear detonation builds on expertise and contributions from a wide range of federal agencies; state, local, regional, and tribal planners; academia; and the private sector. Over the last few years, a number of comprehensive publications and products have been published including the *Planning Guidance for Response to a Nuclear Detonation*[5] and a ten-paper series on *Scarce Resources for a Nuclear Detonation*.[6] Health and medical educational material is available from the Centers for Disease Control and Prevention (CDC)[7] and just-in-

time material, including algorithm-based management, is on the Radiation Emergency Medical Management (REMM) website.[8] The components and their relationship to one another of the overall Nuclear Incident Management Enterprise (NIME)[9] is in Appendix D.

We, in the U.S. Department of Health and Human Services (DHHS), are leading the development of preparedness plans to respond to the public health and medical consequences of a nuclear detonation. A nuclear detonation is one of the most challenging events to plan for and tremendous progress has been made in our understanding of how we as a country and world can respond most effectively to save lives. Throughout development, we realized that the complex information included in these plans—much of it created for the first time by government and non-government experts who committed extraordinary effort to addressing this overwhelming scenario—needed to more readily available for planners and responders. There is the need for a quick, broad overview of complex topics available at one's fingertips, with an ability to drill down as necessary.

Practical Information with Links to Details

The 13 manuscripts in this document were designed to be no more than 7-15 pages with illustrations, tables and bulleted points so the reader can quickly get a sense of the topic and where to find more detailed information. To prepare this essential information, we assembled contributors who are leaders in the field and bring knowledge and experience in planning and response to nuclear and radiological incidents.

During the course of preparing this Decision-Makers Guide an earthquake and tsunami struck Fukushima and triggered its nuclear power plant meltdown. The Office of the Assistant Secretary for Preparedness and Response (ASPR)[10] supported a team of health and medical experts from ASPR, CDC,[6] the National Cancer Institute, and the Food and Drug Administration that was sent to Japan as part of an extensive response by the U.S. This experience provided real-life experience for dealing with the world-wide fear of radiation. Educating and informing the public on radiation required a careful blend of sophisticated explanations and clarity—no easy task with such a complex topic. Ongoing lessons learned include the need for timely, expert communication and the recognition that an important component of community resilience is the ability to make science-based decisions as the situation unfolds.[11, 12] The Guides provides much of the information that would be needed to understand and help manage a major nuclear or radiological disaster.

Working with the Community

In December of 2009, DHHS published the first-ever National Health Security Strategy (NHSS)[13] and in 2012 the NHSS Implementation Plan.[14] This strategy and implementation plan provide a unified and clear national approach to minimizing the risks associated with all hazards, including nuclear detonation. Two of the major goals outlined in the NHSS are building community resilience and strengthening and sustaining health and emergency

response systems. The preparedness plans developed by HHS support national health security only if the plans are integrated at the community level across the nation. One goal of publishing this supplement is to make the tools that have been developed more readily available and usable at the community level.

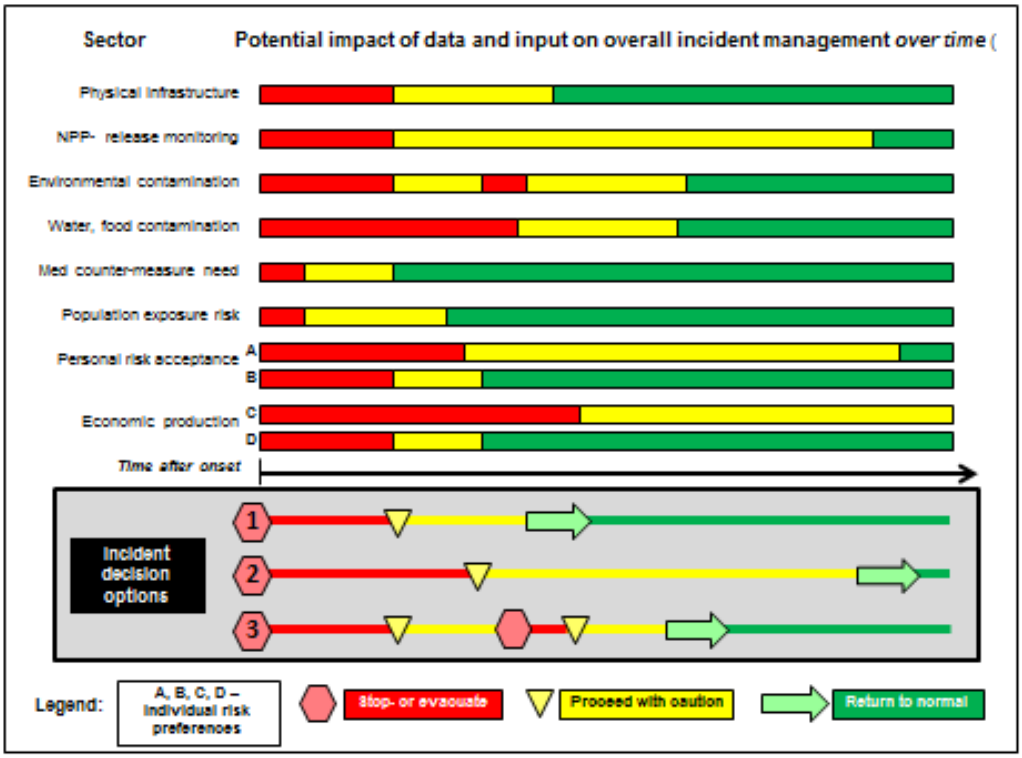
Another way we promote national health security is through the ASPR Regional Emergency Coordinators (RECs), who engage in integrated planning with states and localities. Under the National Response Framework (NRF), DHHS is the lead for federal public health and medical support (ESF #8) to states who request assistance. By engaging in integrated planning with states, DHHS is able to identify states' gaps and anticipate requests for federal resources. In a catastrophic event such as a nuclear detonation or a large earthquake involving multiple states, it is possible that state requests for assistance will exceed the available federal resources. Integrated plans for maximizing available resources and ethically allocating scarce resources need to be developed in advance, and not in the midst of a catastrophic event.

Leadership

Crisis leadership will be critical during response to a nuclear detonation. Public health and medical leaders typically make decisions once data have been collected and analyzed. In a crisis, the available data will be insufficient to make fully informed decisions, and it is critical that leaders learn the important skill of making decisions with incomplete information. A continuous process of re-evaluating decisions as additional information is obtained is the hallmark of public health and medical leadership during disasters.[11] The alternative would be to wait until more complete information is gathered, which can hamper response and lead to disorganization and loss of confidence. Based on a multi-agency experience during the U.S. government's response to the Fukushima nuclear power plant crisis, a Medical Decision Model for Managing an Effective, Timely and Balanced Response was developed and published.[12]

Resilience is a key goal and there can be various approaches decision-makers can take in returning toward normal as illustrated in Figure 1. During the response, conditions in the different issues/sectors can cause the overall progression to normal (or the "new normal") to stop (i.e., red stop sign and bar) based on data that indicate a serious risk of harm. As the situation improves the indications for stopping will no longer be present for various issues/sectors so that some may begin to return toward normal activity. This may require a period of caution (i.e., yellow caution triangle and bar) where there may still be manageable risk. In addition to specific criteria for resuming activity, there are personal preferences for accepting risk, risk averse (A) vs less risk averse (B) and decisions made to resume economic activity sooner (D) or later (C). Overall incident management decisions to return to normal may be most aggressive [#1], cautious [#2] or in between [#3].

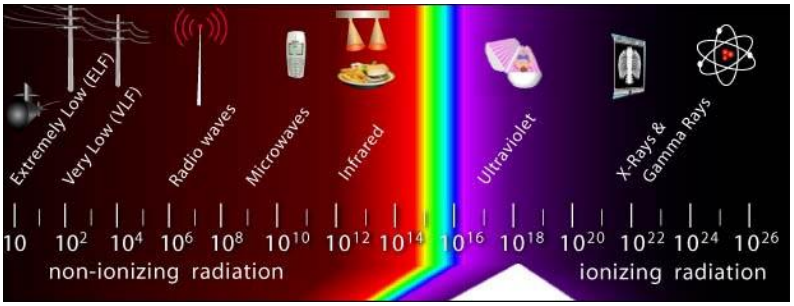
Figure 1. Using a medical decision-making model for issues in support of incident management of a NPP disaster[12]



Mini-Primer on Radiation

Ionizing and non-ionizing radiation: There is constant exposure to non-ionizing and ionizing radiation. The long-term risk of radiation-induced cancer is from ionizing radiation.

Figure 2. Electromagnetic Radiation Spectrum[15]



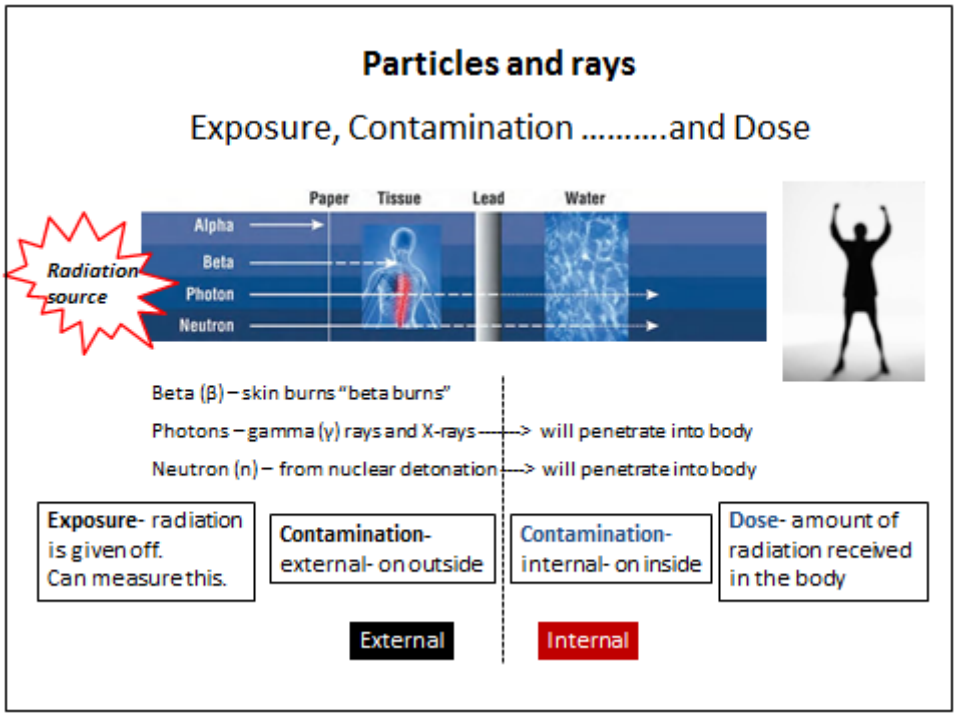
Non-ionizing radiation has less energy than ionizing radiation. Lasers, microwaves, infrared lamps, and radio waves all use non-ionizing radiation. The most energetic form of radiation is ionizing radiation. Ionizing radiation is used to generate electric power, treat cancer, take x-rays, and disinfect medical instruments.

Exposure, contamination and dose: The ionizing radiation of concern includes particles that have an electrical charge (alpha and beta particles), uncharged particles (neutrons), and X-rays

and gamma rays (which are similar). As illustrated in Figure 3, charged particles have limited penetration. Alpha particles can produce a significant dose only if they are internalized. Beta particles can cause skin burns (beta burns) and also produce significant dose if internalized. X-rays/gamma-rays and neutrons are penetrating.

Figure 3 defines exposure, contamination/external, contamination/internal and dose. It is **dose**—the amount of radiation received in the body—that determines the health and medical consequences.

Figure 3. Particles and Rays: Exposure, Contamination, and Dose.
Source: Illustration from the Canadian Nuclear Safety Commission[16]



Assembling the Information

The overarching principle of the preparation, planning, and response at ASPR is that the best science and knowledge must be made available and comprehensible so that is it useable, often without much advance knowledge of the issues. The question we aim to answer for each of the topics is "What do I Do?!" To assemble and present information, we depend on education and information management experts, including those from the Specialized Information Services (NLM/SIS webpage) of the National Library of Medicine[17] and the National Institutes of Health (NIH) Library. We continuously update the various resources on REMM and we have developed a new approach with a State and Local Planner's Playbook for IND[8]

We hope that this Manual provides clear and useful information on the complex issue of preparation for and response to a nuclear or radiological incident and that we achieved the recommendation of Albert Einstein, "Make everything as simple as possible, but not simpler." [19]

Guide 1 - Authors

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Guide 2: Response, Resources, and Resilience: Preparedness and Planning for a Nuclear Detonation

Overview:

Effectively planning for the public health and medical response to a major disaster is critical to saving lives and offering comfort care to as many people as possible. Such planning also enhances the resiliency of the providers, institutions, and community. Preparedness efforts should focus on "all-hazard"[1] issues to ensure that the command, control, coordination, and communications elements of an effective response are as robust and well-practiced as possible within a community. The resources to support a medical response should be understood and augmented to the degree possible given economic and other constraints prior to an incident.

The priority areas and technologies and tools being developed by federal agencies for community resilience are recognized and discussed through planning activities mentioned in this chapter. Response Phases, Organization of the Response, Resource Availability, the Federal Response, and the Continuum of Responders are the key activities identified as vital planning components for establishing community resilience. These key activities, in conjunction with coordination, communication, education, cooperation, and collaboration among the broad spectrum of government, academia, the private sector, and, in particular, the general public, can create communities that will be empowered to endure after a catastrophic and traumatic incident.

It is important to remember that there are two key features of resilience:

- Have as effective a response as possible; and
- Recognize that despite a major tragedy, there is a path toward a plausible, structured recovery that will help survivors cope with inevitable stress and see a way forward to eventually reach a state of "new normalcy."

Scope of the Threat

Certain threats, such as a nuclear device detonation, require specific planning to address the following issues:

- Coping with multiple systems failures, including command and communications and possible loss of major systems or emergency operations center locations;
- Contingencies for overwhelmed responder agencies and organizations;
- Integrating an unparalleled regional, federal and perhaps international response in the face of compromised local infrastructure (e.g., transportation, facilities);
- Medical resource deficits; and
- Patient movement within and out of the affected area.

The breadth and immediacy of response requirements necessitate a ready-to-use checklist that can guide decision making before exact requirements are known. The checklist provides tools, resources, approaches to inter-agency and inter-disciplinary coordination, and flexibility to predict actions and needs during an incident.

Resilience

The National Health Security Strategy (NHSS) of the United States of America[2] defines community resilience as "the sustained ability of communities to withstand and recover—in both the short and long terms—from adversity." Resilient communities draw from numerous community elements (individual, public, and private) to promote healthy lifestyles, prevent disease, and provide access to good healthcare and public health systems. The ultimate goals of resilience are to systematically integrate into the overall community structure a certain amount of risk reduction that is achieved through good baseline health status, strengthened institutions and capacities, and programmatically implemented preparedness, response, and recovery plans.

Five priority areas for community resilience to disasters include:

- Governance and leadership,
- Risk and capability assessment,
- Stakeholder knowledge and education,
- Risk management and vulnerability assessment, and
- Disaster preparedness and response.[3]

Two key features of resilience:

- Have as effective a response as possible; and
- Recognize that despite a major tragedy, there is a path toward a plausible, structured recovery that will help survivors cope with inevitable stress and see a way forward to eventually reach a state of "new normalcy."

Response Phases

The medical and public health response to a nuclear detonation unfolds in phases (Figure 1).[4]

The Protective Action Guide Manual defines three phases (Discussed in Manual #14).

- **Early Phase** — The beginning of a radiological incident when immediate decisions for effective use of protective actions are required and must therefore be based primarily on the status of the radiological incident and the prognosis for worsening conditions. When available, predictions of radiological conditions in the environment based on the condition of the source or actual environmental measurements may be used. Protective actions based on the PAGs may be preceded by precautionary actions during the period. This phase may last from hours to days.

- **Intermediate Phase** — The period beginning after the source and releases have been brought under control (has not necessarily stopped but is no longer growing) and reliable environmental measurements are available for use as a basis for decisions on protective actions and extending until these additional protective actions are no longer needed. This phase may overlap the early phase and late phase and may last from weeks to months.
- **Late Phase** — The period beginning when recovery actions designed to reduce radiation levels in the environment to acceptable levels are commenced and ending when all recovery actions have been completed. This phase may extend from months to years. A PAG level, or dose to avoid, is not appropriate for long-term cleanup.

Table 1 below is from the Federal Register and is included to illustrate the key point that some actions that occur primarily in the later phase must begin very early in the response in order to be effective (e.g., evacuation of patients in the latent phase of radiation syndrome before the full syndrome is present). There are different preparation and response activities by sector: emergency management, emergency medical services, health care facilities, public health, and overall medical system. Pre-incident coordination and communication strategies are essential, as outlined in Koerner.[5]

Table 1. Relationship between Protective Measures, and Timelines for Effects. [4]

Protective Measures	Early	Intermediate	Late
Evacuation	X		
Shelter	X		
Public Access Control	X	X	X
Administration of Prophylactic Drugs	X	X	
Decontamination of People	X	X	X
Relocation		X	X
Food and Water Controls		X	X
Animal Protection	X	X	X

Organization of the Response

The destruction from a nuclear detonation produces both physical damage and radiation exposure. (Figure 1) While the blast, heat, and radiation zones are fairly co-incident close in, **there can be major zones where there is physical injury without radiation (upwind glass breakage injuries) and others where there is radiation with limited or no physical damage to the infrastructure (fallout areas).** The response after a nuclear detonation is organized around and within the damage zones (Table 2): Severe, Moderate, Light Damage Zone, and Dangerous

Fallout zones—all based on damage or presence of fallout—and a variable zone designated >10mR/hr in which response can occur but rescue time may be limited. **The RTR system** (Radiation TRiage, TReatment, and TRansport) (Table 3) overlays a functional response on the physical damage response zones.[6]

Figure 1. Physical Damage and RTR Zones[6].

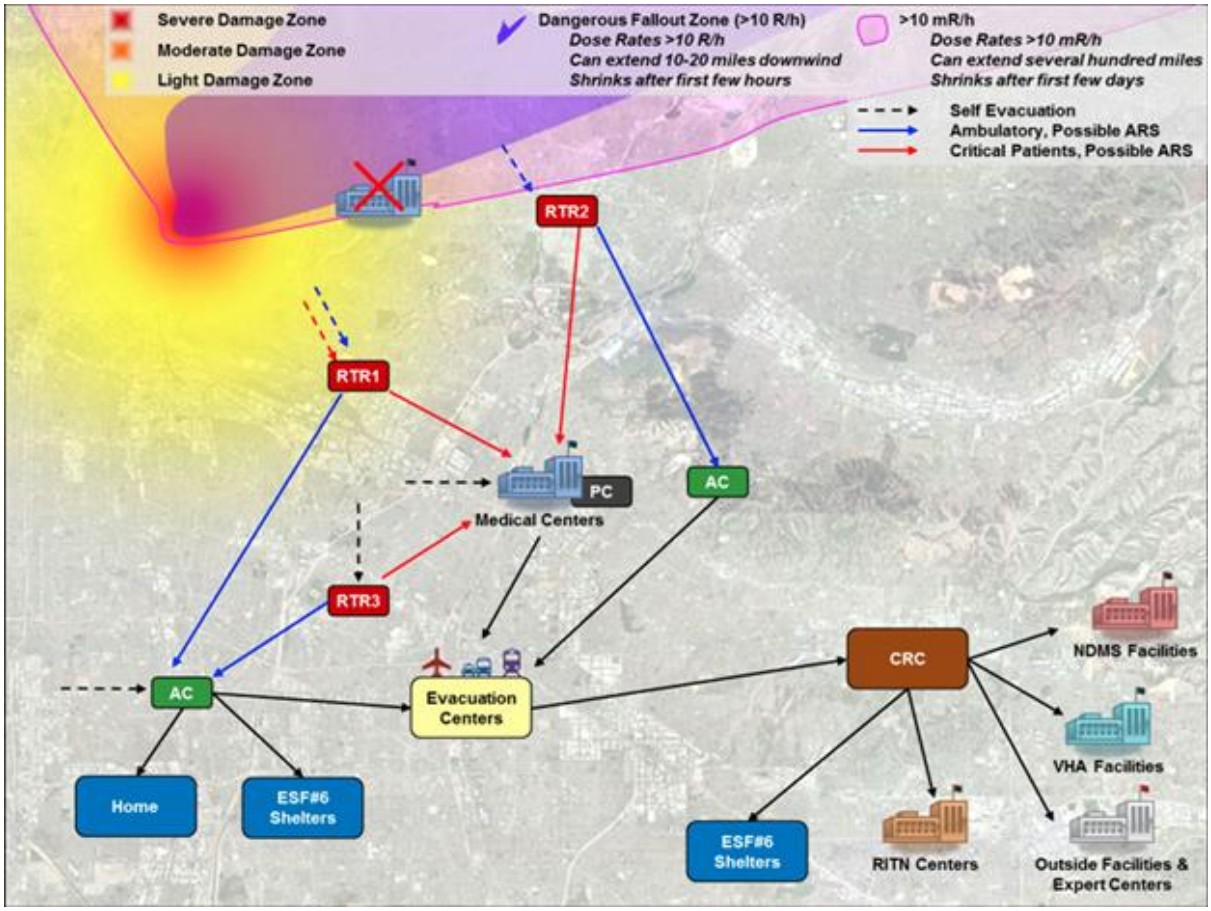


Table 2. Physical Damage Zones

Damage Zone Name	Description
Severe Damage (SD) Zone	Extensive infrastructure damage and few survivors
Moderate Damage (MD) zone	Passable, with variable to no levels of radiation that if present decrease over time
Light Damage (LD) zone	Passable, with little or no radiation other than where fallout areas overlap the LD zone
Dangerous Fallout (DF) zone	Area with a dose rate of 10 R/h or greater – may overlap the above zones. (The DF zone shrinks rapidly as exposure from fallout decays).
A perimeter 10mR/h (0.01 R/h) or greater	Location where time and dose for people working in that zone are monitored. This is outside the DF zone

Table 3. The RTR Functional Response System (Radiation TRiage, TReatment, and TRansport) helps organize the response.

RTR Site Type	Specific Functions
Spontaneously forming RTR sites (casualty collection points)	• RTR1 – at or near **major physical damage** with **radiation present** • RTR2 – **no or limited physical damage** and **radiation present**, likely near the DF zone • RTR3 – **no or limited damage** and **NO radiation**
Pre-designated sites (assembly centers & healthcare facilities)	• Medical Care (MC) sites, including alternative medical care sites • Assembly centers (AC), some of which may be co-located near MC sites for people who do not require medical care • Evacuation centers (EC)

Local planning is most effective when it is integrated across the tiers of response[9] to include the federal tier. Effective integrated planning is facilitated through the use of planning and response tools such as a resource-mapping tool developed by DHHS known as GeoHEALTH (formerly MedMap).[10] GeoHEALTH (Figure 2) facilitates sharing situational awareness with local/regional responders and can show locations of healthcare facilities in relation to other overlays and demographic information. Designated local and state government partners (as defined in the National Response Framework Emergency Support Function #8)[11] can request access to GeoHEALTH through their HHS/ASPR Regional Emergency Coordinators.

Figure 2. GeoHEALTH (formerly MedMap). During an incident, selected access to GeoHEALTH will be available to assure that all responders have coordinated situational awareness.

https://geohealth.hhs.gov/arcgis/home/

Resource Availability

Resource scarcity is the inability of the resources—space, staff, and supplies—to meet the medical needs. The mismatch between need and available resources will vary by type of resource, location of need, and the time following detonation. Table 4 depicts the categorization of supply/demand mismatch as recommended by the Institute of Medicine (IOM).[12]

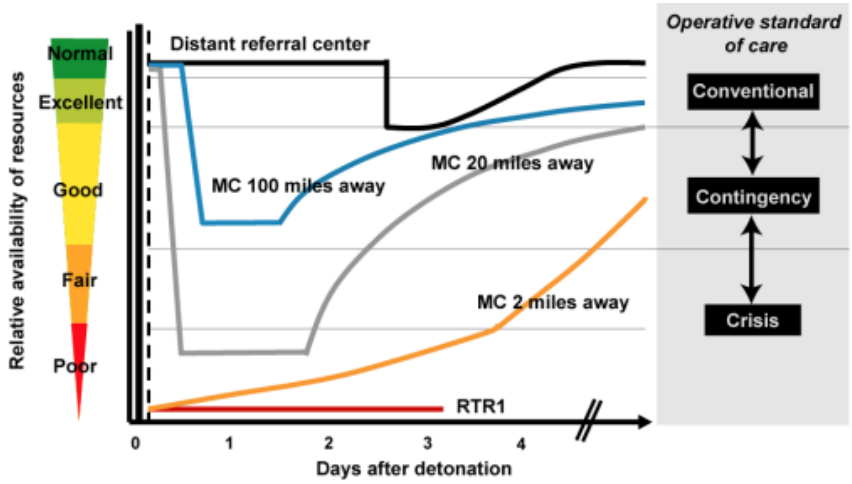
Table 4. Relationship between Resource Availability as Used in This Project to IOM Standard of Care Definitions.

Resource availability	IOM Standard of care	Level of care - recommended by this manuscript
Normal	Conventional	Normal care is provided.
Good	Contingency	"Functionally-equivalent" level of care is maintained by using resource-enhancing strategies such as substituting and conserving resources.
Fair	Crisis	Triage prioritizes those with moderate injuries because those with more severe injuries (trauma, burn, and radiation) will have higher resource requirements and worse prognosis, even with treatment.
Poor	Crisis	Those with severe traumatic, burn and radiation injuries are triaged to the expectant category.

In the setting of a severe crisis there are no longer sufficient resources to treat all patients.[12-15]The Scarce Resources Project for Nuclear Detonation[16, 17] (Table 4) subdivided the IOM crisis standards of care into 4 categories in which crisis care is subdivided into fair and poor resource availability, the latter having severe shortages that impact triage category.[18]

Thus, the scarce resource setting will differ in location and over time and consequently the standards of care will vary; Figure 3 is a graphic representation of this concept (adapted from DiCarlo[19]).

Figure 3. Relative Availability of Resources after a Nuclear Detonation. Resource availability will vary by proximity to the incident and will change over time. (Graphic courtesy of David Weinstock, MD)



An RTR1 site (see Figure 1) will have poor resources—the focus is on moving patients from an RTR to more definitive assessment/care. A medical center (MC) 2 miles away will have poor resource availability but will improve to fair by the third day (assuming infrastructure is relatively intact AND that appropriate requests for resources were able to be made and fulfilled), while a MC 20 miles away will recover faster due to resupply. Even a MC center 100 miles away could be transiently resource limited. These curves assume that there has been appropriate movement of casualties out of the immediate area and establishment of alternative care and screening sites— although the scarce resource setting is likely to vary based on physical location and time since the event, strategies for dealing with even transient scarcity are necessary.

Strategies for Scarce Resource Situations[12-15, 20]

- **Prepare** – stock disaster supplies and increase par levels on commonly needed items such as tetanus vaccines, laceration trays, narcotic analgesics, dressing, etc.[21]
- **Substitute** – use a clinically equivalent item or staff person;
- **Adapt** – use items or technologies to provide sufficient care (use transport ventilators or anesthesia machines instead of full-featured ventilators), use staff with similar or congruent skill-sets (specialty surgeons assisting with trauma surgeries), or adapt locations of care (performing surgical procedures outside of the operating room);
- **Conserve** – use less of a resource by lowering dosage or changing utilization practices;
- **Re-use** – after appropriate disinfection/sterilization, re-use supplies;
- **Re-allocate** – prioritize a therapy in scarce supply so that it is only given to those with a higher chance of benefit or greater need.

Some key planning and early response priorities for these different locales are outlined below.

Jurisdictional Response

Situational awareness and establishment of command/control

- Assess healthcare facility and public safety system damage and infrastructure damage (communications, transportation affecting response).
- Healthcare responses focus on provision of supplemental staff, supplies (e.g., wound dressings) and pharmaceuticals (e.g., cytokines, analgesia, intravenous fluids, and antiemetics) to hospitals, RTR sites, and pre-determined alternative care sites prior to full situational awareness.
- Pre-determined resources should be 'pushed' to affected facilities and agencies (or to regional staging areas) from suppliers, more functional healthcare systems, and jurisdictions. Preplan 'automatic' responses so that functional operations center is not necessary in the first hours after an event.

Triage

- Triage based on physical injury first and then radiation assessment.
- Radiation- assessments (including exposure information and symptom information and lymphocyte counts.

Contamination

- Emergency care takes precedence over decontamination.
- Removal of clothing removes >90% of superficial contamination.
- Decontamination and contamination containment (how are patients designated as 'clean' for shelters and what is the threshold) should be planned by community prior to the event.

Medical care

- Overflow: alternative care sites, temporary RTR3 sites may provide symptomatic care for those without serious injuries to reduce burden on healthcare facilities and reduce panic.
- Non-life-threatening but serious injuries evacuated for necessary care after first-aid (e.g., splinting or covering wound).
- Palliative care plan (supplies, location, managing community expectations).

Mental health

- Responders top priority.
- Victims, including seriously ill and expectant category.
- Communication to help reduce panic and hopelessness.

Transport

- Primarily evacuation and transport out of the area—including those in latent phase of ARS.
- Some back-fill personnel and supplies are transported in.
- May require creative solutions (4-wheel drive vehicles, buses, etc.).
- Coordination with public works likely required to clear streets of debris to facilitate evacuation of patients from RTR and close-in hospitals.

Regional/State Response

The role of the surrounding region is to support, and when needed, assume responsibility for absent command and control mechanisms. Planning requires working with coalitions outside the immediate area, as their support and assistance will be required. Some major considerations for state and regional response include the following:

Command and control

- Regional/state Emergency Operations Center (EOC) may have to take over role of 'local' EOC if command infrastructure is severely damaged

Proactive emergency declaration for state and federal resources

- Pre-scripted declarations and plans

Acute medical care

- Small healthcare facilities may become major providers of triage and care—requires planning and communication/coordination mechanism.
- Regional/statewide hospital coalitions are critical to effective response and medical demand balancing/resource management.

Emergency management assistance compacts (EMACs)

- Pre-planned interstate resource mutual aid may greatly contribute, but impact may be uncertain due to magnitude of crisis.

Regional staging area

- Forward movement of resources to these areas prior to specific assignment will cut hours to days off of usual mechanism for requests.
- Requires planning for accommodations, staff support, communications, and resources (maps, GPS for responding units)

Federal Response

A nuclear detonation will bring an unprecedented number of federal agencies to the jurisdiction. Understanding the resources available and the chains of command, as well as anticipating where and how to accommodate these agencies so that their efforts can coordinate prior to an event, are important. Some of the key players would likely be:

Federal Bureau of Investigation – Crisis management and lead investigative agency following a terrorist event.

Federal Emergency Management Agency[22] – Consequence management and gateway for resource requests via the state to the Federal Coordinating Officer for logistical requirements not able to be supplied by the state or region including personnel, communication, earth-moving equipment, urban search and rescue teams, etc.

U.S. Department of Energy – Provision of modeling and atmospheric data via Laurence Livermore National Laboratories and provision of expert technical assistance from the Radiologic Assistance Program and National Nuclear Security Agency.

- Federal Radiological Modeling and Assessment Center (FRMAC)[23]
- Advisory Team for Environment, Food, and Health (A-Team)[24]

Nuclear Regulatory Commission - Provides expertise on nuclear reactors and reactor sites.[23]

U.S. Department of Health and Human Services (DHHS)

- Centers for Disease Control and Prevention – activation of Strategic National Stockpile[25] and provides epidemiologic assistance.

- National Institute for Health, National Library of Medicine – Radiation Emergency Medical Management (REMM) website and other resources for victim medical treatment.
- Assistant Secretary for Preparedness and Response (ASPR)[26] – National Disaster Medical System (NDMS), U.S. Public Health Service, volunteers, Disaster Medical Assistance Teams (DMATs), Disaster Mortuary Teams (DMORTs)

Department of Defense (DOD) – coordinates airlift capability for NDMS. DOD can provide substantial technical and personnel assistance according to needs identified by the Federal Coordinating Officer.

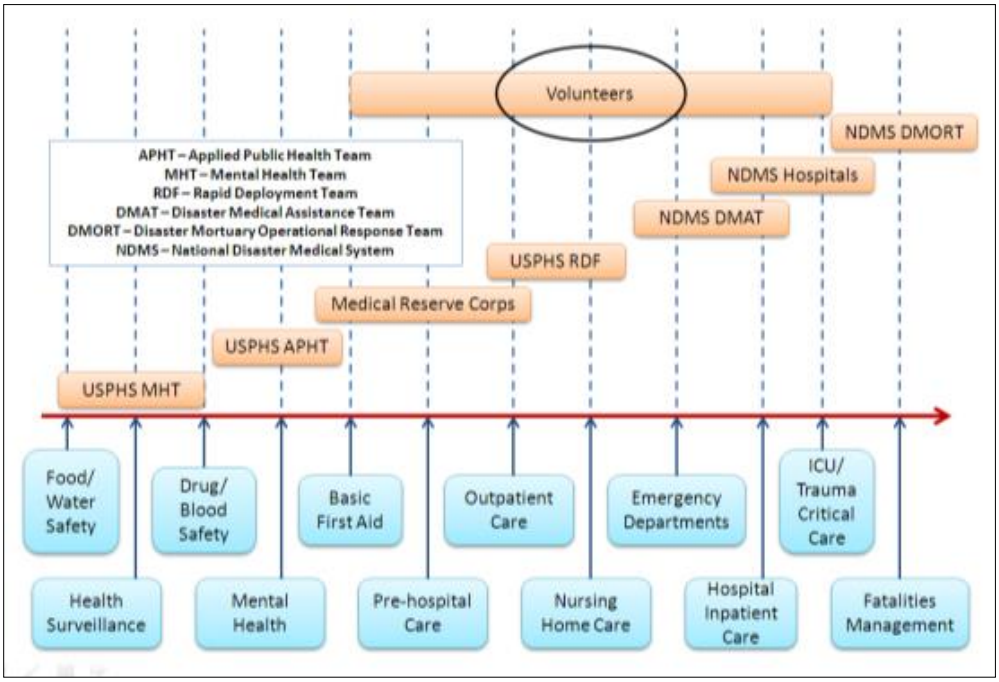
U.S. Department of Veteran's Administration (VA) – activation of Medical Emergency Radiologic Response Team[27] as well as VA Federal Coordinating Centers for patient movement.

Continuum of Responders

Figure 4, below, illustrates the spectrum of DHHS staffing support to the local area and the importance of integration and coordination among a broad base of responders.

DHHS is one aspect of the multiple federal agencies and missions that will be engaged. Volunteer assistance for radiation injury will be from the Radiation Injury Treatment Network (RITN)[28] among others.

Figure 4: The Spectrum of Care and Phased Deployment of DHHS Resources.



Summary

The challenges of planning for a nuclear detonation are many-fold. However, by focusing on the fundamentals of community resilience and concentrating on redundancy of command, control, and communication mechanisms, jurisdictions can build an underlying community structure that can reconstitute and gain situational awareness more rapidly after a detonation. As a planning element, developing a quantitative understanding of the local capacity for non-traditional emergency response assets (e.g., private practices, commercial labs, etc.) and coordinating them is crucial. Planning for proactive resource support from the surrounding region, state, and federal entities and the use of regional staging areas in case of a catastrophic incident will greatly shorten the time to resource availability to the end users. Assembly and evacuation center planning by healthcare facilities and the community at large will greatly mitigate bottlenecks and confusion in the hours and days after an incident. Pre-scripted mission assignments may be constructed for local, regional, or state groups to support these sites. Though a nuclear detonation will be catastrophic, the resilience of the community rests in large part on the success of these key activities during planning, exercising, and response. While one can never be perfectly prepared, and much work remains to be done, there has been substantial progress in defining needs and in developing plans, tools and resources. Coordination, communication, education, cooperation, and collaboration among the broad spectrum of government, academia, the private sector and, in particular, the general public will be needed to conduct the best possible response in the face of such a catastrophic and traumatic incident.

Guide 2 - Authors

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Guide 3: Nuclear Fallout Protection in a Nutshell – What to Do, What Not to Do, and Why

Overview:

Nuclear fallout will occur significantly from a ground-burst and minimally from an air-burst. The most acutely hazardous fallout particles are generally visible as fine sand-sized grains and are deposited within about 20 miles. There are two principal protective action recommendations that may be implemented to protect the public from fallout—taking shelter and evacuation. The best initial action immediately following a nuclear explosion is to take shelter in the nearest and most protective building or structure and listen for instructions from authorities. You should have at least 10 minutes before fallout arrives. Go below grade if that option is available or to the center of the shelter structure and shelter for 12-24 hours.

Evacuation has been recommended as an action after having sheltered in place for at least 12 hours, but can be done prior to the detonation if advanced warning of the incident is available. Overall, people should immediately take shelter in a safe location and listen for further instruction by authorities.

Introduction

Ours is not a nation uninitiated into the fears and concerns of nuclear attack. Those of us who grew up during the Cold War remember the angst associated with Soviet nuclear-tipped intercontinental ballistic missiles (ICBMs), "duck-and-cover" school drills, and fallout shelters. The predictions were dire: whole cities would be wiped from the face of the Earth; millions would be annihilated; and a "nuclear winter" would follow, as predicted by astronomer Carl Sagan.

The Cold War domestic civil defense approach consisted of preparedness measures through public education, and readiness with heavy emphasis on both public and private build-it-yourself fallout shelters and stockpiling. Fallout shelters made sense because a) the threat was serious and perceived as imminent, and b) satellite and radar warning systems would generally provide sufficient notice to hasten into a pre-constructed private or pre-designated public shelter. Post-attack emergency response was not a serious idea.

Fortunately, the Cold War specter of strategic thermonuclear war and "mutually assured destruction," with the possibility of hundreds of nuclear strikes on major cities and the majority of the United States covered with fallout is greatly diminished. However, the possibility of nuclear attack still exists through terrorist use of a low yield nuclear device.

