HEPP New York City Department of Health and Mental Hygiene
Healthcare Emergency Preparedness Program

NYC Hospital Guidance for Responding to a Contaminating Radiation Incident

April 2009

Created by
NYC Hospital Radiation Response Working Group
NYC Department of Health and Mental Hygiene
Healthcare Emergency Preparedness Program

NYC Health

This publication was supported by Grant Number U3RHS05957-01-00 from the Health Resources and Services Administration. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of HRSA.

All inquiries about the "Hospital Guidance for Responding to a Contaminating Radiation Incident"
may be addressed to:

Healthcare Emergency Preparedness Program
c/o NYC Department of Health and Mental Hygiene
125 Worth Street, RM 222, Box 22A
New York, NY 10013
Phone: 212-788-4277

or by e-mail at
hepp@health.nyc.gov

List of Contributors

NYC Hospital Radiation Response Working Group

Chairperson

Curt Dill, MD

Director
Emergency Medicine
VA New York Harbor Hospital System

Project Manager/Editor

Katherine Uraneck, MD

Senior Medical Coordinator
Healthcare Emergency Preparedness Program
NYC Department of Health & Mental Hygiene

Joseph Albanese, Ph.D
Radiation Biodosimetrist
Yale New Haven Center for Emergency
Preparedness and Disaster Response

Manfred Blum, MD
Professor of Medicine & Radiology
NYU School of Medicine

Bruce Ellerin, MD
Radiation Oncology
NYU School of Medicine

Kent Friedman, MD
Assistant Professor of Radiology
Division of Nuclear Medici
NYU School of Medicine

Christopher Freyberg, MD
Director, Emergency Department
Southern Arizona VA Health Care System

Naomi H. Harley, PhD
Research Professor
Department of Environmental Medicine
NYU School of Medicine

Lewis R. Goldfrank, MD
Professor and Chair, Emergency Medicine
New York University School of Medicine
Director, Emergency Medicine
Bellevue Hospital/NYU Hospitals/VA
Medical Center
Medical Director
New York City Poison Center

Christopher Marshall, Ph.D
Professor Emeritus of Radiology
NYU School of Medicine

Rajesh Mittal, MD
Emergency Medicine
SUNY Downstate/Kings County Hospital
Center

Gabriella Wernicke, MD
Associate Professor Radiation Oncology
Radiation Oncology
NYU Clinical Cancer Center

Ellen Webb
Coordinator
New York Center for Terrorism
Preparedness
Bellevue Hospital Center

Forward

1. What is this guidance document?

The aim of this publication, *NYC Hospital Guidance to Responding to a Contaminating Radiation Incident*, is to serve as a practical resource for New York City Hospitals in planning a response to an emergency involving radioactive contamination.

This guide was developed by The New York City Hospital Radiation Working Group, a multi-hospital working group convened by the NYC Department of Health and Mental Hygiene (DOHMH) that included nuclear medicine, radiation oncology, emergency medicine, health physics, emergency management, mental health, environmental medicine, and radiation-related treatment and monitoring professionals. Every effort has been made to ensure the information in this manual is accurate and consistent with sound radiation protection and assessment methods, policies, and practices.

2. Are the recommendations in this guideline mandatory?

The NYC Department of Health and Mental Hygiene (DOHMH) do not require that hospitals incorporate all the following recommendations verbatim. Rather hospitals should develop a radiological emergency plan consistent with their local perceived radiological threat, while considering their staffing capabilities, equipment resources, and other unique characteristics and condition.

3. Why does my hospital need this guideline?

The manual assumes that, if a radiological incident occurs, hospitals will activate their Hospital Incident Command System (HICS) and the hospital specific emergency response plan. Each plan should include a radiation-specific annex. If a hospital does not have a radiation annex, this guideline will assist hospital planners and medical staffs create one.

Hospitals and their personnel must be able to immediately receive, evaluate and treat victims. Some victims will be ill and injured; some will be exposed and/or contaminated while others who have not been exposed will be concerned about their potential exposure. With little or no warning and information and limited access to radiation specialists, front line staff will be called upon to make complex decisions in an austere environment. To effectively meet this challenge, adequate planning and preparation are necessary.

While participation by radiation specialists during planning is critical, the assumption is that adequate numbers of radiation specialists will not be available immediately to perform all essential functions in the event of a radiation emergency. Many tasks must be delegated to the initially available staff. Hence, the Job Action Sheets and appendices were developed to enable non-radiation specialists to perform these essential functions.

4. My hospital plan is to not permit any radiation contamination inside, why do I still need a radiation response annex to my plan?

Controlling and limiting contamination is vital, but planners and administrators must understand that some radioactive material will inevitably enter the hospitals if a large scale radiation contaminating incident occurs. The physical properties of radioactive materials, technical limitations of equipment, demand for immediate clinical care, and relative scarcity of radiation specialists make complete exclusion of radioactivity impossible. However, following the radiation control recommendations in this manual the magnitude of contamination should significantly limited, thereby permitting ongoing clinical responsibilities. The manual addresses how to control such contamination, while continuing critical hospital functions and keeping hospital personnel and patients safe.

5. Who should read this guideline?

The primary audiences for most of the chapters include emergency planners, administrators, security, radiation safety personnel, and emergency department personnel. The recommendations focus on practical response procedures rather than on treatment protocols with the exception of Section 7: Radiation Medicine.

One of the main goals of this document is to adapt the best available knowledge, which is based on the experience gained from treating small numbers of patients, to a potentially overwhelming number in the midst of the chaos of a mass casualty situation.

Katherine Uraneck, MD
Project Manager and Editor
Senior Medical Coordinator
Healthcare Emergency Preparedness Program
New York City Department of Health and Mental Hygiene

Table of Contents

RADIATION ABBREVIATIONS & ACRONYMS

A

AAPM	American Association of Physicists in Medicine
ACR	American College of Radiology
ALARA	as low as reasonably achievable
AMA	American Medical Association
ANS	American Nuclear Society
ANSI	American National Standards Institute
ATSDR	Agency for Toxic Substances and Disease Registry

B

BEIR	biological effects of ionizing radiation
Bq	bequerel

C

CDC	Centers for Disease Control and Prevention
CEDE	committed effective dose equivalent
CFR	Code of Federal Regulations
Ci	curie
CRCPD	Conference of Radiation Control Program Directors, Inc.

D

DDREF	dose and dose-rate effectiveness factor,
DHHS	US Department of Health and Human Service
DHS	US Department of Homeland Security
DNA	deoxyribonucleic acid
DOE	US Department of Energy
DOHMH	NYC Department of Health and Mental Hygiene
DREF	dose-rate effectiveness factor
DTRA	Defense Threat Reduction Agency

E

EEG	electroencephalogram
ELF	extremely low frequency
EMAC	Emergency Management Agreement Compact
EMS	emergency medical services
EPA	US Environmental Protection Agency
ERP	Emergency Response Plan

F

FDA	US Food and Drug Administration
FEMA	Federal Emergency Management Agency

G

GIS	Global Information System
GI	gastrointestinal
Gy	Gray

H

HDR	high dose rate
HEICS	Hospital Emergency Incident Command System
HEPP	Healthcare Emergency Preparedness Program
HPS	Health Physics Society
HRSA	Health Resources and Services Administration

I

IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements
IOM	Institute of Medicine
IND	improvised nuclear device

J

JCAHO	Joint Commission on Accreditation of Healthcare Organizations

K

L

LDR	low dose rate
LET	linear-energy transfer
LLD	lower limit of detection

M

mrem	millirem
mSv	milliSievert

N

NAS	National Academy of Sciences
NCRP	National Council on Radiation Protection and Measurements
NIMS	National Incident Management System
NIOSH	National Institute of Occupational Safety and Health
NIST	National Institute of Standards and Technology
NRC	US Nuclear Regulatory Agency

O

OASPR	Office of the Assistant Secretary for Preparedness and Response
ORH	Office of Radiological Health
OSHA	Occupational Safety and Health Administration

P

PAG	protective action guidelines
PCS	personal communication system
PHS	US Public Health Service
PPE	personal protective equipment
PW	pulsed wave

Q

R

RBC	red blood cells
RBE	relative biological effectiveness of a particular treatment to some other treatment
RDD	radiological dispersal device
RDE	radiological dispersal event
RED	radiation exposure device
REM	Radiation Effective
RPG	radiological protective guideline
RSO	radiation safety officer

S

SI	International System of Units
Sv	Sievert

T

TEDE	total effective dose equivalent
TLD	thermoluminescent dosimeter

U

UA	urine analysis
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
UV	ultraviolet

V

VA	Department of Veterans Affairs

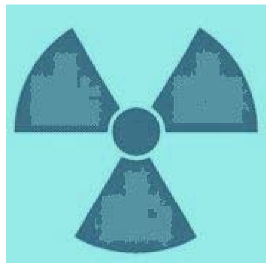
W

WBC	white blood cells
WHO	World Health Organization

XYZ

Z	atomic number

NYC Hospital Guidance for Responding to a Contaminating Radiation Incident



April 2009

PART I

Section 1: Introduction to Planning for a Radiation Incident

Section Contents:

- **Key Planning Considerations for Radiation Incidents**
- **Essential Radiation Concepts and Definitions**
- **NYC Radiological Dispersal Devices Assumptions**

Key Planning Considerations for Radiation Incidents

1. Treatment of life-threatening illness and injury takes precedence over radiological assessment and decontamination. (Burnham and Franco, 2003).

2. Detect High Radiation Sources and control contamination. All hospital emergency departments must have radiation detection equipment and staff trained to use this equipment immediately available 24 hours a day/ 7 days a week.

3. Universal precautions in the emergency room are usually sufficient for treatment of victims of radiological incidents. (NCRP, 2006).

4. Expect early patients to arrive unannounced. Hospitals must be prepared to receive contaminated patients with little to no warning.

5. Clothing removal eliminates up to 80-90% of contamination. (Levitin et al., 2003).

6. Individuals may be advised by public health authorities to self-decontaminate at home if resources do not permit decontamination of large numbers of people. (CRCPD, 2003).

7. In a mass casualty event, it is impractical to assume that all radioactive material will be kept out of the facility. Plans should be developed for critical medical facilities and critical care equipment to continue functioning in low radiation areas. (CEMSA, 2005).

8. Fear of radiation is substantial by both the public and responders. Prioritizing personnel safety concerns prior to and during an event will help to put risk hazard into a proper perspective.

9. Identify radiation experts during planning phase. The emergency response plan should identify radiation expertise available to the hospital to facilitate planning, response, and recovery phases during a radiation incident.

Essential Radiation Concepts and Definitions

Radiation Exposure versus Radiation Contamination of people

- **Radiation Exposure (irradiation):** A general term used to express what a person receives as a result of being exposed to ionizing radiation.The unit of exposure most often used is the roentgen (R). People who have been exposed to radiation only, are not radioactive *AND ARE NOT A RISK TO OTHERS DUE TO SECONDARY CONTAMINATION.*

- **Radioactive Contamination:** the deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or people. It can be airborne, external, or internal.

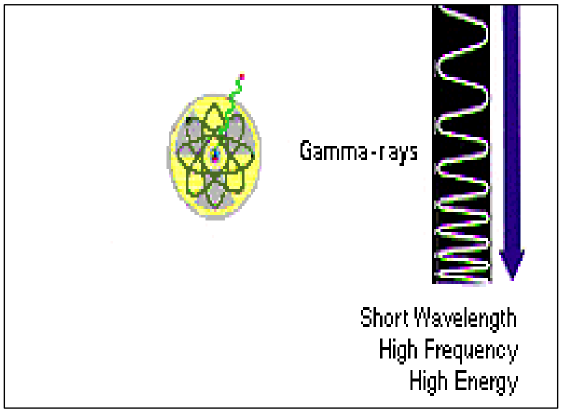
Useful analogy of exposure vs. contamination: Let's allow a camp fire to represent a radioactive source. If you put a Marshmallow near the fire (exposure), the heat (energy) from the fire will begin to brown (damage to the marshmallow). Take the marshmallow away and the browning stops, marshmallow is safe to eat. But drop the marshmallow in the embers and it gets covered with soot and dirt (contamination), now it is not safe to eat.

External Contamination vs. Internal Contamination

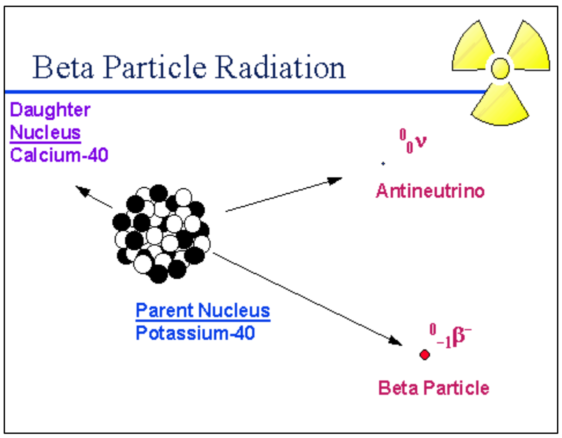
- **External Contamination:** Radioactive material (liquid, powder, metal fragments, dust) contamination on the body surface or clothing. External contamination may be removed by washing with water or simply taking off the outer layers of clothing. Once external contamination is removed and away from the body, it no longer has an effect on the body. Following an RDD event the quantity of radioactive material deposited on an individual is not expected to be high enough to be immediately life threatening.

- **Internal Contamination:** Radioactive material (liquid, powder, metal fragments, or dust) contamination inside the body. Pathways include ingestion, inhalation, injection, or absorption. Internal contamination may be a continuous source of radiation exposure if radioactive material is incorporated into the body and not removed. Certain treatments exist for specific isotopes to lessen the amount of material in the body by either blocking the absorption of the isotope or chelating the material. Everyone has small amounts of radioactive material in their body either from natural sources (such as potassium or radon) or through the uptake of minute amounts of fallout from atomic weapons tests or through smoking (polonium). This level of contamination is not treated. Larger amounts of internal contamination are a concern when the amounts might cause acute symptoms or significantly increase the risk of cancer or other long term effects.

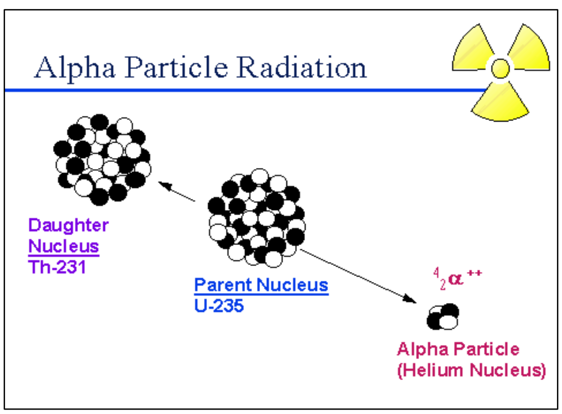
Types of ionizing radiation



Gamma rays High-energy electromagnetic radiation emitted by certain radionuclides when their nuclei transition from a higher to a lower energy state. Gamma rays penetrate tissue farther than do beta or alpha particles, but are less damaging locally.



Beta particles Electrons ejected from the nucleus during radioactive decay. They are less penetrating than gamma rays and can be shielded by a thin sheet of metal. Their chief hazard is ingestion and skin contamination. Beta particles can penetrate the dead layer of skin and cause severe burns.



Alpha particles Equivalent to a helium nucleus (2 protons and 2 neutrons). Alpha particles generally carry more energy than gamma rays and beta particles. They are easily shielded by a sheet of paper or clothing and present no external hazard. Alpha particles are quite damaging if internalized because they deposit all of their energy in a very small volume of tissue.

Hot particles are radioactive fragments that may get embedded in the body. The exposure from such fragments can cause severe local injury and possibly consequential whole body exposure unless they are removed. Removal of clothing and showering should remove any not embedded in the body, but the remainder may require surgical removal.

Selected Radiation Measurement Units
For more information, see Primer on Radiation Measurement in Appendix

- **Rad:** (Radiation Absorbed Dose) The rad is a special unit of absorbed radiation dose. It is a measure of the amount of energy absorbed per unit mass (energy/gram) body. The rad is the traditional unit of absorbed dose but is being replaced by the Standard International (SI) unit, the Gray (Gy). One Gray is equal to 100 rad. See Glossary
- **Gray:** The Gray is the SI unit of dose = absorbed energy per unit mass (Joules/Kg). 100 rad = 1 Gray (Gy). See Glossary
- **Rem:** The rem is a unit of absorbed dose that attempts to normalize the dose from different types of radiation exposure. See Glossary
- **Sievert:** The Sievert is the SI unit used to normalize the dose from alpha, beta and gamma radiation exposures. See Glossary

Radiation Dose: a generic term to describe the amount of radiation absorbed by a person's body. Dose is measured in units of thousands of a roentgen equivalent man (rem) Dose is a general term used to assist in the management of individual exposure to radiation. The international scientific community has adopted the use of a different term for millirem called a milliSievert (mSv). One mSv is the same as 100 mrem.

Radiation Health Effects

Deterministic Effects (Acute) vs. Stochastic Effects (Delayed)

- **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. Examples of a deterministic effect are acute radiation syndrome or hair loss. Almost all immediate safety measures are aimed at preventing acute or deterministic effects.

- **Stochastic effect:** effect that occurs on a probabilistic basis directly related to the size of dose. The effect typically has no threshold and is based on probabilities, with the chances of seeing the effect increasing as the dose of radiation increases. If it occurs, the severity of a stochastic effect is independent of the dose received. Stochastic effects appear years after the exposure. Cancer is a stochastic effect.

High Dose vs. Low Dose

- High doses can generally be considered any dose of radiation that can cause acute deterministic effects. Typically, 10 rem – 15 rem causes fetal abnormalities and decrease in sperm count. For Acute Radiation Syndrome the dose is approximately 100 rem = 1 Sv.

- Low doses are doses that do not produce acute deterministic effects. Below 5 rem (the yearly occupational maximum dose for radiation workers) would be considered a low dose. Low dose radiation can still result in long term effects.

RULE OF THUMB:

Deterministic effects start at HIGH DOSES (see above). After a person has reached the threshold for a given effect, the more radiation, the worse the effect. Acute Radiation Syndrome is an example of an Acute Effect. All the Protective Action Guidelines for Responders are aimed at preventing Acute Effects. Acute usually means the effects occur within in minutes to months of the exposure.

Stochastic effects are health effects that occur over the long term, years and generations later. These are the effects that may or may not be seen with and doses including LOW DOSES (see above). These effects only increase in probability as the dose goes up, not severity. For example, a stochastic effect would be the risk of getting leukemia after a total body exposure, and the leukemia would not be worse if the dose is higher, just a greater probability of getting it.

Pregnancy, Children and Radiation

- Rapidly dividing cells are more sensitive to the effects of radiation. Therefore fetuses, newborns, and children are more susceptible earlier in development the more susceptible to radiation therefore children and Fetuses are most sensitive to radiation during 8-15 weeks following conception. Children and fetuses are more sensitive to radiation because their cells divide at a more rapid rate and there is a greater opportunity for radiation to disrupt this process.

Clinical Status

- **Medical emergency**: a condition in which the absence of immediate medical attention could reasonably result in serious dysfunction, impairment of bodily function, or loss of life.

- **Medical urgency**: A condition that requires attention, but delay in care will not result in serious dysfunction, impairment of bodily functions or loss of life.

Treatment Areas

- **Pre-decontamination Area:** An area designated outside of the **decontamination zone where** patients may or may not be contaminated.
- **Post-decontamination Area:** Area located immediately after decontamination showers where a repeat radiation screening is completed prior to sending patient on to treatment areas or back through decontamination showers.
- **Red (Radiation Controlled) Treatment Area:** The designated treatment area(s) for critically ill and injured patients who may have received minimal or no decontamination and screening prior to entry. Radiation Control and screening procedures will be required for this area and should receive the highest priority for assigning radiation detection equipment.
- **Yellow (Radiation Controlled) Treatment Area**: The designated treatment area for Non-critically ill or injured patients requiring some medical intervention

or hospitalization. Patients should have undergone maximum decontamination prior to entry. However, some radioactive contamination may enter this area. This area should have little to no contamination, but it is still possible that radiation contamination may be inadvertently tracked in and, therefore, radiation control practices should be in place. Additionally, special radiation procedures will be required for this area, for example, treatment of contaminated wounds.

- **Green (Radiation Controlled) Treatment Area:** The designated treatment area(s) for Patients with minimal or no physical illness or injury. Patients should be maximally decontaminated prior to entry to this area, but inadvertent tracking of radiation contamination is possible.
- **Radiation Control Zones:** These zones are not predefined areas, but locations where the ambient radiation dose rates exceed prescribed levels. For example, a heavily contaminated individual may result in a hot zone surrounding his/her stretcher, but the areas farther away may be within normal limits for the public. These designations will be dynamic and need to be determined in real time by the designated radiation control team. Designation of radiation control Zones defines the activities, personnel, and access within that zone. See Section for 3 for Table of Radiation Zones, Stay Times, and Activities. For more information about Radiation Control Zones go to Section 3. Radiation Control—Keeping Facilities Safe during a Radiation Incident.
    - **Extreme Radiation Zone: >** 10,000 mrem/hr
    - **High Radiation Zone:** 1000 **-** 10,000 mrem/hr
    - **Medium Radiation Zone**: 100 - 1000mrem/hr
    - **Low Radiation Zone**: 2 -100mrem/hr
    - **Not controlled** < 2mrem/hr (approximately 1,000 cpm)

Background Radiation: the amount of ionizing radiation from natural sources, such as terrestrial radiation due to radionuclides in the soil, stone, or cosmic radiation originating from space. Radon is the greatest contributor to background radiation.

Radiological Dispersal Devices (RDD) Assumptions

These assumptions were utilized for the basis of all of the recommendations in this guidance document.

1. The inhalation hazard is greatest for those close to the site of an explosion. After the explosion, airborne radioactive material should dissipate within 10-15 minutes. (Mussolino and Harper, 2006).

2. The principal hazard to patients and responders in the immediate area of the explosion will be from radioactive material on the ground and buildings and especially from highly radioactive fragments (hot particles) if they are present.(Mussolino and Harper, 2006).

3. For the most plausible scenarios, the high-risk area is approximately 500 meters (about 7 small city blocks) from the blast point. This is expected to be made smaller as first responders and environmental tests refine and survey the area. (Mussolino and Harper, 2006).

4. Safe and controlled evacuation of potentially contaminated areas is a higher priority than decontamination during the immediate phase of an incident.(Mussolino and Harper, 2006).

5. The affected population within the immediate vicinity of an RDD will be directed away from the blast using all available routes, as long as the routes do not traverse the blast area.

6. Isotopic identification will be conducted by city agencies with subsequent communication to the hospitals through the City Incident Management System.

7. Evacuation Areas will most likely change over the course of days to several weeks after an incident based on the Environmental Protection Agency (EPA) Intermediate and Late Phase Protective Action Guidelines (PAG).

8. Hospitals should be aware that individuals could have significant but not immediately life-threatening levels of radioactive contamination on their clothes or bodies.

