# Population Monitoring in Radiation Emergencies

## A Guide for State and Local Public Health Planners

*Second Edition*

**April 2014**

National Center for Environmental Health
Division of Environmental Hazards and Heath Effects

# Population Monitoring in Radiation Emergencies:

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Developed by the
Radiation Studies Branch
Division of Environmental Hazards and Health Effects
National Center for Environmental Health
Centers for Disease Control and Prevention
U.S. Department of Health and Human Services

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Electronic copies of this document can be downloaded from:
http://emergency.cdc.gov/radiation/pdf/population-monitoring-guide.pdf

# Preface

The first edition of *Population Monitoring in Radiation Emergencies* was published in 2007 after extensive collaboration with representatives from many local, state, and federal agencies and nongovernmental organizations who provided expert input.

Since the publication of the 2007 edition, the Centers for Disease Control and Prevention (CDC) staff and its partners have presented the content of this guide at national and regional technical meetings and training sessions throughout the country to a variety of public health audiences. The content of the guide has been used in the design and conduct of drills and exercises at local, state, and federal levels. States are beginning to incorporate population monitoring into their radiation emergency response plans as awareness of this important preparedness element continues to increase.

The operational concept of the community reception center (CRC)—first described in the 2007 edition—is also being incorporated in radiation emergency response plans across the country. To support this effort, CDC has developed a number of training and planning tools and resources specifically related to population monitoring and CRC operations.

This second edition of *Population Monitoring in Radiation Emergencies* is similar in structure to the first edition. However, it incorporates recommendations received from users and new information from a number of recent national and international consensus documents related to population monitoring. In addition, the expanded appendices contain detailed descriptions of related tools and resources that CDC has developed since 2007.

A list of acronyms used in this guide can be found in Appendix A, and a glossary of terms can be found in Appendix B.

# Acknowledgments

The Centers for Disease Control and Prevention (CDC) thanks the many individuals and organizations that have provided input for this document, beginning with the population monitoring roundtable that was held in Atlanta, Georgia, on January 11-12, 2005.[1]

CDC wishes to thank specifically the representatives from the following agencies and organizations which participated in the Population Monitoring Interagency Working Group beginning in November 2005 and provided valuable input during development of the 2007 edition of this guide:

American Red Cross (ARC)

Conference of Radiation Control Program Directors, Inc. (CRCPD)

U.S. Department of Energy (DOE)

National Nuclear Security Administration (DOE/NNSA)

U.S. Department of Homeland Security (DHS)

U.S. Environmental Protection Agency (EPA)

U.S. Food and Drug Administration (FDA)

U.S. Nuclear Regulatory Commission (NRC)

Oak Ridge Associated Universities (ORAU)

Oak Ridge Institute for Science and Education (ORISE)

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

State of California Department of Public Health

CDC also acknowledges ORAU for its assistance in the final preparation of this guide. The principal authors of this document are Armin Ansari, PhD, CHP, Centers for Disease Control and Prevention, and Kevin Caspary, MPH, Oak Ridge Associated Universities.

[1] The summary report from the 2005 *Roundtable on Population Monitoring Following a Nuclear/Radiological Incident*, including the list of participants, is available at http://emergency.cdc.gov/radiation/pdf/population-monitoring-roundtable.pdf.

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# 1.0 Introduction

This planning guide presents an introduction to population monitoring in radiation emergencies for public health officials and emergency preparedness planners at the state, tribal, and local levels. Developed by the Centers for Disease Control and Prevention (CDC) with extensive input from its partners, it focuses on planning a public health response to radiological or nuclear terrorism incidents involving large populations.

Population monitoring[2] is an essential, often overlooked element in emergency response planning. Many critical components of population monitoring should be put in place in the first few hours after the incident, before the arrival of federal assets that might be used to assist in the monitoring efforts. State and local emergency response and public health authorities can use this guide to

- evaluate their emergency response plan to determine if it adequately addresses population monitoring.
- identify staffing needs, training requirements, and necessary material assets.
- prioritize training needs for their staff.
- further develop local and state health volunteer programs by identifying available resources to meet population monitoring needs.
- be better prepared to prioritize allocation of personnel and material resources in the response to a radiation emergency.

*Population Monitoring in Radiation Emergencies* focuses on the significant effort required to identify, screen, measure, and monitor populations (people and their pets) for exposure to radiation or contamination from radioactive materials. The guide also presents the concept of establishing community reception centers (CRCs) to provide contamination screening and decontamination services to people displaced by a large-scale radiation incident. CRCs will be established to assess people for exposure, contamination—and the need for decontamination—and to register people for follow-up monitoring, medical assessment, or medical management if necessary. As discussed later, sites used for alternate care sites or points of dispensing (PODs), already in many public health emergency response plans, may be used for CRC operations with some additional staffing and resources.

As planning efforts progress, consider the size of the community and the characteristics of the population (age distribution, health status, mobility, diversity, density, etc.).

Planners should explore and consider all potential resources that could be available locally. Consider resources that could be available through agreements with adjoining jurisdictions, as well as the assistance required from federal responders, to conduct population monitoring.

*Population Monitoring in Radiation Emergencies* was developed with input from multiagency working groups that included physicians, health physicists, emergency services personnel, mental health practitioners, environmental scientists, and international specialists in radiation-related treatment,

[2] The term "public monitoring" used in the context of radiation emergency response has the same meaning as population monitoring.

monitoring, and risk assessment. CDC has made every effort to ensure the information included is accurate and consistent with sound radiation protection and assessment methods, policies, and practices.

## 2.0 Scope

This planning guide is specifically intended for public health and emergency preparedness personnel involved in planning for response to a radiation emergency. The following assumptions are made:

- The incident does not involve biological or chemical agents. In such a case, radiation issues may be overshadowed by more immediate health concerns related to those chemical or biological agents.
- The local response infrastructure is relatively intact. In the case of a nuclear detonation, this assumption is not likely to hold. See Appendix C for discussion of population monitoring after a nuclear detonation.

This document does not address environmental monitoring, assessment, or remediation.

### 2.1 States with Operating Nuclear Power Plants

In the United States, 31 states have operating nuclear power plants.[3] Public health planners in those states already have local plans for responding to an incident at a nuclear power plant in their state or in a neighboring state. These plans include requirements related to population monitoring.[4] These plans have also resulted in well-established working relationships with planning partners in the state radiation control program and federal partners in the Federal Emergency Management Agency (FEMA) and the Nuclear Regulatory Commission (NRC). In addition, states with operating nuclear power plants work with area hospitals that already have plans developed for receiving and treating patients as a result of a radiation incident.

Effective response to a radiological or nuclear terrorism incident requires a broader scope of planning and most likely a different mode of response than that described in nuclear power plant emergency plans. Plans need to account for the suddenness of an incident (as opposed to nuclear power plant failure, which would likely unfold over a 24- to 72-hour period); the likelihood that the incident would be larger in scale, involving a much larger urban population; and the unknown aspect of the radionuclide(s) involved. The plans and expertise already developed in states with nuclear power plants can be assets in preparing for a radiological or nuclear terrorism incident with or without mass casualties.

[3] A listing of operating nuclear power plants in the United States is available at www.nrc.gov/info-finder/reactor.

[4] See NUREG-0654/FEMA-REP-1, *Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants*, available at www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0654/.

## 3.0 Guiding Principles

Several key principles specific to radiation are important in planning for response to a radiation incident, including planning for population monitoring.

1. **The first priority is to save lives: respond to and treat the injured first.** Treatment of life- or limb-threatening medical conditions should take precedence over decontamination. Standard Precautions are generally adequate to provide protection for first responders, emergency medical personnel, and clinicians.[5]

2. **Contamination with radioactive materials is not immediately life-threatening.** Decontamination procedures are straightforward; removing clothing and washing the body thoroughly with mild soap and water will eliminate most external contamination.

3. **Initial population monitoring activities should focus on preventing acute radiation health effects.** Cross-contamination issues are a secondary concern, especially when the contaminated area or the affected population is large.[6]

4. **Scalability and flexibility are important parts of the planning process.** The criteria used for contamination screening and the radiation survey methods may have to be adjusted to accommodate the magnitude of the incident and availability of resources.

5. **Fear of radiation is high, perhaps higher than with other agents of terrorism.** Providing information and clear communication prior to and during an incident will help allay fears and allow people to make appropriate response decisions.

6. **A key resource for implementing activities described in this guide is a state's lead agency for radiation control.** Additional expertise and resources to plan for and respond to a radiation incident can be obtained from radiation protection professionals in each community. Local emergency response plans should identify experts such as health physicists or radiation safety officers in area health departments, environmental agencies, hospitals, and universities. Relationships with these experts should be established in the planning stages.

7. **First responders and local officials may not be aware initially that a radiation incident has occurred.** Public health and emergency personnel's initial response to an incident may be an all-hazards approach. However, once these personnel have determined that radiation or radioactive material is involved, they must begin addressing the issues related to this type of incident.

8. **Radiological decontamination recommendations differ from those for chemical or biological agents.** Decontamination for chemical or biological agents must be performed immediately. In a radiation emergency, people may be advised to self-decontaminate at home or at a community reception center. Decontamination should be done as soon as possible, but it usually does not require the same immediacy as chemical or biological contamination does.

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[5] Standard Precautions (previously known as Universal Precautions) are the minimum infection prevention practices that apply to all patient care, regardless of suspected or confirmed infection status of the patient, in any setting where health care is delivered. See CDC's *Guide to Infection Prevention for Outpatient Settings: Minimum Expectations for Safe Care*, May 2011, available at www.cdc.gov/HAI/settings/outpatient/outpatient-care-gl-standared-precautions.html.

[6] Cross-contamination refers to spreading of radioactive materials from one person, object, or place to another.

9. **Law enforcement agencies will be involved in response to a radiological terrorism incident.** If a radiation incident is the result of a terrorist attack, the site will be considered a crime scene. Close coordination with local, state, tribal, and federal law enforcement agencies will be required to manage the public health response, because both public health and law enforcement personnel will need to conduct operations in the same area.[7]

## 4.0 What Is Population Monitoring?

Population monitoring is a process that begins soon after a radiation incident is reported and continues until all potentially affected people have been monitored and evaluated for the following:

- Needed medical treatment
- The presence of radioactive contamination on the body or clothing (external contamination)
- The intake of radioactive materials into the body (internal contamination)
- The removal of external or internal contamination (decontamination)
- The radiation dose received and the resulting health risk from the exposure
- Long-term health effects

These assessments, with the exception of long-term health effects, should be accomplished as soon as possible following an incident. Long-term health effects are usually determined through a population registry and an epidemiologic investigation that will likely span several decades.

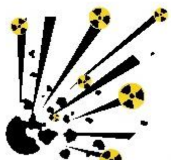
The population to be monitored includes the people in the affected community. In addition, pets may also be included because many people consider them part of their families and will make decisions on that basis. The term population monitoring, as used in this manual, ***does not*** refer to the monitoring of facilities, farm animals, vegetation, or the food supply. The U.S. Environmental Protection Agency, the U.S. Department of Agriculture, and the U.S. Food and Drug Administration have plans and procedures for monitoring the environment, facilities, and the food supply.

To conduct population monitoring, specific instruments are used to survey for radioactive contamination on the body. This is also referred to as monitoring or screening for external contamination. Other instruments and laboratory tests may be needed to determine if and how much radioactive material has been taken into the body. This is also referred to as monitoring or screening for internal contamination. Additional assessments may be needed to determine total radiation dose to an individual or to a population. This is referred to as radiation dose assessment.

[7] For more information on working with law enforcement after a radiation emergency see CDC's *Radiological/Nuclear Law Enforcement and Public Health Investigation Handbook*, September 2011, available at http://www.emergency.cdc.gov/radiation/pdf/radiological%20nuclear%20handbook%2009%2001%2011.pdf.

# 5.0 What Radiation Incidents Should Be Addressed in Emergency Response Plans?

Government authorities and other experts believe a real probability exists that radiological or nuclear devices could be used in a terrorist attack in the future. Therefore, public health authorities should plan for the potential use of radiological or nuclear devices that could quickly overwhelm crisis management personnel. These devices can be grouped into the following categories:



RDD (Radiological Dispersal Device): a device or process used to disperse radioactive material, thereby exposing people and the environment to radiation. Dispersal of radioactive material may be noticeable—for example, from an explosion (commonly known as a dirty bomb)—or it may be silent. An example of a silent dispersal is contamination of the food or water supply. Responders and local officials will know that an RDD has been used when radiation is detected by proper instrumentation or through notification by a law enforcement agency. Even though the health risks may be low or, in case of a dirty bomb, the scope of the physical damage may be limited, a significantly large number of people may need to be monitored for possible contamination.[8]

RED (Radiation Exposure Device): a weapon of terror whereby a high-intensity radiation source is placed in a public area to expose people in close proximity (for example, an industrial radiography source placed under the seat of a bus). Radioactive contamination is not spread, and people do not become radioactive. Rather, prolonged exposure to a high-intensity source may lead to acute radiation syndrome (ARS) or to cutaneous radiation injury (CRI), also known as radiation burns.

IND (Improvised Nuclear Device): fissile or fissionable material, such as uranium 233, uranium 235, or plutonium 239, engineered in such a way that when detonated, it releases significant amounts of energy, creating a shock wave, intense heat and light, and a cloud of radioactive material, also known as fallout. INDs are improvised in the sense that the nuclear material is stolen and then assembled in a makeshift fashion. The damage and deaths associated with an IND will vary according to the technical skills of the perpetrators, its detonation location, the level of shielding in an urban environment, and building construction materials. Most damage and deaths are likely to be centered nearest the detonation point, and injuries (e.g., burns, blindness, and lacerations) will occur among people farther away. The smallest INDs are on the order of 1–10 kilotons of equivalent conventional explosives.

Strategic Nuclear Weapon: a state-sponsored, designed, engineered, and tested weapon. These weapons are tens to hundreds of times more powerful than INDs and may become terrorism threats if acquired by adversaries.

[8] The polonium-210 poisoning incident in London (November 2006) had the characteristics of an RDD. Even though the incident apparently targeted only one person, hundreds of people in several countries, including the United States, were monitored for potential contamination as a result of casual contact with contaminated objects and locations.

# 6.0 What Are the Roles and Responsibilities of Federal, State, Tribal, and Local Public Health Agencies?

If a radiation incident occurs, the chief executive officer of that community (the tribal leader, mayor, city manager, or county manager) is responsible for coordinating the overall local response and resources. State, tribal, and local public health agencies will have many responsibilities, including the following:

- Protecting the public's health and safety
- Monitoring workers' health and safety
- Ensuring provision of health and medical services
- Ensuring safe shelters for displaced populations
- Ensuring the safety of food and water supplies
- Coordinating sampling and laboratory analysis of clinical, agricultural, and environmental samples
- Conducting field investigations
- Monitoring people who may have been contaminated with radioactive materials or exposed to radiation (population monitoring)
- Conducting or assisting in decontamination
- Developing criteria for temporary re-entry, operations within, and permanent return to the incident site
- Recommending disease prevention and control measures
- Recommending management protocols for affected populations or individuals
- Communicating necessary information to medical providers
- Communicating situation assessments and required safety measures to the public
- Assisting law enforcement agencies with the criminal investigation

Local health agencies may call on state health officials, who in turn may request assistance from the federal government.

The Nuclear/Radiological Incident Annex of the National Response Framework describes how federal agencies will coordinate a response to nuclear or radiological incidents. Under this annex, the U.S. Department of Health and Human Services (HHS) is responsible for the following population monitoring activities:

- Coordinating federal support for external monitoring of people
- Assisting local and state health departments in establishing a registry of potentially exposed people
- Performing dose reconstruction
- Conducting long-term monitoring of the exposed population for potential long-term health effects

These services will be provided to support the affected state or states. As a general rule, during the initial stages of the incident local and state officials should be prepared to handle the crisis without federal assistance. Contamination screening and decontamination of people impacted by the incident are accomplished locally and are the responsibility of state, tribal, and local governments. Federal resources are provided at the request of, and in support of, the affected state or states. HHS, through Emergency Support Function 8 and in consultation with the coordinating agency, coordinates federal support for population decontamination. HHS also assists and supports state, tribal, and local governments in performing monitoring for internal contamination and administering available pharmaceuticals for internal decontamination, as deemed necessary by state health officials.

# 7.0 What Are the Key Considerations in Planning for Population Monitoring?

Planning for a radiation emergency, particularly a large-scale terrorism incident, involves complicated issues and processes. The key considerations in planning for population monitoring in the wake of a radiological terrorism incident are stated below.

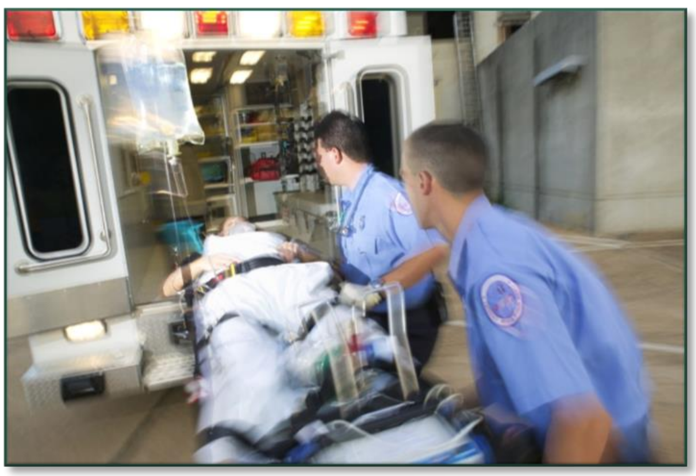
## 7.1 Objectives of Population Monitoring

The objectives of the population monitoring process are the following:

- Identify individuals whose health is in immediate danger and who need immediate care, medical attention (whether radiation-related or not), or decontamination.
- Identify people who may need medical treatment for contamination or exposure, further evaluation, or short-term health monitoring.
- Recommend (and to the extent possible, facilitate) practical steps to minimize the risk of future health consequences (e.g., cancer).
- Register potentially affected populations for long-term health monitoring.

