

Major Radiological or Nuclear Incidents: Potential Health and Medical Implications

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This ASPR TRACIE document provides an overview of the potential health and medical response and recovery needs following a radiological or nuclear incident and outlines available resources for planners.

The list of considerations is not exhaustive, but does reflect an environmental scan of publications and resources available on past incident response, numerous exercises, local and regional preparedness planning, and significant research on the subject. Those leading preparedness efforts for, or response and recovery from, a radiological or nuclear incident may use this document as a reference, while focusing on the assessments and issues specific to their communities and unmet needs as they are recognized.

It is important to note, however, that entities engaged in planning for or responding to radiological incidents should consult with the radiation protection authorities in their state in addition to federal resources. Most states and local jurisdictions have existing plans for responding to radiological incidents and these plans can provide local information for health and medical providers.

The U.S. Department of Health and Human Services (HHS) [Radiation Emergency Medical Management \(REMM\)](#) and the [Centers for Disease Control and Prevention \(CDC\) Radiation Emergencies](#) sites provide guidance for healthcare providers, primarily physicians, about clinical diagnosis and treatment of radiation injury and response issues during radiological and nuclear emergencies. HHS REMM aims to provide just-in-time, evidence-based, usable information with sufficient background and context to make complex issues understandable to those without formal radiation medicine expertise. REMM is also downloadable to mobile platforms.

Recommended links from the HHS REMM site include:

- [Learn about Radiation Basics](#)
- [Radiation Incidents](#): Discovering an incident, characterizing severity, timeline, specific incident types, nuclear explosions, and public messages
- [Information for First Responders in the Field](#)
- [Information for Preparedness and Response Planners](#)
 - [Triage Guidelines](#)
 - [Radiation Algorithms](#)
 - [On-Scene Management](#)
 - [Victim Transport](#)
 - [Hospital Medical Orders During a Radiation Incident](#)
 - [Hospital Activities](#)

Recommended links from the CDC Radiation Emergencies site include:

- [Contamination vs. exposure](#)
- [FAQs about Radiation Emergencies](#)
- [Information for Clinicians](#)
- [Medical Countermeasures \(treatments\) for Radiation Exposure and Contamination](#)
- [Radiation Emergencies and Your Health](#)

In addition to HHS REMM and CDC, the following resources are recommended by members of the ASPR TRACIE Subject Matter Expert Cadre as important reference documents for radiation emergency information.

Additional Quick Links for Radiation Information

- [ASPR TRACIE Radiological and Nuclear Topic Collection](#)
- [A Decision Makers Guide: Medical Planning and Response for a Nuclear Detonation](#)
- [Acute Radiation Syndrome: A Fact Sheet for Clinicians](#)
- [Communication and Public Information in Radiation Disasters](#)
- [National Alliance for Radiation Readiness \(NARR\) Tools](#)
- [Radiological Terrorism: Emergency Management Pocket Guide for Clinicians](#)
- [Radiological Terrorism: Just in Time Training for Hospital Clinicians](#)

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Background Information

Radiological and nuclear incidents can have tremendous, wide-ranging effects on the healthcare system. This resource focuses on the impact to the healthcare system, with additional, broader public health and community recovery considerations that may tangentially affect healthcare discussed in the section titled [Long Term Considerations and Recovery](#).

Types of radiation incidents include:

- Worksite incidents (also transportation incidents)
- Covert assassination incidents
- Nuclear power plant incidents
- Radiological Dispersal Device (RDD) / Radiological Exposure Device incidents
- Nuclear detonation

Radiation terminology and information can be confusing when not used regularly. [Appendix A: Radiation Terminology](#) contains information on:

- [Types of Radiation](#)
- [Exposure and Dosing](#)
- [Radiation Dosing Comparisons](#)
- [Radioactive Isotopes and Byproducts](#)
- [Ways to Detect Radiation](#)

Table 1 compares and contrasts these different incidents and highlights healthcare system impacts across this spectrum of incident type.

Table 1: Incident Type Comparisons

Incident Type	Description	Known Isotopes?	Size of Impact	Healthcare Facility Protective Measures	Healthcare System Considerations/Impacts			
					Loss of Facilities/Critical Systems	Mass Casualty	Exposure Tracking	Injury/Illness Patterns
Worksite Exposure	Unintentional event causing the release of radioactive isotopes in an industrial or medical facility that regularly uses the materials Could also include the accidental release following an incident involving the transport of radioactive material	Yes. The facility would know the isotopes and be familiar with the treatment, decontamination procedures, and countermeasures.	Small or limited, usually just a few people exposed	Personal Protective Equipment (PPE) appropriate for exposure and job classification It is possible that the patient could present to a medical facility with gross contamination.	Most likely no loss of facilities	Unlikely	Could potentially need to track or trace exposure if detection was delayed and secondary contamination occurred	Skin, eye irritation, burns, inhalation, and internal contamination, acute radiation syndrome (ARS) in a few cases. Most exposures are very low-level.
Covert Assassination Incidents	The use of radioactive isotopes for covert assassination is a possibility. The perpetrator and the intended victim could be exposed, in addition to anyone else in the vicinity of the victim or the exposure source – usually an ingested isotope. Refer also to radiological exposure device (below).	No. Testing would be required and radiation exposure would not necessarily be immediately obvious.	Small or limited, usually just a few people exposed	PPE appropriate for exposure and job classification	No loss of facilities	Unlikely	Could potentially need to track or trace exposure if detection was delayed and secondary contamination occurred	Skin, eye irritation, burns, acute radiation syndrome (ARS) depending on source / route / level of exposure
Nuclear Power Plant	Could include accidental or intentional release of materials, or accidental or intentional failure of safety systems which at worst could lead to core material meltdown. Large scale release of radioactive isotopes is extremely rare. In most instances release of isotopes is small scale, restricted to facility personnel, and	Includes multiple byproducts, depending on the isotope being used on site including: Iodine-131, Strontium-90, Cesium-137, Plutonium-239	On-site release may be confined to a room/ chamber – significant atmospheric release usually limited to a roughly 10 mile radius of the plant and across a downwind plume. Many more people will	Evacuation or shelter in place if directed by authorities. PPE appropriate likely only for power plant response/recovery exposure and job classification	Facilities within the evacuation zone of a nuclear power plant could be required to evacuate or shelter in place, in which case they would be inaccessible due to evacuation zones. If there	Possible	Geographically based Reception centers needed	Skin, eye irritation, burns, acute radiation syndrome (ARS) unlikely but possible as most exposures low-level. Population doses from this type of release have not been associated with either long term or short term health effects. This excludes health effects observed during the Chernobyl release

Incident Type	Description	Known Isotopes?	Size of Impact	Healthcare Facility Protective Measures	Healthcare System Considerations/Impacts			
					Loss of Facilities/Critical Systems	Mass Casualty	Exposure Tracking	Injury/Illness Patterns
	contained.		seek evaluation or treatment than are actually affected.		is significant radiation exposure, those facilities could be closed permanently.			which must be noted came from a release initiated by an explosion at a reactor that had basically no containment and suffered an inextinguishable fire from the graphite core. If a blast occurred at the plant, might include blast and burn injuries. Injury potential from evacuations Population-wide behavioral health concerns People should not use potassium iodide (KI) unless directed to do so.
Radiological Dispersal Device Radiological Exposure Device	Radioactive substance left where it can passively expose people (exposure device - RED) or in the form of a "dirty bomb" (dispersion device), where radioactive isotopes would be added to a conventional explosive blast, with radiation contamination of the blast radius. RDDs do not cause "fallout." RDD can also be non-explosive with food, water or other	No. Testing would be required. May be mixed radionuclides to cause confusion. Nine isotopes are available in concentrated amounts and/or can be easily obtained for potential RDD use: - o Americium-241 (Am-241) - o Californium-252 (Cf-252)	Limited to the affected area of the blast and debris, which is typically several city blocks in range. Depending on type of device may have radioactive shrapnel, a plume, radioactive smoke or both. Primary hazard is	Evacuation or shelter in place if directed by authorities. PPE appropriate for exposure and job classification	Facilities within the affected area could be contaminated and be closed until remediated. For non-explosive an extensive effort will be needed to determine both time of initial exposure and extent.	RDD explosion may injure many persons, RED may expose many persons but casualties very unlikely.	Geographically based and patient based Reception centers needed	Skin, eye irritation, burns, acute radiation syndrome (ARS) is unlikely but possible if the device utilizes radioactive shrapnel and depending on isotope, time/distance/shielding. External contamination likely from RDD requiring decontamination. Internal contamination possible from inhaled radioactive dusts.

Incident Type	Description	Known Isotopes?	Size of Impact	Healthcare Facility Protective Measures	Healthcare System Considerations/Impacts			
					Loss of Facilities/Critical Systems	Mass Casualty	Exposure Tracking	Injury/Illness Patterns
	contamination. This could be a challenge to determine a Time-Zero (start of incident) and even location.	- o Cesium-137 (Cs-137) - o Cobalt-60 (Co-60) - o Iridium-192 (Ir-192) - o Plutonium-238 (Pu-238) - o Polonium-210 (Po-210) - o Radium-226 (Ra-226) - o Strontium-90 (Sr-90)	blast and fragmentation injuries in the immediate area of the blast. Many, many more people will seek treatment than are actually affected. A non-explosive contamination could affect many people with widespread concern (e.g., milk supply).					Population-wide behavioral health concerns
Nuclear detonation	A massive explosion caused by fission of nuclear material which is immensely powerful.	Near the blast, will include prompt radiation doses from gamma rays and neutrons. Dangerous fallout is produced by fission products and neutron-induced radionuclides and may travel many miles. It may include 100's of isotopes of which 19 are most likely to affect people's health. Relatively rapid decline in dose rate	Yield-dependent but capable of destroying majority of a city.	Shelter in place then evacuation as directed by authorities. If in dangerous fallout area, use building to shield and reduce exposures while sheltering. PPE appropriate for exposure and job classification Screening needed for people entering facility	Facilities within the affected area could be damaged or contaminated and be closed temporarily or permanently. Severe infrastructure damage is likely. Utility and communication outages could also affect facilities ability to operate.	Yes Triage of casualties very important to avoid overwhelming medical capabilities. First 24-48h focus on trauma care, then radiation injury assessment / care and patient transfer.	Geographically and meteorologically based Fall out cloud can go many miles. High altitude dissemination can cause far-reaching effects. Assembly (screening centers) and triage / treatment areas needed – reception centers needed in receiving communities.	Blast injuries, burns, crush injuries, skin, eye, and lung irritation Pressure induced injuries – ear drums, lungs, impact Pressure related injuries from blast wave Flash injuries to eyes ARS and other radiation related sequelae Responder exposure thresholds should be observed Population-wide behavioral health concerns

Potential Considerations

Impacts to the Healthcare System – Overview

As noted in Table 1, the impact on the healthcare system varies depending on the incident type.

Radiological incidents can affect a single person after an industrial exposure, or affect millions after a nuclear detonation, which drastically and catastrophically impacts the entire healthcare system infrastructure and overwhelms those resources still operational with national and international consequences. This document contains resources for all incident types, but is focused on the larger scale or catastrophic incidents. In subsequent sections, impacts and considerations are discussed.

When dealing with any type of radiation incident, the highest priority is to ensure lifesaving emergency care is administered *first* and contamination / exposure is addressed second.

When dealing with any type of radiation incident, the highest priority is to ensure lifesaving emergency care is administered *first* and contamination / exposure is addressed second. Radiation exposure is seldom a threat to providers and treating the injuries should take precedence over performing a radiological assessment. During recovery, radiation professionals will be on scene to monitor and assist with radiation protection issues such as dose and contamination control. The immediate concerns for the healthcare system affected by or adjacent to a radiological or nuclear incident are personnel/facility safety and early patient triage, treatment, transport. [Clinical management and personal protection](#) issues are described later in this document. The primary, initial focus will depend on the incident:

- RDD / dirty bomb – focus is on blast injury management and **detection and decontamination of minor residual external and potential internal contamination**. High-level gamma exposure is unlikely when associated with a device that uses radioactive material in powder form. However, extreme caution should be exercised if it is apparent that radioactive shrapnel may have been dispersed. Certain types and forms of radioactive shrapnel may have extremely high radiation dose rates (e.g., Cobalt 60) that could result in a significant absorbed dose for victims and responders. For a non-explosive RDD (radiologic exposure device), the fear of radiation exposure, and the need for mitigation will likely produce a surge of concerned individuals.
- Nuclear detonation – focus is on initial trauma care and then **assessing and managing high levels of absorbed radiation** (i.e. radiation injury from contamination is usually minimal compared to the high doses of gamma radiation from the blast or fallout). Injuries occur from the initial blast as well as initial release of radiation (prompt radiation) and deposition of radioactive debris from the blast (fallout). Residual environmental contamination is widespread but a minor concern compared to finding patients with acute radiation syndrome from irradiation (gamma radiation that the body absorbed but with no residual contamination). There are multiple issues and priorities, which are highlighted in the article, [Health Care System Planning for and Response to a Nuclear Detonation](#), and discussed below.

KEY CONCEPTS

- Rescue and emergency medical care take precedence over radiological assessment and decontamination (as opposed to chemical events where decontamination is a priority)
- Nuclear and radiological incidents can be safely managed using emergency responders' equipment and protocols;
- Standard infection control precautions including use of standard respirator masks are generally sufficient for treatment of victims of radiological incidents;
- Being contaminated is rarely life-threatening; and
- Being exposed to radiation does not make an individual radioactive.

After a nuclear detonation, beyond initial patient management, healthcare system considerations and impacts include:

- **Overwhelmed healthcare system** – Damage to the hospitals, communication, EMS, and other infrastructure can cripple the healthcare response at a time when an overwhelming number of victims (including first responders) need acute medical care. Triage / treatment casualty collection points need to be established and resources brought in to support compromised infrastructure. The [Radiation-specific TRIage, TReatment, TRansport sites \(RTR\) system](#) should be considered as a framework for the initial healthcare response. Many people will flee the area and seek initial care in communities up to hundreds of miles away.
- **Sheltering orders** – Because the fallout is likely to place hundreds of thousands of persons at risk, sheltering orders for those in the plume area should be issued immediately and will affect healthcare facilities and the healthcare response. Sheltering is extremely effective and should usually be carried out for 24 hours until radiation levels fall significantly (refer to [A Decision Makers Guide: Medical Planning for a Nuclear Detonation, Second Edition](#)).
- **Need to identify population at risk** – Thousands of people will die from radiation illness with the number greatly reduced if they are identified and treated (e.g., with antibiotics to control infections and cytokines to support blood cell production in the injured bone marrow). Because Absolute Lymphocyte Counts (ALC) may not be available, clinical triage criteria may need to be used to screen victims at community-based Assembly Centers (e.g., [the Exposure and Symptom Triage Tool](#)). Many patients will have limited initial symptoms and then feel well, before developing infection and other complications weeks later that can lead to death if not aggressively treated. Triage is essential, as noted below.
- **Patient movement** – Most patient victim movement will be self-evacuation, particularly early on. Once the potentially exposed population has been identified, they should be moved or directed to areas of the country that have healthcare capacity. Because they should be in the latent phase of illness with relatively few symptoms, most can be transported by usual means (airplane, train, bus). Nuisance contamination should be detected and eliminated by decontamination prior to transport.