9. Free standing city-based screening and monitoring stations may be created, but will not be immediately available.

10. Seriously ill or injured patients should decontamination procedures that delay medical care, but should have a rapid radiation survey prior to entry into a hospital or ambulance.

Section 2: Staff Safety during a Radiation Incident

Section Contents:

Occupational Safety Recommendations

General Overview

Perhaps the most important issue for emergency planners to address prior and during any disaster is protection of the staff members and first responders. Workers should be monitored for radiation exposure and use caution rendering care, but the risk of health effects must be kept in perspective to allow for optimal evaluation and care of victims.

During the unknown early phase of a disaster, staff must observe an all-hazards approach and assume that biological, chemical, and radiological hazards may be present. Only after other hazards are excluded should staff limit their focus to radiological hazards. Protection should focus on minimizing external exposure, and preventing inhalation, or inadvertent ingestion. In most cases protection is accomplished by observing standard precautions, also referred to as level D PPE, generally observed in the hospital setting.

It is absolutely essential that radiation monitoring equipment is immediately available in the Emergency Department and that staff are sufficiently trained to perform basic radiation surveys 24 hours a day 7 days a week. Basic radiation surveillance should focus on identifying the presence of radiation, protecting staff and patients, and controlling the spread of contamination. Radiation specialists should be able to characterize the hazards more specifically.

In addition to these general precautions, front line staff should have received basic training on how to recognize and respond to a radiological emergency.

No health care workers who have adhered to appropriate guidelines have become contaminated or suffered from radiation injuries from handling a contaminated patient. (Waselenko, *et.al.*, 2004)

Personal Protective Equipment (PPE)

PPE for Decontamination Personnel Working with Contaminated Patients

Until additional chemical agents are excluded, the "Decontamination Staff" working in the Pre-Decontamination Area and in the Decontamination Showers should don "all-hazards PPE" (a minimum of Level C with PAPRs or higher)as per Occupational Safety and Health Administration recommendations[1].

Electronic personal dosimeters, if used, should be water resistant, such as the Canberra Ultraradiac, and should attached to the outside of the surgical gown at the waist where they can be easily removed and read. Dosimeters should be usable with heavy gloves. If thermoluminescent dosimeters (film badges) are used, they should be worn underneath the outer water-proof gear.

PPE for Hospital Personnel Providing Care with Contaminated Patients Inside Facility or Post-Decontamination Area

The purpose of protective clothing during a contaminating radiation incident is to keep bare skin and personal clothing free of contamination. Universal precautions (*i.e.*, standard hospital personal protection procedures) in the emergency room and/or any other room where potentially contaminated patients may be treated protects against particulate contamination and against radiation injury from alpha particles, since alpha particles would not be able to penetrate through standard level D PPE.

- Teams should dress in standard universal precautions with some modifications (scrubs or **Tyvek**®, suits, water-repellent surgical gown, mask, cap, eye protection, and double gloves, seams taped). See PPE Donning and Doffing Procedure located in this section and the appendix;
- Waterproof shoe covers and two pairs of surgical gloves are recommended. The first pair of gloves should be taped to the arm cuff of the gown and the second pair can be replaced frequently if contaminated;
- Lead aprons will **not** stop most gamma rays and **are not** recommended;
- Standard surgical masks should generally be adequate protection against inhalational contamination. Where there is contaminated debris or dust an N-95 respirator mask provides better protection; and,
- Electronic personal dosimeters, if used, should be attached to the outside of the surgical gown at the neck or waist where they can be easily removed and read. Thermoluminescent dosimeter (film badges), if used, should be worn underneath the outer water-repellent cover.

---

[1] OSHA (2005). Occupation Safety and Health Administration. *Best Practices for Hospital Based First Receivers of Victims from Mass Casualty Incidents Involving the Release of Hazardous Substances*, http://www.osha.gov/dts/osta/bestpractices/html/hospital_firstreceivers.html (accessed August 2, 2007) (Occupation Safety and Health Administration, Washington).

Comfort and the ability to function (including operating the radiation detection equipment) while wearing the appropriate protective wear is important as it relates to compliance with proper precautions.

Specific PPE Considerations

- Staff members in the post-decontamination areas and inside the hospital who may get wet with potentially contaminated liquid should wear waterproof shoe covers and outerwear;
- Staff members should survey themselves or be surveyed by co-workers frequently for possible contamination;
- For staff working with potentially contaminated patients in the Red, Yellow, and Green Radiation Controlled Ares should change outer gloves frequently (after every patient contact or more frequently during prolonged procedures) to prevent the spread of radioactive contamination to themselves or to other areas on the patient; and,
- At the completion of the tour of duty, or upon exiting any of the radiation controlled areas, should be radiological screened prior to entering clean areas.

See PPE Donning and Doffing Procedure, page 17, at the end of this chapter for more detail.

Radiation Safety Practices

Optimally, all personnel entering or working in a radiation control zone should wear personal dosimeters. In the early phases of a disaster this may not be feasible, in which cases dose estimates will need to be reconstructed from survey readings and the estimated time personnel spent in that area.

Occupational safety personnel must keep a record of all employees exposed or potentially exposed in the event of a radiological emergency. It would be important for planners to have in place the necessary forms to document the names, locations, and hours worked for all personnel who work in radiation control areas.

Under all circumstances, radiation exposure should be kept AS LOW AS REASONABLY ACHIEVEABLE (ALARA) while preserving critical operations and resources.

- Observe universal precautions: including splash and water protection
- Staff actively attending contaminated patients should wear personal monitors, such as real-time dosimeters and/or film badges, unless the level of exposure is known to be negligible or well within public exposure limits.
- General Radiation Protection principles
    - **Time** Minimize time spent near radioactive source
    - ***Distance*** Maximize distance from source
    - ***Shielding*** Place physical shields around source

Radiation Dose Recommendations for Hospital Personnel during a Radiation Incident

The purpose of dose guidelines are to ensure that certain critical doses are not exceeded, thus providing protection from serious harm from radiation, and also help mange doses to levels that are as low as reasonably achievable (ALARA). (CRCPD, 2006).

Standard regulatory guidelines pertain mainly to occupational and public exposures to low-level radiation exposure over prolonged periods of time. The primary goal of these standards is to ensure that industries using radiation design operations to minimize the risk of radiation induced cancers and other health effects to their workers and to the entire population.

The United States Nuclear Regulatory Commission requires that licensees limit radiation exposure to individual members of the general public to 100 mrem (1 mSv) per year. Radiation workers may receive up to 5000 mrem = 5 rem (0.05 Sv = 50 mSv) per year. (NRC Regulations Title 10, Code of Federal Regulations Part 20) These doses are in addition to doses from natural background exposure (US Average: 360 mrem (3.6 mSv) per year). These limits are considered conservative.

Under normal circumstances, hospital staff members are considered members of the general public unless they work in areas of the hospital that use radiation and are designated "radiation workers".

Under exceptional circumstances, such as an accidental release from an nuclear power plant or radiological terrorism are exceptional events, adhering to routine radiation protection guidelines may not be feasible in order to save lives, protect public health, and critical infrastructure (EPA, 1992; NCRP, 1993 and 2001; CRCPD, 2006).

An emergency response differs in that it is a single event, and uncontrolled by definition. The recommendations in this document serve as a starting point in circumstances where the exact nature of the event is unclear and preceding the arrival of the formal radiation control experts. Once radiation control experts arrive and the event is clearly understood, experts will modify the plan according to real-time assessments.

In published national guidelines during radiation emergencies, regulatory dose limits are relaxed for radiation workers and emergency personnel such as police, firemen and first responders (EPA, 1992). Hospital workers may also be considered in this category. **This relaxation is for the immediate emergency phase only and does not include recovery or remediation phases.**

In the unlikely event that, high levels of radiation are encountered at the hospital, specific actions must be taken to limit the dose to rescue and hospital personnel. The optimal method of determining the hazard a critically injured, radioactively contaminated patient presents to hospital personnel is through a joint evaluation of the patient by both healthcare provider and radiation specialist trained in radiation protection (Smith, *et. al.*, 2005.)

It is conceivable that a RDD event could result in high radiation levels near the site of the event (within 500 m), but it is extremely unlikely, although plausible, that very high levels of radiation would be transported from the site to the hospital. (Musolino & Harper, 2006) Therefore, the radiation doses to hospital staff members could possibly exceed that of a normal day, but will mostly remain well within the normal regulatory guidelines.

Radiation Dose Limits for Extreme Circumstances

Although unlikely, it is possible that hospital workers will be confronted with a highly radioactive source, such as a highly radioactive piece of shrapnel impaled in a patient. Whether exact dose rates are known precisely or estimated, such exposures must be controlled by the surveying of patients and environment by persons knowledgeable in radiation safety. In addition, providers subject to such exposures should be volunteers and must be specifically counseled about the risk of the anticipated radiation dose. For example, a surgeon should be advised on the expected dose and stay time near the patient if he/she is required to remove a hot particle, radioactive fragment or piece of shrapnel, from a patient.

Recommended Occupational Exposure Limits in an Emergency for Hospital Staff

Operation	Dose guidance (NCRP,1993)
Life Saving in Extreme Conditions	Up to Whole body dose may exceed 50 rem And/or 500 rem to skin • Voluntary basis only • Personnel must be fully aware of risk involved
Urgent actions	< 5 rem
Recovery and Restoration Return to regulatory occupational and public limits	5 rem for radiation workers 100 mrem for general public

For life saving or equivalent activity, the NCRP (1993) allows doses approaching or exceeding 50 rem (0.5 Sv) whole body exposure and 500 rem (5 Sv) to the skin.

Generally, the threshold for acute effects of radiation is 100 rem (1Gy) (Gusev, 2001). The 50 rem (0.5 Gy) threshold provides a margin of safety by a factor of 2. While it is permissible to exceed the 50 rem (0.5 Gy) limit, it is preferable to rotate in a new volunteer. At 150 rem (1.5 Gy) acute fatalities begin to occur and rise sharply with higher doses.

At 50 rem (0.5 Gy) the excess lifetime risk of fatal cancer increases approximately 4 % over the 24% baseline risk (NAS/NRC, 1990). The margin of safety should also consider that a given individual may be more susceptibility to radiation and that the exact circumstances may not be understood at the time of such procedures. Therefore, if the provider develops symptoms such as nausea or vomiting, they should be removed from the area immediately and the situation should be reassessed.

Under conditions that may lead to doses above normal occupational exposure limits(5 rem for radiation workers and 100 mrem for general public), workers should be volunteers and should be instructed in dealing with radiation hazards to allow them to make informed decisions. Female workers who may be pregnant or nursing should not participate in these operations.

Radiation Safety Information Sheet for Staff Members

[*The following sheet may be used as a handout for staff members prior to a radiation incident*]

1. Is it safe to work if patients have radiation contamination from a "dirty bomb?"

Radiological Dispersal Device scenarios imply that hospital staff members have little risk of harmful radiation exposure when performing normal care of injured and ill patients who may be contaminated with radioactive material as long as they follow certain precautions:

- Wear Universal Precautions to prevent the contamination of skin;
- Minimize unnecessary time in radiation control areas (areas that are designated to treat patients that might have radiation contamination;
- Attempt to maintain distance from any radioactive source, even moving away by 1 foot can make a significant difference;
- If assigned a digital dosimeter (small meter used to display radiation levels) these should be worn in a place that can be easily read;
- Follow instructions given to you by hospital radiation safety staff; and
- DO NOT EAT OR DRINK IN RADIATION CONTROL AREAS – to take a break, staff should go to buffer areas, disrobe, wash hands, and get surveyed prior to eating. This is to prevent the accidental contamination of food or ingestion of radioactive material.

2. What are the risks of radiation exposure?

According to radiation protection guideline assumptions, even the smallest exposure has a theoretical tiny probability of causing a long term effect, such as cancer. For example, there is a hypothetical risk of cancer from receiving radiation from a single chest x-ray, the risk is so small that it impossible to statistically prove this. Every year, you as a New Yorker receive a small amount of radiation, called background radiation, just by working in the city, breathing air, living in a building or house, and other activities of normal life. This radiation is equivalent to about 12-15 chest x-rays a year, and this is considered a normal yearly exposure. Other activities, like smoking, can greatly increase ones annual dose of radiation.

On the other hand, very high radiation doses received in a short period may cause serious illness and even death. Acute effects (Deterministic) such as these are only seen when a certain thresholds are exceeded. For example, it would take the same amount of radiation that would used in 3,330 chest x-rays to reach the lowest threshold to cause mild radiation sickness. Please see the attached table for more examples of risks from radiation exposure.

The radiation doses to staff members involved in an emergency response are expected to be well below these thresholds and well within the annual range of radiation exposures. All attempts will be made to keep them well below what is considered low radiation exposure, or about 1/3rd of the annual dose everyone receives.

Radiation Exposure Doses and Health Consequences

The following table compares doses from commonly encountered radiation exposures to the doses required to cause acute radiation illness or recommended dose limits.

Radiation Dose* (rem)	Health Effect or Radiation Exposure
400 = 400,000 mrem	50 % die from radiation sickness if untreated (equivalent to 12,000 chest x-rays)
100 = 100,000 mrem	Threshold for Acute Radiation Syndrome Additional cancer risk 8%/100mrem (equivalent to 3300 chest x-rays)
75 = 75,000 mrem	Earliest onset of Radiation Sickness
30 = 30,000 mrem	Average dose Hiroshima Nagasaki survivors (equivalent to 1000 chest x-rays)
10 = 10,000 mrem	No Acute Effects Additional cancer risk less than 1% (equivalent to ~333 chest x-rays)
5 = 5000 mrem	Annual Occupational Dose Limit for Radiation Workers (equivalent to ~170 chest x-rays)
2.5 =2,500 mrem	5-hour transcontinental flight
1 = 1000 mrem	Radiation from an Abdominal CT Scan (equivalent to ~33 chest x-rays)
0.5 = 500 mrem	Annual Dose Limit for Pregnant Radiation Worker (equivalent to ~17 chest x-rays)
0.1 = 100 mrem	Annual Dose Limit for General Public (equivalent to ~ 3 chest x-rays)
0.03 = 30 mrem	Radiation from a standard Chest X-ray
2.5 mrem	Smoking 1 pack of cigarettes

Adapted from "Radiation and Risk," The University of Michigan Health Physics Web Site http://www.umich.edu/~radinfo/introduction/risk.htm Last Accessed October 11, 2007

*These doses are in addition to the normal background radiation dose of 360 mrem/year.

PERSONAL PROTECTIVE EQUIPMENT (PPE) DONNING AND DOFFING PROCEDURE

For a visual aide and training module on proper donning and doffing procedure go to REAC/TS Procedure Demonstration web site at http://orise.orau.gov/reacts/guide/procedures.htm and view, "Dressing to Prevent the Spread of Radioactive Contamination."

Donning Personal Protective Equipment

1. Personnel should dress in surgical clothing
    - Scrub suit and gown (cloth or papter) or Tyvek® overalls
    - Surgical mask with eye protection or face shield
    - Double gloves
        - Inner gloves under the arm cuff and secured by tape to the gown
        - Outer gloves should be easily removable and changed frequently
    - Head cover or bonnet
    - Waterproof shoe covers
    - Waterproof aprons or outer gowns for staff using liquids for decontamination or at risk for splash of liquids
2. Tape shut all open seams and cuffs using water-resistant heavy tape, such as duct tape or chemical decontamination suit tape.
3. Assign personal self-reading dosimeters to staff working closest with contaminated patients. Attach to outer garment where they can be easily removed and read.
4. Thermoluminescence Dosimeters (TLDs), also known as film badges, if worn, should be placed near the neck, under the surgical gown to avoid gross contamination. Consider dispensing these personal passive dosimeters to all staff members involved in response.

Doffing Personal Protective Equipment

Prior to exiting from a controlled area, personnel begin doffing at the control line, the border between controlled area and clean area, as described below:

1. Remove outer gloves first, turning them inside-out as they are pulled off.
2. Give dosimeter to radiation safety officer (or insure that reading is recorded)
3. Remove all tape at trouser cuffs and sleeves.
4. Remove outer surgical gown, turning it inside-out -- avoid shaking.
5. Pull surgical trousers off over shoe covers.
6. Remove head cover and mask.

7. Remove shoe cover from one foot and let radiation safety officer monitor shoe; if shoe is clean, step over control line, then remove other shoe cover and monitor other shoe.
8. Remove inner gloves.
9. Do total-body radiological survey of each team member.

Employee Radiation Exposure Worksheet

(Complete worksheet for each shift or day employee worked during radiation incident)

NAME________________SSN_____________ DATE: __________

DATE OF BIRTH______________ Gender _____ Possibly Pregnant Y N

DEPARTMENT _________________ Contact Information__________

Describe event, include isotope(s) involved, quantity or radiation, and date of incident:

Work assignment during the Emergency Period
__ direct patient care __ clerical __ security ___decontamination
__ environmental or radiation safety __ housekeeping
__ other please describe _____________________________________

Location of work

- __ Pre-Decon Area
- __ Decontamination
- __ Red Treatment Area
- __ Yellow Treatment Area
- __ Green Treatment Area
- __ Other, Please describe _____________________________________

Time started ___________ Time ended shift ______________

Note other events that might affect total dose (open wounds, splashed in face, etc.) ____

Dosimeter assigned Yes ___ NO ______

Type ___________________ #Serial No. ___________________
If digital, reading at beginning of shift ________________
If digital, reading at end of shift _________________
If film badge, date sent ____________ Reading _________________

Corrections and other adjustments___________________________

Results of Bioassays / thyroid monitoring if obtained _______________

Effective Dose Equivalent _______________________________

Significant Previous Exposure___________________________

TOTAL ACCUMULATED DOSE ____________________________

Name and title of person completing work sheet Date complete

Section 3: Radiation Control – Keeping Facilities Safe during a Radiation Incident

Section Contents:

Radiation Control General Recommendations

In the early phases of a disaster it is more important to detect the presence of radiation than to quantify the readings precisely. Radiation specialists may not be immediately available and front line clinicians will be required to assume radiation safety roles early in a disaster. Later, when the full radiological support team arrives, more accurate measures can be made. Until than the number one priority for radiation safety is identifying, if present, high radiation areas or hot spots from relatively low radiation areas.

While no official guidance exists to determine what radiation levels should used to demarcate the radiation control zones, the levels in this document are consistent with safe radiation control practices. It is also important to realize that homogeneous distributions of radiation exposure rates will not occur. Rather, one may anticipate so-called "hot spots", especially if highly radioactive fragments are transported from the scene, included as shrapnel imbedded into patients.

Procedures should be instituted to minimize radioactive contamination of the hospital recognizing that some contamination may be unavoidable. As a general principle, only patients with serious illness or injury should enter the hospital prior to optimal decontamination. Those patients entering the hospital prior to decontamination must have their clinical care and radiation decontamination accomplished simultaneously when possible.

Other patients should be treated in other care areas within or near the hospital after optimal decontamination. Patients triaged to other areas of care should not be transferred to the ED unless their clinical condition deteriorates and the alternative care areas are incapable of providing adequate care.

Plans should be in place for critical medical facilities and critical care equipment to continue functioning with low levels of radioactive contamination. (NCRP, 2005)

Radiation Control and Safety Team (RCST)

In order for hospitals to limit the amount of radiation contamination and to advise staff on the safest procedures for managing radioactive contaminated patients they will need multiple individuals trained in radiation control and safety practices. RCST should function using incident command language and structures. This team would be tasked with the duties of radiation surveying, maintaining radiation control areas, locating radiation zones, and advising staff of radiation control processes. Additionally, team members should be non-clinical staff, freeing providers to do direct patient care.

- A senior specialist (Radiation Safety Officer or similarly trained person) or designee should lead the radiological control response. If the senior specialist or designee cannot be physically present, another individual will have to assume these responsibilities. The Radiation Safety officer or designee should make real-time surveillance priorities during a disaster.

- Hospitals without capacity to provide these specialists must ensure that the staff members assigned to perform radiation screening and radiation safety roles during an incident can do so competently.

- Emergency Radiological Surveyors should be drawn from staff other than physicians and nurses if feasible.

- The Radiation Equipment to be used in a disaster must be maintained and tested.

- The Radiation Control and Safety Team should have between four and six Geiger-Mueller survey meters available during a disaster. Surveyors will be required to asses areas inside and outside to the hospital, patients, staff, and equipment. The job action sheets describe the tasks to be performed according to a geographic location and are available at the end of this section. The surveying roles to be considered, but not limited to, in the RCST include:

    - General Radiation Surveyor
    - Pre-Decontamination Radiological Surveyor
    - Post-Decontamination Radiological Surveyor
    - Red Control Treatment Area Surveyor
    - Yellow Control Treatment Area Surveyor
    - Green Control Treatment Area Surveyor

RCST Personnel

Emergency Management planners should assess their risk and available resources to determine the need and make-up of their own Radiation Control and Safety Team. Personnel who are knowledgeable about radiation and radioactivity can be drawn from the following professions according to the facility's resources in order to assist emergency planners with facility preparation, planning and response.

Radiation specialties and specialists to consider as potential members of the Hospital RCST include the following

- Radiation Safety Officer (RSO)
- Medical Physicists
- Health Physicists
- Nuclear Medicine physicians and technologists
- Radiation Oncology physicians and technologists
- Radiology professionals
- Medical School researchers with radiation control and safety training

Priorities of RCST Members

General Priorities for All RCST Members

1. Search for high radiation sources (any source that has a dose rate of > 100 mrem/hr at 1 foot) -- once found, these should be appropriately isolated, shielded, or removed as per radiation safety procedures

2. Coordinate with facility security on access to radiation control areas

3. Shield sources with high radiation levels

4. Minimize the contamination within control Areas and inform staff working in Areas of dose rates

5. Control the spread of contamination outside of control areas

6. Assess patients and staff for external contamination as frequently as possible

Pre-Decontamination Area Priorities

1. Conduct general radiological surveys to detect high levels of contamination (>100 mrem/hr) on arriving patients and vehicles with high activity sources on or in them

2. Identify and prioritize the radiation assessment of arriving patients including pregnant women and children(See Prioritization of Radiological Screening of Victims in Section 5)

3. Conduct **Rapid Radiological Survey** (see Rapid Radiological Screening Survey Procedure at end of Section 5.)**,** if time and equipment permit

4. Rapidly Survey patients going to the **RED Treatment Area** and assist with the removal and control of contaminated clothing

5. Rapidly asses the need for decontamination for patients whose rapid medical designation is **YELLOW** or **GREEN**

6. If the number of patients exceeds the capacity to conduct complete surveys on all patients in a timely fashion, surveyors can conduct rapid surveys (See Conducting a Rapid Radiological Screening Survey) above the waist and hands only

7. Empirically decontaminate patients obviously contaminated with debris from the explosion

Priorities in Post-Decontamination Area

1. Conduct post-decontamination survey using GM survey meter and Pancake probe (See Conducting Whole-body Radiological Survey at end of Section 5)

2. Repeat decontamination up to a total of 3 times if persistent contamination exceeds twice background (>200 cpm). Readings of < 1,000 counts per minute are acceptable as not requiring further decontamination if:

    - Additional decontamination is not feasible

    - Additional decontamination does not reduce contamination

- The patient has undergone whole body decontamination 3 times.