With these objectives in mind, this guide may be used to work through the planning process for population monitoring.

## 7.2 Identifying and Prioritizing the Affected Population



In the event of a terrorist attack, many people in the affected area would likely request an assessment and treatment from public health authorities, hospitals, clinics, and private physicians. Other people who were not exposed or contaminated may request evaluation to confirm their condition or seek reassurance. Every effort should be made to keep those who do not need immediate medical attention from overburdening local and area hospitals. This may be accomplished by identifying the time periods and locations where members of the public could have received an exposure of concern. This information should then be communicated to members of the public to help them make informed decisions.

The highest treatment priority is for people who have life-threatening injuries or who are in need of immediate medical care, which may or may not be related to the radiation incident (e.g., heart attack or a pre-existing critical condition). As will be discussed later, effective public communication is a key component of the emergency response. In a mass casualty incident, uninjured people can be encouraged to go home, self-decontaminate, and then return for monitoring at designated locations according to a priority schedule.

**The highest treatment priority is for people who have life-threatening injuries or who are in need of immediate medical care.**

The triage process should identify and prioritize people for external contamination screening and identify and prioritize a subset of those individuals for internal contamination screening and medical follow-up, if needed.

Local and state officials should ensure that the following capabilities are available within the first 24 to 48 hours.

- Making radiation dose projections (external irradiation and plume predictions)
- Assessing the risk of exposure by time and location
- Identifying victims within range, location, and proximity to the incident
- Identifying potential acute symptoms (nausea, vomiting, etc.)
- Providing radiation detection equipment to detect the evidence of external beta, gamma, or alpha contamination as applicable, and following up with decontamination
- Performing periodic blood tests (CBC with differential white cell count) for direct exposure assessment if large, whole-body doses are suspected
- Collecting urine samples for bioassays if internal contamination is suspected (not a priority after an IND scenario)

The prioritization scheme to identify individuals for monitoring can be based on the following:

- Radiation dose projections, if available (external irradiation and plume predictions)
- Specific times and locations where people may have had a higher probability of being exposed or contaminated
- Presentation of clinical symptoms consistent with acute radiation syndrome, especially if this is correlated with relevant times and locations specified above
- Other factors, such as age and pregnancy

### *7.2.1 Special Populations*

Public health authorities and emergency planners should identify and prioritize special populations in the community that have special needs after a radiation incident. These include the following:

- Children (Note: Be cognizant of minor children without custodial adults present, e.g., school children. Families should remain together.)
- Pregnant women
- Nursing mothers
- Elderly people requiring assistance
- Immunocompromised individuals
- Disabled persons requiring the use of wheelchairs or other mobility aids
- Workers
    - Emergency responders
    - Transient or migrant workers
    - Commuters
- Homeless people
- Institutionalized individuals who may or may not be able to evacuate or relocate
- Hospital patients
- Residents of nursing homes or other institutions
- Prison inmates, guards, and workers required to maintain, operate, or secure critical and essential infrastructure

Public health authorities and emergency planners should also

- determine any cultural or religious factors in the community that would affect the population monitoring process. For example, changing clothing in a public setting may present a complication for some people.
- identify and develop relationships with organizations that are currently assisting special populations in or near the community. They may be able to provide assistance.
- ensure that communications and educational materials are provided in appropriate languages and literacy level for the community. People who do not speak English as a first language could have great difficulty in understanding instructions when under the stress of a terrorist incident. Consider visuals, universal signage, or videos to communicate vital information.
- determine how pets will be handled and how this will affect population monitoring.

## 7.3 Population Monitoring (The Initial Hours)

In large metropolitan areas, population density is high during business hours, and tens or hundreds of thousands of people may be in the immediate vicinity of the incident.[9] There may be an inclination to cordon off the area and contain the population that may be contaminated until they can all be properly screened and decontaminated. For a variety of reasons, this response is ineffective. The longer members of the public are kept waiting, the higher their level of anxiety will be. Long wait times may also increase their potential radiation dose from external sources and the likelihood of ingesting or inhaling radioactive material.

The highest priority is to care for people who are critically injured. Others can be divided into the following two groups:

- **People who self-evacuate.** Guidance should be given to this population through multiple communication methods (television, radio, Internet, and social media) on what actions to take and how to decontaminate themselves. Explain that, like dirt, most contamination washes off with soap and water. They should act as if they were going home in clothes covered with mud or dust and do not want to track it into their homes. Undressing at the doorway or in the garage is desirable. Provide instructions for them to do the following tasks:
    - Avoid unnecessary hand-to-face contact to minimize potential spread of contamination (avoid smoking, chewing gum, etc., until after decontamination).
    - Remove clothing and place it in a sealed plastic bag.
    - Gently blow nose, wipe eyelids, and clean out ears.
    - Shower thoroughly with warm (not scalding hot) water and mild soap, allowing the water to run away from the face.
    - Change into clean clothing.
    - Wash out tub or shower.
    - Tune in to television or radio for further instructions from public health and emergency response officials.

**Guidance should be given to people who self-evacuate on what actions to take and how to decontaminate themselves.**

[9] This discussion is not applicable to a nuclear detonation scenario. Please see Appendix C for specific considerations on population monitoring after a nuclear detonation.

- **People who stay on the scene.** These people need immediate instructions on what to do while waiting to be helped. These instructions could include the following:
  - Avoid touching suspected contaminated surfaces.
  - Keep hands away from face (especially mouth) and do not smoke, eat, or drink until hands and face have been washed.
  - Carefully remove outer clothing and place in plastic bags (provided).
  - Wash hands and face if water is available, or wipe hands and face with moist towels or disposable baby wipes (provided).

A quick assessment must be conducted to decide how best to assist this second group in the initial hours. If the incident happens on a winter afternoon, there may be only a few hours (or less) to respond and help the affected population get to their homes or to shelters before dark. Traditional planning for radiation incidents at this stage focuses on thorough monitoring for radioactive contamination followed by on-scene decontamination using portable or fixed decontamination showers. Contamination screening and decontamination should be offered, if feasible, in these early hours. However, this is highly dependent on the number of people waiting and the extent of available resources. If more timely decontamination can occur by sending people home to shower, this action is preferred rather than having them wait for on-scene decontamination that could take significantly longer. If there is a large crowd that exceeds the local capacity for processing in these early hours, people can be encouraged to go home and self-decontaminate, then return for monitoring on a priority schedule.

**More timely decontamination may occur by sending people home to shower.**

A geographic zoning approach may be used (e.g., those within a certain radius, those in a certain city block) to prioritize the population who will receive immediate initial monitoring and assistance with decontamination. If possible, a rapid radiation screening method could be used to isolate those with highest levels of contamination (see Contamination Screening Criteria below).

Although decontamination by showering or washing with mild soap is the best method of external decontamination, people can take several practical steps by themselves without any washing to markedly minimize the levels of external contamination and the likelihood of internal contamination. For example, plastic garbage bags can be provided to people, along with instructions to carefully remove their coats or outer garments and bag them (especially if clothing has visible dust). Moist towels or disposable wipes can be provided so that people can wash their faces and hands while they wait or as they leave to go home. If possible, clean outer garments can be given to them for warmth. This method may be preferred to outdoor showering at this stage, especially when temperatures are cold or the number of people is large.

### *7.3.1 Contamination Screening Criteria*

CDC does not recommend setting a pre-determined, fixed screening criterion to be applied to all people for all incidents under all circumstances. State planners and decision makers, along with state radiation control authorities, should consider a range of possible circumstances, keeping the following in mind:

**CDC does not recommend setting a predetermined, fixed screening criterion.**

- Population monitoring objectives described in this guide
- Specific radiation detection equipment instrumentation responders will be using (dose rate meters, beta/gamma portal monitors, and specific type of surface contamination monitors)
- Staffing resources and the size of population expected to be processed
- Facilities and resources available for on-the-scene contamination screening and decontamination
- Availability of other resources

Planning should be done in advance with some room for flexibility. Emergency responders must have very clear instructions to follow on the basis of the evaluation of the specific local circumstances. CDC is available to assist in the planning process. A discussion of key considerations in selecting an external contamination screening criterion and a number of benchmark screening criteria are described in Appendix D. Furthermore, a discussion of key considerations in selecting an internal contamination screening criterion is provided in Appendix E.

In addition, if requested after an incident, the Federal Advisory Team for Environment, Food, and Health can assist in establishing practicable screening criteria based on specific local circumstances. In some situations, it may be practical to use geographic zoning criteria to prioritize the population in most urgent need of assistance with decontamination.

### 7.3.2 Radiation Survey Methodology

In occupational settings, a contamination screening from head to toe is standard radiation protection work practice. This is not a recommended survey methodology for the first few hours after a mass casualty radiation emergency since any unnecessary delay can potentially increase the radiation dose to people waiting to be surveyed. If a large population must be screened for contamination, screening only the head, face, shoulders, and hands is acceptable because these are the most likely locations of contamination.

Handheld instruments, such as Geiger-Mueller (GM) pancake survey meters, are suitable for either detailed or spot surveys because they are portable, versatile, rugged, easy to use, and common in the radiation protection community. In addition to beta and gamma contamination, GM pancake probes can also detect alpha contamination although not with the same efficiency.[10] Portal beta/gamma radiation monitors can also be used at this stage, although they are usually limited in availability and require more skilled operators. Walk-through portal monitors may be best employed during later stages of monitoring, such as in community reception centers or in entrances to critical structures, such as hospitals, public buildings, airports, train stations, and bus terminals.

### 7.3.3 Clothing Services

Planning should include provisions for distributing clothing to people who are asked to remove and bag their contaminated outer garments before they leave the scene of the incident. This measure will also help significantly reduce the extent of cross-contamination away from the scene. People going home are the easiest to clothe, because durability of that clothing is secondary. In such circumstances, hospital scrubs, paper clothing, sweat suits, and t-shirts, perhaps with blankets for warmth, can be provided. Planners should make arrangements in advance with large retailers in the community to provide children’s clothing, shoes (or flip-flops or sandals), or other clothing needs. People going to shelters need more durable, robust clothing. Communities should include participating retailers in the local emergency response plans. If possible, emergency purchase agreements should be negotiated in advance.

[10] If it is determined that contamination is primarily an alpha-particle emitter, there are handheld detectors specifically designed to detect alpha particles. It will take longer, however, to screen each individual.

### *7.3.4 Transportation Services*

It is prudent to plan for providing transportation services in the first few hours after an incident for people who have places to go (e.g., their own homes) but have no means of transportation to reach them. Cross-contamination of the buses or other vehicles used for this transportation is a secondary issue. Vehicles do not have to be decontaminated between loads of passengers. They will be decontaminated later, prior to their return to normal service.

### *7.3.5 Washing Facilities*

As will be described later, it is important to establish facilities for thorough washing at or near public shelters and community reception centers (CRCs). Many communities have plans for deploying portable decontamination facilities in the first few hours after a radiation incident. However, in mass casualty incidents, it may not be possible to process a large number of people quickly enough by using portable decontamination facilities. As stated earlier, a number of services can be provided in the first few hours to assist people in reducing their dose and decreasing the likelihood of internal contamination. These services include the provision of proper instructions and basic supplies, such as plastic bags for containing their outer garments and moist towels and disposable wipes for cleaning their faces and hands.


In the first few hours, it may be necessary to help get the most heavily contaminated people to washing facilities. The goals at this stage are to get a person out of contaminated clothing immediately and get the radioactive material off the body as soon as possible. Replacement clothing must be nearby. People who are able to shower themselves should use mild soap and warm water. Cold water or water from hydrants should not be used unless there are no other options available and definitive provision is made to dry and warm each person directly after a short wash. After showering, people should be screened again for contamination and, if necessary, they should take a second shower. If this simple decontamination fails, the person should be designated for further assessment for possible internal contamination.

Sports arenas and gymnasiums may provide suitable showering facilities. If such facilities are difficult to locate in the affected area, consider transporting people or using a nearby hotel, especially if outdoor weather conditions are not favorable. Staff members can escort people to rooms where showers can be used with minimal impact on the hotel. People may be instructed to wait in hotel rooms until suitable clothing arrives. Allowing them to use the telephone and television in the room will assist in keeping them calm.

Note that providing showering facilities and associated staff services in these first few hours can be done for only a relatively limited number of people. If the radiation screening criteria is too stringent or the geographic zoning criteria is set too broadly, a large and unmanageable number of people will be designated for processing at showering facilities, defeating the purpose of expeditious decontamination.

At no time should an individual's identification, jewelry, money, or credit cards be collected. People can try to wash these things as they wash themselves, or the items can be bagged. All contaminated clothing collected before the washing process should be bagged and labeled for further epidemiological and law enforcement purposes.

### *7.3.6 Registration*

A critical function that should start as early as possible is the registry of the affected and possibly exposed population. This topic is addressed later in more detail. Initially, the most basic and critical information to collect from each person is his or her name, address, telephone number, and contact information. If time permits, other information can be recorded, including the person's location at time of the incident and radiation readings, but this is not essential and should not become a bottleneck in the registration process. Additional information can be collected later as people are processed to send home or when they report to community reception centers (CRCs). This registry information will be used to contact individuals for follow-up activities, if needed.

**Registration should start as early as possible, but it should not become a bottleneck.**

### *7.3.7 Collection of Clinical Samples*

Typically, it is not practical for local or state responders to collect bioassay samples in the first few hours after an incident. Bioassay samples, however, provide a powerful diagnostic tool for assessment of internal contamination and, in cases where relatively high radiation doses are expected, for detection of acute radiation syndrome. In the case of a RDD incident, the most useful bioassay for dose estimation is a urine sample. In the IND case, a blood sample can be used to help estimate the dose received from external radiation exposure.

Local hospitals or public health laboratories should be prepared to analyze blood samples (CBC with differential white cell count) to assess for acute radiation syndrome, if warranted.

Federal resources may be able to assist in the collection and analysis of urine bioassays for assessing internal contamination from a RDD, but these resources will not be available in the first few hours. Federal assets may also be available to analyze blood samples from an IND incident using cytogenetic dosimetry to more accurately assess radiation dose. However, this laboratory capacity is very limited and it takes 3-4 days to complete the analysis. Samples should be prioritized for cytogenetic analysis on a case-by-case basis. Planners should keep in mind that the limited capacity to perform cytogenetic dosimetry makes this technique practical only for a limited number of exposed people in a relatively small incident. After an IND incident, for example, it is not practical to use this technique for estimating radiation dose for large numbers of exposed people.

### *7.3.8 Worker Protection*

Population monitoring should preferably take place at a location that is not contaminated or is minimally impacted by contamination, and where no known airborne or respiratory hazards exist. Nevertheless, many people reporting to be screened could be contaminated with radioactive material on their clothes or bodies, presenting a possibility of cross-contamination and a potential inhalation hazard to the staff. Universal medical precautions, including gown, gloves, face mask, safety glasses, and appropriate respiratory protection (as determined by the safety officer) will provide adequate protection. The safety officer will evaluate the need for, and issue as appropriate, personal dosimetry devices and other personal protective equipment to the staff. Staff should try to minimize physical contact with people, and gloves should be changed or checked frequently for contamination.

## 7.4 Population Monitoring (Day 2 and Beyond)

On the day after the incident, there still may be only a limited number of federal responders at the site. As federal teams arrive to assist, many of the services described in this section can be augmented, but the initial setup and conduct of these operations will rely on local, tribal, or state resources. Under certain scenarios (e.g., an IND detonation in another city resulting in a large displaced population), there may not be any immediate federal assistance for 48 to 72 hours or longer, and local responding officials need to include such scenarios in their planning.

### *7.4.1 Setting Up Community Reception Centers*

A radiation incident that impacts a large population will require planners to establish one or more community reception centers (CRCs), to assess people for exposure, contamination, and the need for decontamination or medical follow-up. Some CRCs should be established at or near shelters.

The CRC model developed by CDC and ORAU presented in Appendix F breaks down the CRC process into the following stations:

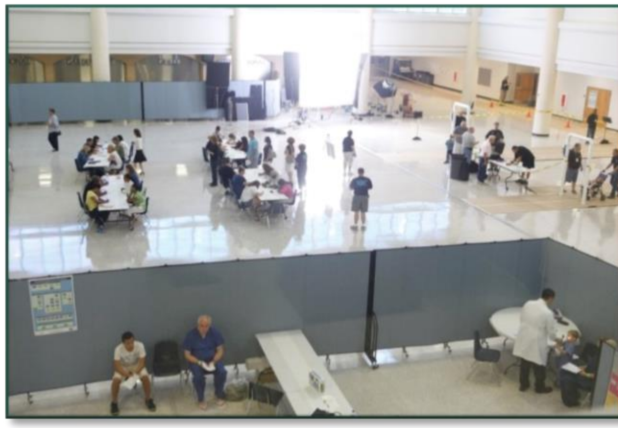
- Initial Sorting
- First Aid
- Contamination Screening
- Wash
- Pet Services (for pet-friendly CRCs)
- Registration
- Radiation Dose Assessment
- Discharge

CRC staff should be able to do the following:

- Support contamination detection through beta/gamma portal monitors, if appropriate.
- Support general contamination screening via handheld instruments.
- Field questions and address concerns.
- Provide information and give instructions, as applicable.

Appendix G describes tools available for CRC training and planning.

