

Section 8

Radiation Emergencies

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Introduction

A radiation emergency involves the release of potentially dangerous radioactive materials into the environment. Such incidents can occur anywhere radioactive isotopes are used, stored, or transported. Radiation provokes a special fear but, with appropriate understanding and preparation, effective medical care can be provided to exposed victims. It can be easily detected with equipment carried by many emergency responders. Radiation may contaminate homes, work places, and other resources, requiring extensive and costly remediation and the potential disruption of lives and livelihoods for extended periods of time. Serious psychological problems can result in those who think they are being, or have been, exposed.

In the event of a terrorist attack or other radiation disaster, clinicians will play vital roles as responders and as sources of accurate information for patients, the public, and the medical community. The immediate clinical effects of large doses of radiation are well known and can be assessed with the use of simple laboratory tests such as blood cell counts. To decrease morbidity and mortality from a radiation disaster or terrorist attack, physicians should have a basic understanding of radiation illness and treatment principles.

Radiation effects its toxicity on biological systems through ionization, which creates tissue damage by the generation of free radicals, disruption of chemical bonds, and direct damage to cellular DNA and enzymes. Optimal management of radiation casualties requires:

- Knowledge of the type and dose of radiation received;
- Recognition of the manifestations of radiation sickness;
- Use of standard medical care;
- Decontamination; and
- Decorporation techniques.

The health effects of radiation exposure tend to be directly proportional to the amount of radiation absorbed by the body (radiation dose) and are determined by the:

- Radiation type (ie, alpha, beta, x-ray, or gamma radiation);
- Means of exposure, internal or external (absorbed by the skin, inhaled, or ingested); and
- Length of time exposed.

Externally contaminated individuals may expose or contaminate others with whom they come in close contact and should avoid such contact until they are appropriately decontaminated. The health threat to response personnel is low, however, and can be minimized by using universal safety precautions. Victims who have inhaled or ingested radioactive material require medical attention. Currently, there are no reliable antidotes to treat victims once radiation is inhaled or ingested but symptoms can be treated effectively. Oral and intravenous agents are available that can help remove certain radioactive materials from the body.

This *Resource Guide* provides quick access to current information on preparing for a radiation emergency, handling contaminated persons, dose assessment, radiation health effects, and accessing emergency assistance. Some of the links also provide helpful information for medical responses to other public health emergencies.

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Immediate Emergency Response Information

Quick Reference Guides

AMA Quick Reference Guide: Radiation Exposure

Dose-Related Survival Times, Prodromal Symptom Onset Times, and Absolute Lymphocyte Counts for Acute Whole-Body Irradiation					
Estimated Dose ^a	Survival Probability ^b	Prodromal Symptom Onset Time (hrs) ^c	Absolute Lymphocyte Count ^d (x10 ⁹ cells/liter)		
			0.5 Day Post-Exposure	2 Days Post-Exposure	6 Days Post-Exposure
~1 Gy (100 rad)	Certain	Variable (>5)	2.30	1.90	1.15
~3 Gy (300 rad)	Probable	~2 to 5	2.03	1.15	0.25
~5 Gy (500 rad)	Possible	~1 to 3	1.79	0.69	0.06
~10 Gy (1,000 rad)	Improbable	<1	1.31	0.20	0.001

^a Unit of absorbed dose = Gray (Gy). An older unit still used in the literature is the rad (radiation absorbed dose); 1 Gy = 100 rad.

^b Based on 60+ day survival following acute radiation exposure

^c Measured in hours (hrs) following initial radiation exposure and encompasses nausea, vomiting, and anorexia

^d Normal range: 1.4-3.5 x 10⁹ cells/liter

Clinical Manifestations of Acute Radiation Syndrome (Whole-Body or Extensive Partial-Body Exposure)		
Dose*	Clinical Status	Description
<1 Gy (0 to 100 rad) 0.05 Gy 0.15 Gy 0.5 Gy	Generally asymptomatic	White blood cell count normal or minimally depressed below baseline at 3 to 5 weeks post-exposure <ul style="list-style-type: none"> ○ No symptoms ○ No symptoms, but possible chromosomal aberrations in cultured peripheral blood lymphocytes ○ No symptoms (minor decreases in white cell and platelet counts in a few persons)
1 to 8 Gy (100-800 rad) 1 Gy 2 Gy 4 Gy 6 Gy	Hematopoietic syndrome (prodromal phase followed by latent period of 1 day to 2 weeks depending on radiation dose)	<ul style="list-style-type: none"> • Prodromal signs and symptoms (generally lasting 24-48 hrs): anorexia, nausea and vomiting • Skin erythema, fever, mucositis, and diarrhea also may be present • Bone marrow suppression (average 2-3 weeks post-exposure) • Laboratory analysis in patients with whole-body exposure greater than 2 Gy can show an initial granulocytosis, with pancytopenia evident 20 to 30 days post-exposure • Subsequent systemic effects: <ul style="list-style-type: none"> – immunodysfunction – increased susceptibility to infectious complications – possible hemorrhage – sepsis – anemia – impaired wound healing ○ Nausea and vomiting in approximately 10% of patients within 48 hr after exposure ○ Nausea and vomiting in approximately 50% of persons within 24 hr, with marked decreases in white cell and platelet counts ○ Nausea and vomiting in 90% of persons within 12 hr, and diarrhea in 10% within 8 hr; 50% mortality within 60 days without medical treatment ○ 100% mortality within 30 days due to bone marrow failure in the absence of medical treatment
8 to 20 Gy (800 to 2,000 rad) 8-10 Gy	Gastrointestinal syndrome (latent period <1 day)	<ul style="list-style-type: none"> • Symptoms may include severe gastrointestinal damage, with nausea, vomiting, and watery diarrhea occurring within minutes or hours of exposure • Hematopoietic syndrome occurs concomitantly • In severe cases, patient may present with shock and possibly renal failure and cardiovascular collapse • Death usually occurs in 2 to 3 weeks post-exposure without medical treatment ○ Approximate maximum dose that may be survivable with the best medical therapy available
>20 Gy (>2,000 rad)	Cardiovascular/Central nervous syndrome (no latent period; immediate onset of overt illness)	<ul style="list-style-type: none"> • Medical intervention is supportive • Within minutes of exposure, patients may experience burning sensation • Within the first hour post-exposure, patients experience nausea and vomiting followed by prostration, and neurological signs of ataxia and confusion • Deteriorating state of consciousness follows, with tremors and convulsions, leading to coma, cardiovascular collapse, and death • Significant neurological symptoms indicate lethal dose • Death is inevitable and usually occurs within 24 to 72 hr

* Unit of absorbed dose = Gray (Gy). An older unit still used in the literature is the rad (radiation absorbed dose); 1 Gy = 100 rad.