3. Document final post decontamination result

Priorities within Radiation Control Treatment Areas

1. Survey environment for radioactive contamination
2. Control the spread of contamination (See General Radiation Control Practices below)
3. Assist with the monitoring of contaminated wounds or patients with embedded high activity fragments while procedures are being conducted
4. Survey patients and staff members entering and leaving treatment areas and document results
5. Document contamination levels, if persistent, of patients admitted to the hospital or discharged
6. Advise staff working in treatment areas on appropriate radiation safety and control practices.

General Radiation Control Practices for All Treatment Areas

Evacuation of the Emergency Department and preparation of the area for the arrival of new patients should follow established HICS guidelines. Planning principles for a radiation contamination event include prioritizing clinical status over radiation concerns, while including measurements to minimize contamination of the facility. Additional radiation control and safety practices include the following:

- **Secure entry points with hospital security**

Establish a control line at the entrance to the treatment and decontamination areas. Clearly mark the area to differentiate the controlled (contaminated) from the non-radiation controlled (uncontaminated) side.

- **Set up controlled treatment areas large enough to hold the anticipated number of victims**
- **Cover traffic area floors and treatment areas**

If time permits, securely tape durable non-slip covering to the floor. Clearly mark the area to prevent unauthorized entry. Placing floor covering should not delay urgent or emergent medical care.

- **Restrict Access to Decontamination and Treatment Areas**

Use strict isolation precautions, including protective clothing and double bagging discarded items, clothing, and waste. In addition, establish a buffer Area or control line.

- **Monitor *anyone* or *anything* leaving the controlled areas**
- **Frequently monitor/survey controlled treatment areas**

Frequent environmental monitoring is recommended ensure that high contamination or hot sources are found and limited. Results of surveys should be posted and visible to all staff

- **Prepare Survey Instruments**

Check Survey instruments including batteries. Surveyor should document background radiation levels. Monitor anyone or anything potentially contaminated within the area and anyone or anything leaving a controlled area.

- **Cover equipment and stretchers**

Cover all equipment in treatment areas. Protect stretchers with several layers of waterproof, disposable sheets.

- **Manage waste**

Prepare multiple waste containers. Control waste by using large, plastic-lined containers for clothing, linens, dressings, etc. They should be at least double bagged and changed frequently to accommodate a large quantity of potentially contaminated clothing and other material. Label containers RADIOACTIVE WASTE.

- **Change instruments, outer gloves, drapes, etc., when they become contaminated**
- **Use waterproof materials to limit the spread of contaminated liquids**; for example, waterproof aperture drapes
- **Manage contaminated water spills**

Do not allow potentially contaminated water to collect in pools or spread. Mops may simply spread the contamination, and contaminated mops should be impounded. Absorbing small quantities into absorbent pads may be effective. A wet vacuum may be useful to remove pools as well.

- **Limit movements of patients and visitors in radiation control areas**

Restrict the movement of patients and visitors within and between controlled treatment areas to limit any unnecessary radiation contamination.

Red Radiation Control Treatment Area Special Considerations

This area is for patients too seriously injured to undergo routine decontamination. These patients may or may not be contaminated with radioactive material. Therefore, procedures should be instituted to minimize the potential spread of radioactive contamination. All staff should wear protective clothing and dosimeters in this area. Patients should be surveyed and decontaminated simultaneously with clinical care if possible.

1. Conduct operations as a potentially contaminated area

2. If time permits, specifically prepare buffer areas according to number of patients expected and contamination potential. This may not be feasible in a mass casualty incident and such measures should not delay care of the patients.

3. Remove all non-essential supplies

4. Cover other equipment with sheets or plastic wrap

5. Floor covering should be considered
    - Avoid slippery or flimsy material
    - Temporary floor covering should be tapped down
    - Recognize that most clinical areas are covered with washable tile material which can be replaced at relatively low cost

6. **All emergent patients arriving without prior decontamination should have clothing removed, at a minimum, and placed on a clean stretcher prior to entry into area.**

7. Seriously injured or ill patients should be surveyed for contamination simultaneously with stablization

8. Screen staff and patients leaving potentially contaminated areas

9. Red Treatment Area assigned radiation surveyor should make frequent environment survey sweeps of the area at least every 30 minutes and post the results for staff

10. Any elevated radiation areas should be (> 100 mR/hr) should be marked off and appropriate signage posted

YELLOW Radiation Control Treatment Area Special Considerations

Most of the sick patients should come to the yellow area. This area should be capable of advanced clinical care, especially for respiratory illness, eye irritation, orthopedic injuries and open wounds. Patients coming to the Yellow area should have maximum decontamination to the extent feasible by their clinical condition and available resources.

1. All patients coming to this area should be pre-screened for radiation contamination and should be decontaminated if necessary prior to arrival. They also should be screened prior to leaving this area.

2. Only under extreme circumstances should patients be moved from this area to the RED Area. There should be limited movement of patients from clean or low contaminated areas to areas with potentially higher levels of contamination, such as the RED Area.

3. Intensive care units, Operating rooms and hospital wards should accept and receive patients from this area.

4. If the Yellow Radiation Control Area is the location that patients with open wounds with potential radioactive contamination are treated, then the procedure should be conducted in teams of clinicians and radiological surveyors.

GREEN Treatment Area Special Considerations

Victims who are concerned about contamination but who are neither physically ill nor significantly injured should be evaluated in an additional area designated to address concerns about radiation contamination, exposure and risk.

1. The Green Area, if remote from the emergent and urgent clinical treatment areas, should be capable of providing minor treatment care and evaluation if the patient decompensates clinically.

2. The area should be staffed with fewer physicians, more psychosocial support staff, and individuals prepared to discuss radiation exposure and the psychological consequences of the event.

3. Victims should have basic radiation screening and assessment to determine the need to perform decontamination prior to entering this area.

Radiation Safety Officer Responsibilities

Planning

- The Radiation Safety Officer will be responsible for radiological safety including general surveillance over all activities involving radioactive material and determining compliance with rules and regulations.

- The Radiation Safety Officer or designee will conduct training programs for all staff who potentially may use radiation safety equipment, as well as those who are at risk for receiving a significant radiation dose in a disaster.

- The Radiation Safety Officer or designee will perform checks on survey equipment and review the radiation safety program annually.

Response

- The Radiation Safety Officer or designee will advise the incident commander about issues related to a radiological disaster and oversee the radiation control team.

- If the Radiation Safety Officer is not immediately available to respond to a disaster other staff members will assume radiation monitoring duties.

Recovery

- The Radiation Safety Officer is responsible for providing advice regarding, safe handling, monitoring, and disposal of all radioactive sources.

- The RSO will obtain records of personnel exposure for all significantly exposed staff members and will notify individuals of their exposures.

GENERAL RADIOLOGICAL SURVEYORS

Job Action Sheet

Mission: To monitor treatment areas and individuals for radiation contamination

Immediate

- ____ Receive appointment
- ____ Read this entire Job Action Sheet
- ____ Review organizational chart for radiation incidents
- ____ Wear position identification vest
- ____ Obtain briefing from Treatment Area Supervisor
- ____ Put on personal dosimeter, record reading if not at zero
- ____ Establish control Areas according to protocol
- ____ Sign out survey meter
- ____ Assure that there are adequate bags for radiation waste such as personnel clothing in the hot Area and red treatment area
- ____ Ensure survey meter and probe are in protective covering

Intermediate

- ____ Meet with the Treatment Area Supervisor
- ____ Perform Background Check
- ____ Screen victims for contamination
- ____ Survey open wounds
- ____ Monitor patients within treatment area
- ____ Monitor area frequently and post readings
- ____ Survey patients and document findings before leaving the treatment areas
- ____ Assist with surveying staff leaving treatment areas
- ____ Advise staff on proper radiation safety practices

Extended

- ____ Complete paperwork
- ____ Ensure appropriate transfer of dosimeters and survey meters as team members change shifts
- ____ Assure proper functioning of dosimetry and metering equipment
- ____ Conduct background readings in area of no known contamination
- ____ Attend post-event debriefing
- ____ Other concerns: ________________________

PRE-DECONTAMINATION RADIOLOGICAL SURVEYORS

Job Action Sheet

Mission: General survey of patients following rapid medical visual assessment
(*Prior to clothing removal)*
Environmental survey in the pre-triage area
DETECT HIGH ACTIVITY SOURCES
PRIORITIZE PATIENTS PRIOR TO DECONTAMINATION

Immediate

____ Receive appointment
____ Read this entire Job Action Sheet
____ Review organizational chart for radiation incidents
____ Wear position identification vest
____ Don appropriate PPE as assigned
____ Obtain briefing from Treatment Area Supervisor
____ Put on personal dosimeter, record reading if not at zero
____ Sign out Geiger-Mueller survey meter
____ Perform Background Check of Pre-Decontamination area
____ Ensure survey meter and probe are in protective covering

Intermediate

____ Survey the pre-triage area and arriving patients for high activity sources (see Rapid Radiological Survey of Crowds Procedure)
____ Isolate and shield any high activity sources if found
____ Conduct RAPID RADIOLOGICAL SCREENING SURVEY (see Rapid Radiological Screening Survey Procedure)

1. Perform Rapid Survey with clothes on
2. If Radioactivity found refer to Decontamination Area
3. If no radiation is found refer to previously designated clinical area

____ Prioritize patients for decontamination
____ Routinely screen areas where discarded clothing and belongings are kept for increasing radiation levels—follow hospital procedures and report to radiation safety if levels are above 100 mrem/hr

Extended

____ Complete paperwork
____ Assure proper functioning of dosimetry and metering equipment
____ Assure appropriate transfer of dosimeters and survey meters as team members change shifts
____ Ensure proper functioning of meter
____ Attend post-event debriefing
____ Other concerns: ________________________

POST-DECONTAMINATION RADIOLOGICAL SURVEYORS

Job Action Sheet

Mission: Survey patients following decontamination for persistent contamination to determine if decontamination is adequate to proceed to clinical areas

Use a pancake style Geiger-Mueller detector probe.

Immediate

_____ Receive appointment
_____ Read this entire Job Action Sheet
_____ Review organizational chart for radiation incidents
_____ Wear position identification vest
_____ Don level D PPE (See Donning and Doffing Procedure)
_____ Obtain briefing from Treatment Area Supervisor
_____ Put on personal dosimeter
_____ Sign out hand held Geiger-Muller survey meter
_____ Perform Background Check
_____ Ensure survey meter and probe are in protective covering

Intermediate

_____ Screen patients as they emerge from Decontamination Shower (see Conducting Whole-Body Radiological Survey)
_____ Direct for repeat decontamination shower or to designated clinical area
_____ Complete Post-Decontamination Survey Sheet for each patient
_____ Monitor decontamination team at completion of shift

Extended

_____ Complete paperwork
_____ Ensure appropriate transfer of dosimeters and survey meters as team members change shifts
_____ Ensure proper functioning of dosimetry and metering equipment
_____ Conduct background checks in area of no known contamination
_____ Attend post-event debriefing
_____ Other concerns: ________________________

RED AREA RADIOLOGICAL SURVEYORS

Job Action Sheet

Mission: To monitor treatment areas and individuals for radiation contamination
Use a pancake style Geiger-Mueller probe

Immediate

____ Receive appointment
____ Read this entire Job Action Sheet
____ Review organizational chart for radiation incidents
____ Don level D PPE (See Donning and Doffing Procedure)
____ Wear position identification vest
____ Obtain briefing from Red Treatment Area Supervisor
____ Put on personal dosimeter
____ Sign out hand held Geiger-Muller survey meter
____ Ensure that there are adequate bags for radiation waste such as personnel clothing in the hot Area and red treatment area
____ Perform Background Check of Red Treatment area
____ Ensure survey meter and probe are in protective covering

Intermediate

____ Meet with the Treatment Area Supervisor
____ Monitor patients arriving within treatment areas for radiation
____ Document areas of contamination for on patients
____ Monitor staff within treatment area
____ Survey open wounds
____ If elevated radiation readings are found within Red Treatment area mark areas and post results
____ Survey staff and equipment entering and exiting area
____ Survey equipment and accumulated trash
____ Frequently monitor Red Treatment Area and post results
____ Survey patients and document findings before leaving the treatment areas
____ Advise staff on proper radiation safety practices

Extended

____ Complete paperwork
____ Ensure appropriate transfer of dosimeters and survey meters as team members change shifts
____ Ensure proper functioning of dosimetry and metering equipment
____ Conduct frequent background checks in area of no known contamination
____ Attend Post-Event debriefing
____ Other concerns: ________________________

YELLOW AREA RADIOLOGICAL SURVEYORS

Job Action Sheet

Mission: To monitor yellow treatment areas and individuals for radiation contamination

Use a pancake style Geiger Mueller probe

Immediate

- ____ Receive appointment
- ____ Read this entire Job Action Sheet
- ____ Review organizational chart for radiation incidents
- ____ Don level D PPE (See Donning and Doffing Procedure)
- ____ Wear position identification vest
- ____ Obtain briefing from Treatment Area Supervisor
- ____ Put on personal dosimeter
- ____ Sign out hand held Geiger-Muller survey meter
- ____ Make sure that there are adequate bags for radiation waste such as personnel clothing in potentially contaminated areas
- ____ Perform Background Check
- ____ Ensure survey meter and probe are in protective covering

Intermediate

- ____ Meet with the Treatment Area Supervisor
- ____ Monitor patients within treatment area
- ____ Survey open wounds
- ____ Identify highly active radioactive fragments especially in open wounds
- ____ Frequently monitor Yellow Treatment Area and post results
- ____ Survey staff, patients and equipment leaving the treatment areas
- ____ Advise staff on proper radiation safety practices

Extended

- ____ Complete paperwork
- ____ Ensure appropriate transfer of dosimeters and survey meters as team members change shifts
- ____ Ensure proper functioning of dosimetry and metering Equipment
- ____ Conduct background checks in area of no known contamination
- ____ Attend post-event debriefing
- ____ Other concerns: ________________________

GREEN AREA RADIOLOGICAL SURVEYORS

Job Action Sheet

Mission: To monitor treatment areas and individuals for radiation contamination

Use either General Geiger-Mueller Survey Tube or Pancake Probe

Immediate

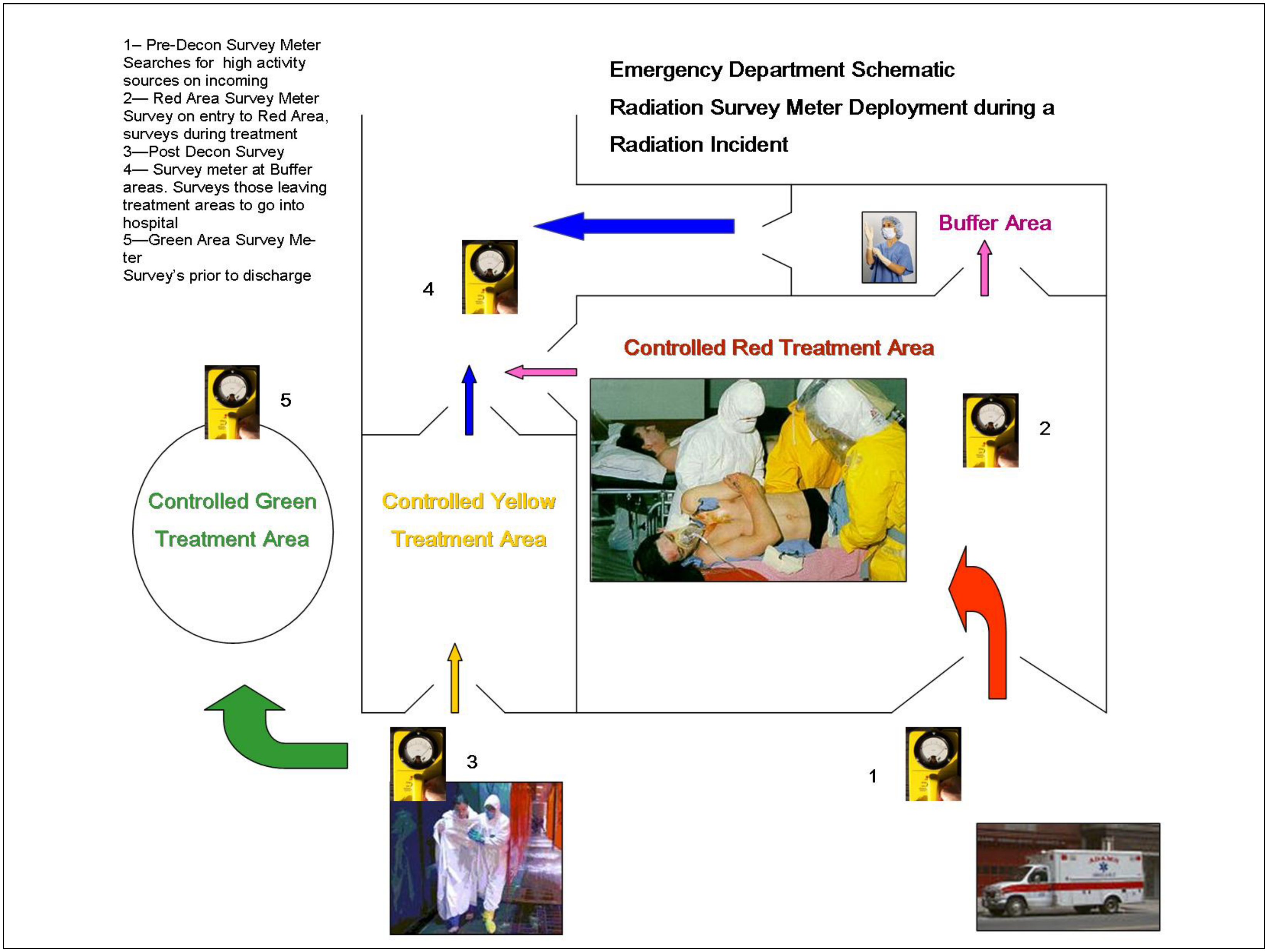
_____ Receive appointment
_____ Read this entire Job Action Sheet
_____ Review organizational chart for radiation incidents
_____ Wear position identification vest
_____ Obtain briefing from Treatment Area Supervisor
_____ Put on personal dosimeter
_____ Sign out hand held Geiger-Muller
_____ Perform background check
_____ Ensure survey meter and probe are in protective covering

Intermediate

_____ Meet with the Treatment Area Supervisor
_____ Monitor patients within treatment area
_____ Thoroughly screen victims for contamination prior to discharge and document results
_____ Survey open wounds
_____ Survey staff, patients and equipment leaving the treatment areas
_____ Assist other Surveyors especially post-decontamination screener
_____ Advise staff on proper radiation safety practices

Extended

_____ Complete paperwork
_____ Ensure appropriate transfer of dosimeters and survey meters as team members change shifts
_____ Ensure proper functioning of dosimetry and metering equipment
_____ Conduct background checks in area of no known contamination
_____ Attend Post-Event Debriefing
_____ Other concerns: _______________________


1– Pre-Decon Survey Meter
Searches for high activity sources on incoming
2— Red Area Survey Meter
Survey on entry to Red Area, surveys during treatment
3—Post Decon Survey
4— Survey meter at Buffer areas. Surveys those leaving treatment areas to go into hospital
5—Green Area Survey Meter
Survey's prior to discharge
Emergency Department Schematic
Radiation Survey Meter Deployment during a
Radiation Incident
Buffer Area
4
Controlled Red Treatment Area
5
2
Controlled Green
Treatment Area
Controlled Yellow
Treatment Area
3
1

What to Do if Elevated Radiation Levels are Encountered

During the frequent surveys of different areas, surveyors may encounter elevated dose rates indicating levels of radiation that may require special attention by staff. If the source(s) causing this does rate is not able to be isolated and shielded, then the surveyor will need to mark off the area, post appropriate signage, and advise staff of the activities that can take place in the area, also known as a radiation zone. These zones may change as people and equipment move throughout areas. Additionally, the zones may be small. **These zones are important only for incidents involving penetrating radiation (gamma or photon emitting radionuclides). Radiation zones are not the same as radiation control treatment areas.**

As an Example How to Use this Table: A patient may arrive in the RED Control Treatment Area with an embedded radioactive source. While conducting a radiation survey of the supine patient, the surveyor may find dose rates as high as 200 mrem/hr (Medium Radiation Zone) within 1 foot of the stretcher. The surveyor must alert staff caring for the patient of this dose rate, and advise staff to increase distance from patient except for necessary treatments, stretcher should be labeled as a Medium Radiation Zone, and surveyor should remain to give real time readings as staff attempt to locate and isolate the radioactive source(s) emitting this dose rate.

These are the recommended dose rates to utilize ***during the emergency phase of a radiation incident.***

Radiation Zones, Stay Times, and Suggested Activities for Each Zone During the Immediate Phase of a Radiological Contaminating Incident with a Gamma Emitter (CRCPD, 2006)

RADIATION ZONE	Dose Rate mR/hr	Stay Times	Radiation Control Activities
Extreme Caution High risk of Acute Radiation Syndrome	$\geq$ 10,000	Minutes to hours (only for life saving activities) Staff or patient would receive an occupational dose limit in 30 min.	• Time limited rescue operations only • Only extreme need • Planned entry and exit required • Alarming Dosimeters • Only staff over 40 years of age and volunteers • Real time RSO Guidance
High-Radiation Zone	1000-<10,000	30 min – 5 hours At 1000 mR/hr staff would need to stand for 5 hours in order to	• Critical tasks only • Staff should be advised of the amount of time they can spend in the area

		receive 5 rem. They would need to stand for over 50 hours to begin to see changes in blood cell counts.	• Alarming Dosimeters • Real time RSO Guidance
Medium Radiation Zone	100- <1000	5– 12 hours At 100 mR/hr staff would need to stand for 50 hours in this location in order to receive 5 rem = the occupational dose limit for radiation workers	• Restrict to only those required to care for patient(s) in area • Dosimetry for all working in this area • Real time RSO Guidance
Low Radiation Zone ***It is expected that this dose rate may be the highest dose rate in hospital areas after an RDD.***	2 -100	Full 12 hour Shift Staff would need to stand for 500 hours or more in this location in order to receive 5 rem = the occupational dose limit for radiation workers.	• Restrict access to only those required to care for patient(s) in area • Personal Dosimeters recommended • RSO assesses frequently
Not controlled	< 2	2mrem over one hours is the allowed dose for unrestricted areas for the public (EPA).	• Contamination may still be present
Background	<0.1		• No restrictions • Unlimited access

Section 4: Triage and Patient Flow during a Radiation Incident

Section Contents:

- **Introduction Triage**
- **Medical Triage**
- **Radiological Triage**
- **Prioritization of Screening of Radiation Contaminating Victims**
- **Hospital Triage Process for Arriving Victims of Contamination Radiological Incident**
- **Summary Flowchart of Radiation/Medical Triage**
- **Flow Charts of Radiation Control Treatment Areas Activities**
    - **Red**
    - **Yellow**
    - **Green**
- **Conducting a Rapid Radiological Survey of Crowds**
- **Conducting a Rapid Radiological Screening Survey**
- **Conducting a Full-Body Radiological Survey on an Ambulatory Person**
- **Post Decontamination Survey Sheet**

Introduction to Triage

Triage is the processes of sorting and allocating resources according to clinical need and availability of resources. When clinical capacity is adequate to meet needs, triage is straightforward process. When the need exceeds clinical capacity, triage becomes more complex.