This Guide addresses one of the more significant causes of morbidity and mortality following the detonation of a small nuclear device (approximately 10 kilotons) in an urban area—highly radioactive fallout—and the effectiveness and implementation of protective strategies, such as sheltering in place.

Fallout Basics

Radiation from a nuclear explosion falls into 2 categories: 1) initial nuclear radiation (prompt radiation and neutron activation), which originates from the explosive event and the early fireball, and 2) residual radiation which is largely associated with fallout. Both prompt and fallout radiation can cause health effects and the severity increases as the dose increases (as discussed in Guide #6: Acute Radiation Syndrome: Medical Guidance and National Response). The exposure pathway of greatest concern up to several days after the incident is external irradiation from fallout(and not ingested or inhaled radiation) In the first hour, fallout dose rates in the hundreds of R/hour should be expected, and may be 1000 R/hour (10 Gy/h) or higher in localized areas.

UNITS: R/hr is technically Roentgen's per hour but is often used interchangeably with rad/hour or rem/hour [rem is used for radiation protection as it accounts for the type of radiation, e.g., neutrons, x-rays or particle]. Gy, or Gray is the preferred international unit [and Sievert is the unit for radiation protection]. **Therefore, 100 rad = 1 Gy, and 100 rem = 1 Sv.**

Fallout is generated when the dust and debris excavated by the explosion is combined with radioactive fission products produced in the nuclear explosion and drawn upward by the heat of the event. This cloud rapidly climbs through the atmosphere, potentially up to 5 miles or higher, forming a "mushroom cloud" from which highly radioactive particles coalesce and drop back down to earth as they cool. It is important to note that Hiroshima and Nagasaki did not have significant fallout because their detonations occurred at altitude (air-burst) and the fission products did not have the opportunity to mix with excavated earth, as in a ground-burst. The majority of the radioactivity in fallout comes from fission products, or the radionuclides produced as a result of uranium or plutonium nuclei splitting apart in the nuclear fission reaction.

The hazard from fallout comes from being exposed to the ionizing radiation the particles give off after they have settled on the ground and roofs, *not from breathing the particles*. Radiation levels from these particles will drop off quickly, with *most (~55%) of the potential exposure occurring within the first hour and 80% occurring within the first day*. Although it is highly dependent on weather conditions, the most dangerous concentrations of fallout particles (i.e., potentially fatal to those outside) occur within 10 to 20 miles downwind of the event and are clearly visible as they fall, often the size of sand, table salt,[1] or ash.[2]

This rule states that for every sevenfold increase in time after detonation, there is a tenfold decrease in the radiation rate, as shown in Table 1.[3] **After about 24 hours (and in most cases 12 hours), even the highest early dose rates have diminished to the point where exposures may be incurred without suffering acute radiation effects.**

Table 1. Example dose rate decay from early fallout as a function of time after a nuclear explosion
Source: Adapted from Glasstone.[3]

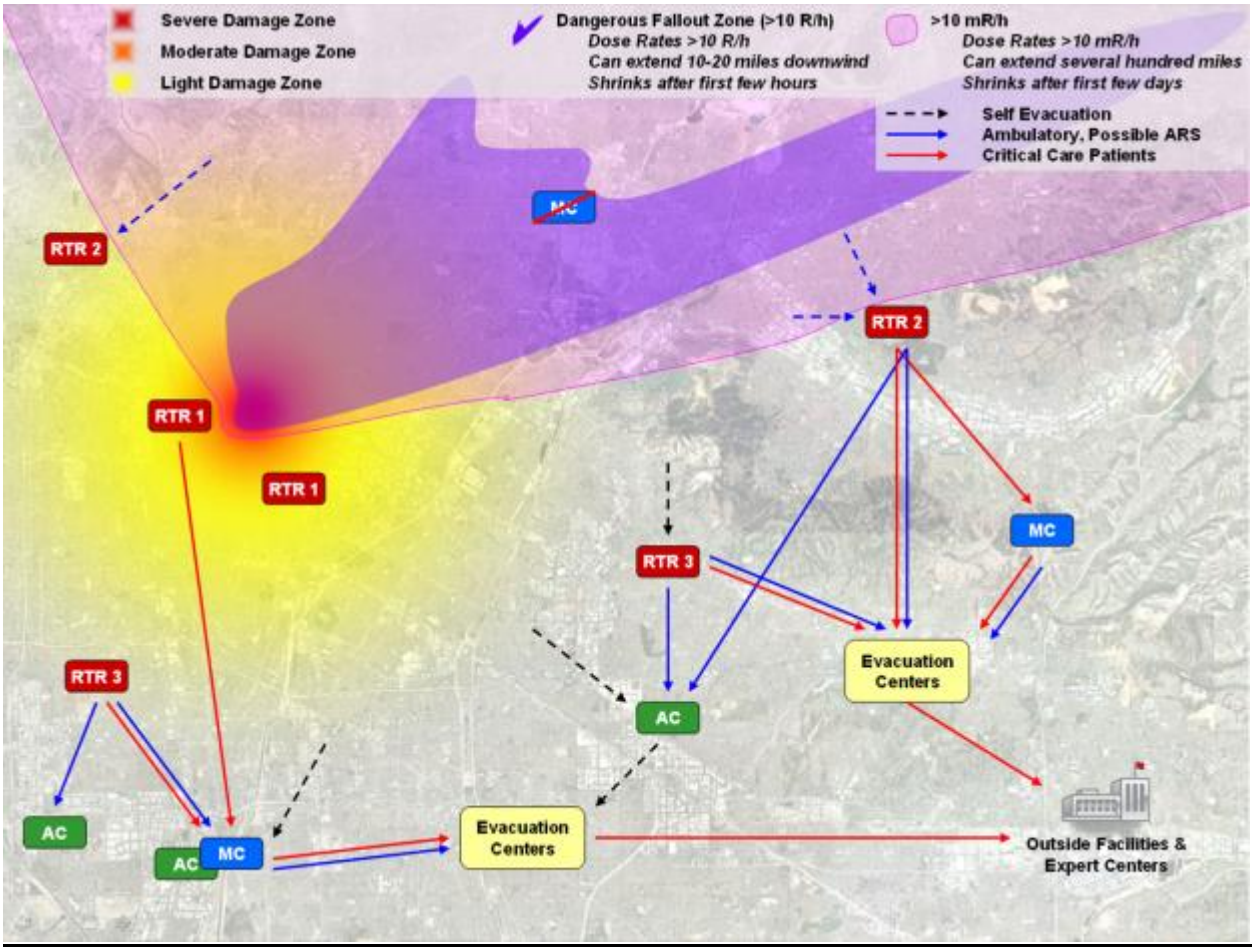
Time (hours)	Dose Rate (R/h)
1	1,000
1.5	610
2	400
3	230
5	130
6	100
10	63
15	40
24	23
36	15
48 (2 days)	10
72 (3 days)	6.2
100 (~ 4days)	4.0
200 (~ 8 days)	1.7
400 (~ 17 days)	0.69
600 (~ 25 days)	0.40
800 (~ 33 days)	0.31
1,000 (~ 42 days)	0.24

While fallout particle sizes range from centimeters to submicron, most of these smaller particles will remain in the upper atmosphere for days or weeks.

- The most acutely hazardous fallout particles are generally visible as fine sand-sized grains and are deposited within about 20 miles.
- The lack of apparent fallout should not suggest the lack of hazardous radiation.[4]
- Predicting where lethal fallout will deposit cannot be done reliably in the short time after a detonation although there will be a good estimate of what is called the dangerous fallout zone (Figure 1).
- Therefore, protective guidance should apply widely, regardless of meteorological observations or early plume model results.
- Fallout deposition on areas where survivors are likely to be found (outside the more severely damaged areas) may be expected to begin in about 10 minutes.[5]

As shown in Figure 1, there are 3 damage zones: 1) Severe, where there will be mostly fatalities, 2) Moderate, where there will be many survivors, and 3) Light, where most injuries will be from glass or accidents. The Dangerous Fallout Zone has a potentially high enough dose to cause the acute radiation syndrome (see Guide 6: Acute Radiation Syndrome: Medical Guidance and National Response) and there is a larger fallout zone for which care will be needed regarding food, water and evacuation. The various spontaneously-forming emergency response sites (RTRs)[6] indicate the type of injuries, and the various predetermined medical response sites and evacuation centers are also indicated (more information the RTR is available in Manual Section 7.).

Figure 1. Physical Damage and RTR Zones[6].



Protective Actions Guides and Protective Action Recommendations

A Protective Actions Guide (PAG) is "the projected dose…from an unplanned release of radioactive material at which a specific protective action to reduce or avoid that dose is recommended".[7]

A Protective Action Recommendations (PAR) is a *recommended action* to reduce or avoid the projected dose.

- At low dose rates (1-5 rem), a decision should be made whether the cost and risk of the protective action is warranted by the projected collective dose to the affected population. This makes sense far downwind, but not closer in.
- At high doses (> 100 rem) protective actions are always warranted. The difficulty lies in identifying the protective action that results in the lowest overall risk to the population under the circumstances.

The Protective Actions and Protective Actions Guides can be found online at the REMM website REMM PAG Information and the U.S. Environmental Protection Agency's website EPA PAG website.

Shelter and Evacuation

There are two principal PARs that may be implemented to protect the public from fallout: *taking shelter* and *evacuation*.[4] Either PAR can be executed on an individual basis (by self-evacuation) or facilitated in an organized fashion at any time before or after the incident. The timing and execution of protective actions are critical to their effectiveness. In nuclear terrorism scenarios, no advance notice is presumed that would afford time to either shelter properly or evacuate from the target (e.g., city center).

Immediate evacuation has serious drawbacks as a protective action in the early hours after detonation:

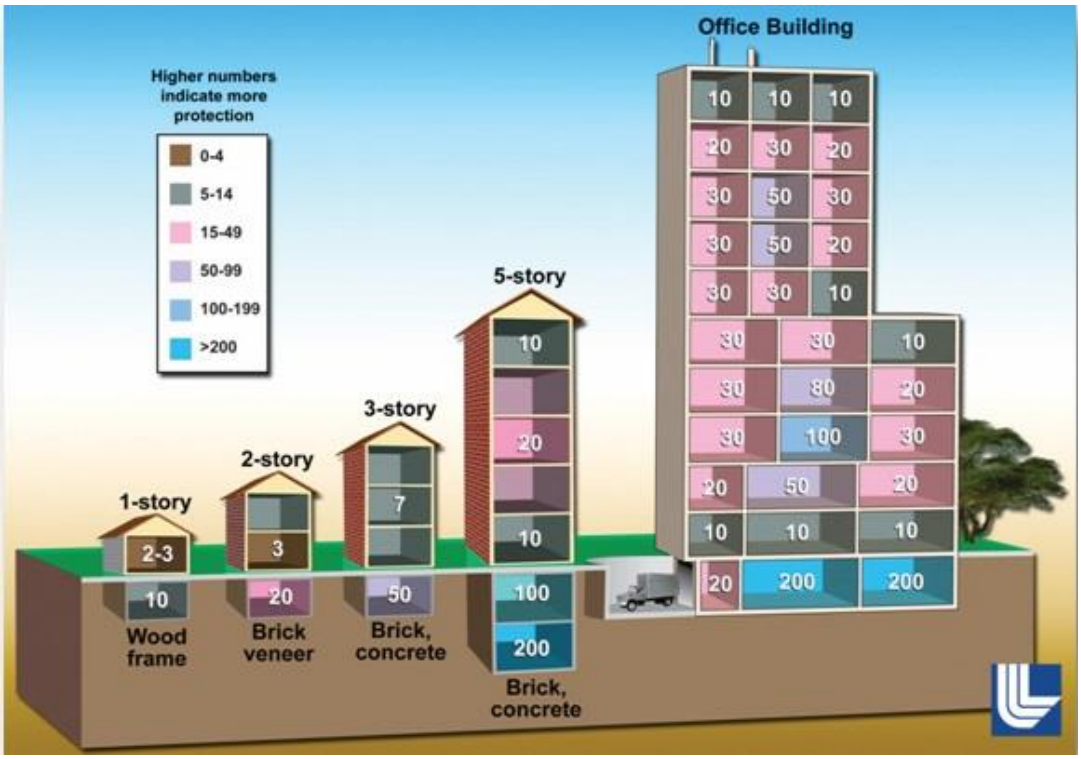
- The high initial dose rates from fallout mean that early evacuation can cause the highest exposures;
- It will be difficult to predict which areas will be impacted by fallout and attempted evacuations could move people into or through areas of higher contamination;
- Cars offer little protection from fallout and those evacuating on foot would have no protection; and
- All evacuations take time. Moving any number of people even a few miles, especially with damaged infrastructure, obstructed roadways, and jammed highways, will take many hours.

Sheltering can be done easily, especially when people are already in some form of structure at the time of the incident.

- If an individual is caught outside, they should seek adequate shelter immediately. It is important to be sheltered when the fallout arrives.
- Radiation is best attenuated by dense material (earth, concrete, stone), and dose is reduced by increasing distance from the source and reducing the time spent exposed.

Although any shelter will provide some protection and reduction of dose, some shelter locations can provide superior protection and should be sought out to prevent adverse effects within the dangerous fallout zone. Generally, below grade (e.g., a basement or underground garage) is better than above grade, large buildings are better than small, and heavy concrete or masonry walls are better than wood. Shelters such as houses with basements, large multi-story structures, and underground parking garages, or tunnels, can generally reduce doses from fallout by a factor of 10 or more (see Figure 2). These structures would generally provide "adequate" shelter. Single-story wood frame houses without basements and vehicles provide only minimal protection and are not considered adequate shelter. The worst situation is being caught outdoors when fallout arrives or choosing to go outdoors in the early hours when fallout is most radioactive.

Figure 2. Fallout Protection Factors for Various Structures. (Image courtesy of: Lawrence Livermore National Laboratory). The larger the PF number the greater the protection. For example, 10 means 1/10th the exposure compared to no protection and 100 means 1/100 (1%).



Conclusion

What to Do: Because the fallout radiation hazard is so high early after the detonation and within about 20 miles of ground zero, and because the deposition of fallout is unpredictable, taking immediate shelter in an adequate shelter is the unequivocal recommendation of the federal government.[4]

Seek early adequate shelter for 12-24 hours, followed by informed evacuation

- It is important to be in the shelter when the fallout arrives.
- Fallout arrival times vary with weather, but if you are outside of the building collapse area, you should have at least *10 minutes* before fallout arrives.
- Adequate shelters are locations that place as much earth, building materials, or distance between the occupants and horizontal surfaces that will accumulate fallout (including roofs). Examples of adequate shelters include basements, usually against a basement wall; multi-story brick or concrete structures (towards the center of the structure); office buildings (central core or underground sections); multistory shopping malls (away from roof or periphery); and tunnels, subways, and other underground areas.
- If you are outdoors or in a car, seek the nearest adequate shelter.
- Note: Even an inadequate shelter will provide some protection.

The best initial action immediately following a nuclear explosion is to take shelter in the nearest and most protective building or structure and listen for instructions from authorities. You should have at least 10 minutes before fallout arrives. Go below grade, if that option is available, or to the center of the shelter structure. Shelter for 12-24 hours.

Shelters such as houses with basements, large multi-story structures, and underground parking garages or tunnels, can generally reduce doses from fallout by a factor of 10 or more. These structures would generally provide *adequate* shelter.

What to Avoid: The worst thing a survivor can do is to get caught outdoors when fallout arrives, or choose to go outdoors when fallout is fresh. You cannot predict where fallout will deposit, or how radioactive it will be.

Avoid all hazards, not only fallout. Relocate if your shelter is threatened by fire, building collapse, or other immediate threats. Immediate medical needs of life threatening injury would also take precedent over fallout protection.

Avoid Immediate and/or uniformed evacuation

- Survivors should plan on sheltering for at least 12 hours.
- Unless threatened by other hazards or medical necessity, survivors should not leave adequate shelter on their own; wait for officials to facilitate evacuation.

Guide 3 - Authors

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Guide 4: Preparing the Home for Sheltering In Place Following a Nuclear Detonation

Overview:

Every American family should prepare their home for the possibility of disaster.[1] This is especially important for a nuclear detonation, since you may be advised to "shelter in place" in order to reduce your exposure to radiation.[2] Individual and family preparedness can aid the response to a radiological incident by decreasing the likelihood of injury, reducing the sense of panic and the pressure on the overall response so responders can focus the injured. The following steps (compiled largely from FEMA Nuclear Blast preparedness website and CDC Radiation Emergency website can help you prepare your home for any disaster, including a nuclear detonation:

1. Psychological preparation
2. How to choose a safe room
3. Recommended emergency supplies
4. How to maintain your safe room

Psychological preparation for a disaster means acknowledging that there is a possibility a nuclear explosion can happen and that there are protective actions one can take to reduce serious injury. One such protective action is to choose a safe room. The safest room in a house is a basement or a room with as few windows as possible.

Step 1: Become Psychologically Prepared

In this context, psychological preparation means being motivated to create a safe room and to anticipate and resolve potential obstacles to remaining in it following a nuclear detonation. To be prepared psychologically, individuals must recognize that nuclear terrorism is possible; understand key protective actions; and put plans in place to support these actions. Simply put, people need to know how to select a safe room and/or seek adequate shelter, and anticipate how to fill physical and psychological needs so that they can remain there until it is safe to leave.

People are more likely to prepare a safe room when they have credible information from multiple sources about the value of a safe room in reducing exposure to fallout and the subsequent radiation injuries. Social science research has demonstrated that individuals are more motivated to prepare for emergencies when those who have made preparations share what they have done.[3, 4] The more that people see, hear, and talk about safe rooms, the more

likely they are to create them. Moreover, since safe rooms afford protection for a wide range of hazards, highlighting the aspects that are especially important for fallout protection can reinforce general all-hazard education activities.

However, being motivated to create a safe room is only one part of psychological preparedness. It is equally important to address psychological issues that could interfere with people's willingness to remain in a safe room. Following a disaster, there is a universal urge to connect with friends and loved ones to check on their welfare and make sense of what has happened. Parents, in particular, will feel a strong emotional pull to immediately reunite with their children and bring them home.[5] In the case of fallout, rushing to pick up children may jeopardize the health of both the child and the parent. Therefore, it is important that parents have confidence that schools have identified adequate shelters and supplies to ensure their children's safety. They also need to know the school's plan and contingency plans for reuniting with their children. If these measures are in place, parents are more likely to remain in their safe room or at least wait an hour or more for radiation levels to fall. Similarly, confidence that adult loved ones will shelter is also important. In the event that people are unable to communicate by phone or email, worry may cause them to leave shelters in order to physically check on their loved ones. Knowing that a loved one is in a home that has a safe room and will stay there may help reduce anxiety and fear.

From a psychological perspective, knowing what to expect—even if it is painful—is less terrorizing than surprise. For example, knowing that cell phones may not work initially due to network congestion, a damaging electromagnetic pulse, or loss of a cell tower can minimize surprise. Similarly, keeping a hand crank radio, in anticipation of electrical blackouts, can foster a sense of connectedness with the outside world and help people feel less alone.

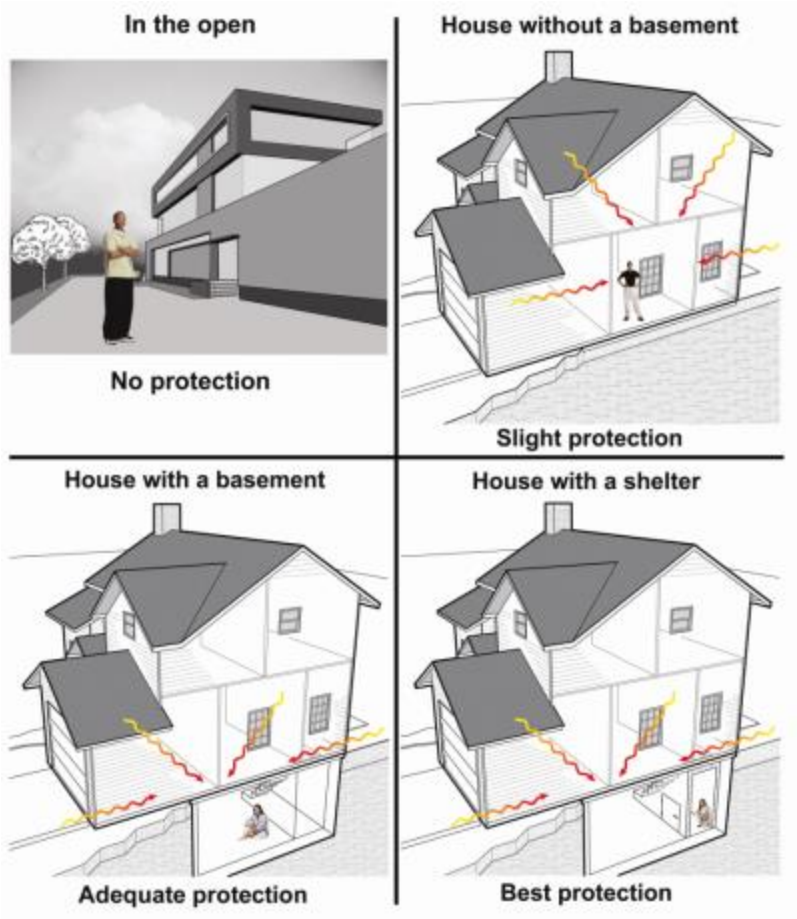
During emergencies, people often find that they experience physical and psychological signs of distress. These can range from insomnia to excessive worry or depression. Psychological first aid or similar approaches teach people the basic skills for supporting each other during stressful times.[6-10] There are free courses available online that can be completed in as little as 60 minutes. Some basic understanding of how to keep yourself and those around you calm can foster better decision making during a radiological event and help ensure survival.

Step 2: Choose a Safe Room[1, 11, 12]

The safest place in your home following a nuclear detonation incident is a centrally located room or basement with as few windows as possible. The rooms in your home that give the highest fallout protection are the ones that put the most earth, building material, and distance between you and the fallout (the radioactive particles that may land on the roof and ground

outside your home). Figure 1 illustrates this principle. Store emergency supplies in this area. If you have pets, prepare a place for them to relieve themselves in the safe room. Pets should not go outside following a nuclear detonation because they may track radioactive materials into the room.

Figure 1. The Rooms in Your Home That Give the Highest Fallout Protection Are the Ones That Put the Most Earth, Building Material, and Distance Between You and the Fallout. (Illustration courtesy of Lawrence Livermore National Laboratory)



Step 3: Gather Supplies[1, 11]

Gather the necessary supplies for a closed-in stay of up to 3 days in your safe room. Tables 1 and 2 contain a list of some supplies to consider. (For a full list, see FEMA Disaster Supply Recommendations)

Table 1a. Safe Room Supplies - Communications

Items	Quantity	Description
Battery-operated or hand-crank radio	1	In case electrical power is out, a battery-operated radio will allow you to listen to emergency messages. You may consider keeping another radio in your car.
Extra batteries	2 sets	Make sure the batteries are not expired.
A telephone or cell phone	1	Although cell phone or ground phone service may be interrupted, there is still a chance that you will be able to use a phone to call outside for information and advice from emergency services. SMS (text) messages are more likely to get through than voice. *(Note: If electrical power is out, old model phones (landlines) may be useful since they get power from the phone lines.)*
List of critical phone numbers	1	This may include family members, workplace, colleagues, schools, doctors, pharmacies, places of worship, or other people/places that play a role in your everyday routine and health maintenance.
Emergency plans	1	If your school, civic organization, or workplace has emergency plans, it would be good to keep copies in your safe room.

Table 1b. Safe Room Supplies – Self Protection

Items	Quantity	Description
Face masks or dense-weave cotton material	Enough for everyone	Gather material that snugly covers your nose and mouth and is specifically fit for each member of the family. Do whatever you can to make the best fit possible for children.
Duct tape and heavy plastic sheeting	Enough to seal room	If a radioactive plume is passing over your home, these items may be used to seal the door to your shelter and to seal any vents that open into your shelter for a <u>very</u> short period of time. *(Note: This may not be necessary, and is certainly not recommended for more than a few hours.)*

Table 1c. Safe Room Supplies – Food and Water

Items	Quantity	Description
Water	3 gals per person	Each person in the household will need about 1 gallon of water per day; plan on storing enough water, per person, for at least 3 days. Include additional water for pets.
Food with a long shelf life	Enough for 3 days	Examples of this include canned, dried, and packaged food products. Choose foods your family will eat and don't forget comfort foods.
Pet food	Enough for 3 days	If you have pets, keep a 3-day supply of pet food.
Baby formula	Enough for 3 days	If you have an infant, store enough extra formula for at least 3 days.
Paper plates, paper towels, and plastic utensils	Enough for 3 days	Store disposable dishware and utensils because you will not have enough water to wash dishes and because community water sources may be contaminated.
Manual can opener	1	

Table 1d. Safe Room Supplies – Medical and Personal Supplies

Items	Quantity	Description
Prescription or other medication	Enough for 3 days	Have 3 days' worth of your current prescription (or non-prescription) medicines in a childproof bottle; label with the name and expiration date of the medicine. *Discuss with your doctor the best way to obtain this small amount of extra medicine*.
First aid kit	1	You can purchase a first-aid kit or prepare one yourself. (*See Table 2 for list of recommended first aid supplies.)*
Extra eyeglasses and contact lenses	1	Have enough cleaning supplies for 3 days
Toiletries	Enough for 3 days	Keep a supply of soap, hand sanitizer, toilet paper, deodorant, disinfectants, feminine supplies, and other personal hygiene items.

Table 1e. Safe Room Supplies – Clothing and Bedding

Items	Quantity	Description
A change of clothes and shoes	1 change	Remember to include underwear, socks, sturdy shoes or work boots, and winter or summer clothes as needed.
Bedding	1 set per person	Store sheets, blankets, towels, and cots for use during the time that you cannot leave your safe room.

Table 1f. Safe Room Supplies – Waste Management

Items	Quantity	Description
Plastic bags	Enough for 3 days	Because you may not be able to leave your safe room for several days, you will need to collect your waste in plastic bags until it can be removed.
Newspapers, litter, or other material for pets to relieve themselves	Enough for 3 days	Pets should not go outside following a nuclear detonation because they may track radioactive materials into the room.

Table 1g. Safe Room Supplies – Other

Items	Quantity	Description
Flashlight /Batteries	1/ 2 sets	Electrical power may be out for several days.
Games, books, and other entertainment	Enough for 3 days	Because you may be in your safe room for several days, keep items on hand to occupy your family during that time. Children are likely to get bored if they have to stay in one place for long periods. Think of activities that they will enjoy doing while in the shelter—finger painting, coloring, playing games, etc.

Table 2. First Aid Kit Minimum Recommended Supplies

Item	Amount
Eye wash solution	1 bottle
Moist towelettes	1 pkg
Antiseptic ointment	1 tube
Tube of petroleum jelly or other lubricant	1 jar
Soap or hand sanitizer	1 bottle or pkg
Sterile latex or vinyl gloves	2 pairs
Safety pins	1 pkg
Aspirin or aspirin-free pain reliever	1 bottle or pkg
Anti-diarrheal medication	1 bottle or pkg
Laxatives	1 bottle or pkg
Antacids for stomach upset	1 bottle or pkg

Step 4: Maintain the Safe Room[1, 11]

Make sure that all family members know where the shelter is and what it is for. Caution them not to take any items from that area. Routinely check supplies as suggested in Table 3.

Table 3. Safe Room Maintenance

Frequency	Maintenance activity
Weekly	Verify that cell phones or other communication devices are fully charged
Every 6 months	Check all supplies
	Replace expired medications
	Replace expired food
	Replace expired batteries
	Replace all of the water in your safe room to keep it fresh
	Replace clothes that are unsuitable for seasonal weather

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Guide 5: Population Monitoring after a Nuclear Detonation (see disclaimer ^)

^Disclaimer: "The findings and conclusions in this publication are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention or the Oak Ridge Institute for Science and Education."

Overview:

Following any large scale radiation disaster, the evacuated, sheltered, or otherwise affected members of the public would require monitoring for external and/or internal contamination, and decontamination, if indicated. In addition, the potentially-affected individuals should be identified so that epidemiologic data can be collected. These data will be used to identify vulnerable populations (e.g., children, pregnant women), those at risk of overexposure, and those with high levels of contamination. These persons may need dose reconstruction, biodosimetry/bioassay, medical treatment, and inclusion into long-term health and medical monitoring programs and registries. These vital activities are part of a process called population monitoring.

Population Monitoring Process

The general process of population monitoring is described in detail in the Department of Health and Human Services (HHS) Centers for Disease Control and Prevention (CDC) guide on population monitoring.[1] Considerations that are particularly applicable to a nuclear detonation scenario are discussed in detail in the federal *Planning Guidance for Response to a Nuclear Detonation*.[2]

The primary considerations regarding screening and monitoring of the population after a nuclear detonation are described below.

1. **Identification of individuals who are in immediate danger and require emergent medical stabilization**. Near the incident site, this monitoring need is accomplished as part of the medical triage process.
    a. Management of serious injury takes precedence over radiological decontamination.
    b. Radioactive contamination is not immediately life threatening.
2. **Detection and removal of contamination.** In most cases, external decontamination of skin and clothing can be self-performed (i.e., showering or washing with water and changing into clean clothes) if straightforward instructions are provided.
    a. External decontamination removes fallout particles and other radioactive debris from clothes and the external surface of the body.
    b. Plastic bags are useful for containing contaminated clothing and moist wipes are useful for cleaning the skin when water is scarce.
    c. Internal decontamination, if needed, requires the administration of medications or therapies to reduce the amount of radioactivity in the body.
3. **Prevention of acute radiation syndrome and acute local radiation injury**. Population monitoring personnel should offer or recommend gross external decontamination, such as brushing away dust or removal of outer clothing and cleaning of the skin. Cross-

contamination issues (e.g., from transport vehicles) are of secondary concern, especially in a nuclear emergency where the contaminated area and the potentially-impacted population are large.

4. **Maintaining flexibility and scalability**. Population monitoring and decontamination activities should remain flexible and scalable to reflect the available resources and competing priorities.

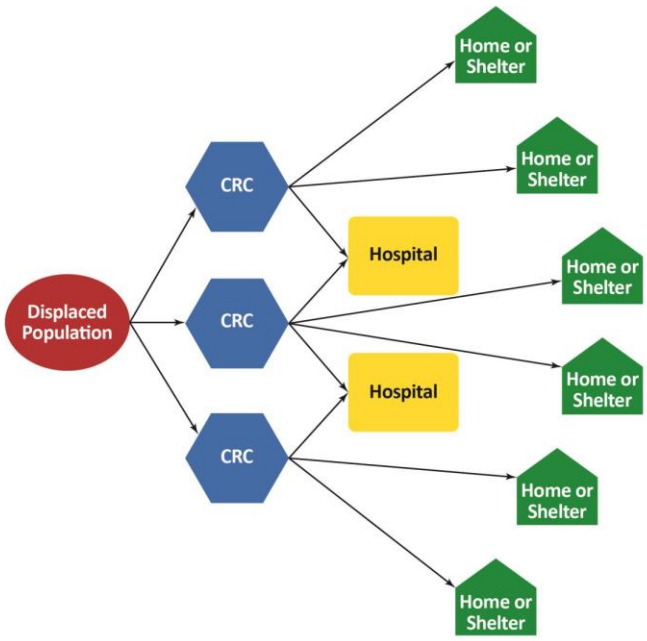
In the immediate phase of the response and in areas surrounding the damaged zone:

- Any responder actions to assist with screening and decontamination of people, pets, or vehicles should not restrict or inhibit necessary evacuation procedures.[2]
- Radiation monitoring and assistance with decontamination can be done at any location of opportunity or at ad hoc facilities set up by emergency response organizations to facilitate washing.
- An ample supply of clean replacement clothing, plastic bags, and moist wipes should be available and would be a valuable resource at these ad hoc facilities.[2]

Community Reception Centers

The focus of this article is on population monitoring activities that take place away from the impacted area at locations referred to as Community Reception Centers (CRC).[1] The displaced population who arrive in a host community are directed to CRC locations for assistance before they proceed to stay with family or friends or seek temporary housing at public shelters that local communities establish to receive and care for this population (Figure 1).

Figure 1. Schematic Representation of How a Community Reception Center would fit into a Response. Community Reception Centers are set up in unaffected host communities to provide population monitoring services before people move on to temporary housing. Each CRC can serve multiple public shelters.



As stated in the National Response Framework (NRF) – Nuclear/Radiological Incident Annex, "decontamination of possibly affected victims is accomplished locally and is the responsibility of state, tribal, and local governments."[3] It is prudent to assume that after a large-scale nuclear emergency, the burden of providing population monitoring services in host communities away from ground zero will fall primarily on local resources. Therefore, it is necessary for local communities to include population monitoring after a radiation emergency as part of their all-hazard preparedness planning.

Community Receptions Centers are opened within 24 to 48 hours after a radiation emergency (or sooner if resources are available) in locations outside the affected areas. The basic services offered at a CRC include:

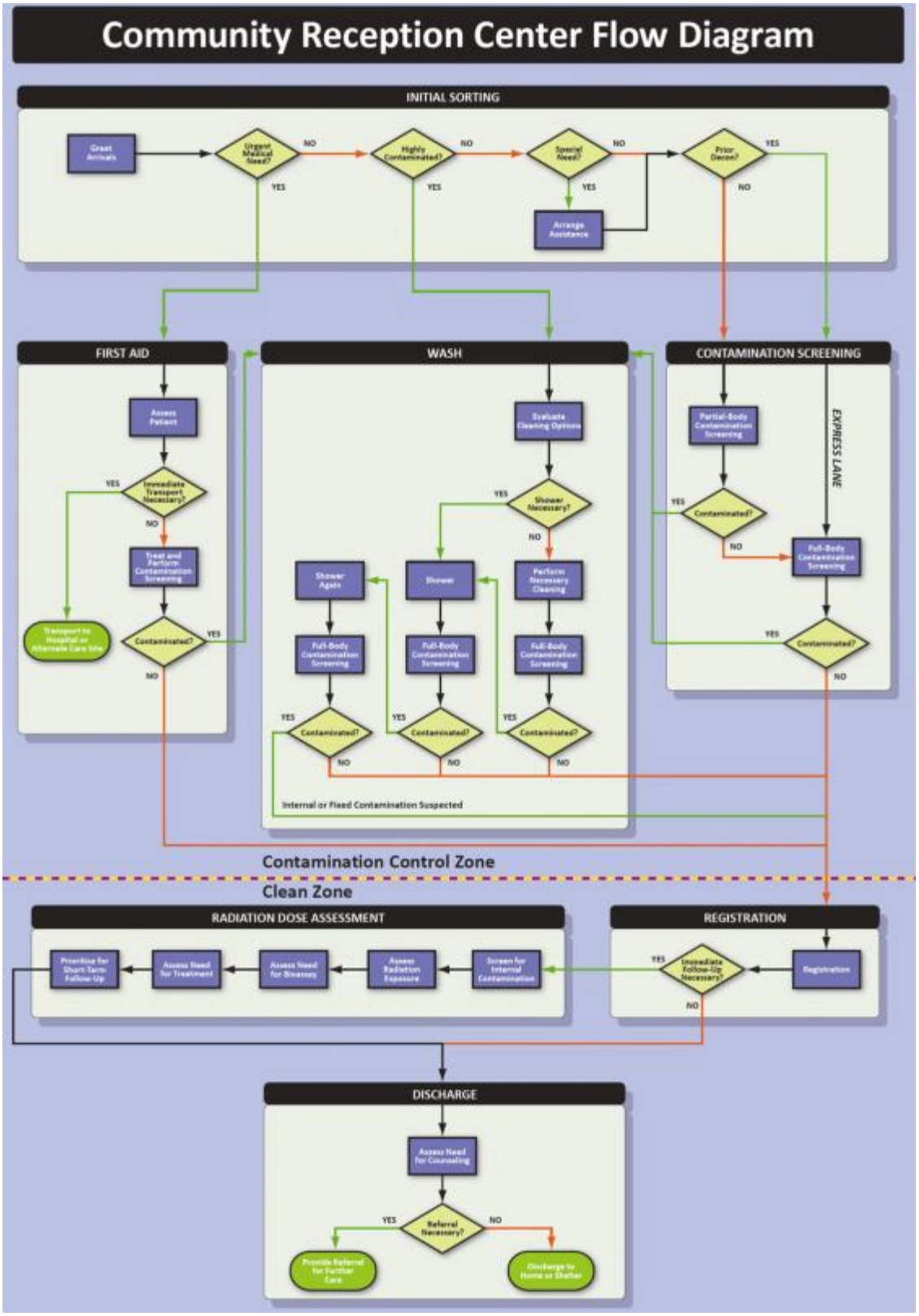
- Screening people for radioactive contamination;
- Assisting people with washing or decontamination;
- Collecting epidemiologic data and registering people for long-term follow up; and
- Prioritizing individuals for further care.

CRCs are modeled closely after points of dispensing (POD) sites, which many public health departments across the United States have already incorporated into their response plans for biological threats. Establishing and operating a CRC is a community effort that involves local emergency management, law enforcement, and public health agencies, as well as other local response and volunteer organizations. In addition to providing vital services to people who need them, establishing CRCs helps reduce the potential burden on hospitals and maximize scarce medical resources. As discussed earlier, another important benefit is supporting the operations of public shelters.

CDC and Oak Ridge Institute for Science and Education (ORISE) have developed a standardized CRC model that is modular and can be adapted to the needs and resources of each community. The process flow diagram for CRC is shown in Figure 2. A similar diagram for a pet-friendly CRC is available from CDC.[4]

In addition, CDC and ORISE have developed an interactive web-based training program that allows users to explore a CRC in a virtual space. This product is called the *Virtual Community Reception Center (vCRC)* and includes a step-by-step description of the CRC process, embedded videos to describe the screening and decontamination process, and a variety of support resources such as job aids, job action sheets, posters, and forms, which users can customize and include in their CRC plans.[4]

Figure 2. The Standardized Process Flow Diagram of a Community Reception Center (CRC). [CRC Flow Diagram website]



Establishing a Registry

A registry of the affected population will need to be established as early as possible. Immediately after an incident, it may be possible to collect only limited essential information, such as name and contact information. As time and resources permit, additional information relevant to exposure or contamination status of the individuals can be collected. In the short-term, this information is used to contact people who require immediate medical follow-up. As appropriate, some individuals may need long-term health monitoring. There are many example registration tools available.[4-7] Jurisdictions can adopt a registry tool unique to their own requirements and tracking systems.