Facilities or sites in the community being considered for use as CRCs should be assessed on the following characteristics:



- Size
- Location
- Adequate restroom facilities
- Shower (decontamination) rooms or facilities
- Accommodations for people with disabilities
- Environmental control (against excessive heat or cold)
- Adequate access and exit control (in case of an emergency evacuation)

An all-weather facility designed for crowds, such as a covered sports arena or convention center, would be ideal, but depending on the circumstances and weather, a nearby park or large parking lot would also suffice. Many jurisdictions have identified high schools as potential CRC sites because school gymnasiums provide adequate space to conduct contamination screening and locker rooms provide indoor shower facilities to conduct decontamination. Agreements should be established in advance with facility or site owners and operators.

It is important to note that planning for CRC operations does not involve much more than what is most likely already included in existing public health emergency response plans. Many communities have emergency plans to establish alternate care sites (ACS) or neighborhood emergency help centers (NEHC) to provide health and medical services to those who may need assistance or medical care but do not need hospitalization (likely the majority of the affected population).[11] These are usually well-known locations within the community, such as the area high schools. Many communities also have plans to use these facilities as points of dispensing (PODs) for medical supplies from the Strategic National Stockpile in case of pandemic flu, for example, or other biological threats.[12]

**The same facilities used for ACSs, NEHCs, and PODs can be used for CRCs with the addition of radiation detection equipment and radiation protection personnel.**

Because these other public health response operations have very similar functions and staffing requirements, the same facilities used for ACSs, NEHCs, and PODs can be used for CRCs with the addition of radiation detection equipment and radiation protection personnel. Radiation protection personnel in the CRC will conduct contamination screening, evaluate the results, and assist with decontamination. A suggested listing of supplies, resources, and staffing needs for CRCs is provided in Appendix H. Many of these may already be part of plans to set up PODs, NEHCs, or ACSs.

The CRC should have sufficient staff, both technical and nontechnical, to manage the center for up to several days or weeks. A technical staff that is competent in the use of radiation detection equipment must be available for contamination screening. Additional staff members will be needed to process people and help with decontamination. Additionally, CRCs will likely need one or more

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[11] Appendix B in *Altered Standards of Care in Mass Casualty Events*, Agency for Healthcare Research and Quality (AHRQ), U.S. Department of Health and Human Services, April 2005; *Expanding Local Healthcare Structure in a Mass Casualty Terrorism Incident*, U.S. Department of Defense, June 2002; *A Mass Casualty Care Strategy for Biological Terrorism Incidents*, U.S. Department of Defense, May 2001.

[12] For an example, see the Philadelphia Department of Public Health POD Manual available at http://www.naccho.org/toolbox/_toolbox/POD%20operations%20manual_1.pdf.

clinicians to assess and refer people who need medical follow-up or to administer pharmaceutical countermeasures. As federal personnel and assets arrive, they can be employed at CRCs to provide relief for staff or the expansion of services.

As with PODs, NEHCs, or ACSs, there must be a plan to set up a registry area within the CRC to do the following:

- Manage the registration process and provide support to volunteers and data collectors.
- Register and log in those who arrive.
- Issue wristbands or other identification materials.
- Control crowds.
- Collect health information related to the incident and enter it into a computer database.
- Distribute information sheets.

As members of the public are released from CRCs, each person should be given discharge instructions written in clear, easy-to-understand language. It should tell people that the health department may need to contact them to conduct further monitoring or an additional medical evaluation. The instruction sheets should also provide the following: (1) basic information about radiation and its effects on human health; (2) recommended actions to be taken by the public to safeguard their health; and (3) points of contact for news and information. CDC recommends reviewing this information periodically to ensure its accuracy because these contacts may change.

Contact information for people discharged from CRCs should be maintained in a database common to all service centers. This database can be used for potential follow-up activities. Physicians can also use the database to access information about their patients who have gone to a CRC for evaluation. Health care providers should receive training on managing victims of radiation exposure and contamination.

**Be prepared to provide behavioral and mental health services at the CRC.**

In addition, public health and emergency preparedness personnel should plan to augment preexisting behavioral health and mental health services. Such services will be in demand both by people acutely affected by the radiation incident as well as by members of the public with chronic, long-term mental health needs. The need for such services will increase following a radiation incident, whether or not it involves mass casualties.

### *7.4.2 Practical Considerations for Community Reception Center Operations*

The primary purpose of the CRC is to identify people who may need immediate assistance—decontamination and the use of washing facilities, medical attention, or other special assistance. These services must be provided expeditiously for large numbers of people. Many people who come to the CRC will not be contaminated, but nevertheless are concerned. Effective communication through the news media and easily understood schedules that stagger the times people report to CRCs can help ensure the timely provision of services to those who really need them. It is better for people who may not need services to come to CRCs rather than go to nearby hospital emergency departments that could be already overwhelmed.

If the local media are operational, use them to educate the public on how to control contamination and self-decontaminate at home before they go to the CRCs. Removal of clothing can eliminate most of the external contamination on a person, and washing can remove most of the residual contamination.

Communicating with people about the process and goals of population monitoring will be important in managing the monitoring process. This critical function can be performed by greeters who can answer quick questions, direct people to monitoring areas, and try to identify those needing special attention. Having an adequate number of greeters is important for crowd control because it helps people understand what is happening and how their needs will be addressed quickly. Greeters who speak additional languages that are common in the local area are extremely helpful.

Families should not be separated.

The stations should be set up to optimize flow through the CRC. CRC staff should consider providing services while people wait in line, such as collecting information for entry into a registration system. Even if it takes a long time for everyone to get through the screening and decontamination stations, crowd control will be significantly improved if staff make productive use of people's time in line.

As lines form, one or more staff members with radiation detection equipment should walk the line looking for people who

- are highly contaminated.
- have small children.
- might have medical problems.
- might be pregnant.
- do not speak or understand English.
- have cultural or religious considerations.

This initial screening begins a triage system intended to identify people in need of priority care or services. Having two staff members per line would be ideal for this initial screening, one concentrating on radiation readings (using headphones with external speaker off) and the other observing and interacting with people in line. It is important to remember that family members should not be separated.

Those needing medical assistance should be taken to the First Aid Station immediately. It may be prudent to divide the others into two groups: (1) those who have performed self-decontamination at home (showered and changed clothes), and (2) those who have not showered or changed clothes.

Appendix F contains more detailed information about the CRC process.

### *7.4.3 Pets*

The Pet Evacuation and Transportation (PETS) Act of 2006 requires that state and local emergency plans address the needs of people with household pets or service animals.[13] Therefore, as resources permit, animal issues should be managed as an element of protecting public health and safety.

Although it may be difficult to wash animals at a CRC, the concern with contamination of the facility and its occupants is significant, and owners should be apprised of options to clean their pets or service animals. Cross-contamination of the owner and contamination of those in the CRC are of greater concern than the dose to the animal. Pet owners should be encouraged to wash their own pets, when able to do so, unless disaster response teams are specially trained and available to care for animals. People with service animals may need assistance caring for their animals.

### *7.4.4 Scaling for Size of Incident*

The size of incident is a major consideration in planning for population monitoring. Population monitoring plans should be scalable, up or down, based on the number of people affected. If dozens of people need to be surveyed and decontaminated, responders can probably provide very thorough services at the scene. However, if thousands of people are affected, plans will have to be modified so that everyone can be processed quickly and safely.

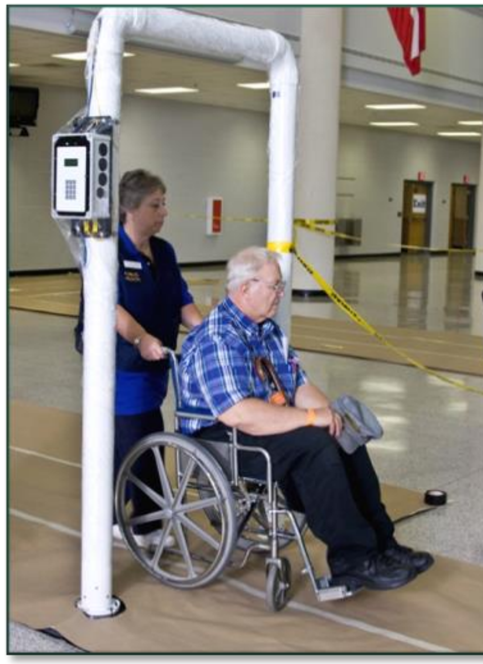
[13] Public Law 109-138, October 6, 2006.

### 7.4.5 Screening for External Contamination and Conducting Decontamination

If resources allow, consider using more stringent contamination screening criteria.

As mentioned previously, decontamination may be performed at various stages in the population monitoring process. Immediate decontamination may be necessary to reduce an individual's exposure to radiation from radioactive contamination and to help control cross-contamination at the scene.

The first step in external contamination screening is to check people for radioactive contamination on their bodies and clothing. Note that at this stage, if adequate decontamination resources allow, more stringent contamination screening criteria than those used in the early hours after the incident may be considered. For external contamination screening, responders should verify that appropriate instruments (portal monitors or handheld meters) are available[14] and that the instruments are working properly. Be sure to check for both beta-gamma radiation and (if suspected) alpha radiation, and document the results. Refer uncontaminated people to the Registration Station and contaminated people to the Wash (decontamination) Station.



Ensure that materials needed for external decontamination are available, and route lines in such a way that people in need of decontamination do not come in contact with people who have already washed.

Plans should assume that most people will be able to self-decontaminate, but be prepared to provide assistance to those who cannot, such as people with disabilities. Determine if parents can assist their children with washing. Direct people with wounds to the First Aid Station for special handling, and institute a referral plan for transfer to hospitals and other health care settings. For people who do not have wounds, direct them to do the following:

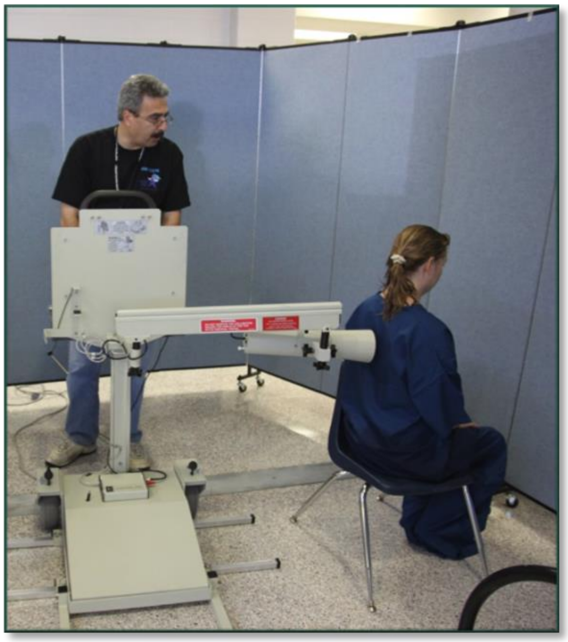
- Wash with warm water and mild soap.
- Scrub gently with a cloth, sponge, or soft brush.
- When showering, begin with the head and proceed to the feet.
- Keep soap and water out of eyes, nose, and mouth.
- Avoid causing mechanical, chemical, or thermal damage to skin.

After decontamination, screen each person again. If needed, ask them to wash again. People who are still contaminated after the second washing may be referred to the Radiation Dose Assessment Station. Collect basic demographic information, health history, and exposure history. Some people may decide to leave the CRC without being decontaminated. CRC staff should explain why decontamination is important and advise these people to decontaminate themselves as soon as possible when they reach their destination.

Be prepared to provide assistance with decontamination for people with special needs.

[14] These instruments are for screening people. You should also consider area-monitoring devices at CRCs to assess and monitor background radiation levels. Consult with your state's radiation control program. A list of state radiation control program directors is available at www.crcpd.org/Map/default.aspx.

### *7.4.6 Screening for Internal Contamination and Conducting Decontamination*



Internal contamination is when radioactive material enters the body through ingestion, inhalation, or through cuts or wounds. Having accurate information about the levels of internal contamination is important in deciding whether medical intervention is warranted. The methods and equipment needed for assessing internal contamination are more advanced than the equipment required to conduct external contamination screening. Collectively, procedures to screen for internal contamination are referred to as bioassays. In general, these bioassays require off-site analysis by a clinically certified radiological laboratory. People should be advised that it may be some time before results are available.

For gamma-emitting radionuclides, external contamination screening can provide some indication of the extent of internal contamination. Furthermore, factors such as physical location during the incident or the extent of external contamination on the body can be additional indicators of the likelihood and degree of internal contamination. However, laboratory results can provide definitive information, especially in the case of alpha-emitting radionuclides. Appendix E provides a discussion on screening criteria for internal contamination.

Identify in advance personnel and resources necessary for these evaluations. These can include whole-body counters and lung counters (for in-vivo analysis), and the ability to perform radiochemical analysis of urine. Other needed resources are sample collection kits, appropriate administrative forms, and chain-of-custody documentation.

When a person is internally contaminated, depending on the type of radioactive material, certain medications can be administered to speed up the rate at which the radioactive material is eliminated from the body. *Internal decontamination is a medical procedure and should only be performed at the order of, and under the guidance of, a licensed physician*.

The Strategic National Stockpile (SNS) can provide pharmaceuticals to states for this purpose (see Appendix I). State health officers can contact CDC to discuss procedures and receive more information about the SNS. In addition, the following resources can provide information about treatments for internal contamination.

- The U.S. Food and Drug Administration (FDA)
  www.fda.gov/Drugs/EmergencyPreparedness/BioterrorismandDrugPreparedness/ucm063807.htm
- Radiation Emergency Assistance Center/Training Site (REAC/TS)
  http://orise.orau.gov/reacts/resources/package-inserts.aspx
- Radiation Emergency Medical Management (REMM) – Guidance on Diagnosis and Treatment for Healthcare Providers
  www.remm.nlm.gov
- Centers for Disease Control and Prevention (CDC)
  http://emergency.cdc.gov/radiation/countermeasures.asp
- National Council on Radiation Protection and Measurement (NCRP) Report 165, Management of Persons Accidentally Contaminated with Radionuclides
  www.ncrppublications.org/Reports/165

## 7.5 Dose Assessment and Laboratory Capabilities

For medical management of patients, it is helpful to assess the total radiation dose to each individual. The total dose a person receives is made up of two components: the internal dose from radioactive material inside the body and the external dose from exposure to external sources of radiation. There are specific laboratory analyses that can help with these assessments.

**A prioritization scheme for analysis of bioassay samples will be necessary.**

Analysis of radioactivity in urine can establish amounts of radioactive material in the body. Although the analysis can be performed fairly rapidly, it will take some time for this information to be available for everyone in the affected and potentially affected populations. Therefore, some prioritization scheme for analysis of samples will be necessary (see Appendix E).

Analysis of chromosomal aberrations (cytogenetic analysis) can estimate the external radiation dose to the individual; however, these results will not be immediately available. Furthermore, the capacity to perform cytogenetic analyses is limited and will not meet the demand in an incident where large numbers of people are exposed (such as a nuclear detonation incident). Performing a complete blood count with differential (standard and routine analysis in local clinics and hospitals) and noting the time delay to the onset of nausea can provide estimates of the range of acute radiation doses. This information can be used to assist in medical management of patients.[15]

Issues that should be addressed in planning for laboratory analysis include, but are not limited, to the following:

- Analytical capability
- Sample prioritization and triage
- Turnaround time
- Sample throughput
- Sample volume
- Sample storage capacity
- Confidentiality assurance
- Protocols for reporting analytical result

In the planning process, public health laboratory directors should assess their roles and capabilities following a radiation emergency. The following resources can provide additional information to assist in laboratory planning.

- For information about analysis of radioactive contamination in urine, contact CDC's Environmental Health Laboratory: http://www.cdc.gov/nceh/dls
- For information on cytogenetic analysis of blood samples, contact REAC/TS Cytogenetic Biodosimetry Laboratory: http://orise.orau.gov/reacts/cytogenetics-lab.htm

[15] More information on medical management is available at http://emergency.cdc.gov/radiation/healthandsafety.asp and the Radiation Emergency Medical Management (REMM) website www.remm.nlm.gov/.

## 7.6 Psychosocial Issues

Psychosocial issues will present significant challenges to public health and medical practitioners both during and after a radiation emergency. The psychosocial consequences of radiation emergencies are unique and serious, and in many ways they can be even greater and longer-lasting than the physical or economic consequences. Public health and medical systems could be overwhelmed by people seeking assessment and care. Many jurisdictions recognize that preparing to deal with psychosocial issues is critically important for efficiently managing and monitoring the affected population and engaging in other response efforts. Planners should work with behavioral health and mental health specialists to include them in preparedness planning and response.

Psychological first aid is a way to help reduce the initial distress caused by traumatic events. Responders who interact with the public can benefit from training in psychological first aid.[16] Responders should anticipate normal stress reactions and promote the following principles of psychological first aid.

- Safety: provide repeated, simple, and accurate information on how to meet basic needs. This may be especially important for CRC staff wearing personal protective equipment that hinders communications (such as masks).
- Calm: speak calmly and be compassionate and friendly.
- Connectedness: keep families together.
- Self-efficacy: give practical suggestions to help empower people.
- Help: direct people to available services.

If possible, include behavioral health or mental health professionals on staff at each CRC. During the planning process, establish a contact list of credentialed personnel who could provide these services.

Plans should also include providing counseling for CRC staff and responders. Adequate rotation of staff members to reduce physical and emotional fatigue will be essential.

[16] For an example of such training, see CDC's *Psychological First Aid in Radiation Disasters,* available at http://emergency.cdc.gov/radiation/resourcelibrary/all.asp.

## 7.7 Registry


State and local agencies should establish a registry as early as possible after a radiation incident. This registry will be used to contact people who require short-term medical follow-up or long-term health monitoring. The long-term monitoring process involves observing and recording any health effects that could be related to radiation exposure, including effects on subsequent generations. Extensive resources will be required, and CDC and the Agency for Toxic Substances and Disease Registry (ATSDR) will provide assistance in establishing and maintaining this registry.