- **Extensive geographic area impacted** – The impacted area expands far beyond the immediate area of detonation. Broken windows and structural damage can extend for miles and the radiation plume follows the predominant weather/wind patterns for long distances. This large area of impact can make mutual aid and resource sharing difficult. However, using radiation dose assessment, many areas will have low (and decreasing) radiation exposure so that responders can remain there by monitoring exposure rates and following thresholds under the [Protective Action Guidelines](#).
- **Psychological impact** – Any emergency, including those involving radiation, can cause emotional and psychological distress. Radiation is a complex topic, and it is unfamiliar to many people, which can make the psychological effects of a radiation disaster stronger. Monitoring and treating mental and physical symptoms during a radiation emergency is important for short- and long-term mental health. Many symptoms of severe psychological stress are similar to those of acute radiation syndromes (vomiting, headache, dizziness, trouble concentrating).

Other radiological and nuclear incidents may cause similar impacts to the healthcare system, and are discussed below.

Clinical Management Considerations

Personal Protective Equipment and Responder Safety and Health

As discussed in the [Radiation Dosing Comparisons](#) section of this document, **time, distance, and shielding** are the key components for preventing or reducing radiation exposure. Safety Officers at the scene of an incident will need to establish perimeters based on the environmental readings and first responders should have dosimeters to monitor their exposure rate and exposure. HHS REMM provides information from various sources on [radiation control zones and perimeters](#) for responders. Protecting the safety and health of emergency responders is critical in a radiological and nuclear incident. Dose thresholds are discussed [below](#). Note that some dose thresholds apply to exposure over a sustained time period (up to years or even lifetime). They are additive and not limits that “reset.” In general, acute exposure to more than 5 rad should be avoided, though 25 rad in lifesaving situations is appropriate.

Radiation levels after a nuclear incident fall off rapidly over time; and local radiation levels can vary greatly depending on the type of device/incident, the weather, and the types of structures around the incident location.

Note: time, distance, and shielding are the key components for preventing or reducing radiation exposure.

Guidance on [REMM for Personal Protective Equipment in Radiation Emergencies](#) includes:

- In a radiation emergency, the choice of appropriate personal protective equipment (PPE) depends on:
 - Response role and specific tasks (e.g. responder to the site vs. those performing decontamination at a CRC)
 - Risk of contamination
 - Type of contamination

- PPE can protect against:
 - [External contamination](#)
 - [Internal contamination](#) via inhalation, ingestion, absorption through open wounds
 - Other physical hazards (e.g., debris, fire/heat, or chemicals)
- PPE **cannot** protect against exposure from high energy, highly **penetrating** forms of ionizing radiation associated with radiation emergencies, which can occur from blast and fallout.
 - Lead aprons worn in diagnostic radiology do not provide sufficient shielding against these kinds of radiation and are impractical.
 - See [Types of Ionizing Radiation and Shielding Required](#)
- Equipment should include a [personal radiation dosimeter](#) (ideally digital readout with alarms) whenever there is concern about exposure to penetrating ionizing radiation.
 - Direct-reading personal radiation dosimeters may be used to monitor radiation dose and can help workers stay within recommended [Dose Limits for Emergency Workers](#).
 - Direct-reading dosimeters should be worn so that a worker can easily see the read-out and/or hear warning alarms.
- Recommended respiratory PPE when respirable particles are present includes a [full-face piece air purifying respirator](#) with a High Efficiency Particulate Air (HEPA) filter (e.g. N100/P100).
 - Other respiratory protective equipment (e.g., a simple surgical facemask), non-fit tested respirators, or ad hoc respiratory protection may not deliver sufficient respiratory protection though any protection is better than none – the less inhaled particles the better – and most particles are larger dusts rather than the tiny profile of the viruses that require the highest level of filtration.

Environmental testing and hazard assessment by a safety professional can help identify hazards and risk levels and direct choices of appropriate PPE. Immediate life-saving activities should not be delayed for determination or distribution of PPE.

Nuclear Detonation Incident Note: Responders in the dangerous fallout zone should shelter with the rest of the population until monitoring demonstrates it is safe to resume response.

For More Information:

- [ASPR TRACIE Responder Safety and Health Topic Collection](#)
- [ASPR TRACIE Tips for Retaining and Caring for Staff after a Disaster](#)
- [Field Guide for Health and Safety Officers: Radiological Incidents](#)
- [HHS REMM: Personal Protective Equipment in a Radiation Emergency](#)
- [IND Health and Safety Planning Guide for Planners, Safety Officers, and Supervisors for Protecting Responders](#)
- [IND Quick Reference Guide for Planners, Safety Officers, and Supervisors for Protecting Responders](#)

Health Effects of Ionizing Radiation

Exposure to high levels of radiation can cause two kinds of health effects: deterministic effects and stochastic effects.

- Deterministic effects are directly dose-related and manifest as Acute Radiation Syndrome (ARS) soon after exposure with effects such as vomiting, diarrhea, headache, fever, skin burns, hair loss, or death. Others occur later (e.g., lung injury).
- Stochastic effects are long-term effects such as cancer. The risk of occurrence increases in relation with dose received, but it is more difficult to predict the specifics for an individual. And the severity of the cancer, once it occurs, does not depend directly on the dose. Factors include dose, target organ, and underlying susceptibility. Younger persons are more likely to experience stochastic effects simply because they have more years to experience the potential effects, particularly cancers.

Radiation dose determines the severity and extent of deterministic effects and the probability of developing stochastic effects.

For More Information:

- [CDC Radiation Emergencies, Information for Clinicians](#)
- [Health Physics Society: Specialists in Radiation Protection](#)
- [Information for Health Care Personnel](#)
- [Information for Homeland Security](#)
- [Medical Management of Radiation Incidents](#)

Short-Term Health Effects (Deterministic Effects)

Acute Radiation Syndrome (ARS) and Cutaneous Radiation Injury (CRI) are the two primary short-term health effects.

Treating patients during the latent phase improves survival chances.

Acute Radiation Syndrome

ARS is an acute illness caused by a high dose of penetrating radiation to the whole body in a short period of time. Note that *all* patients with possible ARS should have an absolute lymphocyte count (ALC) obtained as soon as possible for more accurate prediction of dose and risk. Unless very severe, most ARS follows three phases: initial symptoms appear within the first hours to days, then a "latent period" occurs without many symptoms (this may last a few days to a few weeks), then infections and other complications set in as the existing white blood cells die and are not replaced due to bone marrow injury. If patients can be treated during the latent phase they have an improved chance of survival. Damage also occurs to the overall vascular system and there can be a loss of platelets or abnormal bleeding due to vascular injury. Delayed deaths usually occur from infection as the body has no white blood cells to protect it, and damage to organs allows intestinal bacteria into the bloodstream. In severe cases at high doses there is no latent phase and death occurs early from brain swelling and other complications.

It is highly unlikely that response to radiation events will result in dangerous levels of radiation to first responders and receivers except in the immediate aftermath of a nuclear event close to

the detonation. [Experience has shown](#) that medical workers providing care to the contaminated victims of a radiological incident are unlikely to exceed the occupational dose limits for a radiation worker, 50 mSv (5 rad). Medical personnel near the Chernobyl nuclear reactor accident who treated contaminated workers accumulated doses < 10 mGy (1 Rad).

As the dose increases, there are four general clinical manifestations of ARS; hematopoietic, gastrointestinal, cutaneous, and neurovascular syndromes. Each is described below and hyperlinked to the HHS REMM Managing ARS Tool.

[Hematopoietic](#)

- Hematopoietic effects are dose dependent and there is good correlation with the amount of whole body radiation received and changes in blood cell counts (particularly absolute lymphocyte count - ALC). Significant effects on cell counts are usually seen above 1 Gy (100 Rad) exposures.
- Bone marrow is damaged by radiation – some of the white blood cells (granulocytes, monocytes) currently in circulation survive, but are not replaced if the damage was significant. This causes an increased risk of infection in the weeks following the exposure.
- Effects can be partially mitigated with administration of cytokines that stimulate the bone marrow to produce new cells; this is especially effective in the first few days after radiation exposure.
- Antibiotics should be given prophylactically to prevent infection in significant ARS and any infection should be aggressively treated with broad spectrum antibiotics.
- Blood products may be needed to support lost components – platelets in particular may be needed.

[Gastrointestinal](#)

- Indicated by nausea and vomiting (although many other factors can contribute to nausea and vomiting, including stress, viral/food related, and head injury). Threshold for vomiting is usually around 1-2 Gy/ 100-200 Rad.
- Diarrhea, cramps, and stomach pain can be seen in higher level exposures.
- Gastrointestinal bleeding can be an early or late complication and may require transfusion.
- Anti-emetics and anti-diarrheals may be helpful.
- IV fluid replacement may be needed.

[Cutaneous](#)

- Skin changes not due to thermal injury can occur hours to weeks after exposure and include redness, swelling/edema, blistering, and sensitivity.
- These effects generally reflect a poor prognosis if significant areas involved due to correlation with substantial radiation exposure.
- Late skin changes include skin sloughing and loss, hair loss, changes to the nails and nail beds, and ulcers or necrosis.
- Topical applications of various products depending on the symptoms could include lotions, powders, anti-inflammatory glucocorticoids, antihistamines, antibiotics, and

drying agents.

- Pain management may be an important component of treatment.
- Use debridement, dressings, skin grafts, and burn consultations, as appropriate.

Neurovascular

- Fluctuating blood pressure and body temperature (particularly fever) may occur at higher exposures (although many other things can also cause this).
- Fatigue, headache, and lack of appetite are common post exposure.
- Cognitive and neurological deficits can occur hours to weeks after significant exposure, usually beginning with confusion.
- Manage symptoms: anti-emetics, fluid management, glucocorticoids and hypertonic solutions (if increased intracranial pressure), temperature control, blood pressure.
- Monitor neurological status.
- Pain management may be an important component of treatment.

For More Information:

- [CDC Acute Radiation Syndrome: A Fact Sheet for the Public](#)
- [CDC Acute Radiation Syndrome: A Fact Sheet for Physicians](#)
- [REMM Exposure: Diagnose/Manage Acute Radiation Syndrome](#)
- [HHS REMM: Managing Acute Radiation Syndrome](#)
- [Radiation Injury Treatment Network® \(RITN\)](#)

Cutaneous Radiation Injury

Cutaneous Radiation Injury is different than cutaneous subsyndrome of ARS in that it does not occur with ARS and can be from more localized radiation exposure or from exposure that did not penetrate beyond the skin (e.g., “beta burns”). These radiation injuries are different from thermal or chemical burns in that they can manifest later and can result in malignancy. Treatment, however, is similar to cutaneous ARS or thermal burns.

For More Information:

- [CDC Cutaneous Radiation Injury](#)
- [CDC Cutaneous Radiation Injury: A Fact Sheet for Physicians](#)
- [HHS REMM: Cutaneous Subsyndrome](#)

Long-Term Health Effects (Stochastic Effects)

Cancer, prenatal radiation effects, and disaster behavioral health issues are the primary long-term health effects that victims will face after radiation exposure.

Cancer

Some population data indicates a slight increased risk of some cancers in areas that have experienced past radiation exposure, but the numbers are far less than what is assumed among the lay public. These cancers include leukemia, breast, bladder, colon, liver, lung, esophagus, ovarian, multiple myeloma, stomach, prostate, nasal/sinus, pharyngeal, laryngeal, and pancreatic cancers.

Currently in the U.S., approximately 40% of the population will experience cancer and 23% of the population will experience a fatal cancer. A radiation dose of 25 rad (0.25 Gy) would increase the average individual lifetime risk of fatal cancer from 23% to 24.8%, or by 1.8%. Similarly, a dose of 100 rad (1 Gy) would increase the average individual lifetime risk of fatal cancer by 8%.

For More Information:

- [CDC: Cancer and Long-Term Health Effects of Radiation Exposure and Contamination](#)
- [U.S. Nuclear Regulatory Commission: Radiation Exposure and Cancer](#)

Prenatal Radiation Exposure

The effect of radiation on a fetus is based on the amount of radiation exposure that occurred and the gestational age of the fetus. Fetuses are particularly susceptible to radiation-induced organ damage between 2 and 18 weeks gestation. Negative health effects could include stunted growth, deformities, abnormal brain function, or cancer later in life. Pregnant women who are exposed to levels of radiation over 20 Rad may have a higher risk of miscarriage.

For More Information:

- [CDC: Cancer and Long-Term Health Effects of Radiation Exposure and Contamination](#)
- [CDC Information for Clinicians](#)
- [EPA Radiation Health Effects](#)
- [NRC Radiation and Its Health Effects](#)

Disaster Behavioral Health Needs

Disasters can lead to significant mental and behavioral health consequences that will directly impact healthcare systems. The demand for disaster behavioral health services spikes immediately following an incident and decreases but continues over time.

Radiological emergencies are frightening for most people, including first responders, healthcare personnel and their families. The health effects, exposure risk, and general recovery from these incidents are not well understood by the general public and will likely cause significant psychological stress including in areas not directly affected by the incident. The scale and emotional impact of a radiation event—particularly a nuclear detonation—will have profound psychological effects beyond usual disaster incidents. Past incidents provide some information on how the general public will react to radiological emergencies. Ensuring a disaster behavioral health program is in place, along with a rapidly deployed risk communication program to explain the exposure and risks and calm the fears of those outside the affected area, will be critical to preserve healthcare system resources.