Treatment of Selected Internal Radioactive Contaminants			
Radionuclide	Medication	Dosage and Administration	Principle of Action
Iodine	<u>KI</u> Potassium iodide	Adult (18-40 yrs): 130 mg (tabl) stat, followed by 130 mg qd x 7 if indicated Pediatric: 16 to 65 mg/d (dose varies according to age)	Blocks thyroid deposition
Plutonium and other transuranic elements	<u>Ca-DTPA</u> <u>Zn-DTPA</u>	1 gm Ca-DTPA (Zn-DTPA) in 150-250 ml 5 % D/W IV over 60 minutes	Chelation
Uranium	Bicarbonate	2 ampules sodium bicarbonate (44.3 mEq each; 7.5%) in 1000 cc normal saline @ 125 cc/hr; alternately, oral administration of two bicarbonate tablets every 4 hours until the urine reaches a pH of 8-9	Alkalinization of urine; reduces chance of acute tubular necrosis
Cesium Rubidium Thallium	<u>Prussian Blue</u> [ferrihexacyano-ferrate (II)]	1 gm with 100-200 ml water po tid for several days	Blocks gastrointestinal absorption and prevents recycling.
Tritium	Water	Force fluids	Isotopic dilution
Unknown	Emetics, lavage, charcoal, laxatives		Reduction of absorption in cases of ingestion

Physicians should report noticeable increases in unusual illnesses, symptom complexes, or disease patterns (even without definitive diagnosis) to public health authorities. Prompt reporting of unusual patterns of illness can allow public health officials to initiate an epidemiologic investigation earlier than would be possible if the report awaited definitive etiologic diagnosis. Any suspicious or confirmed exposure to a radioactive agent should be reported immediately to the local health department, the Centers for Disease Control and Prevention at **770-488-7100**, and the Department of Energy's Emergency Operations Center's Radiological Hotline at **202-586-8100**. Any incident related to terrorism or possible terrorist activity also requires telephonic notification to the National Response Center at **800-424-8802** and the local Federal Bureau of Investigations office. This includes bombings, bomb threats, suspicious letters or packages, and incidents related to the intentional release of chemical/biological/radioactive agents.

If an unusual disease or possible outbreak is suspected, contact the state or local health department at:

<http://www.statepublichealth.org>

<http://www.naccho.org/general8.cfm>

Information contained in this table was current as of November 2004, and is intended for educational purposes only. Medication information should be researched and verified before initiation of patient treatment.

These tables were compiled from the following references:

US Department of Homeland Security [Medical Treatment of Radiological Casualties](#).

Mettler FA Jr, Voelz GL. [Major radiation exposure-what to expect and how to respond](#). *N Engl J Med*. 2002;346:1554-1561.

Singh VK, Seed TM. Radiation effects. In: Roy MJ, ed. *Physician's Guide to Terrorist Attack*. Totowa, New Jersey: Humana Press; 2004.

Radiation Emergency Assistance Center/Training Site (REAC/TS). [Treatment of Selected Internal Radioactive Contaminants](#).

Waselenko JK, MacVittie TJ, Blakely WF, Pesik N, Wiley AL, Dickerson WE, et al. [Medical management of the acute radiation syndrome: recommendations of the strategic national stockpile radiation working group](#). *Ann Intern Med*. 2004;140:1037-1051.

Other Quick Reference Guides

[Biological, Chemical, and Radiological Terrorism: An Overview of Indicators and Response](#)
Medical Society of the State of New York

[How to Recognize and Initially Respond to an Accidental Radiation Injury](#)
International Atomic Energy Association and World Health Organization

[Radiological Terrorism Pocket Guide](#)
Department of Veterans Affairs

[Radiological Terrorism: Rapid Response Card](#)
New York State Department of Health

[Treatment Recommendations for Acute Radiation Syndrome](#)
Veterans Health Administration, Emergency Management Strategic Healthcare Group

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Key Points About Radiation Emergencies

Although the likelihood of a thermonuclear war is low, the possibility of either a single nuclear detonation or an incident involving unintentional or deliberate radiological contamination has increased; the most likely deliberate radiation event involves direct placement of a radioactive source in a public place or detonation of a high yield explosive contaminated with radioactive material (ie, a dirty bomb).

The primary risk of a dirty bomb or other isolated radiation incident is the psychological impact on a population rather than acute or delayed radiation sickness.

The longer one is exposed to radiation, the greater the dose; victims should be removed as quickly as possible from the disaster scene.

Radiation exposure is inversely related to the square of the distance from the source; the farther away you are from the source, the lower the radiation dose.

Heavy density materials such as lead and concrete are best for shielding from gamma rays and x-rays; plastics are preferred for shielding beta particles. Water and concrete are used as shielding material for neutrons. Overall, concrete and earth are the most effective shielding materials.

When caring for radiation victims, primary consideration should be given to:

- addressing immediate critical care needs (eg, traumatic injuries, burns);
- eliminating additional radiation risk to the patient; and
- preventing contamination and radiation exposure of first responders and health care workers.

Emergency responders should wear protective gloves, protective clothing, and radiation dosimeters; respirators or protective masks can prevent inhalation of radioactive particles.

Removal of clothing and washing with soap and copious amounts of water are sufficient to remove most external radiation contamination.

Treat life-threatening injuries first. Radiation treatment, other than decontamination, is a secondary concern; most deaths from radiation occur as a result of bone marrow damage and secondary infection.

Persons being examined for potential radiation exposure may not exhibit significant symptoms when first examined (even if they received a considerable radiation dose) due to the characteristic delayed onset of symptoms following exposure. Follow-up examination over the ensuing hours and days is essential to establish the true nature and extent of exposure.