The registry should include information from the following:

- All members of the public who were potentially contaminated or exposed
- All first responders, public health workers, and hospital staff who were potentially contaminated or exposed or who responded to a radiation incident within the jurisdiction

It is recommended that unique identifiers be assigned to each individual as people present themselves to the CRC and are registered. Initially gather basic information such as name, address, telephone number, other contact information, date of birth, and sex. If possible, copying a driver's license or other form of identification with current information can expedite the registry process. It may be helpful to include the individual's status as the following:

- A paid responder
- A volunteer responder at the scene
- A person affected at the scene of the incident
- A person who heard a public announcement and believes he or she fits the category for monitoring

If possible, include spatial and temporal information related to the incident. Ask questions such as, "Where were you when the incident occurred? How close were you to the incident location? How long were you there?"

Also consider categorizing (triaging) people radiologically:

- External contamination
- Internal contamination
- External exposure only
- Neither contaminated or exposed
- Unknown

Plans should address confidentiality and potential liability issues associated with registering and collecting data on all persons who come to a processing center, even if they were not exposed to radiation or contaminated with radioactive material. The public should be informed that inclusion in the registry does not imply any form of future compensation. Determine, in advance, who will have access to the registry database and how it will be archived.

ATSDR has developed a Rapid Response Registry to assist state and local personnel with epidemiological investigations.[17] Other examples of registry and epidemiological tracking forms are available from the National Alliance for Radiation Readiness (NARR)[18] or as part of the Virtual Community Reception Center (vCRC)[19] training program.

## 7.8 Radiation Dose Reconstruction

Radiation dose reconstruction is a scientific study that estimates radiation doses to people after a radiation incident. Radiation dose reconstruction studies typically focus on determining who (if anyone) may be at a greater risk for cancer. In this context, dose reconstruction to estimate cancer risk is not an emergency response activity. Dose reconstruction will, however, use information that was collected during the emergency response.

Radiation dose reconstruction studies determine external dose rates and radionuclide concentrations at various times and locations, how people were exposed to radiation, and the amount of radioactive material that was taken into their bodies. HHS/CDC will provide technical support and assistance to state and local authorities to conduct dose reconstruction studies, using sophisticated computer models. Local public health agencies will provide public information and collect data to be used in the dose reconstruction.

## 7.9 Training


Training for the public health and emergency response communities is essential in building a population monitoring capability. Training should focus on increasing the understanding of radiation and demystifying radiation and its effects. In addition, it should prepare public health workers to focus on roles and responsibilities, resource identification, proper use of radiation detection equipment, clinical sample collection, and laboratory methods and procedures.

Training should be provided to promote awareness of population monitoring among the following:

- First responders
- Elected officials and community stakeholders
- Public information and communication specialists
- Clinicians, health practitioners, and hospital staff
- Journalists and radio and television broadcasters
- Response volunteer organizations, such as the American Red Cross and the Medical Reserve Corps

Training should be interactive and affordable. Use drills and exercises to test health preparedness plans; ensure that all entities that will be involved in the response (from both the emergency response and the health care/hospital worker communities) are involved. Existing training

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[17] ATSDR Rapid Response Registry form and training CD are available at www.atsdr.cdc.gov/rapidresponse/.

[18] The NARR is an interagency collaboration among key stakeholders in public health preparedness, radiation response, and emergency management that maintains a clearing house of documents and resources used in radiation emergency planning and exercises (www.radiationready.org).

[19] vCRC is an interactive training program developed by CDC and ORAU that allows users to explore a virtual CRC and access templates for forms, job action sheets, and other planning materials (http://emergency.cdc.gov/radiation/crc/vcrc.asp).

resources, such as satellite broadcasts, webcasts, videos, and print materials, are available on many federal and state websites; these materials can be adapted for the community. Partner with other agencies and organizations to reduce the cost of training.

Awareness level training topics should address the following:

- Types of radiation hazards
- Principles of radioactivity and radiation safety
- Contamination control
- Minimizing individual exposure
- Principles of dose reconstruction
- Principles of registry management

Training for public health personnel should cover these activities:

- Determining the location of CRCs based on the amount of space needed, the anticipated magnitude of the radiation incident, and the population and special needs of the community
- Establishing crowd management operations, including the development of triage procedures and the distribution of information during population monitoring
- Using on-site equipment to monitor external contamination
- Identifying and handling special population needs
- Recognizing psychological trauma and practicing psychological first aid
- Identifying the process and procedures for requesting federal support
- Establishing and maintaining contacts with federal agencies for equipment, personnel, and expertise
- Working effectively with partner agencies (e.g., DHS/FEMA, HHS/CDC, HHS/FDA, DOE, EPA, NRC, USDA, and the American Red Cross)

Medical personnel should be trained on the following:

- Emergency and first aid procedures for radiation victims
- Diagnosis of acute radiation health effects
- Assessment of external and internal radiation exposure
- Prompt triage and management of contaminated patients
- Psychological features and dynamics of radiation incidents

## 7.10 Communications

Communicating about radiation and related emergency issues is extremely challenging. Radiation is unfamiliar to and not well understood by most people. Effective communication in radiation emergencies can decrease illness, injury, and death; facilitate response and recovery efforts; avoid misallocation of limited resources; reduce rumors; and minimize medically unnecessary self-referrals to hospitals and other critical facilities.

Information needs will primarily revolve around questions to help determine the risk, as well as questions on protective actions to reduce risk. Such questions could include the following:

- Am I in danger from the radiation?
- Am I radioactive?
- Am I still carrying around radioactive material on my body? Skin? Clothes? How do I get it off? What symptoms should I expect? Is my condition contagious? Is it curable?
- Did I eat or breathe in radioactive material? Is it inside my body now? If so, how long will the material stay in my body? Should I be medically treated?
- Were my children exposed? Were my pets exposed?
- I'm pregnant – will my baby be all right?

For any levels or amounts of exposure, even miniscule, people will want to know what health effects they may have in the future. The communication strategy should meet people's information needs, bridge the gap between technical information and risk perception, and promote responsible public actions.

Effective and credible communication strategies are needed to explain that most radiation exposures will not result in any measurable health effects. The U.S. Environmental Protection Agency has prepared a useful booklet on this subject.[20] In addition, research conducted by the CDC has identified best practices in communication in radiation emergencies, which include the following:

- Create messages that address public concerns.
- Provide prioritized instructions and directions.
- Tailor messages by time post-incident.
- Tailor messages by distance from the incident.
- Tailor messages by delivery method (television, radio, Internet, social media, etc.).
- Create messages that are urgent and serious in tone, yet provide a sense of hope.
- Avoid using messages that contain perceived contradictions.
- Use plain, non-technical language.
- Make messages concise.
- Avoid or define unfamiliar and technical terms and phrases.
- Repeat messages as appropriate.

In a radiation emergency, people will seek information using multiple communication channels. Providing a consistent message through television, radio, websites, and social media, along with any other public information methods, will maximize message efficiency and efficacy.

Communication and public information staff should establish a network of qualified public health media contacts, specifically those with radiation expertise. Key public health spokespeople should be identified and trained in advance for media announcements or interviews, and plans to communicate with special populations should be developed.

Ensure that the public health department is aware of procedures for contacting community and civic organizations, local government and corporate officials, and appropriate federal agencies. Local government and corporate officials need to be aware of their roles in the overall response plan, ideally through participation in training, drills, and exercises.

## 8.0 Additional Information About This Guide

For more information about population monitoring, this guide, or the public health role in radiation emergency preparedness, please contact the Radiation Studies Branch at CDC via e-mail at rsbinfo@cdc.gov.

Other sources of information about radiation emergency preparedness can be found in Appendix J.

In a public health emergency, contact the CDC Director's Emergency Operation Center, 24 hours a day at 770-488-7100.

[20] U.S. Environmental Protection Agency, *Communicating Radiation Risks*, EPA-402-F-07-008, September 2007. www.epa.gov/radiation/pubs.html To request a PDF or printed copy of this document, please e-mail radiation.information@epa.gov or call the U.S. EPA's Radiation Protection Division at 202-343-9290.

# APPENDIX A: ACRONYMS

# Appendix A

## Acronyms

| | |
|---|---|
| ACS | Alternate care site |
| AHRQ | Agency for Healthcare Research and Quality |
| ALI | Annual limit on intake |
| ARC | American Red Cross |
| ARS | Acute radiation syndrome |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| CBC | Complete blood count |
| CDC | Centers for Disease Control and Prevention |
| CRC | Community reception center |
| CRCPD | Conference of Radiation Control Program Directors, Inc. |
| CRI | Cutaneous radiation injury |
| CSF | Colony stimulating factor |
| DHS | U.S. Department of Homeland Security |
| DOE | U.S. Department of Energy |
| DOE/NNSA | U.S. Department of Energy/National Nuclear Security Administration |
| DTPA | Diethylenetriamine pentaacetate |
| EPA | U.S. Environmental Protection Agency |
| FDA | U.S. Food and Drug Administration |
| FEMA | Federal Emergency Management Agency |
| GM | Geiger-Mueller |
| HHS | U.S. Department of Health and Human Services |
| IAEA | International Atomic Energy Agency |
| ICRP | International Commission on Radiological Protection |
| IND | Improvised nuclear device |
| MRC | Medical Reserve Corps |
| NCRP | National Council on Radiation Protection and Measurements |
| NEHC | Neighborhood emergency help center |
| NRC | U.S. Nuclear Regulatory Commission |
| ORAU | Oak Ridge Associated Universities |
| ORISE | Oak Ridge Institute for Science and Education |
| POD | Point of dispensing |
| RDD | Radiological dispersal device |
| REAC/TS | Radiation Emergency Assistance Center/Training Site |

| | |
|---|---|
| RED | Radiation exposure device |
| REMM | Radiation Emergency Medical Management |
| RRVC | Radiation Response Volunteer Corps |
| SNS | Strategic National Stockpile |
| USDA | U.S. Department of Agriculture |
| vCRC | Virtual Community Reception Center |

# APPENDIX B: GLOSSARY

# Appendix B

## Glossary

B

**Absorbed dose:** The amount of energy deposited by ionizing radiation in a unit mass of tissue is called radiation absorbed dose. It is expressed in units of joule per kilogram (J/kg), which is given the special name *gray (Gy)*. The conventional unit (or non-SI unit) of absorbed dose is the rad. 1 Gy = 100 rad, 1 rad = 0.01 Gy. For more information, see CDC Primer on Radiation Measurement:

http://emergency.cdc.gov/radiation/glossary.asp#primer

**Activity (radioactivity):** The amount of radioactive material expressed as the number of atoms breaking down per second measured in units called *becquerels* or *curies*.

**Acute radiation syndrome (ARS):** A serious illness caused by receiving a large dose of radiation energy that penetrates the body within a short time (usually minutes). The first symptoms include nausea, vomiting, and, in severe cases, diarrhea starting within minutes to days after the exposure and lasting for minutes to several days. These symptoms may come and go and, depending on the dose of radiation, may fully resolve for variable periods of time. ARS victims then become sick again with loss of appetite, fatigue, fever, nausea, vomiting, diarrhea, and possibly seizures and coma. This seriously ill stage may last from a few hours to several months.

Clinically, ARS is very difficult to diagnose in the absence of other data or information from the incident scene because symptoms within the first few hours after high dose radiation exposure are similar to those associated with commonly occurring viral or bacterial illnesses or even high levels of stress. Proper diagnosis of exposure to ionizing radiation (not contamination) and an estimate of the total dose can only be achieved by analysis of the complete blood count (CBC), chromosome aberration cytogenetic biodosimetry, and consultation with radiation experts. For more information, see:

http://emergency.cdc.gov/radiation/ars.asp

**Alpha particle:** One of the primary forms of ionizing radiation, the others being beta particles, gamma rays, x-rays, and neutrons. 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 pose a hazard as long as they are outside the body. Protection from this radiation is directed at preventing, or at least minimizing, inhalation or ingestion of the radioactive material.

Alpha particles are difficult to detect because they penetrate only a few inches in air, and most general purpose detection instruments are poorly suited or not usable for detecting alpha particles. If beta or gamma radiation is detected at an incident scene, instruments should be brought in as quickly as possible to determine whether or not alpha-emitting radioisotopes are also present.

**Annual limit on intake (ALI):** The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the amount of intake that would result in a committed effective dose equivalent of 0.05 sievert (5 rem) or a committed dose equivalent of 0.5 sievert (50 rem) to any individual organ or tissue. The unit of ALI is the *becquerel (Bq)* or the conventional unit, *curie (Ci)*.

**Background radiation:** This is the radiation that the population is naturally and continually exposed to from natural sources. It consists of radiation from natural sources of radionuclides such as those found in soil, rocks, air, human bodies, and food, as well cosmic radiation originating in outer space.

**Becquerel (Bq):** The international unit describing an amount of radioactivity. One Bq is the amount of a radioactive material that will undergo one decay (disintegration) per second (dps), a very small rate. Industrial sources of radioactivity are normally described in terms of giga-becquerels (GBq), or one billion Bq. The conventional unit for radioactivity is the curie (Ci). 1 Bq = $2.7 \times 10^{-11}$ Ci. See *Curie*.

**Beta particles:** One of the primary forms of ionizing radiation, the others being alpha particles, gamma rays, x-rays, and neutrons. They travel only a few feet in air and can be stopped by a thin sheet of aluminum. However, beta particles of sufficient energy can penetrate the dead skin layer and, if present in large amounts for sufficiently long periods of time, cause burns to the skin and to the eyes. Protection from this radiation is directed at washing the skin with mild soap and water and preventing, or at least minimizing, inhalation or ingestion of the radioactive material.

Beta particles are easier to detect than alpha particles. While most general purpose detection instruments can detect beta particles, the instrument must be within a few yards of a sizeable source. Fortunately, the vast majority of beta-emitting radioisotopes also release high-energy gamma rays that can be detected at distances of tens of yards.



When radiation is detected at an incident scene, proper instruments should be brought in as quickly as possible to determine whether pure beta-emitting radioisotopes are present or not, followed in turn by alpha monitoring equipment.

**Bioassay (radiobioassay):** An assessment of radioactive materials that may be present inside a person's body through analysis of the radioactivity in a person's excreta (primarily urine), known as *indirect bioassay*, or by detection methods to monitor the gamma radiation emitted from the body, known as *direct bioassay*.

**Biological half-life:** Once an amount of radioactive material has been taken into the body, this is the time it takes for one half of that amount to be expelled from the body by natural metabolic processes, not counting radioactive decay.

**Contamination (radioactive):** The deposit of radioactive material on the surfaces of structures, areas, objects, or people (where it may be external or internal). *External contamination* occurs when radioactive material is outside of the body, such as on a person's skin. *Internal contamination* occurs when radioactive material is taken into the body through breathing, eating, or drinking. For more information, see:

http://emergency.cdc.gov/radiation/contamination.asp

**Curie (Ci):** The conventional unit describing an amount of radioactivity. The international unit for radioactivity is the becquerel (Bq). 1 Ci = $3.7 \times 10^{10}$ Bq. See *Becquerel*.

**Cutaneous radiation injury (CRI):** The complex syndrome resulting from significant skin exposure to radiation. 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:

http://emergency.cdc.gov/radiation/cri.asp

**Decontamination:** Removal of radioactive materials from people, materials, surfaces, food, or water. For people, external decontamination is done by removing the clothing and washing the hair and skin. Internal decontamination is a medical procedure and should be performed at the order and under the guidance of a licensed physician.

**Decay, radioactive:** Disintegration of the nucleus of an unstable atom by the release of radiation.

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

**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 a possibly 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 nuclear weapon. See discussion on radiological dispersal device (RDD) in the text.

**Dose rate meters:** Instruments that measure 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 reconstruction is done by determining how much material was released, how people came in contact with it, and the amount absorbed by their bodies.

**Dosimetry:** Assessment (by measurement or calculation) of radiation dose.

**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*, *radioactive half-life*.

**Exposure (irradiation):** This occurs when radiation energy penetrates the body. Exposure to very large doses of radiation may cause death within a few days or months. Exposure to lower doses of radiation may lead to an increased risk of developing cancer or other adverse health effects later in life. Compare with *contamination*. For more information, see:

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http://emergency.cdc.gov/radiation/contamination.asp

**Fallout, nuclear:** The descent of radioactive debris from the atmosphere to ground level following a nuclear explosion. For more information, see:

www.cdc.gov/nceh/radiation/fallout/RF-GWT_home.htm

**Gamma rays:** One of the primary ionizing radiations, the others being alpha particles, beta particles, x-rays, and neutrons. Gamma rays are highly penetrating (up to tens of yards in air) and pose an external radiation exposure hazard. Gamma rays also penetrate tissue farther than do beta or alpha particles. Gamma rays are relatively easy to detect with commonly available radiation detection instruments.

**Geiger-Mueller (GM) survey meter:** Also called Geiger counters, these survey meters are the most widely recognized and commonly used portable radiation detection instruments. The pancake GM detector can detect gamma, beta, and, to a limited extent, alpha contamination.

**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. The conventional unit of absorbed dose is the *rad*. 1 Gy = 0.01 rad. For more information, see:

http://emergency.cdc.gov/radiation/glossary.asp#primer

**Half-life (radioactive):** The time it takes for any amount of radioactive material to decay (and reduce) to half of its original amount. See also *biological half-life, 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 people from any potential hazards of radiation. For more information, see the Health Physics Society website:

http://www.hps.org/

**Health physicist:** A specialist in radiation safety. See *health physics*.

**Intake:** Amount of radioactive material taken into the body by ingestion, inhalation, or absorption through the skin via wounds or injection.

**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.

**Irradiation:** Exposure to radiation. See *exposure* and compare with *contamination*.

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

**Neutron:** One of the primary forms of ionizing radiation, the others being alpha particles, beta particles, gamma rays, and x-rays. Neutrons are highly penetrating and are a radiation hazard in the time immediately following a nuclear detonation. In almost all other radiation emergency scenarios, encountering neutron radiation or contamination is unlikely. Detection of neutrons requires specialized equipment.