For More Information:

- [ASPR TRACIE Disaster Behavioral Health: Resources at Your Fingertips.](#)
- [ASPR TRACIE Mental/Behavioral Health \(non-responders\) Topic Collection.](#)
- [ASPR TRACIE Responder Safety and Health Topic Collection.](#)
- [ASPR TRACIE Tips for Retaining and Caring for Staff](#)
- [HHS REMM Mental Health Professionals](#)

Decontamination

If radioactive contamination exceeding the criterion established by local authorities is detected, individuals and their belongings should be decontaminated before entering the shelter clean zones. The contamination threshold is established by responding jurisdictions and can vary based on incident specifics.

Unlike many chemical and biological agents, radioactive material contamination [rarely represents an immediate danger to the health of the victim or the responder](#). This reduces the immediacy of the need for decontamination and allows greater flexibility in selecting decontamination options. So, a scalable approach is required for decontamination planning. Because radionuclide contamination is not likely to be an immediate health threat to the victims, the size of the incident will determine the type of decontamination procedures that can be employed. Do not delay emergency medical response to remove low level, relatively fixed contamination in the early stage response. Contamination control will likely not be possible during the early (emergency) phase of an incident and minor contamination of an area should not prevent its use. However, reasonable attempts should be made to limit the spread of contamination. If an area such as a room in a hospital emergency department designated for the reception of contaminated injured patients becomes heavily contaminated, performing limited decontamination of the area will reduce the doses received by people working in the area and the spread of contamination to other areas.

People without injury who were in an at-risk area should perform decontamination at home in large-scale incidents by undressing at the entry to the home, bagging clothing in a sealable plastic bag, showering with usual household soap and water and then reporting for further evaluation to an assembly center or reception center to be screened by hand-held or portal monitors. Decontaminating a person can be as simple as removing an article of clothing or it can require multiple showers or special techniques to remove stubborn contamination. In general, people can be cleaned as if they were covered in dust or mud. Always check the soles of the feet for contamination, as walking through a contaminated area is common! Clothing may need to be brought to the screening center for assessment.

Radiation safety experts will assign thresholds for clothing contamination. Most clothing should be able to be washed and then used again, but some clothing may have higher levels of contaminant and may need to be destroyed.

Organizations with emergency-response vehicles, particularly ambulances, should recognize that complete contamination control will likely not be possible during the early (emergency) phase of an incident and that minor contamination of a vehicle's interior should not prevent or

delay its use. However, reasonable attempts should be made to limit the contamination inside a vehicle. Methods for minimizing contamination of the interior of an ambulance include:

- Removing the outer clothing of a contaminated patient before loading the patient into an ambulance;
- Placing two sheets on the gurney before placing a contaminated patient on the gurney; and
- Folding the edges of the sheets over the patient as a 'cocoon'.

Furthermore, reasonable attempts should be made to reduce the amount of radionuclide contamination inside a vehicle after a task, such as transportation of a contaminated injured patient to a hospital. These measures will reduce the doses received by people working in the vehicle.

Universal precautions (i.e., standard hospital personal protection procedures) in the emergency room are generally sufficient for treatment of victims of nuclear or radiological incidents.

On-scene personnel that may be exposed to respirable dusts should use respiratory protection. Radiation safety professionals on scene will determine appropriate decontamination procedures for the type of radioactive contamination present. Ensure that all decontamination procedures are strictly enforced.

Below are high-level, immediate actions for gross decontamination. Healthcare practitioners should follow the [Radiation Treatment Protocol from the Radiation Emergency Assistance Center \(REAC/TS\)](#) for specific actions and care pathways.

If running water is available:

- People should first be spot decontaminated by using material such as baby wipes to reduce the amount of contaminated wash water and to more quickly and effectively decontaminate the individual.
- Carefully removing their outer layer of clothing can greatly reduce the contamination.
- If clothing removal and spot decontamination efforts are not effective, then shower or wash exposed skin at a sink or shower.
- Do not allow wash water from hair to run down onto body/creases to avoid contamination of skin crevices (i.e., bend over toward shower stream to wash hair).
- Individuals who are unable to perform these tasks by themselves will require personal assistance.

If running water is NOT available:

- People should carefully remove their outer layer of clothing and decontaminate exposed skin with moist wipes or damp towels, or use other dry decontamination techniques.
- Individuals who are unable to perform these tasks by themselves will require personal assistance.
- Use the technique of ‘single wiping’ – wipe and discard – do not scrub or wipe back and forth across an area.
- Dry decontamination techniques focus on clothing control and may also include using tape or lint rollers to remove visible dust from clothing or skin.

For More Information:

- [ASPR TRACIE Hospital Victim Decontamination Topic Collection.](#)
 - [Radiological-specific decontamination resources are also available under a separate heading in this Topic Collection.](#)
- [ASPR TRACIE Pre-hospital Victim Decontamination Topic Collection.](#)
- [HHS REMM: Decontamination Procedures](#)
- [Radiation Emergency Assistance Center/Training Site: Radiation Patient Treatment Protocol](#)
- [The Medical Aspects of Radiation Incidents](#)

Healthcare Response - Triage and Monitoring

There are many locations following a radiological or nuclear incident where patient care and victim assessment may take place, including casualty collection points, medical centers, alternate care sites, community reception centers, and assembly centers.

- Casualty collection points or Rapid Triage and Treatment (RTR) points are spontaneously established and intended for primary assessment of injuries and triage to medical centers or alternate care sites.
- Medical centers– these may be damaged or overwhelmed – the closer the center to the incident, the worse the situation is likely to be.
- Alternate care sites may be spontaneous or planned locations that act as overflow for the medical centers and provide patient care.
- **Community reception centers (CRC)** are designed for formal screening, decontamination, registration, and assessment of internal and external contamination potential including sample collection for bioassays. They require significant resources and are *not* established in close proximity to a nuclear detonation event but must be established in nearby communities where resources are sufficient.
- **Assembly centers** are intended for rapid, qualitative screening of very large numbers of uninjured persons that were in a fallout or prompt radiation exposure area after a nuclear detonation. They are assessed for symptoms of ARS and prioritized for evacuation from the area and cytokine use. These centers should be located near the margins of the dangerous fallout zone (DFZ) and opened around

the time the 24 hour sheltering orders expire. The functions of these centers are described in detail in a white paper titled [Population-Based Triage, Treatment, and Evacuation Functions Following a Nuclear Detonation](#). Screening tools such as the “[EAST- Exposure and Symptom Triage](#)” tool may facilitate categorization of a large number of persons. Table 2 illustrates the difference between CRCs and Assembly Centers.

Table 2. Assembly Centers and Community Reception Centers

	Assembly Center (AC)	Community Reception Center (CRC)
Location	Close to detonation	Far from detonation
Resources in community	Scarce	Adequate
Goal	Rapid assessment for total body radiation exposure	Detailed assessment for external and internal residual radiation
Resources required	Minimal	Extensive
Decontamination	Gross / Containment	Technical
Registration / interview	Minimal	Detailed
Other functions on site?	Likely – some medical care, cytokine administration, possible shelter / support operations	Unlikely

The [RTR system](#) provides a [comprehensive schema](#) for local planners to establish ad hoc sites, assembly centers, and coordinate transport to medical centers and definitive care via evacuation centers.

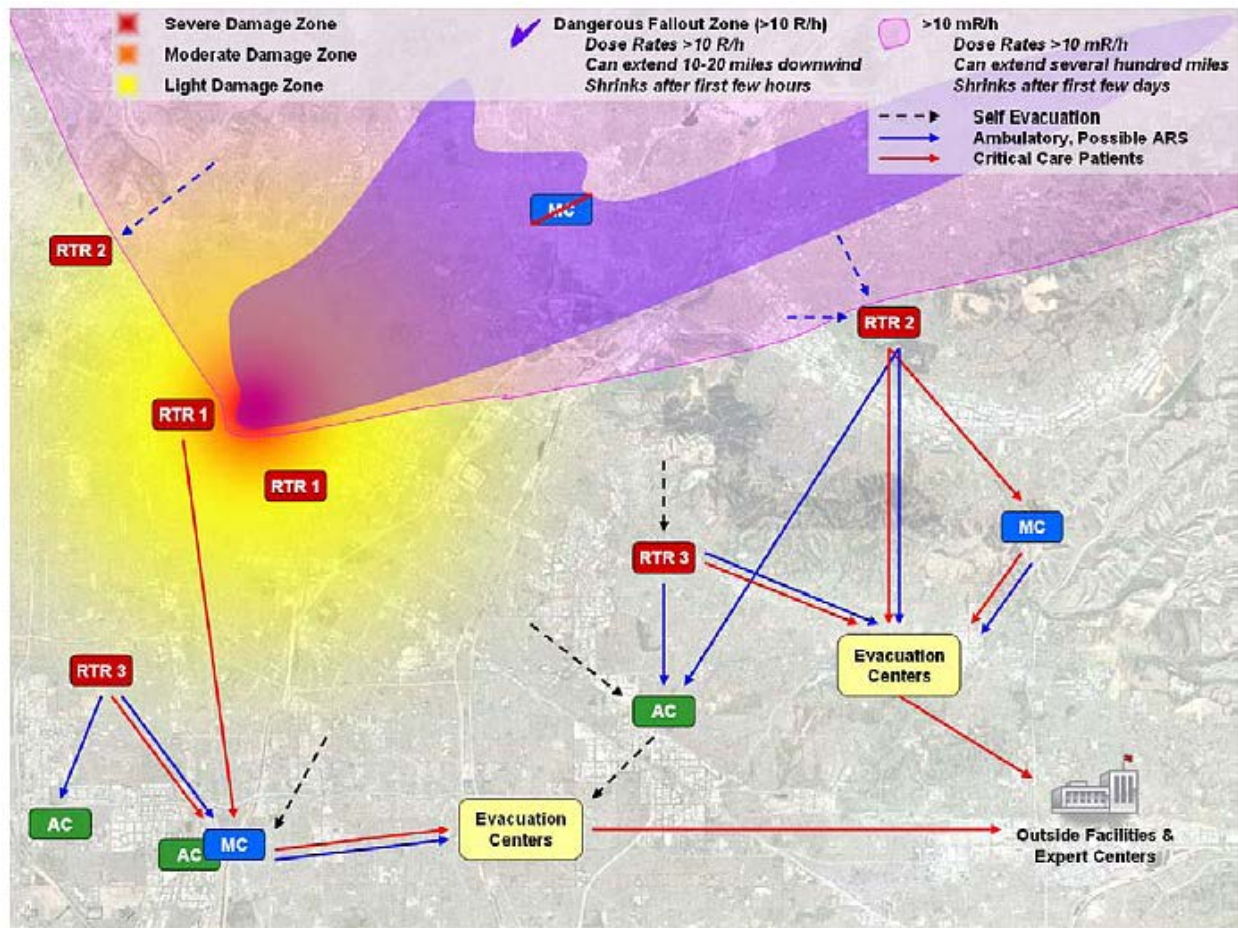


Figure 1. RTR System drawing from HHS REMM

Community Reception Centers

As mentioned above, formal CRCs do not appear on this figure as they are locations that would be established by public health, healthcare, and other response partners to provide radiation contamination assessment of uninjured evacuees after a radiological incident in areas where adequate resources exist. The use of this term may vary among the CDC and the local communities. This discrepancy is unfortunate but should be addressed by planners and incident managers to prevent confusion. Terminology and function can also vary with centers established for nuclear power plant incidents.

CRCs are located *outside* of the affected area to service the people living in that community, and the displaced population arriving there. The CRC is primarily designed to assess *external* contamination which may have no bearing on prognosis after irradiation following a nuclear incident but is extremely important after other types of radiation events such as RDD. The basic services include:

- Quantitative screening for external radioactive contamination
- Decontamination
- Assessment for need for bioassay and other testing to evaluate internal contamination
- Registering people for long-term follow-up and collecting epidemiologic information

- Prioritizing future testing and other steps for the individual

The CDC shares guidance for CRCs in the document [Population Monitoring in Radiation Emergencies](#).

Healthcare Response - Radiation Countermeasures

There are a number of countermeasures and other pharmaceuticals available in limited quantities for radiation exposure all discussed at length on the [HHS REMM site](#). For the purposes of this document, the most commonly available and prescribed countermeasures are discussed below. Medical physicists and/or clinicians with access to the proper detectors or laboratories will provide the information. Indeed, using the wrong countermeasure can be harmful and certainly waste time and resources. Clinicians also need to manage symptoms caused by exposure and not just treat the exposure with a countermeasure.

Cytokines (Neupogen, Neulasta, Leukine)

Cytokines are unique among the radiation countermeasures in that they help mitigate the effects of overall radiation injury to the bone marrow, if received in a timely manner. The purpose of administering these medications is to stimulate white blood cell and bone marrow growth and thereby shorten the duration of severe neutropenia (decreased neutrophils, a type of white blood cell that is important to infection control), minimize risk of complications (e.g., infections), and improve survival in those patients that received radiation exposure above the dose of 2 Gy to an extensive amount of the body. During a mass casualty incident, consult [HHS REMM's Interactive Scarce Resources Tool](#) for triage criteria for the administration of cytokines when there are more patients than medications, staff, or beds available. For maximum effectiveness the cytokines should be given within the first 2 days after exposure. Beyond 48 hours they are not as useful but may still be helpful to prevent complications.

Neupogen and the other cytokines are administered by injection and complete blood counts are needed every few days to monitor effectiveness.

For More Information:

- [CDC: Neupogen](#)
- [FDA Approves Leukine for Acute Radiation Syndrome](#)
- [HHS REMM: Myeloid Cytokines](#)
- [Radiological and Nuclear Emergency Preparedness Information from FDA](#)

The countermeasures listed next are most appropriate for use after an RDD incident when internal contamination is the dominant route of radiation exposure and a single isotope is involved, and are not typically needed after a nuclear incident when total body irradiation is the primary exposure pathway and ingestion/inhalation of isotopes is a relatively minor contributor. Further, a nuclear detonation and many nuclear power plant incidents result in a variety of isotopes being released, most of which have no specific countermeasure.

Most countermeasures act as a "sponge" to bind a specific radioactive isotope and help get it out of the body but are not an "antidote" to the isotope's effects. Clinicians need to match the

suspected isotope causing exposure to the correct countermeasure for there to be any clinical benefit.

DTPA

Diethylenetriamine pentaacetate (DTPA) is a medication that can bind radioactive plutonium, americium, and curium to diminish the amount of time the elements are in the body and facilitate elimination through urine.