Epidemiology data

If resources are available at the CRC, pertinent information can be collected to assist in monitoring the health status of the affected population, identifying the most important health needs, and counting persons with illnesses and radiation contamination. Epidemiology can also be used to identify risk factors for radiation exposure and contamination and identify ways public health officials can help to reduce those risks. This information, combined with results from radiation contamination assessments and laboratory testing, may enable public health officials to assess population- and individual-level radiation exposure, contamination, and the potential for associated health effects; identify populations most likely to need medical care and treatment; and study long-term health effects. Table 1 provides a sample of the type of detailed data that could be collected at a CRC following a radiation emergency. A more complete question bank is available from CDC.[4]

Figure 3. Sample Data Elements that could be collected at the CRC. A more complete question bank and example forms are available from CDC[4]

Contact Information	**Contamination Assessment**
Name	Contamination detected?
ID Number	Contamination detected in the breathing zone (face/neck)?
Date of birth	Decontamination performed?
Home and alternate address	Contamination detected on the body after decontamination?
Home and mobile phone	Any open wounds or embedded pieces of material?
E-mail address	Radionuclides detected and dose/dose-rate measured
Demographics	**Medical Assessment**
Age, Sex	Signs and symptoms consistent with acute radiation syndrome
If female, pregnancy status	Past medical history, including cancer
Race and ethnicity	Disposition (i.e., sent home, referred to medical facility)
Exposure Assessment	
Location at incident time and thereafter (i.e., within evacuation or fallout zone)?	
Length of time within evacuation or fallout zone?	
Shielded or sheltered while in evacuation or fallout zone?	
First responder at the incident site?	

Staffing

CRCs are staffed by local government employees, as well as organized volunteers such as members of the Medical Reserve Corps.[8] As indicated earlier, CRCs are modeled closely after PODs, and their staffing parallels that of PODs. An important difference is the need for radiation detection equipment and trained radiation protection personnel who can operate and interpret the screening results, as well as resources to assist with decontamination.

Table 1 provides an example of a fully-staffed CRC with all modules in operation at a host community to provide population monitoring services to a displaced population or concerned citizens in that community. These estimates were developed using the Community Reception Center Simulation Tool for Evaluation and Planning (CRC-STEP), a simulation program that uses Arena® simulation software (Rockwell Automation, Milwaukee, WI) to estimate CRC throughput. In this simulation, it was assumed that 50% of the people reporting to the CRC have either self-decontaminated or had prior assistance with decontamination before arrival, and only 1% of the population is contaminated on arrival. The CRC throughput will vary depending on specific circumstances, available staffing and instrumentation, specific screening procedures and service times. CRC-STEP allows users to plan ahead by running various simulations to optimize the CRC set up and provides a tool for planning CRC drills and testing CRC procedures.

Table 1. Example Showing Resources and Throughput for a Fully-Staffed CRC Using the Community Reception Center Simulation Tool for Evaluation and Planning (CRC-STEP) More information about this simulation tool is available from the CDC's Virtual Community Reception Center (vCRC) Web site.[4]

To achieve CRC Throughput of 500 people per hour requires:

Staff Function	Number of Staff	Instrument Type	Number of Instruments	Arriving Survivor Status	% of Survivors	Survivor Time in CRC	Minutes
Radiation screening	18	Portal monitor	2	Prior Decon	50	Average	18
Decontamination	2	Hand-held	14	Need Decon	1	Minimum	12
Medical	2			No Decon	49	Maximum	60
General	33						
Total	55						

Note: All input parameters and default assumptions can be tailored by the user to specific situations.

A key and limiting resource for CRC operations is the insufficient number of radiation staff trained to operate radiation detection equipment and interpret the results. While the number of radiation protection staff employed by local and state governments is extremely limited, there are tens of thousands of radiation professionals who can be encouraged to volunteer and be organized and credentialed in a state volunteer registry. The Conference of Radiation

Control Program Directors and CDC have been working to promote this sensible, practical, and cost-effective approach to address the critical local and state staffing needs for population monitoring after a radiation emergency.[9]

If a nuclear incident occurs anywhere, most communities throughout the country will be involved in the public health response to that emergency. Planning for population monitoring is an important element of local response. Local and state emergency management and public health planners can use the available guidance documents, planning and training tools to better prepare their communities.

KEY POINTS

- Population monitoring refers to a set of actions for expeditious screening of a population potentially exposed to radiation or contaminated with radioactive material, providing assistance with decontamination, evaluating information related to their exposure history, and registering people for subsequent follow-up.
- Because of the anticipated large number of displaced persons and the widespread geographic distribution of this population, we recommend that communities throughout the country incorporate population monitoring in their response plans.
- Population monitoring activities should remain flexible and scalable to reflect the prioritized needs of the affected individuals and the availability of resources at any given time and location.
- Community Reception Centers (CRCs) are locations where local response agencies provide population monitoring services.
- State and local agencies should plan to accommodate the needs of pets and service animals in CRCs. Contaminated pets can present a health risk to their owners, especially children who pet them.
- Operation of public shelters after a nuclear detonation depends heavily on the successful implementation of population monitoring activities at these Community Reception Centers.
- There are a number of resources available to local and state planners to plan, train, and prepare for population monitoring.

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Guide 6: Acute Radiation Syndrome: Medical Guidance and National Response

Overview:

Detonation of an improvised nuclear device (IND) within a U.S. city could result in hundreds of thousands of casualties, many with clinically significant bone marrow injury.[1] In addition, industrial accidents involving ionizing radiation exposure, such as those in Goiania and Chernobyl, can affect many people and require specialized medical treatment for exposure and internal contamination.[2,3]

The 4 organ systems affected by classical descriptions of the acute radiation syndrome (ARS) and the Delayed Effects of Acute Radiation Injury (DEARE) are the *hematopoietic (aka marrow), gastrointestinal (gut), cutaneous (skin), and neurovascular (nerves) systems*. Other organs are also affected including kidney and lung. DEARE refers to medical effects that are due to the initial exposure but may take weeks to months to years to develop.

The severity of clinical ARS and necessary treatment are dependent on radiation dosage, dose rate, quality of the radiation (X-rays, neutrons), host factors, amount of the whole body irradiated, and the length of time between exposure and medical intervention. Information with links to primary resources is available on the Radiation Emergency Medical Management (REMM) website Radiation Emergency Medical Management Homepage. The REMM website also provides mobile electronic access to medical management and triage models for use by emergency responders and medical personnel.

Key to an effective response is to understand the manifestations and management of ARS and then to match available resources to radiation casualties after a large incident. The Radiation Injury Treatment Network (RITN)[4] is a voluntary program that can provide care for radiation injury resulting in marrow damage. We describe a hospital-based surge capacity survey that highlights key points relevant locally and to a nationwide radiation casualty response.

Acute Radiation Syndrome (ARS) Management

Historically, clinical assessments after radiation exposure have focused on the four most relevant organ systems, specifically the *hematopoietic, gastrointestinal, cutaneous, and neurovascular systems*. The unit for radiation dose absorbed by an individual is the Gray, abbreviated Gy. Radiation injury depends on the dose received and the extent of the body exposed. When discussing ARS, whole-body exposure (or at least most of the body) is assumed. For a nuclear detonation, it is the external radiation that is critical as there is very little significant internal exposure (from ingestion or inhalation). Generally, there may be some nausea and vomiting at whole-body dose of ~1 Gy, which might require some symptom control, but serious ARS begins at ~ 2Gy, especially for those with combined injury (Figure 1). However,

radiation can cause damage to essentially any organ system and much of the acute damage is related to a systemic inflammatory response.[5]

Figure 1. Time Course of ARS Following Exposure to Radiation.

As the dose of radiation increases, injury is more severe and occurs more promptly. At the lower doses (bands A and B in Figure 1) there may be initial symptoms, and then delays of days to a few weeks (latency period) before the major consequences occur.

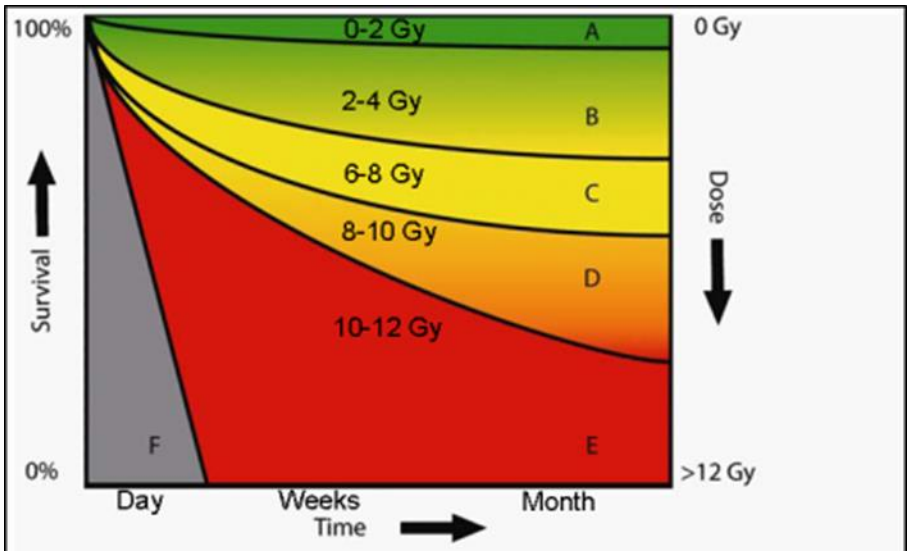
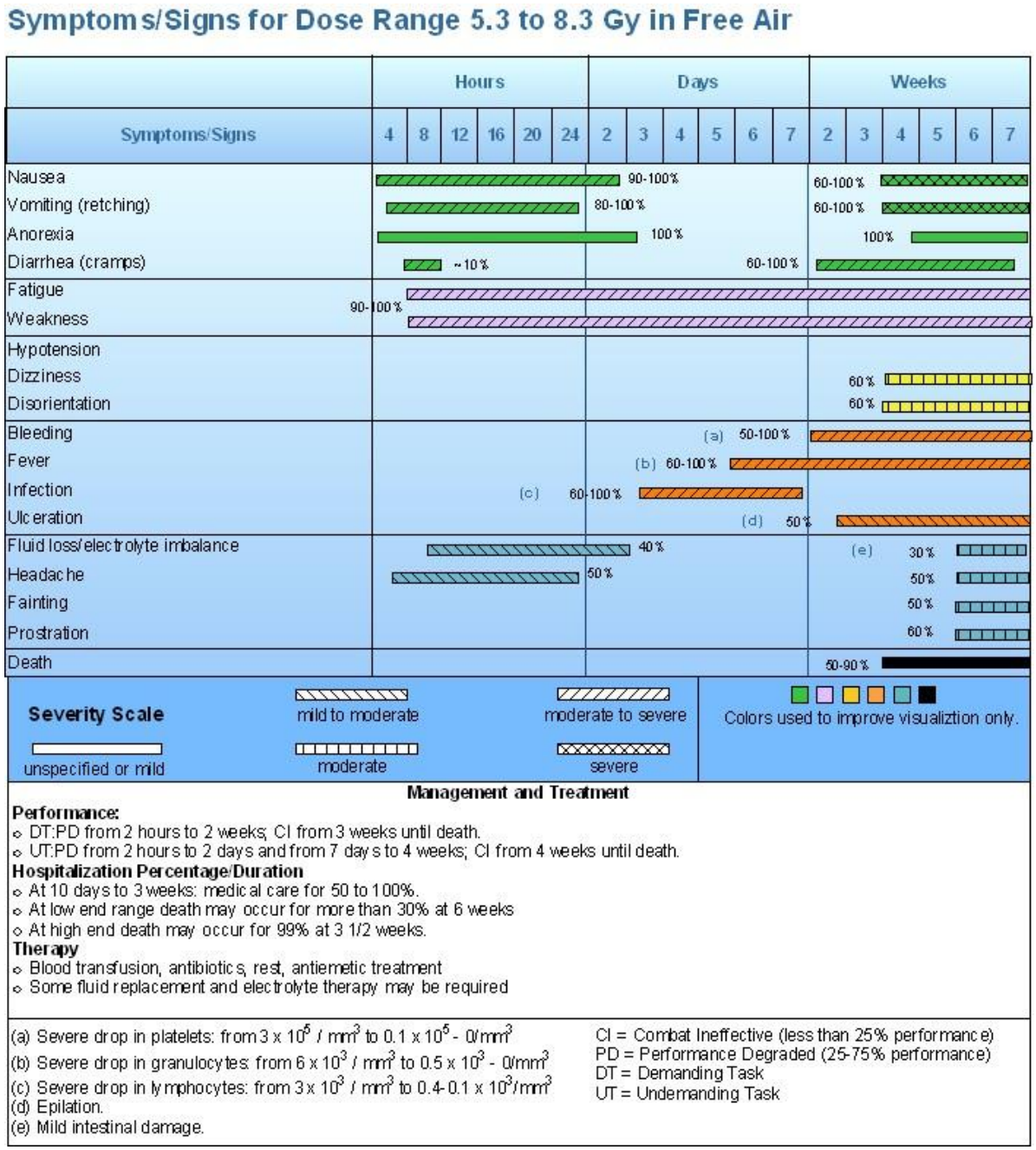


Figure 1. Spectrum of Outcomes Following Exposure to Ionizing Radiation

A. 0 to <2 Gy, no therapy needed
B. 2 to 6 Gy, onset of hematopoietic syndrome, possible cytokine and/or pharmacological intervention
C. 6 to 8 Gy, onset of GI syndrome, rescue by intensive supportive care, immune reconstitution, cellular therapy
D. 8 - 10 Gy, rescue through stem cell transplantation
E. 10 - 12 Gy, salvage through somatic stem cell regeneration
F. >12 Gy, neurovascular syndrome, multiple organ failure, no effective intervention available

Systems that utilize clinical and basic laboratory data to estimate radiation dose (i.e., biodosimetry) have been established by the METREPOL group in Europe[6] and the U.S. Armed Forces Radiobiology Research Institute,[7] and are available on the REMM website[8]. These systems can help determine the level of exposure and therefore guide triage and treatment. Figure 2 is an example of the more serious consequences at a dose of 5.3- 8.3 Gy. *For information on other dose ranges see REMM.*

Figure 2. Time/Dose Effects in ARS Following Single Dose Whole Body Irradiation. Image courtesy of REMM. Visit the REMM website, for the interactive tool, Time/Dose Effects in Acute Radiation Syndrome - Acute Clinical Effects of Single-Dose Exposure of Whole-Body Irradiation (5.3 - 8.3 Gy) REMM Tool for Dose-rate Effects. (Illustration Adapted from NATO Handbook on Medical Aspects of NBC, 1 February, 1996.



Further illustrations of the phases of ARS are available on REMM (REMM Time Phases of ARS).

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TRIAGE: In a large mass casualty setting, efficient triage of irradiated casualties is essential to identify those casualties who have received clinically significant—but not invariably lethal—doses of radiation, which range between 2-10 Gy whole-body exposure. These are the victims who need specialized and sometimes urgent care. In resource-scarce settings, symptomatic care is given if possible and life-sustaining measures should be withheld from casualties with non-survivable trauma, thermal burns, and/or radiation exposures. *Extensive triage algorithms are available to guide the selection of appropriate candidates for life-sustaining care in resource limited settings*.[9]

Figure 3a is an example of how triage category varies by radiation dose and how it changes based on the standards of care in place at the time and location where triage is being done. Figure 3b shows the impact of radiation on the triage based initially on trauma. The full set of algorithms is on REMM.[10]

- Level of exposure can be determined by geographic, clinical, or laboratory means. The level of exposure can guide treatment and therefore the resources required for care.
- Exposures of 2-10 Gy of ionizing radiation are treatable if acted upon promptly.
- Combined injury- radiation plus physical trauma can have a worse prognosis.
- Re-evaluation is crucial.
- Estimate of exposure helps in decision-making, however, medical management decisions are made by healthcare workers who use other clinical and laboratory information.

Figure 3a. Triage Schema Dependent on Radiation Dose and Available Resources for Radiation Injury Only[9].

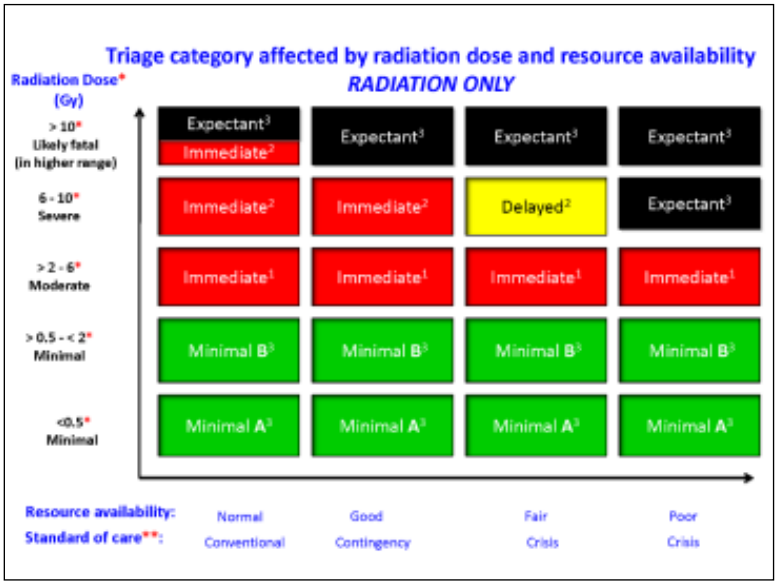
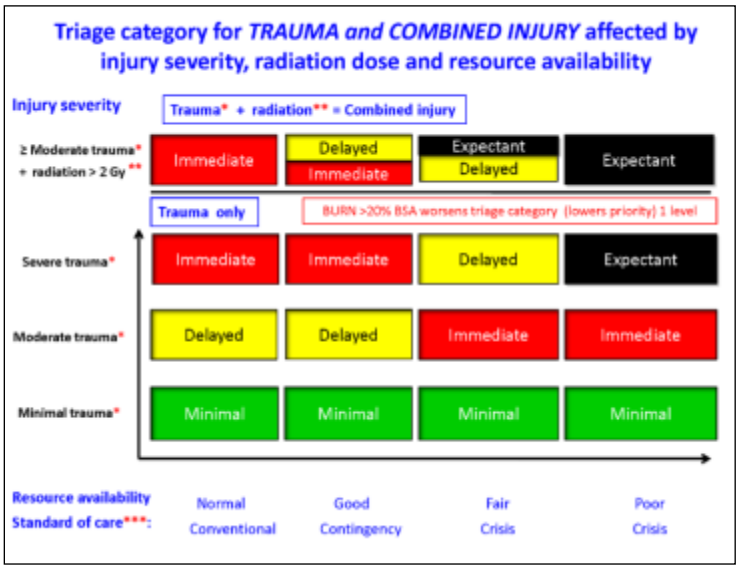


Figure 3b. Triage Schema Dependent on Radiation Dose and Available Resources for Combined Injury[9]. NOTE: There are "triage cards" for radiation only and for combined injury, as well as, a "triage tool" on REMM. TRIAGE Categories (Expectant, Immediate, Delayed, and Minimal, as used for a nuclear detonation) are described in detail in "Involving the Community" along with the ethics issues, which require community involvement.



Legend- Trauma and combined injury

* Adding > 20% total body surface area burn to trauma worsen triage priority by 1 category (puts them *lower on the priority list*).

** Radiation dose received by the whole body or a significant portion of the whole body

At higher radiation doses (>6 Gy), triage category may worsen- as on Combined Injury card

*** Crisis standards of care, IOM letter report, 2009

Trauma category	Description
Combined injury	•Radiation dose of > 2Gy to whole body or significant portion of whole body *plus moderate or severe* trauma and/or burn injury.
Severe trauma	•Stabilization requires complex treatment; •>20% chance of death even with treatment.
Moderate trauma	•Without stabilization, potential for death within hours •<20% chance of death with stabilization and treatment.
Minimal trauma	•Injuries pose no significant risk to life and limb in next 3-4 days •Limited or no treatment prior to referral in the next 3-4 days.

Determining Dose from Exposure for Use in Clinical Triage

- **Dose reconstruction** from victim's geographic location(s) (location relative to detonation and radioactive fallout)
- **Clinical signs and symptoms** of the acute radiation exposure (ARS)
- **Laboratory assessments to estimate whole body dose** (biodosimetry including blood cell counts, dicentric chromosome analysis, and others) to estimate dose and the necessity for intervention.
- Blood cell kinetics, particularly the absolute lymphocyte count (ALC) may be particularly useful for predicting clinical course. This is more accurate when serial measurements of

ALC are obtained. For more information visit the REMM website for interactive tools on Dose Estimator for Exposure: 3 Biodosimetry Tools REMM Dose Estimator Tools for Exposure.

Acute intervention for irradiated casualties:

1. **Exposure minimization** (i.e., sheltering, shielding, removal of contaminated clothing if they are in fallout). Note: internal contamination is not an important issue for acute exposure in a nuclear detonation (this is different than a radiological dispersal device or nuclear power plant incident);
2. **Supportive care** to mitigate the morbidity and mortality of radiation exposure (e.g., hydration, antibiotics, antiemetics, skin care); and
3. **Radiation medical countermeasures (MCMs),** which, unlike supportive care, have the potential to alter the natural history of radiation exposure.

Patients with a high likelihood of exposure to > 2 Gy based on medical history, location or blood counts, should be given cytokines within 24 hours of exposure to ionizing radiation. Efficacy of these drugs is likely, albeit probably reduced, if drug is given 24 hours after the end of exposure. It is typical to continue medications for 14-21 days or until normalization of granulocyte count under expert supervision.

CAUTION: Cytokine use should be based on clinical information and not given indiscriminately to everyone with potential radiation exposure.

- This is particularly true in the context of limited supplies, when inappropriate administration may result in a casualty who could have benefited from cytokines having to go without.
- It is important to note that most of the available consensus focuses on healthy adult population. There is a paucity of data and consensus for treatments in children, the elderly, and immunocompromised individuals.

Treatment of ARS- hematological syndrome (general approach)

- The current management of ARS does not substantially differ from the management of pancytopenia in other settings, such as after treatment with myelosuppressive chemotherapy. Myeloid cytokines[12] (granulocyte-colony stimulating factor [G-CSF; Filgrastim], granulocyte monocyte-colony stimulating factor [GM-CSF; sargramostim] or pegylated G-CSF [pegfilgrastim] can reduce the duration of neutropenia (<500 neutrophils per mm^3), hospital length of stay, and overall costs (MacVittie, personal communication).

- All patients with confirmed neutropenia are potential candidates for myeloid cytokines. Laboratory studies suggest that *initiating myeloid cytokines within 24 hours of exposure may improve outcomes*.
- Specific indications for initiating myeloid cytokines prior to the onset of neutropenia include a projected whole body dose of 2 Gy or more based geographic information and clinical signs and/or blood cell kinetics*. These should not be used without an indication!*
- Drug should be continued for 14-21 days or until normalization of the granulocyte count.
- In austere circumstances, it may be necessary to modify generally recommended dose schedules to help more people receive these medications.

Supportive care measures are equally important. These relatively simple measures (although perhaps not so simple in mass casualty events) have been shown to improve survival in animal models of ARS:

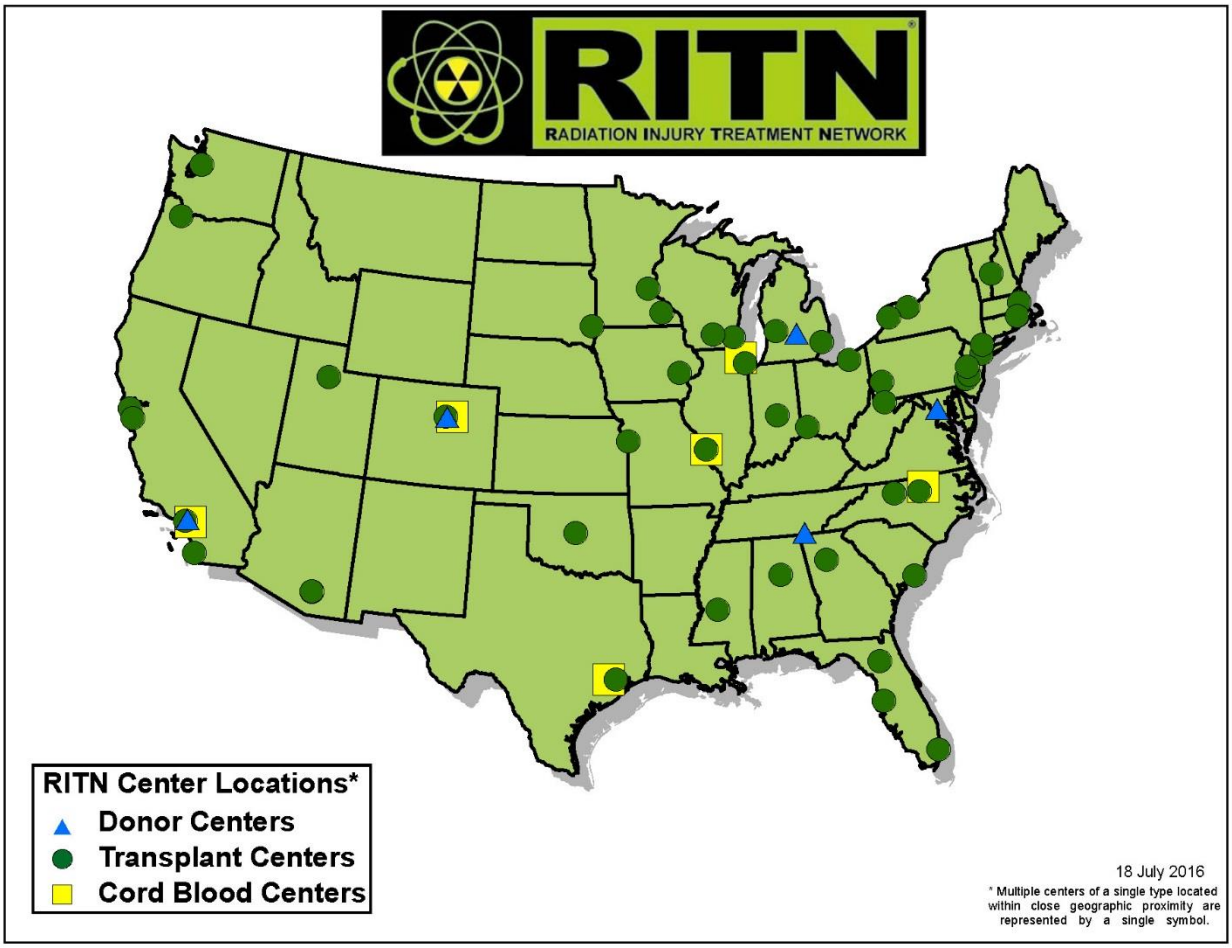
- Antiemetics for the gastrointestinal symptom relief from nausea and vomiting;
- Hydration to support intravenous fluid balance due to rapid shifts of volume; and
- Antibiotics to prevent bacterial infections especially during the neutropenic period.
- Antifungals and antivirals may become useful in patients with persistent infections who do not respond to antibiotics.

Radiation Injury Treatment Network (RITN) RITN Website

After a mass casualty radiation incident, the ability to perform triage and provide care will depend on both the residual local infrastructure and the mobilization of resources from across the nation or even internationally. Ideally, triage centers would be organized around concentric rings, providing initial stabilization prior to transport to unaffected medical centers. Many organizations have recognized that a networked response by medical professionals can increase surge capacity and improve the quality of care.

RITN, a collaboration of over 60 medical centers and hospitals with expertise in the management of myelosuppression (marrow injury), blood donor centers, and umbilical cord banks (Figure 4), was established through collaboration between the American Society for Blood and Marrow Transplantation (ASBMT) and the National Marrow Donor Program (NMDP), with support from the U.S. Office of Naval Research. RITN has established standard operating procedures and treatment guidelines that can be used by medical professionals that are outside the RITN network, but are participating in the incident response. These guidelines have been developed based both on the medical expertise of RITN leadership and the abundant literature available in this field.[13-22]

Figure 4. National Map of the Radiation Injury Treatment Network (RITN) (List on website)



As of July 2016, the total number of NDMS centers- 53; HPP centers -58; and the total number of pediatric or pediatric/adult centers- 33.

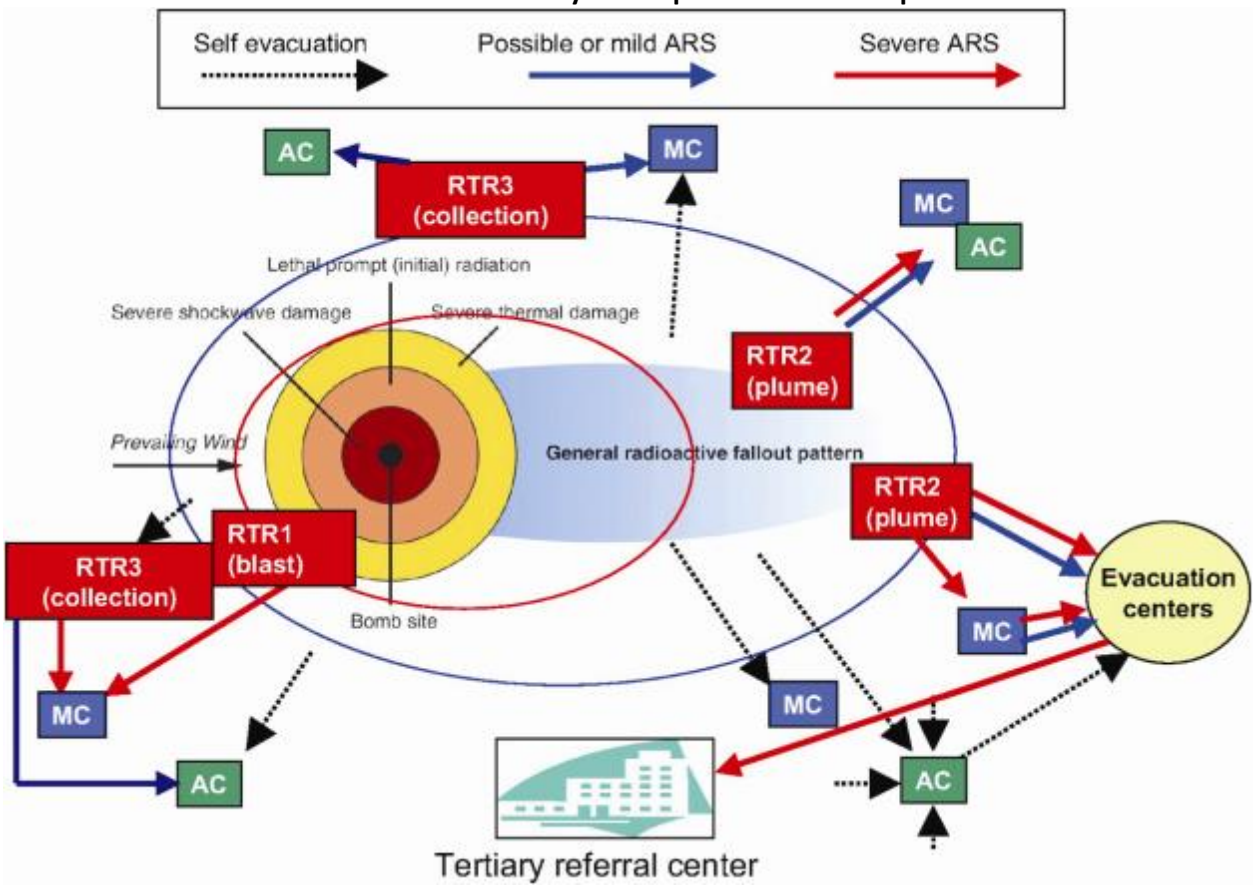
The goals of RITN are:

1. to develop treatment guidelines for managing hematologic toxicity among victims of radiation exposure,
2. to educate health care professionals about pertinent aspects of radiation exposure management,
3. to help coordinate the medical response to radiation events, and
4. to provide comprehensive evaluation and treatment for victims at participating centers.

RITN centers *are not first responders, nor are they decontamination facilities*. Initial decontamination and the treatment of life threatening injuries would have to be completed prior to RITN involvement (Figure 5). Transport of casualties from the incident site would be organized through the National Disaster Medical System (NDMS).[23] RITN centers have existing infrastructure and expertise for managing casualties with bone marrow toxicity. Most of these

casualties would require supportive care, either as in-patient or out-patient, and would not undergo hematopoietic cell transplantation (aka marrow transplant). A small fraction of casualties may sustain irreversible bone marrow injury, and therefore require an unrelated marrow or cord blood match from the *Be the Match Registry®* operated by the NMDP. As of December 2014, the Be the Match Registry® contained over 12.5 million potential hematopoietic cell donors and more than 209,000 cord blood units, the largest source of hematopoietic cell donors in the world. The registry is a national resource—a "genetic safety net" in a time of a radiological/chemical crisis.

Figure 5. Schematic for Triage and Response to a Large-Scale Radiation Event Developed by the Office of the Assistant Secretary for Preparedness and Response.

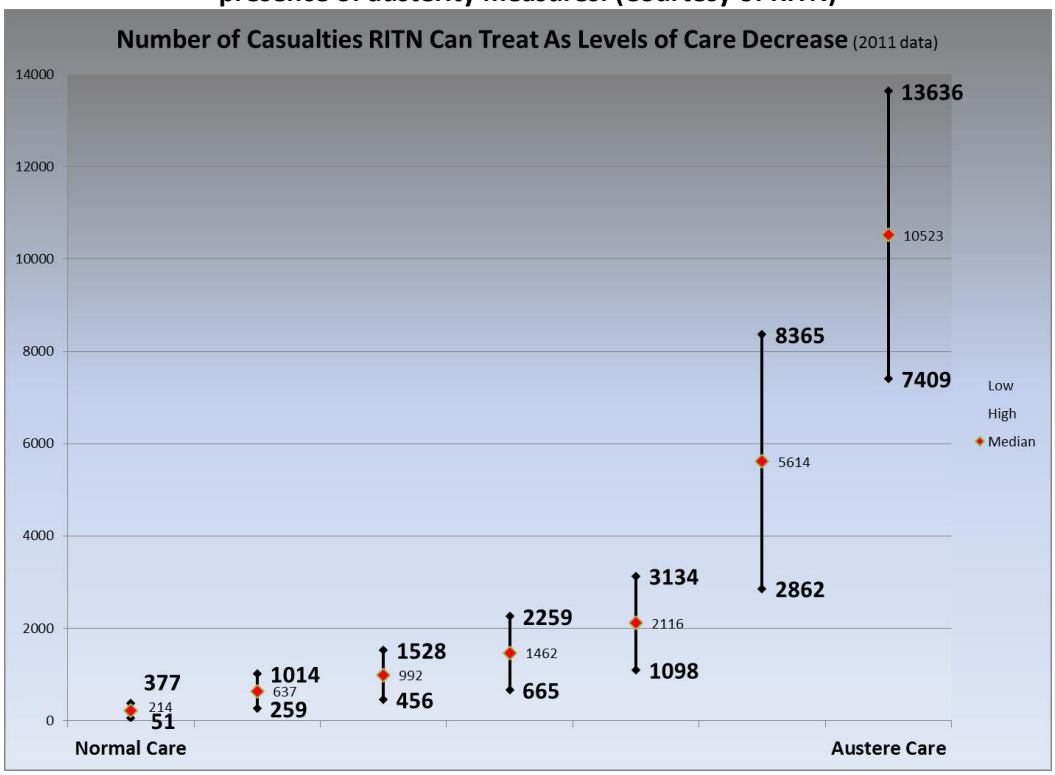


Triage centers are located in concentric rings around the affected area, providing initial stabilization and decontamination (RTR1 - RTR3), more extensive Medical Care (MC), and rapid screening of unexposed or minimally exposed individuals at Assembly Centers (AC). Patients who require further care are evacuated to referral centers in unaffected regions.[24]

Maximizing Surge Capacity

In April 2011, RITN performed a survey to determine the willingness of RITN centers to voluntarily accept irradiated casualties across a range of hypothetical circumstances. The number of casualties accepted by centers increased markedly with the 1) utilization of partner hospitals to offload existing patients and/or irradiated casualties, or 2) clearly-defined austerity measures. These austerity measures included the treatment and housing of casualties in non-traditional sites such as a stadium or other disaster shelter (Figure 6).

Figure 6. RITN Survey of member medical centers and their ability to increase the numbers of victims that could be accommodated based on different scenarios for off-loading existing patients and presence of austerity measures. (Courtesy of RITN)



Local/regional planning is the primary responsibility of state and local governments. No clear guidelines have been established by the federal government for establishing alternate care sites at distant locations from a mass casualty incident. Utilizing such sites and thereby modifying the normal standards of care raise a host of legal, financial, and ethical issues for medical centers asked to accept casualties.[9, 25-34] Not surprisingly, self-imposed changes in standards of care had very little effect on capacity This suggests that specific guidelines for alterations in standards will be necessary to effectively expand capacity.

Concerns and Future Plans

A catastrophic incident, such as an IND detonation, would overwhelm the capacity of the health care system, even at a national level. The need for international cooperation in the face of such an incident is clear. While there are clearly defined processes for some aspects of response (e.g., emergency use authorization for drugs in the national stockpile), work is ongoing in the following critical areas:

- Details of how payment will be worked out and the willingness of hospitals to receive patients, even with existing Centers for Medicare & Medicaid Services (CMS) codes for reimbursement.
- Legal protection, which is largely a local issue and varies by state.[34]
- Clearly established guidelines for alternate standards of care for medical centers that may be asked to receive injured casualties.[9, 10, 25, 35]
- New approaches to rapid dosimetry in a mass casualty setting to complement hematology and cytogenetics.
- Novel medical countermeasures to reduce morbidity and mortality to complement medical management as described above. The concept of "dual-utility" is emphasized using drugs/agents that have routine clinical use so that resources are available as is experience with the agent.
- Further expansion of the RITN network, as well as, integration with NDMS and local government efforts, which will be essential to optimize the efficient triage, transport and management of irradiated casualties after a mass casualty incident.