**Non-stochastic effects:** See *deterministic effects*.

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**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.

**Population monitoring:** The process of identifying, screening, and monitoring people for exposure to radiation or contamination with radioactive materials.

**Portal monitor:** A portable doorway-like radiation detection system for monitoring people for radioactive contamination. The monitors look similar to metal detectors used in airport security screening stations. Certain types of portal monitors are used routinely to monitor vehicles or waste containers leaving hospitals or entering junk yards. When used to monitor people, they can be used in walk-through mode or by having each person stand in the monitor for a brief time period. The portal monitors do NOT produce radiation, and they can only measure gamma and high-energy beta radiation.

**Plume:** A cloud, gas, or vapor that carries radioactive material released into the atmosphere away from the incident site in the direction of the wind. Making plume concentration predictions with time after the incident is necessary to determine whether affected populations should shelter in place or evacuate. Plume predictions use mathematical models and, although very helpful, are prone to inherent uncertainties.

**Prenatal radiation exposure:** Radiation exposure to an embryo or fetus while it is still in utero (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 certain radiation dose levels. For more information, see:

http://emergency.cdc.gov/radiation/prenatal.asp

**Public monitoring:** See *population monitoring*.

**Rad (radiation absorbed dose):** A unit of measurement for absorbed dose. It measures the amount of energy absorbed in a material. The unit rad can be used for any type of radiation, but it does not describe the biological effects of the different radiations. The international unit of absorbed dose is the *gray (Gy)*. 1 rad = 0.01 Gy; 100 rad = 1 Gy. See *absorbed dose*. For more information, see:

http://emergency.cdc.gov/radiation/glossary.asp#primer

**Radiation:** Energy moving in the form of particles or waves. Familiar radiations are heat, light, radio waves, and microwaves. Gamma rays (like x-rays) are ionizing radiation, a very high-energy form of electromagnetic radiation.

**Radiation sickness:** See *acute radiation syndrome (ARS)*.

**Radioactive contamination:** See *contamination*.

**Radioactive decay:** See *decay, radioactive*.

**Radioactive half-life:** See *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 that are often accompanied by gamma rays. This process is referred to as decay or disintegration of an atom. See *activity*.

**Radiobioassay:** See *bioassay*.

**Radiogenic:** Health effects caused by exposure to ionizing radiation.

**Radiological or radiologic:** Related to radioactive materials or radiation. The radiological sciences focus on the measurement and effects of radiation.

**Radionuclide:** An unstable and therefore radioactive form of an element.

**Rem:** (roentgen equivalent man): A conventional unit for a derived quantity called radiation 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 thousandths of a rem, or millirem (mrem). The international unit for radiation dose equivalent is the *sievert (Sv)*. 1 rem = 0.01 sieverts (Sv). For more information, see:

http://emergency.cdc.gov/radiation/glossary.asp#primer

**Resuspension:** The physical process of making airborne radioactive contamination that otherwise would have remained deposited on the surface of objects. For example, wind blowing across a sidewalk will resuspend previously deposited contaminants, making them airborne in the breathing zone.

**Roentgen (R):** A unit of exposure to x-rays or gamma rays.

**Shielding:** Material that can block or intercept radiation emanating from a radioactive source.

**Sievert (Sv):** The international unit for a derived quantity called radiation 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 microsieverts (µSv). The conventional unit for radiation dose equivalent is the *rem.* 1 Sv = 100 rem. For more information, see:

http://emergency.cdc.gov/radiation/glossary.asp#primer

**SI 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:

http://emergency.cdc.gov/radiation/glossary.asp#primer

**Somatic effects:** The health 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*.

**Stochastic effects:** The health effects that occur on a random basis independent of the size of dose (e.g., cancer). The effects typically have no threshold and are based on probabilities, with the chances of seeing the effects increasing with dose. If they occur, the severity of stochastic effects is independent of the dose received. See also *deterministic effects*.

**Teratogenic effects:** 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*.

# APPENDIX C: ADDITIONAL CONSIDERATIONS AFTER A NUCLEAR DETONATION

# Appendix C

## Additional Considerations After a Nuclear Detonation

One assumption in defining the scope of this guide is that the local response infrastructure remained relatively intact. This assumption is not likely to hold in the case of a nuclear detonation (i.e., military weapon or improvised nuclear device). The public health authorities responding to a nuclear detonation are likely to be from surrounding communities that are less affected by the detonation and from even further distant communities that may be receiving displaced populations from the affected areas.

This appendix describes how key concepts provided in this guide can be used in planning for population monitoring after a nuclear detonation. In addition, you should become familiar with the *Planning Guidance for Response to a Nuclear Detonation* where a chapter is dedicated to the subject of population monitoring and decontamination.[21]

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In a nuclear emergency, the most pertinent guiding principles of population monitoring, as outlined in this guide, are the following:

- The first priority is to save lives; respond to and treat the injured first.
- Initial population monitoring activities should focus on preventing acute radiation health effects.
- Scalability and flexibility are important parts of the planning process.

Early decisions by emergency responders and response authorities related to contamination screening and decontamination should be made in the context of the overall response operations. For example, survival rates will decrease if emergency evacuation is constrained by policies that inhibit the transportation of potentially contaminated patients and their admission into medical facilities.[21]

Furthermore, the needs of a displaced population and concerned citizens hundreds of miles away are different from those of the immediate victims near the site of detonation. Therefore, radiation survey methods, screening criteria, and decontamination protocol should be adjusted to reflect the prioritized needs of the affected population and the availability of resources at any given location.

## What Are the Objectives of Population Monitoring After a Nuclear Detonation?

The objectives of population monitoring are also applicable to a nuclear detonation. These objectives are listed in order of priority.

1. Identify individuals whose health is in immediate danger and who need immediate care, medical attention (whether radiation-related or not), or decontamination.
2. Identify people who may need medical treatment for contamination or exposure, further evaluation, or short-term health monitoring.
3. Recommend (and to the extent possible, facilitate) practical steps to minimize the risk of future health consequences (e.g., cancer).
4. Register potentially affected populations for long-term health monitoring.

Priorities after a nuclear detonation will differ from priorities after a radiological incident (such as the detonation of a dirty bomb). In a radiological incident, the majority of the population will be cared for

[21] Homeland Security Council (HSC) Interagency Policy Coordination Subcommittee for Preparedness & Response to Radiological and Nuclear Threats (SubIPC). *Planning Guidance for Response to a Nuclear Detonation*. Second Edition. June 2010. Washington, D.C.

under Objective 3. This is because relatively few casualties are expected from a radiological incident, and few people will be contaminated with amounts of radioactive material that will be immediately hazardous to their health.

However, after a nuclear detonation, focus will be on Objective 1. The number of people who would need immediate medical care is almost certain to overwhelm available resources. Models of a small improvised nuclear device detonation predict upwards of 300,000 victims who will have a variety of immediate medical needs.[22] Therefore, the focus should be placed on locating people who need immediate medical care and providing that care. Extensive search and rescue operations will require accompanying health physics support and expertise due to the residual radiation environment. Providing medical care to those in immediate need will likely consume all of the available medical staff's time and resources.

### Are There Any Radioactive Contamination Issues?



The potential contamination issues will be very significant. A terrorism-related nuclear detonation is likely to be a ground burst or detonation at a low elevation that causes significant nuclear fallout. This can result in additional (but avoidable) casualties. Emphasis should be placed on preventing or minimizing exposure to nuclear fallout. By issuing timely recommendations for protective action (what to do or what to avoid doing), public health authorities can help people in the community minimize their exposure to nuclear fallout.

### Are Community Reception Centers Still Needed?

A multitude of community reception centers (CRCs) will have to be established in surrounding communities, perhaps stretching as far as hundreds of miles away, to address the needs of people who have been displaced because of the blast or evacuated because of the fallout. The needs in this population—such as contamination screening for external and internal contamination and providing clothing, shelter, and counseling—are similar to those described in other sections of this guide.

Care facilities established near the detonation site will be focused on providing immediate medical care to those who are injured. Screening for radioactive contamination, decontamination, and other issues typically addressed at CRCs will be a secondary priority.

### What Types of Injuries Are Expected from a Nuclear Blast?

For more detailed information regarding medical management of radiation injuries, health care providers will find the following website a helpful resource:

Radiation Emergency Medical Management (REMM)—Guidance on Diagnosis and Treatment for Health Care Providers (http://www.remm.nlm.gov/)

The following overview is provided for public health planners.

People who survive the immediate effect of a nuclear detonation are likely to suffer from combined injury. They may have sustained flash blindness, skin burns, hearing loss, and other physical trauma in addition to radiation exposure.

[22] Weisdorf D, Chao N, Waselenko JK, Dainiak N, Armitage JO, McNiece I, Confer D (2006). *Acute Radiation Injury: Contingency Planning for Triage, Supportive Care, and Transplantation.* Biology of Blood and Marrow Transplantation *12(6)*:672-82.

People who are exposed to radiation fall into one of three general categories:

1. Individuals who may be expected to make a full recovery from their radiation exposure with little or no medical intervention.
2. Individuals who are unlikely to survive regardless of the level of medical care provided.
3. Individuals whose survival will depend on the careful administration of supportive care. The ability to deliver supportive care will depend on the number of casualties and available resources.

Supportive care for acute radiation syndrome (ARS) includes several modalities. While administration of colony stimulating factors (CSFs) is critical to recovery, the provision of high-quality intensive nursing care is equally important to ensuring the long-term survival of ARS patients. Supportive care interventions requiring skilled physician and nursing care include the following:

- Antibiotic, antiviral, and antifungal medications
- Antiemetics to control vomiting
- Antidiarrheals
- Fluid and electrolyte resuscitation
- Pain management
- Endotracheal intubation
- Blood products
- Stem cell transplantation
- Cytokines and other medical countermeasures
- Combined injury management (i.e., treatment of flash blindness, skin burns, eardrum rupture, and other injuries).

People who have sustained combined injury represent a separate triage category. These individuals, depending on their radiation dose and the nature of their trauma, have a higher risk for a poor prognosis. Individuals requiring surgical intervention should undergo necessary surgery within 36 hours and no later than 48 hours post-injury.

As the number of victims rises in a nuclear mass casualty incident, and because the management of ARS victims is complex and resource intensive, medical authorities working in resource-depleted conditions may be faced with making difficult decisions to focus on patients with better prognoses for survival.[23]

Clearly, any available resources will be directed toward these lifesaving activities in support of the first objective of the population monitoring process.

[23] Waselenko JK, MacVittie TJ, Blakely WF, Pesik N, Wiley AL, Dickerson WE, Tsu H, Confer DL, Coleman CN, Seed T, Lowry P, Armitage JO, Dainiak N (2004). *Medical Management of the Acute Radiation Syndrome: Recommendations of the Strategic National Stockpile Radiation Working Group*. Annals of Internal Medicine 140:1037-51.

# APPENDIX D: RADIOLOGICAL SCREENING CRITERIA – EXTERNAL CONTAMINATION

# Appendix D

## Radiological Screening Criteria—External Contamination

Radiological screening for external contamination is performed to assess the amount of radioactive materials on the skin and clothing. These materials can irradiate the body when beta- and gamma-emitting radionuclides are present. If the radioactive material remains on skin or clothing, it could be released into the air and inhaled or it could be incidentally ingested, resulting in internal contamination. Internal contamination is particularly significant in the case of alpha-emitting radionuclides.

External contamination on the body can be spread to other people, places, or items, resulting in cross-contamination. Cross-contamination is a public health concern, although it is secondary to immediate concerns for people's health and safety.

In this appendix, a number of benchmark screening criteria and their technical bases are briefly described. This description is followed by recommendations on how to select particular screening criteria to best serve public health in a variety of circumstances.

The information in this appendix is intended for planning purposes. Planners should consider and discuss this information with health physics/radiation protection experts in their state radiation control and public health programs during the planning process for a range of possible circumstances, prior to any incidents.

The screening values are listed using the same measurement units as the original guidance documents for easy reference. When appropriate, unit conversions are given in parentheses.

## Benchmark Screening Criteria

This appendix will describe the following documents:

- FEMA (1995). Federal Emergency Management Agency, *Contamination Monitoring Standard for a Portal Monitor Used for Radiological Emergency Response*, FEMA-REP-21, March 1995.
- FEMA (2002). Federal Emergency Management Agency, *Contamination Monitoring Guidance for Portable Instruments Used for Radiological Emergency Response to Nuclear Power Plant Accidents*, FEMA-REP-22, October 2002.
- NCRP (2005). National Council on Radiation Protection and Measurements, *Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism*, Commentary No. 19, December 2005.
- NCRP (2008). National Council on Radiation Protection and Measurements, *Management of Persons Contaminated with Radionuclides: Handbook*, Report No. 161, December 2008.
- NCRP (2010). National Council on Radiation Protection and Measurements, *Population Monitoring and Radionuclide Decorporation Following a Radiological or Nuclear Incident*, Report No. 166, April 2010.
- CRCPD (2006). Conference of Radiation Control Program Directors, Inc., *Handbook for Responding to a Radiological Dispersal Device. First Responder's Guide— the First 12 Hours*, September 2006.
- IAEA (2005). International Atomic Energy Agency, *Generic Procedures for Medical Response During a Nuclear or Radiological Emergency*, April 2005.
- IAEA (2006). International Atomic Energy Agency *Manual for First Responders to a Radiological Emergency*, October 2006.

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- IAEA (2011). International Atomic Energy Agency, *Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency*. General Safety Guide No. GSG-2, May 2011.
- EPA (1992). U.S. Environmental Protection Agency, *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents*, EPA-400-R-92-001, May 1992.
- EPA (2013). U.S. Environmental Protection Agency, *PAG Manual, Protective Action Guides and Planning Guidance for Radiological Incidents*, draft for interim use and public comment, March 2013.

The FEMA REP-21 and REP-22 documents have associated technical background documents that discuss the technical bases and assumptions of the guidance. These two guidance documents are intended for radiation emergencies involving nuclear power plant facilities. They do not address terrorism incidents. The remaining documents do address terrorism, with CRCPD specifically focusing on Radiological Dispersal Device (RDD) incidents. With NCRP and IAEA, there is a progression of guidance documents addressing the skin contamination criteria.

Lastly, the 1992 EPA Manual of Protective Action Guides (PAGs)—which is the earliest of documents described here—has been updated. The updated EPA PAG Manual was issued in 2013 for interim use and public comment. The recommended skin contamination screening levels remain unchanged in the draft 2013 PAG Manual and are described in this appendix.



### *Radiation Control Zones*

Although this topic does not directly deal with population monitoring, it does affect the manner in which people at the scene are directed. FEMA REP documents do not address this topic, but the NCRP 2005, CRCPD, and IAEA 2006 documents are consistent in the manner in which they delineate radiation control zones at the scene. All three documents identify two major zones:

- Inner perimeter with radiation levels exceeding 100 mSv/h (10 R/h) and where only lifesaving or other mission-critical activities should be performed with very short (few minutes) stay times.
- Outer perimeter with radiation levels exceeding 0.1 mSv/h (10 mR/h) from which people are evacuated. The area is isolated, and controlled entry is implemented to allow in only first responders with appropriate personal protection equipment.

CRCPD recommends that the outer perimeter should be set at lower than 0.1 mSv/h (10 mR/h) if it is practical (i.e., the area does not become too large or too distant from the epicenter of the blast). CRCPD also states that responders *may* define additional boundaries, if needed, at 1 mSv/h (100 mR/h) and 10 mSv/h (1000 mR/h).

### *People (Skin and Clothing) Screening Criteria*

Both the FEMA REP documents and the NCRP 2005 recognize two health-based concerns:

- Deterministic effects—acute exudative radiodermatitis has the limiting radiation dose threshold
- Long-term stochastic effects—skin cancer

FEMA also defines two types of contamination: loose and fixed. Loose contamination can be removed by washing or changing clothes. FEMA assumes that, on average, people will be able to bathe and remove loose contamination within 36 hours of the incident. Fixed skin contamination will remain even after bathing and will be removed by natural processes within 2 weeks.

Concerning acute effects, FEMA sets a limit of 3.7 kBq (0.1 µCi) for fixed contamination on a spot of skin.[24] If it is assumed that contamination is mixed (loose-plus-fixed contamination), FEMA sets a higher limit of 37 kBq (1.0 µCi) for spot contamination.

Concerning the stochastic effects, FEMA sets a limit of 2.7 MBq (74 µCi) for fixed contamination over the body, regardless of distribution. If uniformly distributed over the surface of an adult body, this corresponds to 150 Bq/cm$^2$, which is equal to 0.004 µCi/cm$^2$ or 9,000 disintegrations per minute (dpm)/cm$^2$. If it is assumed that contamination is mixed, a higher limit of 27 MBq (740 µCi) is set for distributed contamination. For an adult, this is equal to 1.5 kBq/cm$^2$, which is equal to 0.04 µCi/cm$^2$, or 90,000 dpm/cm$^2$.

NCRP 2005 states that people with spot contamination on the skin exceeding 2.2 x 10$^6$ dpm have priority for decontamination. This equals FEMA's 37 kBq (1 µCi) limit for mixed contamination described above.

NCRP 2005 further states that "decontamination procedures should strive to reduce" surface contamination below the following limits:

- 2.2 x 10$^5$ dpm (3.7 kBq; 0.1 µCi) on any one spot
- 10,000 dpm/cm$^2$ (170 Bq/cm$^2$) surface body contamination

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Note that NCRP contamination guides are numerically equal to FEMA's limits for fixed contamination. The language is slightly different in the two documents. Whereas FEMA sets these values as upper limits, NCRP 2005 (Commentary 19) recommends these as guides that decontamination procedures should strive to meet or exceed.

