



Interim Guidelines for Hospital Response to Mass Casualties from a Radiological Incident

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Summary

On September 11, 2001, U.S. symbols of economic growth and military prowess were attacked and thousands of innocent lives were lost. These tragic events exposed our nation's vulnerability to attack and heightened our awareness of potential threats. Further examination of the capabilities of foreign nations indicate that terrorist groups worldwide have access to information on the development of radiological weapons and the potential to acquire the raw materials necessary to build such weapons. The looming threat of attack has highlighted the vital role that public health agencies play in our nation's response to terrorist incidents. Such agencies are responsible for detecting what agent was used (chemical, biological,

radiological), event surveillance, distribution of necessary medical supplies, assistance with emergency medical response, and treatment guidance.

In the event of a terrorist attack involving nuclear or radiological agents, it is one of CDC's missions to insure that our nation is well prepared to respond. In an effort to fulfill this goal, CDC, in collaboration with representatives of local and state health and radiation protection departments and many medical and radiological professional organizations, has identified practical strategies that hospitals can refer to in preparing for and responding to a radiological terrorism event involving mass casualties.

The guidance focuses on six key areas: (1) notification and communication, which emphasizes the importance of hospitals working with their communities and public health agencies on developing emergency communication plans; (2) triage; (3) patient management, including decontamination, treatment, care of special populations, discharge and follow up, and patient mental health concerns; (4) healthcare provider protection, including staff training and practitioner mental health concerns; (5) surveillance, and (6) community planning.

Hospital medical personnel can use these basic guidelines in conjunction with their professional training and experience to aid in the effective and efficient treatment of victims. The purpose of the guidelines is not to address all of the possible emergency-related medical care that may be required by the hospital during such an emergency. Rather, the focus is on unique aspects of a nuclear or radiological event involving mass casualties for which the hospital's emergency department may not be adequately prepared or equipped. It should be noted, however, a successful response is dependent not only on written guidelines, but also on the communication of these guidelines along with partnerships between medical personnel and private, state, local and federal public health agencies and organizations.

Background

In May 2002 the Centers for Disease Control and Prevention (CDC) brought together public health, medical and other scientific experts to discuss practical strategies that hospitals can use in preparation for and managing mass casualties from a radiological incident (see Appendix A for a full list of participants). From the discussions of this roundtable and other available literature, CDC has developed a basic set of practical strategies to provide guidance to hospitals, health care providers, emergency departments, and state and local health departments to aid in managing casualties from a nuclear or radiological incident for the purpose of ameliorating injuries and loss of life. It is recognized that mass casualties from any type of disaster may involve a variety of injuries and illnesses. The purpose of the present guidelines is not to address all of the possible emergency-related medical care that may be required by the hospital during such an emergency. Rather, the guidelines focus on the unique aspects of a nuclear or radiological event involving mass casualties for which the hospital may not be generally trained, equipped or prepared. As an aid to the reader, a Glossary of Terms is provided in the beginning of this document.

There is a variety of potential terrorist incidents involving radiation that could result in mass casualties that could present at hospitals in the area near the incident. The following are meant to be examples of possible radiological scenarios and are sorted in ascending order of potential health effects:

- **Radiation Dispersal Device** – A conventional explosion has scattered radioactive material (“dirty bomb”), saboteurs blew up a truck carrying radioactive material, or an aerosol containing radioactive material has been spread over a large area. There may

be tens to hundreds of injured people, and many hundreds of contaminated or exposed people. However, the radiation levels are not sufficient to cause acute radiation sickness in anyone; rather there are immediate psychological effects and an additional risk of long-term health effects.

- **Major event at or near a nuclear facility** (such as an airplane crash into a nuclear power plant or spent nuclear fuel pool) – Significant amounts of radioactive material have been released. There are dozens of injured people at the facility, many experiencing symptoms related to acute radiation syndrome, and thousands of contaminated or exposed people in the surrounding area who have an increased probability of long-term health effects.

- **Nuclear detonation** – The immediate physical devastation could appear similar to that of the World Trade Center following the events of September 11, 2001. However, the dust and debris from this event will be highly radioactive. There are thousands of people both contaminated and injured at the scene. In addition, there will be thousands of people in a large area potentially extending many miles outward from the initial point of attack with serious radiation exposures although they may have no obvious physical injury or contamination. Radioactive fallout with potential for long-term health effects will extend over a large region far from ground zero. There would likely be many persons experiencing symptoms related to acute radiation syndrome.

List of Acronyms

- AFRRI = Armed Forces Radiobiology Research Institute
- CBC = Complete Blood Count
- COBRA = Consolidated Omnibus Budget Reconciliation Act
- EMTALA = Emergency Medical Treatment and Labor Act
- FEMA = Federal Emergency Management Agency
- FRMAC = Federal Radiological Monitoring and Assessment Center
- FRPCC = Federal Radiological Preparedness Coordinating Committee
- HEICS = Hospital Emergency Incident Command Structure
- HIPPA = Health Insurance Portability and Accountability Act
- IAEA = International Atomic Energy Agency
- ICC = Incident Command Center
- NCRP = National Council on Radiation Protection and Measurements
- NRC = Nuclear Regulatory Commission
- REAC/TS = Radiation Emergency Assistance Center/Training Site

Glossary of Radiological Terms

Absolute risk: the proportion of a population expected to get a disease over a specified time period. *See also* [risk](#), [relative risk](#).

Absorbed dose: the amount of energy deposited by [ionizing radiation](#) in a unit mass of tissue. It is expressed in units of joule per kilogram (J/kg), and called “[gray](#)” (Gy). *For more information, see “[Primer on Radiation Measurement](#)” at the end of this document.*

Activity (radioactivity): the rate of decay of radioactive material expressed as the number of atoms breaking down per second measured in units called [becquerels](#) or [curies](#).

Acute exposure: an exposure to radiation that occurred in a matter of minutes rather than in longer, continuing exposure over a period of time. *See also* [chronic exposure](#), [exposure](#), [fractionated exposure](#).

Acute Radiation Syndrome (ARS): a serious illness caused by receiving a dose greater than 50 [rads](#) of penetrating radiation to the body in a short time (usually minutes). The earliest symptoms are nausea, fatigue, vomiting, and diarrhea. Hair loss, bleeding, swelling of the mouth and throat, and general loss of energy may

follow. If the exposure has been approximately 1,000 rads or more, death may occur within 2 – 4 weeks. *For more information, see CDC's fact sheet "Acute Radiation Syndrome" at <http://www.bt.cdc.gov/radiation/ars.asp>.*

Air burst: a nuclear weapon explosion that is high enough in the air to keep the fireball from touching the ground. Because the fireball does not reach the ground and does not pick up any surface material, the radioactivity in the [fallout](#) from an air burst is relatively insignificant compared with a [surface burst](#). *For more information, see Chapter 2 of CDC's Fallout Report at <http://www.cdc.gov/ncch/radiation/fallout/falloutreport.pdf>.*

Alpha particle: the [nucleus](#) of a helium atom, made up of two [neutrons](#) and two [protons](#) with a charge of +2. Certain radioactive nuclei emit alpha particles. Alpha particles generally carry more energy than [gamma](#) or [beta](#) particles, and deposit that energy very quickly while passing through tissue. Alpha particles can be stopped by a thin layer of light material, such as a sheet of paper, and cannot penetrate the outer, dead layer of skin. Therefore, they do not damage living tissue when outside the body. When alpha-emitting atoms are inhaled or swallowed, however, they are especially damaging because they transfer relatively large amounts of ionizing energy to living cells. *See also [beta particle](#), [gamma ray](#), [neutron](#), [x-ray](#).*

Ambient air: the air that surrounds us.

Americium (Am): a silvery metal; it is a man-made [element](#) whose [isotopes](#) Am-237 through Am-246 are all radioactive. Am-241 is formed spontaneously by the [beta decay](#) of plutonium-241. Trace quantities of americium are widely used in smoke detectors, and as neutron sources in neutron moisture gauges.

Atom: the smallest particle of an [element](#) that can enter into a chemical reaction.

Atomic number: the total number of [protons](#) in the [nucleus](#) of an atom.

Atomic mass unit (amu): 1 amu is equal to one twelfth of the mass of a carbon-12 atom.

Atomic mass number: the total number of [protons](#) and [neutrons](#) in the [nucleus](#) of an atom.

Atomic weight: the mass of an atom, expressed in [atomic mass units](#). For example, the atomic number of helium-4 is 2, the atomic mass is 4, and the atomic weight is 4.00026.

Background radiation: [ionizing radiation](#) from natural sources, such as [terrestrial radiation](#) due to [radionuclides](#) in the soil or [cosmic radiation](#) originating in outer space.

Becquerel (Bq): the amount of a [radioactive material](#) that will undergo one decay (disintegration) per second. *For more information, see “[Primer on Radiation Measurement](#)” at the end of this document.*

Beta particles: [electrons](#) ejected from the [nucleus](#) of a decaying [atom](#). Although they can be stopped by a thin sheet of aluminum, beta particles can penetrate the dead skin layer, potentially causing burns. They can pose a serious direct or external radiation threat and can be lethal depending on the amount received. They also pose a serious internal radiation threat if beta-emitting atoms are [ingested](#) or [inhaled](#). *See also [alpha particle](#), [gamma ray](#), [neutron](#), [x-ray](#).*

Bioassay: an assessment of [radioactive materials](#) that may be present inside a person’s body through analysis of the person’s blood, urine, feces, or sweat.

Biological Effects of Ionizing Radiation (BEIR) Reports: reports of the National Research Council's committee on the Biological Effects of Ionizing Radiation. *For more information, see <http://www.nap.edu/books/0309039959/html/>.*

Biological half-life: the time required for one half of the amount of a substance, such as a [radionuclide](#), to be expelled from the body by natural metabolic processes, not counting radioactive decay, once it has been taken in through [inhalation](#), [ingestion](#), or absorption. *See also [radioactive half-life](#), [effective half-life](#).*

Carcinogen: a cancer-causing substance.

Chain reaction: a process that initiates its own repetition. In a [fission](#) chain reaction, a fissile nucleus absorbs a [neutron](#) and fissions (splits) spontaneously, releasing additional neutrons. These, in turn, can be absorbed by other fissile nuclei, releasing still more neutrons. A fission chain reaction is self-sustaining when the number of neutrons released in a given time equals or exceeds the number of neutrons lost by absorption in non-fissile material or by escape from the system.

Chronic exposure: exposure to a substance over a long period of time, possibly resulting in adverse health effects. *See also* [acute exposure](#), [fractionated exposure](#).

Cobalt (Co): gray, hard, magnetic, and somewhat malleable metal. Cobalt is relatively rare and generally obtained as a byproduct of other metals, such as copper. Its most common [radioisotope](#), cobalt-60 (Co-60), is used in [radiography](#) and medical applications. Cobalt-60 emits [beta particles](#) and [gamma rays](#) during [radioactive decay](#).

Collective dose: the estimated dose for an area or region multiplied by the estimated population in that area or region. *For more information, see* “[Primer on Radiation Measurement](#)” *at the end of this document.*

Committed dose: a dose that accounts for continuing exposures expected to be received over a long period of time (such as 30, 50, or 70 years) from [radioactive materials](#) that were deposited inside the body. *For more information, see “[Primer on Radiation Measurement](#)” at the end of this document.*

Concentration: the ratio of the amount of a specific substance in a given volume or mass of solution to the mass or volume of solvent.

Conference of Radiation Control Program Directors (CRCPD): an organization whose members represent state radiation protection programs. *For more information, see the CRCPD website: <http://www.crcpd.org>.*

Contamination (radioactive): the deposition of unwanted [radioactive material](#) on the surfaces of structures, areas, objects, or people where it may be [external](#) or [internal](#). *See also [decontamination](#).*

Cosmic radiation: radiation produced in outer space when heavy particles from other galaxies (nuclei of all known natural [elements](#)) bombard the earth. *See also [background radiation](#), [terrestrial radiation](#).*

Criticality: a [fission](#) process where the neutron production rate equals the neutron loss rate to absorption or leakage. A nuclear reactor is "critical" when it is operating.

Critical mass: the minimum amount of [fissile material](#) that can achieve a self-sustaining nuclear [chain reaction](#).