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Guide 7: Strategic Framework for Providing Radiation Sickness Medical Countermeasures and Supplies in a Scarce Resources Setting: Local, Regional and Federal Resources

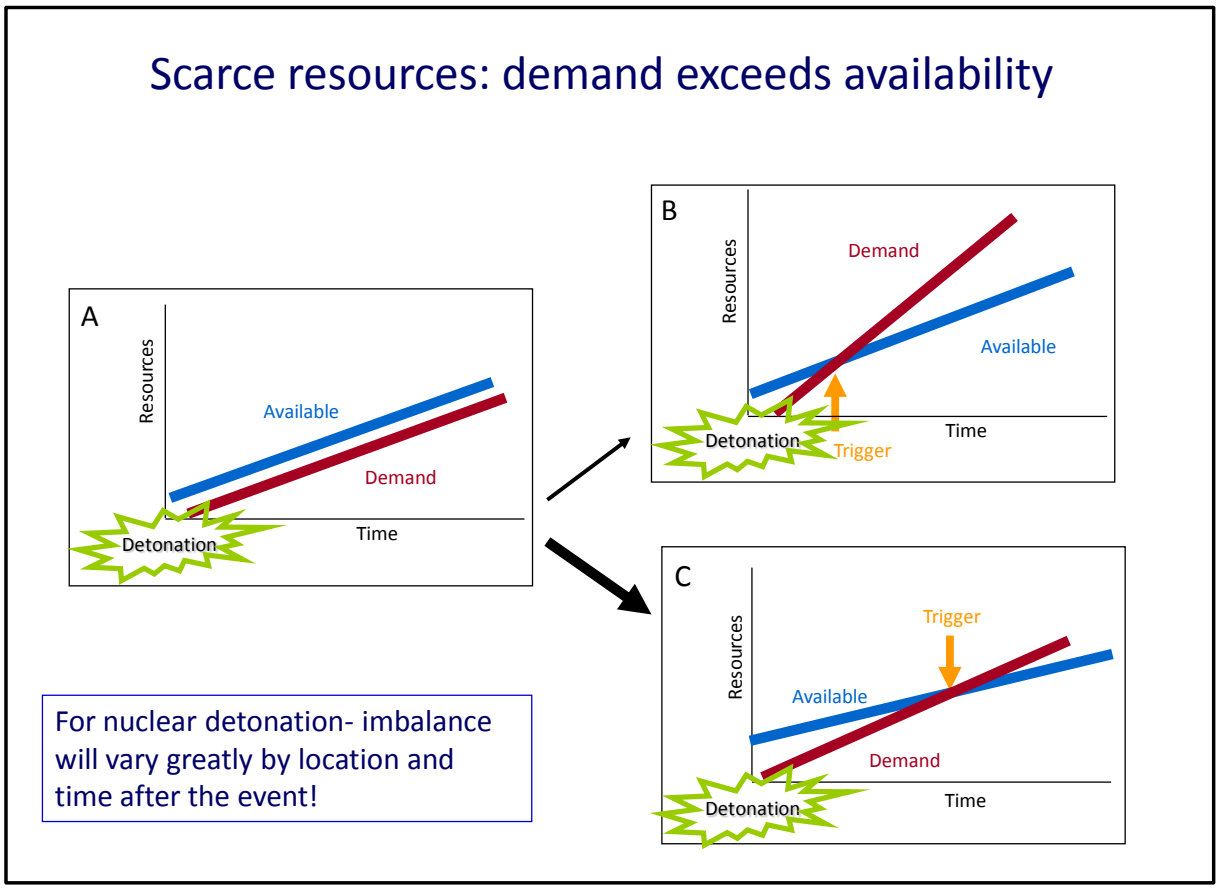
Overview:

The immediate need for space, staff, medical countermeasures (MCMs) and supplies will likely be overwhelmed in a mass casualty incident, possibly creating a scarcity of resources. The extent of the scarcity will determine operational standards of care and the triage category in which medical providers place each individual. Given the extraordinary medical requirement for thousands of injured or sick people, it is not possible to preposition all necessary medical countermeasures and supplies. However, strategies for resource allocation under conditions of scarcity can help save lives, reduce morbidity, and improve the provision of compassionate care in a time of crisis. Current strategies in use or under development include state and regional stockpiles, User-Managed Inventory (UMI), Distributor-Managed Inventory (DMI) and the CDC's Strategic National Stockpile (SNS), which includes Vendor-Managed Inventory (VMI). Community and national preparedness should focus on the positioning and deployability of MCMs with routine medical uses (i.e., those with "dual utility"). For example, drugs that are in routine use for oncology and hematology may be effective MCMs for those with acute radiation syndrome (ARS). Neupogen® has received an indication by the Food and Drug Administration (FDA) for use in ARS; other similar cytokines do not have an indication but may be useful. In order to allow for the use of MCMs for non-labeled indications under declaration of an emergency, the U.S. government has established a mechanism known as Emergency Use Authorization (EUA). Further policy refinement and integration of strategies for addressing the scarcity of resources during a mass casualty incident will be needed to optimize response coordination. These planning efforts could save lives and assist the immediate victims of a mass casualty incident.

Scarce Resources

The goal of planning and preparation is to have resources available to exceed the need, as in Figure 1A.[1] Following a nuclear detonation there will be an imbalance—a "trigger"—(Figure 1B) where need exceeds available resources at some locations[2] (the term "demand" is often used in medical parlance or economics) (see Figure 2 in Coleman[3]). The goal of planning is to delay the trigger (Figure 1C) in order to both reduce the likelihood of scarcity or if one occurs, minimize the time to resource replenishment in order to avoid the "Poor" resource availability setting in the "Crisis" standard of care condition.[3,4]

Figure 1A-C. Scarce Resources Occur as Need Exceeds Available Resources.



The impact of availability of resources on the medical care that can be administered is illustrated in Figure 2 using an example of victims with radiation sickness due to an improvised nuclear device detonation. This example includes people exposed to radiation only (i.e., no physical trauma), and provides a visual illustration of how the triage category would change as resource availability declines.[5] Details of triage for a nuclear detonation can be found in Coleman[5] and on the Radiation Emergency Medical Management (REMM) website REMM Dosimetry Triage Tool

How resource scarcity impacts triage category

People needing immediate life-saving treatment priority (above the green box "Minimal") are most likely to benefit (the red box, "Immediate"), followed by people who can wait, (yellow box noted by the term "Delayed,") and people judged to be (black box) "Expectant." Expectant victims will receive comfort care if available. As resource scarcity worsens, fewer people can be treated effectively and the share of people benefiting from treatment declines as shown on the x-axis of Figure 2. People who have received moderate radiation doses in the range of 2 - 6 Gy are most likely to benefit from medical intervention and would receive "Immediate" attention in all resource settings. On the other hand, the treatment priority of those who received severe

radiation doses in the range of 6 - 10 Gy (and whose lives might be saved given sufficient resources to deliver a "Conventional" standard of care under "Normal" and "Good" resource availability) would be "Delayed" when there are crisis standards with "Fair" resources available, and would be "Expectant" when there is "Poor" resource availability.[5] Stated succinctly, the goal of planning and response is to avoid or delay "Fair" or "Poor" resource availability settings. Similarly, a key goal of planning and response under conditions of limited resource availability is to resolve the shortages as rapidly as possible. Serial triage is an essential component of the response so that a person initially triaged as "Delayed" or even "Expectant" could become "Immediate" as resources arrive.

Figure 2. Triage Category Depends On Both Severity of Injury and Also On Resource Availability[5]

Triage category affected by radiation dose and resource availability
RADIATION ONLY

Radiation Dose* (Gy)	Normal	Good	Fair	Poor
> 10* Likely fatal (in higher range)	Expectant[3] / Immediate[2]	Expectant[3]	Expectant[3]	Expectant[3]
6 - 10* Severe	Immediate[2]	Immediate[2]	Delayed[2]	Expectant[3]
> 2 - 6* Moderate	Immediate[1]	Immediate[1]	Immediate[1]	Immediate[1]
> 0.5 - < 2* Minimal	Minimal B[3]	Minimal B[3]	Minimal B[3]	Minimal B[3]
<0.5* Minimal	Minimal A[3]	Minimal A[3]	Minimal A[3]	Minimal A[3]
Resource availability:	Normal	Good	Fair	Poor
Standard of care:**	Conventional	Contingency	Crisis	Crisis

Legend- Radiation Only

* Radiation dose received by the whole body or a significant portion of the whole body.
** Crisis standards of care IOM Letter Report 2009

Minimal B: Consider repeating both biodosimetry and clinical reassessments, especially at high end of this dose range
Minimal A. <0.5 Those with physical dose estimates based on location below 0.5 Gy need not report for medical evaluation. Joining a registry may be suggested after the incident.

The red/black split triage category for >10 Gy indicates that some victims may receive aggressive treatment at discretion of physician, especially if 10 Gy is received over prolonged time period.

Resource availability below NORMAL:
GOOD conditions allow for maintenance of "functionally-equivalent" care through contingency operations
FAIR conditions require delaying care for severe injuries after moderate injuries
POOR conditions require classifying severe injuries as expectant

Myeloid cytokine category	G-CSF recommendation
1	G-CSF indicated.
2	G-CSF indicated, lower priority than Category 1.
3	G-CSF not indicated.

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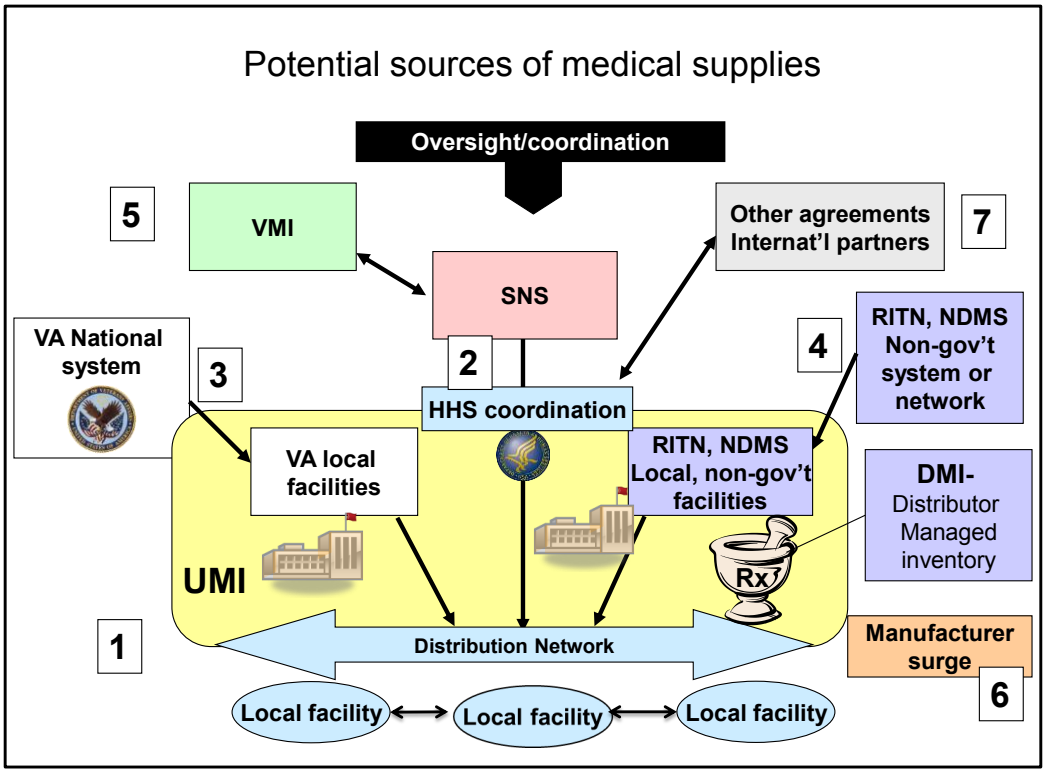
Bone marrow cytokines routinely used in the care of oncology and hematology patients are also critical MCMs for treating ARS in people who have received moderate or severe doses of radiation.[2] One such medical countermeasure is granulocyte-colony stimulating factor (G-CSF); however, there are others in this category. An example of how the need for bone marrow cytokines could be met for ARS is illustrated in Figure 2 with the numbers 1, 2 or 3 following the description in each of the tiles

MCM Availability

Figure 3 illustrates potential sources of medical supplies and MCMs. The medical countermeasures used for the ARS example earlier are the bone marrow cytokines for the acute radiation hematological syndrome.[2] Current evidence indicates that cytokines administered *within 24 hours of exposure* mitigate the severity of the radiation injury, lowering infection rates, improving survival,[7] reducing the need for hospitalization, and decreasing the medical resources, staff, and space required to treat patients.

Figure 3. Potential Sources of Medical Supplies.[8]



The initial medical response will be undertaken by local responders in local facilities. In general, hospitals and medical facilities keep very low inventory and use "just-in-time" inventory management for obtaining and utilizing resources. Working from the local facility up, one could supplement supplies with the following:

- Local distribution networks by the user (i.e., UMI [#1]) or by the distributor (i.e., DMI), which could include a sufficient inventory or "bubble" to help meet immediate surge needs.[8] Since cytokines have a multi-year shelf life and are used routinely in cancer care, it may be possible to keep a 3-12 month supply on hand that could be used before it expires. This would provide many more "first doses" than otherwise possible with the just-in-time inventory approach. Potential participants in UMI include the Veteran's Administration [#3] and the Radiation Injury Treatment Network [#4].[9]
- The Strategic National Stockpile (SNS) [10] is a national repository of pharmaceuticals, medical supplies, and equipment that can be deployed during a public health emergency for use by local/state/regional responders. Initial supplies can reach the affected area within 12-24 hours of the federal decision to deploy. The SNS also has agreements with manufacturers to store some pharmaceuticals and supplies, called VMI, [#5] as part of their operational plan.
- Manufacturer surge capacity, which would likely occur either voluntarily in response to obvious need or by request of the local, state or federal government [#6]. This will likely take days to weeks.
- Medical supplies or drugs obtained from international partners in special circumstances [#7], although importing drugs is complicated and requires complex approval among governments as well as by the FDA.

Dual-Utility Concept of MCMs and Supplies

A favored approach to developing MCMs for terrorism and mass casualty response is to use drugs or supplies that have a routine use in medical care. This ensures familiarity of the MCMs within the medical community. Stockpiling can be problematic for drugs with short shelf lives, as frequent replacement is necessary unless the drug is eligible for the FDA's Shelf-life Extension Program. However, for drugs that may have a limited market, stockpiling may be an incentive to induce entry into the marketplace by drug manufacturers. Bone marrow cytokines fit the definition of "dual utility," as do antibiotics and other drugs.

EUA and "Off-Label" Use

Prescription drugs for use in medical care are approved by the FDA for treatment of a specific condition or disease and the prescribed use defined in the drug's labeling. While physicians routinely use prescription medications for "off-label" use in their daily practice, in a large scale emergency, there will be no or limited physician-patient relationship allowing this to occur. An Emergency Use Authorization[11] would be requested to use the drug for any purpose other than those detailed in the labeling.

The EUA authority granted by Congress in 2004 allows the FDA Commissioner to strengthen the public health protections against biological, chemical, radiological, and nuclear agents that may be used to attack the American people or the U.S. armed forces. Under section 564, the FDA Commissioner may allow MCMs to be used in an emergency to diagnose, treat, or prevent serious or life-threatening diseases or conditions caused by such agents, when there are no adequate, approved, and available alternatives.

Recently Neupogen® has received a specific indication for treatment of ARS. There are other similar drugs used in oncology, hematology, and bone marrow transplantation to mitigate or therapy-induced treat neutropenia (low granulocytes, a type of white blood cell that fights infection). ARS treatment guidelines[6] are based on this prior medical experience and practice. For ARS, Neupogen® can be used. Other similar drugs would be used "off label," as allowed by FDA regulation at the discretion of the physician in an established physician-patient relationship, or under an EUA granted by the FDA Commissioner for a large scale event.

Filling the Gap Before Outside Supplies Arrive - preplanning

The pre-positioning of MCMs as close to an incident location as possible provides both time and logistical advantages for first responders. One consideration for increasing the availability of MCMs as soon as possible after an incident is UMI which would be developed at the local, state and regional level, optimally in coordination with the federal planners.[8] The benefits of UMI go beyond rapid deployment of MCMs by offering a more cost-effective approach for managing the inventory of MCMs compared to central stockpiling or VMI. The UMI concept is an emerging idea for enhancing distribution and stockpiling for MCMs.

The UMI concept is characterized by 4 key features:

1. MCMs that are used for routine medical treatment and believed to be useful for treating mass casualty victims are considered "dual utility" drugs and may be appropriate for UMI consideration;
2. The UMI model would require storage at multiple medical facilities across the nation; participating medical facilities would store a sufficient inventory or "bubble" to help meet immediate surge MCM needs;
3. UMI-related MCMs would be managed to ensure the inventory would not expire before use; and
4. The UMI "bubble" inventory would be used locally to treat casualties in an emergency, including evacuees from other localities.

The UMI "bubble" inventory could also be funneled locally to areas of greatest immediate need similar to central stockpiling and VMI. UMI implies a dynamic response system, linking the local, state, regional, and federal response while providing the potential for a more rapid

response and more efficient management of limited resources; however, UMI would not eliminate the need for other stockpiling options and is not a good fit for all MCMs.

An additional advantage of UMI includes expanding widespread storage of MCMs—reducing the risk of mass MCM destruction at a single storage facility. The Veterans Health Administration medical care system is a natural fit for UMI, given its expanded role in civilian emergency response, its existing network of facilities/resources, and its well-developed pharmacy management system. With experience, data and further development, UMI could be considered for major medical centers, retail pharmacies, and distribution networks. UMI could potentially be more cost-effective than centrally stockpiling MCMs, by using first-in, first-out inventory management protocols that would eliminate wasteful expiration, replacement, and disposal of expensive dual-utility drugs.

Summary

The magnitude of the casualties and physical infrastructure following a nuclear detonation could produce a scarce resources situation, particularly close to the detonation site. This will likely require medical triage that differs from the usual "sickest first" standard.[5] Providing the necessary supplies will require preparation and innovative approaches beyond the "just-in-time" inventory used by medical facilities.

Guide 7 - Authors

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Guide 8: Radiation/Nuclear Medical Countermeasure Research and Product Development Efforts for Public Health Emergencies

Overview:

Medical response for radiological and nuclear incidents, including a nuclear detonation, a radiological dispersal device, a radiological exposure device, or a nuclear power plant accident, involves supplies for treating trauma and burns; drugs for relief of nausea, pain, and infection; and medical countermeasures (MCMs) for radiation injury. Diagnostic assessment is critical to medical management. Rapid and accurate biodosimetry tools are needed to estimate absorbed dose from radiation for useful clinical assessment and triage. Innovative diagnostic approaches, including point-of-care and high-throughput biodosimetry tools, are being identified, optimized, and validated to provide enhanced response capability for triage applications, field-deployable laboratories, and reference laboratories. A range of existing and developing technologies are being considered for incorporation into a Radiation Laboratory Network (RadLN), also referred to as Integrated Clinical Diagnostics System (ICDS), although this network is not yet developed to a point of implementation. The approaches to MCMs, including biodosimetry capabilities, and to RadLN development, involve a continuum of activities from basic science to technology and drug development to preclinical and clinical assessment, all in a context of guidelines and review by the Food and Drug Administration (FDA).

There are 3 types of MCMs that fall into the following categories:

- Protectors – given before exposure to radiation to lessen effects;
- Mitigators – given after exposure to reduce severity of effects before clinical manifestation; or
- Treatments – given after clinical manifestation of effects. An MCM such as a myeloid cytokine for the hematological syndrome can be both a mitigator and a treatment.

Treatments have been approved by the FDA for radionuclide decorporation and recently for ARS (Neupogen®). Other drugs for chemotherapy-induced neutropenia could be used under an Emergency Use Authorization (EUA).

Background

Leading the U.S. Government's (USG) effort to develop medical countermeasures to mitigate radiation injury are components of the Department of Health and Human Services (DHHS): the National Institutes of Health (NIH), particularly the National Institute of Allergy and Infectious Diseases (NIAID); [1-6] and the Office of the Assistant Secretary for Preparedness and Response (ASPR)[7], including the Office of Policy and Planning (OPP) and the Biomedical Advanced Research and Development Authority (BARDA). [5-6] NIAID supports the development of the

research infrastructure and basic science in the understanding of the mechanisms of radiation injuries that is built on basic radiation biology research programs include those in NIH's National Cancer Institute. Additional programs relating to radiation include those in the Department of Defense, Department of Energy (Low-Dose Radiation Program now closing), and National Aeronautics and Space Administration. The product development of radiation/nuclear MCMs, including biodosimetry methods and devices, is through a series of grants, cooperative agreements, and product-development support contracts. ASPR Office of Policy and Planning (OPP) works through the Public Health Emergency Medical Countermeasures Enterprise (PHEMCE) [8] to develop civilian MCM requirements and policy initiatives. ASPR Biodefense Advanced Research and Development Authority (BARDA) supports the advanced product development, FDA-approval, and acquisition of MCMs through contracts with developers and companies. [5-6]

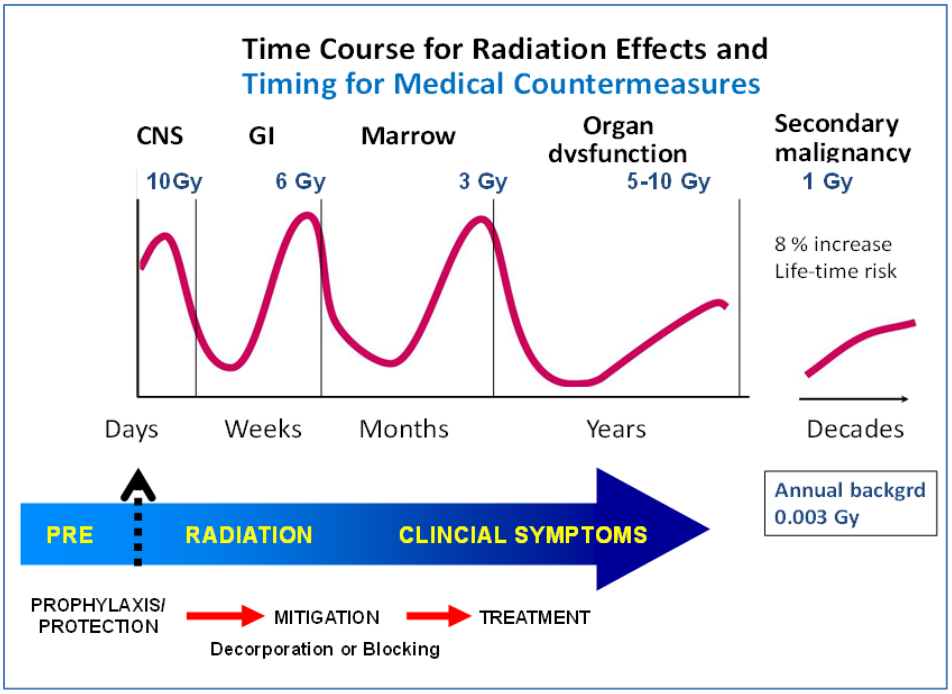
Exposure to ionizing radiation causes a spectrum of injuries that can be minor or lead to death. The damage occurs to DNA, cellular organelles, cells, tissues, and organs, with the extent of damage depending on the absorbed dose. Radiation-induced injury can occur due to exposure to an external radiation source (e.g., an improvised nuclear device [IND] detonation or a radiation exposure device) or by exposure from internal contamination with radionuclides (ingested, inhaled, or received through a wound) dispersed from a radiological dispersal device or a nuclear power plant accident. Acute Radiation Syndrome (ARS) is an acute illness caused by irradiation of a substantial portion of the body. The more radiosensitive tissues are affected first, and as the absorbed dose increases, additional tissues and organs are involved, leading to ARS (with component sub-syndromes, e.g., hematopoietic, gastrointestinal, cutaneous, central nervous system) and delayed effects of acute radiation exposure ([DEARE], including pneumonitis, lung or kidney fibrosis, and increased risk of cancer) (see Table 1). ARS management is discussed in the Guide 6: Acute Radiation Syndrome: Medical Guidance and National Response.

Table 1. Expected Health Outcomes as a Function of Absorbed Radiation Dose.
(Adapted from Waselenko[9])

Dose Range, Gy	Manifestation of Illness	Prognosis (without therapy)
0.5 – 1	Slight decrease in blood cell counts	Almost certain survival
1 – 2	Early signs of bone marrow damage	Highly probable survival (>90%)
2 – 3.5	Moderate to severe bone marrow damage	Probable survival
3.5 – 5.5	Severe bone marrow damage, slight GI damage	Death within 3.5 –6 wk (~50% of victims)
5.5 – 7.5	Pancytopenia and moderate GI damage	Death probable within 2-3 wk
7.5 – 10	Marked GI and bone marrow damage, hypotension	Death probable within 1-2.5 wk
10 – 20	Severe GI damage, pneumonitis, altered mental status, cognitive dysfunction	Death certain within 5-12 d
20 – 30	Cerebrovascular collapse, fever, shock	Death certain within 2-5 d

The time course for radiation effects are illustrated in Figure 1 which includes the definition of MCMs based on when they are administered. Radiation mitigators are the major focus of NIAID and ASPR/BARDA research programs. The Department of Defense focuses on protectors.

Figure 1. Time Course of Radiation Effects and Timing for Medical Countermeasures.
Prepared by CN Coleman for DHHS presentations



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A few MCMs for radiation-related indications are FDA-approved (see list below). Some MCMs approved for other medical indications might be useful to treat ARS[9] or DEARE; these could be used under an Emergency Use Authorization (FDA EUA website). *Indeed, a key approach to MCM development is for a "dual utility" drug that has a routine use in medical care. This will enhance availability and also ensure that medical personnel are familiar with its use.*

List of Approved Radiation Medical Countermeasures.

- Decorporation agents
  - Calcium diethylenetriaminepentaacetate (ca-DTPA)
  - Zinc DTPA (Zn-DTPA)
  - Prussian Blue
- Blocking agents
  - Potassium iodide (KI) tablets and liquid solution
- Radioprotectants
- Anti-neutropenia agents
  - Granulocyte colony-stimulating factor (G-CSF) (ARS indication in 2015)
  - pegylated G-CSF (would need EUA)

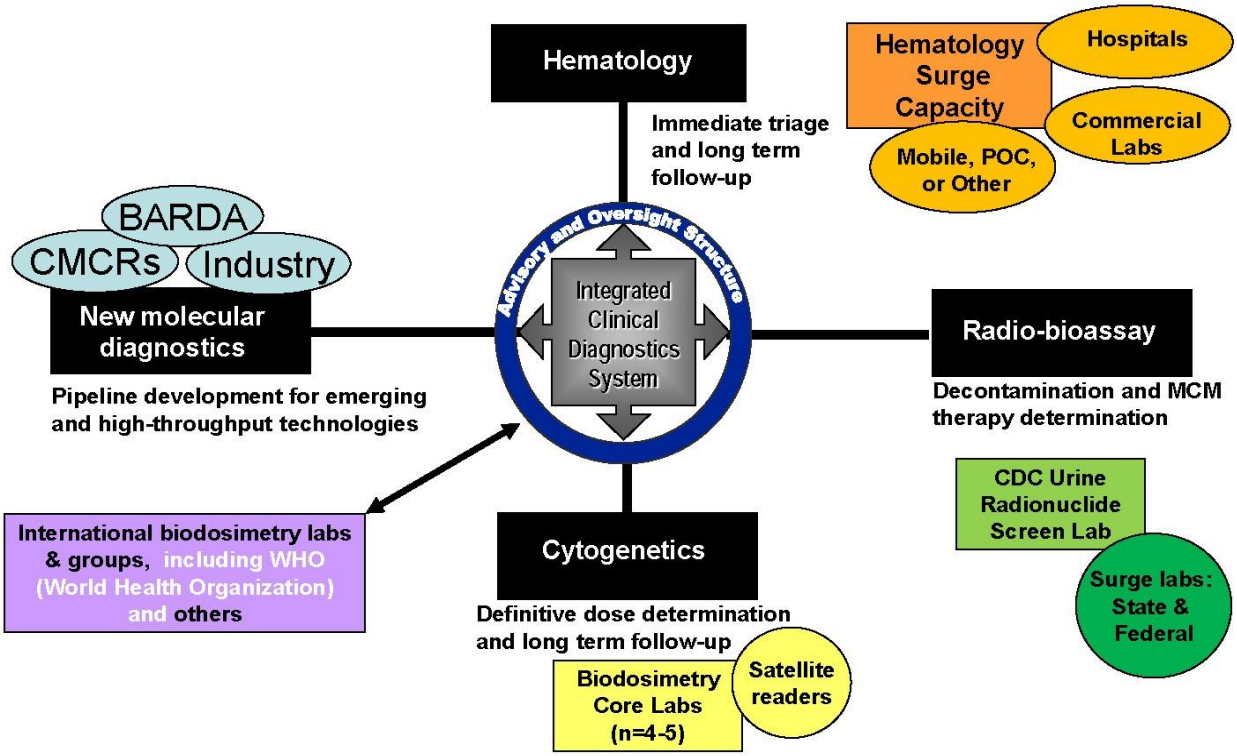
Diagnostics

For efficient employment of medical resources, prompt and effective treatment of exposed individuals, and for optimum use of radiation MCMs to be dispensed to those who need them, first responders and medical teams must be able to make accurate radiation dose assessments. Two of the most reliable biological effects of radiation are DNA damage based on chromosomal aberration assays (the dicentric chromosome or micronucleus assay) and lymphocyte depletion kinetics which can be estimated based on blood counts [10-11] or (REMM Lymphocyte Depletion Kinetics Calculator).

The diagnosis of ARS is currently based on the patient history, signs and symptoms (including the onset of emesis), hematology (blood counts) and manual or semi-automated laboratory-based cytogenetic assays. Diagnostics could be expedited by potentially combining cytogenetic laboratories within an Integrated Clinical Diagnostics System (ICDS) approach and the development and acquisition of novel biodosimetry tools currently supported through the NIAID-to-BARDA pipeline. Environmental radiation dosimeters can be used to measure the exposure that a victim could have received in the area of the dosimeter, even though they do not directly determine absorbed dose to the person. Internal contamination is primarily a risk for radiological dispersal devices (RDDs) or nuclear power plant incidents. Nuclear detonations are not considered to provide a great risk of internal contamination, as the particle size of fallout is often too large to be internalized through inhalation[12] and contamination through food sources can be avoided. The Centers for Disease Control and Prevention (CDC) has a radiobioassay laboratory that can assay for internal radioactive contaminants.[13] Assistance in assaying for internal radioactive contamination could also be obtained from experts in nuclear medicine and radiation safety.

Figure 2 (from Grace et al[6]) is a conceptual approach to developing laboratory capabilities for radiation exposure and internal contamination assessments. The Integrated Clinical Diagnostics System (ICDS) is a concept under development by multi-agency experts coordinated by ASPR with other DHHS and federal partners.[6] It could provide increased cytogenetic dicentric chromosome assay (DCA) capabilities (now available in REAC/TS in Oak Ridge - REAC/TS information on dicentrics) and Armed Forces Radiobiology Research Institute at Uniformed Services University - AFFRI information on dicentrics, enhanced capacities for the CDC Radiobioassay Laboratory, and hematology surge capacities by networking labs (including commercial diagnostic laboratories), increasing mobile capacity, providing certified protocols and guidance, and leveraging international collaboration. Because techniques such as cytogenetics are routinely done in hospitals, regional and state networks can help provide surge capacity with some training in the DCA and exercising as demonstrated in Connecticut.[14] The proposed ICDS concept could also serve as a test bed for assessment and inter-laboratory comparison for novel biodosimetry devices and potential biomarkers and as a node for ensuring adequate oversight, balancing investment, and optimizing or improving existing capabilities.

Figure 2. Components of Integrated Clinical Diagnostics System (ICDS) (modified from Grace[6]).



Medical Countermeasure Developmental Activities

The mission space is extensive and includes MCMs for ARS mitigation, radionuclide decorporation, and biodosimetry (Figure 3). The general types of MCMs that are currently being researched, evaluated, and developed are listed in Figure 4.

Figure 3. Radiation Countermeasure Mission Space

- ARS/ DEARE
  - Hematopoietic ARS
    - Neutropenia
    - Thrombocytopenia
    - Anemia
    - Lymphopenia
  - GI ARS
  - CNS injury
  - Cutaneous injury
  - Lung injury
  - Kidney injury
  - Combined radiation injury
- Biodosimetry Methods and Devices
- Radionuclide Threats
  - Am-241
  - Co-60
  - Cs-137
  - I-131
  - Ir-192
  - Po-210
  - Pu-238/239
  - Sr-90
  - U-235
- Late Effects
  - Carcinogenesis
  - Cardiovascular disease
  - Cataractogenesis

Figure 4. Radiation/Nuclear Medical Countermeasures

- Mechanisms of Action
  - Anti-oxidants
  - Anti-inflammatories
  - Anti-apoptotics
  - Growth factors and cytokines
  - Cell-based therapies
  - Others
- Radiation Syndromes
  - Acute radiation syndromes (HE, GI, CNS)
  - Delayed effects of radiation exposure (skin, lung, kidney, others)
- Radionuclides
  - Blocking agents
  - Decorporation agents

Technologies that are high-throughput, rapid, simple, field-rugged, and inexpensive are currently under development for biodosimetry. Candidate technologies employ the following techniques:

- Genomics
- Proteomics
- Metabolomics
- Lipidomics
- Glycanomics
- Electron paramagnetic resonance
- Optical spin resonance
- DNA damage assay
- Micronucleus assay
- Dicentric assay

Pursuing biomarker validation and FDA clearance of biodosimetry systems for clinical diagnostic use is challenging. Inherent biomarker variables must be addressed including (1) genetic and epigenetic influences; (2) temporal and inter-individual variability of expression; (3) variance of baseline expression; and (4) other confounders (e.g., current medications or supplements, radiation treatment for cancer, age, gender). Additionally, operational issues must be addressed, including (1) sample collection, transport, tracking, and processing in an incident response; (2) assay detection limits; and (3) patient tracking.

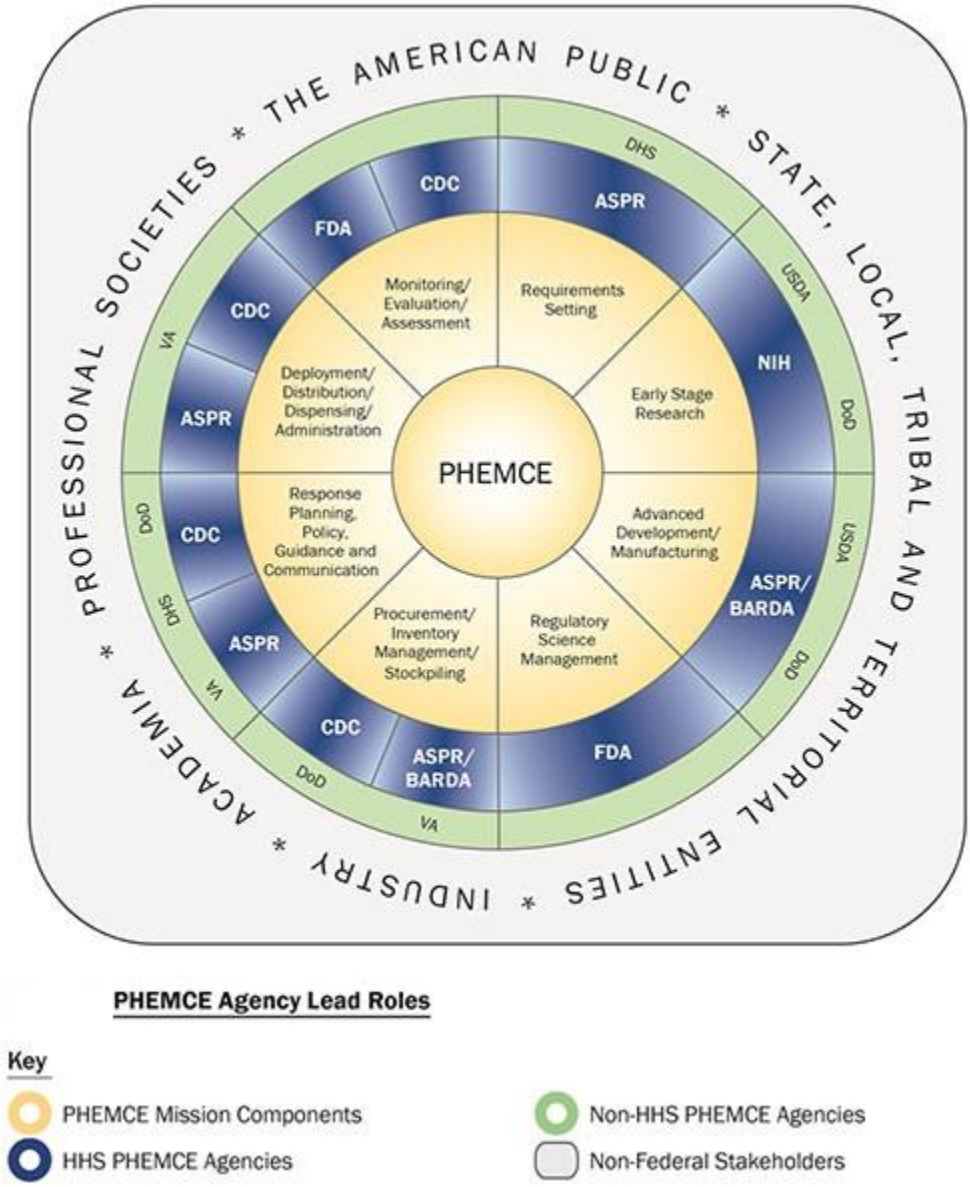
Technologies currently under development for radionuclide decorporation have one or more of the following desirable features:

- Effective and safe for decorporation of multiple radionuclides;
- Route of administration appropriate for mass casualties—oral, dermal patch, metered dose inhaler;
- Oral formulations (ease of distribution and administration in mass-casualty incident and for at-risk populations, including formulations suitable for children);
- Enhance pulmonary clearance (increase mucociliary motility); and
- Chelation capability in molecules with oral absorption, higher potency, or wider range of radionuclide decorporation efficacy than for currently available MCMs

Multi-clinical/medical utility and models of distribution/stockpiling. Given the cost and complexity of drug development, novel approaches to drug development and distribution are considered as detailed in Coleman.[15] In particular, medical countermeasures with ongoing utility in the absence of a mass-casualty incident are particularly desirable—"multi-clinical or medical use" products.[16] Similarly, laboratory networking can be dual-utility with hematology, cytogenetics, drug/toxin assay, nuclear medicine/radiation safety and emerging biomarker tests used for managing diseases such as cancer.