Contamination survey equipment does not measure in units of surface activity such as kBq/cm$^2$ or µCi. The instruments typically read in units of counts per minute (cpm). For first responders, the screening criteria should be given in operational units. The conversion to operational units is made considering the sensitive area of the probe and the probe counting efficiency for the particular type of radionuclide. Operational units may vary by orders of magnitude among the various available probes. Therefore, it is essential to relate or correlate the above criteria to the specific equipment being used by personnel responsible for conducting screening.

FEMA evaluated several instruments and decided to recommend a single value, equivalent to the response for the least sensitive Civil Defense (CD) instrument (CD V-700 with a standard detector). This value is 300 cpm above background. FEMA states that using this criterion with more sensitive instrument combinations will provide an additional level of protection. In the background information document for REP-22 Guidance, FEMA states the following:

- For CD V-700s that have been retrofitted with a GM pancake detector, criteria could be set at 1,000 cpm and 10,000 cpm for fixed and loose-plus-fixed contamination, respectively.
- For more modern (non CD V-700) instruments with pancake detectors, criteria of 10,000 cpm and 100,000 cpm could be used for fixed and loose-plus-fixed contamination, respectively.

Generally, the fixed contamination criterion is applied to people who have showered and changed clothes. The criterion for loose-plus-fixed contamination is applied to those who have not yet washed or changed clothes.

NCRP 2005 (Commentary 19) values correspond to FEMA's values for fixed contamination. NCRP, however, does not provide operational units. Users would have to make such calculations for their own types of instruments.

[24] Spot size is defined by both FEMA and NCRP as an area of 0.2 cm$^2$ or a circle 0.5 cm in diameter.

Both NCRP 2005 and FEMA documents assume a mixture of radionuclides from a nuclear reactor mix.

FEMA REP-21 is the only one of the documents that addresses portal monitors and suggests 37 kBq or 1.0 μCi as the Standard of Detectability for beta/gamma activity.

The CRCPD Handbook focuses on RDD incidents. The screening criteria given in the CRCPD Handbook are in operational units and assume the use of a GM pancake survey meter. CRCPD states the following:

- With contamination levels up to 1,000 cpm, people can be instructed to go home and shower. This level is equal to 440 dpm/cm$^2$, compared to the NCRP value of 10,000 dpm/cm$^2$.[25]
- In case of a large incident or if adequate decontamination resources are not available, the release level can be increased to 10,000 cpm (0.05 mR/h using a gamma detector). This is equal to 4,400 dpm/cm$^2$, compared to the NCRP value of 10,000 dpm/cm$^2$.

The CRCPD Handbook also recommends that to minimize the spread of contamination at hospitals decontamination can be performed to levels below 1,000 cpm by using a GM pancake survey meter, but only if such decontamination efforts do not interfere with patient medical treatment.

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The CRCPD Handbook states that establishing higher decontamination limits (i.e., higher than 10,000 cpm) may be necessary, depending on the number of patients and the decontamination resources available.

The NCRP 2008 (Report 161) provided a graded approach for skin contamination levels that was adopted from an earlier IAEA 2005 guidance. This graded approach provided skin contamination limits for alpha and beta/gamma radiation when no action is required or when intervention may be optional, advisable, or required. Intervention includes preventing inadvertent ingestion and inhalation, limiting the spread of contamination, and decontaminating.

Using the criterion of dose equivalent rate measured at 10 cm from skin surface in a low-background area, the NCRP 2008 recommendation can be simplified as follows:

- 2-3 times background dose rate – intervention is advisable
- 20-30 times background dose rate – intervention is required

The NCRP 2008 stated that the skin decontamination objective is to reduce the level to less than two times background. However, this guidance recognized that less stringent criteria may be used when lack of resources or the number of contaminated people makes it impracticable to achieve this objective.

For situations when large numbers of people are contaminated and the goal of less than two times background is impractical, the NCRP 2008 provided the following decontamination guidance which is similar to NCRP 2005 values for beta/gamma radiation, and it adopted the IAEA 2005 approach by applying a reduction factor of 10 for alpha radiation:

- Beta/gamma < 220,000 dpm (3.7 kBq) on any one spot (0.2 cm$^2$)
- Beta/gamma < 10,000 dpm/cm$^2$ (170 Bq/cm$^2$) surface body contamination
- Alpha < 22,000 dpm (0.37 kBq) on any one spot (0.2 cm$^2$)
- Alpha < 1,000 dpm/cm$^2$ (17 Bq/cm$^2$) surface body contamination

The NCRP 2010 (Report No. 166) stated that the affected individuals whose medical conditions are not life-threatening should receive contamination screening to the extent that their medical conditions, the availability of survey equipment, weather conditions, and personnel resources permit. NCRP 2010 recommended a screening value of 1,000 cpm when surveying with a GM

[25] Assuming a probe area of 15 cm$^2$ and 15% counting efficiency.

pancake survey meter, consistent with the 2006 CRCPD Handbook. NCRP 2010 further stated that individuals with contamination levels exceeding 1,000 cpm should be directed to a decontamination station, and individuals with contamination levels less than 1,000 cpm can be released and advised to shower and change clothes when they go home.

The most recent IAEA guidance, the IAEA 2011 General Safety Guide (GSG-2), provides a dose rate criterion of 1 μSv/h (0.1 mrem/h) measured at 10 cm from the body. This standard is consistent with the earlier guidance in IAEA 2006. This dose rate criterion is used to assess skin or clothing contamination from strong gamma emitters.

In addition, the IAEA GSG-2 provides the following skin surface activity criteria for cases when the radionuclide(s) are unknown or for when an immediate conservative assessment is needed:

- 1,000 counts per second (60,000 cpm) beta skin contamination
- 50 counts per second (300 cpm) alpha skin contamination

The IAEA recommends skin decontamination if these criteria are exceeded. If immediate decontamination is not practicable, people are advised to change their clothing and shower as soon as possible.

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Unlike the earlier IAEA criteria, these latest skin decontamination criteria are in units of counts per second. The IAEA refers to the above skin screening criteria as Operational Intervention Levels (OILs). The response of particular radiation detection instruments may vary significantly depending on detector efficiency, size of the detector window, etc. Therefore, the IAEA recommends that, as part of the preparedness process, these OILs be revised accordingly to be more consistent with the characteristics of particular instruments. The IAEA criteria listed above were established so that the majority of commonly available radiation detection equipment would give a response that is equal to or higher (i.e., more conservative) than the response assumed in developing the default OILs (IAEA 2011).

The EPA Manual of Protective Action Guides was first published in 1992 before the other documents discussed in this appendix. The PAG manual, in the 1992 version and in the updated 2013 version, recommends that contamination screening and decontamination facilities be established in low background areas. These are defined as areas with gamma exposure rates less than 1 μSv/h (0.1 mR/h). The PAG manual also acknowledges that in major radiation incidents, emergency contamination screening stations may need to be set up in areas not qualifying as low background areas. The PAG manual recommends that gamma exposure rates in these areas should be less than 50 μSv/h (5 mR/h).

In either case, EPA's recommended surface screening level for people is set at twice *existing* background. Corresponding levels, expressed in operational units related to particular survey instruments, may be used for convenience. The draft 2013 PAG manual further recommends that levels greater than twice existing background—not to exceed 1 μSv/h (0.1 mR/h)—may be used to speed the monitoring process in very low background areas.

## Selecting a Screening Criterion

As evidenced from the preceding discussion, there are a large number of factors to consider in deciding on a contamination screening criterion. The guidance documents consider health-based criteria for establishing contamination limits. CRCPD screening values are somewhat lower than those recommended by FEMA and NCRP. This is because of consideration given to cross-contamination issues that do not necessarily present a health concern. However, public perception can cause anxiety, lack of confidence, and disruption of other services that could then affect the public health in a different way.

Both the EPA Manual of Protective Action Guides (1992) and NCRP Report 161 (2008) state that the skin decontamination objective is to reduce the level to less than two times background. At the same time, both guidance documents recognize there are situations when this ideal may not be practicable because of the number of contaminated people, lack of facilities, equipment, staff, or other circumstances. Other guidance criteria may be applicable, particularly during the emergency phase of the response.

The initial screening criteria must focus on preventing acute health effects and must take into account the magnitude of the incident and availability of resources. The specific operational criteria provided to first responders must match the types of instruments they will be using.

The plan should also be flexible. It may be prudent to use less stringent criteria (i.e., allowing for greater levels of contamination) for people with their own personal transportation or those using transportation provided by emergency response authorities. On the other hand, using more stringent criteria (i.e., allowing for much less contamination) for people who plan to use uncontrolled public transportation may be warranted.

If the initial screening criterion is isolating an unmanageable number of people for decontamination, the criterion may have to be less stringent. Conversely, if resources allow, a more stringent criterion may be adopted.



In some circumstances, it may be practical to use physical location based on proximity to the incident site as a criterion for prioritizing the population in most urgent need of assistance with decontamination. Under those circumstances, assist those in the specified zone (without any initial screening) to decontaminate at the scene, and instruct people outside the zone to go home to self-decontaminate.

As a result of these considerations, CDC does not recommend setting a predetermined, fixed screening criterion to be applied to all people for all incidents, under all circumstances. CDC recommends that you and your state radiation control authority, as state planners and decision makers, consider a range of possible circumstances, keeping the following in mind:

- Population monitoring objectives as described in this guide
- Specific radiation survey instruments your responders will be using (e.g., dose rate meters, portal monitors, specific types of surface contamination monitors)
- Staffing resources and size of the population you may be expected to process
- Facilities and resources you have for offering on-the-scene contamination screening and decontamination
- Availability of other resources

The planning should be done in advance, allowing some room for flexibility. The emergency responders, however, must have very clear instructions to follow on the basis of your evaluation of the specific local circumstances. CDC is available to assist you in the planning process. In the aftermath of a radiological or nuclear incident, the Federal Advisory Team for Environment, Food, and Health can assist you in establishing practicable screening criteria based on specific local circumstances.[26]

[26] The Federal Advisory Team for Environment, Food, and Health develops coordinated advice and recommendations to the coordinating agencies and state and local governments and includes representatives from CDC, the U.S. Food and Drug Administration (FDA), the U.S Environmental Protection Agency (EPA), the U.S. Department of Agriculture (USDA), and other federal agencies, as needed.

# APPENDIX E: RADIOLOGICAL SCREENING CRITERIA -- INTERNAL CONTAMINATION

# Appendix E

## Radiological Screening Criteria—Internal Contamination

Internal contamination occurs when people swallow or breathe in radioactive materials, or when radioactive materials enter the body through an open wound or are absorbed through the skin. Over time, radioactive material is eliminated from the body in sweat, urine, and feces. This could take days, months, or years, depending on the type of radionuclides and their physical and biological half-lives.

Having internal contamination does not necessarily mean the person is going to experience health problems. Every day, tens of thousands of people in the United States undergo diagnostic testing that involves medical administration of short-lived radioactive materials after which the patients are released to go home.[27]

If the amount of radioactive material is medically significant (this will be discussed later), the person may have an increased risk of developing cancer and in severe cases, develop acute radiation injury. In case of extremely high doses, internal contamination with radioactive material *could* be lethal. However, this is rare. For example, an incident involving a radiological dispersal device is likely to result in a limited number of people with medically significant amounts of internal contamination and a much larger population with only small amounts of internal contamination.

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When a person is internally contaminated, depending on the type of radioactive material he/she is contaminated with, certain medications can be administered to speed up the rate at which the radioactive material is eliminated from the body.[28] Note that **internal decontamination is a medical procedure that should be performed only at the order and under the guidance of a licensed physician.**

Information about the levels of internal contamination is important in deciding whether any or both of the following are warranted.

- Medical intervention
- Long-term health monitoring

Although the decisions about long-term health monitoring can be made in a more deliberate fashion and involve all stakeholders, decisions about medical intervention are time-sensitive.

## Screening Criteria

The National Council on Radiation Protection and Measurements (NCRP) has published an authoritative report regarding medical screening and management of internally contaminated individuals.[28] In this report, the NCRP defined a new operational guide, the Clinical Decision Guide (CDG), to help physicians make clinical decisions about individuals with internal contamination who may need treatment. The numerical values of dose used as a basis for computing the adult CDG intake values for different radionuclides (excluding isotopes of iodine) are as follows:

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[27] NCRP (2009). National Council on Radiation Protection and Measurements, *Ionizing Radiation Exposure of the Population of the United States*, Report No. 160, March 2009.

[28] NCRP (2008). National Council on Radiation Protection and Measurements, *Management of Persons Accidentally Contaminated with Radionuclides: Handbook,* Report No. 161, December 2008.

- 0.25 Sv (50-year effective dose) whole body
- 0.25 Gy-Eq (30-day RBE-weighted absorbed dose) to the bone marrow[29]
- 1 Gy-Eq (30-day RBE-weighted absorbed dose) to the lung

For any particular radionuclide, the most limiting criterion is used to define the CDG. For nearly all radionuclides, the CDG is based on the 0.25 Sv effective dose criterion.

The CDG values are defined for adults. For children and women who are pregnant or nursing, the NCRP recommends that the screening value be reduced to one-fifth (20%) of the CDG.

In the case of iodine-131, the NCRP bases its CDG values on the U.S. Food and Drug Administration (FDA) recommendations.[30] FDA recommends that potassium iodide (KI) in doses ranging from 16 to 130 mg be administered to:

- Adults older than 40 years, if thyroid dose is ≥ 5 Gy. Dose = 130 mg.
- Adults older than 18 years through 40 years, if thyroid dose is ≥ 0.1 Gy. Dose = 130 mg.
- Persons through age 18 years, if thyroid dose is ≥ 0.05 Gy. Dose = 16 mg (birth through 1 month), 32 mg (age over 1 month through 3 years), 64 mg (age over 3 through 12 years), 64 mg (age over 12 through 18 years). If body weight approaches 70 kg, the adult dose is recommended.
- Pregnant or lactating women of any age, if thyroid dose is ≥ 0.05 Gy. Dose = 130 mg.

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The CDG values recommended by the NCRP are similar to the guidance issued earlier by the Internal Commission on Radiological Protection (ICRP) in 2005.[31] The ICRP emphasized that treatment for internal contamination "should be under the direction of a physician experienced in these matters, and should take individual patient factors into account."

In fact, the amount of internal radioactive contamination is only one of many parameters a physician would evaluate in assessing the need for treatment. A person's age and general state of health, organ function (kidney, liver, lung, etc.), pregnancy status, iodine sensitivity, emotional state, time since intake, and the biochemical and physical properties of the internally deposited radioactive material are among the factors physicians might evaluate and consider in order to make their best medical judgment.[32] However, in incidents involving large populations, it is unlikely that detailed medical evaluations can be made for each person.

## Assessing the Amount of Internal Contamination

In general, the amount of internal contamination in the body can be assessed by direct or indirect methods. The direct (*in vivo*) screening relies on measurement of radiation emanating from the body. A typical example is a whole-body counter. The indirect *(in vitro)* screening relies on analyzing material removed or excreted from the body, such as nasal swabs, urine samples, or fecal samples.

For both bioassay methods, it is important to recognize the difference between detection of radiation from a body (direct screening) or quantification of radioactive materials in a sample (indirect screening) and the accurate quantification of intake in an individual. In other words, the estimation

[29] This dose quantity is a measure of radiation dose to a specific organ, and it also accounts for the quality of radiation; RBE = relative biological effectiveness.

[30] U.S. Food and Drug Administration. *Guidance: Potassium Iodide as a Thyroid Blocking Agent in Radiation Emergencies*, 2001, available at www.fda.gov/downloads/Drugs/.../Guidances/ucm080542.pdf.

[31] ICRP (2005). Internal Commission on Radiological Protection. *Protecting People Against Radiation Exposure in the Event of a Radiological Attack*, Publication 96, Ann. ICRP 35 (1), 2005.

[32] NCRP (2010). National Council on Radiation Protection and Measurements, *Population Monitoring and Radionuclide Decorporation Following a Radiological or Nuclear Incident*, Report No. 166, April 2010.

of intake by both bioassay methods involves inherent, often large uncertainties that must be recognized.

The NCRP Report 166 includes an extensive discussion of both these screening methods. This report discusses rapid screening using radiation detection equipment such as GM survey meters, whole-body and lung counters, nuclear medicine thyroid uptake counters and gamma cameras, as well as portal monitors.[33] There is also a discussion of various indirect (*in vitro*) methods, the most practical of which is analysis of spot urine samples. In case of alpha-emitting radionuclides, only laboratory analysis can provide an assessment of internal contamination.

The NCRP Report 166 includes two appendices to describe collection, preparation, and shipping of clinical samples.[32] The CDC can receive and analyze urine samples. For urine samples that are to be shipped to CDC, specific collection, processing, and shipping procedures and protocols can be found on the CDC radiation emergencies website.[34]

## Other Considerations

When the number of potentially contaminated people exceeds the available capacity to collect, transport, or analyze all the samples in a short time period, medical authorities may find it necessary to advise on treatment of internal contamination for a subset of the affected population on the basis of other parameters. These parameters can include a person's physical location at the time of the incident, age, pregnancy status, iodine sensitivity, clinical comorbidities and injuries, or radiation measurements using field-deployable instruments. Very likely, some prioritization scheme will be necessary to identify individuals most in need of follow-up monitoring and medical care, if necessary.