Cumulative dose: the total dose resulting from repeated or continuous exposures of the same portion of the body, or of the whole body, to [ionizing radiation](#). *For more information, see “[Primer on Radiation Measurement](#)” at the end of this document.*

Curie (Ci): the traditional measure of [radioactivity](#) based on the observed decay rate of 1 gram of radium. One curie of [radioactive material](#) will have 37 billion disintegrations in 1 second. *For more information, see “[Primer on Radiation Measurement](#)” at the end of this document.*

Cutaneous Radiation Syndrome (CRS): the complex syndrome resulting from radiation exposure of more than 200 [rads](#) to the skin. The immediate effects can be reddening and swelling of the exposed area (like a severe burn), blisters, ulcers on the skin, hair loss, and severe pain. Very large doses can result in permanent hair loss, scarring, altered skin color, deterioration of the affected body part, and death of the affected tissue (requiring surgery). *For more information, see CDC’s fact sheet “Acute Radiation Syndrome,” at <http://www.bt.cdc.gov/radiation/ars.asp>.*

Decay chain (decay series): the series of decays that certain [radioisotopes](#) go through before reaching a stable form. For example, the decay chain that begins with

uranium-238 (U-238) ends in lead-206 (Pb-206), after forming isotopes, such as uranium-234 (U-234), thorium-230 (Th-230), radium-226 (Ra-226), and radon-222 (Rn-222).

Decay constant: the fraction of a number of atoms of a [radioactive nuclide](#) that disintegrates in a unit of time. The decay constant is inversely proportional to the [radioactive half-life](#).

Decay products (or daughter products): the [isotopes](#) or [elements](#) formed and the particles and high-energy electromagnetic radiation emitted by the nuclei of [radionuclides](#) during [radioactive decay](#). Also known as "decay chain products" or "progeny" (the isotopes and elements). A decay product may be either radioactive or stable.

Decay, radioactive: disintegration of the [nucleus](#) of an unstable [atom](#) by the release of [radiation](#).

Decontamination: the reduction or removal of radioactive [contamination](#) from a structure, object, or person.

Depleted uranium: uranium containing less than 0.7% uranium-235, the amount found in natural uranium. *See also* [enriched uranium](#).

Deposition density: the activity of a [radionuclide](#) per unit area of ground. Reported as [becquerels](#) per square meter or [curies](#) per square meter.

Deterministic effects: effects that can be related directly to the [radiation dose](#) received. The severity increases as the dose increases. A deterministic effect typically has a threshold below which the effect will not occur. *See also* [stochastic effect](#), [non-stochastic effect](#).

Deuterium: a non-radioactive [isotope](#) of the hydrogen atom that contains a [neutron](#) in its [nucleus](#) in addition to the one [proton](#) normally seen in hydrogen. A deuterium atom is twice as heavy as normal hydrogen. *See also* [tritium](#).

Dirty bomb: a device designed to spread [radioactive material](#) by conventional explosives when the bomb explodes. A dirty bomb kills or injures people through the initial blast of the conventional explosive and spreads radioactive [contamination](#) over possibly a large area—hence the term “dirty.” Such bombs could be miniature devices or large truck bombs. A dirty bomb is much simpler to make than a true nuclear weapon. *See also* [radiological dispersal device](#).

Dose (radiation): radiation absorbed by person’s body. Several different terms describe radiation dose. *For more information, see* “[Primer on Radiation Measurement](#)” *at the end of this document.*

Dose coefficient: the factor used to convert [radionuclide](#) intake to dose. Usually expressed as dose per unit intake (e.g., [sieverts](#) per [becquerel](#)).

Dose equivalent: a quantity used in radiation protection to place all radiation on a common scale for calculating tissue damage. Dose equivalent is the [absorbed dose](#) in [grays](#) times the [quality factor](#). The quality factor accounts for differences in radiation effects caused by different types of [ionizing radiation](#). Some radiation, including [alpha particles](#), causes a greater amount of damage per unit of absorbed dose than other radiation. The [sievert](#) (Sv) is the unit used to measure dose equivalent. *For more information, see “[Primer on Radiation Measurement](#)” at the end of this document.*

Dose rate: the [radiation dose](#) delivered per unit of time.

Dose reconstruction: a scientific study that estimates doses to people from releases of [radioactivity](#) or other pollutants. The dose is reconstructed by determining the amount of material released, the way people came in contact with it, and the amount they absorbed.

Dosimeter: a small portable instrument (such as a film badge, thermoluminescent dosimeter [TLD], or pocket dosimeter) for measuring and recording the total accumulated dose of [ionizing radiation](#) a person receives.

Dosimetry: assessment (by measurement or calculation) of [radiation dose](#).

Effective dose: a dosimetric quantity useful for comparing the overall health affects of [irradiation](#) of the whole body. It takes into account the [absorbed doses](#) received by various organs and tissues and weighs them according to present knowledge of the sensitivity of each organ to radiation. It also accounts for the type of radiation and the potential for each type to inflict biologic damage. The effective dose is used, for example, to compare the overall health detriments of different [radionuclides](#) in a given mix. The unit of effective dose is the [sievert](#) (Sv); $1 \text{ Sv} = 1 \text{ J/kg}$. *For more information, see “[Primer on Radiation Measurement](#)” at the end of this document.*

Effective half-life: the time required for the amount of a [radionuclide](#) deposited in a living organism to be diminished by 50% as a result of the combined action of [radioactive decay](#) and biologic elimination. *See also [biological half-life](#), [decay constant](#), [radioactive half-life](#).*

Electron: an elementary particle with a negative electrical charge and a mass $1/1837$ that of the [proton](#). Electrons surround the [nucleus](#) of an [atom](#) because of the attraction between their negative charge and the positive charge of the nucleus. A stable atom will have as many electrons as it has protons. The number of electrons that orbit an atom determine its chemical properties. *See also [neutron](#).*

Electron volt (eV): a unit of energy equivalent to the amount of energy gained by an [electron](#) when it passes from a point of low potential to a point one volt higher in potential.

Element: 1) all [isotopes](#) of an [atom](#) that contain the same number of [protons](#). For example, the element uranium has 92 protons, and the different isotopes of this element may contain 134 to 148 neutrons. 2) In a reactor, a fuel element is a metal rod containing the [fissile material](#).

Enriched uranium: uranium in which the proportion of the [isotope](#) uranium-235 has been increased by removing uranium-238 mechanically. *See also* [depleted uranium](#).

Epidemiology: the study of the distribution and determinants of health-related states or events in specified populations; and the application of this study to the control of health problems.

Exposure (radiation): a measure of [ionization](#) in air caused by [x-rays](#) or [gamma rays](#) only. The unit of exposure most often used is the [roentgen](#). *See also* [contamination](#).

Exposure pathway: a route by which a [radionuclide](#) or other toxic material can enter the body. The main exposure routes are [inhalation](#), [ingestion](#), absorption through the skin, and entry through a cut or wound in the skin.

Exposure rate: a measure of the [ionization](#) produced in air by [x-rays](#) or [gamma rays](#) per unit of time (frequently expressed in [roentgens](#) per hour).

External exposure: exposure to radiation outside of the body.

Fallout, nuclear: minute particles of radioactive debris that descend slowly from the atmosphere after a nuclear explosion. *For more information, see Chapter 2 of CDC's [Fallout Report](#) at <http://www.cdc.gov/nceh/radiation/fallout/falloutreport.pdf>.*

Fissile material: any material in which [neutrons](#) can cause a [fission](#) reaction. The three primary fissile materials are uranium-233, uranium-235, and plutonium-239.

Fission (fissioning): the splitting of a [nucleus](#) into at least two other nuclei that releases a large amount of energy. Two or three [neutrons](#) are usually released during this transformation. *See also [fusion](#).*

Fractionated exposure: exposure to radiation that occurs in several small [acute exposures](#), rather than continuously as in a [chronic exposure](#).

Fusion: a reaction in which at least one heavier, more [stable nucleus](#) is produced from two lighter, less stable nuclei. Reactions of this type are responsible for the release of energy in stars or in [thermonuclear weapons](#).

Gamma rays: high-energy electromagnetic radiation emitted by certain [radionuclides](#) when their nuclei transition from a higher to a lower energy state. These rays have high energy and a short wave length. All gamma rays emitted from a given [isotope](#) have the same energy, a characteristic that enables scientists to identify which gamma emitters are present in a sample. Gamma rays penetrate tissue farther than do [beta](#) or [alpha particles](#), but leave a lower concentration of [ions](#) in their path to potentially cause cell damage. Gamma rays are very similar to [x-rays](#). *See also* [neutron](#).

Geiger counter: a radiation detection and measuring instrument consisting of a gas-filled tube containing electrodes, between which an electrical voltage but no current flows. When [ionizing radiation](#) passes through the tube, a short, intense pulse of current passes from the negative electrode to the positive electrode and is measured or counted. The number of pulses per second measures the intensity of the radiation field. Geiger counters are the most commonly used portable radiation detection instruments.

Genetic effects: hereditary effects (mutations) that can be passed on through reproduction because of changes in sperm or ova. *See also* [teratogenic effects](#), [somatic effects](#).

Gray (Gy): a unit of measurement for [absorbed dose](#). It measures the amount of energy absorbed in a material. The unit Gy can be used for any type of [radiation](#), but it does not describe the biological effects of the different radiations. *For more information, see* “[Primer on Radiation Measurement](#)” *at the end of this document.*

Half-life: the time any substance takes to decay by half of its original amount. *See also* [biological half-life](#), [decay constant](#), [effective half-life](#), [radioactive half-life](#).

Health physics: a scientific field that focuses on protection of humans and the environment from [radiation](#). Health physics uses physics, biology, chemistry, statistics, and electronic instrumentation to help protect individuals from any damaging effects of radiation. *For more information, see the Health Physics Society website:* <http://www.hps.org/>.

High-level radioactive waste: the [radioactive material](#) resulting from spent nuclear fuel reprocessing. This can include liquid waste directly produced in reprocessing or any solid material derived from the liquid wastes having a sufficient concentration of [fission products](#). Other radioactive materials can be designated as high-level waste, if

they require permanent isolation. This determination is made by the U.S. Nuclear Regulatory Commission on the basis of criteria established in U.S. law. *See also* [low-level waste](#), [transuranic waste](#).

Hot spot: any place where the level of [radioactive contamination](#) is considerably greater than the area around it.

Ingestion: 1) the act of swallowing; 2) in the case of [radionuclides](#) or chemicals, swallowing radionuclides or chemicals by eating or drinking.

Inhalation: 1) the act of breathing in; 2) in the case of [radionuclides](#) or chemicals, breathing in radionuclides or chemicals.

Internal exposure: exposure to [radioactive material](#) taken into the body.

Iodine: a nonmetallic solid [element](#). There are both radioactive and non-radioactive [isotopes](#) of iodine. Radioactive isotopes of iodine are widely used in medical applications. Radioactive iodine is a [fission](#) product and is the largest contributor to people's [radiation dose](#) after an accident at a nuclear reactor.

Ion: an [atom](#) that has fewer or more [electrons](#) than it has [protons](#) causing it to have an electrical charge and, therefore, be chemically reactive.

Ionization: the process of adding one or more [electrons](#) to, or removing one or more electrons from, [atoms](#) or molecules, thereby creating [ions](#). High temperatures, electrical discharges, or [nuclear radiation](#) can cause ionization.

Ionizing radiation: any radiation capable of displacing [electrons](#) from [atoms](#), thereby producing [ions](#). High doses of ionizing radiation may produce severe skin or tissue damage. *See also* [alpha particle](#), [beta particle](#), [gamma ray](#), [neutron](#), [x-ray](#).

Irradiation: exposure to radiation.

Isotope: a nuclide of an [element](#) having the same number of [protons](#) but a different number of [neutrons](#).

Kiloton (Kt): the energy of an explosion that is equivalent to an explosion of 1,000 tons of TNT. One kiloton equals 1 trillion (10^{12}) calories. *See also* [megaton](#).

Latent period: the time between exposure to a toxic material and the appearance of a resultant health effect.

Lead (Pb): a heavy metal. Several [isotopes](#) of lead, such as Pb-210 which emits [beta radiation](#), are in the uranium [decay chain](#).