The medication must be administered intravenously, either through a drip or direct injection. There is an inhaled form that can be administered if the radiation was inhaled. DTPA can only be administered under the supervision of a doctor or qualified medical professional. As with most countermeasures, it is most effective when administered immediately after exposure, preferably within 24 hours. Regular collection of blood, urine, and stool samples aid in the determination of continued DTPA administration, so patients need to remain either in a treatment location or come back for regular care. Some states have caches of DTPA and additional courses are available from federal sources.

For More Information:

- [CDC: DTPA](#)
- [HHS REMM: DTPA](#)

Potassium Iodide (KI)

KI is only useful during nuclear power plant incidents. KI can help block radioactive iodine from being absorbed by the thyroid gland, which is the part of the body most susceptible to damage. KI cannot prevent radioactive iodine from entering the body or reverse its effects, so it's critical that KI is taken prior to or immediately after exposure. KI can be issued by communities to those residents living or working within the 10-mile [Emergency Planning Zone \(EPZ\)](#) of a nuclear power plant prior to an incident occurring. Depending on state plans, residents may have the pills in their possession and would take them prophylactically should an emergency occur at the power plant, upon the direction of local emergency management or public health officials, or there may be a process to distribute KI emergently. KI can be purchased without a prescription or dispensed after an incident, but the effectiveness would be limited.

The point of taking the KI prior to exposure or early into ongoing exposure is to “fill up” all the iodine receptors in the thyroid with the stable iodine, so that when radioactive iodine passes through the thyroid, the thyroid is already full of stable iodine and can't absorb any radioactive iodine.

Note that KI is *only* effective in blocking the effects of radioactive iodine on the thyroid tissue. Though radioactive iodine can be released during a nuclear reactor incident it is rarely the only radioactive isotope released. KI has no effect on other radio-isotopes. KI is of limited efficacy in adults as the thyroid does not take up iodine as avidly and the long term risk of cancer is much lower.

For More Information:

- [CDC: Potassium Iodine](#)
- [HHS REMM: Potassium Iodide](#)

There will be many people with physical trauma and little or no radiation exposure and people in the dangerous fallout zone with no physical trauma but with radiation exposure.

Prussian Blue

Prussian blue is a capsule that binds to radioactive cesium and thallium aiding in rapid elimination from the body. Prussian blue binds radioactive cesium and thallium in the intestines and is then excreted in bowel movements. Because of the physiology of intestinal fluids, Prussian blue can help pull cesium or thallium that is still circulating in the blood into the bowel and enhance excretion. It is best started as soon as internal contamination is known but starting it later is still useful, unlike KI.

Prussian blue is administered in pill form, which is generally swallowed whole, but if a patient can't swallow, the capsules can be broken and the contents mixed with food or liquid, but it will turn the patient's mouth and teeth blue. Feces may be blue during the treatment duration which is generally about 30 days long and dependent on regular bioassays to determine efficacy. This can stain growing teeth so using this in children must be done appropriately.

For More Information:

- [CDC: Prussian Blue](#)
- [HHS REMM: Prussian Blue](#)

Medical Surge

Besides the radiation effects of a radiological or nuclear incident, there are other injuries that could occur that will create a surge of patients seeking medical care. These could include:

- Blast-related injuries
- Burns
- Respiratory irritation
- Eye irritation / injury from flash burns, flying debris, and dust/debris
- Acute mental health issues

It is important to recognize that there will be many people with physical trauma and little or no radiation exposure and people in the dangerous fallout zone with no physical trauma but with radiation exposure. Many people will be concerned about radiation exposure well beyond the at-risk areas. The burden on the healthcare system will be complicated in a nuclear event locally by infrastructure loss (including communications) as well as access issues (e.g., road closures). Additional effects on the healthcare system are described in [this article](#).

The entire healthcare system, from 9-1-1 dispatch to definitive care, should be prepared to handle an initial dramatic surge in trauma patients and then an increase over the first few days post-incident in patients with a wide range of chief complaints including radiation-related vomiting and other symptoms. Many patients seen in the days and weeks following an incident will display exacerbations of underlying disease due to disruptions in their care or their

environment. Later patients may be experiencing infections from wounds or from the effects of radiation toxicity.

After a nuclear detonation, many residents will self-evacuate and will present for assessment and care at hospitals hundreds of miles from the detonation. There should be a process in place to refer asymptomatic patients to CRCs or other intake locations.

State, local, and federal staff should be prepared to receive requests for staff and medical service delivery augmentation to support this incident-related surge of patients.

Massive patient movement activities may take up to 72 hours to begin and may continue for many days to weeks as patients are moved to [Radiation Injury Treatment Network \(RITN\)](#) hospitals, communities, and other metropolitan areas for additional assessment and care.

Crisis Standards of Care (CSC) and Triage

What are Crisis Standards of Care/ Allocation of Scarce Resources?

Crisis Standards of Care (CSC) is defined as a substantial change in usual healthcare operations and the level of care it is possible to deliver, which is made necessary by a pervasive (e.g., pandemic influenza) or catastrophic (e.g., earthquake, nuclear) disaster. This change in the level of care delivered is justified by specific circumstances and is formally declared by a state government, in recognition that crisis operations will be in effect for a sustained period. (IOM, 2012)

What do I Need to Know?

Medical care that is rendered during a mass casualty incident occurs across three phases on a continuum (conventional care, contingency care, crisis care):

Table 3. Three Phases of Medical Care Rendered During a MCI

Incident demand / resource imbalance increases → Risk of morbidity / mortality to patient increases ← Recovery			
	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
Normal Operating Conditions		Extreme Operating Conditions	

The objective of mass casualty response is to remain in the conventional and contingency phases of response or to return to them as quickly as possible by effective management of resources.

Four resource categories are the key to successful hospital surge capacity implementation. Emergency physicians should understand the resources available in these areas and how additional resources or assistance may be obtained:

1. **Space:** adequate physical space to care for patients. This may include categories of space such as critical care, medical/surgical, and pediatrics but also includes availability of adequate outpatient space. Emergency providers should understand the expansion/surge plans for their department and region, including triaging of patients to other locations or the opening of other clinical areas for emergency care.
2. **Staff:** sufficient, appropriately educated and trained staff, including subspecialty staff. This includes the ability to call in qualified staff and extend the capacity of current staff (by changing expectations during the incident for charting, etc.).
3. **Supplies:** sufficient pharmaceuticals and medical supplies and equipment to provide care for the arriving patients. Availability of supplies varies greatly, depending on the size of the facility, its preparedness planning, and its role in the community (children's hospital, trauma center, Veterans Administration facility, etc.).

4. **Special:** considerations for specific incidents or populations outside of the usual clinical resources (radiation detection equipment, radiation safety officers / health physicist consultation, countermeasures, decontamination equipment).

When anticipating or faced with a resource shortfall, providers may use 6 key strategies:

- Prepare
- Conserve
- Substitute
- Adapt
- Reuse
- Reallocate

In general, clinical resource shortages can be anticipated to occur in the following areas and strategies should be put in place in advance to curb the need for or length of CSC:

- Oxygen
- Medications (particularly antibiotics, cytokines, anti-emetics, and analgesia)
- Hemodynamic support (including intravenous fluids)
- Ventilators and other critical care technologies (in a pandemic, this could include extracorporeal membrane oxygenation)
- Staff (EMS, medical, and nursing in particular)
- Blood products (unlikely to be in national shortage, aside from platelets in the weeks after a nuclear detonation, but institutional and regional shortfalls may exist for brief periods)
- Trauma care equipment and supplies
- PPE

This [cardset](#) from the Minnesota Healthcare System Preparedness Program and this ASPR TRACIE [Crisis Standards of Care Topic Collection](#) provide additional CSC resources.

Triage

An ethical framework must ground all disaster triage decisions. Core components of ethical decision making are the following:

- **Fairness:** The process is inherently just to all individuals, and the process itself treats all individuals equally who have equal needs.
- **Duty to care:** Physicians have a duty to care as best they can for all victims of the incident.
- **Duty to steward resources:** Physicians have a duty to attempt to obtain the best outcome for the greatest number of patients with the resources available (this does not specifically translate to “save the most lives” because a comfortable death may be a good outcome and thus appropriate to receive resources).
- **Transparency:** Though difficult in reactive triage decisions, the process and criteria should be as transparent as possible.
- **Consistency:** The process should be applied in the same way to all presenting for care.

- **Proportionality:** The degree of resource restriction should be proportional to the demands.
- **Accountability:** Triage officers and others should be able to defend their decisions and be answerable for them. This may involve documentation and potential review of decisions by the institution and possibly outside agencies.

For radiological events, the [Proposed “Exposure and Symptom Triage” \(EAST\) Tool](#) to assess radiation exposure after a nuclear detonation is helpful in addressing triage decisions.

In general, triage is guided by the principles of time, person providing treatment, and treatment – how much time is required, how much expertise by the “treaters,” and how many treatment resources are available. The larger the disaster, the more that medical efforts should focus on those with **moderate injuries**, where small interventions can have major impact on outcomes.

Combined injury (when radiation and trauma injuries co-exist) dramatically increases mortality. [Coleman et al](#) developed a radiation and radiation + trauma triage framework that should be helpful following a nuclear detonation event to prioritize patients for aggressive management.

[Scarce Resources](#)- This full triage module (available on REMM) provides users with access to the information listed below and to an online flowchart/decision tree for complex triage decisions after a nuclear detonation incident. This set of resources provides the background information on the triaging and medically managing patients in the early days following a nuclear detonation. The online triage tool allows for data entry and customization of decision-making.

- [Use triage tool online](#)
- [Download triage tool for use offline by downloading REMM](#)
- [Print triage tool cards](#) (PDF - 664 KB)
 - [Download Mobile REMM](#) which includes "Scarce Resources Triage Tool"
 - Read [Scarce Resources Triage Tool Disclaimer](#) information

For More Information:

- [Using the Model of Resource and Time-Based Triage \(MORTT\) to Guide Scarce Resource Allocation in the Aftermath of a Nuclear Detonation](#)

Additional Immediate Considerations

In addition to the clinical considerations, there are other emergency management and operational issues that must be addressed within the community and within the healthcare system.

Emergency Information and Risk Communication

As the incident evolves from warning to initial impact, then response, and into recovery, risk communication and messaging focus will shift. During a nuclear event, early sheltering orders are critical and can save tens of thousands of lives. Communication includes providing the public with information through verbal, written, or symbolic means. Clear, concise, and coordinated messages provided by trusted leaders before, during, and after an incident can help residents be better informed to make important health-related decisions to help ensure

their safety. Messages should be accessible in multiple languages and through multiple media including social media.

Personal preparedness is critical for population survival and traditional means of communicating emergency messages may be ineffective, so informing the public in advance of protective action measures they can take, including sheltering in place for at least 24 hours following a nuclear incident and home decontamination, is important.

For more information:

- [CDC Radiation Communication and Media Tools](#)
- [CDC Radiological Communications and Public Information](#)
- [Protective Action Guide \(PAG\) Public Communication Resources for a Radiological Emergency](#)

Family Reunification and Patient Tracking

Following a radiological or nuclear incident, friends and family can be separated from each other and reuniting them is a priority for healthcare facilities, public health officials, and emergency managers. Establishing a coordinated approach for using social media, accessing search and rescue data, shelter rosters, and healthcare facility information is key to reuniting those affected by the disaster.

For more information:

- ASPR TRACIE [Family Reunification and Support](#) and [Patient Tracking](#) Topic Collections

Health Information Management

During a disaster, patients may be separated from their “medical home” and medical records. Information technology systems may be damaged in the incident and access to the systems may be limited by physical barriers, access issues, power disruptions or other impacts. Patients being evacuated or moved from one healthcare facility to another need complete medical records transferred with them, but that is not always possible if the facility has experienced significant damage and paper records are damaged or missing and electronic records are not accessible. Redundant IT systems and back-up paper records with the critical information are ways to mitigate this issue.

There is no current national system that can be used as a radiation injury registry or to track cytokine administration or other interventions. Jurisdictions should plan to have basic paper-based tracking systems in place and give an information card to the patient with information about what has been done and further instructions.

For More Information:

- [ASPR TRACIE Communications Systems Topic Collection](#)
- [ASPR TRACIE HIPAA and Disasters: What Emergency Professionals Need to Know](#)
- [ASPR TRACIE Information Sharing Topic Collection](#)

Select Programs/Assets to Consider:

- [HHS Response and Recovery Resources Compendium](#)
 - [Public Health and Medical Information](#)

Pediatric Concerns

Children comprise nearly one quarter of the US population, meaning there are approximately 74 million children under the age of 18, living in the U.S. today. Children are not just small adults. They have different bodies than adults that make them more vulnerable to certain injuries and require special equipment and special training to manage. They are also more easily affected by the changes a disaster has on environment (such as temperature and air quality) and changes to their routines (such as school closures or loss of permanent housing). Children are often disproportionately affected in disasters, which can place a strain on local communities, whose pediatric resources are limited. Their needs are often overlooked and misunderstood and special planning must be done in communities to ensure pediatric issues can be addressed.

In addition to the exposure to the trauma of community destruction, screening and decontamination operations may be frightening for children. Children may be orphaned or separated from parents necessitating a pediatric safe area for observation until a caregiver is located.

Due to the differences in lifespan, similar radiation doses in children confer a higher risk of long-term mortality from malignancy than in adults. The American Academy of Pediatrics information on [Radiologic or Nuclear Terrorism and Agents](#) reviews specific risk factors that make children more susceptible to injury from the effects of radiological emergencies. This AAP resource highlights the following considerations:

- Children have a greater body surface area to weight ratio than adults and skin that is more permeable, rendering them more vulnerable to thermal and radiation burns
- Young children cannot shield their eyes making them more susceptible to ocular injuries
- Children's respiratory rate is higher than adults and they breathe air lower to the ground, making them more susceptible to particulate radiation exposure
- Children are more susceptible to volume loss from gastrointestinal compromise in ARS
- Children will be more vulnerable to the psychological trauma, as in any disaster or emergency.

For more information:

- [Agency for Healthcare Research and Quality: Pediatric Terrorism and Disaster Preparedness: Chapter 6: Radiologic and Nuclear Terrorism](#)
- [HHS REMM: At-Risk/ Special Needs Populations – Infants and Children](#)

Regulatory Concerns

Healthcare facilities in areas affected by potential radiological and nuclear incidents will likely be forced to operate outside their normal operating conditions. This situation could include a surge of patients requiring the healthcare facility to implement mass casualty protocols, crisis standards of care, and/or activate their emergency plans. It could also include impacts that cause the facility to be inoperable forcing evacuation, closure, or other alteration of regular operations. Some of these impacts will have regulatory repercussions at the local, State, and Federal level. The resources listed below provide information on disaster declarations and waivers in disasters related to healthcare entities.