An important consideration when assessing priorities during an event is that the patients who arrive first are generally not the sickest, but rather the most mobile. It is essential to avoid exhausting limited clinical resources on those who arrive early.

Hospitals must asses their surge capacity and implement strategies for managing resources.

Medical Triage

Medical injuries and illness take priority over radiation injuries or illness due to the fact that radiation illness or injuries, if incurred, develop over time and do not require immediate intervention. (NCRP, 2005)

Radioactive contamination or radiation exposure is rarely an immediately life-threatening event. Stabilizing the severely ill and injured should always take precedence over radiological assessment and decontamination.

When the number of potential victims exceeds capacity the first contact should be a rapid medical triage based on visual inspection of the victims.

Performing Rapid Medical Triage

An experienced clinician should be stationed forward as the initial clinical contact. This clinician will be capable of sorting patients into the three designated treatment areas on the basis of brief inspection. This clinician should be wearing level C PPE unless the contaminant is known to only be radiation then level D PPE may be appropriate. Most of these decisions can be made in a few seconds for each patient. It is critical that this step does not bog down from excessive deliberation or indecision.

Red: **(**Medical Emergency)

- Patients seriously ill or injured requiring immediate attention
- Bypass decontamination shower
- Remove the patient's clothing and cover with a clean sheet while moving into the critical care area.

Yellow: (Medical Urgency)

- Patients should undergo rapid radiological triage
- Decontaminate as completely as feasible before entering the Yellow Area

Green: (Ambulatory with or without minor illness or injury)

- Direct to thorough radiological survey if indicated
- Decontaminate as completely as feasible before entering the Gree Area

- Consider limited decontamination if there are overwhelming numbers of individuals triaged as Green then decontamination may be more limited. For example, after a rapid radiological screening finds not hot spots, then only hands and face may be washed and a change of clothing provided. Or if after a radiological survey finds contamination to be if less than 200cpm, the patient may be directed to decontaminate at home.

Radiological Triage

Radiological Triage is the term used here to sort arriving victims from a radiological contaminating incident based on their risk of having significant radiological contamination. This triage function is performed primarily by the Pre-Decontamination Surveyor.

I. The first priority of radiological triage is to identify High Radiation Sources (Hot Particles), if present.

These particles, if not found early and shielded, can place the patient, surrounding people and staff at risk for acute radiation injury**. See Conducting a Rapid Radiological Survey or Crowds at end of section.**

II. The second priority of radiological triage is to identify persons with significant radioactive contamination (>10,000 cpm, or 5 mrem/hr) that requires quick decontamination and possible assessment for internal contamination.

If the number of casualties is not large, every patient should undergo a thorough evaluation with a Geiger-Mueller survey meter (**See Conducting a Full-Body Radiological Survey on an Ambulatory Person**). However, if the number of patients exceeds the capacity to conduct meticulous survey on every patient in a timely fashion then conducting a rapid screening survey is suggested (**See Conducting a Rapid Radiological Screening Survey**). The initial rapid survey in the pre-decontamination area should focus on detecting highly active sources and highly contaminated individuals, and should direct patients to either the decontamination area or alternative survey areas.

III. The third priority of radiological triage is to assess the pre-decontamination area.

This is to detect high activity sources (hot particles) that may have been brought in by vehicles, shoes or other methods of transport.

Prioritizing Radiological Screening of Victims

Even if hospitals have equipment and knowledgeable staff to conduct radiological triage, there may still be too many patients arriving at one time and staff will need a prioritization scheme to best utilize resources. The prioritization scheme attempts to sort out patients with the highest risk for radiological contamination, both internal and/or external, and with the highest risk for radiation injury. This scheme may also be useful for determining which patients should receive priority consideration for other radiation assessment, screening procedures/specialized lab tests, and radioactive counter measures before objective laboratory tests are available. The medical management and evaluation will be discussed in Part II of the Guidance.

1. **Patients with serious injury or illness related to the incident**

   For an explosive incident, these individuals were most likely closest to the epicenter, with the highest levels of radiation exposure. All of these patients will probably require hospital admission, which will allow clinicians ample time for patient observation and collection of 24 hour urine samples and performance of serial Complete Blood Counts (CBC) tests. Patients with the rapid onset and persistence of vomiting are of special concern for the possibility of significant radiation exposure. All patients in this category may require assessment for internal contamination.

   Note: Open wounds must be rapidly assessed to exclude high activity fragments.

2. **Patients with moderate or minor injury or illness related to the incident**

   As in the case of the more seriously injured, these individuals are at a higher risk of radiation contamination due to their proximity to the incident. Most of these patients will not require hospital admission, but may require assessment for radiation contamination and exposure.

3. **Persons with no physical injury but with facial and/or upper body contamination**

   Facial and upper body contamination may indicate that the patient inhaled radioactive contamination and may have internal contamination that requires treatment.

4. **Children <18 years old of age and pregnant women in proximity (500 meters) to the event**

5. **All other individuals without physical injuries**

   Direct to alternative care area to obtain demographics, counseling and assessment

An example of how this prioritization list might be utilized is if surveying rapidly is not possible, due to an overwhelming number of patients or the lack of equipment, then staff may rely only on visual observation and prioritize arriving patients in order to determine who must undergo decontamination first.

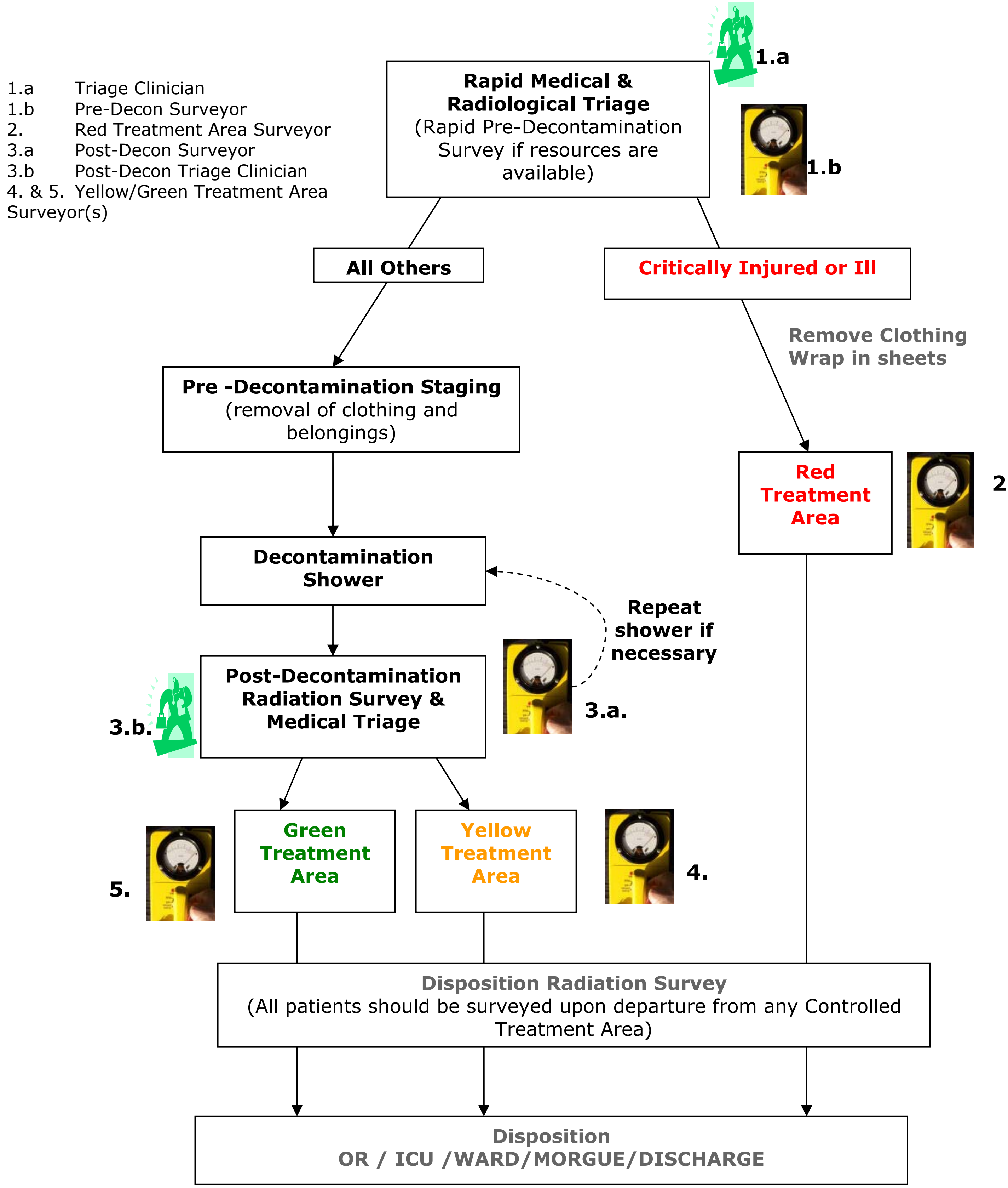
Hospital Triage for Arriving Victims of Contamination Radiological Incident

The following steps require a minimum of 3-5 survey meters and staff trained on their use. Additional staff will be required for medical triage, assisting with pre-decontamination staging area, decontamination showers, and security.

1. Patients arrive via ambulance, on-foot, or other method of transportation.
2. Initial, rapid medical triage conducted by trained clinician in full decontamination PPE. This triage may be visual or based on other agreed upon triage screening tool such as START or JUMPSTART.
    a. **RED** Significantly injured or ill, with life threatening injuries, bypass conventional triage and are sent to **RED CONTROL TREATMENT AREA**. Prior to entry, clothing should be removed and patient should be transferred to a clean stretcher. The Red Treatment Area Surveyor should conduct a radiation survey simultaneous with stabilizing medical treatment.
    b. All others are sent to Pre-Decontamination staging area
3. Pre-decontamination surveyor, also in full decon PPE, will assess arriving victims for high activity sources, and if time permits, conduct rapid radiological screening surveys. The following individuals should receive priority for decontamination showers:
    a. Moderately injured/ill victims should go to head of the decontamination line (if possible, all wounds should be covered with water proof dressing, and decontaminated in treatment areas);
    b. Visual or measured facial or upper body contamination (especially if >10,000 cpm or 5 mrem/hr) without injury should also receive priority for decontamination; and,
    c. Children and pregnant females.
4. Post-decontamination survey should be conducted by the Post-Decontamination Surveyor. These surveys should be documented. (**See Post-Decontamination Survey Sheet**).
    a. If contamination is still present and > 200 cpm = 0.1 mrem/hr (this may be raised to 1000 cpm if the arriving group is large) then patient should be redirected to shower again if their medical condition will allow this.
    b. Continue process until 1) survey indicates level below 200 cpm or 2) unable to decrease contamination or 3) at least 3 showers have been conducted.
    c. If < 200 cpm, then patient to be medically triaged by a clinician to **YELLOW** or **GREEN CONTROL TREATMENT AREAS**.
5. In each treatment area, patients should be frequently medically reassessed and up-triaged if their condition deteriorates.
6. In each treatment area, prior to discharge or disposition, all patients should have a repeat and documented Disposition Radiological Survey (**See Post**

Decontamination Survey Sheet) as well as necessary follow up instructions, necessary treatment, and counseling.

Summary Flow Chart of Triage Process for a Contaminating Radiation Incident



RED TREATMENT AREA ACTIVITIES

Rapid Medical Triage
RED

Remove clothing of victim and screen for high activity sources prior to entry

Red Control Area

Activities

- Conduct all Operations as a potentially contaminated area
- Emergent, stabilizing medical treatment
- Secure and shield any "hot" radioactive particles, if found
- Decontaminate patient as feasible
- Establish radiation control zones within treatment area, if needed
- Personal dosimeters for all staff working in Red Control Area
- Assess all wounds for contamination
- Potentially evaluate for internal contamination
- Counseling & education of all victims
- Survey all staff and patients when exiting area and record results

Operating Room or Intensive Care

Repeat Radiological Survey Prior to Exiting

Hospital ward or Discharge

Morgue

YELLOW TREATMENT AREA ACTIVITIES

Rapid Medical Triage
YELLOW

Decontamination

Yellow Control Area Activities

- Conduct all Operations as a potentially contaminated area
- Standard medical treatment
- Screen for persistent contamination
- Establish radiation control zones
- Personal dosimeters for all staff working directly with any contaminated patients
- Assess all wounds for potential contamination
- Collect contaminated irrigation fluid if wounds are irrigated
- Secure and shield any "hot" radioactive particles, if found
- Consider evaluating patient for internal contamination
- Frequently reassess medically and up-triage if condition deteriorates
- Counseling and education
- Survey all staff and patients when exiting and record results

Admission

Repeat Radiological Survey Prior to Exiting

Discharge

GREEN TREATMENT AREA ACTIVITIES

Rapid Medical Triage
Green

Decontamination

Green Control Area Activities

- Conduct operations as a potentially contaminated area
- Medical treatment if needed
- Reassess medically and up-triage if condition deteriorates
- Survey all staff and patients when exiting and record

Potential Exposure or Contamination

- Consider Assessment for Internal Contamination

No Radiation Exposure or contamination

DISCHARGE INSTRUCTIONS

- Follow-up information as appropriate
- Educational material
- Counseling

Conducting a Rapid Radiological Survey of Crowds Procedure

1. Don appropriate PPE

2. Obtain appropriate security

3. Obtain and check radiation survey meter

    a. Use a Survey meter with NaI scintillation detector if available (see Section 6. Equipment for Radiation Incidents)

    b. Use General GM meter with standard probe otherwise (see Section 6. Equipment for Radiation Incidents)

    c. Begin survey with the meter on most sensitive scale and reduce gain setting if meter saturates

    d. Keep the detector covered with a thin "exam" type of glove to prevent contaminating it

4. Survey crowd or area from a distance, first walking around the crowd with sound turned "on"

5. If source is detected, isolate and move contaminated individual away from the crowd and prioritize care

6. If isolated sources are found, such as on shoes or in clothing, secure or shield isolated sources, remove to distance from group. Do not handle sources with hands, use instruments

7. Prioritize identification of injured, obvious facial and upper body contamination, and children and pregnant women

8. Rapidly survey personnel, equipment and ambulances from the rescue scene for high activity sources

9. Frequently monitor/survey assigned areas, especially areas where discarded clothing, contaminated supplies, linens, or waste may accumulate, to ensure that high contamination radiation levels or hot sources are found and shielded

Conducting a Rapid Radiological Screening Survey Procedure (CRCPD, 2006)

Note that if there are large numbers of people, you may need to perform a limited screening survey, rather than a more detailed survey

1. Hold the survey meter probe about 1-2 inches away from the body (instead of half an inch to insure meters do not become contaminated)

2. Move meter probe 2-4 inches/second. (If the probe is moved too quickly, its detection capability may be reduced.)

3. Surveyor scans the face, hands, and shoulders using a standard radiation survey instrument.

4. If the meter results are positive, then the patient is directed to the decontamination area. Following decontamination a second surveyor should perform a thorough survey documenting contamination levels.

5. Following the secondary (post-decontamination) survey, the patient may require additional decontamination, in which case the patient is returned to the decontamination area.

6. If the post-decontamination survey is negative or if further decontamination is impractical the patient is directed to their designated clinical area.

COMMON MISTAKES TO AVOID:

- Holding the probe too far away from the surface. Probe should be 1-2 inches away for rapid, and ½ inch for detailed survey.
- Moving the probe too fast.
- Contaminating the probe. Probe background should be observed and compared to initial background. Wrapping probe in plastic wrap will help to prevent surface contamination.

Conducting a Full-Body Radiological Survey on an Ambulatory Person Procedure

Adapted from REAC/TS http://orise.orau.gov/reacts/guide/detect.htm

Survey using a Typical Geiger-Mueller (GM) Counter to Survey

Prepare the Meter:

1. Position the Geiger counter with the meter away from you.
2. Locate and open the battery compartment.
3. Put the batteries in the meter using proper orientation (up/down).
4. Close and latch the battery compartment.
5. Check the batteries using the "range" switch or "bat" button; the method depends on the type of instrument. The meter needle should move to area on scale marked battery, indicating the batteries are good. If the batteries are not good, find a flashlight or other source of 2 D-cells and put them in the meter -- check these batteries also.
6. Turn the "F/S" switch to "S" (Slow).
7. Turn the "audio" switch to "ON."

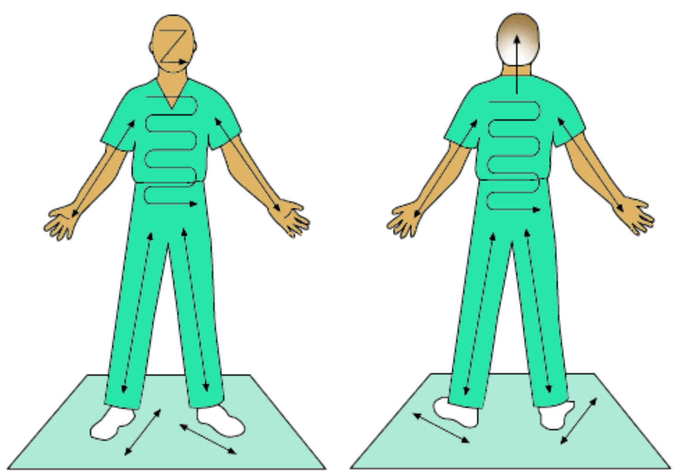
Measure Background Radiation:

1. Check that the "F/S" switch is on "S" (Slow).
2. Move the range switch to the most sensitive position.
3. Remove the probe cover if one is in place.
4. Measure the background radiation for 60 seconds: write down the reading. Since background radiation varies with time, it may be desirable to make several counts and average the results. Record the reading.
5. Expect a reading of 40-100 cpm or a reading of approximately 0.02 mR/hr (i.e. 0.2 on the 0.1 range setting), or 0.2 micro Sv/hr.
6. Record background reading.

Conduct the Survey:

1. Have the person stand on a clean pad.
2. Instruct the person to stand straight, feet spread slightly, arms extended with palms up and fingers straight out.
3. Move the "F/S" switch to "F" (Fast response).
4. Set the instrument selector switch to the most sensitive range of the instrument.
5. Holding the probe approximately 1/2 to 1 inch from the person's skin, systematically survey the entire body from head to toe on all sides.
6. Monitor both hands and arms; then repeat with hands and arms turned over.
7. Starting at the top of the head, cover the entire body, monitoring carefully the forehead, nose, mouth, neckline, torso, knees, and ankles.
8. Have the subject turn around, and repeat the survey on the back of the body.
9. Monitor the soles of the feet.
10. Move the probe slowly (about 1 inch per second).
11. Do not let the probe touch anything.
12. Try to maintain a constant distance.

13. Pay particular attention to hands, face and feet.
14. Note that some GM instruments cannot detect alpha radiation and some low-energy beta radiation. Because alpha radiation is non-penetrating, it cannot be detected through even a thin film of water, blood, dirt, clothing, or through probe cover.
15. *An increase in count rate or exposure rate above background indicates the presence of radiation.*
16. Locate the point that produces the most clicks. (Turn the "F/S" switch to "S" to take a reading at this location. Remember to reset it to "F" before continuing survey.)
17. When necessary, adjust the range of the instrument by moving the range selector switch.
18. Document time and radiation measurements.
19. In general, **areas that register more than twice the previously determined background level are considered contaminated.** For events involving alpha emitters, if the reading is less than twice the background radiation level, the person is not contaminated to a medically significant degree. If the event circumstances indicate that an alpha emitter (such as plutonium) or low energy beta emitter could be a contaminant, a health physicist should always be consulted.



End the radiation survey:

1. Switch off the meter.
2. Replace the cap on the meter probe.
3. Take the batteries out.

Put the Geiger counter back in its case.

COMMON MISTAKES TO AVOID:

- Holding the probe too far away from the surface. Probe should be 1-2 inches away for rapid, and ½ inch for detailed survey.
- Moving the probe too fast. Appropriate speed is 2-4 in/sec for rapid, 1-2 in/sec for detailed survey
- Contaminating the probe. Probe background should be observed and compared to initial background. Wrapping probe in plastic wrap will help to prevent surface contamination.