Lead Federal Agency (LFA): the federal agency that leads and coordinates the emergency response activities of other federal agencies during a nuclear emergency. After a nuclear emergency, the Federal Radiological Emergency Response Plan (FRERP, available at <http://www.fas.org/nuke/guide/usa/doctrine/national/frerp.htm>) will determine which federal agency will be the LFA.

Local radiation injury (LRI): [acute radiation exposure](#) (more than 1,000 [rads](#)) to a small, localized part of the body. Most local radiation injuries do not cause death. However, if the exposure is from penetrating radiation ([neutrons](#), [x-rays](#), or [gamma rays](#)), internal organs may be damaged and some symptoms of [acute radiation syndrome](#) (ARS), including death, may occur. Local radiation injury invariably involves skin damage, and a skin graft or other surgery may be required. *See also CDC's fact sheet "Acute Radiation Syndrome" at <http://www.bt.cdc.gov/radiation/ars.asp>.*

Low-level waste (LLW): radioactively contaminated industrial or research waste such as paper, rags, plastic bags, medical waste, and water-treatment residues. It is waste that does not meet the criteria for any of three other categories of radioactive waste: spent nuclear fuel and [high-level radioactive waste](#); [transuranic](#) radioactive waste; or [uranium mill tailings](#). Its categorization does not depend on the level of radioactivity it contains.

Megaton (Mt): the energy of an explosion that is equivalent to an explosion of 1 million tons of TNT. One megaton is equal to a quintillion (10^{18}) calories. *See also* [kiloton](#).

Molecule: a combination of two or more [atoms](#) that are chemically bonded. A molecule is the smallest unit of a compound that can exist by itself and retain all of its chemical properties.

Neoplastic: pertaining to the pathologic process resulting in the formation and growth of an abnormal mass of tissue.

Neutron: a small atomic particle possessing no electrical charge typically found within an atom's [nucleus](#). Neutrons are, as the name implies, neutral in their charge. That is, they have neither a positive nor a negative charge. A neutron has about the same mass as a [proton](#). *See also* [alpha particle](#), [beta particle](#), [gamma ray](#), [nucleon](#), [x-ray](#).

Non-ionizing radiation: radiation that has lower energy levels and longer wavelengths than [ionizing radiation](#). It is not strong enough to affect the structure of [atoms](#) it contacts but is strong enough to heat tissue and can cause harmful biological effects. Examples include radio waves, microwaves, visible light, and infrared from a heat lamp.

Non-stochastic effects: effects that can be related directly to the [radiation dose](#) received. The effect is more severe with a higher dose. It typically has a threshold, below which the effect will not occur. These are sometimes called [deterministic effects](#). For example, a skin burn from radiation is a non-stochastic effect that worsens as the radiation dose increases. *See also* [stochastic effects](#).

Nuclear energy: the heat energy produced by the process of nuclear [fission](#) within a nuclear reactor or by [radioactive decay](#).

Nuclear fuel cycle: the steps involved in supplying fuel for nuclear power plants. It can include mining, milling, isotopic enrichment, fabrication of fuel elements, use in reactors, chemical reprocessing to recover the [fissile material](#) remaining in the spent fuel, reenrichment of the fuel material refabrication into new fuel elements, and waste disposal.

Nuclear tracers: [radioisotopes](#) that give doctors the ability to "look" inside the body and observe soft tissues and organs, in a manner similar to the way x-rays provide images of bones. A radioactive tracer is chemically attached to a compound that will concentrate naturally in an organ or tissue so that an image can be taken.

Nucleon: a [proton](#) or a [neutron](#); a constituent of the [nucleus](#) of an atom.

Nucleus: the central part of an [atom](#) that contains [protons](#) and [neutrons](#). The nucleus is the heaviest part of the atom.

Nuclide: a general term applicable to all atomic forms of an [element](#). Nuclides are characterized by the number of [protons](#) and [neutrons](#) in the [nucleus](#), as well as by the amount of energy contained within the [atom](#).

Pathways: the routes by which people are exposed to radiation or other contaminants.

The three basic pathways are [inhalation](#), [ingestion](#), and direct [external exposure](#). *See also* [exposure pathway](#).

Penetrating radiation: radiation that can penetrate the skin and reach internal organs and tissues. Photons ([gamma rays](#) and [x-rays](#)), [neutrons](#), and [protons](#) are penetrating radiations. However, [alpha particles](#) and all but extremely high-energy [beta particles](#) are not considered penetrating radiation.

Photon: discrete "packet" of pure electromagnetic energy. Photons have no mass and travel at the speed of light. The term "photon" was developed to describe energy when it acts like a particle (causing interactions at the molecular or atomic level), rather than a wave. [Gamma rays](#) and [x-rays](#) are photons.

Pitchblende: a brown to black mineral that has a distinctive luster. It consists mainly of urananite (UO_2), but also contains [radium](#) (Ra). It is the main source of [uranium](#) (U) ore.

Plume: the material spreading from a particular source and traveling through environmental media, such as air or ground water. For example, a plume could describe the dispersal of particles, gases, vapors, and aerosols in the atmosphere, or the movement of contamination through an aquifer (For example, dilution, mixing, or adsorption onto soil).

Plutonium (Pu): a heavy, man-made, radioactive metallic [element](#). The most important [isotope](#) is Pu-239, which has a half-life of 24,000 years. Pu-239 can be used in reactor fuel and is the primary isotope in weapons. One kilogram is equivalent to about 22 million kilowatt-hours of heat energy. The complete detonation of a kilogram of plutonium produces an explosion equal to about 20,000 tons of chemical explosive. All isotopes of plutonium are readily absorbed by the bones and can be lethal depending on the dose and exposure time.

Polonium (Po): a radioactive chemical [element](#) and a product of [radium](#) (Ra) decay. Polonium is found in [uranium](#) (U) ores.

Prenatal radiation exposure: radiation exposure to an embryo or fetus while it is still in its mother's womb. At certain stages of the pregnancy, the fetus is particularly sensitive to radiation and the health consequences could be severe above 5 [rads](#), especially to brain function. *For more information, see CDC's fact sheet, "Possible Health Effects of Radiation Exposure on Unborn Babies," at <http://www.bt.cdc.gov/radiation/prenatal.asp>.*

Protective Action Guide (PAG): a guide that tells state and local authorities at what projected dose they should take action to protect people from exposure to unplanned releases of [radioactive material](#) into the environment.

Proton: a small atomic particle, typically found within an atom's [nucleus](#), that possesses a positive electrical charge. Even though protons and [neutrons](#) are about 2,000 times heavier than electrons, they are tiny. The number of protons is unique for each chemical element. *See also [nucleon](#).*

Quality factor (Q): the factor by which the [absorbed dose](#) ([rad](#) or [gray](#)) is multiplied to obtain a quantity that expresses, on a common scale for all [ionizing radiation](#), the biological damage ([rem](#)) to an exposed person. It is used because some types of radiation, such as [alpha particles](#), are more biologically damaging internally than other types. *For more information, see "[Primer on Radiation Measurement](#)" at the end of this document.*

Rad (radiation absorbed dose): a basic unit of [absorbed radiation dose](#). It is a measure of the amount of energy absorbed by the body. The rad is the traditional unit of absorbed dose. It is being replaced by the unit [gray](#) (Gy), which is equivalent to 100 rad. One rad equals the dose delivered to an object of 100 ergs of energy per gram of material. *For more information, see “[Primer on Radiation Measurement](#)” at the end of this document.*

Radiation: energy moving in the form of particles or waves. Familiar radiations are heat, light, radio waves, and microwaves. [Ionizing radiation](#) is a very high-energy form of electromagnetic radiation.

Radiation sickness: *See also [acute radiation syndrome](#) (ARS), or the CDC fact sheet “Acute Radiation Syndrome,” at <http://www.bt.cdc.gov/radiation/ars.asp>.*

Radiation warning symbol: a symbol prescribed by the Code of Federal Regulations. It is a magenta or black trefoil on a yellow background. It must be displayed where certain quantities of [radioactive materials](#) are present or where certain doses of radiation could be received.



Radioactive contamination: the deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or people. It can be airborne, external, or internal. *See also [contamination](#), [decontamination](#).*

Radioactive decay: the spontaneous disintegration of the [nucleus](#) of an atom.

Radioactive half-life: the time required for a quantity of a [radioisotope](#) to decay by half. For example, because the half-life of iodine-131 (I-131) is 8 days, a sample of I-131 that has 10 [mCi](#) of activity on January 1, will have 5 mCi of activity 8 days later, on January 9. *See also:* [biological half-life](#), [decay constant](#), [effective half-life](#).

Radioactive material: material that contains unstable (radioactive) atoms that give off [radiation](#) as they [decay](#).

Radioactivity: the process of spontaneous transformation of the [nucleus](#), generally with the emission of [alpha](#) or [beta particles](#) often accompanied by [gamma rays](#). This process is referred to as [decay](#) or disintegration of an atom.

Radioassay: a test to determine the amounts of [radioactive materials](#) through the detection of [ionizing radiation](#). Radioassays will detect [transuranic](#) nuclides, [uranium](#), [fission](#) and activation products, [naturally occurring radioactive material](#), and medical [isotopes](#).

Radiogenic: health effects caused by exposure to [ionizing radiation](#).

Radiography: 1) *medical*: the use of radiant energy (such as [x-rays](#) and [gamma rays](#)) to image body systems. 2) *industrial*: the use of radioactive sources to photograph internal structures, such as turbine blades in jet engines. A [sealed radiation source](#), usually iridium-192 (Ir-192) or cobalt-60 (Co-60), beams gamma rays at the object to be checked. Gamma rays passing through flaws in the metal or incomplete welds strike special photographic film (radiographic film) on the opposite side.

Radioisotope (radioactive isotope): [isotopes](#) of an [element](#) that have an unstable [nucleus](#). Radioactive isotopes are commonly used in science, industry, and medicine. The nucleus eventually reaches a stable number of [protons](#) and [neutrons](#) through one or more radioactive decays. Approximately 3,700 natural and artificial radioisotopes have been identified.

Radiological or radiologic: related to [radioactive materials](#) or [radiation](#). The radiological sciences focus on the measurement and effects of radiation.

Radiological dispersal device (RDD): a device that disperses [radioactive material](#) by conventional explosive or other mechanical means, such as a spray. *See also* [dirty bomb](#).

Radionuclide: an unstable and therefore radioactive form of a [nuclide](#).

Radium (Ra): a naturally occurring radioactive metal. Radium is a [radionuclide](#) formed by the decay of [uranium](#) (U) and [thorium](#) (Th) in the environment. It occurs at low levels in virtually all rock, soil, water, plants, and animals. [Radon](#) (Rn) is a decay product of radium.

Radon (Rn): a naturally occurring radioactive gas found in soils, rock, and water throughout the United States. Radon causes lung cancer and is a threat to health because it tends to collect in homes, sometimes to very high concentrations. As a result, radon is the largest source of exposure to people from naturally occurring radiation.

Relative risk: the ratio between the risk for disease in an [irradiated](#) population to the risk in an unexposed population. A relative risk of 1.1 indicates a 10% increase in cancer from radiation, compared with the "normal" incidence. *See also* [risk](#), [absolute risk](#).

Rem (roentgen equivalent, man): a unit of equivalent dose. Not all [radiation](#) has the same biological effect, even for the same amount of [absorbed dose](#). Rem relates the absorbed dose in human tissue to the effective biological damage of the radiation. It is determined by multiplying the number of [rads](#) by the [quality factor](#), a number reflecting the potential damage caused by the particular type of radiation. The rem is the traditional unit of equivalent dose, but it is being replaced by the [sievert](#) (Sv),

which is equal to 100 rem. *For more information, see “[Primer on Radiation Measurement](#)” at the end of this document.*

Risk: the probability of injury, disease, or death under specific circumstances and time periods. Risk can be expressed as a value that ranges from 0% (no injury or harm will occur) to 100% (harm or injury will definitely occur). Risk can be influenced by several factors: personal behavior or lifestyle, environmental exposure to other material, or inborn or inherited characteristic known from scientific evidence to be associated with a health effect. Because many risk factors are not exactly measurable, risk estimates are uncertain. *See also [absolute risk](#), [relative risk](#).*

Risk assessment: an evaluation of the risk to human health or the environment by hazards. Risk assessments can look at either existing hazards or potential hazards.