Any externally contaminated casualty without respiratory protection should be evaluated for internal contamination.

Documentation of clinical signs and symptoms (affecting the hematopoietic, gastrointestinal, cerebrovascular, and cutaneous systems) over time is essential for triage of victims, selection of therapy, and assignment of prognosis.

Determination of radiation exposure is expedited by the evaluation of hemodynamic values (eg, lymphocytopenia), formation of dicentric chromosomal aberrations in peripheral blood lymphocytes, and time of onset of the prodromal syndrome (eg, nausea, vomiting, anorexia).” A “[Biodosimetry Assessment Tool \(BAT\)](#)” that provides a computer-based program to estimate a victim’s radiation dose based on the time duration to onset of vomiting and sequential lymphocyte counts can be downloaded at no cost from the Armed Forces Radiobiology Research Institute (AFRRI).

Patients with severe radiation exposure develop burns that are subject to secondary infection; antiseptic wound care is critical.

Possible pharmaceutical countermeasures to ionizing radiation can be categorized broadly into three groups:

- Drugs that prevent initial radiation injury
- Drugs that repair the molecular damage caused by radiation
- Drugs that stimulate proliferation of surviving stem and progenitor cells

The only currently available countermeasures that can be used in the field are drugs that block the post-exposure effects of several specific internalized radioisotopes. While there are several investigational drugs that show promise in reducing or preventing the effects of high-dose radiation (ie, radioprotectants), there are no available drugs that can be used outside the clinic to ameliorate the effects of external ionizing radiation on the blood-forming or gastrointestinal systems.

The decision to use oral and intravenous drugs for removal of various radioactive materials from internally contaminated patients should be made after consultation with a nuclear medicine physician or other radiation therapy specialist.

Bone marrow suppression associated with high-dose radiation exposures requires sophisticated treatment such as transfusion of blood products and use of colony-stimulating growth factors and cytokines along with antimicrobial therapy and immunosuppression precautions as the risk of infection and hemorrhaging develops.

When concerned about a known or suspected exposure to radioactive iodine (eg, nuclear power plant incident), potassium iodide (KI) should be administered empirically as a thyroid blocking agent. A one-time dose at levels recommended by the Food and Drug Administration (FDA) is usually all that is required. [Current FDA recommendations](#)

- Since KI is only effective for about 24 hours, it can be dosed daily until the exposure risk is eliminated
- If possible, at-risk children should receive KI before exposure or immediately afterward
- Women who are breastfeeding should take the adult KI dose; the infant should receive the recommended infant dose
- KI will not protect a person from other radioactive materials or protect other parts of the body from radiation exposure

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Key Medical Resources

The likelihood that most physicians will ever have to treat radiation casualties may seem remote, but is nonetheless real. The following resources provide comprehensive clinical information to help physicians and other health care professionals prepare for this possibility. For immediate help in assessing clinical effects from radiation exposures, contact a nuclear medicine physician or radiation therapy specialist.

A 24-hour emergency response program at the Oak Ridge Institute for Science and Education, the [Radiation Emergency Assistance Center/Training Site \(REAC/TS\)](#), is available to consult and assist in the response to all types of radiation accidents and incidents. For treatment information in the event of a radiation emergency, contact REAC/TS at **1-865-576-1005**.

Clinical assistance also is available from the Medical Radiological Advisory Team at the Armed Forces Radiobiology Research Institute at **301-295-0530**.

American Academy of Pediatrics (AAP)

[Radiation Disasters and Children: AAP Policy Statement](#)

Describes special needs and vulnerabilities of children exposed to radiation

American College of Radiology

[Disaster Preparedness for Radiology Professionals](#)

This primer serves as a quick reference in the event of a radiation disaster by summarizing current information on preparing for a radiation emergency, handling contaminated persons, dose assessment and radiation exposure health effects. It also includes information on radiological findings related to agents of biological and chemical terrorism.

Armed Forces Radiobiology Research Institute (AFRRI)

[Medical Management of Radiological Casualties, 2nd edition](#)

This handbook covers nuclear detonation and other high-dose radiation situations; radiation dispersal devices and industrial contamination situations, and radiological response operational aspects for operations other than warfare, including terrorism. Appendices include information on medical assay of patients, internal contaminant radionuclides, medical aspects of radiation injury in nuclear war, decontamination procedures, biological dosimetry and on-site specimen collection procedures, radioactive materials of military significance, and a conversion chart for the international system of units.

Centers for Disease Control and Prevention (CDC)

[Acute Radiation Syndrome: Physicians' Fact Sheet](#)

What physicians need to know about the presentation, diagnosis, and treatment of patients with acute radiation syndrome

[DTPA](#)

Facts about diethylenetriaminepentaacetate (DTPA) and how it can remove select radioactive materials from victim's bodies

[Neupogen](#)

Use of human granulocyte colony-stimulating factor for treatment of radiation injuries

[Potassium Iodide \(KI\)](#)

When to use KI in a radiation emergency

[Prenatal Radiation Exposure: Physicians' Fact Sheet](#)

What physicians need to know about diagnosing, treating, and advising pregnant women who have been exposed to radiation

[Prussian Blue](#)

Facts about Prussian blue and how it can remove select radioactive materials from people's bodies

Department of Homeland Security (DHS)

[Medical Treatment of Radiological Casualties](#)

A report by the DHS Working Group on Radiological Dispersal Device Preparedness discusses medical guidelines, psychological aspects of a radiological/nuclear event, and medical countermeasures

Food and Drug Administration (FDA), Center for Drug Evaluation and Research

[Drug Preparedness and Response to Radiation Emergencies](#)

To help prepare the country for possible terrorism attacks, the FDA is working with other federal agencies to make sure adequate supplies of medicine and vaccines are available to the American public. This Web site provides links to the most current information on radiation drug therapy, plus advice on purchasing and taking medication.

Drug Treatment Information and Package Inserts

- [DTPA \(diethylenetriaminepentaacetate\)](#)
- [Prussian Blue \(ferric hexacyanoferrate, Fe₄\[Fe\(CN\)₆\]₃\)](#)

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

[Hospital Triage in the First 24 Hours after a Nuclear or Radiological Disaster](#)

A clinical response guide for emergency department personnel for the first 24 hours of a radiation emergency so that essential information is gathered and reasonable decisions are made during the triage period.