Science-based discovery, development, and delivery. The components of the PHEMCE participate in a procedural continuum, coordinated by ASPR with the help of its Office of Policy and Planning (Figure 5). As drugs and diagnostics are developed, the delivery and "concept of operations" are modified to take advantage of these improvements.

Figure 5. Cycle from Research and Development through Deployment and Utilization. The MCMs (including diagnostics) are based on basic and applied science.



Conclusion

The health and medical response to a radiological/nuclear incident requires close alignment and coordination of the medical countermeasure technologies that are developed and deployed with the logistical and operational requirements and considerations. The ASPR, with the help of its Office of Policy and Planning, fosters this alignment and coordination through the PHEMCE. NIAID and ASPR/BARDA foster development of MCMs in this context based on novel, high-quality scientific discovery and rigorous product and clinical development programs to achieve FDA approval.

Guide 8 - Authors

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Guide 9: Health Risks From Exposure to Radiation: The Basics

Overview:

In the wake of a nuclear detonation in a populated or metropolitan area, many people will die from the blast and heat combined with lethal doses of radiation. However, people who are at some distance from the detonation and those who are in shielded structures will have survivable doses. Others will have some potential health consequences, despite very minimal exposures. In general, health consequences can be divided into "early" health conditions, that appear within minutes to days after exposure, and "late" health conditions, that typically occur several years to decades after exposure. Early conditions are generally associated with high exposures that are often life-threatening in the short-term. Those who may develop late conditions can number thousands or more since, by definition, those persons survived the blast and other immediate life-threatening circumstances (e.g., loss of medical and hospital services). Late conditions include damage to organ systems (e.g., lung, thyroid or cardiovascular system) and radiation-induced cancer, which is the major issue of concern to the public.

The study of radiation health consequences usually differentiates early *organ damaging* conditions by the fact that the *severity* of the early health condition is related to the magnitude of the dose. In contrast, late *radiation-induced cancers* occur in a higher frequency with increasing dose but with a severity not related to the dose. In other words, it is the *chance* of developing a radiation-induced cancer that is the actual late consequence of exposure, not the severity of the effect. The chance associated with the development of a radiation-related health effect is usually termed "radiation risk." In this Guide, we discuss the concepts underlying radiation health risks including the types of health outcomes, how they are similar or different from health conditions occurring in the absence of radiation, the rate at which they might be expected to occur after a mass exposure event, and how those rates are related to doses that might be received.

As a frame of reference, everyday life exposes people to ionizing radiation from a variety of natural and manmade sources, including:

a) Naturally-occurring radiation that emanates from minerals in the ground;
b) Radiation that is incident on the earth directly from space and as a result of the way it interacts with molecules in the atmosphere;
c) Naturally-occurring radioactivity that enters the body through foods we eat, in particular, from crops grown on soil that is partly composed of naturally-occurring radioactive minerals; and
d) Radiation used in industry, medical care, and consumer products.

Introduction

Health consequences from radiation exposure can include both early and late consequences.[1] [Note: concepts of dose and exposure are in Guide 2: Response, Resources, and Resilience: Preparedness and Planning for a Nuclear Detonation.[2]]

Early ("Acute") Health Effects:

- The *severity* of the condition is related to exposure.
- Only observed a few times since they are associated with exposures that are much greater than typically received from any normal occupational or medical exposure.
- Radiation accidents have resulted in radiation doses high enough to produce early effects in very few persons, despite drawing great national and international interest.
- Often mistaken as the most likely outcome of unintended exposures, such as a might occur from a nuclear detonation, they will affect only a small fraction of those exposed because of the serious competing causes of death involved (including both radiation and physical injury).

Late Health Effects:

- The *likelihood of occurrence* is related to exposure.
- Those that manifest themselves most commonly are an increase in the rate of development of cancer years or decades after the exposure.
- Much more important in terms of numbers of persons likely affected.

Radiation Risk: What It Means and What It Implies

It is important to define the concept of radiation risk.[3-5] In its most general sense, the risk of radiation exposure includes the possibility of developing any of the health consequences that are known to be associated with radiation exposure, and it includes both early and late effects. For persons who receive a whole-body radiation dose of approximately 1 Sievert (Sv) [doses to be discussed in a subsequent section], certain conditions are quite likely to occur—in particular, nausea and vomiting, possibly diarrhea, and a mild decrease in the white blood cell count (leukopenia). Fortunately, at this dose none of those conditions are life threatening, although moderate level doses (1-2 Sv) combined with major physical trauma or burn—called "combined injury"—can be life threatening. At whole-body doses over 2 Sv , more serious acute medical conditions occur from hours to days after exposure, including damage to specific systems of the body such as the blood-forming tissues, the brain, and the gastro-intestinal and cardiovascular systems (discussed in Guide 6: Acute Radiation Syndrome: Medical Guidance and National Response[6]).

The more conventional scientific meaning of radiation risk is important to understand because it is used in all radiation recovery planning efforts. Several terms with similar meanings are often used to explain radiation risk: *chance*, *likelihood* or *probability*. As noted earlier, the

severity of radiation-induced cancer is not related to the radiation dose. Instead, the chance (or the likelihood or the probability) of the effect to occur is related to the radiation dose. On an individual level, the chance of developing a cancer is challenging to define and to understand since each person develops a cancer or does not—there is no intermediate condition. Conceptually, what we mean when discussing radiation risk is that if a person were to be exposed along with a large group of similar persons (e.g., adult males or adult females), a radiation-related cancer would develop among a certain percentage of that group. For example, a 10% chance of an individual developing a radiation-related cancer would mean that about 10% *of the group that is similar to them* and who were equally exposed to radiation would develop a radiation-related cancer. In simple terms, we can equate individual risk with the proportion of persons in a similar population to develop the health condition. The chance of developing a radiation-related condition is the essence of the concept of radiation health risk.

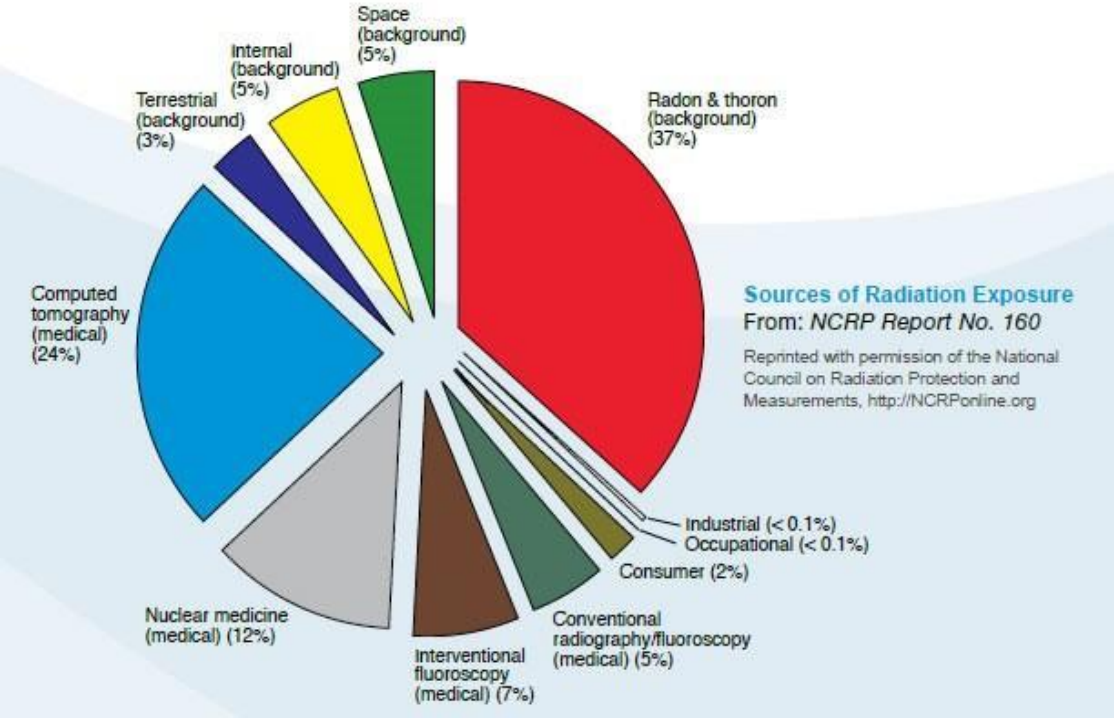
Radiation Dose: The Basics

Everyday life exposes people to ionizing radiation from a variety of natural and manmade sources, including:

a) Naturally-occurring radiation that emanates from minerals in the ground (e.g., uranium) and from radioactive by-products those minerals emit (e.g., radon gas);
b) Radiation that is incident on the earth directly from space and as a result of the way it interacts with molecules in the atmosphere;
c) Naturally-occurring radioactivity that enters the body through foods we eat, in particular, from crops grown on soil that is partly composed of naturally-occurring radioactive minerals; and
d) Radiation used in industry, medical care, and consumer products.

All of these sources have been long studied and are known to have been present throughout the evolutionary history of Homo sapiens. Hence, our bodies' cells and tissues have developed in the presence of radiation and have repair mechanisms to deal with injury. The dose we are routinely exposed to from the natural environment is well cataloged and represents about one-half of the radiation exposure typically received by Americans and others living in societies with modern medical care. The natural radiation exposure of society today is supplemented considerably by the use of radiation in modern medical care, most notably by computed tomography (CT scans) and fluoroscopy, which is widely used for cardiovascular procedures in older adults. The division of typical exposures between natural sources and medical radiation is presented in Figure 1.[7]

Figure 1. Sources and Average Proportions of Annual Radiation Exposure (Reprinted with permission of the National Council on Radiation Protection and Measurements, NCRP Website



Radiation dose describes the amount of energy absorbed by the human body that is of sufficient strength to ionize—to remove electrons—from atoms in the tissue with which it interacts. The concept of ionization distinguishes x-ray and gamma radiation from ultra-violet radiation from the sun, which has sufficient energy to damage the skin, but cannot ionize the atoms of the body. [Note: See electromagnetic spectrum discussed in Coleman[2]] While many molecules in the body can be ionized by x-rays and gamma rays, damage to the DNA (hereditary material) in cells is felt to be the key lesion that either may lead to mutation, if the cell is not too heavily damaged, or cell death if the damage is extensive. While extensive cell death could result in an acute syndrome, it is important to note that cells that die from extensive radiation damage cannot produce cancer. A detailed understanding of radiation dose and its effect has been developed from scientific studies and is used in medicine, the nuclear power industry, and other occupations that use radiation.

Radiation doses that might be received from any source (e.g., a medical procedure, working in a nuclear power plant, or an exposure from a nuclear detonation) all use the same scientific theory and units to describe the magnitude of the radiation effect. Efforts to communicate the basics of radiation science to the public have always been challenging—the unfamiliarity of radiation concepts and units often leads to ineffective communication and an incorrect understanding of the magnitude of doses that might be received.

The lowest typical levels received over the course of a year by Americans range from about 1 milliSievert (1 mSv = 1/1000 of a Sievert) of radiation emitted from minerals in the ground up to about 6 mSv (total) from all sources of natural and background radiation, including the radiation from typical medical care (averaged over all persons in the U.S.).[7] Persons who receive an above average amount of medical care due to specific disease conditions may accumulate significantly greater amounts of radiation, though usually limited to the specific portion of the body receiving treatment or examination.

The upper end of exposures considered here are for persons who might be exposed to a nuclear detonation or involved in the recovery activities of a nuclear or radiation accident. In such cases, a dose of 1 Sievert over the whole body would be considered undesired. If received over a short time (a few minutes or less), a 1 Sv dose would likely lead to vomiting and nausea. Persons who might receive more than 2 Sv but less than 8 Sv would undoubtedly have significant damage to their blood-forming tissues and gastrointestinal tract and would require medical care to ensure survival. Those in the upper end of this range (7-10 Sv) would be at very high risk of radiation-related death within days of exposure.

In the U.S. and other developed nations, a system of regulations and strategies for radiation protection ensures the health of workers by limiting their long-term cancer risk to accepted norms. This is accomplished by standards that permit annual occupational exposures to be only a few times greater than background radiation. For example, in the U.S., radiation workers are allowed an annual occupational exposure up to 50 mSv (= 0.050 Sv) or about eight-times the typical dose received by Americans.

Table 1. General Dose Ranges for Radiation. Note ***that each row is about 10 times higher*** than the one below it so that top row and bottom row differ by a factor of 100,000.
Adapted from the Department of Energy[8]

Description of Dose Range	Dose, Sv (top of range in mSv)	Dose, rem (top of range)
Cancer radiotherapy (total dose to tumor)	10 – 100 Sv (100,000 mSv)	10,000 rem
Acute Radiation Syndrome (ARS)	1- 10 Sv (10,000 mSv)	1,000 rem
Very high background; Dose limits for rescuing people during radiation catastrophe	0.1- 0.25 Sv (250 mSv)	25 rem
Moderately high natural background; CT scans or fluoroscopy Dose limit for nuclear worker [n]	0.02- 0.09 Sv (90 mSv) [50mSv]	9 rem [5 rem]
Natural background range (including medical radiation)	0.003 – 0.006 Sv (6 mSv)	0.6 rem
Air travel, recommended annual limit for public	0.0001-0.001 Sv (1 mSv)	0.1 rem

Note: [The preferred unit is the Sievert. The dose in rem is included as a point of reference.]

KEY POINTS ON RADIATION

1) All Americans, as well as people everywhere, receive radiation doses each year of several mSv (a few thousandths of a Sv);
2) Exposures to radiation in medicine may increase the dose a person has received in a given year by tens of mSv, depending on the number of CT examinations, fluoroscopy procedures, etc. they have had;
3) Annual occupational doses in the U.S. are permitted up to 50 mSv. This dose limit is considered highly protective;
4) Few if any early or acute effects are associated with doses less than 1,000 mSv (1 Sv); while
5) Doses of several thousand mSv (i.e., > 2 Sv or 2000 mSv) will likely produce early or acute effects and may require sophisticated medical care to ensure survival.

Early and Late Health Risks: The Basics

As noted earlier, the general concept of health risk can include both early and late effects. Figure 2 summarizes the radiation syndromes, the doses at which they occur, and the general time scale. Detailed discussions on the radiation syndromes are available on the Radiation Emergency Medical Management (REMM) website[9] and in Guide 6: Acute Radiation Syndrome: Medical Guidance and National Response.[6] Delayed effect of acute radiation exposure (DEARE) is a useful concept in that it may take months or even years for some radiation effects to develop that depend on the dose received. These include lung fibrosis (scarring), soft tissue fibrosis, and damage to blood vessels.

Figure 2. Radiation Syndromes and their Corresponding Radiation Exposure Doses.

Radiation Syndromes:

- **Acute Radiation Syndrome (ARS) and Delayed Effect of Acute Radiation Exposure (DEARE). [*Severity depends on dose*]**
  - **Continuum of injuries**
  - **Time to clinical manifestation depends on organ system and dose**
  - **Phases: Prodrome → Latent → Manifest**

Hematological syndrome (>2 Sv)	**few days to 2 months**
Gastrointestinal syndrome (>6 Sv)	**few days to a week**
CNS/Cardiovascular syndrome (>10 Sv)	**immediate**
Cutaneous syndrome (>6 Sv)	**few days to weeks**
Combined injury (early intervention required)	**immediate**
Radiation-induced cancer [*risk depends on dose*]	**years to decades**

The concept of health risk applies most clearly to long-term or late health effects because the probability of the health effect occurring is related to the magnitude of the dose received.

Understanding health risk from radiation requires; however, an appreciation of the background rates of cancer in the world population. U.S. rates are traced annually by the National Cancer Institute's SEER registry.[10] The cancer incidence in the overall population is over 40% which implies that the lifetime risk (chance) for Americans to develop cancer is over 40%. Any increase in the cancer risk due to exposure to radiation will simply add to that chance. [Note: A recent review of SEER data[11] suggested the risk of developing cancer and risk of dying from cancer for all invasive sites was 44.29% and 23.20%, respectively, for males and 37.76% and 19.58%, respectively, for females.]

The studies of Japanese atomic-bomb survivors and persons exposed to occupational and medical radiation are some of the primary subjects in the field of radiation epidemiology. Epidemiology studies follow the health of an exposed population for many years or decades and relate the excess cancer incidence (excess above the background rate) to the exposures the persons in the group received. These types of studies have allowed scientists to estimate the magnitude of the increase in cancer risk that would likely result from each increment in exposure. There are many specifics about radiation cancer risk beyond what can be effectively discussed here but which allow projections of cancer risk to be made for subgroups with specific attributes (e.g., age at time of exposure, gender, nationality, ethnic group).

KEY POINTS ON LONG-TERM CANCER RISK AFTER RADIATION EXPOSURE

1) Risk is higher for many types of cancer when exposed in childhood, in part due to the longer time for late effects to develop;
2) Within the dose range studied (near zero to near fatal dose levels), the risk increases relatively linearly with increasing dose, the only exception being for leukemia;
3) There is no evidence for a threshold dose below which there is no risk;
4) The absolute increase in risk at low doses (10's of mSv) might be considered as small (i.e., a few percent increase at most);
5) Long-term cancer risk can continue for decades after exposure;
6) Not all organs are at equal risk for cancer development after exposure. The most sensitive appear to be blood-forming tissues, the breast, thyroid, colon, and liver, followed by others to a lesser degree;
7) Each gender has unique risks to radiation, for example, risks to breast, lung, and bladder are greatest for females, while liver and colon are higher for males;
8) There are some non-cancer risks for which evidence is accumulating, in particular, risks to the cardiovascular system;
9) Data on A-bomb survivors indicates that the absolute increase in cancer risk is about 5%-8% for each Sievert of radiation received, or fraction thereof for lower doses.
10) In a rough calculation, for a dose of 10 mSv (1 rem), the increased lifetime risk of developing cancer would be approximately 0.8% and of having a fatal cancer of approximately 0.46%.[12] Thus, 10 mSv, which is about 2-3 times the annual background dose would increase the lifetime risk of developing cancer from approximately 42%[11,12] to 42.8%.

How and What We Learned about the Effects of Exposure to Radiation from Nuclear Weapons

It may be surprising to many that much is known about the effects of exposure of people to radiation from nuclear weapons. A distinction lies in whether the persons studied were exposed to radiation from an actual nuclear weapon (direct information) or whether the persons studied were exposed to radiation from another type of source or device (e.g., a nuclear reactor accident) (indirect information), that emits radiation similar to the radiation from a nuclear detonation.

Indirect studies are by far the most common and include a diverse set of exposure conditions over the past 40 years, including the following:

- Radioactive emissions from weapons fuel (plutonium) production facilities in Hanford in the U.S. and Mayak in the former Soviet Union;
- Radioactive fallout[13] from nuclear weapons tests in Nevada, Utah, and New Mexico, Marshall Islands,[14] Kazakhstan, French Polynesia and elsewhere;
- Radioactive emissions from nuclear power plant accidents including Three Mile Island,[15] Chernobyl,[16] and most recently, the Fukushima Daiichi;
- Gamma radiation from nuclear criticality accidents, such as the Tokaimura criticality accident in Japan in 1999.

The only persons exposed directly to the gamma rays (as well as neutrons) from the detonation of a nuclear weapon are those present at the atomic bomb detonations in Japan during World War II. While the number of early fatalities from the Hiroshima and Nagasaki weapons totaled more than 200,000, several hundreds of thousands of people survived the detonations and have been the most valuable source of information on radiation health risks of any population in history. Even today, the U.S. and Japan continue joint studies of health risks of more than 80,000 A-bomb survivors through a bi-national research organization, the Radiation Effects Research Foundation in Hiroshima and Nagasaki.[16, 17]

It is worthwhile to briefly review the radiation types and circumstances of exposure from a nuclear detonation. Nuclear detonations emit both high intensity gamma rays and neutron radiation. Gamma radiation energies range from those used in medical diagnostic examinations to high-energy isotopes created by the fission of nuclear materials (i.e., within a reactor or weapon detonation). The gamma ray energy from nuclear detonations is, on average, similar to the energy generated by medical accelerators that are used for radiation therapy of cancer; however, the way they are delivered differs.

Nuclear weapon:

- Gamma radiation from a nuclear detonation, often termed prompt radiation, is emitted in a fraction of a second at the time of the detonation, which does not allow for cellular and DNA repair systems to function.

- Persons exposed to prompt gamma radiation are generally exposed equally over their entire body, although there may be some partial shielding by walls or other structures. Whole-body or major partial-body doses of several Sievert can result in the acute radiation syndrome in Figure 2.

Cancer Radiotherapy

- Radiation for cancer therapy is delivered much more slowly, often in numerous fractions over a multi-week period. Radiation that is delivered more slowly allows the body to repair damaged DNA and replace cells. The body's repair capabilities are utilized in the treatment of cancer where healthy tissues adjacent to the tumor are given the opportunity to maintain their health and integrity by a slow enough delivery of the radiation to the tumor.

- Only the tumor and a limited amount of normal tissue are highly exposed, which is seen in the dose ranges in Table 1.

Radionuclide Exposure

In addition to the near instantaneous irradiation of the body by gamma rays from a nuclear detonation, radioactive debris continues to irradiate the environment and persons in it for many years. Radioactive debris from a detonation contaminates the area that is downwind of the detonation. The debris is dispersed both by local wind currents and also by winds in the upper-level atmosphere. These contaminated dust particles eventually fall to the ground. The radioactive material, termed fallout, includes a large number of radioactive isotopes (over 200) that have half-lives (the time for the radioactive emissions to decrease by 50%) ranging from seconds to thousands of years. The most important radioactive isotopes (termed radionuclides) in terms of their potential to expose the public are radioactive Iodine-131 (written ^{131}I) and radioactive Cesium-137 (written ^{137}Cs), which have been studied for nearly 60 years.

Ingestion, inhalation, and radioactive shrapnel (particles in wounds) exposures are termed "internal" since the radioactivity exposes the body from the inside. Exposure from radiation of the ground and surfaces of the environment is termed "external" since the radioactivity exposes the body from the outside.

Iodine-131 (8-day half-life)	**Exposure Pathway (Internal)** • Ingestion of fresh milk products, following contamination of the feed of dairy animals • Can also be inhaled from the air, though that is almost always a minor addition to radiation dose in a nuclear detonation.	• Increased chance of thyroid cancer, usually taking many years and sometimes decades to develop. One of the most treatable and survivable of all cancers. • Iodine is a required nutrient and the human body cannot distinguish between the natural (non-radioactive) variety and the radioactive variety. • Risk from exposure is much higher in children as the thyroid is more active and smaller, which concentrates the radiation. Conversely, there is substantial evidence to suggest that exposure after reaching adulthood is relatively inconsequential.
Cesium-137 (30-year half-life)	**External**: Contaminated ground and surfaces of environment **Internal**: Via meat products when cattle consume contaminated feed, though exposure is much smaller	Does not accumulate in any particular organ or tissue and, for that reason, tends to expose the body uniformly.

A comparison between exposure to the prompt gamma rays from the detonation and exposure to fallout is relatively simple near a detonation (within approximately 1 km). The gamma ray exposure is likely to be the most serious component and potential cause of death. Exposure to prompt gamma rays is greatly attenuated at greater distances and with substantial sheltering as in a basement of a large building. Thus with distance or sheltering, the dose from fallout is the more significant source or radiation. The exposure to prompt gamma rays takes place quickly; preventing cellular and DNA repair processes, while exposure to fallout continues for many years and decades.

KEY POINTS

1) Detonations externally expose a person to radiation by gamma rays and some neutrons;
2) Exposure within seconds is usually more dangerous than equal exposure over long periods of times (days, months, or years);
3) Detonations create radioactive debris that contaminates the environment with fallout;
4) Fallout particles can expose persons externally and the exposure can continue for years or decades, depending on clean-up and recovery;
5) Of the fallout radionuclides created, Iodine-131 and Cesium-137 impart the greatest health risks and are well understood.

Radiation Risk after a Nuclear Detonation: What Might Be Expected?

The health consequences after a nuclear detonation will depend on several variables that are impossible to predict, but some generalizations can be made. The explosive yield and whether it is a ground or air burst will largely determine the amount of prompt radiation released and fallout created. An improvised nuclear device may “fizzle,” meaning little prompt radiation would be released; however, the local area would be contaminated with unfissioned plutonium

or uranium. While this would be a hazard to unprepared persons, trained personnel with proper protective gear could effectively clean up and decontaminate the area.

Following a nuclear detonation, persons receiving less than one (or even two) Sievert of prompt and fallout radiation may have only limited acute effects. This group of people would be the largest group of "victims" and would be at an increased risk for future cancers. Recall that the rate of increase in cancers—but not the severity—would be related to the dose each person received.

Present understanding suggests that there could be a 5% to 8% increase in the absolute cancer rate for those exposed to 1 Sv (100 rem).[19, 20] This means that among persons exposed to 1 Sv (1000 mSv), their individual cancer risk might increase from 40% to about 45% or 48%. Similarly, the percentage of people developing cancer might increase from 40% to 45%-48%.

Not all cancer types would be increased equally by the radiation exposure. Those organs most at risk, as discussed earlier, would include the blood-forming tissues (leading to leukemia), the thyroid, and the breast, followed by others to lesser degrees. While it may be true that cancer can be induced in any organ, there is substantial evidence to suggest that not all organs are at equal risk.

Many people would undoubtedly receive doses much less than 1 Sv from a nuclear detonation. The most common dose received by the A-bomb survivors presently being studied is 5 to 10 mSv, or about equal to one or two years exposure to natural background radiation. The incremental risk experienced by each person would be generally proportional to the dose received and one can simply reduce the estimate of 5% to 8% increase per Sv of radiation by half, quarter, or any fraction, depending on the dose received. Hence, a person receiving 10 mSv would have received 1% of a Sievert and, thus, their incremental risk would be 1% of the possible 5-8% increase found in scientific studies, which is equal 0.05- 0.08%. This could be equivalently stated that the cancer risk would go from the background risk, ~40%, to about 40.05% or as much as 40.08% if they received 10 mSv. In this way, one can see that the most common increase in risk by persons surviving a nuclear detonation will not be large compared to the background cancer risk.

Conclusion

Exposure to ionizing radiation from natural background and manmade sources is always present in our lives. Likewise, diseases such as cancer are common and, while not completely understood, the incidence of cancer is believed to be a result of other causes than background radiation. Cancer is a ubiquitous illness affecting approximately 40% of people in the U.S. and being fatal to over 20% of our population.[11] Additional radiation exposure, whether it be from medical radiation or a nuclear incident, can potentially increase a person's lifetime risk of developing cancer, though small increments of radiation impart only very small risks.

Early consequences from a nuclear event would be relatively few, but may require expert medical care to ameliorate the health consequences, some of which might be life threatening. Most important to society and to recovery efforts is to have an understanding about long-term

cancer risks and to be able to put those into a proper perspective compared to the background cancer risk.

Radiation is only one of many risks faced in daily life, and its fear is often associated with the fact that radiation cannot be seen or felt. Epidemiological studies of many groups of people who have been exposed to radiation have been used to estimate the additional risk of cancer from radiation exposure. However, the survivors of the A-bomb detonations in Japan have given us the greatest insights. This knowledge allows us to quantitatively estimate the individual or population cancer risk after a nuclear detonation or reactor accident if a reliable estimate of the radiation dose is possible.

Guide 9 - Authors

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Guide 10: The Federal Response Structure and Plans: NRF, NIMS, ESFs, and Directives

Overview:

Standardized terminology and organizational structure are key elements of an effective and coordinated response. The overall federal response is described in the National Response Framework (NRF)[1] and is organized into 10 Federal Emergency Management Agency (FEMA) Regions[2] with agency responsibility outlined in the Emergency Support Function Annexes.[3] The National Incident Management System (NIMS)[4] outlines structure, terminology, and procedures with the Incident Command Structure (ICS)[5] organizing the five components: command, operations, planning, logistics, and finance/administration. Development of these systems was originally mandated by Homeland Security Presidential Directive #5 (HSPD-5) – Management of Domestic Incidents.[6]

The NRF is a guide produced by the U.S. Department of Homeland Security (DHS) and approved by the Executive Office of the President to direct communities, states, the federal government, and private-sector and nongovernmental partners to respond to all hazards. Contained in the NRF are Emergency Support Function Annexes. These annexes list the Emergency Support Functions (ESF) and the capabilities, roles, and responsibilities each agency or group provides during response operations and which are supported by FEMA Regions.

The federal response to an improvised nuclear detonation (IND) detonation requires many agencies and resources to ensure an appropriate medical and public health response. At this time, the Department of Health and Human Services (DHHS) Office of the Assistant Secretary for Preparedness and Response (ASPR), in collaboration with subject matter experts and partner agencies (e.g., Centers for Disease Control and Prevention (CDC), National Institutes of Health (NIH), and the National Library of Medicine (NLM), developed the *State and Local Planner's Playbook for Medical Response to a Nuclear Detonation.* HHS ASPR State and Local Planner's Guidance for IND

Guide 10

The National Response Framework – How the Nation Responds to All Hazards

The medical and public health response to a nuclear detonation will require numerous resources, comprehensive planning, effective communication, and novel approaches to addressing an incident of this scale. Guidance on the nation's approach to conducting response efforts is detailed in the NRF.[1] The Nuclear/Radiological Incident Annex (NRIA)[7] to the NRF addresses the unique responsibilities and coordination requirements for the scope of potential accidental or deliberate releases of radiological material or a nuclear detonation. Agency roles, responsibilities, and authorities are specifically described for each type of incident. Additionally, an integrated concept of operations and unique organization, notification, and activation processes and specialized incident-related actions are discussed.

The NRF is built on key response principles with overall goals of a collaborative response structure that is applicable during large or small incidents:

- Engaged partnerships
- Tiered response
- Scalable, flexible, and adaptable operational capabilities
- Unity of effort through unified command
- Readiness to act

The NRF and its list of annexes fully explain the principles that guide national response, roles and responsibilities, response actions, response organizations, and planning requirements to achieve an effective national response to any incident that occurs. A visual structure of the NRF is shown below in Figure 1.

Figure 1. Structure of the National Response Framework.[1] These components are nonspecific and applicable to all hazard incidents and emergency and non-emergency situations to ensure all municipalities develop similar response structures in an effort to integrate response across all levels of government.

Emergency Support Functions (ESFs)

Contained in the NRF are Emergency Support Function Annexes.[3] These annexes list the ESFs and the capabilities, roles, and responsibilities each agency or group provides during response operations. Table 1 describes the roles and responsibilities of ESF partners. "DHHS is the coordinating and primary agency for leading ESF #8 – Public Health and Medical Services.

Table 1. Roles and Responsibilities of the ESFs

Emergency Support Function	Scope	Coordinator	Primary Agency
ESF #1 – Transportation	▪ Aviation/airspace management and control ▪ Transportation safety ▪ Restoration/recovery of transportation infrastructure ▪ Movement restrictions ▪ Damage and impact assessment	DOT - Department of Transportation	DOT
ESF #2 – Communications	▪ Coordination with telecommunications and information technology industries ▪ Restoration and repair of telecommunications infrastructure ▪ Protection, restoration, and sustainment of national cyber and information technology resources ▪ Oversight of communications within the federal incident management and response structures	DHS/NCS - Department of Homeland Security, National Communications systems	DHS/FEMA - Federal Emergency Management Agency
ESF #3 – Public Works and Engineering	▪ Infrastructure protection and emergency repair ▪ Engineering services and construction management ▪ Emergency contracting support for life-saving and life-sustaining services	DOD/USACE - US Army Corps of Engineers	DOD/USACE/ DHS/FEMA
ESF #4 – Firefighting	▪ Coordination of federal firefighting activities ▪ Support to wildland, rural, and urban firefighting operations	USDA/FS - USDA US Forest Service	USDA/FS
ESF #5 – Emergency Management	▪ Coordination of incident management and response efforts ▪ Issuance of mission assignments ▪ Resource and human capital ▪ Incident action planning ▪ Financial Management	DHS/FEMA	DHS/FEMA
ESF #6 – Mass Care, Emergency Assistance, Housing, and Human Services	▪ Mass care ▪ Emergency assistance ▪ Disaster housing ▪ Human services	DHS/FEMA	DHS/FEMA
ESF #7 – Logistics Management and Resource Support	▪ Comprehensive, national incident logistics planning, management, and sustainment capability ▪ Resource support (facility space, office equipment and supplies, contracting services, etc.)	DHS/FEMA/ GSA – US General Services Administration	DHS/FEMA/ GSA
ESF #8 – Public Health and Medical Services	▪ Public health ▪ Medical ▪ Mental health services ▪ Mass fatality management	HHS	HHS

Emergency Support Function	Scope	Coordinator	Primary Agency
ESF #9 – Search and Rescue	▪ Lifesaving assistance ▪ Search and rescue operations	DHS/FEMA	DHS/FEMA/ DOD/USCG/ DOI – US Coast Guard, Department of the Interior
ESF #10 – Oil and Hazardous Materials Response	▪ Oil and hazardous materials (chemical, biological, radiological, etc.) response ▪ Environmental short- and long-term cleanup	EPA – Environmental Protection Agency	EPA/DHS/ USCG
ESF #11 – Agriculture and Natural Resources	▪ Nutrition assistance ▪ Animal and plant disease and pest response ▪ Food safety and security ▪ Natural and cultural resources and historic properties protection and restoration ▪ Safety and well-being of household pets	USDA – US Department of Agriculture	USDA/DOI
ESF #12 – Energy	▪ Energy infrastructure assessment, repair, and restoration ▪ Energy industry utilities coordination ▪ Energy forecast	DOE- Department of Energy	DOE
ESF #13 – Public Safety and Security	▪ Facility and resource security ▪ Security planning and technical resource assistance ▪ Public safety and security support ▪ Support to access, traffic, and crowd control	DOJ – Department of Justice	DOJ
ESF #14 – Long-Term Community Recovery	▪ Social and economic community impact assessment ▪ Long-term community recovery assistance to states, local governments, and the private sector ▪ Analysis and review of mitigation program implementation	DHS/FEMA	DHS/FEMA/ USDA/HUD – Housing and Urban Development
ESF #15 – External Affairs	▪ Emergency public information and protective action guidance ▪ Media and community relations ▪ Congressional and international affairs ▪ Tribal and insular affairs	DHS	DHS/FEMA

FEMA Regions

FEMA operates the regional support structure by managing regional offices. States are divided into 10 regions, which enables FEMA to better coordinate emergency response efforts (see Figure 2). Each region contains a Regional Response Coordination Center (RRCC), which is designed to become response headquarters during or in anticipation of a major incident. The centers are staffed by response personnel in order to fulfill the goals of ESF guidance.[1]

Figure 2. FEMA Regions. (Region IX includes American Samoa, Commonwealth of the Northern Mariana Islands, Republic of the Marshall Islands and Federated States of Micronesia)

National Incident Management System (NIMS)

From the NRF key principles emerge the core principles found in NIMS. NIMS outlines the management structure for response to a large or small specific emergency by establishing unified concepts, terminology, and procedures. It is a template that allows first responders (e.g., police, firefighters, or emergency planners) from various jurisdictions (local, state, tribal, government and non-government organizations) to effectively work together during an all-hazard response.[1]

The Concepts of NIMS

Interoperability and compatibility—balance of flexibility and standardization

Flexibility and scalability:

- Adjustable national framework
- All levels can work together to respond to domestic incidents, regardless of their cause, size, location, or complexity
- Applies across all phases of incident management—prevention, preparedness, response, recovery, and mitigation

Standardization:

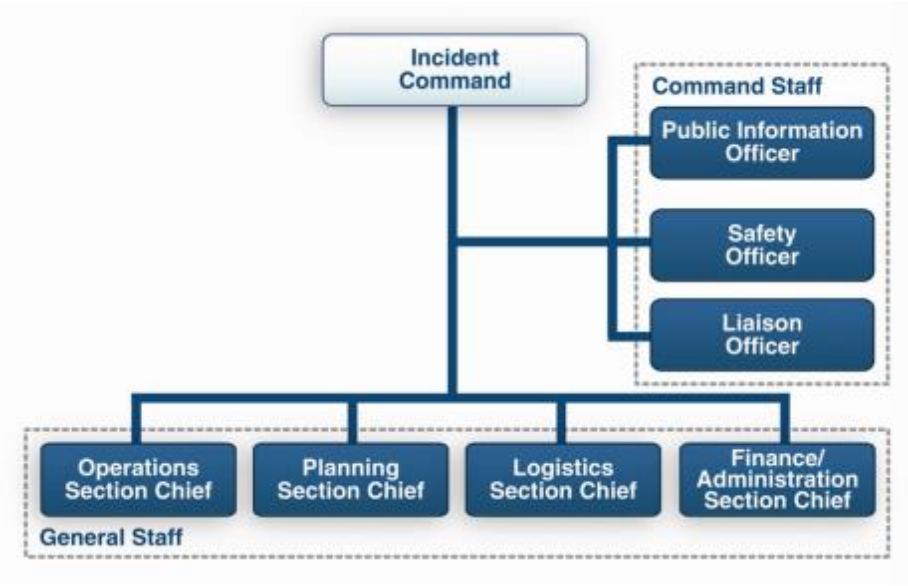
- Organizational structures
- Titles of organizations and positions are standardized

The response to all hazards is unified due to the NIMS concepts, which are built on a widely used organizational structure called the Incident Command System (ICS). NIMS and ICS share common components such as:

- Preparedness;
- Communications and Information Management;
- Resource Management;
- Command and Management; and
- Ongoing Management and Maintenance.