Roentgen (R): a unit of exposure to [x-rays](#) or [gamma rays](#). One roentgen is the amount of gamma or x-rays needed to produce [ions](#) carrying 1 electrostatic unit of electrical charge in 1 cubic centimeter of dry air under standard conditions.

Sensitivity: ability of an analytical method to detect small concentrations of [radioactive material](#).

Shielding: the material between a radiation source and a potentially exposed person that reduces exposure.

Sievert (Sv): a unit used to derive a quantity called [dose equivalent](#). This relates the [absorbed dose](#) in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. [Dose equivalent](#) is often expressed as millionths of a sievert, or micro-sieverts (μSv). One sievert is equivalent to 100 [rem](#). *For more information, see “[Primer on Radiation Measurement](#)” at the end of this document.*

S.I. units: the Systeme Internationale (or International System) of units and measurements. This system of units officially came into being in October 1960 and has been adopted by nearly all countries, although the amount of actual usage varies considerably. *For more information, see “[Primer on Radiation Measurement](#)” at the end of this document.*

Somatic effects: effects of radiation that are limited to the exposed person, as distinguished from [genetic effects](#), which may also affect subsequent generations. *See also [teratogenic effects](#).*

Stable nucleus: the [nucleus](#) of an atom in which the forces among its particles are balanced. *See also [unstable nucleus](#).*

Stochastic effect: effect that occurs on a random basis independent of the size of [dose](#).

The effect typically has no threshold and is based on probabilities, with the chances of seeing the effect increasing with dose. If it occurs, the severity of a stochastic effect is independent of the dose received. Cancer is a stochastic effect. *See also* [non-stochastic effect](#), [deterministic effect](#).

Strontium (Sr): a silvery, soft metal that rapidly turns yellow in air. Sr-90 is one of the radioactive [fission materials](#) created within a nuclear reactor during its operation. Strontium-90 emits [beta particles](#) during radioactive decay.

Surface burst: a nuclear weapon explosion that is close enough to the ground for the radius of the fireball to vaporize surface material. [Fallout](#) from a surface burst contains very high levels of radioactivity. *See also* [air burst](#). *For more information, see Chapter 2 of CDC's Fallout Report at* <http://www.cdc.gov/nceh/radiation/fallout/falloutreport.pdf>.

Tailings: waste rock from mining operations that contains concentrations of mineral ore that are too low to make typical extraction methods economical.

Thermonuclear device: a “hydrogen bomb.” A device with explosive energy that comes from [fusion](#) of small nuclei, as well as [fission](#).

Teratogenic effect: birth defects that are not passed on to future generations, caused by exposure to a toxin as a fetus. *See also* [genetic effects](#), [somatic effects](#).

Terrestrial radiation: radiation emitted by naturally occurring [radioactive materials](#), such as [uranium](#) (U), [thorium](#) (Th), and [radon](#) (Rn) in the earth.

Thorium (Th): a naturally occurring radioactive metal found in small amounts in soil, rocks, water, plants, and animals. The most common [isotopes](#) of thorium are thorium-232 (Th-232), thorium-230 (Th-230), and thorium-238 (Th-238).

Transuranic: pertaining to elements with [atomic numbers](#) higher than [uranium](#) (92). For example, [plutonium](#) (Pu) and [americium](#) (Am) are transuranics.

Tritium: (chemical symbol H-3) a [radioactive isotope](#) of the [element](#) hydrogen (chemical symbol H). *See also* [deuterium](#).

Unstable nucleus: a nucleus that contains an uneven number of [protons](#) and [neutrons](#) and seeks to reach equilibrium between them through [radioactive decay](#) (i.e., the nucleus of a radioactive atom). *See also* [stable nucleus](#).

UNSCEAR: United Nations Scientific Committee on the Effects of Atomic Radiation. *See also* <http://www.unscear.org/>.

Uranium (U): a naturally occurring radioactive [element](#) whose principal [isotopes](#) are uranium-238 (U-238) and uranium-235 (U-235). Natural uranium is a hard, silvery-white, shiny metallic ore that contains a minute amount of uranium-234 (U-234).

Uranium mill tailings: naturally radioactive residue from the processing of uranium ore. Although the milling process recovers about 95% of the uranium, the residues, or tailings, contain several [isotopes](#) of naturally occurring [radioactive material](#), including [uranium](#) (U), [thorium](#) (Th), [radium](#) (Ra), [polonium](#) (Po), and [radon](#) (Rn).

Whole body count: the measure and analysis of the [radiation](#) being emitted from a person's entire body, detected by a counter external to the body.

Whole body exposure: an exposure of the body to [radiation](#), in which the entire body, rather than an isolated part, is [irradiated](#) by an external source.

X-ray: electromagnetic [radiation](#) caused by deflection of [electrons](#) from their original paths, or inner orbital electrons that change their orbital levels around the atomic nucleus. X-rays, like [gamma rays](#) can travel long distances through air and most other materials. Like gamma rays, x-rays require more [shielding](#) to reduce their intensity than do [beta](#) or [alpha particles](#). X-rays and gamma rays differ primarily in their origin: x-rays originate in the electronic shell; gamma rays originate in the [nucleus](#).
See also [neutron](#).

Primer on Radiation Measurement

In the aftermath of a radiological emergency the public will see radiation and its potential hazards described in many different and sometimes confusing ways. This primer is intended to help journalists and community leaders understand these terms.

Activity or radioactivity is measured by the number of atoms disintegrating per unit time. A *becquerel* is 1 disintegration per second. A *curie* is 37 billion disintegrations per second, which is the number of disintegrations per second in 1 gram of pure radium. A disintegrating atom can emit a beta particle, an alpha particle, a gamma ray, or some combination of all these, so becquerels or curies alone do not provide enough information to assess the risk to a person from a radioactive source.

Disintegrating atoms emit different forms of radiation—alpha particles, beta particles, gamma rays, or x-rays. As radiation moves through the body, it dislodges electrons from atoms, disrupting molecules. Each time this happens, the radiation loses some energy until it escapes from the body or disappears. The energy deposited indicates the number of molecules disrupted. The energy the radiation deposits in tissue is called the *dose*, or more correctly, the *absorbed dose*. The units of measure for absorbed dose are the *gray* (1 joule per kilogram of tissue) or the *rad* (1/100 of a gray). The *cumulative dose* is the total absorbed dose or energy deposited by the body or a region of the body from repeated or prolonged exposures.

Alpha particles, beta particles, gamma rays, and x-rays affect tissue in different ways. Alpha particles disrupt more molecules in a shorter distance than gamma rays. A measure of the biologic risk of the energy deposited is the *dose equivalent*. The units of dose equivalent are *sieverts* or *rem*. Dose equivalent is calculated by multiplying the absorbed dose by a *quality factor*.

Sometimes a large number of people have been exposed to a source of ionizing radiation. To assess the potential health effects, scientists often multiply the exposure per person by the number of persons and call this the *collective dose*. Collective dose is expressed as “person-rem” or “person-sieverts.”

Abbreviations for Radiation Measurements

When the amounts of radiation being measured are less than 1, prefixes are attached to the unit of measure as a type of shorthand. This is called scientific notation and is used in many scientific fields. The table below shows the prefixes for radiation measurement and their associated numeric notations.

Prefix	Equal to	How Much Is That?	Abbreviation	Example
atto-	1×10^{-18}	.000000000000000001	A	aCi
femto-	1×10^{-15}	.000000000000001	F	fCi
pico-	1×10^{-12}	.000000000001	p	pCi
nano-	1×10^{-9}	.000000001	n	nCi
micro-	1×10^{-6}	.000001	μ	μ Ci
milli-	1×10^{-3}	.001	m	mCi
centi-	1×10^{-2}	.01	c	cSv

When the amount to be measured is 1,000 (i.e., 1×10^3) or higher, prefixes are attached to the unit of measure to shorten very large numbers (also scientific notation). The table below shows the prefixes used in radiation measurement and their associated numeric notations.

Prefix	Equal to	How Much Is That?	Abbreviation	Example
kilo-	1×10^3	1,000	k	kCi
mega-	1×10^6	100,000	M	MCi
giga-	1×10^9	100,000,000	G	GBq
tetra-	1×10^{12}	100,000,000,000	T	TBq
peta-	1×10^{15}	100,000,000,000,000	P	PBq
exa-	1×10^{18}	100,000,000,000,000,000	E	EBq

Health Effects of Radiation Exposure

Exposure to radiation can cause two kinds of health effects. *Deterministic effects* are observable health effects that occur soon after receipt of large doses. These may include hair loss, skin burns, nausea, or death. *Stochastic effects* are long-term effects, such as cancer. The radiation dose determines the severity of a deterministic effect and the probability of a stochastic effect.

The object of any radiation control program is to prevent any deterministic effects and minimize the risk for stochastic effects. When a person inhales or ingests a

radionuclide, the body will absorb different amounts of that radionuclide in different organs, so each organ will receive a different *organ dose*. Federal Guidance Report 11 (FGR-11) from the Environmental Protection Agency (EPA) lists *dose conversion factors* for all radionuclides. This report can be downloaded from <http://www.epa.gov/radiation/pubs.htm>. The dose conversion factor for each organ is the number of rem delivered to that organ by each curie or becquerel of intake of a specific radioisotope.

External, Internal, and Absorbed Doses

A person can receive an *external dose* by standing near a gamma or high-energy beta-emitting source. A person can receive an *internal dose* by ingesting or inhaling radioactive material. The external exposure stops when the person leaves the area of the source. The internal exposure continues until the radioactive material is flushed from the body by natural processes or decays.

A person who has ingested a radioactive material receives an internal dose to several different organs. The absorbed dose to each organ is different, and the sensitivity of each organ to radiation is different. FGR-11 assigns a different weighting factor to each organ. To determine a person's risk for cancer, multiply each organ's dose by its weighting factor, and add the results; the sum is the *effective dose equivalent* ("effective" because it is not really the dose to the whole body, but a sum of the relative risks to each organ; and "equivalent" because it is presented in rem or sieverts instead of rads or gray).

Committed and Total Effective Dose Equivalents

When a person inhales or ingests a radionuclide, that radionuclide is distributed to different organs and stays there for days, months, or years until it decays or is excreted. The radionuclide will deliver a radiation dose over a period of time. The dose that a person receives from the time the nuclide enters the body until it is gone is the *committed dose*. FGR-11 calculates doses over a 50-year period and presents the *committed dose equivalent* for each organ plus the *committed effective dose equivalent* (CEDE).

A person can receive both an internal dose and an external dose. The sum of the committed effective dose equivalent (CEDE) and the external dose is called the *total effective dose equivalent* (TEDE).

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FOCUSING PREPAREDNESS ACTIVITIES

Rapid response to nuclear or radiological terrorism is crucial. Without special preparation at the local and state levels, a large-scale attack involving radiation could overwhelm the local and perhaps national public health infrastructure. Large numbers of patients, including both the injured and those concerned about potential exposure would seek medical attention, with a corresponding need for medical supplies, diagnostic tests, hospital beds, and information and reassurance. In addition, the medical services delivery system might become quickly disabled if provider facilities, equipment and personnel become significantly contaminated. First responders, hospitals and the Emergency Medical System are generally responsible for ensuring that the contaminated, injured, and those concerned about potential exposure are medically treated in an efficient manner. The potential for alarm and major disruption of everyday life is enormous because of a widespread fear of such an unknown agent as radiation.

Preparedness for radiological terrorism is an essential component of the U.S. public health surveillance and response system, which is designed to protect the population against any unusual public health event. However, hospitals and public health agencies should prepare for the unique features of radiological terrorism, such as mass casualties with blast injuries combined with burns, radioactive contamination, and acute radiation syndrome.

KEY FOCUS AREAS

CDC's recommendations are based on the following six focus areas:

- Notification and Communication
- Triage
- Patient Management
- Healthcare Provider Protection and Resources
- Surveillance
- Community Planning

Notification and Communication

The key to a hospital's capacity to serve the critically ill is to recognize that a hospital is part of a community. It is important that hospitals work with their communities and in particular with local and state health and radiation protection departments on developing plans for notification and communication. The local hospital is an integral part of the community-wide system for emergency response and any existing community emergency response plans are a good place to begin. In this regard, hospitals should:

- Understand community plans and resources and specifically:
 - Determine if there is an existing state or community plan. Consider how the hospital fits into this existing plan. Note that states with nuclear power plants have well-defined plans and an established hierarchy for notification and plan activation.
 - If there is no existing community plan, participate in the development of one. Include the state radiation protection or radiation control program (this program is usually housed within a state's public health, environmental control, or professional licensing agency) in the development of any community plans.