[Managing Radiation Emergencies](#)

Basic explanations and definitions related to radiation and guidance for those responding both at the incident scene (prehospital) and at the hospital.

Strategic National Stockpile Working Group

[Medical Management of the Acute Radiation Syndrome](#)

Consensus recommendations from the Strategic National Stockpile Radiation Working Group, which provide a clinical framework for physicians who may be involved in evaluation, triage, or medical management of large-scale radiation injuries.

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Reporting Safety and Security Concerns

Federal, state, and local officials are responsible for working together to develop community and hospital response plans for the management of radiation emergencies. A coordinated communication network is critical for transmitting reliable information from the incident scene to treatment facilities. Clinicians should be aware of such plans and knowledgeable of whom to contact for situations involving:

- any accident involving a nuclear reactor, nuclear fuel facility, or radioactive materials;
- lost or damaged radioactive materials; or
- any threat, theft, smuggling, vandalism, or terrorist activity involving a nuclear facility or radioactive materials.

Any suspicious or confirmed disaster situation should be reported immediately to the local 9-1-1 emergency response number. If you believe that someone has been exposed deliberately to a biological, chemical, or radioactive agent, or if you believe an intentional terrorist threat will occur or is occurring, please contact your local health department, your local police or other law enforcement agency, and the **Centers for Disease Control and Prevention (770-488-7100)**. Any incident related to terrorism or possible terrorist activity also requires telephonic notification to the **National Response Center at 800-424-8802**. This includes bombings, bomb threats, suspicious letters or packages, and incidents related to the intentional release of chemical, radiological, and biological agents.

A 24-hour emergency response program at the US Department of Energy's (DOE) Oak Ridge Institute for Science and Education, the **Radiation Emergency Assistance Center/Training Site (REAC/TS)**, is available to assist physicians and others in the response to all types of radiation accidents and incidents. Incidents also should be reported to the DOE Emergency Operations Center Radiological Hotline at **202-586-8100**. For expert medical consultation and advice in the event of a radiation emergency, contact REAC/TS at 865-576-3131 or the 24-hour emergency number **865-576-1005**.

National Contacts

[American Association of Poison Control Centers \(AAPCC\)](#)

Poisoning Emergency Hotline: 800-222-1222

[Centers for Disease Control and Prevention \(CDC\)](#)

Emergency 24-hour Response Hotline: 770-488-7100

Clinician email: coca@cdc.gov

Clinician information line: 877-554-4625

Public email: cdcresponse@ashastd.org

Public information line: 888-246-2675

[What to do in an Emergency](#)

Key contact information from CDC's Emergency Preparedness and Response Web site

Department of Energy

Emergency Operation Center Radiological Hotline: 202-586-8100

[National Response Center](#)

24-hour Emergency Hotline: 800-424-8802

[Nuclear Regulatory Commission](#)

Emergency 24-hour Headquarters Operations Center: 301-816-5100

Non-Emergency Toll-Free Safety Hotline: 800-695-7403

[Radiation Emergency Assistance Center/Training Site \(REAC/TS\)](#)

Emergency Phone Number: 865-576-1005

Regional Contacts

[Regional Poison Control Centers](#)

State Contacts

[State Emergency Management Agencies](#)

[State Health Agency Hotline Numbers](#)

[State Health Agency Web Sites](#)

[State Homeland Security Offices](#)

[State Radiation Control Programs](#)

Local Contacts

[FBI Field Offices](#)

[Local Public Health Agencies](#)

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Additional Resource

General Information and Fact Sheets

There are several different types of radioactive particles that differ in mass, extent of radiation emitted, and the degree to which tissue penetration occurs. The amount of tissue damage depends on the specific radioisotope and the radiation dose. The following resources provide basic information about the physical and biological properties of radioactive agents and how to cope with a radiation emergency.

Types of Nuclear/Radiological Catastrophes and Consequences

Historically, the philosophy of nuclear risk has focused on global or strategic exchanges of nuclear weapons and the resulting damage from large-scale thermonuclear releases. Currently, nuclear accidents or terrorist attacks involving low-level or regional release of radiation are considered more likely events.

Nuclear and Radiological Terrorism

The release of radioactive materials by terrorists would likely occur via one of the following scenarios:

1. Detonation of a nuclear device (a nuclear explosion)
2. Sabotage of a nuclear power reactor
3. Dispersal of radioactive material through the use of conventional chemical explosives mixed with radioactive materials such as uranium, plutonium, thorium, cobalt-60, or cesium-137 (ie, radiation dispersal devices or “dirty bombs”)
4. Placement of nonexplosive radioactive material (eg, an industrial radiography device) in a public setting

Nuclear and radiological terrorism are very different events. Nuclear terrorism involves the deliberate detonation of a nuclear weapon; consequences would include fatalities and injuries resulting from the initial explosion and subsequent fires, as well as immediate and long-term effects of radiation exposure. Some assessments suggest that the difficulty of obtaining the materials needed for a nuclear device and the extraordinary technical challenge of building a functioning nuclear weapon make this the least likely form of terrorism.

Radiological terrorism involves the deliberate contamination of an area using radioactive materials. A terrorist could use conventional explosives to disperse a radiation source such as a spent nuclear reactor fuel rod. The technical challenge is far less than that of nuclear terrorism. The overall public health impact also is likely to be less, being limited to the longer term effects of radiation exposure and the challenge of decontaminating exposed victims and environments. Psychological trauma and economic losses, however, could be substantial.