Post Decontamination Survey Sheet

Survey patient after decontamination. Determine if additional decontamination shower is required. ***Complete this form after final decontamination shower.***

Date___________ Time of Survey________Med. Record #____________________

Patients Name: ____________________________Age______ D.O.B.___________

Address____

Phone number____

Parent or Guardian (if child) ____

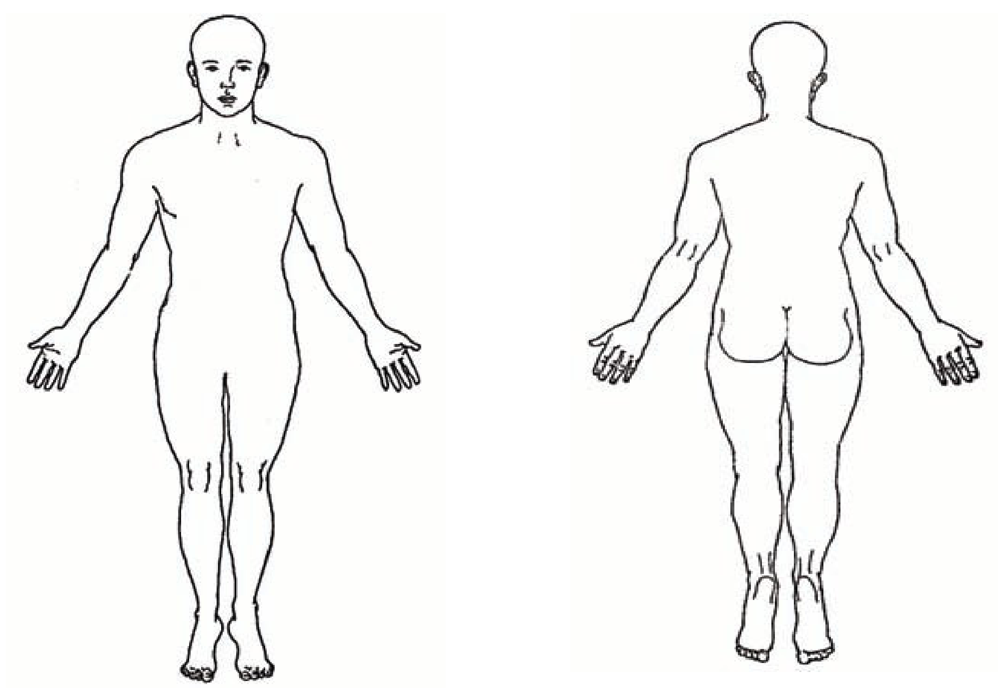
Location at time of incident ____

____

Mark contamination locations and survey reading on the diagram below:

Circle if readings are in CPM mR/hr μR/hr

Mark wounds if present on the diagram below:



Number of Decontamination Showers: 1 2 3 More

External Contamination Present Yes ____ No _____ Unknown_______

Internal Contamination Suspected Yes ____ No _____

Name of person completing survey: ______________________________

Instrument Type: __________________________ Number: ______

Background Reading ________ Counts per Minute (CPM)

Comments ____

Section 5: Decontamination of Patients during a Contaminating Radiation Incident

Section Contents:

Patient Decontamination Procedure Recommendations

Much of the following recommendations are based or procedures and protocols developed by the Radiation Emergency Assistance Center and Training Site. Further reading and excellent demonstrations of procedures may be found at the following web sites:

- **Managing Radiation Emergencies**
  http://orise.orau.gov/reacts/guide/emergency.htm#Decontamination
- **Procedure Demonstrations**
  http://orise.orau.gov/reacts/guide/procedures.htm

Complete decontamination of an individual, which returns to background levels on a survey reading, is not always possible because some radioactive material can remain fixed on the skin surface or remain in a wound. Decontamination should be only as thorough as practical. (REAC/TS, 2007)

Decontamination Procedure Recommendations for Severely Ill or Injured Patients

Prior to entry into the RED Radiation Control Treatment Area:

1. Remove patient's clothing (secure in plastic bags)
2. Wrap the patient in clean sheets and transfer him/her to a clean stretcher
3. Transport directly to the critical care treatment area (RED Treatment Area)

After entry into RED Radiation Control Treatment Area:

4. Conduct a thorough survey within treatment area as soon as possible, simultaneous with medical treatment. [For a photo slide show on how to survey a supine patient go to REACTS web site for Procedures at http://orise.orau.gov/reacts/guide/procedures.htm and click on *Surveying for Radiation Contamination*.]
5. Document results
6. Patient's medical condition should be stabilized prior to decontamination
7. Once stabilized, if contaminated wounds are found, these should be decontaminated prior to full body or intact skin decontamination [See Wound Decontamination Protocol on following pages]

8. If contaminated intact skin is found and patient is stable, contaminated skin area may be draped, then washed under a stream of water and gently scrubbing with a soft sponge or sterile gauze pads, surveying area frequently to reassess if procedure is working. [For a photo slide show on how to decontaminate intact skin on a supine patient go to REACTS web site for Procedures at http://orise.orau.gov/reacts/guide/procedures.htm and click on *Decontaminating Intact Skin*]

9. Gentle sponging for several minutes followed by rinsing, may repeat until back to background reading or no contamination reading does not decrease

10. Excessive or abrasive scrubbing should be avoided

Decontamination Procedure Recommendations for Stable Patients (All Others)

1. Pre-Decontamination Survey

   - Prioritize surveillance of the Head, Neck, Hands, Feet and Shoulders
   - Mark contaminated areas on body in counts per minute
   - If unable to perform survey due to surge of victims or not enough equipment send to decontamination if the patient is obviously covered in high-risk debris from the explosive site

2. Remove Contaminated clothing (removes 75-90% of contamination)

   - Designate a holding area for contaminated clothing away from care area
   - Remove clothing carefully avoiding the face as much as possible
   - Graphic or pictorial instructions should be available to demonstrate the proper means of removing contaminated clothing
   - Pulling clothing over the head, such as T-shirts and sweaters, should be avoided and cut away instead
   - Label bags as radioactive and follow patient identification procedures

3. Complete Basic Decontamination Wash

   - Copious amounts of tepid water
   - Gentle soap
   - No scrubbing (increases chance of internal uptake)
   - No hair conditioner (decreases removal of material from hair)
   - Avoid water runoff from entering the eyes, nose, mouth, or open wounds
   - Hot particles may need to be removed individually in treatment areas (see Embedded Hot Particle Protocol on page 61)

4. Post Decontamination Survey:

   - If feasible, conduct post-decontamination survey
   - If still greater >1000 cpm, repeat whole body decontamination with a goal of reducing contamination

- Stop decontamination if:
    - The patients clinical status precludes additional decontamination showers
    - Additional attempts fail to reduce count rates
    - The patients has undergone 3 whole body decontamination attempts

Stable patients should be optimally decontaminated prior to entering any treatment areas.

Special Decontamination Procedures

Localized skin contamination

1. Put on examination gloves
2. Mark area of contamination with marker
3. Drape area with adherent drapes to prevent contamination from entering other wounds or skin
4. Treat area by gently scrubbing with soft sponge or sterile gauze pads, do not abrade or injure skin
5. Treat highest areas contamination first, then work away from area
6. Place used gauze pads and/or surgical sponges in plastic bag and label with appropriate warning label
7. Mild sticky adhesive tape applied to skin then gently pulled off may also be effective in particle removal
8. Repeat as necessary

Eyes

1. Irrigate with copious amounts of water
2. Make sure water does not enter ear canals or other orifices, placing cotton legates in ears may be helpful
3. Survey irrigation fluid at frequent intervals
4. After decontamination, observe for onset of conjunctivitis

Burns

1. Rinse gently and cover
2. Contaminated burns (chemical, thermal) are treated like any other burn.
3. Exudates will trap most of the contamination
4. Contaminants will slough off with the burn eschar.
5. Leave blisters closed
6. Dressings and bed linens can become contaminated and should be handled appropriately

Wounds

In a contamination incident, any wound must be considered contaminated until proven otherwise. When wounds are contaminated, the physician must assume that uptake (internal contamination) has occurred. Appropriate action is based on half-life, radiotoxicity, and the amount of radioactive material. It is important to consult experts as soon as possible and to initiate measures that prevent or minimize uptake of the radioactive material into body cells or tissues.

1. Ideally a wound should be decontaminated prior to whole body decontamination of intact skin. During a mass casualty incident, this may be impossible.
2. If whole body decontamination is conducted first then the contaminated wounds should be covered with a waterproof dressing **prior** to whole body decontamination
3. After whole body decontamination:
4. Remove waterproof dressing. Contaminated wounds are first draped, preferably with a waterproof material, to limit the spread of radioactivity.
5. Irrigate wound gently with saline or water and contain effluent (in absorbent material, container, or discard in drain). More than one irrigation is usually necessary
6. Do not scrub harshly or abrasively
7. Survey wound after each irrigation
8. Contaminated drapes should be removed before each monitoring for accurate results
9. Following repeated irrigations, the wound is treated like any other wound
10. If the preceding decontamination procedures are not successful, and the contamination level is still seriously high, conventional debridement of the wound must be considered. Excision of vital tissue should not be initiated until

expert medical or health physics advice is obtained. Debrided or excised tissue should be retained for health physics assessment.

Contaminated Hairy Areas:

1. DO NOT SHAVE HAIR
2. Survey area and record results
3. Wrap or position the patient to avoid the spread of contamination
4. Wash area with soap or shampoo (no conditioner) and water
5. Dry with clean uncontaminated towel
6. Re-survey
7. If contamination persists, repeat washing with mild soap or shampoo (without conditioner) and warm water, until o further reduction in contamination can be achieved

Embedded Hot Particles

Embedded particles, if visible, can be removed with forceps or by using a water-pik. Puncture wounds containing radioactive particles, especially in the fingers, can be decontaminated by using an "en bloc" full thickness skin biopsy using a punch biopsy instrument.

1. Remove hot particles with surgical instruments NEVER HANDLE CONTAMINATED PARTICLES WITH HANDS

2. Place any hot particles in a lead container (pig) available from the Nuclear Medicine department or Radiation Safety Officer

Never Handle Radioactive Fragments with Hands!!!
Use instruments such as forceps or clamps.

Decontamination of Non-ambulatory Patients without Life Threatening Conditions Procedure

Patients who are either chronically or acutely immobile require special measures for decontamination. Ambulatory devices such as prosthetic limbs, walkers, canes and wheelchairs should also be cleaned and returned to the patient if possible.

1. Patients already on stretchers or wheelchairs should enter the decontamination area and have their personal property managed in the usual manner except prosthetic devices, ambulatory aids, eyeglasses and wheelchairs (see below).

2. All clothing should be removed from patient and equipment

   - Avoid contaminating the mouth and nose
   - Cut clothing down center of chest and roll away from face and out from under patient
   - Secure clothing as radioactive contamination

3. The patient on the stretcher or wheelchair should then be rolled with assistance through the shower and decontaminated

   - Health Care providers in PPE should actively wash the patients with particular concern to decontaminate underneath the patient
   - Decontaminate stretcher or wheelchair simultaneously

4. Dry patient and transfer to a clean stretcher or wheel chair and cover in clean sheets or gown/scrubs as indicated

5. Staff decontaminates prosthetics, ambulatory assistance devices and wheelchairs

6. Perform post-decontamination radiological survey

7. Patient's prosthetics, ambulatory assistance devices and wheelchairs should be returned unless they are persistently contaminated (1000 cpm by GM survey)

8. Post decontamination transfer to a dry stretcher/wheelchair is ideal if resources are available

9. Consider designating stretchers to be "FOR DECONTAMINATION ONLY"

10. Cover the stretcher with new sheets between patients. Transfer patient to clean dry stretcher or wheelchair following decontamination. Wipe down the old stretcher, change the sheets, return to the queue and survey the stretcher between patients if feasible.

Decontamination of expired victims

Determine whether a patient is already dead or otherwise expectant prior to decontamination or entry into your hospital facility. These patients should be triaged to the side and decontaminated last after the incident is completed or has abated.

A complete guideline on the management of deceased victims can be found at the CDC Radiation Emergency Website, *Guidelines for Handling Decedents Contaminated with Radioactive Materials,* http://www.bt.cdc.gov/radiation/pdf/radiation-decedent-guidelines.pdf last accessed on Sept. 11, 2007.

Table of Recommended Patient Decontamination Decisions

The following recommendations are to be a guideline for surveyors who are conducting radiation surveys pre- or post- decontamination. These readings are of greater significance if found over the face or upper body.

Counts per minute (CPM)	Dose rate (mrem/hour)	Management
<100 -200	**<0.05 -0.1**	**No further decontamination required**
>200 to <1,000	**>0.1 to 0.5**	**Search for contamination.** **Limited decontamination such as clothing removal and focused cleaning with soap and water** **Patients may be discharged with count rate <1,000 CPM if unsuccessful after 3 attempts at decontamination or if surge of victims is limiting resources**
> 1,000 to <10,000	**>0.5 to 5**	**Decontamination and Resurvey** **Repeat decontamination until level is below 1000 CPM or until no further decontamination is effective.**
>10,000 to 100,000	**>5 to 50**	**Separate from other patients** **Send to front of decontamination line** **Decontaminate immediately** **Search for "hot particle"** **Resurvey immediately following decontamination** **Repeat decontamination until level is below 1000 CPM or until no further decontamination is effective.**
>100,000	**>50**	**All of the above** **People with contamination levels > 100,000 cpm are likely to have internal contamination and should be identified as a priority for evaluation and treatment of internal contamination (CRCPD, 2006)**

Section 6: Equipment for Radiation Incidents

Section Contents:

- **Description of Survey Meters and Personal Dosimeters**
- **Suggested Equipment and Supplies Table**
- **Special Considerations for Planning for Equipment and Supplies**

Radiation Control Equipment Descriptions

Most radiation control and decontamination decisions will be made using with a Geiger-Mueller Survey Meter.

Geiger-Mueller (GM) Counters

These are instruments used to detect radiation contamination both on people and in the environment. These are the instruments needed to survey (also called "frisking") a patient, victim, responder, or employee to see if they have been contaminated. Additionally, they would be needed to survey the area in and around the hospital during and after an event to evaluate potential areas for clean-up.

Various probes, including those shown in this section, can be attached to a general-purpose survey meter to provide a measurement. The faceplate of an instrument may read in exposure rate (mR-milliRoentgen- or R-Roentgen per hour or mSv or Sv per hour), or it may read in counts per minute (cpm), or it may have both scales on one faceplate. Note that if the instrument is reading in exposure rate, the measurement may not be accurate unless the instrument was calibrated for the radionuclide being measured. The most accurate instrument for measuring exposure rates of beta and gamma emitters is an ion chamber, described later in this section.[1]

Pancake Probe (Pancake GM)

A pancake probe detects alpha, beta, or gamma radiation. It is most efficient at detecting beta radiation. This probe begins to be less accurate as the count rate (cpm) increases above 100,000 cpm. By 400,000 cpm it will respond low by a factor of about three, and therefore should not be used above 400,000 cpm. [1]

This probe is best for looking for low levels of radioactive contamination (readout in cpm) on people or on surfaces (ground). When it is used to detect gamma radiation with readout in mR/hr, beta radiation can be shielded out. This is accomplished by facing the back of the probe towards the area being monitored (it is desirable to put the protective cap on as a light shield when used in this mode).

This probe is not energy compensated, meaning that it will read mR/hr accurately for the nuclide with which it was calibrated (normally Cs-137), but may be inaccurate by up to a factor of five for other nuclides. [1]

A typical background reading with this probe is 25-75 counts per minute (cpm).

Sodium Iodide Probe

A sodium iodide (NaI) probe is used to detect gamma radiation only. It is able to detect low levels of gamma emitters, and can be used in radiation fields up to about 200 mR/hr. It is useful in detecting the presence of gamma emitters in a general survey, and can be used to locate discrete gamma sources, or to survey people, property, or the environment.

Background radiation can vary significantly depending on the particular type of sodium iodide probe used. The range of "typical" background readings will depend on the size and thickness of the probe being used, for example:
· For a 1" x 1" probe it is 1,000-5,000 cpm
· For a 2" x 2" probe it is 5,000-25,000 cpm and
· For a 1" x 1-mm probe it is 200-400 cpm.

While a pancake GM probe is better able to detect low levels of contamination on people and surfaces than a NaI probe, the NaI probe will be useful for contamination monitoring in an RDD event due to the anticipated higher levels of contamination that could be encountered. This probe is useful for doing area surveys, surveys of groups of people, and equipment such surveys of ambulances in order to rapidly find high dose sources ("hot particles').

Alpha Particle Survey Meters

A standard Geiger-Mueller survey counter will not detect alpha radiation because these short range particles cannot penetrate the Geiger-Muller case. A thin window GM counter or an alpha scintillation probe is necessary. Most advanced facilities should have access to an alpha-detecting probe.

Electronic (Digital) Dosimeters

Electronic dosimeters can be used to measure an individual's exposure to radiation, also called personal dosimetry. It can also be used to detect and measure radiation. Generally, they may have a small sodium iodide or a GM probe inside. Most can be used in either a rate mode, which gives exposure per unit time, or an integrated mode, which will give an accumulated exposure for the wearer until the instrument is reset. Often they have an alarm that can be set to alert the user to a preset radiation level or cumulative exposure. Note that if a sodium iodide probe is used it may saturate in a high radiation field.

Personal Passive Detectors

These are known as film badges although the current technology does not use film. They render a good assessment of individual radiation total dose over the period used and are inexpensive. All staff who will be potentially exposed to a significant radiation dose should wear one. The badges do not give real time readings and typically must be sent to an outside contractor for verification for read out of results.

Ionization Chamber

A primary instrument with high accuracy for measuring low levels of gamma ray radiation. Normally used for measurement of natural background and small multiples of background, such as around nuclear reactors. They are gas filled chambers and rely on measuring the electric current from collection of the ionization formed (electrons) from radiation passage.

Multi-channel Analyzer (MCA)

A multi-channel analyzer can identify the exact radioisotope(s) involved based on the energy spectra of the gamma radiation. They are expensive and require sophistication in radiation detection to use them.

Suggested Emergency Department Radiation Equipment and Materials E= Essential O=Optional		
Equipment Type	**Suggested Amount**	**Importance**
Personal electronic self-reading dosimeters (Dosimeters should be water resistant if used in decontamination showers). Personnel with direct patient close contact with contaminated victims or	10-30 for RSO and primary persons directly attending contaminated persons	E
Personal Passive dosimeters (OSL, TLD, film badges)	For all staff persons involved	E
Geiger-Mueller (GM) Survey Meters with thin window probe (thickness <2.0 mg/cm^2 for alpha)	6	E
Geiger-Mueller (GM)-energy compensated for better dose estimates	1	O
Ludlum model (such as model 3-98) with specialized probe for alpha detection	1	O
MCA Detector for isotopic analysis	1	O
Area Radiation Monitor	2 for ED entrances	E
Portal Monitor	1	O
Clothing (Post Decontamination Treatment Areas)		
Tyvek coveralls or Scrubs	3-5 x no. of staff responding to event	E
Surgical gloves, masks and caps	*	E
Disposable shoe coverings (plastic)	3-5 x no. of staff responding to event	E
Surgical Gowns, Water Resistant	3-5 x no. of staff responding to event	E
Masking Tape (to tape gloves, sleeves, and cuffs)	10-20 rolls	E
Clinical Equipment Type		
Blood tubes (EDTA preservative)	100-250	E
Specimen cups	100-250	E
24 hour Urine Specimen Containers	25-100	
Contamination Control Equipment Type		
Redressing "modesty packs" or Tyvek suit for post decontamination clothing, slippers	100-500	E
Plastic Bags (large) (for discarded clothing, supplies)	500	E
Tape (heavy) Duct or other (tape floor coverings, plastic sheeting)	25-50 Rolls	E
Absorbent Towels (clean up spills and to assist with decontamination of patients in Red Radiation Control Treatment Area)	*500-1000	E
Scrub Brushes (soft)	500-1000	E
Plastic Sheeting (used for covering equipment, stretchers, portable X-Ray machines, etc.)	*Multiple rolls for each area	E
Soap		E
Permanent markers	10 boxes	O
Radiation Area Signs	*Multiple for each area	E
Hazardous Waste Containers, bags or drums (large) [Must label for use]	*Multiple for each area	E
Adsorbent Floor Cover (Heavy or plastic-backed paper or butcher paper to cover floors and hallways)	*Multiple rolls for each area and hallways	O

Suggested Emergency Department Radiation Equipment and Materials (Cont'd) **E= Essential O=Optional**		
Equipment Type	**Suggested Amount**	**Importance**
Waterproof wound dressings (such as Tegaderms, used to cover wounds while patient goes through decontamination)	*500	O
Plastic wrap (such as Saran Wrap, used to cover skin with adherent contamination)	*25 Rolls	
Sterile Gauze pads (Useful for careful wound decontamination or skin decontamination)	*	E
Caution line tape to mark off perimeters of radiation control areas	10-20 Rolls	O
Sticky step-off pads (useful to keep contamination from tracking around area)	100-500	O
Contamination survey forms	500-1000	E

*Special Considerations for Planning Equipment and Supplies for a Contaminating Radiological Incident

Individuals responsible for planning and stocking equipment and supplies for a contaminating radiation incident must take into account the special needs that staff will require in order to respond safely and to limit the amount of secondary contamination that could occur in the facility. Supplies should be especially stocked for the Red Radiation Control Treatment Area, since patients will be requiring decontamination simultaneously with treatment.

- Covering floors and hallways with an absorbent floor covering will limit the amount of contamination that may occur especially in the Red Radiation Control Treatment Area, where patients may be decontaminated in rooms;
- Wound care will require large amounts of absorbent gauze, water proof drapes, and large basins to collect the water used to decontaminate wounds;
- Absorbent towels are better than mops to clean up spills on floors; mops tend to spread contamination around rather than clean it up;
- Healthcare providers will be changing gloves frequently if caring for contaminated patients;
- Outer gowns should also be changed after caring for each contaminated patients and if going into the buffer zones or other areas to eat or drink during breaks;
- Hazardous waste receptacles will need to be located in multiple locations and it is expected that hazardous waste bags will be needed for both the pre-decontamination area, as well as through out any treatment areas where contaminated patients may need to be cared for, such as wound care areas or Red Radiation Control Treatment Areas; and,
- Wound care requires special consideration for covering while patient goes through decontamination to prevent contaminants washing into wound, and patients with persistent contamination on skin that is unable to be removed should have these areas covered with some type of water proof dressing prior to discharge.

Section 7: Training Resources and Competencies for Radiation Incidents

Section Contents:

Introduction

All staff members who may be involved in a radiation disaster response should receive radiation response training annually. RDD training is critical for these responders because specialized resources or hospital/radiological subject matter experts may not be immediately available to assist them at the onset of emergency response.

Training for emergency response following an RDD event should achieve several essential objectives, including:

- Enhancing personnel's' ability to take appropriate measures to protect themselves and the public; and
- Increasing personnel's' confidence when managing an emergency that involves radioactive materials or radiation.

Essential Training Competencies

All emergency response personnel should be trained at a level corresponding to the duties and responsibilities that they will be expected to perform during a radiological incident. Planners can establish training programs for emergency responders and receivers as well as radiation experts who could be called to assist responders after an RDD event.

- **First Receivers**

  First receivers, healthcare workers who might risk exposure when hospitals or healthcare facilities receive contaminated patients, should be trained specifically to receive contaminated patients after a mass casualty incident. The National Council on Radiation Protection and Measurements' (NCRP) *Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism*, NCRP Commentary No. 19 identifies essential knowledge, skills, and abilities that first receivers will require to prepare for and to respond to an RDD event.[1.] See Essential Training Competencies at end of chapter.

- **Medical Facility/Academic Radiation Experts (Subject Matter Experts)**

  Plans can include guidelines for training radiation experts to understand basic emergency response requirements and procedures. These SMEs can be trained to integrate their technical knowledge into the local emergency response framework. Training also could emphasize the application of their radiological expertise to local requirements, resources, and likely RDD incident conditions.

Essential Training Competencies*

For First Receivers

Healthcare workers at a hospital receiving irradiated or contaminated victims for treatment may be termed first receivers (OSHA, 2005a). This group is a sub-set of emergency responders. However, first receivers are usually remote from the location where the incident occurred. Thus the exposure of first receivers is limited to the radioactive material arriving at the hospital as a contaminant on victims and their clothing or personal effects. First receivers typically include personnel in the following roles: clinicians (physicians, nurses, nurse practitioners, physician assistants, and others) and other hospital staff who have a role in receiving and treating contaminated victims (*e.g.*, triage, decontamination, medical treatment, and security) and those whose roles support these functions (*e.g.*, set up and patient tracking).

A.3.1 *Awareness Level*

This level is appropriate for hospital personnel, such as administrators, maintenance or office staff members that are not directly involved in the triage, decontamination or medical treatment of irradiated or contaminated patients. First receivers at the awareness level should have sufficient training or sufficient experience to demonstrate competency in:

- being aware of the distinction between an irradiated and a contaminated patient, as well as the difference between being internally and externally contaminated;
- being aware that the radiation hazard to attending personnel from an irradiated patient is zero, and that from most contaminated patients it is minimal;
- being aware of the necessity for access control to areas where potentially contaminated patients are being received and treated; and
- being sensitive to the particular needs of victims of nuclear and radiological incidents.