- Utilize the resources available from FEMA as a means of locating both planning information and state emergency management agencies (www.fema.gov). Also take into consideration the many other organizations and entities that deal with emergency-related services during disasters, such as the National Disaster Medical System (www.oep-ndms.dhhs.gov/), the American Burn Association (www.ameriburn.org), Emergency Nurses Association, American College of Emergency Physicians, Society for Emergency Physician Assistants, and American Psychological Association's Disaster Response Network.
- Use the community's Poison Control Centers as a resource (to find your local Poison Control Center see: www.aapcc.org/findyour.htm).
- Know that the radiological community has many recognized experts who can assist in response to plan activation. A good resource for expertise in radiation dose estimation would be a hospital medical physicist or health physicist. One might also find expertise in this area at the following internet sites: www.crcpd.org/contact.asp and www.hps1.org/ahp/members/members.htm
- Determine whether the hospital needs an Incident Command Center (ICC). One useful ICC model is the Hospital Emergency Incident Command Structure (HEICS) system used in California (www.emsa.ca.gov).
- Assign and prepare staff in advance by:
 - o Ensuring that roles and responsibilities are clearly defined.
 - o Assigning a staff person, who is available all hours, responsible for making the proper notifications (externally and internally) regarding the hospital's

response to the incident and ensuring they have an accurate and updated list of experts that the staff can contact for guidance.

- o Having back-ups for key officers, in case they are not available.
- Use existing resources to:
 - o Regularly revise and update existing plans for radiological incidents.
 - o Ensure that hospital personnel are familiar with the community's ICC and, specifically, who is responsible for what and how it will be established.
- Activate a plan that:
 - o Uses a confirmed incident, suspicious incident, or expected incident as a trigger for the plan.
 - o Is cautious about triggering emergency response. There may be graded responses, not just an all or none response. Putting unneeded "All Hazards" contingencies in place may result in slowing down delivery of everyday patient care. The HEICS system (referred to above) is designed for modular activation.
 - o Considers adopting the concept of modular activation, so that parts of the disaster plan may be activated without activating the entire plan and causing major disruption, especially early on when it may be unclear how much of a disaster exists.
 - o Establishes a strong link with the ICC during the disaster to determine exactly what is taking place. Know who is in charge of your community's ICC ahead of time.

Hospital Communications

- Phone and cellular circuits are frequently overloaded in disasters, possibly rendering them useless. Therefore, 2-way radios and satellite phones should be available as backup communication methods for key hospital personnel.
- A communications plan should be developed in advance for disaster and emergency situations (such as a radiological terrorist event) that outlines the audiences, procedures, and key messages. The plan should be exercised similar to the overall hospital response plan. CDC has a CD-Rom available that outlines the steps for developing a communications plan, called CDCynergy ERC. You can contact Judith Courtney at jcourtney@cdc.gov for a copy of the disc. Training information is also available at <http://www.cdc.gov/cdcynergy/emergency/>.
- External stakeholders are the key audiences for communications. These include:
 - First Responders, EMS, Fire, and Police who are vital to protecting the hospital's resources and are priority stakeholders.
 - Media who can play a key role in providing accurate information and therefore possibly reducing the number of concerned individuals who come to the hospital.
 - Victims and potential victims
 - Family members
 - Community members
 - Local medical facilities
 - Health departments
 - Local elected officials
 - Local hospital and disaster volunteers

- Ensure that all messages are consistent, immediate, accurate, and open. Key message topics include:
 - If you think you are exposed ...
 - If you are injured ...
 - Likely effects of radiation contamination include...
 - To avoid contamination ...
 - Available resources, experts/contacts for medical information include...
- Develop a media relations plan that:
 - Builds relationships with reporters to ensure accurate and timely reporting.
Hospitals should invite the media to participate in pre-planning activities and drills. This is a two-way learning opportunity: media learns about strategic factors in a disaster and medical personnel learn how to work with the media.
 - Includes media in the community planning process so they understand the hospital's contingency plans.
 - Designates a spokesperson and spokes-hospital if multiple hospitals are involved in the incident response. Any spokesperson should have prior training in media relations.
 - Focuses on what the hospital is doing rather than the disaster. Questions not related to the hospital's response should be referred to state or local emergency management agencies. Hospital personnel should not contribute to the misinformation by discussing topics outside their areas of expertise.
 - Designates who is coordinating and integrating information going out to the public.

- Informs the media of local and national experts and contacts.
- Ensures back-up communication equipment and power sources.

- Develop prepared information packets in advance. Remember that unique messages are called for in an incident involving radiation.
- Practice rumor control by monitoring the local media reports and addressing and correcting “misinformation” immediately. Rumors will arise to fill gaps in information, so if the hospital does not speak about an issue, someone else will.
- Be certain that the hospital is linked to the community’s emergency alert system (stations are required to have equipment to broadcast emergency alerts). The emergency alert system has fallen into disuse, but it is available for this type of communication. Hospitals can contact their county’s emergency management agency director to develop a Reverse 911 ® program that allows the 911 center to categorize a geographic area and broadcast a specific recorded message to that area.
- Develop a press plan since it is an essential component of any community disaster plan. Credibility is key to effective crisis communication. Spokespersons should remain calm, be empathetic and avoid discussing issues outside their areas of expertise.

Triage

Triage is the sorting and allocation of treatment to patients, especially disaster victims, according to a system of priorities designed to maximize the number of survivors. The diagnosis and mitigation of illness and injury caused by radiological terrorism is a complex triage process that involves numerous partners and activities. Meeting this challenge will require special emergency preparedness in all communities throughout the U.S.

Planning for Triage

- In most mass casualty incidents:
 - A large majority of people will self-triage and go directly to the closest and most familiar hospitals; they will probably bypass field triage and treatment whether contaminated or not (1). Therefore, hospitals often have little, if any, advance notification of incoming patients.
 - Most of the individuals who come to the hospital are ambulatory, minimally injured, or those who are concerned about potential contamination.
 - The general community medical needs to continue despite the occurrence of a disaster.
- Hospitals should have plans in place to transfer patients (if conditions allow) to other hospitals or other medical facilities during disasters according to pre-arranged formal agreements. Hospitals are protected from having to transfer unstable patients under the provisions of the Emergency Medical Treatment and Active Labor Act (EMTALA) (2).

- Every individual involved in the response to a mass casualty incident, especially the Fire and Police, should be familiar with the triage process and how to determine who should be sent to the hospital.
- The triage plan should include a process for establishment of an assessment center, separate from the emergency department. The assessment center can be used to rapidly screen victims for injury and contamination, as well as to serve as a location removed from the emergency department where decontamination of victims can take place. The assessment center should also be used for observation, limited treatment and evaluation and reuniting with family members where possible.
- Consideration should be given to setting up a temporary *primary* assessment center that would be located on the hospital campus, removed from the Emergency Department, or depending upon logistics and the magnitude of the event, a temporary *secondary* assessment center that would be located within the community but removed from the hospital. If practical, any outside assessment center should be set-up upwind from the patient arrival area (3).
- Hospitals must ensure that the triage process has an efficient record-keeping process to be sure injured persons are not missed. The Armed Forces Radiobiological Research Institute (AFRRI) and the Radiation Emergency Assistance Center/Training Site (REAC/TS) have developed and tested a record-keeping process and a system of tagging for triage, AFRRI's Biodosimetry Assessment Tool software application (4).
- Hospitals need to take into consideration that corpses from a radiological event may be contaminated with radioactive material. Guidance on handling contaminated corpses is provided by the National Council of Radiation Protection and Measurements

(NCRP Report No. 37, “Precautions in the Management of Patients Who Have Received Therapeutic Amounts of Radionuclides,” 1970, NCRP, Washington, D.C.) and by the National Health and Medical Research Council of Australia (1986;AGPS Press, Australian Government Publishing Service, G.P.O., box 84, Canberra, A.C.T. 2601).

The Triage Process

- The hospital triage plan should be based on and coordinated with the community plan. It should focus on training and exercises.
- Triage will be conducted at the scene and at the hospital, but communities and responders should attempt to do as much as possible at the scene.
- After a mass casualty or Hazardous Materials (HazMat) incident, hospitals should “lock down,” providing only two entrances:
 - A site for triage and patients
 - A site for personnel, staff, press, officials, etc.
 - It will require community support and local law enforcement to assist in the lock down because the hospital is an important disaster response asset.
 - Casualty distribution to participating health care facilities should be based on and coordinated with the community plan.
 - Hospital space must be reserved for the most critically injured or ill.
- The assessment center should be used for observation, decontamination, limited treatment and evaluation and reuniting with family members where possible.

- Under the triage process for patients with **life-threatening** conditions, emergency department staff should stabilize and treat physical symptoms according to standard procedures. The threat of contamination should not preclude patient treatment.
- Under the triage process for patients with **non-life threatening** conditions:
 - When possible, trained staff should survey all patients for radioactive contamination (See Appendix C for information on radiation survey instrumentation).
 - o If contamination is detected or suspected, remove the patient's clothing, give the patient a shower, then treat physical symptoms according to standard procedures.
 - o Localized contamination can be rinsed off with pre-moistened wipes or washed with soap and water as opposed to showering the individual.
 - o If radiation is still detected after washing, admit the patient if medically warranted and arrange for further evaluation and decontamination.

Key Principles of Contamination Containment

- Hospitals should use contamination containment processes with which the staff are familiar and should apply universal precautions and isolation techniques. Staff should use universal precautions when making direct contact with contaminated patients.
- Staff should double bag, tie, seal, and label any contaminated material in plastic bags to be stored in a predetermined, secure storage area (labeling should include appropriate identifying information, e.g., patient name, hospital number, date, and

time of day). The bagged items should be removed from the patient treatment area as soon as possible to eliminate any further contamination.

- In a mass casualty emergency, staff should dispose of the water used to decontaminate patients via the sewer system. (It is unlikely hospitals will have an effective water-holding system for any mass casualty event.) The EPA has issued guidance to the effect that: “Contaminated runoff should be avoided whenever possible, but should not impede necessary and appropriate actions to protect human life and health. Once the victims are removed and safe from further harm and the site is secured and stable, the first responders should be doing everything reasonable to prevent further migration of contamination into the environment.” (EPA 550-F-00-009, July 2000; www.epa.gov/ceppo)
- Hospitals should prepare personnel to rapidly identify and notify pre-identified resources who can provide assistance.
- Hospitals should use appropriately trained staff with properly maintained and tested radiation survey meters to determine contamination.
- Hospitals should consider purchasing personal dosimeters for rapid response teams or others who might be subject to contact with contaminated patients or materials. Personal dosimeter data for hospital staff provide exposure documentation after the fact.
- Hospital staff should remember that it may take time before a disaster is recognized as a *radiological* incident and assume contamination is present; however, the first time

radioactive contamination is clearly identified, all staff and first responders must be notified as soon as possible.

Key Principles of Control

- Hospitals should designate a central point where patients are funneled into the hospital (ensure that it is within walking distance from the hospital).
- Hospitals should clearly identify demarcation points (use control points, pylons, or tape) where people will be monitored when coming in and going out of the hospital. The hospital should provide survey monitors at both points. This also includes the restricting staff movement.
 - Designate separate “clean” vs. “contaminated” areas in the hospital.
 - Segregate contaminated and non-contaminated patients and arrange a location where contaminated patients can be observed with limited staff contact.
- Hospitals should plan to contact local law enforcement and to augment hospital security staff to control facility ingress and egress (including the parking lot).
 - These security staff must control entrance of vehicles also.
 - They will also work with EMS to determine how to address contaminated EMS vehicles.

Patient Management

The management of patients following suspected or confirmed radiological events involving mass casualties must be well organized and rehearsed. Patient management

includes determining the signs and symptoms of acute radiation exposure, determining the extent the patient may be contaminated, providing for decontamination when necessary, treating specific injuries, collecting specimens for laboratory testing, providing care for special populations (e.g., pregnant women), providing discharge information, follow-up care, and post-mortem procedures, and addressing the psychological effects of patients and their mental health concerns. The psychological trauma in a radiological incident may be as varied in severity and type as physical trauma and will require special skills and training to adequately meet the needs of those affected.