As one example of such prioritization, the Conference of Radiation Control Program Directors, Inc. (CRCPD) recommends that people with external contamination greater than 100,000 cpm (measured with a GM pancake probe) be identified as a priority for follow-up of potential internal contamination.[35]

As part of the planning process, public health authorities should evaluate their ability to screen people for both external and internal contamination, and they should support medical providers caring for internally contaminated patients. The logistics of collecting and processing clinical samples as well as administering medical countermeasures need careful planning and consideration. CDC is available to assist in the planning process. In the aftermath of a radiological or nuclear incident, assistance can be requested from the Federal Advisory Team for Environment, Food, and Health.[36]

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[33] In addition to NCRP Report 166, see these publications as examples: Wesley E. Bolch et al., Guidance on the use of handheld survey meters for radiological triage: time-dependent detector count rates corresponding to 50, 250, and 500 mSV effective dose for adult males and adult females. *Health Phys*. 102(3):305-25 (2012); Gary H. Kramer, et al., The HML's New Field Deployable, High-Resolution Whole Body Counter, *Health Phys*. 89(5 Suppl):S60-8 (2005).

[34] http://emergency.cdc.gov/radiation/labinfo.asp

[35] CRCPD (2006). Conference of Radiation Control Program Directors, Inc., *Handbook for Responding to a Radiological Dispersal Device. First Responder's Guide – the First 12 Hours*. September 2006.

[36] The Federal Advisory Team for Environment, Food, and Health develops coordinated advice and recommendations to the coordinating agencies and state and local governments and includes representatives from CDC, the U.S. Food and Drug Administration (FDA), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Agriculture (USDA), the U.S. Department of Homeland Security (DHS), and other federal agencies, as needed.

# APPENDIX F: COMMUNITY RECEPTION CENTER SPECIFICATIONS

# Appendix F

## Community Reception Center Specifications

A radiation incident impacting a large population will require local response authorities to establish one or more population monitoring and decontamination facilities to assess people for exposure, contamination, and the need for decontamination or other medical follow-up. These facilities are known as community reception centers (CRCs).

CRCs should be located outside of the affected area and be operational within 24 to 48 hours after an incident or sooner if resources are available.

The basic services offered at a CRC include the following:

- Screening people for radioactive contamination
- Assisting people with washing or decontamination
- Registering people for subsequent follow-up
- Prioritizing people for further care

One important benefit of establishing CRCs is to reduce the potential burden on hospitals and maximize scarce medical resources. Another benefit is to support the operations of public and special needs shelters that will be hosting the displaced population. To best support shelter operations, planners should consider establishing one or more CRCs at or near shelters operated by the American Red Cross or other local organizations. For large incidents, planners may establish a network of CRCs that feeds into a larger network of shelters, as diagramed in Figure 1.

Many communities have previously developed plans for responding to other public health emergencies. These plans may already include provisions for establishing alternate care sites (ACS) to help the majority of the people who may need some assistance or medical care but do not need hospitalization. In some communities, these may be referred to as neighborhood emergency help centers (NEHC). Plans usually call for these to be set up in well-known locations within the community, such as high schools. Many communities also have plans to use these facilities as Points of Dispensing (PODs) for distribution of medical supplies from the Strategic National Stockpile in case of pandemic flu or other biological threats. These same facilities can also be used as CRCs because they have very similar functions and staffing requirements. A new requirement would be to add radiation detection equipment and radiation protection support personnel for contamination screening and decontamination.

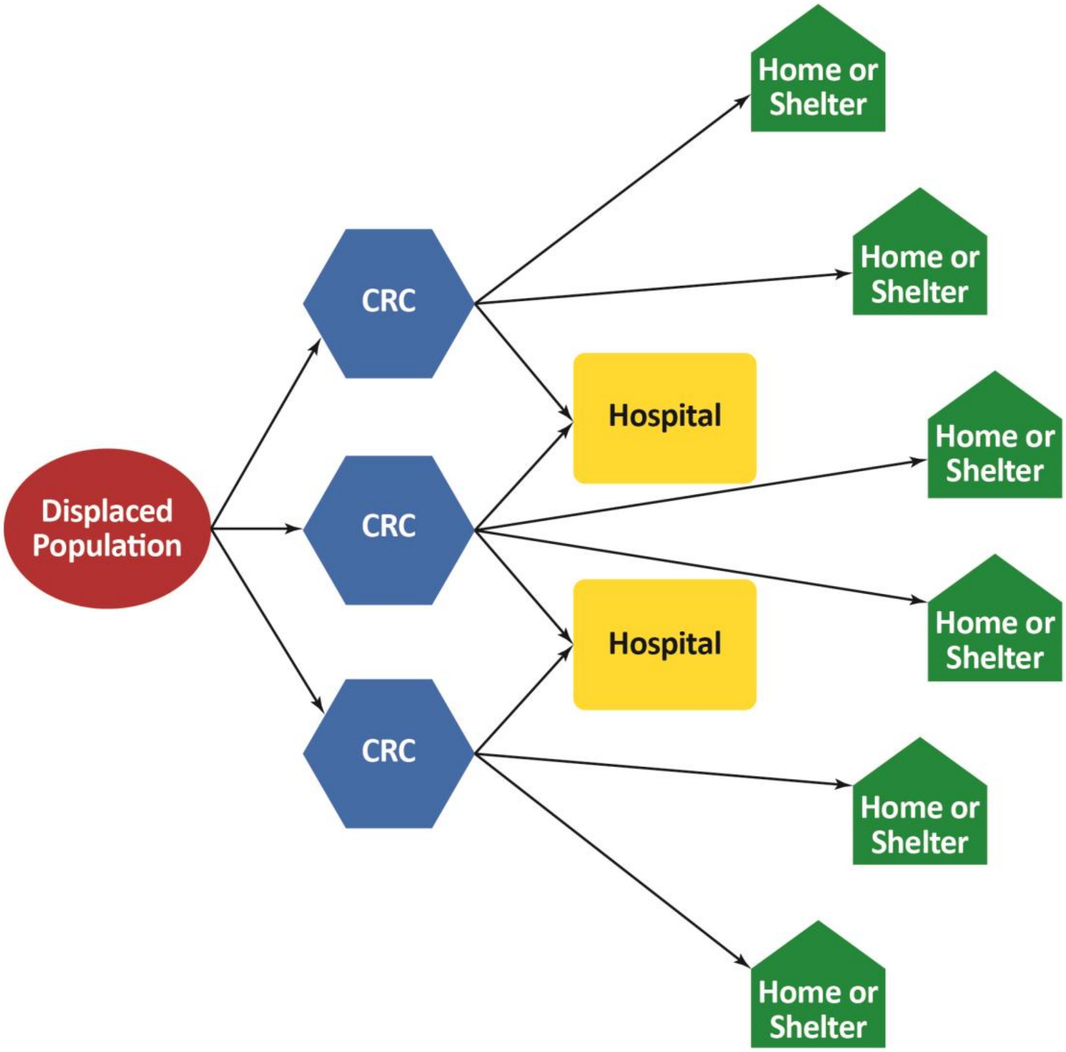


**Figure 1: CRC Network Diagram**

This appendix describes some of the features and requirements for CRCs and provides a breakdown of the CRC process. Planners can compare the description with what is already included in the public health emergency plan for setting up PODs.[37]

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[37] For example, see *Point of Dispensing (POD) Operations Manual*, Philadelphia Department of Public Health, Division of Disease Control, Emergency Preparedness and Bioterrorism Program, 2006. Available at www.naccho.org/toolbox/_toolbox/POD%20operations%20manual_1.pdf Also see archived CDC Webcasts, *Mass Antibiotic Dispensing: Streamlining POD Design and Operations*, available at http://www2a.cdc.gov/tceonline/registration/detailpage.asp?res_id=1863, and *Mass Antibiotic Dispensing: Taking the Guesswork out of POD Design*, available at http://www2a.cdc.gov/tceonline/registration/detailpage.asp?res_id=1518.

### *Facility Description*

Evaluate facilities or sites in your community that potentially could serve as CRCs. Planners should consider the following:

- Size
- Location
- Adequate restroom facilities
- Shower (decontamination) rooms or facilities
- Accommodations for people with disabilities and for pets
- Environmental control (against excessive heat or cold)
- Adequate access and exit control (in case of emergency evacuation)

To process large numbers of people, the facility should have adequate space and must have definable entries and exits that can be controlled. Choosing an all-weather facility, like a covered sports arena or convention center, is ideal. However, depending on the circumstances and weather, a nearby park or large parking lot will suffice. Planners should establish agreements in advance with facility or site owners and operators.

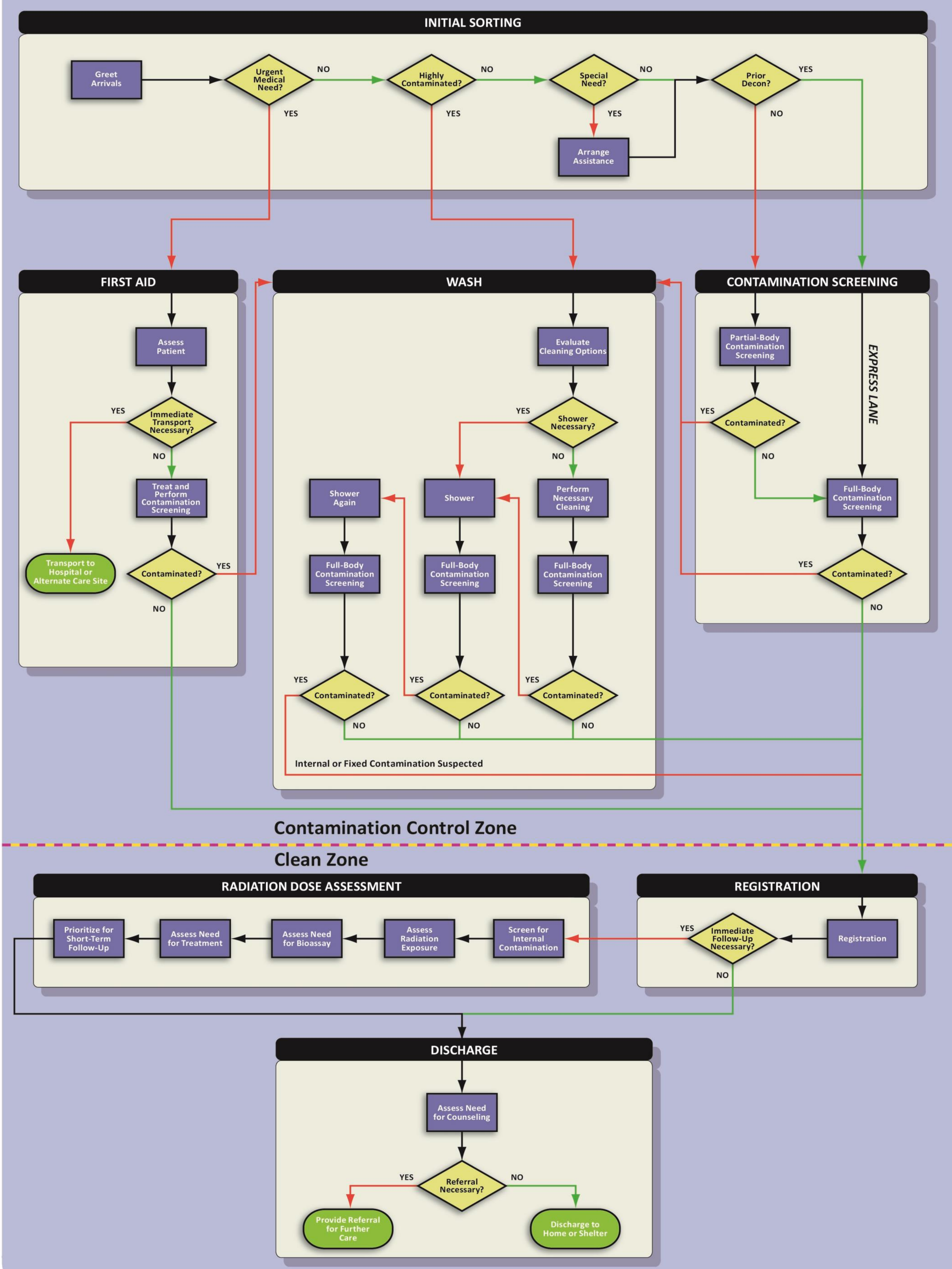
The CRC model (Figure 2, see foldout) contains seven stations, each described further in subsequent sections. This CRC model is scalable and flexible according to the demands of the incident, and it can be modified to accommodate pets (Figure 3, see foldout). Table 1 shows which stations fall within the Contamination Control Zone and which stations fall within the Clean Zone. Staff working at stations within the Contamination Control Zone may require personal protective equipment, as determined by the site safety officer, to protect against cross-contamination.



**Table 1: CRC Stations and Zones**

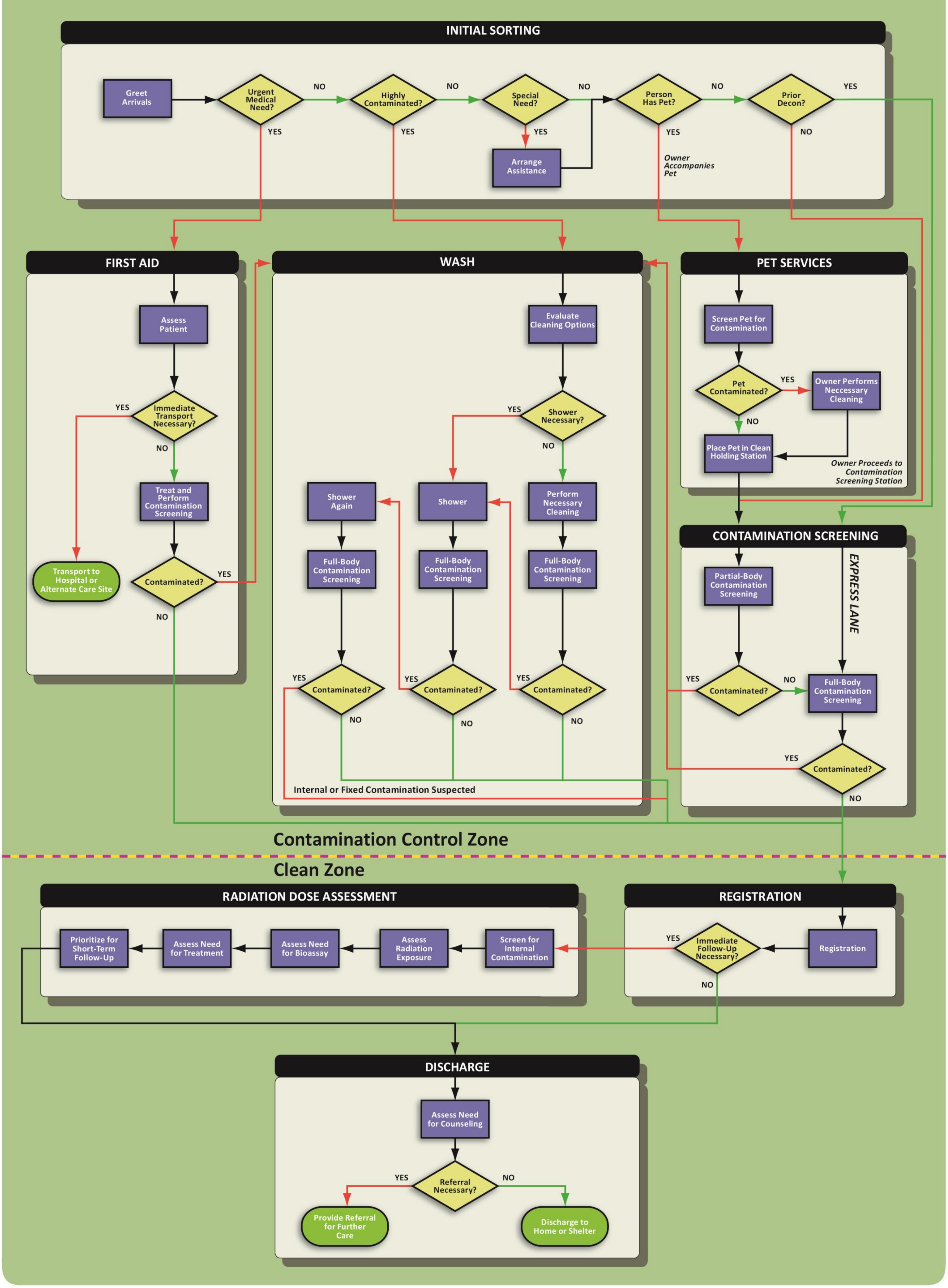
| Station | Zone |
|---|---|
| Initial Sorting<br>First Aid<br>Contamination Screening<br>Wash<br>Pet Services | Contamination Control Zone |
| Registration<br>Radiation Dose Assessment<br>Discharge | Clean Zone |

# Community Reception Center Flow Diagram




For updates and additional resources, visit:
http://emergency.cdc.gov/radiation

# Pet-Friendly Community Reception Center Flow Diagram




For updates and additional resources, visit:
http://emergency.cdc.gov/radiation

## Initial Sorting Station

At the Initial Sorting Station, staff greet and direct people where to go in the CRC. Staff will determine whether a person

- has an urgent medical need.
- is highly contaminated with radioactive material.
- requires special assistance.
- has already showered or been decontaminated before coming to the CRC.

Initial Sorting staff may also assign ID numbers to people as they enter. These ID numbers can be used for record-keeping purposes and tracking people and their belongings through the center.

Contamination Screening staff may be assigned to the Initial Sorting Station to screen people and pets for high levels of radioactive contamination. This screening should be quick and nonintrusive, and it can be done with a variety of radiation detection instruments. Planners should consult the radiation control authorities in their jurisdictions to develop the screening protocol for the Initial Sorting Station.

People who have special needs should be accompanied through the CRC by a staff member or a caregiver. Children should not be separated from their parents. Some processes may need to be modified to accommodate children or people with special needs. People arriving with pets should be directed to the Pet Services Station to evaluate their pets for contamination.