For more information:

- [ASPR TRACIE Healthcare-Related Disaster Legal/Regulatory/Federal Policy Topic Collection](#)
- [EMTALA and Disasters](#)

Handling Contaminated Medical Waste

A radiological or nuclear incident will generate a larger than usual amount of radioactive and medical waste. Healthcare facilities should discuss contingency planning and surge pick up plans with their current medical waste vendors. Police stations, fire and EMS stations, hospitals, and other healthcare facilities should be prepared for people to bring their waste, such as bagged clothing, to the facilities for disposal if they don't know or aren't told what to do with it.

Emergency management will need to determine a process for screening clothing. This could occur at the CRC or other locations. Thresholds will need to be set for release of clothing vs. destruction of clothing and communications and logistics addressed to assure that salvageable clothing is washed appropriately.

For more information:

- [Management of Radioactive Waste from the Use of Radionuclides in Medicine](#)
- [Radioactive Waste Disposal Fact Sheet](#)
- [Disposal of Waste from the Cleanup of Large Areas Contaminated as a Result of a Nuclear Accident](#)

Ongoing Considerations

(in alphabetical order)

Exacerbation of Chronic Medical Conditions

Any chronic medical condition can be exacerbated in a disaster due to the stress of the incident, loss of physical support systems, lack of access to medications, and/or loss of access to equipment or systems needed to support daily medical care. In particular, the following patients are particularly vulnerable during power plant or nuclear incidents:

- Dialysis Patients
- Patients dependent on medical devices that require electricity (e.g., oxygen concentrators, ventilators, and home dialysis systems).
- Patients who are receiving hospice care.
- Patients whose conditions must be continually managed by prescription medications (e.g., seizure disorders, diabetes).
- Patients with mental health diagnoses and/or alcohol or drug dependency.

Patients need access to healthcare facilities and services, chronic or maintenance medications or therapies, and access to operational medical equipment to return to their pre-disaster health conditions.

Utilizing the [emPOWER](#) program, local authorities can identify Medicare patients who are dependent on durable medical equipment and other vulnerable diagnosis codes in order to target post emergency canvassing. The data includes information on beneficiary claims for ventilator, BiPAP, internal feeding, IV infusion pump, suction pump, at-home dialysis, electric wheelchair, and electric bed equipment in the past 13 months; oxygen concentrator equipment in the past 36 months; and an implanted cardiac device (i.e., LVAD, RVAD, BIVAD, TAH) in the past 5 years. Ideally, this information is made available as part of a pre-event planning operation, but just-in-time coordination with the emPOWER program is possible.

The [Emergency Prescription Assistance Program \(EPAP\)](#) is a potential resource available for affected areas to support access to prescription medications. In addition, national pharmacy chains have mobile pharmacy units available to deploy to local communities. [Rx Open](#), managed by [Healthcare Ready](#) helps patients find nearby open pharmacies in areas impacted by disaster.

Additional information on EPAP and historical use from past activations can be found on ASPR TRACIE:

- [EPAP Overview Fact Sheet](#)
- [EPAP Louisiana Floods](#)
- [EPAP Hurricane Ike](#)
- [EPAP Hurricane Gustav](#)
- [EPAP Superstorm Sandy](#)

Extended Loss of Power

If communities face extended loss of power, residents with chronic medical conditions may experience exacerbated symptoms, people can become sick from spoiled food, and medications that need to be refrigerated can lose potency. Local healthcare systems may experience those and a host of additional secondary and tertiary effects can be felt by the healthcare system. Healthcare facilities must have power in order to continue operations. Rapid needs assessment of healthcare and residential care facilities and supplementation with external generators may be critical to preventing evacuation.

High altitude aerial detonation of a nuclear device can theoretically generate an electromagnetic pulse (EMP). This EMP effect could damage the electrical grid, but it could also

damage individual electronic equipment, meaning that even if a generator is available, it may not work and electronic equipment may not work. Devices may be unusable or may only need a “re-boot”. There are differing opinions on the potential impact of EMP effect. Most experts agree that EMP effects from a ground burst detonation will be negligible.

For More Information:

- ASPR TRACIE Topic Collections:
 - [Continuity of Operations \(COOP\)/ Failure Plan](#)
 - [Utility Failures](#)
- [Planning for Power Outages: A Guide for Hospitals and Healthcare Facilities](#)
- EMP Resources:
 - [Assessing the Risk of Catastrophic Cyber Attack: Lessons from the Electromagnetic Pulse Commission](#)
 - [The Emerging EMP Threat to the United States](#)
 - [Electromagnetic Pulse \(EMP\), Part I: Effects on Field Medical Equipment](#)

Select Programs/Assets to Consider:

- [HHS Response and Recovery Resources Compendium](#)
- [Potable Water/Wastewater/Environmental Health](#)

Fatality Management

Radiological and nuclear incidents have the potential to cause mass fatalities and they present challenges to death scene investigation, patient identification, decedent transport and storage, and notification of family. Fatality management resources may also be limited due to the size of the incident. Radiological incidents pose the additional challenge of decedent contamination. As difficult as this decision may be, given the catastrophic nature of the scenario, care of living patients must take precedent over fatality management.

For More Information:

- [CDC Guidelines for Handling Decedents Contaminated with Radioactive Materials](#)
- [HHS REMM: Management of the Deceased](#)
- [Model Procedure for Medical Examiner/Coroner on the Handling of a Body/Human Remains that are Potentially Radiologically Contaminated](#)

Healthcare Facility Evacuations and Sheltering in Place

Healthcare facilities in the immediate area of a radiological or nuclear incident will likely be asked to shelter in place and facilities can prepare in advance for this possibility. Facilities may also need to evacuate after the immediate impact of a radiological or nuclear incident, if the location or the facility is deemed unsafe. However, evacuations may be delayed due to difficulty reaching the facility and the competing community needs that EMS and other agencies will have. The longer a facility has to evacuate, the more orderly the process can be and the more prepared a facility is to shelter in place, the better protection of patients and staff during radiological and nuclear incidents. The risks of evacuation and shelter in place

decisions must be balanced and consideration for capacity of the region to transport, track, and accommodate patients must also be considered. Hospitals should plan for shutting down their air handling systems to prevent contamination inside the facility.

Healthcare coalitions and health systems can be excellent resources in making system decisions and supporting evacuation operations.

For More Information:

- ASPR TRACIE Topic Collections:
 - [Healthcare Facility Evacuation/Sheltering](#)
 - [Patient Movement and Tracking](#)
 - [Pre-Hospital](#)

Select Programs/Assets to Consider:

- [HHS Response and Recovery Resources Compendium](#)

Medical Services Replacement or Augmentation

Healthcare facilities could be damaged or destroyed by a nuclear incident or be forced to close due to plume (e.g. power plant, nuclear), contamination, loss of utilities, or other physical issues and be “off-line” for an indefinite amount of time. Individual healthcare providers may be personally affected by the disaster and unable to report to work. Some may choose to not work in a radiation incident. Individual or small-office practitioners may not be able to open their offices/clinics because of lack of staff, physical damage, or loss of communications. Alternate care sites should be implemented to provide additional capacity and medical support may be needed at Assembly Center sites.

There will be a need to coordinate replacement healthcare services for those that are temporarily unavailable and those that have been permanently damaged. There will also be a need to augment existing healthcare facilities as they see a surge of patients seeking routine care (non-disaster related) in new locations, due to a lack of ability to seek care from their pre-disaster providers.

For More Information:

- ASPR TRACIE Topic Collections:
 - [Alternate Care Sites](#)
 - [Ambulatory Care and Federally Qualified Health Centers \(FQHC\)](#)
 - [Crisis Standards of Care](#)
 - [Hospital Surge and Immediate Bed Availability](#)
 - [Mental/Behavioral Health](#)
 - [Pre-Hospital](#)
 - [Virtual Medical Care](#)

Select Programs/Assets to Consider:

- [HHS Response and Recovery Resources Compendium](#)
 - [Hospital Care](#)
 - [Mass Care](#)

- Medical Care Personnel
- Medical Equipment and Supplies
- Outpatient Services
- State Medical Response Teams (Inter- or Intrastate)
- Emergency Management Assistance Compact

Shelter and Congregate Living Health and Health Concerns

Widespread, sustained structural damage and/or radiological contamination could create the need for large and sustained shelter operations. While the goal for emergency management is to return people to their homes or to provide transitional housing that process can take time.

The priority for health and medical response and recovery personnel is to ensure the shelter environment is safe and that shelter residents have access to basic hygiene and healthcare services, clean water, security, and safe food.

Shelters will need to be able to conduct radiation screening at their entrances in order to keep contamination to a minimum. Background levels of radiation will rise over time, and acceptable levels of contamination to enter the shelter will need to be determined and adjusted as needed. In Japan, a threshold of less than 100,000 cpm on a portal monitor was used in many areas after the Fukushima event and over 440,000 persons were screened over four days. Over 400,000 persons required shelter in the immediate aftermath and over 90,000 were still in shelters three months later.

Depending on how long people will reside in shelters, potential public health hazards must be monitored (e.g., food safety and hygiene [toilets and showers]). Ensuring surveillance is in place to monitor for infectious disease outbreaks, specifically respiratory and gastrointestinal diseases, is critical.

People may report to shelters or to hospitals or other alternate care sites with their pets. Coordination between health personnel and public health and emergency management partners will be necessary to manage patients' pets. Pet radiation and decontamination services must be addressed in community radiation response plans.

Staff Fatigue, Replenishment, and Willingness

In the first few days of a response, staff are focused on rescue and response operations and often can't or won't rest or remove themselves from operations. Staff who maintain facility operations are a critical component of the response phase and expected to care not only for their own loved ones, but community members and the facility, too. Fatigue, stress, and inadequate nutrition and hydration can lead to declining cognitive abilities, increased risk taking (e.g. failure to use protective equipment), and emotional exhaustion. Reactions stemming from extended periods of stress can place both staff and patients at risk. Incident management should prioritize staffing planning including adequate rest and replenishment cycles.

In addition to health system partners, state and federal supplemental staff and Medical Reserve Corps volunteers should be sought to assist and support the local healthcare assets.

Finding additional staff may prove challenging in a radiation event, due to a lack of understanding of risk from the event to healthcare workers. Numerous studies on healthcare personnel's willingness to report to work have found that staff are far less willing to respond to a radiological event than to a natural disaster. Some suggested reasons for this reluctance include perceived high personal health risk, [lack of training/knowledge](#) on the risks and impacts of radiological events, lower confidence in ability to perform ones' clinical role, and negative perceptions of hospitals' ability to protect staff.

Some ways to reduce staff anxiety, increase their sense of safety, and improve willingness to respond includes: education (prior to event and just-in-time) on radiological risks, use of electronic dosimeters to demonstrate the low levels of exposure, treatment and response training and practice, clear and consistent risk communication, and demonstrable investment in staff safety precautions.

For more information:

- [ASPR TRACIE Tips for Retaining and Caring for Staff in a Disaster](#)
- [Characterizing Hospital Workers' Willingness to Respond to a Radiological Event](#)
- [Factors Affecting Hospital-based Nurses' Willingness to Respond to a Radiation Emergency](#)
- [Willingness of Health Care Personnel to Work in a Disaster: An Integrative Review of the Literature](#)

Transportation

EMS providers may have difficulty accessing patients and/or their fleet may have suffered disaster-related damage. Residents may not be able to use traditional modes of transportation to access their healthcare providers or emergency services. Their vehicles may have been damaged or inaccessible, buses may not be running, taxis and car services may not be operational, and para-transit, Handi-vans and other medical transportation providers may be otherwise committed to response operations.

Roads may not be accessible, so physical access to facilities for both ambulances and self-referred patients can be an issue. Other vehicles including buses, air medical transport, and military vehicles may be needed to transport the injured to functioning hospitals.

Many services that provide support to healthcare facilities will have access issues including courier services that handle lab specimens and delivery services that bring supplies, equipment, linen, food, fuel, and other necessary resources. These services and vendors may also have difficulty crossing security barriers into affected neighborhoods if they lack proper paperwork or identification.

[RITN should be contacted](#) for coordination and transportation of patients being referred to their facilities.

Long-Term Considerations and Recovery

Change to the Baseline Level of Health

If regular and consistent access to healthcare is impeded due to the impact of a radiological incident, or if widespread radiation contamination occurs, the overall health of a community can be impacted. If the healthier members of the community choose to relocate, leaving behind those with pre-existing conditions and a lack of resources, the baseline health of the community can be affected but with disproportionate effects on those with chronic conditions and those with access and functional needs. During recovery, efforts to assure continuity of services for these populations is critical to health maintenance. Radiation exposure registries may be established to track the long-term health effects of those exposed to the incident.

Contaminated Areas (Permanent and Temporary)

Depending on the incident type and severity, there may be areas that cannot be occupied either in the short-term or long-term. The community will need to assess what assets and facilities are affected by this contamination and re-evaluate where needed healthcare services should be located.

For context, following the 2011 nuclear incident at the Fukushima Daiichi nuclear power plant, officials issued evacuation orders that extended 20 kilometers (about 12 miles) from the plant, in some areas more, due to plume pathways. As of the September 2015, the government had just started lifting the orders for locations on the perimeter after conducting [massive rehabilitation efforts](#) including washing down buildings and structures, and the removal of 9 million cubic meters of soil. Many residents and business owners have yet to return because they have personally determined the risk is too high. [This page, maintained by the Fukushima prefecture](#) includes a map of the affected area with current radiation readings (7 years after the incident).

Loss of Facilities and Providers

Many of the healthcare facility closures or disruptions during and immediately following the incident could be temporary and normal operations can resume relatively quickly, but there will be facilities that will not be able to quickly or easily re-open, if damage or contamination is widespread. In addition to the loss of healthcare facilities, the impacted area may experience a loss of individual healthcare providers. Those providers may have relocated due to radiation exclusion areas, their own personal loss during the disaster or may have relocated because there was no available work in the short-term recovery phase due to facility damage or lower patient volumes. Providers who have relocated, found a new job, and resettled may be reluctant to return to the disaster impacted area once their previous facility is operational again.