Possible Impact

Detonation of a “dirty bomb” or detonation of the high explosives in a nuclear weapon (with no nuclear chain reaction occurring) can result in:

- Explosive dispersal of radioactive material in the environment
- Blast injuries, burns, and trauma, with possible entrapment of some victims
- Possible localized radiation injuries due to radioactive material blown onto skin or embedded in wounds
- Internal contamination of victims if material is vaporized or dispersed in fine particles
- Acute radiation syndrome is not likely unless victims are trapped near sources of penetrating gamma radiation (such as iridium-192, cesium-137, cobalt-60)
- Vaporization/aerosolization of radioactive materials and subsequent dispersal by wind and weather could cause contamination of the environment and economic disruption
- Widespread psychological trauma

Explosive destruction of a nuclear reactor can result in:

- Blast injury to those in the vicinity
- Radiation exposure and contamination to those onsite and in surrounding areas
- Airborne dispersal of radioactive materials that could cause contamination of the environment and economic disruption
- Release of radioactive iodine necessitates administration of thyroid-blocking potassium iodide (KI) to children, pregnant women, and others
- Widespread psychological trauma

Detonation of a nuclear weapon can result in:

- Massive widespread destruction with catastrophic consequences from the blast, heat, and radiation
- Hundreds to thousands of immediate deaths
- Hundreds to thousands of victims with burns, blast injuries and trauma, radiation exposure, contamination, flash blindness, and other injuries
- Destruction of medical facilities, fire, EMS services, and emergency management capabilities in the involved area with loss of personnel
- Widespread environmental contamination
- Nationwide psychological trauma
- Computer, electrical equipment, phone system malfunction due to an electromagnetic pulse that can occur with a nuclear detonation

Glossaries of Radiation Terms

Centers for Disease Control and Prevention (CDC)

[Glossary of Radiological Terms](#)

Environmental Protection Agency (EPA)

[Radiation Terms A-Z](#)

Basics of Radiation Safety

Centers for Disease Control and Prevention (CDC)

[FAQ About a Radiation Emergency](#)

How you can protect yourself and your family in a radiation emergency

[Radioactive Contamination and Radiation Exposure](#)

Describes radioactive contamination and radiation exposure that could occur if radioactive materials are released into the environment as the result of an accident, an event in nature, or an act of terrorism

[Radiation Facts](#)

Basic information about radiation

[Radioactive Isotopes](#)

Information about isotopes that might be used in a terrorist attack

[Radiation Measurement](#)

Explanation of measurement units with examples of common radiation exposures

[Sheltering in Place During a Radiation Emergency](#)

When and how you need to shelter-in-place during a radiation emergency

Environmental Protection Agency (EPA)

[Common Questions, Clear Answers about Radiation and Radioactivity](#)

[Estimating Annual Radiation Exposures](#)

A method for calculating your annual radiation dose

[EPA – Radiation Risk](#)

Discusses the risks and realities of radiation exposure

[Radionuclide Facts](#)

Federal Emergency Management Agency (FEMA)

[Radiological Accidents](#)

Health Physics Society

[“Ask the Experts”](#)

[Radiation Fact Sheets](#)

National Institutes of Health (NIH)

[What We Know About Radiation](#)

Nuclear Regulatory Agency

[Fact Sheet on Biological Effects of Radiation](#)

[Radiation Sources and Regulation](#)

Discusses the sources of different types of radiation, its effects, and its regulation

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

[Basics of Radiation](#)

Addresses basic explanations and definitions related to radiation

[Detection](#)

Describes various instruments available for detecting and measuring radiation

[Measurement](#)

How to determine the amount of radioactivity present in a quantity of material

[Safety Around Radiation Sources](#)

Information about radiation exposure and ways to limit exposure as much as is possible or practical

[Types of Radiation Exposure](#)

Discusses the three mechanisms for radiation-induced injury: external irradiation; contamination with radioactive materials; and incorporation of radioactive material into body cells, tissues, or organs

U.S. Department of State

[Guidance for Responding to Radiological and Nuclear Incidents: Fact Sheet](#)

Virginia Department of Emergency Management

[Terrorism Information: Nuclear and Radiological Weapons](#)

Comprehensive public information, in question-and-answer format, on radiation emergencies and disaster planning

World Health Organization (WHO)

[Health Protection Guidance in the Event of a Nuclear Weapons Explosion](#)

Health Effects of Radiation

Agency for Toxic Substances and Disease Registry (ATSDR)

[Toxicological Profiles on Various Radioisotopes](#)

Centers for Disease Control and Prevention (CDC)

[Acute Radiation Syndrome](#)

What you need to know about radiation sickness

[Nuclear Terrorism and Health Effects](#)

What happens during a nuclear or radiation terrorist attack and how to respond

[Radiation Exposure to Unborn Babies](#)

How radiation exposure affects pregnant women and their unborn babies

[Radiation and Health Effects](#)

How exposure to radiation can affect your health

National Library of Medicine (NLM)

[Radiation Exposure – MedlinePlus](#)

A comprehensive resource on adverse effects of radiation exposure

Children and Radiation

American Academy of Pediatrics (AAP)

[Radiation Disasters and Children: Q & A](#)

Dirty Bombs

Centers for Disease Control and Prevention (CDC)

[Dirty Bombs](#)

Center for the Study of Bioterrorism, Saint Louis University School of Public Health

[Radiological Terrorism Fact Sheet: “Dirty” Bombs](#)

Department of Homeland Security (DHS)

[Be Informed: Radiation Threat](#)

Institute for Homeland Security

[The Down and Dirty on Dirty Bombs](#)

National Academies

[Radiological Attack: Dirty Bombs and Other Devices](#)

A factsheet from the National Academies and the U.S. Department of Homeland Security offers clear, objective information on “dirty bombs” and other devices that could be used in a radiological terrorist attack. Created for journalists participating in the Academies’ News and Terrorism: Communicating in a Crisis workshops, the brief is the first in a series on weapons of mass destruction. Forthcoming factsheets will address chemical, biological, and nuclear attacks.

Nuclear Regulatory Commission

[Fact Sheet on Dirty Bombs](#)

World Health Organization (WHO)

[Nuclear Terrorism and Dirty Bombs](#)

Nuclear Blasts

Centers for Disease Control and Prevention (CDC)

[Nuclear Blast](#)

FAQs about what a nuclear blast is and how to protect yourself

Center for the Study of Bioterrorism, Saint Louis University School of Public Health

[Radiological Terrorism Fact Sheet: Nuclear Blast/Reactions](#)

Department of Homeland Security (DHS)

[Be Informed: Nuclear Blast](#)

World Health Organization (WHO)

[Nuclear Bombs](#)

Nuclear Power Plant Emergencies

Federal Emergency Management Agency (FEMA)

[Backgrounder: Nuclear Power Plant Emergency](#)

National Disaster Education Coalition

[Nuclear Power Plant Incidents](#)

Nuclear Regulatory Commission

[Fact Sheet on Nuclear Reactor Risk](#)

Potassium Iodide

Food and Drug Administration (FDA)

[Frequently Asked Questions on Potassium Iodide \(KI\)](#)

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Your feedback is welcome. E-mail comments to: disastercd@ama-assn.org.