A.3.2 *Operations Level*

Personnel involved with receipt, triage, initial medical treatment, and decontamination of patients should be trained at the operations level, which includes (in addition to the awareness level competencies), competency in:

- knowing medical triage, and particularly the necessity of assessing traumatic injury and medical conditions prior to consideration of radiation exposure or contamination;
- knowing contamination control methods, and that removing clothing removes most external contamination;
- recognizing that mass casualties may overwhelm health care resources and adaptable triage methods will be indicated, including the

use of the onset of time to vomiting as a key indicator of the radiation dose and prognosis;
- being aware of the psychosocial impacts of nuclear and radiological incidents, including their potential effects on the general public and on responders;
- knowing methods for decontamination of radioactive materials from skin and wounds;
- taking a medical history and conducting a physical examination;
- knowing the prodromal signs and symptoms of ARS and the importance of noting their time of onset, duration and severity;
- being aware of the usefulness of nasal swabs for evaluating the presence of internal contamination *via* inhalation;
- being aware of the availability of cytogenetic biodosimetry;
- knowing the need for an initial complete blood count and a repeat count every 4 to 6 h to evaluate lymphocyte depletion kinetics;
- being aware of a possible need for treatment for internal contamination; and
- knowing the potential medical complications and management of casualties with combined injuries (*e.g.*, radiation and thermal burns, radiation and wounds).

A.3.3 *Technician Level*

These are mainly the physicians and other medical staff who are responsible for the longer-term medical treatment of individuals who are significantly irradiated or internally contaminated. These individuals should have competency in:

- knowing the levels of radiation dose associated with the onset of dermal (skin) manifestations;
- knowing the levels of radiation dose associated with ARS;
- obtaining cytogenetic biodosimetry;
- knowing the therapeutic and palliative treatments for irradiated patients;
- knowing current methods for the treatment for internal contamination;
- understanding the psychological impacts of nuclear and radiological incidents, and of resources and approaches for assisting patients and their families; and
- managing casualties with combined injuries.

**Excerpted from NCRP Commentary No. 19, Key elements of preparing emergency responders for nuclear and radiological terrorism. NCRP, Dec. 2005.*

References

1. Best Practices: Radiological Dispersal Device Incident Response Planning: Training and Exercises, www.llis.gov, Jan. 2007.

2. NCRP Commentary No. 19, Key elements of preparing emergency responders for nuclear and radiological terrorism. NCRP, Dec. 2005.

Training Resources

NYC DOHMH CBRNE Training Program
http://www.nyc.gov/html/doh/html/bhpp/bhpp-train-cbrne.shtml

NYC DOHMH Radiological Detection Equipment Training Program
http://www.nyc.gov/html/doh/html/bhpp/bhpp-train-cbrne-rad.shtml

Yale New Haven Center for Emergency Preparedness Disaster Response provides narrated CD-ROMs of their introductory course, "Introduction to Emergency Management (EM 103)," and "Introduction to Radiological Emergency Preparedness (EM 110)," upon request. Contact Yale New Haven Center for Emergency Preparedness and Disaster Response, 1 Church Street, 5th Floor, New Haven, CT 06510
Phone: (203) 688-3224 Fax: (203) 688-4618 E-mail: Center@ynhh.org. Web site http://ynhhs.emergencyeducation.org/ .

DOE Office of Emergency Management's Transportation Emergency Preparedness Program (TEPP) was developed as a nationwide program to ensure training consistency for responders involved in a radiological material transportation incident response. The Modular Emergency Response Radiological Transportation Training provides materials on such topics as radioactive materials, initial response issues, radiological instrumentation, incident control, and offensive actions at radioactive material incident sites.
http://www.em.doe.gov/TEPPPages/TEPPTraining.aspx

Centers for Disease Control and Prevention (CDC), Public Health Training Network: The CDC Radiation Studies Branch provides health personnel with courses on radiation principles, signs and symptoms of radiation syndrome, decontamination procedures, possible radioactive material release scenarios, radiation protective measures, and evacuation and sheltering guidelines. The main web site for the CDC Radiation Emergencies can be found at http://www.bt.cdc.gov/radiation/ . Specific training materials include:

- Smith, James M. **Interim Guidelines for Hospital Response to Mass Casualties from a Radiological Incident.** December 2003.
  http://www.bt.cdc.gov/radiation/pdf/MassCasualtiesGuidelines.pdf
  98 page overview of management of radiation events. First 37 pages are glossary with dozens of hyper-links for additional resources, followed by a primer on radiation. The document describes general management, making broad recommendations for care. Includes mental health concerns, community involvement issues, and ends with a brief glossary of radiation detection equipment.

- **Radiological Terrorism: A Tool Kit for Emergency Services Clinicians**
  Includes several items that may be useful for emergency services clinicians including videos, handouts, and fact sheets.
  http://www.bt.cdc.gov/radiation/toolkit.asp

- **Video Webcast: Medical Response to Nuclear & Radiological Terrorism**

Feb 10, 2004. Instructs clinicians on how to distinguish between radiation exposure & contamination; recognize the signs & symptoms of acute radiation syndrome & cutaneous radiation syndrome; & decontaminate a patient. http://www2.cdc.gov/phtn/webcast/radiation-04/default.asp

- **Video: Just in Time Training for Hospital Clinicians**
  Brief video covering key radiation principles & radiological procedures
  http://www.bt.cdc.gov/radiation/justintime.asp

- **Radiological Terrorism: Emergency Management Pocket Guide for Clinicians**
  Printable version of CDC's quick reference radiological response pocket guide for clinicians.
  http://www.bt.cdc.gov/radiation/pdf/clinicianpocketguide.pdf

- **Training: "Radiological Terrorism: Medical Response to Mass Casualties"**
  Interactive self-study training intended to provide clinician education on local medical response to mass casualties during the immediate aftermath of a radiological or nuclear terrorism incident.
  http://www.bt.cdc.gov/radiation/masscasualties/training.asp

- **Fact Sheet: Acute Radiation Syndrome**
  What physicians need to know about the presentation, diagnosis, & treatment of patients with acute radiation syndrome.
  http://www.bt.cdc.gov/radiation/arsphysicianfactsheet.asp

- **Fact Sheet: Prenatal Radiation Exposure**
  What physicians need to know about diagnosing, treating, & advising pregnant women who have been exposed to radiation.
  http://www.bt.cdc.gov/radiation/prenatalphysician.asp

- **Fact Sheet: Cutaneous Radiation Injury**
  What physicians need to know about the presentation, diagnosis, & treatment of patients with cutaneous radiation injury.
  http://www.bt.cdc.gov/radiation/criphysicianfactsheet.asp

- **Guidelines for Handling Decedents Contaminated with Radioactive Materials**
  Detonation of a nuclear weapon or activation of a radiological dispersal device could cause radioactively contaminated decedents. These guidelines address how medical examiners, coroners, and funeral directors should handle decedents in both of these scenarios.
  http://www.bt.cdc.gov/radiation/pdf/radiation-decedent-guidelines.pdf

Federal Emergency Management Agency, Emergency Management Institute: The Emergency Management Institute offers traditional courses as well as downloadable, Web-based, and computer-based training. The National Emergency Training Center's (NETC) Virtual Campus, http://training.fema.gov/VCNew/isnote.asp, is the FEMA's online training site. NETC Virtual Campus courses are intended for emergency management personnel, fire service personnel, emergency responders, Department of Homeland Security personnel, and the public. Sample applicable courses include:

- **IS-100.HC Introduction to the Incident Command System for Healthcare/Hospitals**
- **IS-200.HC Applying ICS to Healthcare Organizations**
- **IS-301 Radiological Emergency Response**
- **IS-302 Modular Emergency Radiological Response Transportation Training**
- **IS-330 Refresher Course for Radiological Response**
- **IS-331 Introduction to Radiological Emergency Preparedness (REP) Exercise Evaluation**

Oak Ridge Institute for Science and Education's (ORISE) Radiation Emergency Assistance Center/Training Site (REAC/TS): **REACT/TS** Offers on-line several educational materials in handling radiation emergencies. Additionally, REAC/TS offers training courses in Oak Ridge, TN. ORISE is also accredited to provide continuing medical education for physicians by the Accreditation Council for Continuing Medical Education. http://orise.orau.gov/reacts/ Specific training materials provided by REAC/TS include:

- **Guidance for Radiation Accident Management** The information provided here addresses not only basic explanations and definitions related to radiation but also offers guidance to those responding both at the scene of an accident (pre-hospital) and at the hospital. http://orise.orau.gov/reacts/guide/index.htm
- **Basics of Radiation** On-line materials that explain in simple terms the basics of radiation http://orise.orau.gov/reacts/guide/define.htm
- **REAC/TS Poster: Radiation Patient Treatment** http://orise.orau.gov/reacts/combined-injury.htm

Department of Homeland Security offers an online *Compendium of Federal Terrorism Training for State and Local Audiences*. The Compendium is meant to help responders identify and access available resources. Several of these courses include RDD incident response operations. http://www.dola.colorado.gov/dem/publications/FEMA_Training_Compendium.pdf

Department of Homeland Security Working Group on Radiological Dispersal Device (RDD) Preparedness. This document, a joint venture of the Department of Homeland Security, The Department of Veterans affairs and the Department of Health and Human Services, is comprehensive and easily understood by the general planner and healthcare professional. http://www1.va.gov/emshg/docs/Radiological_Medical_Countermeasures_Indexed-Final.pdf

Armed Forces Radiological Research Institute (AFRRI) offers a training course, "Medical Effects of Ionizing Radiation," at AFRRI and at other venues throughout the country. The course provides medical and operational personnel with up-to-date information concerning the biomedical consequences of radiation exposure, how the effects can be reduced, and how to medically manage casualties.
http://www.afrri.usuhs.mil/outreach/meir/meir.htm
Training materials and resources available on-line include the following:

- **Terrorism with Ionizing Radiation General Guidance Pocket Guide**—A Department of Veterans Affairs document, this guide provides information for dealing with terrorism involving ionizing radiation. It includes such topics as diagnosis, treatment consideration, decontamination procedures, and public-health reporting procedures. When an emergency occurs, the Pocket Guide can be consulted quickly for aid in assessing and controlling the situation. http://www.afrri.usuhs.mil/www/outreach/pdf/pcktcard.pdf
- **Medical Management of Radiological Casualties Handbook –** Published in April 2003 by the AFRRI, the Handbook provides concise supplemental reading material for the AFRRI Medical Effects of Ionizing Radiation (MEIR) Course. It and the MEIR Course are designed to prepare medical-care providers to treat injuries complicated by ionizing-radiation exposure and radioactive contamination. http://www.afrri.usuhs.mil/www/outreach/pdf/2edmmrchandbook.pdf
- **AFRRI Adult/Pediatric Field Medical Record –** Provides a convenient one-page form for recording emergency medical information in the field. Applicable for both adult and pediatric cases. http://www.afrri.usuhs.mil/www/outreach/pdf/afrriform330.pdf
- **AFRRI Biodosimetry Work Sheet**—Provides a four-page data-entry work sheet for gathering facts about a case of radiation exposure, including the source and type of radiation, the extent of exposure, and the nature of the resulting injuries. Applicable to both adult and pediatric cases. http://www.afrri.usuhs.mil/www/outreach/pdf/afrriform331.pdf
- **AFRRI Radiocesium Worksheet**—Provides steps for screening patients suspected or confirmed of having been exposed to radiocesium during a radiation dispersal device (RDD) event. http://www.afrri.usuhs.mil/www/outreach/pdf/afrriform335.pdf

U.S. Department of Labor Occupational Safety & Health Administration
This is an essential reference site for Emergency Planners involved in Occupational Safety and Health. The site features basic information on Radiological Dispersal Devices (RDD), ionizing radiation safety facts and a hot-link to Ready.gov.
http://www.osha.gov/SLTC/emergencypreparedness/radiation_sub.html

Nuclear Regulatory Commission The US Nuclear Regulatory Commission oversees the licensing of nuclear power plants and other civilian use of nuclear materials. There are descriptions of nuclear reactors and the nuclear fuel cycle as well as numerous highly technical regulatory documents which are only comprehendible by specialists in these fields. The Emergency Planning materials is focused on nuclear reactors with peripheral information about radiological dispersal devices. There is also information focusing on public education of the relative safety of radiation, especially as it relates to civilian power source. There is little additional information for hospital planning for a radiological event that does not directly involve nuclear reactor. http://www.nrc.gov/

Health Physics Society
This site has detailed and accurate information which is easily understood. It contains multiple authoritative references and position statements. www.hps.org/

- An excellent Microsoft PowerPoint presentation created by the Health Physics Society on **"Emergency Management of Radiation Casualties"** can be found at http://hps.org/hsc/documents/emergency.ppt

National Council on Radiation Protection (NCRP) The National Council on Radiation Protection and Measurement was founded by congressional charter in 1964 to become the scientific experts for the United States. It is independent of the Federal Agencies above. The NCRP documents are the national standards for radiation protection. http://www.ncrponline.org/ Manuals that can be ordered from this site are considered the gold standard for radiological response include:

- **Commentary No. 19 - Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism (2005)**

- **Report No. 138 - Management of Terrorist Events Involving Radioactive Material (2001)**

- **Report No. 65 - Management of Persons Accidentally Contaminated with Radionuclides (1979)**

Part I References

ACR Disaster Planning Task Force (American College of Radiology/American Association of Physicists in Medicine/American Society for Therapeutic Radiology and Oncology) (2002). Disaster Preparedness for Radiology Professionals Response to Radiological Terrorism (American College of Radiology).

AFRRI (2003). Armed Forces Radiobiology Research Institute. *Medical Management of Radiological Casualties*, 2nd ed., http://www.afrri.usuhs.mil/www/outreach/pdf/2edmmrchandbook.pdf (accessed November 18, 2005) (Armed Forces Radiobiology Research Institute, Bethesda, Maryland).

ACR (2002). American College of Radiology. Disaster Preparedness for Radiology Professionals Response to Radiological Terrorism ACR Disaster Planning Task Force. Committee on Environmental Health, "Radiation Disasters and Children", (2003). Pediatrics **111** (6), 1455-1466.

ANNO G.H., BAUM S.J., WITHERS H.R. and Young R.W., (1989). "Symptomatology of acute radiation effects in humans after exposure to doses of 0.5-30 Gy." Health Phys. 56, 821-838.

BHATTACHARYYA, M. H., BREITENSTEIN, B. D., METIVIER, H., MUGGENBURG, B. A., Stradling, G. N., and VOLF, V. (1992) "Guidebook for the Treatment of Accidental Internal Radionuclide Contamination of workers." Eds GB Gerber and RG-Thomas, Rad. Prot. Dosim. **41**(1), 1-49.

BECKER, S.M. (2004). "Emergency communication and information issues in terrorism events involving radioactive materials," Biosecur. Bioterror. **2**(3), 195–207.

BOSCARINO, J.A., ADAMS, R.E. and GALEA, S., (2006). "Alcohol use in New York after the terrorist attacks: a study of the effects of psychological trauma on drinking behavior", Add. Beh. **31**(4), 606-21.

Bureau of Environmental Disease Prevention & the Office of Radiological Health (2003). New York City Department of Health & Mental Hygiene RADIOLOGICAL Resource Manual, 1st Edition, (New York City Department of Health and Mental Hygiene, New York City).

BURNHAM, J. and FRANCO, J. (2005) "Radiation" Criti Care Clinics, **21**(4), 785-813

CDC (2005) Centers for Disease Control and Prevention National Center for Environmental Health Division of Environmental Hazards and Health Effects Radiation Studies Branch "Roundtable on Population Monitoring Following a Nuclear/Radiological Incident", Contract Number 200-1999-00061 0012 9 (January, 2005). (Centers for Disease Control and Prevention (CDC), Atlanta, Georgia).

CDC (2007) Centers for Disease Control and Prevention Radiation Studies Branch, Division of Environmental Hazards and Health effects, National Center for

Environmental Health. Guidelines for Handling Decedents Contaminated with Radioactive Materials, http://www.bt.cdc.gov/radiation/pdf/radiation-decedent-guidelines.pdf (accessed Sept. 11, 2007) (Centers for Disease Control and Prevent, Atlanta, Georgia).

CEMBER, H. (1996) Introduction to Health Physics, 3rd Edition (McGraw-Hill Companies Inc, New York).

CEMSA (2005). California Emergency Medical Services Authority. *Patient Decontamination Recommendations For Hospitals*, http://www.emsa.cahwnet.gov/hbppc/cbrne_resources.asp (accessed December 31, 2005) (California Emergency Medical Services Authority, Sacramento, California).

CEMSA (2005). California Emergency Medical Services Authority. *CBRNE: Emergency Preparedness for Medical Care Providers*, http://www.emsa.cahwnet.gov/hbppc/cbrne_resources.asp (accessed December 31, 2005) (California Emergency Medical Services Authority, Sacramento, Califorinia).

CRCPD (2006) Conference of Radiation Control Program Directors. Handbook for Responding to a Radiological Dispersal Device: First Responder's Guide-The First 12 Hours, (Council of Radiation Control Program Directors, Frankfort, Kentucky).

DAINIAK, N., CARPINI, D.D., BOHAN, M., DOMENICO, D.C., BOHAN, M., ERDMANN, M., WILDS, E., BARLOW, A., BECK, C., CHENG, D., DALY, N., GLAZER, P., MAS, P., NATH, R., PIONTEK, G., PRICE, K., ALBANESE, J., ROBERTS, K., SLANER, A.L. and ROCKWELL, S., (2006). "Development of a statewide hospital plan for radiologic emergencies", Int. J. Radiat. Oncol. Biol. Phys. **65** (1), 16 – 24.

DE LORENZO, R. (2005). DISASTER AND TERRORISM/EDITORIAL "When It's Hot, It's Hot", Annals of Emergency Medicine **45** (6), 653.

Department of the Navy, Bureau of Medicine and Surgery (2003). Initial Management of Irradiated or Radioactively Contaminated Personnel. BUMED INSTRUCTION 6470.10B, (Department of the Navy, Bureau of Medicine and Surgery, Washington, DC).

DILL, C. and HOFFMAN, R. (2002). "Radiation Emergencies, Biological and Chemical Hazards", Resid. Staff Physician **48**(8), 24-33.

EPA (1992). U.S Environmental Protection Agency. Manual of Protective Action Guides and Protective Actions for Nuclear Incidents, EPA 400-R-92-001. http://www.epa.gov/radiation/docs/er/400-r-92-001.pdf (accessed August 2, 2007) (US EPA, Washington).

FELTON, C.J. (2002). "Project Liberty: a public health response to New Yorkers' mental health needs arising from the World Trade Center terrorist attacks", J Urban Health **79**(3), 429-433.

GALEO, S, RESINICK,H., AHERN, J., GOLD, J., BUCUVALAS, M., KILPATRICK, D., STUBER, J. and VLAHOV, D., (2002). "Posttraumatic Stress Disorder in Manhattan, New York City after the September, 11 Terrorist Attacks", J Urban Health **79**(3), 340-353.

GOANS, R.E. Medical Management of Internal Contamination. MJW Corporation, 2006.

GOANS, R.E., HOLLOWAY, E.C., BERGER, M.E. and RICKS, R.C. (1997). "Early Dose Assessment Following Severe Radiation Accidents," Health Phys. **72**(4), 513-518.

GOANS R.E., HOLLOWAY E.C., BERGER M.E. and RICKS, R.C. (2001). "Early dose assessment in Criticality accidents", Health Phys. 81, 446-449.

GOANS, R.E. (2006). Medical Management of Internal Contamination. MJW Corporation.

GOTTLOBER P., STEINERT M., WEISSM, BEBESHKO V., BELYI D., NADEJINA N., STEFANI F.H., WAGEMAKER G., FLIEDNER T.M. and PETER R.U., (2001). "The outcome of local radiation injuries: 14 years of follow-up after the Chernobyl accident", Radiat Res. **155** (3) 409-416.

GUSEV, I.A., GUSKOVA, A.K. and METTLER, F.A. (2001). *Medical Management of Radiation Accidents*, 2nd Edition, (CRC Press, Boca Raton, Fl).

JOHNSON, R., "Facing the terror of nuclear terrorism",   Occupational Health & Safety **72**(5), 44-49.

GUSKOVA, A.K., BARANOV, A.E. and GUSEV, I.A. Acute radiation sickness: underlying principles and assessment. In: Gusev IA, Guskova AK, Mettler FA, editors. Medical management of radiation accidents. 2nd edition. Orlando (FL) 7 CRC Press; 2001. p. 33– 51.

IAEA (1986). International Atomic Energy Agency. *What the General Practitioner (MD) Should Know About Medical Handling of Overexposed Individuals*, IAEA-TECDOC-366., (International Atomic Energy Agency, Vienna).

IAEA, FAO, ILO, OECD/NEA, PAHO, and WHO (1996b). International Basic Safety Standards for Radiation Protection against Ionizing Radiation and for the Safety of Radiation Sources. (International Atomic Energy Agency, Vienna).

IAEA and WHO (1998a). International Atomic Energy Agency and World Health Organization. *Planning the Medical Response to Radiological Accidents*. Safety Reports Series No.4. (International Atomic Energy Agency, Vienna).

IAEA and WHO (1998b). International Atomic Energy Agency and World Health Organization. *Diagnosis and Treatment of Radiation Injuries*. Safety Reports Series No.2, (International Atomic Energy Agency, Vienna).

ICRP (1991). International Commission on Radiological Protection. *1990 Recommendations of the International Commission on Radiological Protection*, ICRP Publication 60, Ann. ICRP **21**(1–3) (Elsevier Science, New York).

KOENIG, K.L., GOANS, R.E., HATCHETT, R.J., METTLER, F.A., SCHUMACHER, T.A., NOJI, E.K. and JARRETT, D.G. (2005). "Medical Treatment of Radiological Casualties:

Current Concepts", Disaster and Terrorism/Review Article Annals of Emergency Medicine **45**(6), 643-652.

LEON, G.R. (2004), "Overview of the psychosocial impact of disasters", Prehospital Disaster Medicine **19**(1), 4-9.

LEVITIN, H.W., SIEGELSON, H.J., DICKINSON, S., HALPERN, P., HARAGUCHI, Y., NOCERA, A. and TURINECK, D. (2003). "Decontamination of Mass Casualties-Re-Evaluating Existing Dogma". Prehosp. Disast. Med. **18**(3), 200-207.

METTLER, F.A. (2005). "Medical Resources and Requirements for Responding to Radiological Terrorism", Health Phys. **89**(5), 488–493.

MUSOLINO, S.V. and HARPER F.T. (2006). "Emergency response guidance for the first 48 hours after the outdoor detonation of an explosive radiological dispersal device", Health Phys. **90**(4) 377-385.

NAS/NRC (1990). National Academy of Sciences/National Research Council. *Health Effects of Exposure to Low Levels of Ionizing Radiation*, Committee on the Biological Effects of Ionizing Radiations, BEIR V, (National Academy Press, Washington, DC).

NCRP (1980). National Council on Radiation Protection and Measurements. *Management of Persons Accidentally Contaminated with Radionuclides*, NCRP Report No. 65 (National Council on Radiation Protection and Measurements, Bethesda, Maryland).

NCRP (1987a). National Council on Radiation Protection and Measurements. *Ionizing radiation exposure of the population of the United States*, NCRP Report No. 93 (National Council on Radiation Protection and Measurements, Bethesda, Maryland).