Additional Radiation-Specific Resources

In addition to the clinical considerations discussed above, there are other emergency management and operational issues that must be addressed. The following resources can provide information to all emergency decision makers in a radiological or nuclear event.

Radiation Emergency Assistance Center/Training Site (REAC/TS)

The Radiation Emergency Assistance Center/Training Site (REAC/TS) is a world-renowned, U.S. Department of Energy (DOE) asset and a leader in emergency medical response to radiological/nuclear incidents, providing emergency response, advice, and consultation for the National Nuclear Security Administration's (NNSA) Office of Counterterrorism and Counterproliferation. REAC/TS is located at the Oak Ridge Institute for Science and Education in Tennessee and is operated for DOE by ORAU.

Subject matter experts at REAC/TS are on-call and ready to deploy (as well as available for phone advice and consultation) 24 hours a day, seven days a week in support of DOE/NNSA and may provide direct support to the DOE/NNSA Federal Radiological Monitoring and Assessment Center.

REAC/TS supports the international community as a Pan American Health Organization (PAHO)/World Health Organization (WHO) Collaborating Center for radiation emergency management and participates in WHO Radiation Emergency Medical Preparedness and Assistance Network (REMPAN). As a DOE asset, REAC/TS is also an active member of the International Atomic Energy Agency (IAEA) Radiation Assistance Network (RANET).

REAC/TS can be consulted by contacting the DOE Watch Office 24hr number: 202-586-8100 or the emergency number: 865-576-1005 (ask for REAC/TS).

For More Information:

- [REAC/TS](#)

Medical Radiobiology Advisory Team (MRAT)

The Medical Radiobiology Advisory Team (MRAT) is a deployable team responsible for providing expert advice to incident commanders and staff during a radiological incident. The MRAT is a two-person team, usually consisting of 1 health physicist and 1 physician, specializing in the health effects of radiation, biodosimetry, and treatment of radiation casualties.

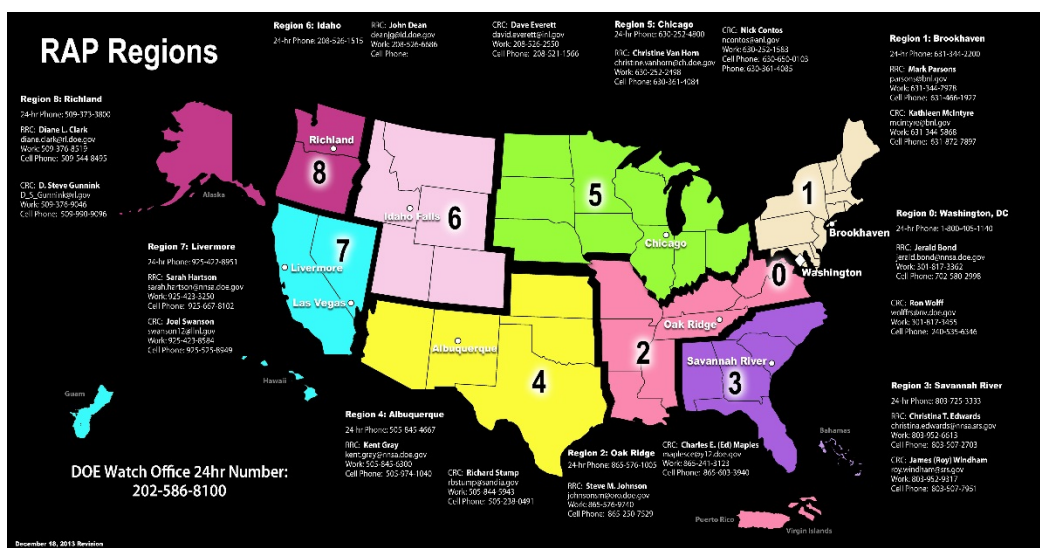
To contact the Medical Radiobiology Advisory Team, please call the MMO Duty Officer at (301) 295-0989. You may also contact the AFRRRI security desk at (301) 295-3038 and ask for the MRAT.

For More Information:

- [Armed Forces Radiobiology Research Institute](#)

Department of Energy Radiation Assistance Program (DOE RAP)

RAP provides advice and radiological assistance for incidents involving radioactive materials that pose a threat to the health and safety or the environment. RAP can provide field deployable teams of health physics professionals equipped to conduct radiological monitoring and assessment activities. RAP can be activated by notifying the DOE Watch Office 24hr number: 202-586-8100.



For More Information:

- [NNSA Nuclear Incident Response](#)

Medical Emergency Radiological Response Team, Veterans Administration

The Medical Emergency Radiological Response Team (MERRT) is a specially trained team of medical providers who can support federal, state, and local response to nuclear power plant incidents and other radiological or nuclear emergencies. They can be deployed to an off-site location to provide direct patient care and technical advice.

For more information:

- [VA Office of Emergency Management MERRT](#)

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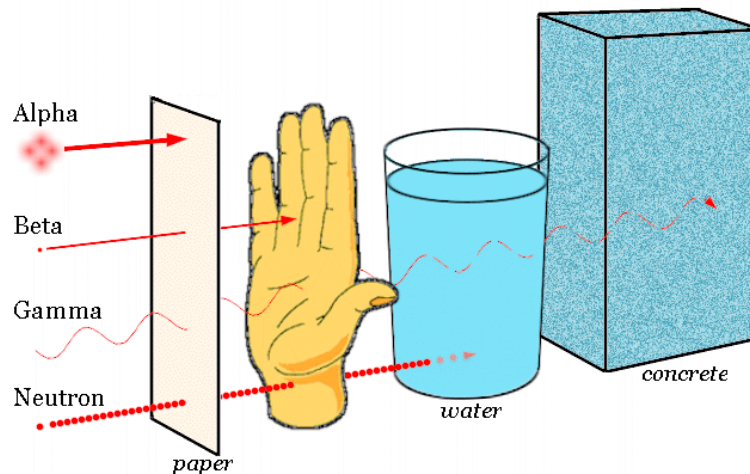
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Appendix A: Radiation Terminology

Types of Radiation

There are four types of radiation: alpha, beta, neutron, and gamma as described below. Many sources of radiation emit more than one type of radiation, but some remit only one type.

Radiation Type	Components	Properties	Penetration	Health Effect	Detection	Common Isotopes
Alpha (α)	Two protons and two neutrons	Heaviest radiation particle and travels only a short range Can remain on skin causing contamination	Usually unable to penetrate skin, can't penetrate clothing, paper	Can be harmful if inhaled, swallowed or absorbed through open wounds	A thin-window Geiger-Mueller probe can detect the presence of alpha radiation, but usual survey instruments can't detect the presence of alpha radiation reliably since the rays cannot penetrate even dust	Alpha emitters include radium, radon, uranium, thorium (many also emit other types of radiation – few are pure alpha emitters)
Beta (β)	Electron not attached to an atom	Light, short range particle Can remain on skin causing contamination	Can travel several feet and can penetrate several layers of skin. Clothing can provide "some" protection	If beta particles are left on the skin they can cause skin injury (beta-burns) Can be harmful on direct skin contact, if inhaled, swallowed or absorbed through open wounds	Can be detected by many survey instruments and a thin-window Geiger-Mueller probe	Beta emitters include strontium-90, carbon-14 (used in carbon dating), hydrogen-3 (tritium), and sulfur-35
Neutron (n)	Present in the nucleus of an atom	Byproduct of nuclear fission and fusion as created by nuclear power plants and nuclear weapons Would NOT be present in RDD	Highly penetrating and can travel a great distance, but can be stopped by high volumes of water	Can be damaging to human tissue	Personal radiation detectors can detect gamma and/or neutron radiation Most handheld survey meters detect beta and gamma radiation, but some can detect all types.	
Gamma (γ)	High-energy photons, same electromagnetic spectrum as light (10,000 times as much energy as visible photons)	No mass and no electrical charge (therefore no contamination) Gamma rays frequently accompany alpha and beta radiation	Highly penetrating electromagnetic radiation – can easily penetrate most material, including human tissue and can travel thousands of meters in the air before expending their energy Dense material is needed for shielding such as several layers of lead lining or many feet of concrete	Can be damaging to human tissue to include the full range of acute and chronic radiation sequelae	Easily detected by instruments and probes with sodium iodide detector Gamma waves often pass through the body leaving no contaminant but causing significant injury (irradiation, not contamination) – patients exposed to gamma emitters need evaluation for both	Gamma emitters include iodine-131, cesium 137, cobalt-60, radium 226, and technetium-99m



Source: Photo courtesy of Baylor College of Medicine

For More Information:

- [CDC Radiation and Your Health](#)
- [EPA Radiation Protection](#)
- [Health Physics Society: What Types of Radiation Are There?](#)
- [U.S Nuclear Regulatory Commission. What are the Different Types of Radiation?](#)

Exposure and Dosing

International scientists use the System Internationale (SI) derived from the metric system when referring to radiation measurement. Scientists in the United States use the conventional system of measurement, which can lead to the use of different terms for the same measurement.

The term used to measure the amount of radiation emitted from a radioactive source is either a **curie (Ci)** in conventional measurement or **becquerel (Bq)** in SI.

The term used to measure the radiation dose absorbed by a person (energy deposited in human tissue) is either a **rad** in conventional measurement or a **gray (Gy)** (100 rad) in SI. This is the absorbed dose.

The risk of biological exposure or equivalent dose is measured in **rem** in conventional measurement or **Sievert (Sv)** (100 rem) in SI. This dose is a calculation of the absorbed dose multiplied by a converting factor based on the medical effects of the specific type of radiation as noted in [Federal Guidance Report 12: External Exposure to Radionuclides in Air, Water, and Soil](#).

From an initial response standpoint it is acceptable to consider rad and rem and also Gy and Sv interchangeable when performing initial screening or establishing safety zones when the incident does not involve significant alpha contamination.

People can receive an external dose by being near radiation sources and an internal dose by inhaling or ingesting radioactive material. External exposure stops as soon as you leave the

affected area or remove the external contamination. Internal exposure continues until the material is removed from the body.

Radionuclides also have different uptake and impacts for various organs. Internal dose can be calculated for each organ separately. In order for a healthcare practitioner providing definitive radiation injury management, the effective dose equivalent should be calculated using the FGR 11 weighting factor for each organ. Each organ's dose is multiplied by its weighting factor and the results are added together to calculate the effective dose equivalent which provides a risk for developing stochastic effects of radiation, such as cancer (CDC, 2018). Health physicists are critical to these calculations.

Remember that *irradiation* is when gamma waves pass through the body – this can induce severe injury but leave no contamination at all for the survey instruments to pick up! On the other hand, contamination can result in impressive numbers of 'clicks' on the survey counters but still represent trivial radiation exposure to the body, depending on the level and type of radiation emitted, and the duration of exposure. It is important to consult radiation experts to assist in assessing the risks of radiation exposure and contamination specific to each particular incident.

For More Information:

- [CDC Measuring Radiation](#)
- [CDC Radiation Dictionary](#)
- [CDC Primer on Radiation Measurement](#)
- [Environmental Protection Agency Radiation Protection](#)
- [Health Physics Society](#)

Radiation Dosing Comparisons

As scientists from across the world are working together, the United States is moving to use the SI terminology, but not all comparison charts and treatment information has been updated. For purposes of comparing and understanding exposure and dosing between the two measurement systems, the following conversions are used:

- One Ci is equal to 37 billion Bq.
- 100 rad is equal to One Gy.
- 100 rem is equal to One Sv.

For More Information:

- [HHS REMM Radiation Units and Conversions](#)

Sources of “Everyday” Radiation and Dosing

The CDC provides common radiological exposures for comparison in their [Radiation Thermometer](#).

Common Exposures

- Exposure to cosmic rays during a roundtrip airplane flight from New York to Los Angeles: 0.0035 rem/0.035 mSv
- One dental x-ray: 0.0005 rem/ 0.005 mSv
- One chest x-ray: 0.01 rem/ 0.1 mSv
- One CT scan: 1 rem/ 10 mSv
- One year of exposure to natural radiation (from soil, cosmic rays, etc.): 0.31 rem/ 3.1 mSv.

In radiation incidents, the following dose thresholds can be used for predictive purposes.

- Relocation Threshold (the point at which people should be relocated if it is expected that they will receive a dose, at or above this point, for the coming year): 2 rem/20 mSv
- Damage to blood cells: 50 rem/ 500 mSv
- Acute Radiation Syndrome/Increased Cancer risk: 100 rem/ 1000mSv/ 1 Sv
 - Lowest dose that could cause acute radiation syndrome
 - Dose for which risk of getting a fatal cancer increases from about 22% to 27%
- 50% Lethality with no medical interventions: 400 rem/ 4000 mSv / 4 Sv
- 100% Lethality: 1000 rem/ 10000mSv / 10 Sv

The EPA states that environmental exposure of more than 75 rad/ 0.75 Gy in a short time is the minimum amount to cause acute health effects. Exposures between 5 and 10 rad/ 0.05 - 0.10 Gy usually result in no health effects.

Responder thresholds:

These thresholds are typically established for the incident by the incident commander or radiation authorities.

- Emergency responders should try to keep doses below 5 rad
- In life-saving situations, responders may go up to 25 rad or more depending on the relative risks to responders and victims

Radiation exposure is reduced by:

- Time – limiting the time of exposure
- Distance – radiation decreases with increase in distance from the radiation source. For every doubling of distance away from the sources, the radiation exposure decreases to one-fourth of the exposure rate at the previous location (double the distance is one fourth the dose) therefore, even very small amounts of distance between the person and the source can result in dramatic reductions in the level of exposure

- Shielding – when possible, using shielding to block the radiation – easy for alpha and beta, not easy for gamma or neutrons (though x-rays are stopped by thin lead shields, these have little effect on most gamma rays). Shielding is also not as effective in a contamination field where there is not a single source of radiation, but many sources.

Radioactive Isotopes and Byproducts

[Radioactive Isotopes Half Life Chart](#) lists all radioactive isotopes with greater than 100 year half-life. An element decays to undetectable levels within 10-15 half-lives (6 half-lives is good estimate)

The HHS REMM lists [isotopes of interest](#) including properties, treatment, and fact sheets.