Management of Exposed Victims

Agency for Toxic Substances and Disease Registry (ATSDR)

[Case Studies in Environmental Medicine: Radiation Exposure From Iodine 131](#)

Describes major sources of I-131 exposure, population groups most at risk, health implications, and indications for prophylactic use of potassium iodine (KI) after an I-131 exposure.

American Academy of Pediatrics (AAP)

[Children, Terrorism & Disasters](#)

Seeks to ensure: (1) that pediatricians and other pediatric providers have the information they need about terrorism and disasters as fast as it becomes available; (2) that children's needs are considered in all terrorism and disaster planning and response efforts; and (3) functioning linkages with all national, state and local governmental and private entities working on issues concerning terrorism and disasters.

[Radiation Disasters and Children: AAP Policy Statement](#)

Describes special needs and vulnerabilities of children exposed to radiation

American College of Preventive Medicine (ACPM)

[Radiation Exposure and Potassium Iodide \(KI\)](#)

Information about use of KI in a radiation emergency. Includes archives of a 90-minute expert session entitled "Environmental Radiation Exposure, Emergencies, and Public Health Response: Potassium Iodide Revisited," which was presented at the ACPM annual meeting in 2002.

American College of Radiology (ACR)

[Disaster Preparedness for Radiology Professionals](#)

This primer serves as a quick reference in the event of a radiation disaster by summarizing current information on preparing for a radiation emergency, handling contaminated persons, dose assessment and radiation exposure health effects. It also includes information on radiological findings related to agents of biological and chemical terrorism.

Armed Forces Radiobiology Research Institute (AFRRI)

[Biodosimetry Assessment Tool \(BAT\) Computer Program](#)

The BAT is a computer-based program that helps to provide diagnostic information (eg, clinical signs and symptoms, physical dosimetry) to healthcare providers to manage radiation casualties. It includes a computer-based algorithm for estimating a victim's radiation dose based on the time duration to onset of vomiting and sequential lymphocyte counts. The program is designed primarily for early use after a radiation incident and permits collection, integration, and archiving of data obtained from patients exposed to ionizing radiation.

[Medical Management of Radiological Casualties, 2nd edition, April 2003](#)

This handbook covers nuclear detonation and other high-dose radiation situations, radiation dispersal devices and industrial contamination situations, and radiological response operational aspects for operations other than warfare, including terrorism. Appendices include information on medical assay of patients, internal contaminant radionuclides, medical aspects of radiation injury in nuclear war, decontamination procedures, biological dosimetry and on-site specimen collection procedures, radioactive materials of military significance, and a conversion chart for the international system of units.

Centers for Disease Control and Prevention (CDC)

In addition to the following resources, the CDC provides a [free registry](#) to provide clinicians with real-time information to prepare for (and possibly respond to) terrorism and other emergency events. Participants receive regular email updates on terrorism and other relevant emergency issues and training opportunities.

[Acute Radiation Syndrome: Physicians' Fact Sheet](#)

What physicians need to know about the presentation, diagnosis, and treatment of patients with acute radiation syndrome

[Casualty Management After a Deliberate Release of Radioactive Material](#)

Immediate actions for first responders when radioactive material has been scattered by a conventional explosion or spread through an aerosol

[Casualty Management After Detonation of a Nuclear Weapon in an Urban Area](#)

Immediate actions for first responders when a nuclear weapon has been detonated in an urban area

[DTPA](#)

Facts about diethylenetriaminepentaacetate (DTPA) and how it can remove select radioactive materials from victim's bodies

[Health Advisory Alert Network](#)

A nationwide, integrated information and communications system serving as a platform for distribution of health alerts and national disease surveillance information, as well as for dissemination of prevention guidelines and distance learning opportunities to support CDC initiatives to strengthen emergency preparedness at the local and state levels.

[Neupogen](#)

Use of human granulocyte-colony stimulating factor for treatment of radiation injuries

[Potassium Iodide \(KI\)](#)

When to use KI in a radiation emergency

[Prenatal Radiation Exposure: Physicians' Fact Sheet](#)

What physicians need to know about diagnosing, treating, and advising pregnant women who have been exposed to radiation

[Prussian Blue](#)

Facts about Prussian blue and how Prussian blue can remove select radioactive materials from people's bodies

[Strategic National Stockpile](#)

National program to ensure the availability and rapid deployment of life-saving pharmaceuticals, antidotes, other medical supplies, and equipment necessary to counter the effects of chemical agents, biological pathogens, and trauma. The CDC provides such supplies at 10 locations across the country. Called “push packs,” they are filled with antibiotics, vaccines, antidotes, antitoxins, and other medical supplies that can be delivered anywhere in the United States within 12 hours in the event of an emergency.

Center for the Study of Bioterrorism, Saint Louis University School of Public Health

[Radiological Terrorism – Primary Care Preparedness](#)

A Web-based tutorial for primary care physicians consisting of 4 lectures, reference documents, and additional resources by event; CME credit is offered for this program

Department of Homeland Security (DHS)

[Medical Treatment of Radiological Casualties](#)

A report by the DHS Working Group on Radiological Dispersal Device Preparedness discusses medical guidelines, psychological aspects of a radiological/nuclear event, and medical countermeasures

eMedicine

[Warfare – Biological, Chemical, Radiological, Nuclear, and Explosive](#)

An extensive list of online articles on the evaluation and treatment of victims exposed to various biological, chemical, explosive, incendiary, and radioactive agents, including personal protection measures

Food and Drug Administration (FDA), Center for Drug Evaluation and Research

[Drug Preparedness and Response to Radiation Emergencies](#)

To help prepare the United States for possible terrorism attacks, the FDA is working with other federal agencies to make sure adequate supplies of medicine and vaccines are available to the American public. This Web site provides links to the most current information on radiation drug therapy, plus advice on purchasing and taking medication.