NCRP (1987b). National Council on Radiation Protection and Measurements. *Use of Bioassay Procedures for the Assessment of Internal Radionuclide Deposition.* No. 87 (National Council on Radiation Protection and Measurement, Bethesda, Maryland).

NCRP (1993). National Council on Radiation Protection and Managements. *Limitation of Exposure to Ionizing Radiation*, NCRP Report No. 116 (National Council on Radiation Protection and Managements, Bethesda, Maryland).

NCRP (2001). National Council on Radiation Protection and Measurements. *Management of Terrorist Events Involving Radioactive Material*, NCRP Report No. 138 (National Council on Radiation Protection and Measurements, Bethesda, Maryland).

NCRP (2005) National Council on Radiation Protection and Measurements. *Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism,* NCRP Report No. 19 (National Council on Radiation Protection and Measurements, Bethesda, Maryland).

New York City Department of Health & Mental Hygiene, RADIOLOGICAL Resource Manual: Bureau of Environmental Disease Prevention & the Office of Radiological Health, 1st Edition. (December 2003). (New York City Department of Health & Mental Hygiene, New York City).

NRC Regulations Title 10, Code of Federal Regulations Part 20—Standards for Protection Against Radiation Subpart D--Radiation Dose Limits for Individual Members of the Public § 20.1301 Dose limits for individual members of the public. http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/part020-1301.html last accessed 9/19/07.

NRC (2003). US Nuclear Regulatory Commission, *"Dirty Bombs",* fact sheet, http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/dirtybombs.html (Accessed Feb. 2005) (US Nuclear Regulatory Commission, Washington).

OSHA (2005). Occupation Safety and Health Administration. *Best Practices for Hospital Based First Receivers of Victims from Mass Casualty Incidents Involving the Release of Hazardous Substances*, http://www.osha.gov/dts/osta/bestpractices/html/hospital_firstreceivers.html (accessed August 2, 2007) (Occupation Safety and Health Administration, Washington).

SHEA, D.A., (2004). Congressional Research Service, Resources, Science, and Industry Division, United States Congress, Radiological Dispersal Devices: Select Issues in Consequence Management, CRS Report for Congress, http://www.fas.org/spp/starwars/crs/RS21766.pdf. (Accessed Feb. 2005) (Congressional Research Service, Resources, Science, and Industry Division, Washington, DC).

SCHUSTER, M.A., STEIN, B.D., JAYCOX, L.H., COLLINS, R.L., MARSHALL, G.N., ELLIOTT, M.N., ZHOU, A.J., KANOUSE, D.E,, MORRISON, J.L. and BERRY, S.H. (2001). "A National Survey of Stress Reactions after the September 11, 2001 Terrorist Attacks", J Medicine **345**(20): 1507-12.

SIMONS, J.S., GAHER, R.M., JACOBS, G.A., MEYER, D. and JOHNSON-JIMENEZ, E., (2005). "Associations between alcohol use and PTSD symptoms among American Red Cross disaster relief workers responding to the 9/11/2001 attacks", J Drug & Alcohol Abuse, **31**(2), 285-304.

SMITH, J.M., ANSARI, A., and HARPER, F.T. (2005). "Hospital management of mass radiological casualties: Reassessing exposures from contaminated victims of an exploded radiological dispersal device," Health Physics. 89(5), 513-520.

VANDERFORD, M.L. (2004). "Breaking New Ground in WMD Risk Communication: The Pre-Event Message Development Project", Biosecur Bioterror. **2**(3), 193-194.

VLAHOV, D., GALEO, S., RESNICK, H., AHERN, J., BOACARINO, J.A., BUCUVALAS, GOLD, J. and KILPATRICK, D. (2002). "Increased Use of Cigarettes, Alcohol, and Marijuana among Manhattan, New York Residents After the September 11 Terrorist Attacks", J Epidemiology. **155**(11), 988-996.

VLAHOV, D., GALEA, S., AHERN, J., RESNICK H. and KILPATRICK, D. (2004). "Sustained increased consumption of cigarettes, alcohol, and marijuana among Manhattan residents after September 11, 2001*", J* Public Health. 94, 253-254.

VOELZ, G.L. Assessment and treatment of internal contamination: general principles. In: Gusev IA, Guskova AK, Mettler FA, editors. Medical management of radiation accidents. 2nd edition. Orlando (FL) 7 CRC Press; 2001. p. 319– 36.

WASELENKO, J.K., MACVITTIE, T.J., BLAKELY, W.F., PESIK, N., WILEY, A.L., DICKERSON, W.E., TSU, H., CONFER, D.L., COLEMAN, C.N., SEED, T., LOWRY, P., ARMITAGE, J.O. and DAINIAK, N. (2004). "Medical Management of the Acute Radiation Syndrome: Recommendations of the Strategic National Stockpile Radiation Working Group", Ann Intern Med **140**(12), 1037–51.

YEHEZKELLI, Y., DUSHNITSKY, T. and HOURVITZ, A. (2002). "Radiation Terrorism-The Medical Challenge", Non-Conventional Warfare Medicine, IMA J. **4**, 530-3

Glossary of Radiological Terms

Adapted from the CDC web site http://www.bt.cdc.gov/radiation/glossary.asp

A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z

A

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 Becquerel's 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 75 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/nceh/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.

B

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.

C

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.

D

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 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.

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., Sievert 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.

E

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 Sv = 1 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.

F

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.

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.

G

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.

H

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.

I

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.

K

Kiloton (Kt): the energy of an explosion that is equivalent to an explosion of 1,000 tons of TNT. One kiloton equals 1 trillion (1012) calories. *See also* megaton.

L

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.

M

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 (1018) 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.

N

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 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.

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.

P

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.

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.

Q

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.

R

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.

S

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-Sievert (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. Stronium-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.

T

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.

U

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.

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).

W

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

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.

For additional information or comments on this document contact:

Healthcare Emergency Preparedness Program
c/o NYC Department of Health and Mental Hygiene
125 Worth Street, RM 222, Box 22A
New York, NY 10013
Phone: 212-788-4277

or by e-mail at
hepp@health.nyc.gov

List of Appendices

Conversions of Conventional and International System of Units

In the United States, absorbed dose is commonly given in rad, and other protection quantities, such as equivalent dose and effective dose, are given in rem. The following table is provided to help avoid confusion among persons not familiar with the International System; in which absorbed dose is given in gray (Gy) and other protective quantities are given in sievert (Sv).

Conversions for absorbed dose: 1 Gy = 100 rad

0.001 rad	= 1 mrad	= 0.01 mGy	
0.01 rad	= 10 mrad	= 0.1mGy	
0.1 rad	= 100 mrad	= 1 mGy	= 0.001 Gy
1 rad	= 1,000 mrad	= 10 mGy = 1cGy	= 0.01 Gy
10 rad		= 100 mGy	= 0.1 Gy
100 rad		= 1,000 mGy	= 1 Gy
1,000 rad			= 10 Gy

Conversions for effective dose, equivalent dose, and dose equivalent, 1 Sv = 100 rem

0.001 rem	= 1 mrem	= 0.01 mSv	= 10 μSv
0.01 rem	= 10 mrem	= 0.1 mSv	
0.1 rem	= 100 mrem	= 1 mSv	= 0.001 Sv
1 rem	= 1,000 mrem	= 10 mSv = 1 cSv	= 0.01 Sv
10 rem		= 100 mSv	= 0.1 Sv
100 rem		= 1,000 mSv	= 1 Sv
1,000 rem			= 10 Sv

Symbol	Name	Multiplier	Value
p	pico	10^{-12}	Million millionth
n	nano	10^{-9}	Thousand millionth
μ	micro	10^{-6}	Millionth
m	milli	10^{-3}	Thousandth
c	centi	10^{-2}	Hundredth
k	kilo	10^{3}	Thousand
M	mega	10^{6}	Billion
G	giga	10^{9}	Thousand billion
T	tetra	10^{12}	Million billion
P	peta	10^{15}	Billion billion
E	exa	10^{18}	

Appendix 1.a. Radiation Safety Information Sheet for Staff Members

[*The following sheet may be made as a handout for staff members prior to a radiation incident*]

1. Is it safe to work if patients have radiation contamination from a "dirty bomb?"

Radiological Dispersal Device scenarios suggest that hospital staff members have little risk of harmful radiation exposure when performing normal care of injured and ill patients who may be contaminated with radioactive material as long as they follow certain precautions.

- Wear Universal Precautions to prevent the contamination of skin
- Minimize unnecessary time in radiation control Areas (areas that are designated to treat patients that might have radiation contamination)
- Attempt to maintain distance from any radioactive source, even moving away by 1 foot can make a significant difference
- If assigned a digital dosimeter (small meter used to display radiation levels) these should be worn in a place that can be easily read
- Follow instructions given to you by hospital radiation safety staff
- DO NOT EAT OR DRINK IN RADIATION CONTROL AREAS – to take a break, staff should go to buffer areas, disrobe, wash hands, and get surveyed prior to eating

2. What are the risks of radiation exposure?

According to radiation protection guideline assumptions, even the smallest exposure has a theoretical tiny probability of causing a long term effect, such as cancer. For example, there is a hypothetical risk of cancer from receiving radiation from a single chest x-ray, the risk is so small that it impossible to statistically prove this. Every year, you as a New Yorker receive a small amount of radiation, called background radiation, just by working in the city, breathing air, living in a building or house, and other activities of normal life. This radiation is equivalent to about 12-15 chest x-rays a year, and this is considered a normal yearly exposure. Other activities, like smoking, can greatly increase ones annual dose of radiation.

On the other hand, very high radiation doses received in a short period may cause serious illness and even death. Acute effects (Deterministic) such as these are only seen when a certain thresholds are exceeded. For example, it would take the same amount of radiation that would used in 3,330 chest x-rays to reach the lowest threshold to cause mild radiation sickness. Please see the attached table for more examples of risks from radiation exposure.

The radiation doses to staff members involved in an emergency response are expected to be well below these thresholds and well within the annual range of radiation exposures. All attempts will be made to keep them well below what is considered low radiation exposure, or about 1/3rd of the annual dose everyone receives.

Radiation Exposure Doses and Health Consequences

Radiation Dose* (rem)	Health Effect or Radiation Exposure
400 = 400,000 mrem	50 % die from radiation sickness if untreated (equivalent to 12,000 chest x-rays)
100 = 100,000 mrem	Threshold for Acute Radiation Syndrome Additional cancer risk 8%/100mrem (equivalent to 3300 chest x-rays)
75 = 75,000 mrem	Earliest onset of Radiation Sickness
30 = 30,000 mrem	Average dose Hiroshima Nagasaki survivors (equivalent to 1000 chest x-rays)
10 = 10,000 mrem	No Acute Effects Additional cancer risk less than 1% (equivalent to ~333 chest x-rays)
5 = 5000 mrem	Annual Occupational Dose Limit for Radiation Workers (equivalent to ~170 chest x-rays)
2.5 =2,500 mrem	5-hour transcontinental flight
1 = 1000 mrem	Radiation from an Abdominal CT Scan (equivalent to ~33 chest x-rays)
0.5 = 500 mrem	Annual Dose Limit for Pregnant Radiation Worker (equivalent to ~17 chest x-rays)
0.1 = 100 mrem	Annual Dose Limit for General Public (equivalent to ~ 3 chest x-rays)
0.03 = 30 mrem	Radiation from a standard Chest X-ray
2.5 mrem	Smoking 1 pack of cigarettes

Adapted from "Radiation and Risk," The University of Michigan Health Physics Web Site http://www.umich.edu/~radinfo/introduction/risk.htm Last Accessed October 11, 2007

*These doses are in addition to the normal background radiation dose of 360 mrem/year

Appendix 1.b. Post- Decontamination Survey Worksheet

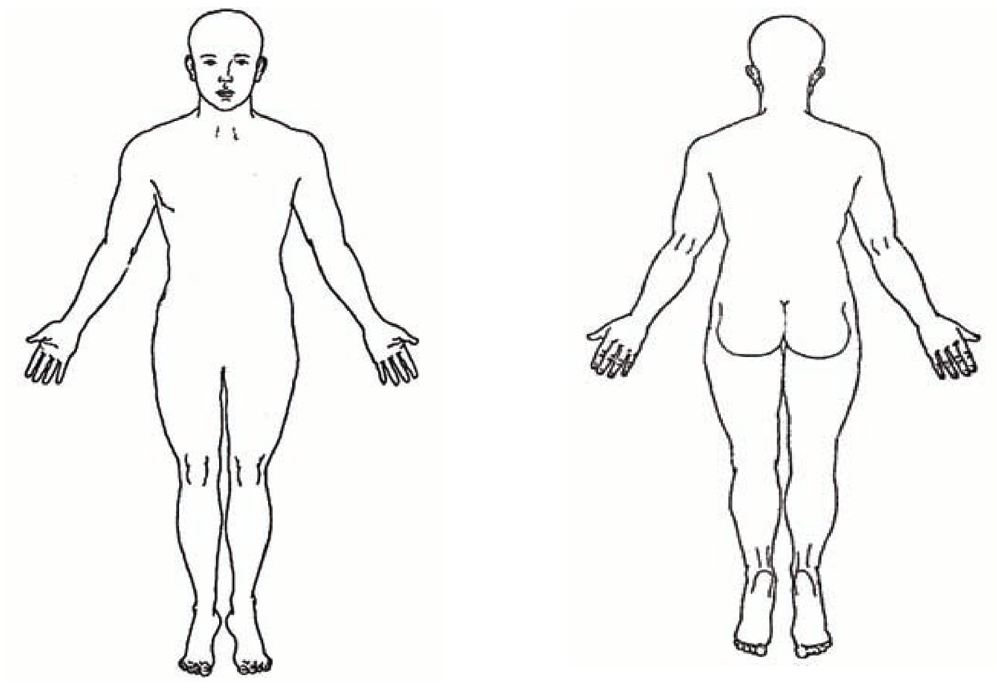
Survey meter serial No. ____

Name: ______________ Date___________ Time of Survey________

Survey patient after decontamination. Determine if additional decontamination shower is required. **Complete this form after final decontamination shower.**

Mark contamination on the diagram below in Counts per Minute:

Mark wounds if present on the diagram below:



Number of Decontamination Showers: 1 2 3 More

External Contamination Present Yes ____ No _____ Unknown_______

Internal Contamination Suspected Yes ____ No _____

Name of person completing survey: ______________________________

Instrument Type: __________________________ Number: ______

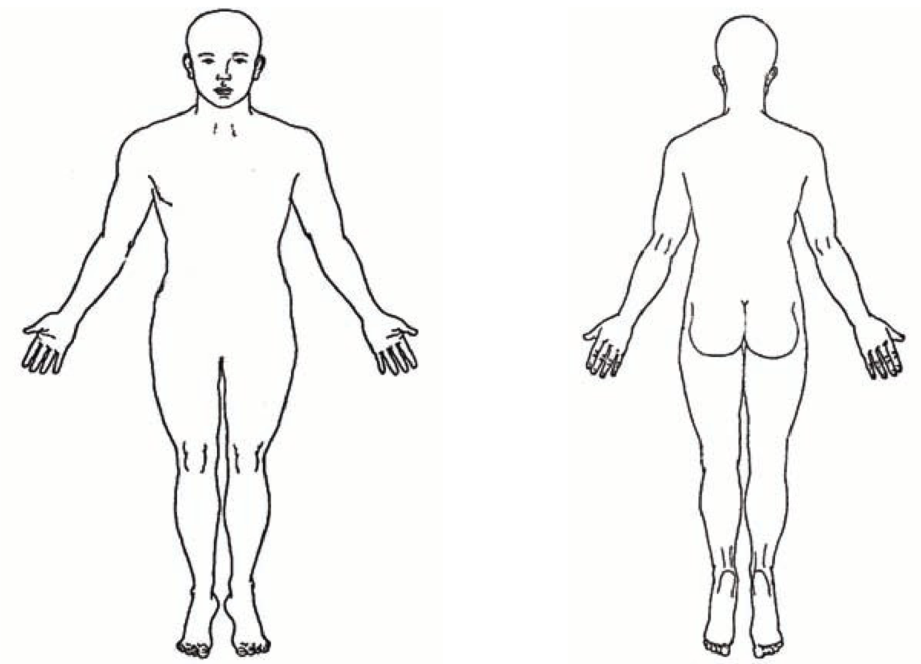
Background Reading ________ Counts per Minute (CPM)

Appendix 1.c. Wound Survey Worksheet

Name of Patient: ____
Date___________ Time of Survey________

Survey wound after whole body decontamination.

Take photograph if feasible
Mark open wounds on the diagram
If residual contamination is present, please indicate (cpm or mR/Hr):



Number of Decontamination Showers: 1 2 3

Wound Care, please describe:___________________________________
____
____
____

Hot Particle Present	Yes ___ No _____	Unknown_______	
Hot Particle Removed	Yes ___ No _____		
Residual Activity	Yes___ No _____	CPM _______	
Background		CPM _______	

Internal Contamination Suspected Yes ____ No _____

Name of person completing survey: ___________________________

Instrument Type: __________________________ Number: _______

Appendix.1.d. Patient Biodosimetry Worksheet

To be completed by radiation health physicist or other after hospitalization

Name of Patient	
Time of exposure:	Nature of exposure (inhalation, ingestion, exposure, and/or foreign body)
Injuries:	
External Exposure Overview	
Total body: Yes No	Partial body: Yes No
Contamination Overview	
External contamination: Yes No	Contaminated wound: (Please describe)
Internal contamination: Yes No	

Signs and Symptoms (None 0; Mild 1; Moderate 2; Severe 3)			
Symptom	Time (onset):	Duration	Severity
Nausea:			
Vomiting:			
Headache:			
Diarrhea:			
Fatigue:			
Erythema:			
Radionuclide(s)	List if identified:		Alpha (α): Yes No Beta (β): Yes No Gamma (γ): Yes No

Blood Cell Counts					
Dates	WBC	Lymphocytes (results should be Absolute Lymphs)	Granulocytes	RBC	Platelets
First					
Second					
Third					
Fourth					
Additional Information					

Name	
Weight	Nature of exposure
Injuries	
Gender	Smoker

Contamination Overview	
External contamination: Yes No	Contaminated wound:
Internal contamination: Yes No	

Pathway	**Inhalation**	**Ingestion**	**Open Wound**	**Cutaneous**

Radiation Source	Alpha (α): Yes No	Beta (β): Yes No	Gamma (γ): Yes No	Other

Laboratory Value					
Dates	Urine	Feces	Nasal Swab	Hair	Blood
First					
Second					
Third					
Fourth					

Treatments Attempted
Additional Information

Appendix 1.e. Employee Radiation Exposure Worksheet

(Complete worksheet for each shift or day employee worked during radiation incident)

NAME________________SSN_____________ DATE: __________

DATE OF BIRTH______________ Gender _____ Possibly Pregnant Y N

DEPARTMENT _________________ Contact Information__________

Describe event, include isotope(s) involved, quantity or radiation, and date of incident:

Work assignment during the Emergency Period
__ Direct patient care __ clerical __ security ___decontamination
__ environmental or radiation safety __ housekeeping
__ other please describe ______________________________________

Location of work
__ Pre-Decon Area
__ Decontamination
__ Red Treatment Area
__ Yellow Treatment Area
__ Green Treatment Area
__ Other, Please describe ______________________________________

Time started ___________ Time ended shift ______________

Note other events that might affect total dose (open wounds, splashed in face, etc.) ____

Dosimeter assigned Yes ___ NO ______
Type ___________________ #Serial No. ___________________
If digital, reading at beginning of shift ________________
If digital, reading at end of shift _________________
If film badge, date sent ____________ Reading _________________

Corrections and other adjustments____________________________

Results of Bioassays / thyroid monitoring if obtained ______________

Effective Dose Equivalent ______________________________

Significant Previous Exposure_________________________

TOTAL ACCUMULATED DOSE ___________________________

____

Name and title of person completing work sheet Date completed

Appendix 1.f. INSTRUCTIONS TO THE PUBLIC WAITING FOR DECONTAMINATION AT THE SCENE OF THE INCIDENT

(CRCPD, 2006)

You may have been exposed to radioactive particles. The particles may have settled as dust on your clothes or body from the explosion. In order to help protect the health and safety of everyone, you may be asked to go to a decontamination center. Do not panic, your health is not in immediate danger. You should follow these directions to prepare for decontamination:

1. Go to the designated area.
2. Do not touch your face or put anything into your mouth.
3. Enter the screening area and stand for a screening (survey) of yourself with clothing, and provide the workers with necessary personal information.
4. After you are screened, you will be directed to leave if minimal or no contamination is present. If contamination is found, you will be directed to the wash area.
5. If you are directed to enter the wash area, prepare to remove your outer garments behind the privacy curtain. You will be segregated with individuals of the same gender. To the extent possible, families will be kept together through the decontamination process.
6. Prepare to remove your outer garments behind a privacy screen or curtain. If radioactive materials are on your clothes, removing them will reduce the amount of contamination on you.
7. When removing clothing be careful about any that must be pulled over your head. Either cut the clothing away or hold your breath while removing clothing over the head.
8. Caregivers or parents should assist young children removing their clothing.
9. You will be provided with plastic bags. Place all of your clothing in one bag and your valuables into another plastic bag and seal them. You will be instructed on how to handle these items at a later time when we know more about the hazards of the material used.
10. Pass through the wash area.
11. When you reach the end of the wash station you will be given clothing to put on, and then be directed to the final staging area.

Appendix 1.g. INSTRUCTIONS TO PERFORM DECONTAMINATION AT HOME

You may have been small amount of radioactive particles. The particles may have settled on your hair, skin and clothing as dust or dirt. You are not in immediate danger from these small radioactive particles, however you do need to go home or to another designated area to remove this dirt as a precaution. Removal of outer clothing should reduce the almost all of this dirt, also known as contamination by up to 90%. In order to help protect your health and safety as well as others, please follow the directions.

You can take the following steps to wash off radioactive dirt:

- Get out of the immediate area quickly. Go directly home, inside the nearest safe building, or to an area to which you are directed by law enforcement or health officials.
- If radioactive material is on your clothes, removing them will reduce the dirt and decrease the risk of radioactive particles getting inside your body. When removing the clothing be careful of any clothing that has to be pulled over the head. Try to either cut the article off or prevent the outer layer from coming in contact with the nose and mouth area. You may also hold your breath while carefully pulling the article over the head.
- Removal of clothes should be done in a garage or outside area if available, where the ground can be washed with a hose. If an outside area is not available, the removal of clothing should take place in a room where the floor can be easily cleaned, such as the tub or shower areas. Clothing should be rolled up with the dirty side facing-in.
- If possible, place the clothing in a plastic bag, and then place this inside another large plastic bag, and leave it in an out-of the-way area, such as outside of the building, waste pick up area or garage. Keep people away from it to reduce their exposure to radiation. You may be asked to bring this bag for follow up readings or for disposal at a later time.
- Keep cuts and abrasions covered when handling contaminated items to avoid getting radioactive dirt in the wound.
- Shower and wash all of the exposed parts of your body and hair using soap and lukewarm water to remove contamination. Simple washing will remove most of the radioactive dirt or contamination. Do not use abrasive cleaners, or scrub. Do not use hair conditioners. This process is called decontamination.
- Put on clean clothes.
- Parents or caregivers should assist young children and those needing assistance with removing clothing and showering.