How do you know if someone is contaminated?

- Radiological contamination cannot be detected without specialized equipment (See Appendix C for information on radiation survey instrumentation).
- When conducting a radiation survey of the patient, the technician should initially conduct a scan of the face, hands, and feet using a standard radiation survey instrument. If the meter results are positive, then the technician should conduct a thorough survey (5-8 minutes per person). The speed of the survey should not exceed 2 inches per second, and the distance between the probe and the patient should be approximately 1 inch. Staff should consider covering the survey probe in plastic to prevent contamination of the instrument. (See also the REAC/TS Website for additional information on patient scanning. www.orau.gov/reacts/intro.htm)
- Ensure that data recorded from radiation detection instrumentation is understandable to clinical practitioners.

- The provider should arrange for bioassays if internal contamination is suspected (5)
Body fluids used for laboratory analysis include blood, urine, feces, nasal and saliva swabs, sputum, vomitus, and wound secretions.

Decontamination

- Radiation decontamination should not interfere with medical care of patients with life-threatening injuries or illness.
- If possible, staff should screen and survey for levels of contamination before moving a patient into the facility; this will minimize staff and equipment exposure. As a control, staff should attempt a background reading of the facility before surveying the patient.
- Only properly trained personnel should use radiation survey equipment. (Web Site links to many basic radiation training courses can be found at www.umt.edu/research/eh/radiationsafety.htm)
 - Most things needed for decontamination are already available in a hospital – the only additional recommended equipment is radiation survey equipment to measure beta and gamma rays. Radiation survey equipment to detect contamination includes a Geiger counter to detect beta and gamma radiation. Although not specifically designed to quantify alpha radiation, pancake probes that are available for Geiger counters will detect the presence of most alpha radiation sources, as well as beta and gamma radiation. (See Appendix C) Many hospitals have at least one survey instrument in-house. Make certain that trained personnel are always on duty and know how to use survey instruments properly.

- Hospitals should ensure that personnel have proper personal protection equipment. Universal precautions as practiced with any other mass casualty incidents (trauma, chemical, biological, etc.) is generally sufficient for protection from radioactive contamination.
 - Under Standard Precautions, surgical masks are used to reduce the possibility of blood splashes to the mouth and nose and hand-oral contamination (reference: Gusev, et. al, p. 432). Surgical masks do not protect against inhaling all respiratory hazards. A higher level of protection is provided by fitted particulate respirators such as N95 or higher. These respirators should be available in hospitals because they already are recommended for health care worker protection against SARS, tuberculosis, and certain other infectious diseases. However, these respirators must be used in an OSHA-compliant respiratory protection program that includes medical clearance, training, and fit testing. Experience in human decontamination indicates that careful procedures for removing clothing and decontaminating patients prevents aerosolization of radioactive particles, and dosimetry of health care workers using surgical masks has not found evidence of contamination (Reference: personal communication, Dr. Robert Ricks, Department of Energy REAC/TS, Oak Ridge TN, July 17, 2003). This suggests that if N95 respirators are not available, surgical masks should provide adequate protection if other precautions are observed.
- Responders should attempt as much decontamination as possible either at the designated assessment center or outside the hospital. Minimize the amount of

contamination that actually enters the emergency department or the hospital.

Decontamination areas should be separated from the hospital.

- Removing the clothing from the patient should remove 70 to 90% of the contamination (6). Staff or responders should bag and tag clothing, dressings, etc., for future evaluation and potential use as criminal evidence and small personal belongings (jewelry, wallet, etc.) should be surveyed for contamination. If the personal belongings are not contaminated they can be returned to the patient. Otherwise, steps must be taken to decontaminate the items before giving them back to the patient. If the patient is medically able to remove his/her own clothing and wash, then the patient should do so; however, providers should maintain communication during the process.
- Staff should address privacy concerns of patients who are undressing. Disposable dressing gowns should be provided for patients concerned about modesty and to ensure that the environment is appropriate to remove clothing (e.g., not too cold).
- The patient should be washed with water and soap, taking care not to abrade or irritate the skin. Water is the most important ally in this setting. Ambulatory patients can be washed easily; however, non-ambulatory patients must be on gurneys that can be washed.
- Staff trained in using survey instrumentation should resurvey the patient after washing and rewash until no further reduction in contamination is achieved or a set threshold is attained, generally considered less than two or three times background. Providers should isolate and cover any area of the skin that is still positive after washing with a plastic bag or wrap.

- Care should be taken with the washing procedure, ensuring that radioactive materials are not incorporated into a wound.
- If a patient has both wounds and very high, localized levels of internal contamination, this may indicate that the patient has a radioactive fragment or fragments internally. The physician, in consultation with the hospital radiation safety officer if possible, should consider surgically removing the fragment(s) using forceps to avoid potential local radiation injury to the hands of the provider.
- To ensure best use of the health care providers' time and resources, hospitals should consider having other personnel perform the decontamination process. But the "other personnel" should be appropriately trained to prevent injury to the patient and to minimize the possibility of contaminating themselves during decontamination of the patient.
- Hospitals should decontaminate the facility and staff who had contact with contaminated patients to prevent the spread of contamination. Staff should consult their radiation safety officer for step-by-step procedures. (Also refer to Gusev, et al. Medical Mgt. Of Rad Accidents).
- If the patient does not show any signs of contamination or meet hospital admittance criteria, providers should recommend that the patient take a thorough shower as soon as possible.

Patient Treatment

- Staff must not allow the threat of contamination to impede the delivery of medical assistance. The right thing to do in almost every occasion when an individual who is contaminated and has a life-threatening condition is to admit him/her to the Emergency department for immediate care.
- It is crucial to educate staff on the realities and history of a patient's contamination to provide appropriate patient treatment. Staff who work in an emergency department are exposed to certain risks, including ordinary hospital radiation sources.
- Initially, hospitals should obtain as much patient and situation history as possible, noting circumstances surrounding the patient and the situation that might indicate exposure. This also includes looking for corroborating evidence. AFRRRI has developed a software program in conjunction with Radiation Emergency Assistance Center/Training Site (REAC/TS) that can be effectively used to record information. This software can also be used for dose assessment and treatment management. It can be found at: www.afri.usuhs.mil/www/outreach/batpage.htm
- Emergency department staff can measure complete blood counts (CBCs) with differential initially to serve as a baseline measurement. CBCs taken over the next several days can then be compared to the baseline measurements and used to assess the radiation dose received. These data are of key importance in evaluating patients for acute radiation syndrome. (also see Appendix B)
- When internal contamination is suspected, body excreta may contain radioactive substances. Collection of urine and feces should be considered on those patients.

Also, swabs from body orifices should be taken for survey or analysis for radionuclides. Although state and federal assistance may be made available for receiving and analyzing these samples, hospitals should identify during their emergency planning what agencies or laboratories the samples should go to for analysis.

- In the first 48 hours, the basic premise is that physicians should conduct standard patient assessment, take care of immediately life-threatening problems, and take care of all other problems that require immediate attention. Emergency department staff should:
 - Treat symptoms according to ordinary patient treatment practices and procedures.
 - Take care of wounds by irrigating, debriding, and covering to the best extent possible.
 - Look for the symptoms of acute radiation syndrome (See Appendix B). Have a trained technician perform a radiation survey if symptoms, patient history, and situation history indicate the possibility of contamination.
- Suggested supplies and medications to keep on hand and have easily accessible in large quantities include IVs, fluid support, anti-diarrhea, anti-emetic medications, and potassium iodide tablets.
- Hospitals should consider keeping a supply of potassium iodide to help reduce the risk of thyroid cancer from radioactive iodine exposure. Such exposures may arise from a nuclear power plant incident or in radioactive fallout from a terrorism event involving the detonation of a nuclear device.

- Hospitals should adhere to FDA recommendations (*Guidance: Potassium Iodide as a Thyroid Blocking Agent in Radiation Emergencies*, U. S. Department of Health and Human Services, Food and Drug Administration, Center for Drug Evaluation and Research, December, 2001) for administration of Potassium Iodide, which is summarized in Table 1.

Table 1 FDA Recommendations for the Administration of Potassium Iodide (KI)

Threshold Thyroid Radioactive Exposures and Recommended Doses of KI for Different Risk Groups				
	Predicted Radiation Dose to Thyroid (cGy or rad)	KI dose (mg)	# of 130 mg tablets	# of 65 mg tablets
Adults over 40 years	≥ 500	130	1	2
Adults over 18 through 40 years	≥ 10			
Pregnant or lactating women	≥ 5	65	1/2	1
Adolescents over 12 through 18 years*				
Children over 3 through 12 years				
Over 1 month through 3 years				
Birth through 1 month				
		32	1/4	1/2
		16	1/8	1/4

* Adolescents approaching adult size (≥ 70 kg) should receive the full adult dose (130 mg).

- Potassium iodide supplementation is not as effective for those individuals over 40 years of age and therefore it is generally recommended that these individuals only receive supplementation if it is estimated that their exposure is significant enough to potentially destroy the thyroid leading to hypothyroidism (7). FDA guidance on the administration of potassium iodide (KI) based on age, predicted thyroid exposure, pregnancy and lactation status is below. Potassium iodide should be taken immediately though it may still have a significant impact if taken even 3-4 hours after exposure (8). It should be available to those in a radioactive fallout area. The Nuclear Regulatory Commission requires that states with a population within the 10-mile emergency planning zone of commercial nuclear power plants consider including potassium iodide as a protective measure for the general public to supplement sheltering and evacuation in the unlikely event of a severe nuclear power plant accident.
- Hospital staff should also note that FDA Guidance recommends “that persons with known iodine sensitivity should avoid potassium iodide, as should individuals with dermatitis herpetiformis and hypocomplementemic vasculitis, extremely rare conditions associated with an increased risk of iodine hypersensitivity.” Individuals with multinodular goiter, Graves' disease, and autoimmune thyroiditis should be treated with caution -- especially if dosing extends beyond a few days. Unless other protective measures are not available, it is not recommended to provide repeat dosing in pregnant females and neonates because of the potential for potassium iodide to suppress thyroid function in the fetus and neonate (9).

- Hospital staff should avoid giving the perception to patients and the community that potassium iodide prevents adverse health effects from radiation exposure in general. However, staff should understand that offering potassium iodide may help address some patient psychological concerns.

Care of Special Populations

- Special populations include pregnant women, immunocompromised patients, equipment-dependent patients (especially those requiring ventilators), disabled persons requiring wheelchairs or other mechanisms of assistance, nursing home and jail residents, people with various physical challenges, the mentally ill, children, elderly, and persons with cultural and language barriers.
- In general, special populations should not be treated differently from other populations. One exception would be pregnant women and small children:
 - There are no special pharmaceutical treatments for a pregnant woman, but they will require considerable reassurance and communication.
 - If radioactive iodine exposure has occurred, consider giving children potassium iodide tablets according to FDA guidance (8)
www.fda.gov/cder/guidance/4825fnl.htm)

Patient Discharge and Follow-up

- Patient discharge sheets should include basic information about radiation exposure and accurate information about the long-term health effects of radiation exposure. Hospitals can customize and relate these possible effects to the specific situation.

If the incident is thought to be of criminal intent, the discharge staff should explain the need for reporting to and cooperation with law enforcement.

- Along with discharge sheets hospitals should provide Q&A sheets and fact sheets. Fact sheets should include expert contacts and phone numbers and reliable sources of information.
- There is the risk of information overload to the patient. Printed materials should be brief and easy to understand (e.g. reading level of Flesch-Kincaid 6.0 or lower).
- Hospitals should avoid generic discussions about radiation, which could promote unwarranted concern. The more that information is customized to an individual's circumstances, the more helpful it will be.

Laboratory Issues

- In the management of mass casualties, basic precepts of medicine should take hold with regard to testing: minimize the amount of testing, only doing those tests that can affect the immediate care of the patient.
- In a mass casualty incident, hundreds to thousands of patients may attempt to come to a hospital, putting the hospital in the position where it cannot practically take a blood count on every patient. Anyone who has or might exhibit prodromal effects (see Appendix B) would need to be considered for a CBC with differential to test for acute radiation syndrome. If practicable, this should be repeated every 6 hours for about 72 hours.
- Other laboratory tests to consider if warranted include cytogenetic analysis, i.e., collecting blood for dosimetry. All samples must be placed in separate, labeled

containers that specify patient name, date, and time of sampling. Hospitals should consider in the planning process how to manage the shipping and transportation of samples to qualified laboratories.