Health Physics Society

Recent position statements that can help guide hospital and community response to a radiological terrorist event:

[Guidance For Protective Actions Following a Radiological Terrorist Event](#)

- [Background Information on "Guidance For Protective Actions Following a Radiological Terrorist Event"](#)

[Radiation Risk in Perspective](#)

Illinois Department of Nuclear Safety[Radiation Accidents: A Guide for Medical Professionals on Handling, Transporting, Evaluating, and Treating Patients Accidentally Exposed to Radiation or Contaminated with Radioactive Materials](#)

General guidance for emergency medical personnel in handling patients with typical injuries complicated by radioactive contamination and those patients suspected of having been exposed to elevated radiation levels

International Atomic Energy Association (IAEA)[Diagnosis and Treatment of Radiation Injuries](#)

Joint effort of the IAEA and World Health Organization to help physicians who may be involved in the early handling of radiation victims with prompt diagnostic measures and treatment.

Mailman School of Public Health, Columbia University[National Center for Pediatric Preparedness Consensus Report](#)

National consensus conference report and recommendations for ensuring the needs of children are met in planning and preparing for disasters and terrorist events

Radiation Emergency Assistance Center/Training Site (REAC/TS)[Hospital Triage in the First 24 Hours after a Nuclear or Radiological Disaster](#)

A clinical response guide for emergency department personnel for the first 24 hours of a radiation emergency so that essential information is gathered and reasonable decisions are made during the triage period.

[Managing Radiation Emergencies](#)

Explanations and definitions related to radiation and guidance to those responding both at the scene of an accident (prehospital) and at the hospital.

Strategic National Stockpile Working Group[Medical Management of the Acute Radiation Syndrome](#)

Consensus recommendations from the Strategic National Stockpile Radiation Working Group, which provide a clinical framework for physicians who may be involved in evaluation, triage, or medical management of large scale radiation injuries.

U.S. Army[Handbook on the Medical Aspects of NBC Defensive Operations \(FM 8-9\) PART I – Nuclear](#)

This handbook is a guide for medical officers on the medical aspects of nuclear, biological, and chemical (NBC) operations. The handbook is in three parts, Part I-Nuclear, Part II-Biological, and Part III-Chemical. There is some necessary overlap and several aspects are common to all three, for example: combined injuries, the effect of radiation on the response to infection and on the healing of thermal and chemical burns, psychological factors and morale, public health aspects, and medical care in a mass casualty situation.

[Health Service Support in a Nuclear, Biological and Chemical Environment \(FM 4-02.7\)](#)

Field manual providing tactics, techniques, and procedures for health service support personnel operating in a hazardous nuclear, radiological biological, and chemical environment.

[The Medical NBC Battlebook](#) (Army Tech Guide 244)

Addresses operational health concerns related to NBC threats, protective clothing and measures, and management of NBC casualties

[Textbook of Military Medicine: Medical Consequences of Nuclear Warfare](#)

Developed with the Borden Institute, this online textbook was adapted from its original hardbound version published by the Office of the Surgeon General, U.S. Department of the Army.

[Treatment of Nuclear and Radiological Casualties Army Field Manual FM 4-02.283](#)

Reference guide for military and other medically qualified personnel on the recognition and treatment of nuclear and radiological casualties

U.S. Navy

[Bureau of Medicine and Surgery \(BUMED\) Instruction 6470.10A – Initial Management of Irradiated or Radioactively Contaminated Personnel](#)

Direction to military and civilian medical personnel for the initial exposure assessment, management, and treatment of individuals who are irradiated or externally or internally radioactively contaminated.

World Health Organization (WHO)

[Radiation Accidents and Emergencies](#)

The WHO works closely with the International Atomic Energy Agency to prepare for and respond to nuclear accidents and radiological emergencies, principally to coordinate and provide medical assistance to victims of such events where severe radiation exposure has occurred. Emergency medical support for radiation exposed individuals is provided through WHO's Radiation Emergency Medical Preparedness and Assistance Network (REMPAN).

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Hospital and Community Preparedness for Radiation Disasters

Centers for Disease Control and Prevention (CDC)

[Interim Guidelines for Hospital Response to Mass Casualties from a Radiological Incident](#)

Guidance from a multidisciplinary collaboration on practical strategies for hospitals in preparing or responding to a radiological terrorism event involving mass casualties. The document addresses notification and communication, triage, patient management, healthcare provider protection, surveillance, and community planning.

[Roundtable on Hospital Communications: Participants' Comments, Ideas, & Recommendations – A Summary Report](#)

A report from the CDC communications roundtable (January 2003) on communication challenges facing hospitals during radiation emergencies

[Strategic National Stockpile](#)

National program to ensure the availability and rapid deployment of life-saving pharmaceuticals, antidotes, other medical supplies, and equipment necessary to counter the effects of chemical agents, biological pathogens, and trauma. The CDC provides such supplies at 10 locations across the country. Called “push packs,” they are filled with antibiotics, vaccines, antidotes, antitoxins, and other medical supplies that can be delivered anywhere in the United States within 12 hours in the event of an emergency.

Department of Defense (DoD) Threat Reduction Agency

[Nuclear Accident Response Procedures \(NARP\) Manual](#)

The NARP provides guidance for military personnel in conducting site remediation activities following an accident involving a nuclear weapon in DoD custody or other types of radiological accidents or incidents. It assumes that a radiological release of some magnitude has occurred and that some remediation of the affected land is required. It is not intended as a comprehensive document to encompass all aspects of site remediation, but seeks to define a process by which response organizations may face the challenge of site remediation. This manual also describes the substantial resources other federal agencies make available to assist in the response effort.

Department of Energy (DOE), Federal Radiological Monitoring and Assessment Center

[Radiological Emergency Response Health and Safety Manual](#)

Radiological health and safety protection plans for emergency response operations

Department of Homeland Security (DHS)

[Federal Radiological Emergency Response Plan](#)

Information about the federal government's role in a radiation emergency

Department of Transportation (DOT)[Emergency Response Guidebook](#)

Developed jointly by the DOT, Transport Canada, and the Secretariat of Transport and Communications of Mexico for use by fire fighters, police, emergency services personnel, and other first responders in quickly identifying the specific or generic hazards of potentially dangerous materials involved in a transportation-related emergency and protecting themselves and the public during the initial response phase of the incident.