Contact your local/state Department of health for additional guidance.
NYC Dial 311 for more assistance
NYC Poison Control 212-POISONS or 212-340-4494
Or if internet is available, http://www.nyc.gov/health

Appendix 2. a. PORTABLE RADIOGRAPHIC EXAMINATION OF THE CONTAMINATED PATIENT

1. Portable X-rays should be used for radiographic examinations performed within the contaminated treatment areas.
2. Prior to entrance into the contamination area, the X-ray technician will don a surgical scrub suit, shoe covers, cap, mask and gloves and should place a plastic protective covering over all film cassettes to be used for the contaminated patient.
3. No special protection is required for the portable X-ray unit ***providing*** that it does not come into direct contact with the contaminated patient.
4. The X-ray technician should ask the Emergency Department Physician or Radiation Safety Officer present to point out those areas of the patient's body that have the highest levels of contamination.
5. If possible, the patient should be transferred to a clean stretcher prior to radiography.
6. Extra care should be taken by the X-ray technician when handling a contaminated patient so that the spread of contamination can be minimized.
7. "Hands-off" the cassette, holding onto the plastic cover, to a colleague in the buffer or clean zone.
8. Contaminated items will be placed in the container labeled "Contaminated Linen and Trash" prior to exiting the decontamination area.
9. Survey the technician, the X-ray unit, and the film cassette prior to release from the contaminated area.
10. The technician removes protective outer clothing in buffer zone (previously described).

Alternatively:

1. An X-ray technician remains in the contaminated treatment area and passes the clean film cassettes across the control line to a receiving technician who has the cassette surveyed, and if clean, takes the cassettes for development.
2. Contaminated items are controlled by the RSO and either decontaminated or removed for storage.

Modified from Daniak ND *et al*. Development of a statewide hospital plan for radiological emergencies. *Int J Rad Onc* 2006; 65: 16-24 and 16.e1-16.e15.

Appendix 2.b. CT OR RADIOLOGY SUITE RADIATION SAFETY

All attempts should be made to limit the use of radiology suites for contaminated patients. In the event that a victim of a radiation event requires an emergency radiological procedure or use of radiological equipment that is not portable, the following precautions should be taken to minimize the spread of contamination:

1. Maximally decontaminate victims prior to leaving the clinical area. There are few if any indications to move a patient from the clinical area to radiology prior to optimal decontamination.
2. If a risk of cross-contamination remains: Mark areas of gross contamination on patient and cover with a plastic covering prior to transfer.
3. Limit the number of CT suites used for contaminated victims. The room should be close to the Contaminated Treatment Areas. Mark and label the area(s) clearly.
4. Mark the pathway from the Treatment Area to the CT suite and limit access to essential personnel.
5. Cover everything in the room with disposable plastic coverings, especially examination tables or CT gantries.
6. Consider covering the floor with disposable covering, such as butcher paper. Plastic may be too slick and increase risk of falls
7. Extra plastic waste bins with additional plastic waste bags should be made available in the room.
8. Staff must observe standard precautions including double gloving.
9. Staff members who handle a contaminated patient should change gloves after touching the patient or patient stretcher. They should change outerwear between patients.
10. Survey the room and equipment between patients to avoid the spread of contamination.
11. If multiple patients will be using the room, with limited time to re-drape or clean room between patients, at a minimum, the examination table or gantries should have disposable covering replaced in order to limit cross contamination.
12. Upon completion of the procedure(s), the Radiation Safety Officer or his/her designee will survey the room, equipment, surgical garb and the plastic coverings to ascertain contamination.
13. Secure contaminated items for interim storage in the Nuclear Medicine Department.
14. Survey staff members as they exit any potentially contaminated area.

Appendix 2.c. OPERATING ROOM RADIATION SAFETY

Patients exposed to radiation but not contaminated require no special care in the Operating Room. Patients externally contaminated should be decontaminated prior to leaving the resuscitation area reducing the risk of cross contamination. If the patient requires resuscitation in the OR prior to decontamination the OR should be treated as a potentially contaminated area. Special attention is required for handling radioactive "hot particles".

1. A conventional operating room may be used, provided that there is adequate space to accommodate the standard Operating Room staff and additional radiation personnel.
2. Cover all OR equipment with disposable plastic coverings.
3. Cover the floor with disposable covering, such as butcher paper. Plastic may be too slick and increase risk of falls
4. Provide extra plastic waste bins.
5. Body areas grossly contaminated should be marked clearly and covered with plastic prior to surgery.
6. Consider consulting the RSO regarding the use of decorporation treatment.
7. Routine antisepsis measures ensure adequate protection of the Operating Room staff against secondary contamination.
8. Unless otherwise directed by the Radiation Safety Officer (RSO), there is no danger of contamination to the anesthesiologist or to the anesthesia equipment including the breathing circuit.
9. Rotate surgical instruments and change gloves as indicated. An adequate supply of surgical equipment (i.e. triplicate) should be present.
10. Survey surgical equipment after use and prior to sterilization.
11. Contaminated items should be secured in the Nuclear Medicine Department.
12. Secure contaminated tissue in either the Nuclear Medicine Department or other appropriate location for storage of radioactive waste. The RSO should be notified of location of stored tissue.
13. All personnel should be monitored with a standard GM-meter prior to exiting the Operating Room suite.

Modified from Daniak ND *et al*. Development of a statewide hospital plan for radiological emergencies. *Int J Rad Onc* 2006; 65: 16-24 and 16.e1-16.e15.

Appendix 2.d. Conducting an Area Rapid Radiological Survey of Crowds

The primary purpose of this survey is to quickly locate individuals in a crowd who have significant radiological contamination, hot particles, and/or significant injuries. These individuals require special treatment, rapid decontamination, and/or quick removal from others.

1. Don appropriate PPE

2. Obtain appropriate security

3. Obtain and check radiation survey meter

    a. Use a Survey meter with NaI scintillation detector if available

    b. Use General GM meter with standard probe otherwise

    c. Begin survey with the meter on highest sensitivity setting (this will enable surveyor to locate high activity sources -- the lowest setting (or most sensitive) would decrease of surveyors ability to isolate individuals with hot particles from a crowd of people having

    d. Keep the detector covered with a thin "exam" type of glove to prevent contaminating it

4. Survey crowd or area from a distance, first walking around the crowd with sound turned "on"

5. If source is detected, isolate and move contaminated individual away from the crowd and prioritize care

6. If isolated sources are found, such as on shoes or in clothing, secure or shield isolated sources, remove to distance from group. Do not handle sources with hands, use instruments

7. Prioritize identification of injured, obvious facial and upper body contamination, and children and pregnant women

8. Rapidly survey personnel, equipment and ambulances from the rescue scene for high activity sources

9. Frequently monitor/survey assigned areas, especially areas where discarded clothing, contaminated supplies, linens, or waste may accumulate, to ensure that high contamination radiation levels or hot sources are found and shielded

Appendix 2.e. Conducting a Rapid Radiological Screening Survey (CRCPD, 2006)

Note that if there are large numbers of people, you may need to perform a limited screening survey, rather than a more detailed survey

7. Hold the survey meter probe about 1-2 inches away from the body (instead of half an inch)
8. Move meter probe 2-4 inches/second. (If the probe is moved too quickly, its detection capability may be reduced.)
9. Surveyor scans the face, hands, and shoulders using a standard radiation survey instrument.
10. If the meter results are positive, then the patient is directed to the decontamination area. Following decontamination a second surveyor should perform a thorough survey documenting contamination levels.
11. Following the secondary (post-decontamination) survey, the patient may require additional decontamination, in which case the patient is returned to the decontamination area.
12. If the post-decontamination survey is negative or if further decontamination is impractical the patient is directed to their designated clinical area.

An additional clinician should be available to reassess the patient for a change in their triage designation.

COMMON MISTAKES TO AVOID:

- Holding the probe too far away from the surface. Probe should be 1-2 inches away for rapid, and ½ inch for detailed survey.
- Moving the probe too fast. Appropriate speed is 2-4 in/sec for rapid, 1-2 in/sec for detailed survey
- Contaminating the probe. Probe background should be observed and compared to initial background. Wrapping probe in plastic wrap will help to prevent surface contamination.

Appendix 2.f. Conducting a Full-Body Radiological Survey on an Ambulatory Person

Adapted from REAC/TS http://orise.orau.gov/reacts/guide/detect.htm

Prepare the Meter:

8. Position the Geiger counter with the meter away from you.
9. Locate and open the battery compartment.
10. Put the batteries in the meter using proper orientation (up/down).
11. Close and latch the battery compartment.
12. Check the batteries using the "range" switch or "bat" button; the method depends on the type of instrument. The meter needle should move to area on scale marked battery, indicating the batteries are good. If the batteries are not good, find a flashlight or other source of 2 D-cells and put them in the meter -- check these batteries also.
13. Turn the "F/S" switch to "S" (Slow).
14. Turn the "audio" switch to "ON."

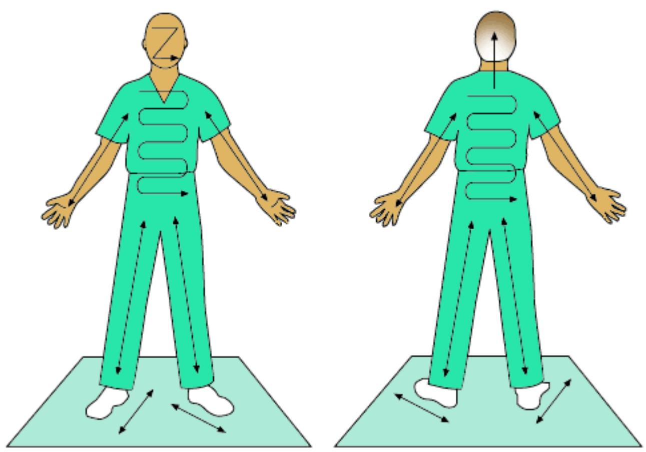
Measure Background Radiation:

7. Check that the "F/S" switch is on "S" (Slow).
8. Move the range switch to the most sensitive position.
9. Remove the probe cover if one is in place.
10. Measure the background radiation for 60 seconds: write down the reading. Since background radiation varies with time, it may be desirable to make several counts and average the results. Record the reading.
11. Expect a reading of 40-100 counts/min or a reading of approximately 0.02 mR/hr (i.e. 0.2 on the 0.1 range setting), or 0.2 micro Sv/hr.
12. Record background reading.

Conduct the Survey:

20. Have the person stand on a clean pad.
21. Instruct the person to stand straight, feet spread slightly, arms extended with palms up and fingers straight out.
22. Move the "F/S" switch to "F" (Fast response).
23. Set the instrument selector switch to the most sensitive range of the instrument.
24. Holding the probe approximately 1/2 to 1 inch from the person's skin, systematically survey the entire body from head to toe on all sides.
25. Monitor both hands and arms; then repeat with hands and arms turned over.
26. Starting at the top of the head, cover the entire body, monitoring carefully the forehead, nose, mouth, neckline, torso, knees, and ankles.
27. Have the subject turn around, and repeat the survey on the back of the body.
28. Monitor the soles of the feet.
29. Move the probe slowly (about 1 inch per second).
30. Do not let the probe touch anything.
31. Try to maintain a constant distance.
32. Pay particular attention to hands, face and feet.

33. Note that some GM instruments cannot detect alpha radiation and some low-energy beta radiation. Because alpha radiation is non-penetrating, it cannot be detected through even a thin film of water, blood, dirt, clothing, or through probe cover.
34. *An increase in count rate or exposure rate above background indicates the presence of radiation.*
35. Locate the point that produces the most clicks. (Turn the "F/S" switch to "S" to take a reading at this location. Remember to reset it to "F" before continuing survey.)
36. When necessary, adjust the range of the instrument by moving the range selector switch.
37. Document time and radiation measurements.
38. In general, areas that register more than twice the previously determined background level are considered contaminated. For events involving alpha emitters, if the reading is less than twice the background radiation level, the person is not contaminated to a medically significant degree. If the event circumstances indicate that an alpha emitter (such as plutonium) or low energy beta emitter could be a contaminant, a health physicist should always be consulted.



End the radiation survey:

4. Switch off the meter.
5. Replace the cap on the meter probe.
6. Take the batteries out.

Put the Geiger counter back in its case.

COMMON MISTAKES TO AVOID:

- Holding the probe too far away from the surface. Probe should be 1-2 inches away for rapid, and ½ inch for detailed survey.
- Moving the probe too fast. Appropriate speed is 2-4 in/sec for rapid, 1-2 in/sec for detailed survey
- Contaminating the probe. Probe background should be observed and compared to initial background. Wrapping probe in plastic wrap will help to prevent surface contamination.

Appendix 2.g. PERSONAL PROTECTIVE EQUIPMENT (PPE) DONNING AND DOFFING PROCEDURE

Donning Personal Protective Equipment

5. Personnel should dress in surgical clothing
    - Scrub suit and gown or Tyvek® overalls
    - Surgical mask with eye protection or face shield
    - Double gloves
        - Inner gloves under the arm cuff and secured by tape to the gown
        - Outer gloves should be easily removable and changed frequently
        - Use more rugged material as needed
    - Head cover or bonnet
    - Waterproof shoe covers
    - Waterproof aprons or outer gowns for staff using liquids for decontamination or at risk for splash of liquids
6. Tape shut all open seams and cuffs using heavy tape
7. Assign personal self-reading dosimeters to staff working closest with contaminated patients. Attach to outer garment where they can be easily removed and read.
8. Thermoluminescence Dosimeters (TLDs), also known as film badges, if worn, should be placed near the neck, under the surgical gown to avoid gross contamination. Consider dispensing these personal passive dosimeters to all staff members involved in response.

Doffing Personal Protective Equipment

Prior to exiting from a controlled area, personnel begin doffing at the control line as described below:

10. Remove outer gloves first, turning them inside-out as they are pulled off.
11. Give dosimeter to radiation safety officer (or insure that reading is recorded)
12. Remove all tape at trouser cuffs and sleeves.
13. Remove outer surgical gown, turning it inside-out -- avoid shaking.
14. Pull surgical trousers off over shoe covers.
15. Remove head cover and mask.
16. Remove shoe cover from one foot and let radiation safety officer monitor shoe; if shoe is clean, step over control line, then remove other shoe cover and monitor other shoe.

17. Remove inner gloves.
18. Do total-body radiological survey of each team member.

For a visual aide and training module on proper donning and doffing procedure go to REAC/TS Procedure Demonstration web site at http://orise.orau.gov/reacts/guide/procedures.htm and view, "Dressing to Prevent the Spread of Radioactive Contamination."

Appendix 2.h. HOW TO DISTINGUISH BETWEEN ALPHA, BETA AND GAMMA RADIATION USING A PANCAKE GM SURVEY METER

(CRCPD, 2006)

Many studies show that the most likely radionuclide(s) to be used in a dirty bomb would be either a gamma emitter or a beta-gamma emitter. However, it is possible that the radionuclide may be a pure beta emitter such as strontium 90 (Sr-90) or an alpha emitter such as americium 241 (Am-241). This appendix describes a technique using a pancake GM meter (and if available, a sodium iodide - NaI meter) that may be employed by responders to make a quick, initial determination of the type of radiation present at the scene (alpha, beta, or gamma). This methodology was developed to assist responders in making an initial determination of the type of radiation present, until radiation control staff arrive at the site with more sophisticated instrumentation to identify the radionuclide(s).

Pancake GM survey meters will respond to beta, gamma, and X-radiation. They have very limited response to alpha radiation. Sodium iodide or NaI survey instruments will only respond to gamma radiation or x-rays. Do not be misled into thinking that radionuclides are not present by the lack of response from a NaI survey meter, since it can not detect alpha or beta radiation.

TO DETERMINE THE PRESENCE OF STRONTIUM 90 USING ONLY A PANCAKE GM SURVEY METER:

- Take a measurement with the window side of the pancake probe (mesh covered side) facing the ground at approximately 6 inches from the ground in an area that yields a meter reading between 500 – 1500 cpm. Then take another measurement with the window side facing up (away from the ground) at the same height.
- Compare the two measurements:
  - If only strontium 90 is present, the window up reading will be near background (background will be in the range of 25 to 75 cpm), and the window facing down reading should be 10 or more times greater than the window up reading. This is because the beta emissions are not able to penetrate the backside of the GM pancake probe.
  - If gamma or beta-gamma emitter is present (e.g. cesium 137, iridium 192, cobalt 60), the window facing down reading at 6 inches, will be approximately twice the window up reading.

TO DETERMINE THE PRESENCE OF AN ALPHA EMITTING RADIONUCLIDE USING ONLY A PANCAKE GM METER:

It is important to check for the presence of alpha emitting radionuclides. Alpha emitters can be very harmful when inhaled or ingested. Because the instruments normally available to responders will not readily respond to alpha radiation, it is important to use appropriate respiratory protection when monitoring for radionuclides.

- Take readings at approximately 3 inches and about ½ inch above the ground (or as close as possible trying not to touch the ground). If the instrument reading increases by more than a factor of 3 at the ½ inch measurement (as compared to the 3 inch measurement), suspect alpha contamination (such as americium 241).
- Next place a sheet of paper on the ground and take a reading with the window side down directly on top of the paper. The alpha radiation will not penetrate the paper, and the window down reading should significantly decrease to near background level. If the window down measurement taken over the paper does not decrease significantly, the nuclide is likely not an alpha emitter.

Appendix 3. On-line Resources

Local Resources

New York City Department of Health and Mental Hygiene
http://home2.nyc.gov/html/doh/html/bt/bt_radio.shtml

This is the Official Website of the New York City Department of Health and Mental Hygiene and contains New York City specific information. It includes a link to this document as well as to useful information from the Centers for Disease Control and Prevention.

Federal Resources

Centers for Disease Control and Prevention
http://www.bt.cdc.gov/radiation/

Frequently updated information specifically designed for Health Care facility response. The site is user friendly and easily searchable. It is resource rich for patient information sheets and frequently asked questions. It also contains treatment options for specific isotopes.

Smith, James M. *Interim Guidelines for Hospital Response to Mass Casualties* from a Radiological Incident. December 2003.
http://www.bt.cdc.gov/radiation/pdf/MassCasualtiesGuidelines.pdf

This is a 98 page overview of management of radiation events. The first 37 pages are a glossary with dozens of hyperlinks for additional resources, followed by a primer on radiation. The document describes general management with broad recommendations for care. The document includes mental health concerns, community involvement issues, and ends with a brief glossary of radiation detection equipment.

Department of Health and Human Services
Radiation Event Medical Management Site
http://www.remm.nlm.gov/index.html

Well developed site with extensive guidance for the medical management of radiation incidents.

Department of Veterans Affairs
http://www1.va.gov/emshg/docs/Radiological_Medical_Countermeasures_Indexed-Final.pdf

The Department of Homeland Security Working Group on Radiological Dispersal Device (RDD) Preparedness. This document, a joint venture of the Department of Homeland Security, The Department of Veterans affairs and the Department of Health and Human Services, is comprehensive and easily understood by the general planner and healthcare professional

Department of Homeland Security
http://www.dhs.gov/dhspublic/ or http://ready.gov/america/radiation.html

A very short discussion defining dirty bombs, plus visual instructions on how to protect oneself. This site is best for general information.

Environmental Protection Agency
http://www.epa.gov/rpdweb00/rert/index.html

The web page of the U.S Environmental Protection Agency defines the coordinated response with other federal agencies. The site has general information for Emergency Planners rather than clinicians.

Federal Emergency Management Agency (FEMA)
http://www.fema.gov/hazard/terrorism/rad/rad_during.shtm

The site links to radiation emergency training opportunities through FEMA and articulates the National Incident Management System (NIMS) The information addresses Emergency Planning and coordination of federal, state and local assets. Less informative than the other sites a healthcare perspective.

Armed Forces Radiobiology Institute
www.afrri.usuhs.mil/

This joint venture of experts from various branches of the United States Military provides multiple educational and policy statements including official recommendations for the use of Prussian blue and potassium iodide. Specifically this sites references the located, and how long it would take to receive it. Also includes information on the handbook "Medical Management of Radiological Casualties" and how to obtain the BAT (Biodosimetry Assessment Tool).

U.S. Department of Labor: Occupational Safety & Health Administration
http://www.osha.gov/SLTC/emergencypreparedness/radiation_sub.html

This is an essential reference site for Emergency Planners involved in Occupational Safety and Health. The site features basic information on Radiological Dispersal Devices (RDD), ionizing radiation safety facts and a hot-link to Ready.gov.

Nuclear Regulatory Commission
http://www.nrc.gov/

The US Nuclear Regulatory Commission oversees the licensing of nuclear power plants and other civilian use of nuclear materials. The documents are specialized descriptions of nuclear reactors and the nuclear fuel cycle as well as numerous highly technical regulatory documents. The Emergency Planning materials are focused on nuclear reactors with additional information about radiological dispersal devices. There is also information focusing on public education to describe the relative safety of radiation, especially as it relates to civilian power sources. There is little information for hospital planning for a radiological event other than that directly involving a nuclear reactor.

International Resources

International Atomic Energy Agency
http://www.iaea.org/worldatom/

International Commission of Radiological Protection
http://www.icrp.org/

Non-governmental Authorities

Council of Radiation Control Program Directors, Inc.
www.crcpd.org/

CRCPD is a nonprofit organization of individuals, include state Radiation Control Directors, that regulate and control the use of radioactive material and radiation sources.

Useful materials for responding to Radiation Dispersal Device may be found at http://www.crcpd.org/RDD.htm

Health Physics Society
www.hps.org/

This site has easily understandable detailed and accurate information. Multiple authoritative references and position statements are offered.

Oak Ridge Institute for Science and Education
(Radiation Emergency Assistance Center/Training Site)
http://www.orau.gov/reacts/

This is official website of the organization/center used to create the atomic bomb. The site offers the basics of radiation, measurement, detection, medical stabilization, dose estimates, a 20-questions "test your knowledge of radiation event management", and information on courses available through REAC/TS.

Berger, ME. Hospital Triage in the First 24 Hours after a Nuclear or Radiological Disaster. 2000. Oak Ridge Associated Universities. http://www.orau.gov/reacts/triage.pdf

This document was prepared by the experts at the Radiation Emergency Assistance Center/Training Site. It is a useful guide for patient management decisions. Helpful standardized patient information sheets and diagrams for medical recording are provided.

National Council on Radiation Protection (NCRP)
www.ncrponline.org

The National Council on Radiation Protection and Measurement was founded by congressional charter in 1964 to act as the scientific experts for the United States. The council independent of Federal Agencies. The NCRP documents are the national standards for radiation protection. Proper Emergency Preparedness requires analysis of the following NCRP documents.

- Commentary No. 19 - Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism (2005)
- Report No. 138 - Management of Terrorist Events Involving Radioactive Material (2001)
- Report No. 65 - Management of Persons Accidentally Contaminated with Radionuclides (1979)