ICS is the combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure, designed to aid in domestic incident management activities (see Figure 3). It is used for a broad spectrum of emergencies, from small to complex incidents, both natural and manmade, including acts of catastrophic terrorism. It is divided into 5 functions: Command, Operations, Planning, Logistics, and Finance. This structure was designed for use by federal, state, local, and non-government organizations while managing incidents.

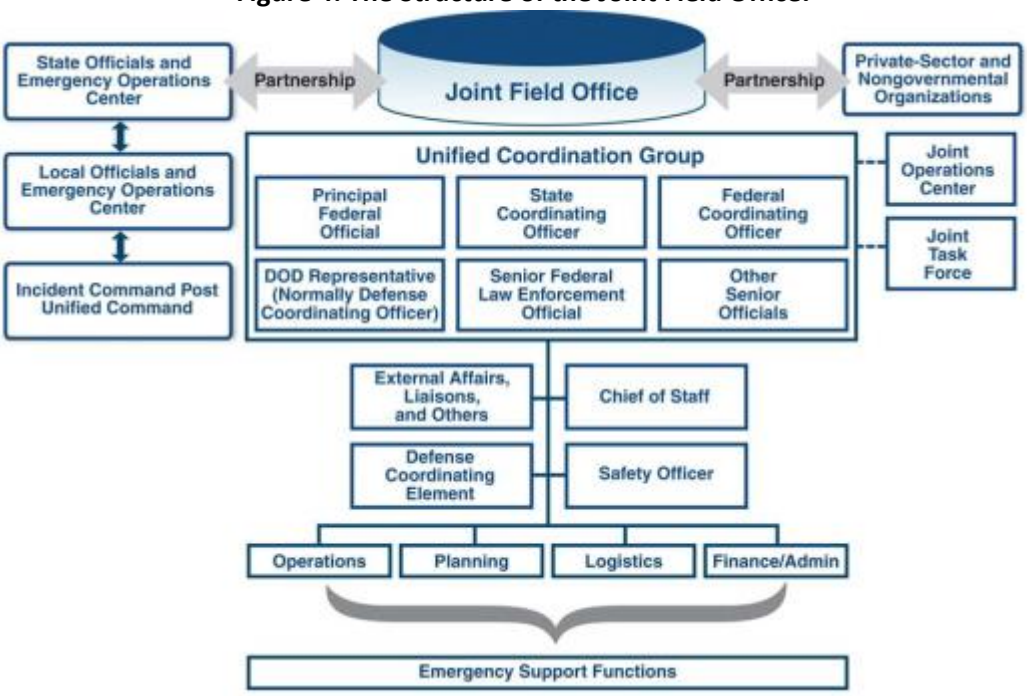
Figure 3: Incident Command Structure.



Joint Field Office (JFO)

The Joint Field Office (JFO) is the federal incident management structure (Figure 4). It is a temporary multiagency coordination center established at, or near, the incident site to provide a central location for coordination of federal, state, local, tribal, nongovernmental, and private-sector organizations with primary responsibility for incident oversight, direction, and/or assistance to effectively coordinate protection, prevention, preparedness, response, and recovery actions. The JFO is not designed for tactical incident response despite utilizing the ICS structure. The JFO focuses on providing support to on-scene efforts and conducting broader support operations that may extend beyond the incident site.[1]

Figure 4: The Structure of the Joint Field Office.



The Federal Response Structure Applied to IND Response Plans

The medical and public health response to an IND is complex and will require numerous resources. The NRIA of the NRF describes specific response activities, capabilities, and responsibilities carried out by coordinating and cooperating agencies to support the state, tribal, and local activities during the response. In the NRIA, HHS's responsibilities through ESF #8 – Public Health and Medical Services include: coordination of population monitoring; certain laboratory analyses; guidance and technical assistance for population decontamination and internal contamination monitoring; provision of medical countermeasures from the Strategic National Stockpile (SNS); coordination of fatality management; and provision of medical surge.

Responders and planners can use tools developed by DHHS and based on the NRF, NIMS, and ESF guidance to navigate through response planning complexities. ASPR, in collaboration with subject matter experts and partner Agencies (e.g., CDC, NIH, and the National Library of Medicine) developed the *State and Local Planner's Playbook for Medical Response to a Nuclear Detonation*[8] was developed. (HHS ASPR State and Local Planner's Guidance for IND)

The *State and Local Planners Playbook* is an interactive resource offered as a guide to assist local, state, regional, tribal and territorial medical and public health planners and other subject matter experts in preparing for a nuclear detonation. It provides sequential guidance and specific action steps to coordinate the medical response to a nuclear detonation and detailed time-phased, sector-oriented approaches to response activities with linked references. It is intended to assist emergency management planners and provide a linkage to overall federal medical and public health planning efforts.

Conclusion

The ESF guidance lists the specific agency responsible for particular responsibilities and capabilities whereas the NRF driven concept of operations (CONOPS) describes the steps required to perform medical and public health services. DHHS guidance from ESF #8 resulted in the development of "Action Steps" which are sequential response steps and highlight the collaborative, interagency and multi-jurisdictional operational activities and capabilities outlined in the NRF, in the DHHS Playbooks (not publicly available), and the *IND State and Local Playbook* (prepared specifically for State/Local/Tribal planners. These action steps were developed to guide emergency management leaders from pre-incident to tasks 96 hours after the incident. They were designed for response to a radiological detonation but can be applied to manage the medical and public health response to all hazards.

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Guide 11: Involving the Community: Operationalizing a Playbook, Engaging Regional Emergency Coordinators, and Considering Ethical Issues

Overview:

Planning for the medical and public health response to the detonation of an improvised nuclear device in a U.S. city is a complex process of coordinating and integrating resources, organizations, and capabilities from the full spectrum of federal, regional, state, local, tribal, and territorial responders. As the federal lead for medical and public health preparedness and response (ESF 8), the Department of Health and Human Services (HHS) Office of the Assistant Secretary for Preparedness and Response (ASPR), in conjunction with its partners and stakeholders, has developed the *State and Local Planners Playbook for Medical Response to a Nuclear Detonation*[1] (*State and Local Planners Playbook*) as a web-based, interactive guide for planning. This Guide describes the genesis and use of the *State and Local Planners Playbook*, how to contact and work with DHHS Regional Emergency Coordinators (RECs), as well as, an approach to addressing the ethical issues for communities conducting such planning.

Given the complexity of planning and preparing for an IND, the *State and Local Planners Playbook* has been created for regional, state, local, tribal, and territorial planners to facilitate their efforts so localities can add details to these documents as they develop their own plans. The Action Steps of the *State and Local Planners Playbook* provide users with a detailed list of actions and issues specific for that particular phase of the incident. Planners have the option of downloading an electronic copy of the text itself or using the interactive version online. The web-based version allows users to go directly to a specific phase or action issue. Lastly, the *State and Local Planners Playbook* examines the ethical decisions related to triage after a nuclear explosion with a scarcity of resources. It provides models on how to categorize patients ethically when conducting triage and examines patient's needs versus condition-based issues.

Background

The predicted structural damage and the morbidity and mortality following the detonation of an improvised nuclear device (IND) in a U.S. city are enormous. Careful pre-incident deliberate planning can help to more efficiently and fairly utilize already scarce resources and maximize lives saved.[2,3] Effective planning can improve coordination of various response assets and ensure vertical and horizontal integration of the response from the community level to and through the federal, regional, and state levels. DHHS is the coordinating agency for the federal Public Health and Medical Emergency Support Function (ESF) #8[4] under the National Response Framework[5] and the associated Nuclear/Radiological Incident Annex.[6] As such, ASPR has the responsibility to coordinate and conduct planning for the federal health and medical response to an IND detonation.

To meet this responsibility, ASPR has created an ESF #8 playbook for the anticipated federal response to an IND detonation. The *IND Playbook* is part of a suite of playbooks created to address each of the 15 National Planning Scenarios.[2] ASPR is in the process of coalescing these scenario-based playbooks into an All-Hazards Playbook that will reflect general similarities in response actions and have annexes to address the details unique to each scenario. The

playbooks provide strategic guidance for ESF #8 response and inform senior leadership by describing response operations that will require complex coordination of numerous entities and assets in a time-phased manner. The playbooks' sections which apply to all hazards focus on a spectrum of anticipated planning requirements and operations including:

- Scenario
- Concept of Operations
- Action Steps/Issues
- Pre-Scripted Mission Assignment Sub-Tasks
- Essential Elements of Information

Addressed are the core emergency response functions (management, command and control, logistics, planning, and operations) and ESF #8 operational activities and capabilities to provide for life-saving emergency medical care and support, restoration of the public health and medical infrastructure, patient evacuation and return, veterinary medical assistance, fatality management assistance, and human service and at-risk population needs.[7]

Community Planning and the State and Local Planners Playbook

The Federal Emergency Management Agency (FEMA) has produced guidance to facilitate the integration of state, local, tribal, and territorial planning with the anticipated federal response. The *Comprehensive Preparedness Guide 101*[8] describes ways to align community planning with the broader response should that community become overwhelmed and require additional assistance. In order to assist state and local medical planners in their own IND response planning and ensure that those plans link and integrate with the anticipated federal response, ASPR coordinated a group of experts from across multiple disciplines to adapt the *ESF #8 IND Playbook* and develop the ASPR *State and Local Planners Playbook for Medical Response to a Nuclear Detonation.*[1,9] The key principles of the medical and public health response to a nuclear detonation and other planning factors are summarized in the Background section of the *State and Local Planners Playbook* and include:

- Concept of Operations (CONOPs) using Damage Zones
- Number and Spectrum of Injuries
- Decontamination
- Response Worker Safety
- Triage
- Scarce Medical Resources and Standards of Care
- Organization of Medical Response
- Radiation TRiage, TReatment, and TRansport Response Organization System (RTR)
- Summary and Intent of Anticipated Operations
- Certain Response Considerations

Organization of the State and Local Planners Playbook

The *State and Local Planners Playbook* is intended to be scalable and customizable based on a specific jurisdiction's capabilities, requirements, and needs and will be periodically improved

and updated to reflect the most current knowledge, lessons learned, and changes in capabilities. The Action Steps section is provided by phase (see Figure 1) and provides sequential guidance to coordinate the medical response to a nuclear detonation at all levels. It is written in plain language and intended to better align jurisdictional planning methods and capabilities with the *ESF #8 IND Playbook*. The Action Steps section provides detailed time-phased, sector-oriented approaches to response activities with linked references.

Figure 1: Playbook Action Steps

Detailed time-phased, approaches to sector-oriented response activities with linked references.

The sectors used are:

- General Readiness Planning and Emergency Management
- Emergency Medical Services (EMS)
- Health and Facility Response, Public Health
- Medical System Response
- Evacuee Medical Care and Fallout-related Illness
- Recovery

Action steps are complete for each Sector so each can follow their steps and can also see what other Sectors are doing. Again, these are only meant as helpful guides or templates and can be adapted by each jurisdiction.

To use the State and Local Planners Playbook, planners have the option of downloading an electronic copy of the text itself or using the interactive version online. The downloadable version can be printed to provide a checklist for planners.

The Regional Emergency Coordinators

Regional Emergency Coordinators (RECs)[11] are the primary point of contact for state public health departments and emergency management agencies to assure the coordination and integration of a federal response relating to ESF #8. Jurisdictional planners will find the RECs to be a crucial link for assistance or coordination regarding IND or other planning efforts. The U.S. and territories are organized into 10 regions (Figure 2). RECs serve as ASPR's primary representatives in each of the 10 regions plus the District of Columbia.

Figure 2. FEMA Regions
(Region IX includes American Samoa, Commonwealth of the Northern Mariana Islands, Republic of the Marshall Islands and Federated States of Micronesia)

The main role of the RECs is to build relationships with federal, regional, state, local, tribal and territorial officials and health care representatives (partners and stakeholders) in order to conduct planning for effective federal emergency response for all hazards, and to facilitate coordinated preparedness and response activities for public health and medical emergencies. This is accomplished in a variety of ways to include:

- Enhancing cross discipline integration among public health and medical and emergency management partners;
- Providing situational awareness to headquarters;
- Responding to events and providing command and control for deployed Departmental resources and assets; and
- Providing exercise support to stakeholders.

Incorporating Ethical Decision Making Into Planning

Saving lives is the primary mission in planning and response to an IND and triage is a major driver of that mission.

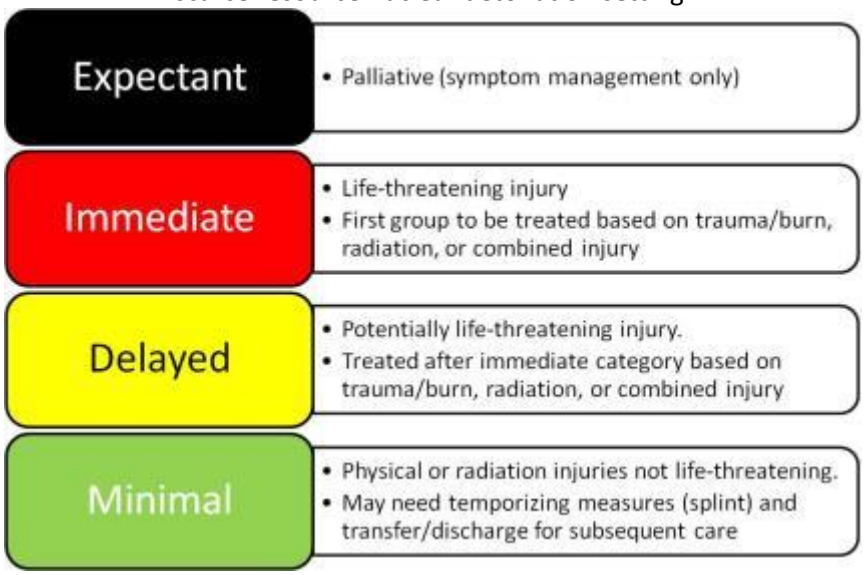
Success in this mission will be strongly impacted by the extent and location of the incident, pre-planning, responder training, public co-operation, and the anticipated temporary scarcity of resources that will happen at the beginning of the incident. Senior leaders will have to consider certain trade-offs that will be necessary to achieve the best possible outcomes.

Perhaps the most difficult issue for medical decision-making is triage under chaotic, austere circumstances by physicians and other triage personnel untrained in this aspect.

The 4 victim triage categories applicable to the scarce resources setting are in Figure 3 (adapted from Coleman[12]). The categories are slight modifications of the categories used in non-scarce

resource settings, for example, minimal may need medical care but not immediate life-saving care. Triage cards and system are included in Guide 6: Acute Radiation Syndrome: Medical Guidance and National Response. For more detailed information see REMM website.

Figure 3. Triage Categories for Nuclear Detonation: Scarce Resources Setting.
This is a modification of triage categories from "standard systems" to accommodate the mass casualty, scarce resource nuclear detonation setting.



The order of triage depends on the medical condition and the scarcity of resources, as discussed in Coleman[12] and Coleman[13] and illustrated in Guide 6. As resources become increasingly scarce, the resource-rich order of "always sickest first" may be modified by goals of fair treatment.[3, 14]

An interactive tool that can implement this set of triage categories is found on the REMM website REMM on-line Triage Tool.

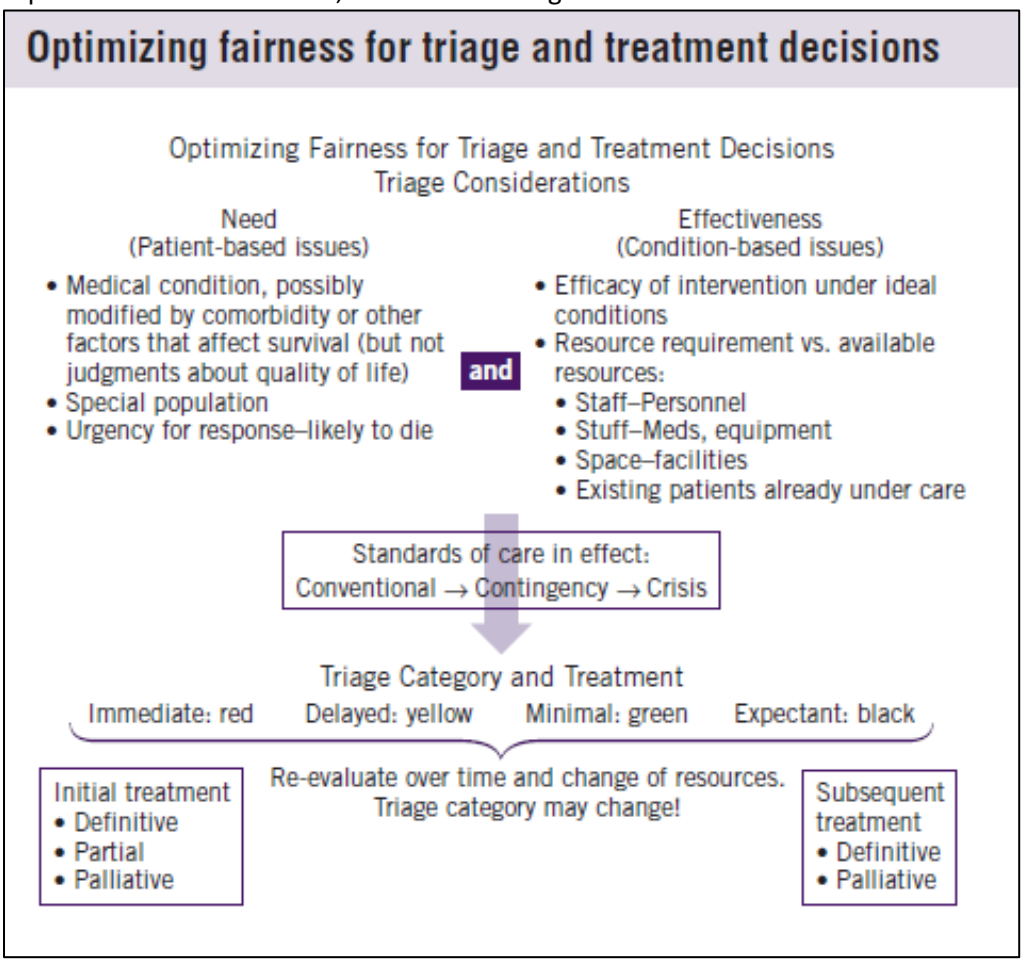
Fairness is the key factor in ethical decision-making.[14] The importance of community- and region-wide participation in planning is critical to establishing a response that will be judged as fair. Figure 4, below, is somewhat complex, but illustrates the issues that go into a triage decision:

1. "Need" is based on the medical condition
2. "Effectiveness" determines whether the need can be met under the circumstances. This depends on the efficacy of the intervention and on the resources available to deliver it.

For example, someone with severe abdominal injury who is critically ill might require extensive surgery, blood transfusions and post-op care might be the "sickest" and therefore would ordinarily be the first or highest priority receive medical care (triage to **Immediate**). This might save his/her life 80% of the time in normal circumstances. However, in austere circumstances, there may be a diminished blood supply, and few health care personnel or operating room available. If this one person used extensive resources, care might be unavailable for 20 other

persons. So instead of i**mmediate**, this patient might need to be triaged to **delayed or expectant**, so more people can be attended to, and the goal of the greatest good for the greatest number is selected, rather than treat the sickest first. As more resources arrive, re-evaluation of this individual might be changed from **Delayed** or **Expectant** to **Immediate.**

Figure 4. Optimizing Fairness for Triage and Treatment Decisions. The medical need depends on the person's clinical condition, whether resulting from the nuclear detonation or not**.**



A special issue published in *Disaster Medicine and Public Health Preparedness*[12, 14] from March 2011 discusses the allocation of scarce resources resulting from an IND in further detail. Ideally, community preparedness would include discussion and consensus regarding the conditions that would change a person's priority for treatment (e.g., previously comatose).

To initiate discussion and attempt consensus building prior to a nuclear event, public health officials and disaster response professionals are encouraged to begin compiling information—through focus groups or opinion polling—about the interests and preferences of various communities related to the utilization of scarce medical resources. Focus groups participants can include specialized populations in a specific geographic area with similar disease conditions, social characteristics, or religious beliefs. These group discussions can be useful in developing a

cache of information, building consensus where possible, and providing immediate direction for local hospitals regarding clinician training and dissemination of information to the public.

Conclusion

Given the complexity of planning and preparing for an IND, a modifiable *State and Local Planners Playbook* has been created for regional, state, local, tribal, and territorial planners to facilitate their efforts.[1] The RECs form the link between the state/local planners and responders and the federal ESF #8 response. Localities can add details to these documents as they develop their own plans.

Plans should reflect the assumption that medical resources in the region surrounding a nuclear detonation will be scarce, at least for the first few days. The subsequent inability to meet patients' needs will require medical triage to be modified from the usual "sickest first." These are very challenging decisions, and best discussed well in advance.

Guide 11 - Authors

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Guide 12: Communicating About a Nuclear Detonation

Overview:

The fear and confusion following a nuclear detonation could lead people to take actions that inadvertently put them in greater danger. Lack of understanding of radiation, its effects, and how it is measured can enhance the short- and long-term anxiety. Communicating a clear and effective message is a challenge, and it is critical for reducing panic and saving lives. Response requires pre-scripted messages, expert spokespersons, credible experts, and rapid restoration of an effective communications infrastructure.

Specific suggestions for communicating effectively after an improvised nuclear detonation (IND) have been previously published.[1-7]

One challenge after a detonation will be making sure the communication infrastructure remains sound after the incident. Officials must ensure there alternate avenues of communication are in place in case there is significant damage to the infrastructure. Planners must consider the allocation of resources to supply information to these outlets and which outlets to use to gather situational awareness information.

Background

After a nuclear detonation, public safety depends on the ability to quickly communicate appropriate safety measures.

The Centers for Disease Control and Prevention (CDC) has created and user tested a simple, clear public message for use after a nuclear detonation: *Get Inside, Stay Inside, Stay Tuned*.[7]

Empowering people with information to protect themselves and their families can save thousands of lives.

People will be affected in different ways and will have different information needs depending on their proximity to the blast and fallout plume, and their ability to hear and understand official information. For further details see Figure 1 and Table 1 Guide #2.

> ***Blast Damage and Dangerous Fallout (DF) Zones:*** People in these areas need life-saving information. Anyone who might be in the path of the radioactive plume must quickly get inside and stay inside to avoid a potentially fatal dose of radiation.
>
> ***Surrounding Area:*** People in this area will be concerned for their immediate health and safety and will want to know what they should do. The surrounding area will also be faced with concerns about contaminated people and vehicles entering their communities. These communities will also serve as reception communities for evacuees.

National and International Communities: People in other parts of the nation and across the world will be seeking information and trying to get in touch with loved ones who may be in affected areas. There will be concern about a second attack. This is an opportunity to provide situation and response updates, educate the population about appropriate safety measures, and address concerns about the perceived health and other risks of those outside the affected areas.

Key goals of health officials and clinicians will change over the course of the incident. Initial activities include:

- Promote shelter in place for the first few hours;
- Enable first responder rescue teams to access those in need safety;
- Identify and manage the threat ;
- Maintain and restore public order and infrastructure; and
- Facilitate medical and personal care for those affected.

Over time, it will become necessary to identify and remove contamination and control its spread. Guidance about recovery are found in the U.S. Environmental Protection Agency's (EPA) Protective Actions Guides (PAG) manual.[8]

Effective communications will be a key factor in facilitating the achievement of these activities.

Messaging About Protective Actions and Radiation

Messages prepared, tested, and practiced in advance are fundamental to conveying clear, consistent information and instructions during an emergency. Many of the questions the public will have after a nuclear detonation can be anticipated and answered in advance.

When anticipating questions, planners must keep in mind both the broad audiences (listed above) as well as audiences with special communication needs (e.g., responders themselves with concerns about protecting their own health, residents with limited English proficiency, hospital and nursing home staff and patients, pregnant women, homeless populations, etc.). To some extent, each audience will have specialized information needs, and long-term messages should be able to be tailored to meet those needs.

In a nuclear incident, people may be primarily concerned with protecting themselves and their families. Protective action messages should provide simple, direct instruction to people in the affected areas about how to do this.

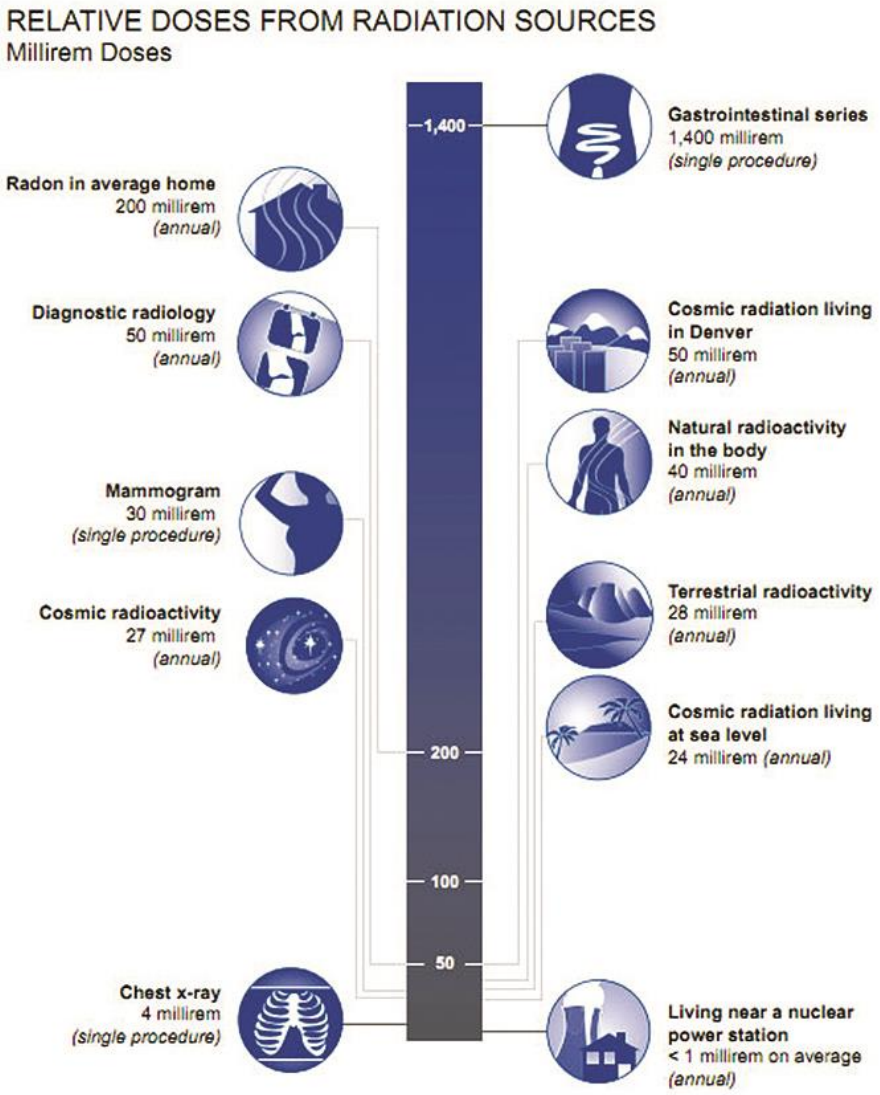
Audience research provides the following recommendations for messages:

- Write short, concise, and actionable messages;
- Use directive and authoritative language;
- Provide prioritized instructions and directions in each message;
- Provide information for a variety of environments;
- Create a message to encourage people not to leave their homes to check on loved ones in schools, daycares, and elder-care facilities;
- Acknowledge that there is a process in place to recover from this incident.

- Be consistent, compassionate, and respectful;
- Avoid or define unknown terms and phrases;[9]

To help people understand information about the radiation threat, it is important to put the levels being detected in the context of the radiation we live with every day. Experience with the U.S. response to the Japanese nuclear plant emergency in 2011 highlighted the public's desire for information about "how much" radiation they might be exposed to and how that compared with other radiation exposures.[10] Figure 1 is a useful illustration for helping to accomplish communicating what a certain dose of radiation means.

Figure 1. Doses from Common Radiation Sources. Source: U.S. Environmental Protection Agency. Relative doses from radiation sources. Available at: EPA Site for Common Radiation Sources



NOTE: Both units rem and Sv are used, Sv preferred internationally. 1 Sv = 10 rem; Units are discussed in Appendix A. Normal background radiation is ~6mSv/year. Discussed in detail in Manual 11

Notes of caution:

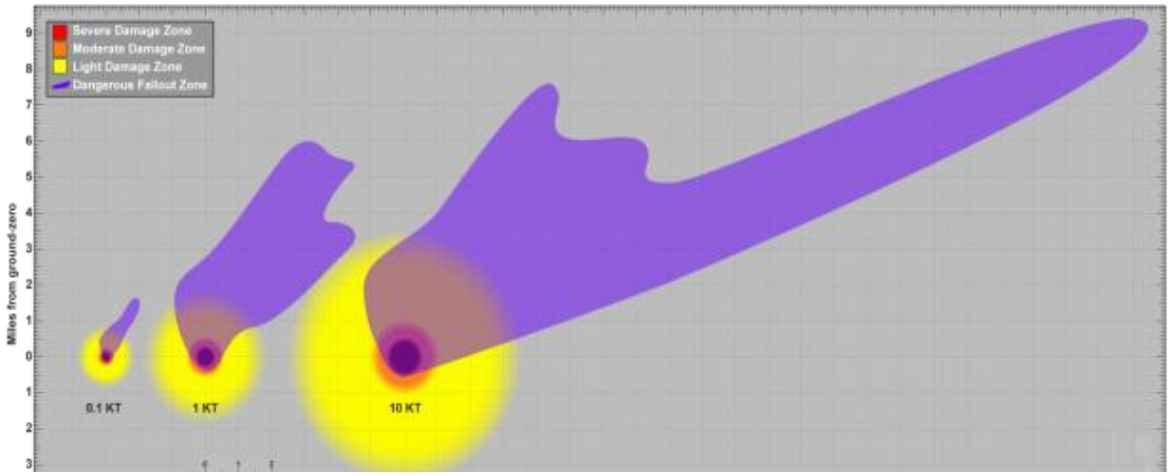
- Some individuals may find the comparisons to other radiation exposures to be minimizing their concerns.
- Expert spokespersons should be available to discuss radiation and risk at a sophisticated level and be able to explain and/or counter partial or incorrect information that may be in the media.

Communications Infrastructure

A key concern following a nuclear detonation incident will be the integrity of the communications infrastructure. How will officials communicate messages to affected audiences? The difficulty that will inevitably follow a nuclear detonation drives home the importance of pre-event preparedness. Officials anticipate the following infrastructure issues.[11]

***Blast Damage Area*:** In the physically damaged areas (see Figure 2) there will be minimal, if any, ability to send or receive communications. All communications capabilities will be destroyed or severely hindered from the blast damage to the communications systems. Electrical, phone, and cellular systems will be down, and an electromagnetic pulse (EMP) will devastate electronics in the physically damaged area and possibly beyond. Televisions, computers, laptops, tablet computers, cell phones, and smartphones may also be impacted. Phones that do withstand the EMP impact will likely be in the hands of survivors, because the person possessing it is sufficiently sheltered underground. However, this deep shelter could render cell phones or other devices useless until an individual finds a way to the surface, which could subject him or her to life-threatening radiation exposure. It may be days before communications capabilities are reestablished.

Figure 2. Nuclear Detonation Impact Zone and Action Area. Source: National Security Staff Interagency Policy Coordination Subcommittee for Preparedness and Response to Radiological and Nuclear Threats. Planning Guidance for Response to a Nuclear Detonation. 2nd edition. June 2010. Available at: REMM Fallout Models



After a nuclear detonation, people in the blast damage zones will have limited or no communications abilities. However, the majority of treatable injuries will be in the zones that will likely have intact infrastructure including light damage zone and dangerous fallout zones.

Along with commercial systems, public safety systems in this area (e.g., land and mobile radio and 911 call centers) may also suffer communications failures. Although these systems are typically more robust and less susceptible to failure than their commercial counterparts, they will be severely damaged or degraded in the blast and surrounding areas. These systems are critical to emergency responders for life-saving and rescue operations and must be restored as quickly as possible.

As part of the federal response to a major disaster, the Federal Emergency Management Agency (FEMA) will activate the Communications Annex of the National Response Framework, Emergency Support Function #2, to coordinate with the private sector, state, and local entities in restoring the commercial communications infrastructure and public safety and emergency responder networks.[12] Industry continually monitors its own networks for outages and reduced capabilities and will usually begin recovery operations relatively quickly. Commercial providers typically have transportable restoration capabilities (e.g., cellular on wheels and cellular on light truck) strategically located around the country to minimize response times. With proper planning and preparedness, public safety and emergency responder networks can be augmented and/or temporarily restored through assets that the state, National Guard, and surrounding localities may be able to provide. As part of the federal response, FEMA can typically have communications assets on the ground in the contiguous 48 states within 24-48 hours after an incident.

Surrounding Area: The surrounding area may include surrounding communities, counties, bordering states, and people in the path of the radioactive plume, including the dangerous fallout zone. After a nuclear detonation, there is the potential for cascading effects along transmission lines in this area caused by EMP, which may extend hundreds of miles from the detonation site. This could mean electrical, phone, and Internet outages. *The EMP should have limited, if any, effect on electronic devices in the surrounding area and DF zone outside of the blast damage zone. Electronic devices may only require resetting switches and circuit breakers.* Reception communities may not have significant infrastructure issues, but connectivity will be essential for them to adequately prepare for receiving potentially thousands of evacuees.

National and International Communities: In any major national emergency, a sudden increase in the need for information and human connectivity can severely stress and sometimes exceed the capacity of the communications infrastructure. This will hinder the ability to communicate into or out of the physically damaged areas, the regional DF zone, and possibly the surrounding vicinity. Planners must know what types of systems are available to enable responder communications in case normal communications methods are unavailable.

Communication Channels

In a nuclear denotation, every available information outlet must be used to gather information about the health and safety issues the community and responders face; to provide guidance to affected populations; and to address health, economic, safety and other concerns of people across the country and throughout the world. **Information outlets include electronic and hard copy billboards, reverse-911 systems, Emergency Alert System, short-wave radio, siren warning systems, radio, television, newspapers, flyers, public announcement (PA) systems,**

text messages, and social media and websites. Planners must consider the allocation of resources to supply information to these outlets and which outlets to use to gather situational awareness information.

Radio broadcasts may be the most effective means to reach people closest to the nuclear explosion. Emergency Alert System, National Oceanic and Atmospheric Administration (NOAA) weather radio broadcasts, reverse 911 systems, flyers, PA systems, short-wave radio, and siren warning systems may be useful in rapid dissemination of emergency information in the affected area. Although additional outlets, particularly electronic outlets, are more likely to be useful away from the blast site, these outlets should be considered in emergency communications plans.

A 2014 Pew Research Center report found that 90 percent of adults in the U.S. own a cell phone, and 64 percent have a smartphone. As of May 2013, 63 percent of adult cell owners used their phones to go online, and 34 percent of cell internet users go online mostly using their phones and not using other devices such as computers.[13] Among internet users, 74 percent reported using social networking sites; 71 percent of online adults are on Facebook and roughly half of all online adults 65 and older use Facebook, representing 31 percent of all seniors in the United States.[14] In addition, half (50 percent) of social network users shared or reposted news stories, images or videos while 46 percent discussed news issues or events on social network sites.[15] With broader mobile adoption, residents play important eyewitness roles in news events; roughly 1 in 10 social network users reported posting news videos they took themselves.[15]

Table 1. Social Media Usage (2014). Social media usage is also increasing for all age groups.[14]

Age	Percent Using Social Media
19-29	89%
30-49	82% (up from 61% in 2010)
50-64	65% (up from 47% in 2010)
Over 65	49% (up from 26% in 2010)

These figures suggest that disaster communications plans must include use of social networks in disaster response. In addition to serving as information outlets, these internet sites also provide responders with situational awareness during the disaster response and recovery.

These figures suggest that disaster communications plans should include use of social networks in disaster response. In addition to serving as information outlets, these internet sites also provide responders with situational awareness during the disaster response and recovery.

Planners should also enlist community and national organization partners, including faith-based organizations, to support communications efforts in a nuclear emergency response. Given the magnitude of the communication task in such a response, partners can serve as force multipliers—providing information between organization members and emergency response

agencies. Most people look for confirmation from five sources before evacuating an area,[16] and trusted partners can provide this confirmation, encouraging evacuation as well as compliance with other health and safety actions.