Ways to Detect Radiation

The [HHS REMM](#) site provides a description of numerous radiation detection devices and describes the proper situations to use them. Below is a simple description of a selection of devices that are commonly referenced and available to first responders and screening personnel. In addition to those listed below, there are portal detectors (for screening people or vehicles), fixed detectors, radionuclide identifiers, dose rate meters, and other devices. The choice of detector depends on both the goal of use as well as the training of the user. Planners should be familiar with what assets exist in their area and how they are to be used. Remember that none of these detect radiation injury from *irradiation* that occurred from gamma waves that passed through the patient so they are not a screen for radiation injury – only contamination. Most units do not detect alpha particles well and have variable sensitivity for beta.

Geiger Counter

A Geiger counter is the classic device used to detect levels of radiation in the environment or on a person. They often use a pancake probe attached to a main unit. They cannot tell you the isotope, only the number of ion pairs created in the instruments chamber, per minute which reflects emission activity. If the speaker part of the instrument is turned on, you can hear the clicks per minute and it usually has a needle on a scale (dependent on the unit may be counts/minute, mR/h, etc. Sporadic clicks represent normal background radiation and for persons getting screened, an impressive number of clicks still usually represents low level contamination.

Hospitals should work with their radiation safety officer and nuclear medicine department (if the facility has one) on their radiation response plans. These personnel will be more familiar generally with radiation safety processes, screening, and use of survey equipment.

Personal Dosimeters

Personal dosimeters are small radiation monitoring devices typically worn by people working in environments where exposure to radiation is possible, such as medical radiology staff, first

responders, or staff that operate in a nuclear power plant. There is a huge variation in type and reliability of personal dosimeters on the market. Some detect extremely low exposure levels, some require a significant exposure to register. Some provide real-time alerts to exposure (e.g. digital dose-rate meters), whereas others are worn for a scheduled period of time and then submitted for evaluation on a routine basis (e.g. film badges).

RadNet

Different from a hand held or personal device, [RadNet](#) is a nationwide environmental radiation monitoring program managed by the Environmental Protection Agency (EPA). RadNet has more than 130 radiation air monitors in 50 states, monitoring 24/7 for gamma radiation. By running constantly, the system is able to determine the “normal”, background level of radiation and can detect spikes or surges in near real time. For selected special events, mobile monitors may be deployed at ground level or via airborne surveys to provide early potential warning of ground-based terrorist attacks.

For More Information:

- [EPA RadNet](#)
- [Medical Isotopes: General Concepts](#)
- [REMM Radiation Detection Devices](#)

Appendix B: Additional and Cited Resources

ASPR TRACIE Tip Sheets and Fact Sheets

EMTALA and Disasters

HIPAA and Disasters: What Emergency Professionals Need to Know

Mass Burn Event Overview Document

No-Notice Incident Fact Sheets and Information

Tips for Retaining and Caring for Staff After a Disaster

Other Potentially Relevant ASPR TRACIE Topic Collections:

Access and Functional Needs (e.g., at-risk populations, vulnerable populations, CMIST)

Alternate Care Sites (including shelter medical care)

Burns

Communication Systems

Continuity of Operations/Failure Plan

Crisis Standards of Care

Disaster Ethics

Disaster Veterinary Issues

Emergency Public Information and Warning/Risk Communications

Explosives (e.g., bomb, blast) and Mass Shooting

Family Reunification and Support

Fatality Management

Healthcare Facility Evacuation / Sheltering

Healthcare-Related Disaster Legal/ Regulatory/ Federal Policy

Hospital Patient Decontamination

Hospital Surge Capacity and Immediate Bed Availability

Incident Management

Information Sharing

On-Scene Mass Casualty Triage and Trauma Care

Patient Movement and Tracking

Pediatric

Pre-Hospital

Pre-Hospital Patient Decontamination

Recovery Planning

Responder Safety and Health

Utility Failures

Virtual Medical Care

Other External Resources

Crisis Standards of Care

Hanfling, D., Hick, J., and Stroud, C. (2013). [Crisis Standards of Care: A Toolkit for Indicators and Triggers](#). Institute of Medicine, Washington, DC: National Academies Press.

This toolkit contains key concepts, guidance, and practical resources to help individuals across the emergency response system develop plans for crisis standards of care and respond to a catastrophic disaster. It includes sample indicators, triggers, and sample tactics for use in the transition from conventional surge to contingency surge to crisis surge, and a return from crisis response to conventional response.

Hick, J.L., Hanfling, D., and Cantrill, S.V. (2012). [Allocating Scarce Resources in Disasters: Emergency Department Principles](#). *Annals of Emergency Medicine*. 59(3): 177-187.

The authors summarize key elements contained in the Institute of Medicine work on crisis standards of care. Written for the emergency medicine community, this paper is intended to be a useful adjunct to support discussions related to the planning for large scale disaster incidents.

Foundational CSC Documents

The [Crisis Standards of Care](#) publication (2012) by the Institute of Medicine (IOM) of the National Academies serves as a key CSC foundational document. It includes seven volumes that provide discipline-specific recommendations and assessments tool for CSC planning. States, regions, locals, and healthcare facilities should utilize the guidance provided in the IOM reports, specifically *Crisis Standards of Care: A Systems Framework for Catastrophic Disaster Response*, to help develop an operational CSC plan.

- [Volume 1, Chapter 2](#) provides an overview of the CSC framework and planning milestones when developing a plan.
- [Volume 1, Chapter 3](#) provides the legal issues in emergencies that would impact allocation of resources and establishment of CSC.
- [Volume 2- State and Local Government](#)
- [Volume 3- Emergency Medical Services](#)
- [Volume 4- Hospitals](#) includes the roles/responsibilities of health care facilities and operational considerations.
- [Volume 5- Alternate Care Systems](#)
- [Volume 6- Public Engagement](#)

Best Practice Plans

The following CSC documents are recommended as “promising/best practices” in that they address a number of the elements noted in the IOM report.

- [Washington DC: Modified Delivery of Critical Care Services in Scarce Resource Situations, Overview of a strategy to be implemented by the DC Emergency Healthcare Coalition and its member organizations](#)
 - Page 3: Tiered approach to modified healthcare delivery in scarce resource situations
 - Page 18: Modified Delivery of Critical Care Services: Preparedness Considerations
- [Minnesota:](#)
 - [Patient Care: Strategies for Scarce Resources Situations-](#) decision support tool to be used by key personnel, along with incident management.
 - [Ethically Rationing Health Resources in Minnesota in a Severe Influenza Pandemic](#)
 - [Science Advisory Team Crisis Standards of Care Charter](#)
- [Hennepin County, MN:](#) (obtain from ASPR TRACIE):

Hennepin County Medical Center (HCMC) Crisis Standard of Care Guidelines- Draft September 14, 2009.

- HCMC Disaster Surge Capacity Plan (2015)
- [Arizona Department of Health Services. Arizona Crisis Standards of Care Plan: A Comprehensive and Compassionate Response.](#)
 - Page 19: Indicators for CSC Activation
 - Page 23: Healthcare facility scripted tactics for CSC

Other Resources

Aloise, Gene. (2010). [Combating Nuclear Terrorism: Actions Needed to Better Prepare to Recover from Possible Attacks using Radiological or Nuclear Materials](#). Washington, DC: U.S. Government Accountability Office.

This report details the role of the federal government in helping cities and states clean up after terror attacks using a radiological dispersal device or improvised nuclear device. Recovery activities after the 2006 United Kingdom (UK) polonium incident and the UK Nuclear Recovery Plan Template are also discussed.

American College of Radiology Disaster Preparedness for Radiology Professionals. (2006). [Disaster Preparedness for Radiology Professionals](#).

This educational resource can be used as a quick reference for preparing for a radiation emergency, managing contaminated patients, and assessing radiation exposure health effects. This resource also includes special considerations for pediatric patients exposed to radiation disasters.

Bagshaw, S. (2014). [Population Displacement in the Aftermath of Nuclear Weapon Detonation Events](#).

This paper, written for and presented at the Vienna Convention of the United Nations describes the humanitarian crisis that would occur following a nuclear weapon detonation.

Baker, G.H. and Vollandt, S. (2018). [Cascading Consequences: Electrical Grid Critical Infrastructure Vulnerability](#). Domestic Preparedness.

This article provides an overview of the national power grid, and related threats (e.g., coordinated physical attacks, cyber-attacks against industrial control systems, electromagnetic pulse denotation, and severe solar storms). The authors examine risks, threats, impacts, current state of preparedness, and conclude with recommendations to enhance critical infrastructure resilience.

Becker, S. (2013). [From Radiological Incidents to Nuclear Calamities: Social, Behavioral, and Risk Communication Issues in Radiation Emergencies](#).

This resource is a 69 minute audio/video recording of a presentation posted by the Institute of Disaster Mental Health. The goal of the training was to increase the knowledge base among emergency and disaster response personnel, as well as the general public, about the probability, effects, and consequences of radiological disasters and the importance of clear risk communication before, during, and after an event or incident.

Becker, Steven M. (2013). [The Fukushima Dai-Ichi Accident: Additional Lessons from a Radiological Emergency Assistance Mission](#). (Abstract only.) Health Physics 105, no. 5 (2013): 455–461.

The author describes response and recovery lessons learned by team members (including an emergency physician, health physicist, and a disaster management specialist) who spent 10 days conducting fieldwork in areas affected by the incident.

Bromet, E. (2014). [Emotional Consequences of Nuclear Power Plant Disasters](#). Health Physics. 106(2): 206-210.

This article describes the emotional consequences and resilience of two groups of nuclear power plant disaster survivors: mothers of young children and nuclear plant workers. The authors stress the need for considering physical and mental health "in an integrated fashion," the need for more long-term research, and the need for healthcare providers to be able to recognize and manage psychological symptoms.

Caro, J.J., DeRenzo, E.G., Coleman, C.N. et al. (2011). [Resource Allocation After a Nuclear Detonation Incident: Unaltered Standards of Ethical Decision Making](#). Disaster Medicine and Public Health Preparedness. Volume 5. Supplement 1.

The authors provide practical ethical guidance for healthcare providers faced with making decisions after a nuclear detonation, prior to the establishment of a coordinated response.

Casagrande, R., Wills, N., Kramer, E., et al. (2011). [Using the Model of Resource and Time-Based Triage \(MORTT\) to Guide Scarce Resource Allocation in the Aftermath of a Nuclear Detonation](#). Disaster Medicine and Public Health Preparedness. Volume 5. Supplement 1.

The authors used the model of resource- and time-based triage (MORTT) and found that in settings where resources were scarce, prioritizing victims with moderate life-threatening injuries over victims with severe life-threatening injuries saves more lives and reduces demand for intensive care.

Centers for Disease Control and Prevention (2011). [Virtual Community Reception Center](#).

This interactive webpage is designed as a planning/training experience where users learn how to describe the process flow, identify key stations, and recognize essential services for each station in a community reception center.

Centers for Disease Control and Prevention. (2014). [Population Monitoring in Radiation Emergencies: A Guide for State and Local Public Health Planners](#). Second Edition.

This guide provides information for state and local planners to develop post radiological emergency response plans. This guide describes processes for managing the radiation monitoring required to evaluate exposure in the affected population, including the use of community reception centers.

Centers for Disease Control and Prevention. (2014). [Radiological Terrorism A Tool Kit for Emergency Services Clinicians](#).

This toolkit contains resources (such as videos and pocket guides) on decontamination, population monitoring, and psychological first aid in radiation emergencies.

Centers for Disease Control and Prevention. (2015). [Radiation and Your Health](#).

This webpage includes information for individuals on the effects of ionizing and non-ionizing radiation. Separate tabs provide information on “Radiation in Your Life,” “Health Effects of Radiation,” and “Radiation Basics.”

Centers for Disease Control and Prevention (2017). [Community Reception Center \(CRC\) Drill Toolkit](#).

The CRC Drill toolkit provides guidance and templates that any jurisdiction can adapt to exercise the full range of CRC operations. The drill was developed to be compatible with the U.S. Department of Homeland Security’s Homeland Security Exercise and Evaluation Program (HSEEP). It also incorporates insights, issues, and lessons learned from real-world events.

Centers for Disease Control and Prevention. (2018). [Information for Clinicians](#).

This webpage provides links to information on patient management, guidelines and recommendations, training, and the “Radiological Terrorism: Toolkit for Emergency Services Clinicians.”

Centers for Disease Control and Prevention, National Center for Environmental Health. (2015). [A Guide to Operating Public Shelters in a Radiation Emergency](#).

This document can assist emergency managers with planning and response efforts related to shelter operations in a radiation emergency. The guide includes information on screening for radioactive contamination, decontamination, radiation monitoring, registration, health surveillance, and communications consistent with Centers for Disease Control and Prevention Community Reception Center guidance. Chapter Three of this guidance document shares strategies for screening and decontamination (of people, service animals, pets, possessions, and vehicles) in shelters. Quick guides on decontamination are provided as appendices.

Centers for Disease Control and Prevention. (2018). [Radiation Emergency Training, Education and Tools](#).

This webpage offers links to educational videos, resource tools, online training modules, and webinars designed to prepare public health and healthcare professionals to respond to radiation emergencies and disasters.

Centers for Disease Control and Prevention, Emergency Preparedness and Response. (2015). [Virtual Community Reception Center \(vCRC\)](#).

This web-based training tool teaches emergency healthcare planners how to conduct population monitoring after a mass casualty radiation emergency in community reception centers.

Chatham County (GA) Health Department. (n.d.). [EOP/ Incident Annex G / Appendix 1: CRC Specifications](#). (Accessed 3/13/2017.)

Appendix 1 includes Community Reception Center (CRS) features and requirements, and includes an equipment list, a staffing matrix, and a list of potential CRC sites.

Coleman, N. (2015). [Public Health and Medical Preparedness for a Nuclear Detonation: The Nuclear Incident Medical Enterprise](#). Health Physics.

The authors summarize Nuclear Incident Medical Enterprise (NIME), the approach developed by the U.S. Department of Health and Human Services by both government and non-government experts. NIME can be used by emergency healthcare planners to support planning for, responding to, and recovering from the effects of a nuclear incident.

Coleman, C.N., Knebel, A. R., Hick, J.L. et al. (2011). [Scarce Resources for Nuclear Detonation: Project Overview and Challenges](#). Disaster Medicine and Public Health Preparedness. Volume 5. Supplement 1.

This article summarizes the medical challenges associated with scarce resources and nuclear detonations, and serves as an introduction to the rest of the articles in this issue.

Coleman, C.N., Weinstock, D.M., Casagrande, R. et al. (2011). [Triage and Treatment Tools for Use in a Scarce Resources-Crisis Standards of Care Setting After a Nuclear Detonation](#). Disaster Medicine and Public Health Preparedness. Volume 5. Supplement 1.