- Preparation steps that hospitals can take to address laboratory capacity include:
 - Ensuring that mutual aid agreements with area laboratories are in place.
 - Determine if it is possible to transfer non-critical patients to other local facilities.
 - Keep a stockpile of CBC tubes (use purple top tubes¹ for CBCs).
- Hospitals should keep in mind that while they are treating the casualties, other local, state, and federal organizations are dealing with the scene. Hospitals need to know how to connect with these responding organizations to get needed information, such as radionuclide data and radiation dose assessment.
- A lesson learned from past incidents is that healthcare providers should have heightened awareness of significant political pressure to use the most accurate tests available and avoid reliance on random testing of individuals.

Patient Mental Health Concerns

- A mass casualty event involving radiation has the potential to yield a large number of psychological casualties (10).

¹ Tubes for blood collection and testing are standardized by the color of the rubber stopper placed in each. The different stopper colors refer to the additives placed in each tube (these additives are necessary to preserve the appropriate blood product for different blood tests). A purple tube top contains (K3) EDTA as a preservative for whole blood.

- The majority of these will not have severe psychiatric conditions that result from the incident. The initial reaction of many is one of shock, immobilization and fear. Most people will exhibit higher levels of anxiety rather than psychotic behavior; some will also experience Post Traumatic Stress Disorder (PTSD). Concern and anxiety are natural reactions to the uncertainty associated with a radiological incident (10). Also, many people will come to the hospital for fear of loss of access to mental health medications.
- It is probable that family members will attempt to gather information about other family members who are experiencing heightened anxiety and have sought medical attention. Hospitals should dedicate space in the facility and a phone number (if possible) to keep family members informed.
- Long-term psychological effects, which could arise from 48 to 72 hours after the incident and from then on for several months, include anxiety disorders, PTSD, depression, traumatic neurosis, insomnia, and acute stress disorder (10).
- It is very important to distinguish between those concerned about potential exposure and people who have a non-incident-based psychological dysfunction.
- Since the situation is frightening to most people, hospitals should be proactive in reassurance and communication to reduce psychological issues. Hospitals should:
 - Dispense timely and accurate information, including an accurate description of the incident and its location to the public. This will allow them to take appropriate actions before they come to the hospital.
 - Counsel patients on both acute and potential long-term physical and psychological effects. Include this information in patient discharge sheets.

- Hospitals also should ensure that trained counselors are on site, and screen persons who may be at higher risk for PTSD (i.e., people who have been previously traumatized or have been in other disasters). These individuals will require follow-up.
 - Dedicate a lead person responsible for the counselors.
 - Provide radiological education/training for the staff performing the psychological evaluations and counseling. Staff who cannot function in times of high stress should not be assigned to these duties.

Healthcare Provider Protection

While patient care is a top hospital priority, it is vital that hospital personnel are protected from injury and disease while doing their job. During a mass casualty radiological event it is likely that hospital personnel will be concerned about radiation contamination. To alleviate their concern, hospital personnel should be educated about the potential health effects resulting from radiation exposure, learn what personal protective equipment they will need for precautionary measures and be trained so they can respond effectively to a radiological incident. In addition, hospitals must prepare for potential psychological effects resulting from such a stressful event.

Employee Protection (Physical)

- Initially obtaining as much information as possible is proactive protection. Obtain as much patient and site information as feasible from first responders.

- The first step in protecting employees is to establish an assessment center removed from the emergency department to rapidly screen victims for injury and contamination and to provide for decontamination. Radiation control zones, where potential radioactive contamination exists, should be established within the hospital and the administration should ensure that there is someone in charge of access to/from the control zones, and that they have a law enforcement representative present.
- Suggested personnel protection equipment that also facilitates the ease of clean-up includes:
 - Universal precautions clothing (facemask, goggles, gowns, double-gloves with inner one taped and outer glove removed after each contact).
 - Plastic wrap (e.g., disposable trash bags, Saran Wrap™, ZipLoc™ bags, etc.) to cover and protect instruments and equipment.
 - Disposable shoe coverings.
 - Butcher paper or equivalent on floor.
 - If possible, personal dosimeters (see Appendix C) for staff members who might have frequent contact with contaminated patients.
- Hospitals should purchase and maintain radiation survey meters for detection procedures.
 - Each hospital should have at least three actively working and maintained radiation survey meters, one each at points of egress and ingress and the third in circulation.
 - Large hospitals might consider a portal monitor for 24/7 monitoring and protection. (See Appendix C)

- Hospitals should ensure that designated personnel are properly trained on the use of the survey meters, and that the meters are maintained and calibrated according to the manufacturer.
- Protective clothing does not always reduce risk of exposure since penetrating beta and gamma radiation may go through it. However, it prevents personal contamination of radioactive substances and limits the spread of contamination.
- Hospitals should take extra precautions to protect special populations, especially pregnant employees.
- Hospitals should provide employees with immediate and accurate communication, such as public announcements, media packets, information packets for the Emergency department waiting area, and web site updates.
- Hospitals should consider providing copies of the North American Emergency Response Guide for staff (www.envectra.com/env/erg/erg.htm).
- Issues to consider in funding or obtaining needed equipment include:
 - Considering a billable patient surcharge for disaster preparedness. Federal or state government grants may be available for PPE and radiation detection devices.
 - Considering other resources in the community that also have survey meters and equipment.
- Employees are best protected when hospitals activate the radiological component of their emergency response plan when there is any probability of a radiological mass casualty event.

- Employees should remember, in the event of a radiological emergency, apply time, distance, and shielding principles (i.e., limit time spent near contamination; keep as much distance from the contaminated area as practicable; and shield with any available material).

Training of Hospital Staff

- Every employee at the hospital needs simple, competency-based training that is preferably conducted on-site and includes:
 - The basic principles of radiation protection and the realities of treating contaminated patients.
 - A clear definition of the roles and responsibilities of all staff members involved in a response to a mass casualty incident.
 - Hospitals should incorporate this training into employee orientation and differentiate radiation training from other HazMat trainings.
 - Basic radiation training for staff will help to reduce stress and increase quality of care in a radiological mass casualty incident.
- Specific skill-based training includes:
 - Radiation survey meter use and interpretation for those who will test individuals for contamination.
 - Decontamination training for those who will most likely decontaminate patients.
 - Setting up control zones and a global perspective for head nurses in the Emergency Department.

- How to plan for a radiological emergency for members of the disaster planning committee.
- Equipment decontamination for janitorial staff.
- Hospitals can emphasize continuing medical education credits (CMEs) to encourage physicians to participate in training, especially training on patient treatment for the first 48 hours after a radiological mass casualty incident.
- Ensure that hospital staff who will most likely respond to a radiological incident or those at highest risk for radiation exposure receive the most training.
- Since the hospital will not be able to train the entire staff in all scenarios, it should create easy access to radiological experts, beginning with the hospital radiation safety officer, but including medical physicists, health physicists, and radiation protection technologists.
- Training should extend beyond hospital staff; the hospital's training plan and Emergency Response Plan should be coordinated with the first responders, the American Red Cross and civil authorities. Because of the constant interaction of hospital and non-hospital staff during any disaster, it should conduct joint interactive training if at all possible.

Practitioner Mental Health Concerns

- There is a basic assumption that health care providers operating outside of their areas of expertise will share many of the same concerns as the public and probably some of the same mental health effects.
- The most likely psychological consequences for medical staff as a result of treating patients in a mass casualty incident are:
 - Fear, primarily because many people know a little about the effects of radiation and assume that radiation is more dangerous than it actually might be. There is also the lingering concern about unknown long-term side effects, such as the increased risk of cancer.
 - Suspicion of being contaminated by radiation and carrying that radiation home to one's family. This preoccupation may distract health care providers from their work.
 - The decisions made regarding who to save and who not to save. Providers are likely to have a real sense of guilt when they cannot treat everyone and are not able to do as much as possible for each patient. This concern could result in anger, feelings of helplessness, depression (potentially long-term), and sleep disturbances. All of these will be aggravated by fatigue and exhaustion from response demands.
 - Apprehensions, when the state or federal government personnel arrive, that their decisions will be second-guessed. This could lead to guilt and anxiety.
- Possible physical signs that staff may be experiencing psychological effects include vomiting, diarrhea, nausea, and headaches (10). Coincidentally, these physical signs are also associated with acute radiation exposure.

- Psychological effects are most likely to occur among staff who have the greatest amount of contact with the deceased and/or dying, and those dealing with children or pregnant women. These effects are more likely to occur with staff who are severely fatigued by being on duty for a long period of time.
- Prevention is the best treatment and, because prevention and treatment for provider mental health concerns are so intertwined, it is important to educate health care providers now to provide the best care for all when it is needed.
 - The first lesson in treatment is to have a critical incident stress management team that includes credentialed mental health providers in place at each facility before a critical incident.
 - Hospitals should have mental health providers who can dedicate time to staff support.
 - Hospitals should screen for those who are at higher risk of psychological complications.
 - Provider education and training are key components. Do not assume that practitioners know more about radiation than the general public.
 - Staff will be concerned about their own families, so hospitals should establish a communication liaison for them.
 - Provide for rotation of staff to reduce fatigue.
- Hospitals should conduct tiered levels of debriefing after a mass casualty event to gather data and to address mental health concerns. The debriefing groups should not be cross-discipline (physicians with nurses, etc.). This allows participants to express concerns more freely.

Surveillance

Surveillance is the ongoing systematic collection, analysis and interpretation of health outcome data for use in the planning, implementation and evaluation of public health practice (11). There are many purposes for surveillance including: to establish a registry for follow up and epidemiological investigations as well as to use as a resource for short-term disaster medical intervention. It is especially critical the first 48 hours as information gathered then is used to determine action and treatment. In addition, surveillance is needed to treat and track patients and to learn from the incident.

- Patient care comes first, so hospital personnel should focus on decision-making data, especially for patient treatment. Records should be user-friendly to practitioners.
- Key data for collection includes patient demographics, patient location at the time of the incident, and contact information for later follow-up.
 - Consider including the patient's description of what happened, details about the conditions at the location at the time of exposure, and the patient's chief complaints.
 - Record therapeutic data, including treatment, body location of radioactive contamination and isotope identification if known.
- It would be valuable to gather data for an hour-by-hour summary of some basic information that includes a count of people affected by the immediate incident (the number could grow markedly over time) and key patient complaints.

- Encourage staff to use current technology/electronic storage to implement and integrate surveillance information.
- Radiation exposure may have long-term consequences; therefore, there is an additional long-term issue of registry tracking. Although this should not be an immediate concern of the hospital, the hospital can readily define the population up front for future tracking and epidemiological studies.

The Health Insurance Portability and Accountability Act (HIPAA) rules limit access to this information; therefore it is not clear now how this will play out in an incident involving mass casualties. Some states have flexibility for creating a list of reportable conditions to track and report. HIPAA allows (but does not require) health care providers to supply this information to appropriate authorities without patient authorization for law enforcement and public health activities (45 CFR164.512 (a) (1) and (2). Additionally, some states require reporting of suspected terrorism incidents. Hospitals should check with their state on these issues.

Community Planning

Although providing the highest quality health care and patient treatment is the hospital's primary goal, hospitals should work with community emergency planners to determine its role in the community's response to mass casualty incidents. It is important that hospitals work with their communities and in particular with local and state health and radiation protection departments on community planning. However, the hospital may have to take the lead in creating a community plan for responding to such events. An important benefit of the overall planning process, however, is developing new partnerships and

reaffirming long-standing ones. In time of crisis, these established relationships usually prove invaluable.

- A hospital's responsibility in community planning and in responding to a mass casualty incident includes:
 - First and foremost, receiving and treating patients: To be successful, a hospital needs to develop strategies to treat a large number of patients during a mass casualty incident, including having easy access to medications. (Hospitals should consider entering into formal agreements with local hospitals and pharmacies as part of emergency planning and preparation.)
 - Convening community partners if the health department has not already assumed this role.
 - Establishing adequate and redundant two-way communication with staff and partners; two-way radios can be used for this purpose.
 - Knowing how to avoid becoming a second-hand casualty (provide emergency power, etc).
 - Planning for a move if the hospital becomes dangerously contaminated.
 - Coordinating human resources including staff members, individual and organizational volunteers, and Good Samaritan health care professionals. The hospital should have liability and malpractice coverage that automatically covers this additional help. Furthermore, hospitals should address an emergency credentialing policy in advance (reference: May 2002 issue of the *National Association of Medical Staff Services*; Hospital Accreditation Standards, Joint Commission on Accreditation of Healthcare Organizations, 2002).