Table 2. Communication Channels by Target Audience. C*ommunication channels can and should be approached with partners who can amplify the message and serve as force-multipliers for emergency responders.*

Public Information Target Audience	Suggested Communication Channels
Blast Damage Zone	Radio Short-wave and NOAA weather radio Public announcement (PA) systems Flyers Siren warning systems NOAA weather radio Door-to-door Monitor social media for situational awareness
Dangerous Fallout Zone	Radio Short-wave and NOAA weather radio Regular radio Public announcement (PA) systems Siren warning systems Electronic billboards Flyers 911 systems Monitor social media for situational awareness
Surrounding Area	Radio Television Newspapers Text messaging systems Electronic and hard-copy billboards Social media Websites Flyers
National and International Communities	Social media Television Newspapers Magazines Websites

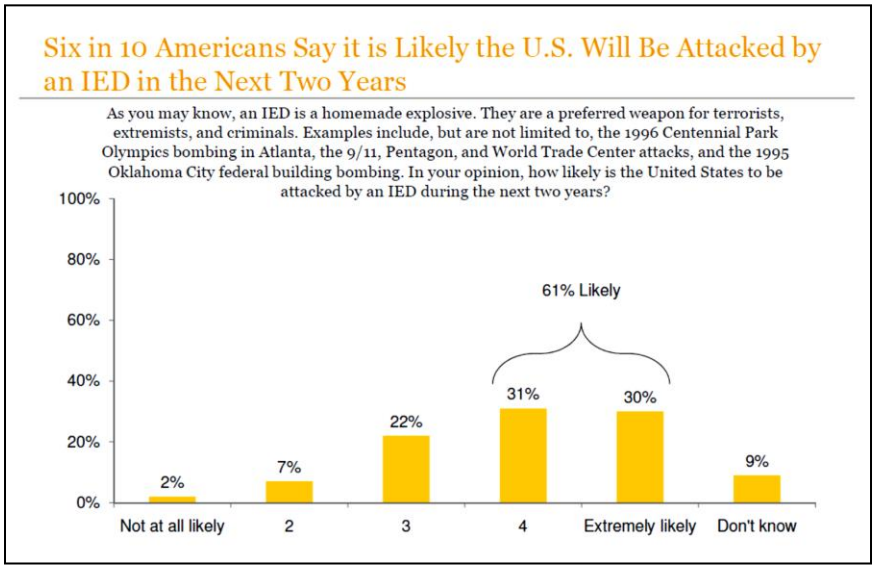
Challenges to Preparedness and Opportunities for Planning

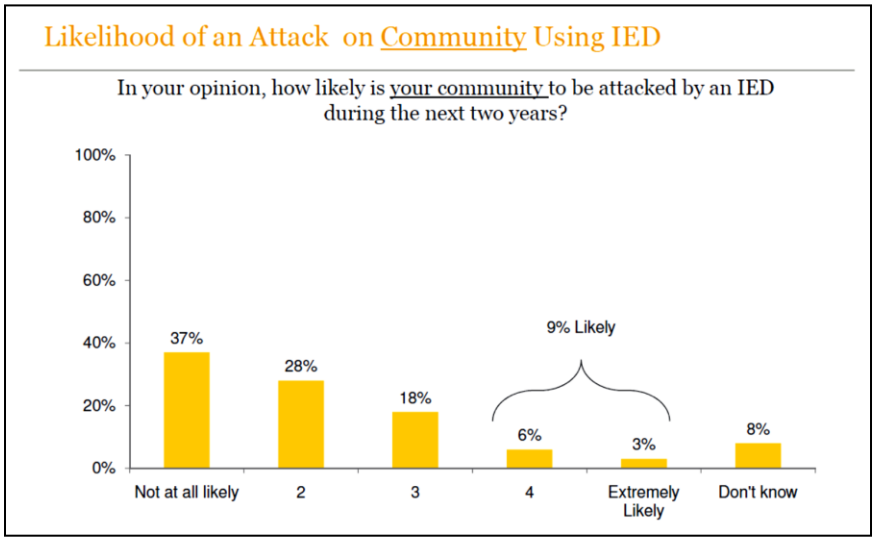
Given the critical need to communicate rapidly and effectively following an IND incident, pre-event planning is essential. However, significant challenges exist.

In a Gallup panel (Figure 3) including more than 25,000 individuals from across the country, 61 percent of people believed an improvised explosive device would be used in an attack on U.S. soil in the next two years; however, only 9 percent believed it would happen in their community. One of the greatest challenges to getting the public to prepare for any type of

terrorist incident is finding ways to motivate a public who believes the threat is real, but does not believe it will impact them.[17]

Figure 3. Perceptions of Local Impact. Source: *Printed with permission from Gallup*





In addition, there is a legacy of public emergency preparedness campaigns, such as the Cold War's "duck and cover" and the more recent "plastic sheeting and duct tape," that leave the public confused or even skeptical of preparedness messages. Many people do not believe that a nuclear detonation is survivable. This sense of futility, fatalism, and hopelessness severely impacts the public's desire and ability to absorb information and follow instructions.[18] Many people do not own or have access to emergency radios, which may lead to problems communicating protective actions and safety information.

Opportunities to educate the public about radiation and IND preparedness do exist, including:

- Taking advantage of other pre-incident education campaigns, such as National Preparedness Month or FEMA's Radiological Emergency Preparedness (REP) Program[19] educational campaign around nuclear power facilities.
- Thinking All-Hazards. The key protective action message *Get inside, Stay inside, Stay tuned*[7] applies to more than just nuclear detonations. This type of all-hazards messages can apply to any emergency situation where people need to get off the streets and listen for instructions before taking action. Response to a nuclear detonation has similarities to sheltering for tornadoes.
- Focusing on target audiences and community leaders who are the people most likely to act on the information and influence those around them. Market research conducted by FEMA in 2013 indicated that people are more likely to take preparedness steps if they participate in drills and when information about preparedness comes from organizations of which they are members, such as workplaces, civic organizations, and faith-based organizations.[17] Target audiences may include workplace supervisors and business owners who can inform employees and encourage appropriate protective actions and require drills and readiness activities at work; religious leaders who can inform their congregations and plan drills and readiness activities for places of worship, and first responders who can educate their communities.

Educate responders on radiation and protective measures.

Educating responders on radiation and protective measures serves two purposes. First, this information increases their comfort level and willingness to participate in response and recovery operations. Second, responders may serve as credible sources of information to their families, communities and the media, including social media. They will need accurate information to provide about the incident and about personal protective actions people can take.

Communications will be a driving factor in the response to and recovery from a nuclear detonation. Planning and preparedness are essential for effective messaging and a resilient communications infrastructure in such an emergency.

Additional Communication Resources:

Centers for Disease Control and Prevention. Communicating in the First Hours: Initial Communication with the Public during a Potential Terrorism Event. Available at: CDC Terrorism Communications Guidance

Centers for Disease Control and Prevention. Public Service Announcements for Disasters. Available at: CDC Public Service Announcement Guidance

Centers for Disease Control and Prevention. Crisis & Emergency Risk Communication (CERC). Available at: CDC Crisis Communications Guidance

U.S. Environmental Protection Agency. Communicating Radiation Risks: Crisis Communications for Emergency Responders. June 2008. Available at: EPA Radiation Risk Communication Guidance

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Guide 13: The Increasing Role of Technology in Educating Responders and Planners about Mass Casualty Radiation Emergencies

Overview:

The complex knowledge required for planning for and responding to medical aspects of a mass casualty radiation incident includes understanding at least the following: (1) the types of radiation emergencies that might occur, (2) how responses to "small" and "large" incidents differ, (3) the basics of radiation physics, (4) the difference between exposure and contamination, (5) how to diagnose and manage external and internal contamination, (6) how to diagnose and manage acute radiation syndrome, (7) principles, practices, and regulations of radiation safety including the proper use personal protective equipment, and (8) the basics of long-term effects of radiation exposure.

The actual depth of knowledge required will vary considerably, depending on the actual professional role during the incident (e.g., subject matter expert, emergency physician, trauma surgeon, health physicist, nurse, first responder in the field, regional response planner, staff at community reception centers and field medical stations). Even medical support personnel in hospitals who do not perform direct patient care will also need some training, as will workers in public safety, public health, public transport, and public utilities. This Guide will focus only on those involved in planning for or delivering patient care.

A variety of types of radiation incidents require this specialized medical knowledge. A nuclear detonation is a complex, low-likelihood, high-consequence incident. Incidents with potentially large but less catastrophic consequences include industrial and transportation incidents, nuclear power plant incidents, large accidental medical exposures, and incidents related to terrorist-instigated radiological dispersal or exposure devices.

While customized pre-incident radiation education and training are available for the full range of health care responders and others, these resources have been significantly underutilized for a variety of reasons. In addition, there are sparse data about effectiveness of the training and how often it needs to be repeated for each type of responder. Currently there are major gaps in what responders do know and what they need to know. This Guide addresses the nature of the gaps and a variety of potential approaches needed to narrow it.

Formulating the Problem: Information Gap

Complex, high-impact, low frequency incidents

Radiation emergencies are more complicated, potentially higher impact, and but much less likely to occur than many other kinds of mass casualty health emergencies that responders and planners routinely face. Recently, the term "black swan" has been applied to incidents of this nature.[1] "Black swan" incidents are not widely anticipated or planned for. Although high impact, mass casualty radiation emergencies are receiving increasing attention among the senior leaders of the medical planning and healthcare response communities[2], radiation-

specific training for the vast majority of planners and responders has lagged behind all-hazard training for other types of mass casualty emergencies.[3]

Lack of knowledge among healthcare workers charged with planning and responding
First responders, first receivers, and planners for radiation mass casualty emergencies need to acquire and maintain radiation-specific knowledge and skills over and above what they know from training for "all hazard" emergencies. At present, there is no universal agreement about the exact nature of the potential core radiation curriculum for the various types of responders. Moreover, few emergency or healthcare personnel have ever responded to or practiced for any type of radiation mass casualty emergency in formal drills or exercises.

Most health care responders with direct patient care responsibilities probably need to learn at least the basics about following:

- The types of radiation emergencies that might occur[4]
- How responses to "small" and "large" incidents differ
- Radiation physics[5]
- The difference between exposure and contamination[6]
- How to diagnose and manage external and internal contamination[7]
- How to diagnose and manage acute radiation syndrome (ARS)[8]
- Principles, practices, and regulations of radiation safety including the proper use personal protective equipment[9]
- The basics of long-term effects of radiation exposure[10]

These knowledge gaps, along with worsening resource constraints, have complicated the development and implementation of detailed radiation emergency response plans. Furthermore, the statutes and regulations that govern federal, state, and local authorities and responsibilities during such incidents are complicated[11], making it difficult to create regulation-compliant, coordinated, realistic, detailed, and implementable plans for all entities that will be involved, including those in the private sector.

Reluctance to engage

Reluctance to train for and respond to radiation mass casualty emergencies has been reported, possibly resulting from one or more commonly held beliefs, including[12-15]

- Radiation medicine is too complicated for me to understand.
- If I learn this material I will forget it, especially if I don't use it.
- My personal risk during and after responding will be too high to participate in the response.
- Protecting and being with my family is my highest priority.
- Radiation response is the job of federal workers.
- Rescuing victims of radiation exposure is futile.
- We don't have the all the equipment and personnel necessary to do this correctly.

Approaching the Solution: Education and Training

Education and training[16-19] can address some of these gap issues, using both traditional and non-traditional (technological-based) means, as set forth in Tables 1 and 2, below.

Table 1. Advantages and Disadvantages of Traditional Education and Training

Traditional: Face-to-Face, Synchronous Classroom Learning
Advantages

• Classroom courses are currently available from many local, state, and federal agencies, [16-18] as well as professional societies, educational institutions, hospitals, and worker associations.
  • Resource materials for these courses are usually vetted by the offering agency/professional society/government agency.
  • Basic concepts are taught along with practical skills, including:
  ○ How to select, calibrate and use radiation survey equipment
  ○ Proper selection, donning, and doffing of personal protective equipment (PPE)
  ○ Selection, wear, and use of personal dosimeters appropriate for each response role
  ○ How to work in teams, especially within the Incident Command System (ICS) [20] and Hospital Incident Command System (HICS) [21]
  • Large government agencies medical credentialing entities can include questions about radiation emergencies in initial re-certification examinations.

Disadvantages

• Expense
  ○ Presenting courses in real time is expensive for agencies.
  ○ Face-to-face classroom training is expensive for students in terms of both money and time away from the job.
• There are relatively few subject matter experts in this field.
• Content must be updated regularly as administrative regulations/plans/procedures are updated and as medical practice advances.
• Official documents about radiation emergencies that underlie these training requirements are lengthy and beyond the expertise of most of trainees, even sophisticated medical responders.[11] Most responders and planners cannot be expected to read and understand them.
• Understanding and retention of complex, seldom-used content is poor.

Table 2. Advantages and Disadvantages of Non-Traditional Education and Training

Non-Traditional (Technology-Based) Educational Resources
Advantages
• Various electronic assets that provide radiation medical training and response already exist including websites and online courses,[16-19, 22-23] as well as content for mobile devices [24] Multimedia (photos, videos, animations) can enhance the efficiency and effectiveness of learning about complex radiation concepts and how to perform tasks.[25] • Novel teaching techniques can enhance interest in this topic and initiate learning in this topic (e.g., role-playing animated modules).[26] • Asynchronous learning is available 24/7, at the convenience of the student, and usually at a smaller cost than classroom training. • "What you need to know" can be provided to planners and responders "just-in-time" at the time of the incident, when they are highly motivated learners. • Agencies leveraging technology assets (personnel and physical) can potentially save time and money, if the scale is large. • Content can be customized to the needs of the student (e.g. physician, nurse, EMT, etc.). • Content updates can be disseminated more cost effectively than with print. • Mobile devices (smart phones) are ubiquitous, useful, and may be carried by many responders during the response[24]. Both interactive apps and content can be stored on smart phones. Tablet devices enhance the ability to carry content offline into the field. • Using continually updated, expert clinical management guidelines can assist clinicians working outside their usual scope of practice. This is familiar to clinicians, as algorithms are commonly used in medicine [6]. Customizable templates for creating radiation emergency plans have been created that assist state and local medical agencies in developing their own response plans.[27-30] Final plans can then be published online in appropriately redacted or access-limited form.
Disadvantages

• Expense
  ○ There can be a major initial financial cost to create or purchase complete learning management enterprise platforms for large numbers of users.
  ○ Responders and planners enter training with widely differing needs, expertise, and sophistication. Customizing content for diverse audiences adds expense.
  ○ Building content for multiple mobile platforms is expensive.
• Pre-packaged, commercially generated course content may not match the procedures, plans, assets, and personnel of each venue.
• Downloaded content can become obsolete. Users need to be notified as content changes to update previously downloaded materials.
• Technology alone cannot totally replace face to face training for many things, including
  ○ Formal training in teams
 	
Assessment of certain physical and cognitive skills like donning and doffing of personal protective equipment, the use of devices measuring radiation)

Technology can also assist with planning for and managing actual radiation incidents. A detailed description of all existing tools is beyond the scope of this chapter, but examples of such radiation incident management technology advances are available.[24] Some of the radiation-specific and all-hazard technological tools that are available are listed below:

Radiation Specific Tools

Hazard analysis with modeling and geographic information systems (GIS) helps managers make better decisions. These can include:

- Maps with measured and estimated location-based radiation exposure levels (and other hazards) over time.
- Maps with likely doses to the public and responders located in a specific area.
- Software to assist with clinical assessments of:
    - Radiation dose (both external[30-32] and internal[30-31]) based on clinical and/or laboratory tests.
    - Risk assessment of potential long-term adverse health effects like cancer[33]

It should be noted that few, if any of these software tools have been approved for clinical use by the U.S. Food and Drug Administration (FDA), and standard texts should also be consulted for estimating clinical dose from exposure and internal contamination.

All-Hazard Tools

- Communication systems that:
    - Create and disseminate iteratively the accurate common operating picture among all responders
    - Enable faster, better, more secure command and control
    - Share operating plans, situation reports, task assignment details
    - Manage incident intelligence
- Social media assists information sharing [34-37]
    - Incident managers can acquire and process information rapidly from the public and disseminate accurate information back to the public.
    - Public and private enterprises can enhance rapid communication within organizations
- Electronic rostering of victims and responders for current and future management
- Methods of finding and reuniting separated family members
- Electronic health records that are easily transferred when victims move
- Detailed reference materials accessible to everyone

So What Is The Solution?

No single approach will fill all radiation training and education needs for each of the health care workers responding to mass casualty radiation emergencies. Each group of planners and responders and each venue will have to customize what they do to be "ready," given their unique set of risks, responsibilities, and assets. Subject matter experts and educators need to

create useful, understandable, well-vetted, and up- to-date radiation medicine curricula that can supplement standard all-hazard training.

Trainers should be aware that technology could provide efficiencies for teaching, learning, credentialing, and responding, especially with "just-in-time" information available on mobile platforms. Nonetheless, it is crucial for students to access authoritative, vetted information, since misinformation is common on the Internet, especially regarding radiation emergencies and their management. One recent example includes the erroneous recommendations about the need for and benefits of potassium iodide in the United States during the 2011 Fukushima power plant incident in Japan.

Even after personal training is completed and repeated at appropriate intervals, healthcare planners and responders need to test and practice their skills and knowledge by participating in realistic, formal drills and exercises with the teams they will actually work with during the emergency.[38] Future enhancements in technology hardware, software, and networking will likely continue to improve managers' effectiveness and efficiency in complex incidents.

The U.S. Department of Health and Human Services (DHHS) has developed several websites, listed below which help fill radiation emergency information and training gaps.

- **Radiation Emergency Medical Management (REMM**) REMM website provides just-in-time information, and vetted background material. There are also clinical tools for responders. Training opportunities from a variety of sources are also aggregated. REMM Training Resources
- **Centers for Disease Control and Prevention (CDC)** focuses on radiation-related public health issues. Training opportunities are also provided. CDC Training Resources
- **Office of the Assistant Secretary for Preparedness and Response (ASPR)** focuses on integrating radiation issues into all-hazard preparedness and response. ASPR webpage

Excellent radiation emergency training is also available on site and off site from:

- Armed Forces Radiobiology Research Institute at the Uniformed Services University of the Health Sciences, Bethesda, MD. AFFRI Training Resources
- Radiation Emergency Assistance Center and Training Site (REAC/TS) at the Oak Ridge Institute for Science and Education (ORISE), Oak Ridge, TN. REAC/TS Training Resources

Conclusion

Although the response to radiation emergency mass casualty incidents is complex, there are new and more efficient ways to assist the responder and planning communities to prepare and respond to these "Black Swan" incidents.[1]

Guide 13 - Authors

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Guide 14: International Agencies, Networks, and Radiation Safety Guidance

Overview:

Any atmospheric release of radiation can become an international issue because radiation travels across borders and it can be detected by sensitive radiation sensors worldwide that monitor for potential nuclear testing and are able to detect very low levels of radiation.

This Guide includes the response capabilities of the major international agencies with whom the U.S. would interact and the response resources the U.S. would provide to other countries.

The lowest levels of radiation that can be detected are well below the amount that requires any protective actions; however, given the fear of radiation, when radiation is detected it often requires investigation, explanation, and public education. The World Health Organization (WHO)[1] (World Health Organization Webpage) and International Atomic Energy Agency (IAEA)[2] (IAEA Webpage), both under the United Nations (UN), develop recommendations for planning and preparedness and assist with networks that have expertise and laboratory capability for biodosimetry (Radiation Emergency Medical Preparedness and Assistance Network [REMPAN])[3] (REMPAN Webpage) and medical response (Response and Assistance Network [RANET])[4] (RANET Webpage) . Individual countries set their own "protective action guides" (projected upper dose recommendations used to limit exposure to workers and the public). These recommendations are based on expertise from professional societies such as the National Council for Radiation Protection (NCRP)[5] (NCRP Webpage) and the International Commission on Radiological Protection (ICRP)[6] (ICRP Webpage).

While all the guidelines are scientifically based, minor differences in dose limit recommendations and in radiation units used (by professional societies, country agencies [e.g. U.S. Environmental Protection Agency, Occupational Safety and Health Administration], cities, and states) can produce confusion when they are implemented.

US Response Capabilities

For responding to radiation incidents, the U.S. has teams from many agencies including:

- US Department of State: United States Agency for International Development (USAID) , Office of U.S. Foreign Disaster Assistance (OFDA), including the Disaster Assistance Response Team (DART)[7] USAID Response Webpage
- US Department of Energy (DOE) Radiological Assistance Program (RAP)[8] DOE RAP Program Webpage and Radiation Emergency Assistance Center/Training Site (REAC/TS)[9] DOE REAC/TS Webpage
- Expert teams from the other federal agencies including the Department of Health and Human Services (HHS), Department of Defense (DOD), Nuclear Regulatory Commission (NRC), and others.

Ideally, data sharing among the various groups will facilitate a coordinated response; however, the initial uncertainties from limited data and the minor differences in protective action

guidelines among nations may serve to produce speculation and some confusion, which the communications and nuclear experts will need to address. Two examples of interagency coordination for a nuclear or radiological incident are:

- **Federal Radiological Monitoring and Assessment Center (FRMAC)[9]**. FRMAC is to coordinate and manage all federal radiological environmental monitoring and assessment activities during a nuclear or radiological incident, within the United States in support of state, local, tribal governments, DHS, and the federal coordinating agency. Radiological emergency response professionals within the Department of Energy's national laboratories support the Radiological Assistance Program (RAP), National Atmospheric Release Advisory Center (NARAC), Aerial Measuring System (AMS), and the Radiation Emergency Assistance Center/Training Site (REAC/TS). (FRMAC Webpage)

- Int**eragency Modeling and Atmospheric Assessment Center (IMAAC)[10].** The Interagency Modeling and Atmospheric Assessment Center (IMAAC) coordinates and disseminates Federal atmospheric dispersion modeling and hazard prediction products. These products provide the Federal position during actual or potential incidents involving hazardous material releases. Through plume modeling analysis, the IMAAC provides emergency responders with predictions of hazards associated with atmospheric releases to aid in the decision making process to protect the public and the environment. Includes: FEMA, DoD, DOE/NNSA, NARAC, DHHS, EPA, NASA, NOAA and NRC. (IMAAC Webpage)

International Response Organizations

International Atomic Energy Agency (IAEA), United Nations[11] (IAEA Webpage)

The prime objectives of the IAEA's Response System are to facilitate:

1. Exchange of official real-time information among Member States/relevant international organizations;
2. Provision of assistance/advice to States/relevant international organizations upon request; and
3. Provision of relevant, timely, truthful, consistent and appropriate public information.

The **Emergency Notification and Assistance Technical Operations Manual (ENATOM)** defines the roles and responsibilities of the IAEA, the State Parties, and the IAEA Member States for being prepared and for responding to nuclear accidents and radiological emergencies. The IAEA maintains an Incident and Emergency Centre (IEC) that fulfills the functions that are placed on the IAEA by the Conventions and by relevant safety standards and decisions of the policy-making bodies.

Response and Assistance Network (RANET)[12] (**RANET Webpage**)

RANET's major objectives:

1. Strengthen the IAEA's capability to provide assistance and advice, and/or to coordinate the provision of assistance as specified within the framework of the Assistance Convention, and
2. Promote emergency preparedness and response capabilities for nuclear or radiological emergencies/incidents among IAEA Member States.

In the U.S., REAC/TS is currently the only deployable response team that supports RANET.

World Health Organization (WHO), United Nations[1] (**WHO Webpage**)

WHO works closely with the IAEA to prepare for and respond to nuclear accidents and radiological emergencies—principally to provide, consult, and coordinate medical assistance to victims of such events where severe radiation exposure has occurred. Advice can also be provided to national authorities on how to prepare and respond to such radiation accidents, or what kind of public health actions may be needed.

WHO REMPAN (**REMPAN Webpage**)

Emergency medical support for radiation exposed individuals is provided through the WHO's **Radiation Emergency Medical Preparedness and Assistance Network (REMPAN).**[3] REMPAN is activated following notification of a radiation accident with casualties from the IAEA or directly to WHO (even in the case of a single victim with severe overexposure).[13,14]

REMPAN's objectives:

1. To promote medical preparedness for radiation emergencies in WHO Member States;
2. To provide medical and public health advice, assistance, and coordination of medical management at international and regional levels in nuclear or radiological emergencies; and
3. To assist in follow-up studies and rehabilitation.

Assistance provided by Collaborating Centers and Liaison Institutes in radiation emergencies may include:

- Human Resources Specialists: Specialists in radiation medicine, health physics, radiology, hematology, and other appropriate specialties (e.g., burn departments), as well as skilled nurses and technicians.
- Equipment: Most centers are well-equipped to provide special medical assistance to overexposed persons. They have portable equipment for radiation monitoring.
- Medical Services: Assistance can be provided for the diagnosis, prognosis, medical treatment, and medical follow-up of persons affected by radiation.
- Scientific Services: Expertise can be provided to assess radiation doses to exposed persons (most of the REMPAN institutions have biodosimetry laboratories).
- Transportation: Advice can be provided on the transportation of affected persons.
- Specialized Teams: WHO can organize multinational teams to render medical assistance onsite.

WHO BioDoseNet[15,16] (**WHO BioDoseNet Webpage**)
WHO's BioDoseNet is a global network of biodosimetry laboratories whose role is to support management and decision-making in cases of large radiation emergency events where the capability of an individual laboratory is likely to be overwhelmed. In preparedness for such events, the BioDoseNet focuses on harmonization of methodology, quality assurance, knowledge-sharing, and intercomparision exercises.

Global Health Security Initiative (GHSI)[17] (**GHSI webpage**)
The Global Health Security Initiative (GHSI) is an informal, international partnership among like-minded countries to strengthen health preparedness and response globally to threats of biological, chemical, radiological, and nuclear (CBRN) terrorism and pandemic influenza. This Initiative was launched in November 2001 by Canada, the European Union, France, Germany, Italy, Japan, Mexico, the United Kingdom, and the United States. The WHO serves as an expert advisor to the GHSI. Technical and policy subject matter experts participate in working groups around specific areas of expertise:

- Risk Management and Communications Working Group
- Pandemic Influenza Working Group
- Chemical Events Working Group
- Radio-Nuclear Threats Working Group
- Communicators Network
- Laboratory Network

Members of the Radio-Nuclear Threats Working Group (RNWG) meet regularly in-person or via teleconference to share information on public health preparedness for radio-nuclear threats in their countries or organization.

US Agencies involved in International Response

Radiation Emergency Assistance Center/Training Site (REAC/TS)[12] (**REAC/TS Webpage**)
The Radiation Emergency Assistance Center/Training Site (REAC/TS), established in 1976 and operated by Oak Ridge Institute for Science and Education (ORISE), provides 24-hour direct or consultative assistance regarding medical and health physics problems associated with radiation in local, national, and international incidents.

REAC/TS is recognized as the established leader in the management of medical accidents involving radiation, both nationally and internationally. A team of leading experts in emergency management and radiation incident response, REAC/TS provides training and consultation to its clients, such as the U.S. Department of Energy (DOE) and the Centers for Disease Control and Prevention (CDC). REAC/TS capabilities include:

On-call 24 hours

A radiological emergency response team consisting of physicians, nurses, health physicists, coordination and necessary support personnel is on 24-hour call to provide first-line responders with consultative or direct medical and radiological assistance at the REAC/TS facility or at the accident site. Specifically, the team has expertise in, and is equipped to conduct:

1. Medical and radiological triage;
2. Decontamination procedures and therapies for external contamination and internally deposited radionuclides;
3. Diagnostic and prognostic assessments of radiation-induced injuries including DTPA and chelation therapy; and
4. Radiation dose estimates by methods that include cytogenetic analysis, bioassay, and in vivo counting.

Training

The REAC/TS facility serves not only as a treatment facility, but also a central training and demonstration unit where U.S. and foreign medical, nursing, paramedical, and health physics personnel receive intense training in medical management for radiation accidents. Regularly-schedule courses for occupational health and emergency medicine professionals, as well as health/medical physicists, include:

- Pre-Hospital Radiation Emergency Preparedness (PREP);
- Radiation Emergency Medicine (REM);
- Health Physics in Radiation Emergencies (HPREM); and
- Advanced Radiation Medicine (ARM).

International Response

REAC/TS participates with the international community via its designation as a WHO Collaborating Center of the REMPAN and the IAEA RANET. In addition, REAC/TS has provided continuing medical education and accident response to over 40 countries.

As a WHO Collaborating Center, REAC/TS can:

- Serve as a focal point for advice and possible medical care in cases of human radiation injuries;
- Facilitate the progressive establishment of a network of equipment and specialized staff in human radiopathology;
- Assist in the establishment of medical emergency plans for large-scale radiation accidents;
- Develop and carry out coordinated studies on human radiopathology and epidemiological studies that may be appropriate;
- Assist in the preparation of relevant documents and guidelines; and
- In the case of actual radiation accident, provide direct or consultative services to foreign governments at the request of WHO or IAEA.

U.S. Agency for International Assistance (USAID), Office of the United States Foreign Disaster Assistance (OFDA), Disaster Assistance Response Team (DART)[7]

OFDA is the office within USAID responsible for facilitating and coordinating U.S. Government emergency assistance overseas. OFDA provides humanitarian assistance to save lives, alleviate human suffering, and reduce the social and economic impact of humanitarian emergencies worldwide.

OFDA deploys DARTs in response to all types of natural disasters and other catastrophes where lives or livelihoods are threatened. These teams are assembled on an as-needed basis and include a range of experts from across the federal, state and local levels of government as well as the private sector. For example, in response to the nuclear accident in Japan, OFDA deployed a DART team consisting of urban search and rescue teams and technical experts in nuclear issues from across the U.S. Government.

Agencies from Health and Human Services (HHS)

The federal response structure is described in Guide 10: The Federal Response Structure and Plans: NRF, NIMS, ESFs, and Directives.[18] Expertise on radiological and nuclear response is available from the Office of the Assistant Secretary for Preparedness and Response (ASPR)[15] and the CDC.[16] These experts will assist international incidents by providing advice and deployment, if requested.

Office of the Assistant Secretary for Preparedness and Response (ASPR)[15]

DHHS leads and coordinates the overall federal health and medical response to an emergency, including supplemental assistance to state, local, tribal, and jurisdictional governments in identifying and meeting the public health and medical needs of victims of major disasters. It is coordinated by the DHHS Secretary principally through ASPR and the Secretary's Operation Center (SOC). The SOC operates 24 hours a day, 7 days a week, 365 days a year and serves as a focal point for synthesis of critical public health and medical information on behalf of the U.S. Government. Its responsibilities include:

- Response Coordination;
- Public Health and Medical Deployment;
- Situational Awareness.

Center for Disease Control and Prevention (CDC), Radiation Emergencies[20]

The CDC Radiation Studies branch and collaborating groups within CDC provides technical expertise, educational fact sheets, tool kits for health professionals and responders, information on population monitoring and community reception centers, and more.[21] The Agency for Toxic Substances and Disease Registry (ASTDR)[22] provides information and expertise on risk communication.

Protective Action Guides (PAG)[23]

A PAG is defined by the EPA as the projected dose to an individual from a release of radioactive material at which a specific protective action to reduce or avoid that dose is recommended as found in Table 1.1, Section 1.4 of the PAG Manual. PAGs are guides to help officials select protective actions under emergency conditions during which exposures would occur for relatively short time periods.

They are not meant to be applied as strict numeric criteria, but rather as guidelines to be considered in the context of incident-specific factors. PAGs do not establish an acceptable level of risk for normal, nonemergency conditions, nor do they represent the boundary between safe and unsafe conditions. The PAGs are not legally binding regulations or standards and do not supersede any environmental laws.

Emergency planners divide responses to radiological incidents into 3 phases of activity. The 3 phases are outlined in Section 1.4, page 5, of the PAG Manual.[23]

> **Early Phase** — The beginning of a radiological incident when immediate decisions for effective use of protective actions are required and must therefore be based primarily on the status of the radiological incident and the prognosis for worsening conditions. When available, predictions of radiological conditions in the environment based on the condition of the source or actual environmental measurements may be used. Protective actions based on the PAGs may be preceded by precautionary actions during the period. This phase may last from hours to days.
>
> **Intermediate Phase** — The period beginning after the source and releases have been brought under control (has not necessarily stopped but is no longer growing) and reliable environmental measurements are available for use as a basis for decisions on protective actions and extending until these additional protective actions are no longer needed. This phase may overlap the early phase and late phase and may last from weeks to months.
>
> **Late Phase** — The period beginning when recovery actions designed to reduce radiation levels in the environment to acceptable levels are commenced and ending when all recovery actions have been completed. This phase may extend from months to years. A PAG level, or dose to avoid, is not appropriate for long-term cleanup.

PAGs are established by a wide range of experts and jurisdictions. Background to the basics of radiation exposure and dose are described in Guide # 9: Health Risks from Exposure to Radiation: The Basics.[24] Protective action guides relate to the risk of developing a radiation-inducible cancer and are not related to the mitigation and medical countermeasures required for the acute radiation syndrome, described in Guide 6: Acute Radiation Syndrome: Medical Guide and National Response[25].

If the PAG dose could be reached by the public or is reached by responders, there are protective action recommendations to avoid reaching that dose. Tables 1 and 2 are U.S. guidance.[19] The National Council on Radiation Protection and Measurements (NCRP) assembles expert panels to address radiation issues.[27]

Table 1. EPA Summary Table for PAGs, Guidelines, and Planning Guidance for Radiological Incidents[a, i]

Phase	Protective Action Recommendation	PAG, Guideline, or Planning Guidance
Early Phase	Sheltering-in-place or evacuation of the public[b]	**PAG**: 1 to 5 rem (10 to 50 mSv) projected dose over four days[c]
	Supplementary administration of prophylactic drugs – KI[d]	**PAG**: 5 rem (50 mSv) projected child thyroid dose[e] from exposure to radioactive iodine
	Limit emergency worker exposure (total dose incurred over entire response)	**Guideline**: 5 rem (50 mSv)/year (or greater under exceptional circumstances)[f]
Intermediate Phase	Relocation of the public	**PAG**: $\geq$ 2 rem (20 mSv) projected dose[c] in the first year, 0.5 rem (5 mSv)/year projected dose in the second and subsequent years
	Apply simple dose reduction techniques	**Guideline**: < 2 rem (20 mSv) projected dose[c] in the first year
	Food interdiction[g]	**PAG**: 0.5 rem (5 mSv)/year projected whole body dose, or 5 rem (50 mSv)/year to any individual organ or tissue, whichever is limiting
	Alternative drinking water	**PAG**: pending finalization of proposal
	Limit emergency worker exposure (total dose incurred over entire response)	**Guideline**: 5 rem (50 mSv)/year
	Reentry	**Guideline**: Operational Guidelines[h] (stay times and concentrations) for specific reentry activities (see Section 4.6)
Late Phase	Cleanup	**Planning Guidance**: Brief description of planning process (see Section 5.1)
	Waste Disposal	**Planning Guidance**: Brief description of planning process (see Section 5.2)

[a] This guidance does not address or impact site cleanups occurring under other statutory authorities such as the United States Environmental Protection Agency's (EPA) Superfund program, the Nuclear Regulatory Commission's (NRC) decommissioning program, or other federal or state cleanup programs.

[b] Should begin at 1 rem (10 mSv); take whichever action (or combination of actions) that results in the lowest exposure for the majority of the population. Sheltering may begin at lower levels if advantageous.

[c] Projected dose is the sum of the effective dose from external radiation exposure (e.g., groundshine and plume submersion) and the committed effective dose from inhaled radioactive material.

[d] Provides thyroid protection from radioactive iodines only. The complete FDA guidance may be found at Full Text of FDA KI Guidance. Further information is also available: Q and A for FDA KI Guidance and FDA FAQ on KI .

[e] Thyroid dose. For information on other radiological prophylactics and treatment, refer to FDA Radiation Emergency Countermeasures Webpage, CDC Radiation Emergency Webpage and REAC/TS Webpage.

[f] When radiation control options are not available, or, due to the magnitude of the incident, are not sufficient, doses to emergency workers above 5 rem (50 mSv) may be unavoidable and are generally approved by competent authority. For further discussion see Chapter 3, Section 3.1.2.

[g] For more information on food and animal feeds guidance, the complete FDA guidance may be found at FDA Food and Animal Feed Guidance for Radiation.

[h] For extensive technical and practical implementation information please see "Preliminary Report on Operational Guidelines Developed for Use in Emergency Preparedness and Response to a Radiological Dispersal Device Incident" (DOE 2009).

[i] This cleanup process does not rely on and does not affect any authority, including the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S.C. 9601 et seq. and the National Contingency Plan (NCP), 40 CFR Part 300. This document expresses no view as to the availability of legal authority to implement this process in any particular situation.

A key concept for managing radiation exposure is ALARA (As Low As Reasonably Achievable). Although it is debated, radiation risk models assume that any radiation can increase the life-time risk of developing cancer with a single dose of 100 mSv increasing the overall lifetime risk of developing cancer by approximately 0.8%.[27-29]

The ICRP's guidance for occupational exposure[26] differs from the U.S. guidance as seen in Table 2. The issues of risk determination are discussed in more detail in Guide 9: Health Risks from Exposure to Radiation: The Basics.[24]

Table 2. International Commission on Radiological Protection Guidance for Occupational Exposure[30]

Dose Guidance Value	Type of Emergency Operation

Normal occupational dose limits apply; i.e.,:
• A limit on effective dose of 20 mSv/year, averaged over 5 years (i.e., a limit of 100 mSv in 5 years) with the further provision that in any single year:
  ○ The effective dose should not exceed 50 mSv, and
  ○ The equivalent dose should not exceed
  ▪ 150 mSv for the lens of the eye,
  ▪ 500 mSv for the skin (average dose over 1 cm^2 of the most highly irradiated area of the skin) and
  ▪ 500 mSv for the hands and feet
	Recovery and Restoration

• In principle, no dose restrictions are recommended if, and ONLY IF, the benefit to others clearly outweighs the rescuer's own risk. Otherwise, every effort should be made to avoid deterministic effects on health (i.e., effective doses below 1000 mSv should avoid serious deterministic health effects, and below ten times the maximum single year dose limit as given above should avoid other deterministic health effects). • All reasonable efforts should be made to keep doses below twice the maximum single year limits (see above).	Rescue operations:* • Saving life • Preventing serious injury • Actions to prevent the development of catastrophic conditions. Other immediate and urgent actions to prevent injuries or large doses to many people.

Source: Table from REMM website[317]

* Under conditions that may lead to doses above normal occupational exposure limits, workers should be volunteers and should be instructed in dealing with radiation hazards to allow them to make informed decisions. Female workers who may be pregnant or nursing should not participate in these operations.

Most guidance documents emphasize the need for prior informed consent about health risks for all responders who may come close to exceeding the Protective Action Guide for their work.

Summary

With the detectability of low levels of radiation, any significant atmospheric release from a nuclear detonation or nuclear power plant incident could become an international issue. The United Nations' IAEA and WHO will be involved in the assessment and medical response based on international reporting regulations and medical response networks.

The U.S. international emergency assistance is coordinated through USAID with reach-back expertise to federal agencies. Health and medical expertise is available through DHHS and REAC/TS (supported by DOE).