Based on the information shared in other articles in this issue, the authors discuss possible triage options during the first four days after an event.

Department of Homeland Security (DHS). (2016). [Nuclear Radiological Incident Annex to the Response and Recovery Federal Operational Interagency Operational Plans October 2016](#).

This planning tool consists of a base document and three corresponding incident-specific planning documents. The base document covers general guidance applicable to all radiological and nuclear incidents, and the other documents provide guidance for suspected or deliberate attacks, inadvertent incidents, and international incidents. This annex can be used by federal, state, local, and voluntary organizations to enhance planning efforts and ensure coordination with federal planning efforts.

Department of Homeland Security (DHS). (2016). [Health and Safety Planning Guide for Planners, Safety Officers, and Supervisors for Protecting Responders Following a Nuclear Detonation](#).

This planning guide can help agencies improve planning for and protection of responders following a nuclear detonation event. The guide covers topic areas such as incident command, responder safety, decontamination, site control, personal protective equipment, radiation detection and air monitoring equipment, training, communications, and record keeping.

Department of Homeland Security. (2017). [Radiological Dispersal Device \(RDD\) Response Guidance Planning for the First 100 Minutes November 2017](#) .

This planning document provides guidance to first responders and local response agencies in understanding the critical missions and tasks that should be undertaken within the first 100 minutes of a radiological dispersal device denotation response. Public messaging, response coordination, personal protective equipment, and equipment resource recommendations are reviewed within the document. The authors also include customizable planning tools and worksheets.

DiCarlo, A.L., Maher, C., Hick, J.L. et al. (2011). [Radiation Injury After a Nuclear Detonation: Medical Consequences and the Need for Scarce Resources Allocation](#). Disaster Medicine and Public Health Preparedness. Volume 5. Supplement 1.

This literature review focuses on radiation injuries from human exposures and animal models and is accompanied by various triage and management approaches (covered in the rest of this special issue).

Dodgen, D., Norwood, A., Becker, S., et al. (2017). [Social, Psychological and Behavioral Responses to a Nuclear Detonation in a US City: Implications for Healthcare Planning and Delivery](#). Disaster Medicine and Public Health Preparedness. 5(Suppl. 1).

The authors reviewed literature on human responses to radiation incidents and disasters in general, with a focus on behavioral health care provider (BHCP) contributions in the hours and days after a nuclear detonation. They listed the following six broad categories of interventions: promoting appropriate protective actions, discouraging dangerous behaviors, managing patient/survivor flow to facilitate the best use of scarce resources, supporting first responders, assisting with triage, and delivering palliative care when appropriate. The authors also shared recommendations regarding response and recovery phase BHCP interventions.

Eckerman, K. and Ryman, J. (1993). [External Exposure to Radionuclides in Air, Water, and Soil. Federal Guidance Report No. 12.](#)

Based on federal guidance, the authors provide a “framework to ensure that the regulation of exposure to ionizing radiation is carried out in a consistent and adequately protective manner.” The report includes tables of dose coefficients, application considerations, and several appendices.

EMP Commission. (2017). [Volume I, Assessing the Threat from EMP Attack – Executive Report](#).

This report provides in-depth details, findings, and recommendations from the EMP Commission on intentional and solar superstorm electromagnetic pulse incidents. The Commission highlights challenges and current planning status, and provides overarching recommendations to improve and mitigate against current threats critical infrastructure systems.

EMP Commission. (2018). [Volume II, Recommended E3 HEMP Heave Electric Field Waveform for the Critical Infrastructures](#).

This report reviews the EMP Commission recommendations for HEMP preparedness to ensure critical infrastructure protection. The authors utilized data from Soviet-era nuclear tests to provide recommendations to protect critical infrastructure against threats and vulnerabilities associated with High Altitude Electromagnetic fields.

Federal Emergency Management Agency. (2008). [Planning Guidance for Protection and Recovery Following Radiological Dispersal Device \(RDD\) and Improvised Nuclear Device \(IND\) Incidents](#).

This guidance can be used by community leaders to help plan for, respond to, and recover from RDD and IND incidents. It describes the various phases of an incident; includes a figure that depicts exposure routes, protective measures, and timelines for effects; lists protective actions; and highlights late phase/recovery activities for planning purposes.

Federal Emergency Management Agency. (2010). [Millstone Power Station. After-Action Report/Improvement Plan](#).

This report covers the June 30, 2010 Host Community Reception Center (CRC) Drill conducted in Windham, CT. The Improvement Plan highlights recommendations and adjudications to the state CRC plan specific to the performance of offsite response organizations. Appendices are included; Appendix C specifically covers the CRC

Florida Department of Health. (2011). [After-Action Report and Improvement Plan Matrix](#).

This report covers the July 12, 2011, Community Reception Center (CRC) Drill conducted at Cypress Creek High School in Orlando, Florida. The Improvement Plan highlights recommendations and adjudications to the state CRC plan. Appendices are included.

Florida Department of Health. (n.d.). [Community Reception Center \(CRC\) Form](#). (Accessed 7/12/2018.)

First responders can use this intake form as a model when creating their own CRC forms. It includes incident-specific questions and two pages of instructions.

Hick J., Weinstock D., Coleman C., et al. (2011). [Health Care System Planning and Response for a Nuclear Detonation](#). Disaster Medicine and Public Health Preparedness. Volume 5. Supplement 1.

The U.S. Department of Health and Human Services developed a State and Local Planners Playbook, which includes guidance on the medical response to a nuclear detonation. The authors of this article provide additional (discipline-specific) information and analysis on the recommended actions identified in the playbook.

Hick, J. and Coleman, N. (2018). [Population-Based Triage, Treatment, and Evacuation Functions Following a Nuclear Detonation](#).

This discussion paper describes the screening function (Exposure And Symptom Triage – EAST) which will primarily be conducted at Assembly Centers after a nuclear detonation. Geared towards jurisdictional emergency planners and responders as a planning reference, it contains response tools and strategies that will assist them in planning for Assembly Centers and mass screening functions.

International Atomic Energy Agency. (2014). [Final Report: The Follow-Up IAEA International Mission on Remediation of Large Contaminated Areas Off-Site the Fukushima Daiichi Nuclear Power Plant](#).

Chapter 5 of this report covers the “Remediation Strategy Implementation,” including hard surface and building decontamination techniques and guidelines, food and agricultural safety, and forest and aquatic area remediation. A chapter on waste management with guidelines on storing contaminated materials follows.

Kinley III, D. (2006). [Chernobyl’s Legacy: Health, Environmental and Socio-Economic Impacts and Recommendations to the Governments of Belarus, the Russian Federation and Ukraine](#). International Atomic Energy Agency.

This report includes follow-up healthcare-specific recommendations for select populations in affected areas and suggestions for future research. Environmental monitoring and remediation suggestions are also provided, followed by recommendations for economic and social policy.

Knebel, A.R., Coleman, C.N., Cliffer, K.D. et al. (2011). [Allocation of Scarce Resources After a Nuclear Detonation: Setting the Context](#). Disaster Medicine and Public Health Preparedness. Volume 5. Supplement 1.

The authors emphasize the need for all involved sectors to plan and practice for the allocation of scarce resources in a nuclear incident.

Lochard, J. and Prêtre, S. (1995). [Return to Normality after a Radiological Emergency](#). Health Physics. 68(1): 21–26.

While slightly dated, the information in this article is focused on helping communities understand how to determine post-incident acceptability (or “return to normal”). The

various components covered by the authors include time post-incident, the zoning process (including the negative effects of establishing zones), and the “reference to the norm.”

Los Angeles County. (2009). [Playbook 9: Monitoring People for Contamination at Public Reception Centers](#). Los Angeles County Multi-Agency Radiological Response Plan.

This document provides steps for responders to take upon receipt of residents at Community Reception Centers. It includes forms for responders and handouts for visitors.

Los Angeles County (2009). [Community Reception Center Flow Diagram](#).

This is a set of floorplans for various stages of CRCs, including intake, emergency medical care or transfer, and discharge.

Morimura, N., Asari, Y., Yamaguchi, Y., et al. (2013). [Emergency/Disaster Medical Support in the Restoration Project for the Fukushima Nuclear Power Plant Accident](#). *Emergency Medical Journal*. 30: 997-1002.

The authors describe the medical response to the incident, including patient decontamination. Photos of the decontamination tent and tables illustrating diagnosis and patient outcome are included.

Moskowitz, S. (n.d.). [Disaster Mental Health: Assisting People Exposed to Radiation](#). (Accessed 7/12/2018.)

This presentation describes the prominent psychosocial issues related to radiological exposure, examines the evidence-based psychosocial interventions, including effective risk communication practices, and identifies key elements of self-care for first responders and public health professionals.

Murrain-Hill, P., Coleman, C.N., Hick, J.L. et al. (2011). *Medical Response to a Nuclear Detonation: Creating a Playbook for State and Local Planners and Responders*. *Disaster Medicine and Public Health Preparedness*. Volume 5. Supplement 1.

The U.S. Department of Health and Human Services developed a State and Local Planners Playbook, which includes guidance on the medical response to a nuclear detonation. The authors of this article provide a template that state, local, regional, tribal governments and nongovernment sectors may use when developing their own plans for a medical response to a nuclear detonation.

Nisbet, A. and Chen, S. (2013). [Decision Making for Late Phase Recovery from Major Nuclear or Radiological Incidents](#).

This presentation details the late-phase recovery framework and includes helpful graphics and emphasizes the importance of stakeholders in the recovery process. The

authors discuss seven “optimization steps” and the eight recommendations provided in the report.

Oak Ridge Institute for Science and Education (ORISE). (n.d.). [Radiation Emergency Assistance Center/ Training Site \(REAC/TS\)](#). (Accessed 7/10/2018.)

This webpage links to the Radiation Emergency Assistance Center/Training Site (REAC/TS), which offers several resources to prepare medical professionals to respond to radiological emergencies. There are links to books, live training courses, online trainings, and assessment and treatment guidance documents. REAC/TS staff are available for deployment to provide medical consultation during emergencies, upon request.

Public Health England. (2015). [UK Recovery Handbooks for Radiation Incidents 2015](#).

These handbooks cover the radiation incident recovery process for food production, inhabited areas, and drinking water.

Radiation Emergency Medical Management (REMM). (n.d.). [Recovery / Resilience after an Incident: Useful Guidance about Recovery and Resilience](#). (Accessed 6/21/2018).

This section of this REMM webpage includes links to guidance specific to response to and recovery from incidents.

Radiation Response Volunteer Corps and Population Monitoring. (n.d.). [Radiation Response Volunteer Corps and Population Monitoring](#). (Accessed 7/12/2018.)

This website includes a “Templates and Forms” tab that takes the user to a Dropbox page. Links to templates are provided here, including:

[Kansas Community Center Flow Diagram](#)

[Kansas Radiation Incident Community Reception Center Standard Operating Guidelines](#)

[Kansas Department of Health and Environment CRC Template](#)

[Union County \(OH\) Example CRC Supply and Equipment List](#)

Schoch-Spana, M. (2013). [Rad Resilient City: A Preparedness Checklist to Save Lives Following a Nuclear Detonation](#). Center for Biosecurity of UPMC.

This checklist provides information to diminish loss of lives following a nuclear detonation. This tool should be used as a preparedness tool and during the planning process.

Sherman, S. (2011). [Legal Considerations in a Nuclear Detonation](#). Disaster Medicine and Public Health Preparedness. Volume 5. Supplement 1.

Although the focus of the article is nuclear events, it provides a general overview of legal authorities relevant to emergencies.

Siembieda, W. (2012). [Multi Location Disaster in Three Countries: Comparing the Recovery Process in Japan, Chile and New Zealand](#). Focus: Journal of the City and Regional Planning Department. 9(1): 43–50.

The author visited each country and explains similarities and differences in their disaster recovery processes.

Tanisho, Y., Smith, A., Sodeoka, T., and Murakami, H. (2015). [Post-Disaster Mental Health in Japan: Lessons and Challenges](#). Health and Global Policy Institute.

This report describes lessons learned from the Fukushima nuclear disaster in 2012. It includes recommendations for ensuring that psychosocial and mental health interventions consider the unique circumstances and cultural issues of a given disaster.

Uniformed Services University. (2018). [Products and Publications](#)

This website includes guidelines, handbooks, planning tools, and medical treatment protocols for radiological and nuclear detonation response.

U.S. Department of Energy, The Electric Power Research Institute. (2016). [Joint Electromagnetic Pulse Resilience Strategy](#) .

This document presents guidance to support and improve response and recovery efforts after an electromagnetic pulse (EMP) denotation. It provides 5 strategic goals to assist energy sector officials in planning and response to minimize EMP impacts and ultimately enhance resilience.

U.S. Department of Health and Human Services. (2011). [State and Local Planners Playbook for Medical Response to a Nuclear Detonation](#).

This playbook provides guidance to state, regional, local, tribal, and territorial sectors; medical professionals; public health planners; and other subject matter experts who are developing plans for a medical response to a nuclear detonation.

U.S. Environmental Protection Agency (EPA). (n.d.). [Radiation Protection](#).

This website provides links to resources that can help protect communities from radiation (e.g., a dose calculator, basic information, protective actions, regulations, and response). A document library and links to related content are also provided.

U.S. Environmental Protection Agency (EPA). (2017). [PAG Manual Protective Action Guides and Planning Guidance for Radiological Incidents January 2017](#).

This manual can help public officials plan for emergency response to radiological incidents. The manual consists of two overarching response areas: protective action guides, and protective actions which are further broken down into early, intermediate,

and late phase response actions for radiological incidents. Each phase describes corresponding response actions (e.g., evacuation, sheltering in place, administration of medication, worker protection, and clean up, and disposal of radiological waste).

Ubaura, M. (2013). [Reconstruction Urban Planning: Current Status and Future Challenges](#). The Great East Japan Earthquake 2011 Case Studies.

This article presents a snapshot of the recovery process in Japan after the 2011 earthquake. Chapter 3 explains the long-term recovery process from urban planning, community development, and specific population perspectives.

Yonekura, T., Ueno, S., and Iwanaka, T. (2013). [Care of Children in a Natural Disaster: Lessons Learned from the Great East Japan Earthquake and Tsunami](#). (Abstract only.) *Pediatric Surgery International*. 29(10): 1047-1051.

The authors incorporate lessons learned from the Fukushima disaster into response recommendations for pediatric surgeons and physicians.