National Institute for Occupational Safety and Health (NIOSH)[Guidance for Protecting Building Environments from Airborne Chemical, Biological, or Radiological Attacks](#)

Preventive measures that building owners and managers can take to protect building air environments from a terrorist release of contaminants.

[NIOSH Approved Respirators](#)

Information on testing and certifying self-contained breathing apparatus (SCBA) for use by emergency responders in chemical, biological, radiological, and nuclear (CBRN) environments

Radiation Emergency Assistance Center/Training Site (REAC/TS)[Hospital Triage in the First 24 Hours after a Nuclear or Radiological Disaster](#)

Information about what needs to be done in the first 24 hours of a radiation emergency so that essential information is gathered and reasonable decisions are made

[Managing Radiation Emergencies: Guidance for Prehospital Emergency Services](#)

Information for firefighters, law enforcement officers, and EMS, and medical personnel

[Radiation Emergencies: Guidance for Hospital Medical Management](#)

Information on assessment, decontamination, and treatment of contaminated victims

Veterans Health Administration, Emergency Management Strategic Healthcare Group[Standard Operation Procedures \(SOPs\) for Radiation Incident Management](#)

Draft manual prepared to assist VA Medical Centers with basic information on emergencies involving radiation. These SOPs are intended to be edited by facilities in order to ensure they reflect local conditions.

[Goals of Contamination Control](#)

Describes general radiation decontamination procedures in emergency departments

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Suggested Reading List

American Academy of Pediatrics (AAP). [Radiation Disasters and Children: AAP Policy Statement](#). Describes special needs and vulnerabilities of children exposed to radiation

American College of Emergency Physicians (ACEP), U.S. Department of Health and Human Services Office of Emergency Preparedness. [Developing Objectives, Content, and Competencies for the Training of Emergency Medical Technicians, Emergency Physicians, and Emergency Nurses to Care for Casualties Resulting from Nuclear, Biological, or Chemical \(NBC\) Incidents](#). Dallas, Texas: American College of Emergency Physicians; 2001.

American College of Radiology. [Disaster Preparedness for Radiology Professionals](#)
This primer serves as a quick reference in the event of a radiation disaster by summarizing current information on preparing for a radiation emergency, handling contaminated persons, dose assessment and radiation exposure health effects. It also includes information on radiological findings related to agents of biological and chemical terrorism.

Armed Forces Radiobiology Research Institute (AFRRI). [Medical Management of Radiological Casualties, 2nd edition, April 2003](#).
This handbook covers nuclear detonation and other high-dose radiation situations, radiation dispersal devices and industrial contamination situations, and radiological response operational aspects for operations other than warfare including terrorism. Appendices include information on medical assay of the radiological patients, internal contaminant radionuclides, medical aspects of radiation injury in nuclear war, decontamination procedures, biological dosimetry and on-site specimen collection procedures, radioactive materials of military significance, and a conversion chart for the international system of units.

Committee on the Biological Effects of Ionizing Radiation, National Research Council. [Health Effects of Exposure to Low Levels of Ionizing Radiation \(BEIR V\)](#). Washington, DC: National Academy Press; 1990.

Committee on Radiation Battlefield Criteria, Institute of Medicine, National Research Council. [Potential Radiation Exposure in Military Operations: Protecting the Soldier Before, During and After](#). Washington, DC: National Academy Press; 1999.

Committee to Assess the Distribution and Administration of Potassium Iodide in the Event of a Nuclear Incident, National Research Council. [Distribution and Administration of Potassium Iodine in the Event of a Nuclear Incident](#). Washington, DC: National Academy Press; 2004.

This book assesses strategies for the distribution and administration of potassium iodine (KI) in the event of a nuclear incident. Potassium iodine can prevent thyroid cancer caused by exposure to radioactive iodine that could be released in such an event.

Fong F, Schrader DC. Radiation disasters and emergency department preparedness. *Emerg Med Clin North America*. 1996;14:349-370.

Goans RE, Holloway EC, Berger ME, Ricks RC. Early dose assessment in criticality accidents. *Health Physics*. 2001;81:446-449.

Gusev I, Guskova AK, Mettler FA Jr (eds). *Medical Management of Radiation Accidents*. 2nd edition. Boca Raton, FL: CRC Press, 2001.

International Atomic Energy Agency. *Planning the Medical Response to Radiological Accidents*. Safety Report Series No. 4. Vienna: IAEA;1998. [Details](#).

Leikin JB, McFee RB, Walter FG, Edsall K. A primer on nuclear terrorism. *Disease-a-Month*. 2003; 49:479-516.

Mettler FA Jr, Voelz GL. [Major radiation exposure-what to expect and how to respond](#). *N Engl J Med*. 2002;346:1554-1561.

Moulder JE. Report on an interagency workshop on the radiobiology of nuclear terrorism. Molecular and cellular biology dose (1-10) radiation and potential mechanisms of radiation protection (Bethesda, Maryland, December 17-18, 2001). *Radiat Res*. 2002;158:118-124.

National Council on Radiation Protection and Measurements. *Management of Persons Accidentally Contaminated with Radionuclides*. NCRP Report No. 65. Bethesda, MD: NCRP; 1980. [More information here](#).

National Council on Radiation Protection and Measurements. *Management of Terrorist Events Involving Radioactive Material*. NCRP Report No. 138. Bethesda, MD: NCRP; 2001. [More information here](#).

Ricks RC, Berger ME, O'Hara FM, eds. *The Medical Basis for Radiation-Accident Preparedness: The Clinical Care of Victims*. Boca Raton, Florida: Parthenon Publishing Group, Inc; 2002.

Timins JK, Lipoti JA. [Radiological terrorism](#). *New Jersey Medicine*. 2003;100:14-22.

Waselenko JK, MacVittie TJ, Blakely WF, Pesik N, Wiley AL, Dickerson WE, et al. [Medical management of the acute radiation syndrome: recommendations of the strategic national stockpile radiation working group](#). *Ann Intern Med*. 2004;140:1037-1051.

Consensus document developed by the Strategic National Stockpile Radiation Working Group to provide a clinical framework for physicians who may be involved in evaluation, triage, or medical management of large scale radiation injuries.

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