Protective Action Guides provide total annual doses for various activities at which protective action recommendations are suggested. They also apply to acute exposure during response to emergencies. These are not fixed numbers and the ALARA (As Low As Reasonably Achievable) concept is important since the risk assumed may vary depending on the benefit derived.

Guide 14 - Authors

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4. Office of the Assistant Secretary for Preparedness and Response, Department of Health and Human Services, Washington DC, USA
5. Radiation Research Program, Division of Cancer Treatment and Diagnosis, National Cancer Institute, National Institutes of Health, Department of Health and Human Services, Bethesda, MD, USA

References

1. World Health Organization. Available at: Source Document. Accessed August 31, 2016.
2. International Atomic Energy Agency. Available at: Source Document. Accessed August 31, 2016.
3. World Health Organization. Radiation Emergency Medical Preparedness And Assistance Network. Available at: Source Document. Accessed August 31, 2016.

Appendices

Appendix A: A Primer on Radiation and Fallout

PURPOSE

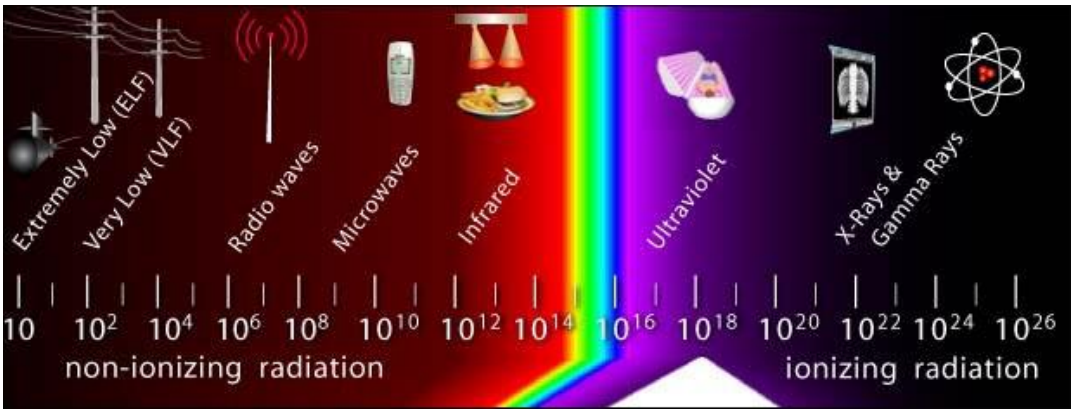
This Appendix is intended to provide a quick reference section with essential information to explain the basic concepts of radiation to aid decision-makers in understanding radiation. Scientific information found throughout Sections and Guides in the document is summarized and consolidated here.

Ionizing and non-ionizing radiation:

There is constant exposure to non-ionizing and ionizing radiation. The long-term risk of radiation-induced cancer is from ionizing radiation.

Non-ionizing radiation includes lasers, microwaves, infrared lamps, and radio waves. The most energetic form of radiation is ionizing radiation. Ionizing radiation is used to generate electric power, treat cancer, take x-rays, and disinfect medical instruments.

Figure 1. Electromagnetic radiation spectrum

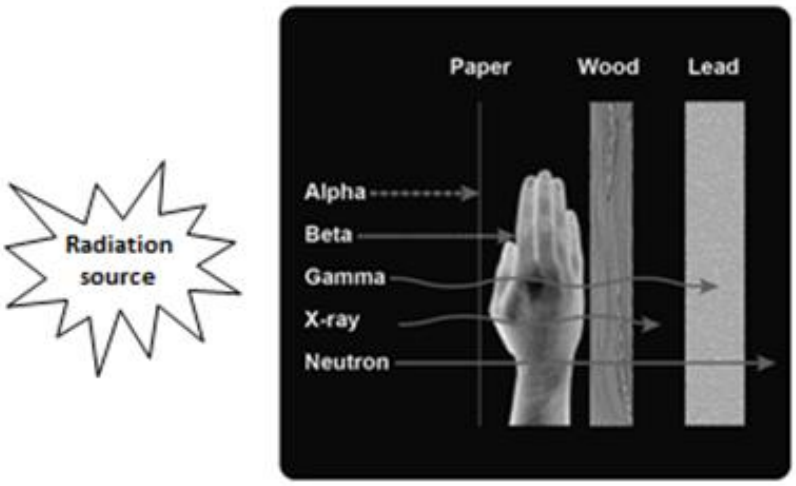


Exposure, contamination and dose:

Ionizing radiation includes alpha and beta particles, neutrons, x-rays, and gamma rays. X-rays and gamma-rays are essentially the same. As illustrated in Figure 2, charged particles (alpha and beta radiation) have limited penetration. Alpha particles can produce a significant dose only if they are internalized. Beta particles can cause skin burns (beta burns) and also produce significant dose if internalized. X-rays/gamma-rays and neutrons are penetrating.

- Radiation produced by a RDD, RED, or IND will be ionizing radiation.
- After an IND incident, irradiation by gamma-rays and neutrons will be of the biggest concern. It is harder to shield against these types of radiation.
- Other particles (alpha, beta) are of concern mostly if they are internalized through ingestion or inhalation, or have prolonged contact with the skin.

Figure 2. Types of ionizing radiation and the type of shielding required to stop penetration.



Exposure - During irradiation there is no material transferred. This means that an irradiated individual has no radioactive material on them and poses no radiological hazard to others. Since there is no radioactive material on the person, exposure cannot be undone by decontamination, but the effects of exposure can be mitigated through medical interventions. An example of an exposure is when a person has x-rays images taken for a broken bone.

Contamination- When people have radioactive materials on/in them they are said to be contaminated. Note that a person is not contaminated with alpha particles but with materials that emit alpha particles.

Dose- The dose is the *amount* of radiation you receive. Dose rate indicates how fast you receive the dose and also relates the *intensity* of the radiation. Dose rate is usually expressed per unit time (e.g., rem/hr). It is a combination of the **dose, type of radiation (e.g., x-ray, neutron, beta, alpha),), and dose rate** that determines the health and medical consequences of the radiation exposure.

Exposure vs. Contamination-

A good analogy to illustrate the concepts of exposure and contamination is to think of a sealed radioactive container of baby powder that gives off gamma-rays[1]. A person can hold the container and be exposed to the gamma rays penetrating through the walls of the container

[1] Analogy from THE MEDICAL ASPECTS OF RADIATION INCIDENTS revised 11/2012 The Radiation Emergency Assistance Center/Training Site.

without getting powder on their hands. Should a leak develop around the lid allowing some of the material to escape, the person may have the powder on their hands, thus resulting in contamination. (Additional links to illustrate this: REMM Contamination v. Exposure Infographic or this CDC Video - Screening for External Contamination)

Units for exposure and dose measurement

The commonly used units in the U.S. for radiation exposure and dose measurements are the Roentgen (pronounced rent'ghen), the rad, and the rem. Internationally, the units used (termed SI units) are the Gray and the Sievert are used in place of the rad and rem, respectively.

The **ROENTGEN (R)** is a measure of *exposure* to x-ray or gamma ray radiation. It is defined only for effect on air.

The **RAD** (Radiation Absorbed Dose) is a measure of the *absorbed dose* in a material.

The **REM** (Roentgen Equivalent in Man) equates the biological damage that would be caused by one RAD of dose in body tissue. REM accounts for the fact that not all types of radiation are equally effective in producing biological change or damage. A *quality factor* is used to convert RAD to REM. The quality factor depends on the type of radiation (alpha, beta, gamma, neutron, x-ray).

U.S. Unit	SI (International) Unit	Measured in	Definition
Roentgen (R)	Roentgen (R) (being phased out)	Air	Measure of exposure to gamma or x-ray radiation. Not a measure of dose, or effects on the body
rad	Gray (Gy)	Any material	Measure of the absorbed dose in a material
rem	Sievert (Sv)	Body tissue	Equates radiation absorption with biological damage

Many radiation detection instruments such as the Geiger-Mueller detector (aka Geiger Counter) use the unit Roentgen (R), For gamma radiation, 1 R ~ 1 rad ~ 1 rem. So, even though the units are different, they are often – conversationally – used interchangeably.

Conversions and equivalences

SI Unit	US Unit	Equivalence	
1 gray (Gy)	100 rad	100 centiGy	1000 milliGy
1 sievert (Sv)	100 rem	1000 milliSv	
1 milliSv	100 millirem		

Note: All the numbers found across a row are equivalent.

Size of a nuclear explosion

Nuclear explosions are classified based on the amount of energy they produce, or "yield". A nuclear attack by terrorists would be expected to have a yield of less than one to several kilotons. A kiloton is not the weight of the bomb but rather the equivalent energy of an amount of the explosive TNT (1 KT = 1,000 tons of TNT). Large military nuclear weapons are in the megaton (MT) range (1 MT = 1,000 KT).

Characteristics of a nuclear explosion

- A **fireball**, roughly spherical in shape, is created from the energy of the initial explosion. It can reach tens of millions of degrees in temperature.
- A **shockwave** races away from the explosion and can cause great damage to structures and injuries to humans.
- A **mushroom cloud** typically forms as everything inside of the fireball vaporizes and is carried upwards. Radioactive material from the nuclear device mixes with the vaporized material in the mushroom cloud. The cloud could climb 5 miles or higher into the atmosphere.
- **Fallout** results when the vaporized radioactive material in the mushroom cloud cools, condenses to form solid particles, and falls back to the earth. Fallout, also called groundshine, can be carried long distances on wind currents as a plume and contaminate surfaces miles from the explosion, including food and water supplies.
- **Electromagnetic pulse (EMP) results from** ionization of the atmosphere around the blast. For ground detonations EMP can drive an electric current through underground wires causing local damage. For high-altitude nuclear detonations, EMP can cause widespread disruption to electronic equipment and networks. Medical equipment may be damaged by EMP.

National Academies and DHS Factsheet

What kind of radiation does an IND produce?

Radiation from a nuclear explosion falls into 2 categories:

1) **Initial nuclear radiation** (prompt radiation and neutron activation), which originates from the explosive event and the early fireball. It happens in the first minute.
2) **Residual radiation (Delayed radiation)** which is mostly fallout. Fallout radiation persists, but decays rapidly.

- Both prompt and (delayed) fallout radiation can cause health effects and the severity of radiation injury increases as the dose increases.
- The exposure pathway of greatest concern up to several days after the incident is external irradiation and contamination from fallout (**and not ingested or inhaled radiation**). In the first hour, fallout dose rates in the hundreds of R/hour should be expected, and may be 1000 R/hour (10 Gy/h) or higher in localized areas after a [what size] detonation.

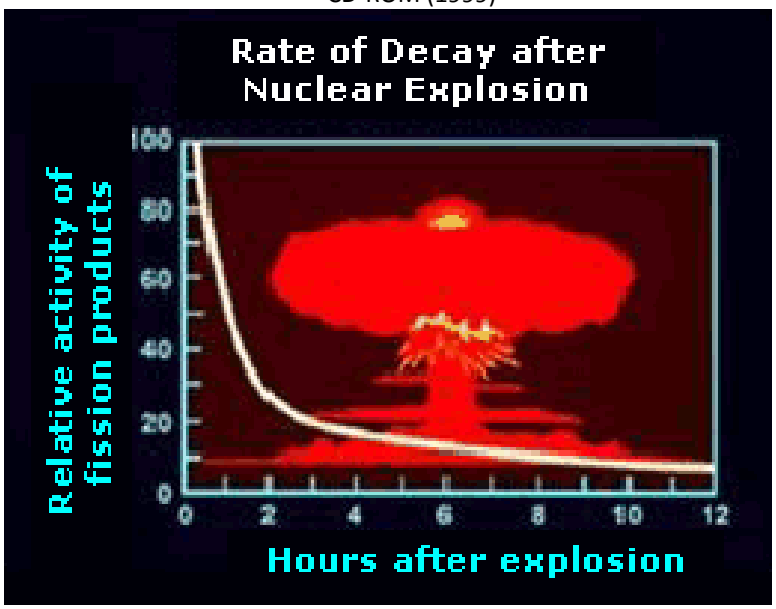
Nuclear Fallout

Nuclear fallout will occur significantly from a ground-burst and minimally from an air-burst because the blast releases radiation, makes objects on the ground radioactive and suspends the particles high into the air. An airburst will produce direct radiation (line of sight) but little fall out. .

- It is important to note that Hiroshima and Nagasaki did not have significant fallout because their detonations occurred at altitude (air-burst) and the fission products did not have the opportunity to mix with earth, as would happen in a ground-burst.

The hazard from fallout comes from being exposed to the ionizing radiation the particles give off after they have settled on the ground and roofs (groundshine), *not from breathing the particles*. Radiation levels from these particles will drop off quickly.

Figure 3: After approximately 24 hours (and in most cases 12 hours), even the highest early dose rates have diminished to the point where exposures may be incurred without suffering acute radiation effects. Source: Armed Forces Radiobiology Research Institute's Medical Effects of Ionizing Radiation Course on CD-ROM (1999)



- Heaviest fallout particles will fall to earth quickly and become groundshine.
- Wind direction affects where fallout lands.
- Most of the smaller fallout particles will remain in the upper atmosphere for days or weeks.
- The most acutely hazardous fallout particles are generally visible as fine sand-sized grains and are deposited within about 20 miles of the detonation.
- The lack of visible fallout particles should not suggest the lack of hazardous radiation.
- Radioactive decay will diminish the amount of radioactivity in groundshine, and the footprint of the high dose rate area will decrease.
- Predicting where fallout will deposit cannot be done reliably in the short time after a detonation although there will be a good estimate of what is called the dangerous fallout zone.
    - Therefore, protective guidance should apply widely, regardless of meteorological observations or early plume model results.
- Fallout deposition on areas where survivors are likely to be found (outside the more severely damaged areas) may be expected to begin in about 10 minutes.

Appendix B: Resource Guide

For additional links to documents, please see the references section (Appendix C)

PURPOSE

This Appendix is intended to provide a quick reference section summarizing available resources described in the various Sections and Guides in the document. These resources include descriptions of various Federal and International response capabilities, guidance, and education and training resources. This is not exhaustive, but highlights critical resources.

Federal Resources:

ASPR Regional Emergency Coordinators

Regional Emergency Coordinators (RECs) are the primary point of contact for state public health departments and emergency management agencies to assure the coordination and integration of a federal response relating to Emergency Support Function (ESF) #8. (ASPR Regional Emergency Coordinators Contact Information)

The main role of the RECs is to build relationships with federal, regional, state, local, tribal and territorial officials and health care representatives (partners and stakeholders) in order to conduct planning for effective federal emergency response for all hazards, and to facilitate coordinated preparedness and response activities for public health and medical emergencies

National Disaster Medical System

The National Disaster Medical System (NDMS) (NDMS Website) is a part of the Department of Health and Human Services; Office of the Assistant Secretary for Preparedness and Response; Office of Emergency Management. Under ESF #8, (HHS ASPR ESF #8 Website) NDMS supports federal agencies in the management and coordination of the federal medical response to major emergencies and federally declared disasters. The overall purpose of the NDMS is to supplement an integrated national medical response capability for assisting state, local, and tribal authorities in dealing with the medical impacts of major peacetime disasters and to provide support to the military and the Department of Veterans Affairs medical systems in caring for casualties evacuated back to the U.S. from overseas armed conventional conflicts.

Components of the NDMS

- Medical response to a disaster area in the form of personnel, teams and individuals, supplies, and equipment.
- Patient movement from a disaster site to unaffected areas of the nation.
- Definitive medical care at participating hospitals in unaffected areas.

Medical Countermeasures

U.S. Government agencies involved in medical countermeasure development and the process of obtaining FDA approval are components of the U.S. Department of Health and Human Services:

- Office of the Assistant Secretary for Preparedness and Response (ASPR) (HHS ASPR Organizational Overview)
    - Office of Policy and Planning (OPP) (ASPR Office of Policy Webpage)
    - Biomedical Advanced Research and Development Authority (BARDA) (ASPR BARDA Webpage)
- National Institutes of Health (NIH), particularly the National Institute of Allergy and Infectious Diseases (NIAID) Radiation and Nuclear Countermeasures Program (NIH NIAID Radiation Countermeasures Program Webpage)
- The Centers for Disease Control and Prevention (CDC) (CDC Radiation Emergencies Webpage)

Strategic National Stockpile

The Strategic National Stockpile is managed by the Centers for Disease Control and Prevention (CDC) (Strategic National Stockpile (SNS) Webpage).

Countermeasures available in the Strategic National Stockpile

- Anti-neutropenia agents
    - Granulocyte colony-stimulating factor (G-CSF)
    - granulocyte-macrophage colony-stimulating factor (GM-CSF).)
- Decorporation agents
    - Calcium diethylenetriaminepentaacetate (ca-DTPA)
    - Zinc diethylenetriaminepentaacetate (Zn-DTPA)
    - Prussian Blue

Federal Documents and Online Resources:

Planning Guidance for Response to a Nuclear Detonation (2nd Ed)

"The purpose of this guidance is to provide emergency planners with nuclear detonation-specific response recommendations to maximize the preservation of life in the event of an urban nuclear detonation. This guidance addresses the unique effects and impacts of a nuclear detonation such as scale of destruction, shelter and evacuation strategies, unparalleled medical demands, management of nuclear casualties, and radiation dose management concepts. The guidance is aimed at response activities in an environment with a severely compromised infrastructure for the first few days (i.e., 24 – 72 hours) when it is likely that many federal resources will still be en route to the incident."

State and Local Planners Playbook for Medical Response to a Nuclear Detonation

DHHS has published a State and Local Planners Playbook that includes "Action Steps", or sequential response steps, and highlights the collaborative, interagency, and multi-jurisdictional operational activities and capabilities outlined in the NRF. This playbook was developed to guide emergency management leaders from pre-incident to tasks 96 hours after the incident. ASPR State and Local Planners Playbook for Medical Response to a Nuclear Detonation

Radiation Emergency Medical Management (REMM)

The website REMM provides just-in-time information and vetted background material for healthcare professionals about radiation emergencies.

GeoHEALTH

GeoHEALTH (formerly MedMap) facilitates the sharing of situational awareness with local/regional

responders and can show locations of healthcare facilities in relation to other overlays and demographic information. Designated local and state government partners can request access to GeoHEALTH through their HHS/ASPR Regional Emergency Coordinators. (ASPR GeoHEALTH Webpage)

Communication Resources

- U.S. Environmental Protection Agency: *Communicating about Radiation Risks*. (Communicating Radiation Risks: Crisis Communications for Emergency Responders)
- U.S. Department of Health and Human Services: *Tools for the Media and Public Health Communicators: Public Health Emergency Response: A Guide for Leaders and Responders* and *Communicating in the First Hours: Initial Communication With the Public During a Potential Terrorism Event.* (ASPR Tools for the Media and Public Health Communicators)
- Centers for Disease Control and Prevention: *A Primer on Health Risk Communication.* (CDC Risk Communication Webpage)
- U.S. Department of Health and Human Services: REMM.(REMM - Resources for Communicating after an IND)

National Response Framework

The NRF and its list of annexes fully explain the principles that guide national response, roles and responsibilities, response actions, response organizations, and planning requirements to achieve an effective national response to any incident that occurs

Comprehensive Preparedness Guide 101

FEMA developed the Comprehensive Preparedness Guide 101 which describes ways to align community planning with the broader response should that community become overwhelmed and require additional assistance. (FEMA - Comprehensive Preparedness Guide (CPG) 101)

National and Regional Resources:

Radiation Injury Treatment Network (RITN) (RITN Webpage)

- RITN is a collaboration of 76 Bone Marrow Donor Centers, Transplant Centers, and Cord Blood Centers, with expertise in the management of marrow-toxic injury.
- **RITN centers *are not first responders, they do not perform decontamination*.**
    - Initial decontamination and the treatment of life threatening injuries will occur days prior to RITN involvement.
    - Transport of casualties from the incident site would be organized through the National Disaster Medical System (NDMS).

International Resources:

Through the United Nations

1) International Atomic Energy Agency (IAEA)
    - Emergency Notification and Assistance Technical Operations Manual (ENATOM)
    - Response and Assistance Network (RANET)
2) World Health Organization (WHO)
    - Radiation Emergency Medical Preparedness and Assistance Network (REMPAN)
    - WHO BioDoseNet
3) Global Health Security Initiative (GHSI)

Training and Education Resources:

Onsite

- **Armed Forces Radiobiology Research Institute** at the Uniformed Services University of the Health Sciences, Bethesda, MD.
- **Radiation Emergency Assistance Center and Training Site (REAC/TS)** at the Oak Ridge Institute for Science and Education (ORISE), Oak Ridge, TN.

Online

- **Radiation Emergency Medical Management (REMM) provides** just-in-time information, and vetted background material. There are also clinical tools for responders. Training opportunities from a variety of sources are also aggregated.
- **Centers for Disease Control and Prevention** focuses on radiation-related public health issues. Training opportunities are also provided.
- **Office of the Assistant Secretary for Preparedness and Response** focuses on integrating radiation issues into all-hazard preparedness and response.

Federal Agencies that can Provide Assistance:

1) **Radiation Emergency Assistance Center/Training Site (REAC/TS)**
2) **U.S. Agency for International Assistance (USAID)**, Office of the United States Foreign Disaster Assistance (OFDA), Disaster Assistance Response Team (DART)

3) **Federal Bureau of Investigation** – Crisis management and lead investigative agency following a terrorist event.
4) **Federal Emergency Management Agency** – Consequence management and gateway for resource requests via the state to the Federal Coordinating Officer for logistical requirements not able to be supplied by the state or region including personnel, communication, earth-moving equipment, urban search and rescue teams, etc.
5) **U.S. Department of Energy** – Provision of modeling and atmospheric data via Laurence Livermore National Laboratories and provision of expert technical assistance from the Radiologic Assistance Program and National Nuclear Security Agency.
    - Federal Radiological Modeling and Assessment Center
    - Advisory Team for Environment, Food, and Health (A-Team)
6) **Nuclear Regulatory Commission** provides expertise on nuclear reactors and reactor sites
7) **U.S. Department of Health and Human Services (HHS)**
    - Centers for Disease Control and Prevention – activation of Strategic National Stockpile and provides epidemiologic assistance.
    - National Institute for Health – National Library of Medicine – Radiation Emergency Medical Management (REMM) website and other resources for victim medical treatment.
    - Assistant Secretary for Preparedness and Response (ASPR) – National Disaster Medical System (NDMS), U.S. Public Health Service, volunteers, Disaster Medical Assistance Teams (DMATs), Disaster Mortuary Teams (DMORTs)
8) **Department of Defense (DOD**) –coordinates airlift capability for NDMS. DOD can provide substantial technical and personnel assistance according to needs identified by the Federal Coordinating Officer.
9) **U.S. Department of Veteran's Administration (VA)** – activation of Medical Emergency Radiologic Response Team[27] as well as VA Federal Coordinating Centers for patient movement.
10) **U.S. Environmental Protection Agency (EPA)** Protective Action Guidelines (PAGs) suggest precautions that State and local authorities can take during a radiation emergency based on the projected amount of radiation that might be received.

Appendix C: References

PURPOSE

This is a consolidated list of key references cited throughout the document.

National Planning Guidance

- ***Planning Guidance for Response to a Nuclear Detonation***: Click Here for Document
- ***Comprehensive Preparedness Guide 101: Developing and Maintaining Emergency Operations Plans*** Click Here for Document
- ***Planning Guidance for Protection and Recovery Following Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents:*** Click Here for Document
- ***Nuclear/Radiological Incident Annex***: Click Here for Document
- ***Manual Of Protective Actions Guides and Protective Actions for Nuclear Incidents:*** Office of Radiation Programs, United States Environmental Protection Agency. Click Here for Document
- ***National Response Framework:*** Click Here for Document
- ***National Planning Scenarios***: Click Here for Document
- ***Emergency Support Function #8 – Public Health and Medical Services Annex, National Response Framework:*** Click Here for Document
- ***ASPR Playbooks***: Click Here for Document
- ***National Incident Management System***: Click Here for Document
- ***Incident Command Structure:*** Click Here for Document
- ***Incident Command System eTool:*** Click Here for Document

NLM Medical Management Information

- ***Radiation Emergency Medical Management***: Click Here for Website

DHHS Guidance

- ***National Health Security Strategy:*** Click Here for Document
- ***State and Local Planners Playbook for Medical Response to a Nuclear Detonation:*** Click Here for Document
- ***CDC Radiation Information on Radiation Emergencies*** Click Here for Webpage

International Guidance

- ***International Atomic Energy Agency (IAEA) Response System:*** Click Here for Webpage
- ***International Atomic Energy Agency (IAEA) RANET:*** Click Here for Webpage
- ***World Health Organization (WHO) Radiation Emergency Medical Preparedness And Assistance Network (REMPAN):*** Click Here for Webpage
- ***World Health Organization (WHO) Radiation Accidents And Emergencies:*** Click Here for Webpage
- ***World Health Organization (WHO) BioDoseNet:*** Click Here for Webpage

Scarce Resources Guidance

- ***Guidance For Establishing Crisis Standards Of Care For Use In Disaster Situations:*** *A Letter Report*. Institute of Medicine: National Academies of Science. Click Here for Document
- ***Nuclear Detonation Scarce Resources Project Working Group Publications***: Click Here for Manuscripts

Other Guidance:

- ***RTR System*:** Hrdina CM, Coleman CN, Bogucki S, Bader JL, Hayhurst RE, Forsha JD, et al. The "RTR" Medical Response System for Nuclear and Radiological Mass-Casualty Incidents: A Functional Triage-Treatment-Transport Medical Response Model. *Prehospital Disaster Medicine* 2009 May-Jun;24(3):167-178. Click Here for PubMed Citation
- ***Manual For First Responders to a Radiological Emergency***: International Atomic Energy Agency (IAEA). 2006. Click Here for Document

Government Agency Websites

- ***FEMA:*** Click Here for Webpage
- ***CDC:*** Click Here for Webpage
- ***ASPR:*** Click Here for Webpage
- ***Public Health Emergency Medical Countermeasures Enterprise (PHEMCE):*** Click Here for Webpage

Available Medical Response Assets

- ***Advisory Team:*** Click Here for Webpage
- ***Strategic National Stockpile***: Click Here for Webpage
- ***Medical Emergency Radiological Response Team:*** US Department of Veterans Affairs. Emergency Management Click Here for Webpage.
- ***Radiation Injury Treatment Network***. Click Here for Webpage
- ***Radiation Emergency Assistance Center/Training Site (REAC/TS):*** Oak Ridge Institute for Science and Education. Click Here for Webpage
- ***Office of US Foreign Disaster Assistance***, US Agency for International Development. Click Here for Webpage

Communication Resources:

- ***Communicating about Radiation Risks:*** U.S. Environmental Protection Agency. Click Here for Document
- ***Tools for the Media and Public Health Communicators.*** U.S. Department of Health and Human Services. Click Here for Webpage
- ***A Primer on Health Risk Communication:*** Centers for Disease Control and Prevention. Click Here for Webpage
- ***Nuclear Detonation Preparedness: Communicating in the Immediate Aftermath.*** U.S. Department of Health and Human Services. Click Here for Document

Radiation Education and Training Resources:

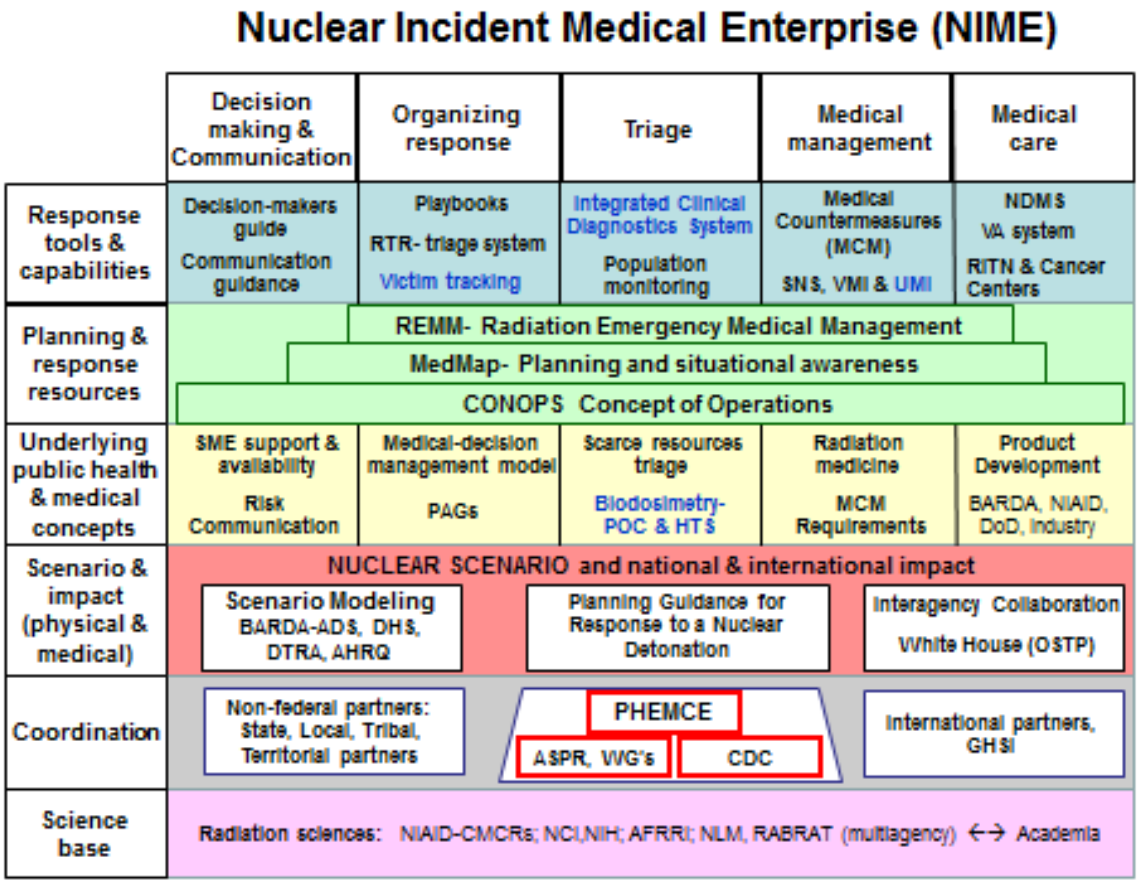
Onsite

- ***Armed Forces Radiobiology Research Institute*** at the Uniformed Services University of the Health Sciences, Bethesda, MD. Click Here for Webpage
- ***Radiation Emergency Assistance Center and Training Site (REAC/TS)*** at the Oak Ridge Institute for Science and Education (ORISE), Oak Ridge, TN. Click Here for Webpage

Online

- ***Radiation Emergency Medical Management (REMM)*** provides just-in-time information, and vetted background material. There are also clinical tools for responders. Training opportunities from a variety of sources are also aggregated. Click Here for Webpage
- ***Centers for Disease Control and Prevention*** focuses on radiation-related public health issues. Training opportunities are also provided. Click Here for Webpage
- ***Office of the Assistant Secretary for Preparedness and Response*** focuses on integrating radiation issues into all-hazard preparedness and response. Click Here for Webpage

Appendix D: Nuclear Incident Management Enterprise (NIME)



Key:

- AFRRI — Armed Forces Radiobiology Research Institute (Department of Defense)
- ASPR — Office of the Assistant Secretary for Preparedness and Response (DHHS)
- A-Team — Advisory Team for Environment, Food and Health
- ATSDR — Agency for Toxic Substances and Disease Registry
- BARDA — Biomedical Advanced Research and Development Authority (DHHS)
- CDC — Centers for Disease Control and Prevention
- CONOPS — Concept of Operations
- CMCR — Centers for Medical Countermeasure against Radiation (NIAID-NIH)
- CRC — Community reception center
- Diagnostics — Point of Care (POC) and high throughput screening (HTS)
- DHS — Department of Homeland Security
- DHHS — Department of Health and Human Services
- EPA — Environmental Protection Agency
- HSC — Homeland Security Council (White House)
- GeoHEALTH — DHHS/ASPR interactive tool: an electronic, layered "war map" for rapid response (Formerly called MedMap)
- GHSI — Global Health Security Initiative
- MedMap — Is being upgraded as GeoHEALTH
- NIAID — National Institute of Allergy and Infectious Diseases (NIH)

- NIH National Institutes of Health
- NLM National Library of Medicine (NIH)
- NMDP National Marrow Donor Program
- NDMS National Disaster Medical System (DHHS)
- OSTP/NDRD Office of Science and Technology Policy/Nuclear Defense R & D
- PAGs Protective Action Guides (EPA)
- PARs Protect Action Recommendations (EPA)
- PHEMCE Public Health Emergency Medical Countermeasures Enterprise
- RABRAT Radiation Bioterrorism Research & Training (NCI- multi-agency group)
- REMM Radiation Emergency Medical Management (with ASPR/NLM)
- Requirements Working groups determine products and quantity
- RITN Radiation Injury Treatment Network (with NMDP)
- RTR Radiation TReatment, TRiage and TRansport system
- SME Subject Matter Expert (Subject Matter Expert Advisory Resource Team- SMART)
- SNS Strategic National Stockpile
- SOC Secretary's Operations Center, (DHHS/ASPR)
- UMI User-managed inventory
- VMI Vendor-managed inventory
- WGs Working Groups

Coleman CN et al. Public health and medical preparedness for a nuclear detonation: the Nuclear Incident Medical Enterprise (NIME). Health Physics, 108: 149-60, 2015

Appendix E: Acronyms and abbreviations

A-Team	Advisory Team
AC	Alternate care site (in RTR system)
AFFRI	Armed Forces Radiobiology Research Institute (DoD)
ALARA	As Low As Reasonably Achievable
AMS	Aerial Measuring System (DOE/NNSA)
ARS	Acute radiation syndrome (or sickness)
ASPR	Office of the Assistant Secretary for Preparedness and Response (DHHS)
BARDA	Biodefense Advanced Research and Development Authority
BioDoseNet	WHO global network of biodosimetry laboratories
CDC	Centers for Disease Control and Prevention
CMCR	Centers for Medical Countermeasure Against Radiation (NIAID)
CMS	Center for Medicare & Medicaid Services
CRC	Community Reception Center
DART	Disaster Assistance Response Team (USAID)
DEARE	Delayed effect of acute radiation exposure
DHS	Department of Homeland Security
DHHS	Department of Health and Human Services (aka HHS)
DMAT	Disaster Medical Assistance Team
DMORT	Disaster Mortuary Operational Response Team
DoD	Department of Defense
DOE	Department of Energy
DOS	Department of State
EC	Evacuation center (in RTR system)
EPA	Environmental Protection Agency
EMAC	Emergency Management Assistance Compact
EMP	Electromagnetic pulse
ENATOM	Emergency Notification and Assistance Technical Operations Manual (IAEA)
ESF	Emergency Support Function
FBI	Federal Bureau of Investigation
FDA	Food and Drug Administration (DHHS)
FEMA	Federal Emergency Management Agency (DHS)
FRMAC	Federal Radiological Monitoring and Assessment Center
GHSI	Global Health Security Initiative (ASPR)
GIS	Geographic information systems
G-CSF	Granulocyte Stimulating Factor
Gy	Gray (unit of radiation dose)

HHS	Health and Human Services (aka DHHS)
HICS	Hospital Incident Command System
IAEA	International Atomic Energy Agency (part of United Nations)
ICS	Incident Command System
ICDS	Integrated Clinical Diagnostics System
ICRP	International Commission on Radiological Protection
IED	Improvised explosive device
IMAAC	Interagency Modeling and Atmospheric Assessment Center
IND	Improvised nuclear device
IND (drugs)	Investigational new drug (Food and Drug Administration)
kT	kilo-ton (1000 metric tons of TNT)
MC	Medical care site (in RTR system)
MCM	Medical countermeasure
MCSR	Division of Medical Countermeasure Strategy & Requirements (ASPR)
NARAC	National Atmospheric Release Advisory Center (DOE/NNSA)
NASA	National Aeronautics and Space Administration
NCI	National Cancer Institute (part of NIH)
NDMS	National Disaster Medical System
NIAID	National Institute of Allergy and Infectious Diseases (part of NIH)
NIH	National Institutes of Health
NIMS	National Incident Management System
NLM	National Library of Medicine
NMDP	National Marrow Donor Program
NNSA	National Nuclear Security Agency (DOE)
NOAA	National Oceanic and Atmospheric Administration
NPP	Nuclear power plant
NRC	Nuclear Regulatory Commission
NRIA	Nuclear/Radiological Incident Annex
NRF	National Response Framework
OFDA	Office of U.S. Foreign Disaster Assistance (USAID)
OPP	Office of Policy and Planning (ASPR)
OSTP	Office of Science and Technology Policy (White House)
PAG	Protective Action Guides (EPA)
PAR	Protective Action Recommendation
PHEMCE	Public Health Emergency Medical Countermeasures Enterprise (DHHS)
R, R/h	Roentgen, Roentgen per hour (unit of radiation exposure)
r	rad (unit of radiation dose)
RAP	Radiological Assistance Program (DOE/NNSA)

rem	rem (unit of radiation dose, corrected for type of radiation)
RANET	Response Assistance Network (IAEA)
RDD	Radiological dispersal device
REAC/TS	Radiation Emergency Assistance Center/Training Site
REC	Regional Emergency Coordinator (DHHS)
REMM	Radiation Emergency Medical Management (website, ASPR/NLM)
REMPAN	Radiation Emergency Medical Preparedness And Assistance Network (WHO)
REP	Regional Emergency Preparedness Program (FEMA)
RITN	Radiation Injury Treatment Network
RRCC	Regional Response Coordination Center (FEMA)
RTR	Radiation TRiage, TReatment, and TRansport system
SEER	Surveillance Epidemiology and End Results (NCI)
SNS, DSNS	Strategic National Stockpile, Department of SNS (CDC)
Sv, mSV	Sievert (unit of radiation dose, corrected for type of radiation)
	mSv is 1/1000th of a Sv or 1 Sv= 1000mSv
UN	United Nations
USG	United States Government
USAID	United States Agency for International Development
VA, DVA	Veterans Administration
VHA	Veterans Health Administration