- Controlling access to the facility.
- Instituting a process to accurately record costs/expenses related to any mass casualty incident for future reference.
- Helpful steps in developing an evidence-based Community Plan include:
 - Checking to see if a Community Plan already exists. If so, it should be revised if it does not include radiological incident-specific information.
 - Exploring evidence-based research and literature on radiation emergency response to stay abreast of new findings.
 - Determining who should be responsible for convening a community planning process; if there is none in place, the hospital should be the leader/convenor.
 - Knowing the key state or regional partners. These will probably include state radiation protection and emergency response staff as well as state health inspectors. Initial players will be EMS, Police, Fire, emergency management agencies, and the health department. This group will expand quickly once the key organizations begin working together (additional partners might include public and private transportation companies, and expanding to other public and private ventures). Hospitals should include local businesses and non-profit volunteer organizations (rescue missions, churches, and food banks) as partners.
 - Having each partner conduct its own internal assessment and then share its findings with the partners.
 - Ensuring that all partners agree on and are familiar with the roles and responsibilities of each partner.
 - Conducting a community-wide risk assessment.

- Developing an integrated training program and conducting at least one training exercise per year, as required by JCAHO.
- Evaluating and reassessing the plan periodically.
- Relationships are just as important as the plan content when it comes to ensuring successful implementation of the plan in response to a mass casualty incident.
- Hospitals should make sure in the community planning process that there is a method in place for finding out which hospitals are still functioning, which ones need help, and which ones should not be receiving additional patients.
- It is important to conduct post-incident debriefing and share these discoveries with hospitals in other communities. There is a need for a national institutionalized process to maximize the lessons we learn from disasters and to serve as a national clearinghouse of published and non-published research. However, hospitals may be reluctant to share information for fear of lawsuits; therefore, the research should be rendered anonymous prior to sharing.
- The benefits of community planning go beyond joint planning to include other collaborative opportunities such as joint purchasing that will reduce costs.

Hospital medical personnel can use these basic guidelines in conjunction with their professional training and experience to aid in the effective and efficient treatment of victims. The purpose of the guidelines is not to address all of the possible emergency-related medical care that may be required by the hospital during such an emergency. Rather, the focus is on unique aspects of a nuclear or radiological event involving mass casualties for which the

hospital's emergency department may not be adequately prepared or equipped. It should be noted, however, a successful response is dependent not only on written guidelines, but also on the communication of these guidelines along with partnerships between medical personnel and private, state, local and federal public health agencies and organizations.

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Appendix A: Participants from the May 2002 CDC Roundtable on the Identification of Emerging Strategies for Hospital Management of Mass Casualties from a Radiological Incident

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Appendix B: Acute Radiation Syndrome

Radiation sickness, known as acute radiation sickness (ARS), is a serious illness that occurs when the entire body (or most of it) receives a high dose of radiation, usually over a short period of time. Many survivors of the Hiroshima and Nagasaki atomic bombs in the 1940s and many of the firefighters who first responded after the Chernobyl Nuclear Power Plant accident in 1986 became ill with ARS.

People exposed to radiation will get ARS only if:

- The radiation dose was high (doses from medical procedures such as diagnostic x-rays are too low to cause ARS; however, doses from radiation therapy to treat cancer may be high enough to cause some ARS symptoms),
- The radiation was penetrating, such as gamma rays or neutrons (that is, able to reach internal organs),
- The person's entire body, or most of it, received the dose, and
- The radiation was received in a short time, usually within minutes.

The first symptoms of ARS typically are nausea, vomiting, and diarrhea. These symptoms will start within minutes to days after the exposure, will last for minutes up to several days, and may come and go. Then the person usually looks and feels healthy for a short time, after which he or she will become sick again with loss of appetite, fatigue, fever, nausea, vomiting, diarrhea, and possibly even seizures and coma. This seriously ill stage may last from a few hours up to several months.

People with ARS typically also have some skin damage. This damage can start to show within a few hours after exposure and can include swelling, itching, and redness of the skin (like a bad sunburn). There also can be hair loss. As with the other symptoms, the skin may heal for a short time, followed by the return of swelling, itching, and redness days or weeks later. Complete healing of the skin may take from several weeks up to a few years depending on the radiation dose the person's skin received.

The chance of survival for people with ARS decreases with increasing radiation dose. Most people who do not recover from ARS will die within several months of exposure. The cause of death in most cases is the destruction of the person's bone marrow, which results in infections and internal bleeding. For the survivors, the recovery process may last from several weeks up to 2 years.

If a radiation emergency occurs that exposes people to high doses of radiation in a short period of time, they should immediately seek medical care from their doctor or local hospital.

For more information about radiation and emergency response, see the Centers for Disease Control and Prevention's website at www.bt.cdc.gov or contact the following organizations:

The CDC Public Response Source at 1-888-246-2675

The Conference of Radiation Control Program Directors (www.crcpd.org) at (502) 227-4543

The Environmental Protection Agency (www.epa.gov/radiation/rert/)

The Nuclear Regulatory Commission Radiation Protection Program (www.nrc.gov/what-we-do/radiation/about-radiation.html) at (301) 415-8200

The Federal Emergency Management Agency (FEMA; www.fema.gov) can be reached at (202) 646-4600.

The Radiation Emergency Assistance Center/Training Site (www.orau.gov/reacts/) at (865)-576-3131

The U.S. National Response Team (www.nrt.org/production/nrt/home.nsf)

The U.S. Department of Energy (www.energy.gov) at 1-800-dial-DOE

Appendix C: Radiation Detection and Measurement Instrumentation

Note: In the descriptions below, the term “radiation” in the context of radiation detection refers to beta/gamma radiation unless noted otherwise. The detection of alpha radiation, or even low energy beta or gamma radiation (like that emitted from tritium), requires special probes or devices and is generally not included in the instruments discussed unless specifically mentioned.

Thermoluminescent dosimeters (TLD) – TLDs are devices that store radiation readings, which can later be measured using an electronic reader. They are rugged and can be stockpiled and rapidly issued. They are usually housed in cards that can color code for different technical specialties or be used as ID cards. TLDs do not have readouts that can be read by those wearing them, so they cannot be used as early warning devices or as indicators that radiation exposure limits have been reached. Once a TLD is read, its reading is cleared, so it can be reused many times. The TLD reader must be regularly calibrated and operated by a qualified and knowledgeable person. TLDs are appropriate for people involved in reentry and cleanup, but should not be used alone by first responders entering high-radiation areas. In the latter case, real-time detection instrumentation should also be carried by the first responders.

Self-reading dosimeters – This type of dosimeter, a small tube about the size of a ballpoint pen, is easy to use and does not require an expensive training program or a skilled technician. The wearer can look through the tube and get a reading of total absorbed dose in real time, so they can be used as an aid in controlling the amount of

time spent in the radiation area. However, they are fragile and tend to go to a maximum reading when dropped, leading to lost data. They can be initialized by electronic chargers and reused many times. Self-reading dosimeters could be used by emergency responders, but because of their sensitivity to mechanical shock or environmental conditions dosimeter cards are preferred.

Dosimeter cards – These devices are about the size of a credit card and can be carried in a pocket. Successive dots on the card change color as levels of radiation exposure are exceeded. They can only be used once, and then must be thrown away, but the cost is minimal at \$5.00 per card. Interpretation of the reading is instantaneous. They are recommended for immediate issue to emergency responders. Because their readings are only approximate and because they can only be used once, they are not recommended for reentry and cleanup personnel.

Monitoring Devices for Decontamination Stations

Decontamination stations should be established as soon as possible after the event. People without serious injuries should be directed to these stations instead of to emergency rooms. Decontamination stations need instruments that can read radiation levels below normal background, but do not need a very high range. Accurate readings of high radiation levels have no practical value; if a person is contaminated, he or she should be immediately decontaminated.

Geiger-Mueller (GM) counter – GM counters are sensitive radiation detection devices that can be capable of measuring alpha, beta, and gamma radiation. The GM counter, or Geiger counter, has a probe that can be aimed at the area of interest and a readout that measures in mR/hr or counts/minute. A special probe, generally referred to as a “pancake” probe, is required for detecting alpha radiation. GM counters also offer an audio option that allows the user to hear clicking proportional to the radiation level. Because they are directional and can give erroneous readings in extremely high radiation fields, GM counters are not recommended for general area readings by the teams entering intense radiation areas to save lives or to map the areas. They are easy to use, but require periodic calibration, which can be done by shipping to a service provider. Organizations using Geiger counters should have access to a qualified technician who can train the team members in use of the device.

Pancake probe – A Geiger-Mueller counter with a wide, flat probe that is capable of detecting alpha, beta, or gamma radiation. The wide sensitive area of the probe allows for more rapid search of an area, and the shield on the back of the probe helps prevent radiation from some other source from interfering with the readings on the area of interest. The detector should be able to read levels below normal background. Because they are directional and can give erroneous readings in extremely high radiation fields, pancake probes are not recommended for general area readings by the teams entering intense radiation areas to save lives or to map the areas. They are easy to use, but require periodic calibration, which can be done by shipping to a service provider. Organizations

using pancake probes should have access to a qualified technician who can train the team members in use of the device.

Alpha detectors – An alpha detector must be very close to the alpha source to detect it. It should be noted that the measurement of alpha radiation can be confounded by the presence of beta/gamma radiation. However, since alpha emitters are internal hazards, not external hazards, if there is any concern about alpha emitters, first responders can enter with respiratory protection and not worry about the presence of the alpha emitting material. The decontamination station personnel can determine whether radioactive material is present using a pancake probe. Alpha detectors are only useful in the reentry and cleanup phase of the incident.

Portable spectrometer – Portable spectrometers are used to determine the specific radioisotopes present. Since the presence or absence of radiation, and its magnitude, is all that emergency responders entering an area to save lives need to be aware of, knowing the specific radioisotope involved would not be immediately helpful. Therefore, portable spectrometers are not recommended for first responders. However, personnel making protective action recommendations need to know what radioisotopes are present, specifically to guide the treatment of internal contamination, so they need the capability of performing isotopic identification.

Area monitor – These monitors are stationary devices set up to detect radiation over a wide area continuously. One form, the gate monitor, is an omnidirectional probe and

meter mounted in a fixed location to check incoming or outgoing material for radiation. An area monitor should be capable of reading below normal background, and it would be worthwhile to connect it to a computer or data-logging device. Logged data would then enable the reconstruction of the extent of possible contamination or staff exposure, especially when emergency room or relocation center staff miss an alarm or choose to ignore it to take care of a gravely injured patient.

Portal monitor – A portal monitor is a doorway-type device that allows people to walk through to detect the presence of radiation. A portal monitor can be used to check large numbers of people more rapidly than a technician with a hand-held meter so they are useful at decontamination stations established for screening mobile but possibly contaminated people. Many types of portal monitors are not wide enough to accommodate wheel chairs or gurneys-and all require periodic calibration and testing. Some portal monitors can be expanded to allow vehicles to pass through, but most are for the monitoring of people.

Air monitor/Air sampler – These terms sometimes create confusion. An air *monitor* is technically an omnidirectional probe mounted in an area of concern, which can record or transmit dose rates in units such as rad per hour. An air *sampler* is a calibrated vacuum cleaner-type device that collects particles from the air on a filter that can be analyzed later. There are some hybrid devices, which pull air through a moving paper tape that is then counted by a detector, usually called an *air particle detector*. An air monitor is useful where there is concern over airborne radiation posing an immediate health risk.

An air sampler is more sensitive than an air monitor, but it does not provide real time information. Samples can be analyzed in a laboratory for total counts, or for specific isotopes.

For assistance in selecting a particular instrument or set of instruments, contact your state's Radiation Control Program Director. You can find the name and telephone number by contacting the Conference of Radiation Control Program Directors at (502) 227-4543 or on the Internet at www.crcpd.org