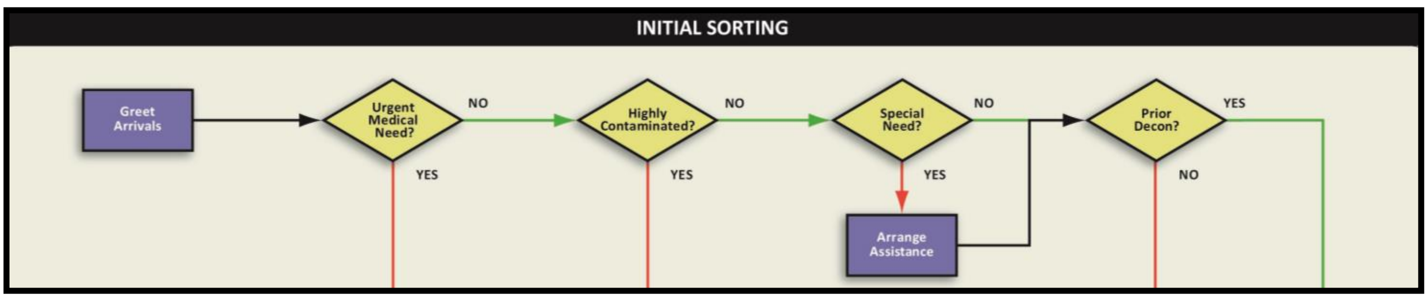



**Figure 4: Initial Sorting Station**

## First Aid Station

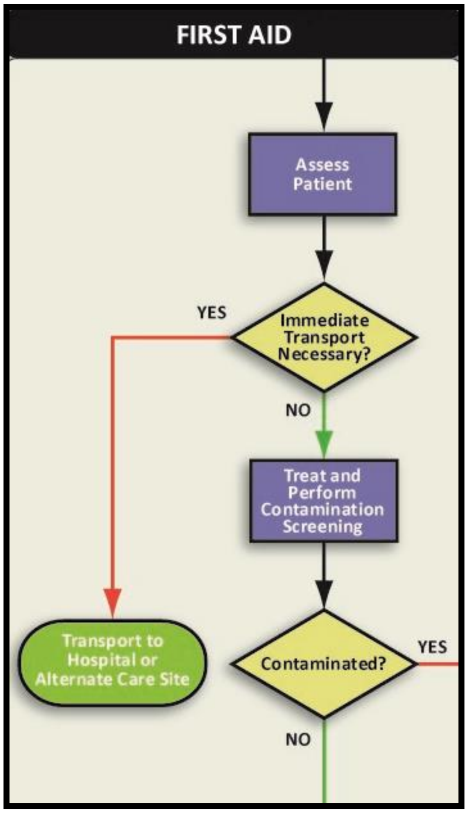



**Figure 5: First Aid Station**

A person with an urgent medical need should be taken directly to the First Aid Station to receive medical care. First Aid staff and Contamination Screening staff should work together to assess the patient's medical needs and, if the patient has not yet been through the Contamination Screening Station, quickly screen the patient for contamination.

If the patient needs advanced medical care, First Aid staff should request medical transport through the chain of command or by calling 911. If the patient is contaminated with radioactive material, First Aid staff can perform a gross decontamination by carefully removing the patient's outer layer of clothing before transport. Lifesaving care should not be delayed due to concerns of cross-contamination.

## Contamination Screening Station

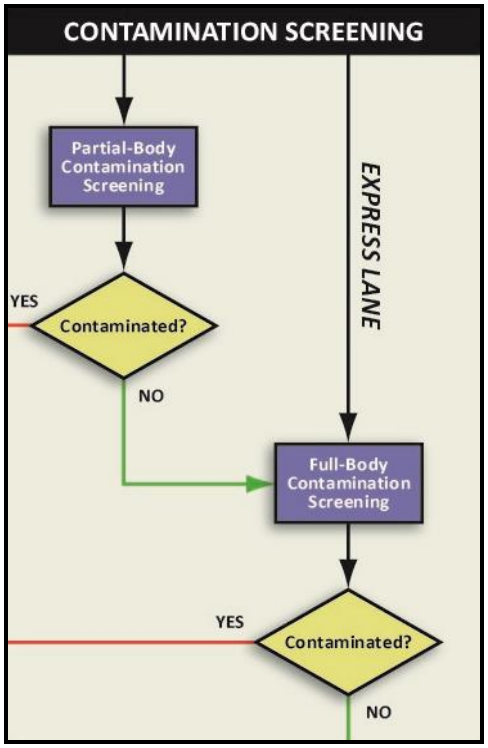



**Figure 6: Contamination Screening Station**

The Contamination Screening Station is where people are monitored for radioactive contamination. Depending on the resources and staff available, a combination of partial-body and full-body contamination screenings can be used to identify contaminated people. An express lane can be established for people who have showered or been decontaminated before coming to the CRC.

A partial-body contamination screening focuses on the hands, face, shoulders, head, and feet and can identify most contaminated people. If contamination is detected during this screening, that person will be escorted to the Wash Station. If not, that person will undergo a full-body contamination screening. The partial-body screening is an optional contamination control measure that protects other people waiting in line and the staff from cross-contamination.

The full-body screening should be conducted by trained staff using either handheld radiation detection instruments or portal monitors. If contamination is detected during this screening, that person will be escorted to the Wash Station. If not, that person will proceed to Registration. Planners should consult the radiation control authorities in their jurisdictions to determine screening protocols and release criteria for the Contamination Screening Station. Under certain circumstances, release criteria may need to be modified to alleviate bottlenecks at this station or at the Wash Station. For example, the Conference of Radiation Control Program Directors, Inc., has suggested release criteria for contamination screenings following a RDD ranging from 1,000 counts per minute (cpm) to 10,000 cpm, depending on the availability of decontamination resources.[38]

Appendix D provides a more detailed discussion of external contamination screening criteria.

[38] CRCPD (2006). Conference of Radiation Control Program Directors, Inc., *Handbook for Responding to a Radiological Dispersal Device. First Responder's Guide—the First 12 Hours*, September 2006.

## Wash Station

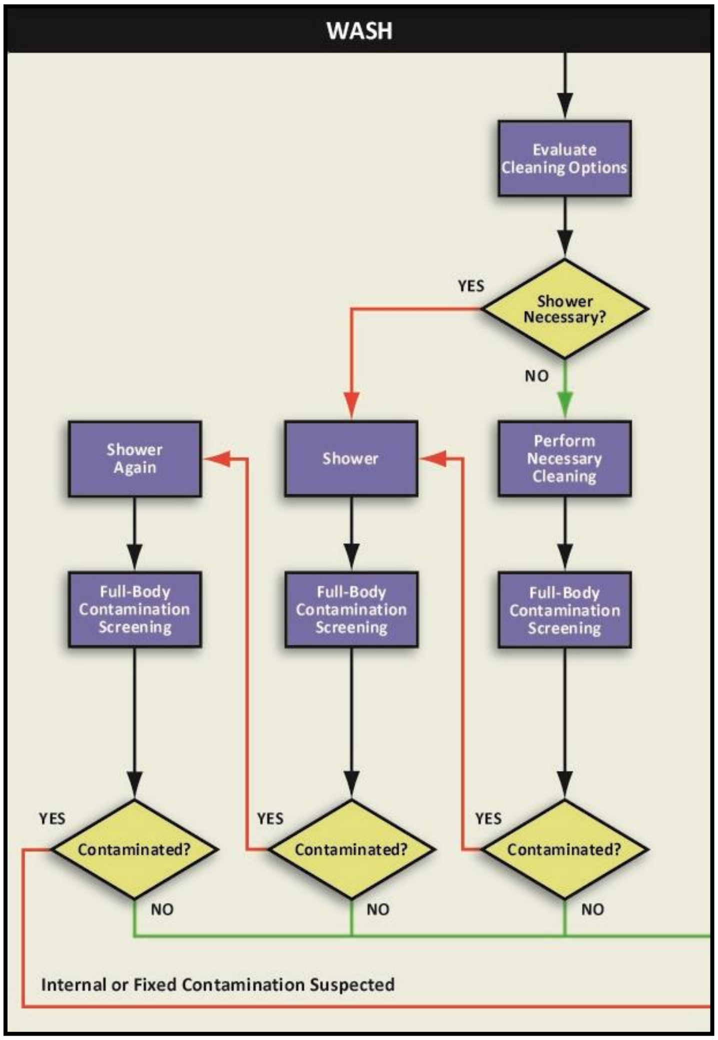



**Figure 7: Wash Station**

Wash Station staff review contamination screening results to determine the best method of decontamination for each contaminated person. After a person finishes washing, Contamination Screening staff will perform a full-body screening to ensure the person is clean and can proceed to Registration.

Depending on the resources available, CRC managers may decide to use existing indoor shower facilities or an outdoor decontamination unit. Contaminated clothing should be bagged and labeled with the person's name and ID number assigned upon entering the CRC.

Contaminated clothing may be required later for epidemiological or law enforcement purposes. Bagged clothes should be stored in a secure, remote location at the CRC.

Other personal belongings, such as wallets, keys, jewelry, and glasses, should not be taken permanently from the owners. As people go through the Wash Station, their personal items should be bagged, labeled with the owner's information, and returned to the owner when he or she exits the Wash Station. If resources permit, these items can be screened for contamination and, if possible, decontaminated before being returned.

Because Wash Station staff will be assisting contaminated people, they will need personal protective equipment to control cross-contamination. This equipment should provide splash protection when working near showers or decontamination units. The site safety officer should coordinate with radiation protection professionals to conduct a hazard assessment and issue the appropriate personal protective equipment to staff members at this station.

## Registration Station

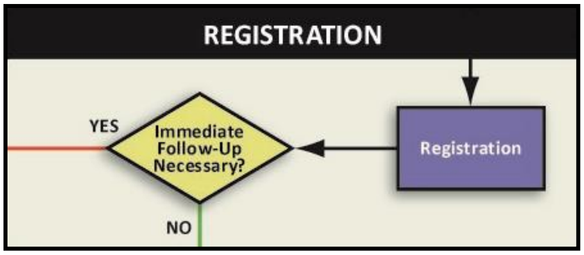



**Figure 8: Registration Station**

Registration staff personnel collect demographic and incident-specific information from people who have been screened for radioactive contamination and cleared to enter the Clean Zone.

This information is used to determine whether someone needs immediate follow-up at the Radiation Dose Assessment Station and possibly long-term follow-up.

Information collected at the CRC must be accurate and accessible for possible additional interviews and investigations. Procedures for managing data need to be clear and easy to understand. Planners should consider modifying existing tools to capture information unique to radiological or nuclear incidents. Because people reporting to this station have been screened and cleared, staff here and at other stations in the Clean Zone require only minimal, if any, personal protective equipment.

## Radiation Dose Assessment Station

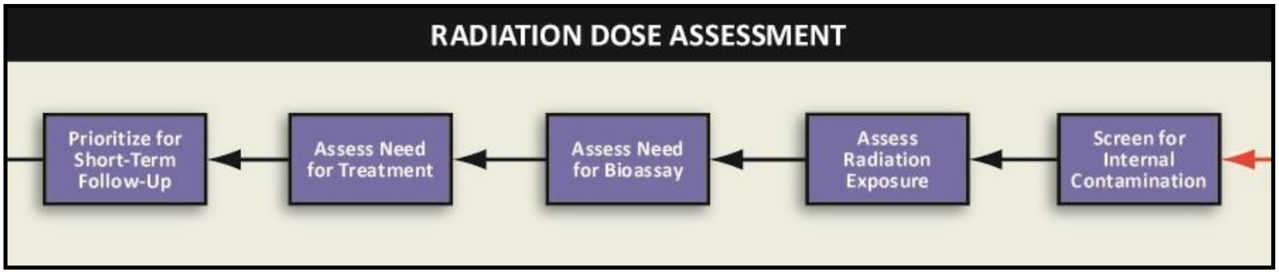



**Figure 9: Radiation Dose Assessment Station**

The Radiation Dose Assessment Station requires specialized staff and equipment to

- screen people for potential internal contamination.
- assess each person's radiation dose.
- collect blood or urine samples for laboratory analysis.
- assess each person's need for treatment.
- prioritize people for further care.

Planning to provide these services should be flexible and scalable, incorporating additional resources as they become available.

If possible, CRC managers should assign a physician and a health physicist to oversee the Radiation Dose Assessment Station. Clinicians and radiation protection professionals will need to work together to determine the person's radiation dose and need for additional medical care or follow-up.

Screening people for internal contamination at the CRC may not be possible in all situations; however, the information gathered from this process can help clinicians prioritize patients for additional medical care or follow-up. If resources are available at the CRC, blood samples can be collected for radiation dose assessment or urine samples can be collected to assess the degree of internal contamination. Trained laboratory staff should oversee sample collection and shipment to appropriate laboratories for processing. As with any medical consultation, staff at this station should take reasonable care to protect a patient's confidentiality and medical information.

## Discharge Station

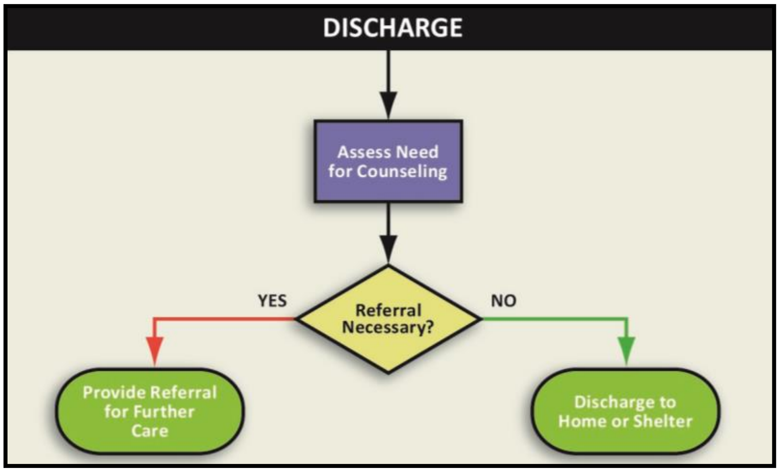



**Figure 10: Discharge Station**

Discharge staff provide information for people leaving the CRC, including referrals to hospitals or alternate care sites for additional medical follow-up. As possible, mental health professionals at this station will assess each person's need for counseling and make themselves available to address psychological needs elsewhere in the CRC. People leaving the CRC may be

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- referred for additional care.
- discharged to their home, to the home of a friend or family member, or to a public shelter.

Planners should work closely with partner agencies, such as the American Red Cross, to streamline the transition from the CRC to a public shelter and to ensure adequate relocation services are provided.

## Pet Services Station

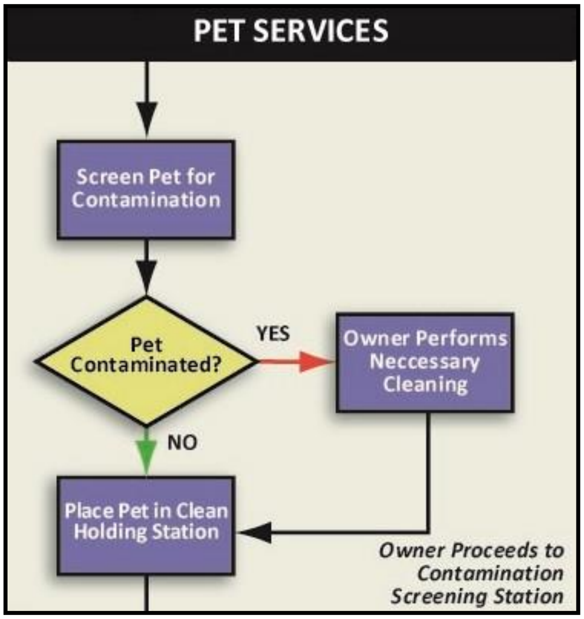


**Figure 11: Pet Services Station**

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People arriving to the CRC with pets or service animals will be evaluated for urgent medical conditions and screened for high levels of radioactive contamination before being directed to the Pet Services Station. Contamination Screening staff will provide a quick screening of pets and service animals. If they are contaminated, the owners will be asked to wash the animal. If the owners are not physically capable, trained staff should be available to provide assistance. After cleaning, pets will be held in an on-site kennel until the owner is discharged from the CRC. Service animals will be allowed to enter the CRC with their owners.

Planners should work closely with partner agencies, such as the Humane Society of the United States, to ensure adequate accommodations for pets.

# APPENDIX G: COMMUNITY RECEPTION CENTER TRAINING AND PLANNING TOOLS

# Appendix G

## Community Reception Center Training and Planning Tools

In addition to the Community Reception Center (CRC) Process Flow Diagrams included in Appendix F, the Centers for Disease Control and Prevention (CDC) has developed the following training and planning tools for CRC operations:

- Virtual Community Reception Center (vCRC), a web-based training tool
- Community Reception Center Simulation Tool for Evaluation and Planning (CRC-STEP), a computer simulation program
- RealOpt-CRC, a computer optimization program

### *Virtual Community Reception Center*

The Virtual Community Reception Center (vCRC) is a web-based training tool that allows users to explore a CRC in virtual space.[39] vCRC features a multipanel display that integrates the three-dimensional CRC scene, interactive process flow diagram, and CRC floor plan to show users where they are in the process (Figure 12). vCRC features embedded videos that provide detailed information about specific steps, and it also includes resources, such as job aids, job action sheets, posters, and forms that users can customize and include in their CRC plans.


**Figure 12: vCRC Interface**

[39] vCRC can be accessed at http://emergency.cdc.gov/radiation/crc/vcrc.asp.

vCRC is well-suited for basic CRC training and can also be used for just-in-time training or to support facilitated discussions and exercises.

vCRC is available online at: http://emergency.cdc.gov/radiation/crc/vcrc.asp.

### *CRC Simulation Tool for Evaluation and Planning*

The Community Reception Center Simulation Tool for Evaluation and Planning (CRC-STEP) is a computer simulation program for CRC operations.[40] CRC-STEP runs on Arena® simulation software and uses a Microsoft Excel® interface for data entry and export (Figure 13).

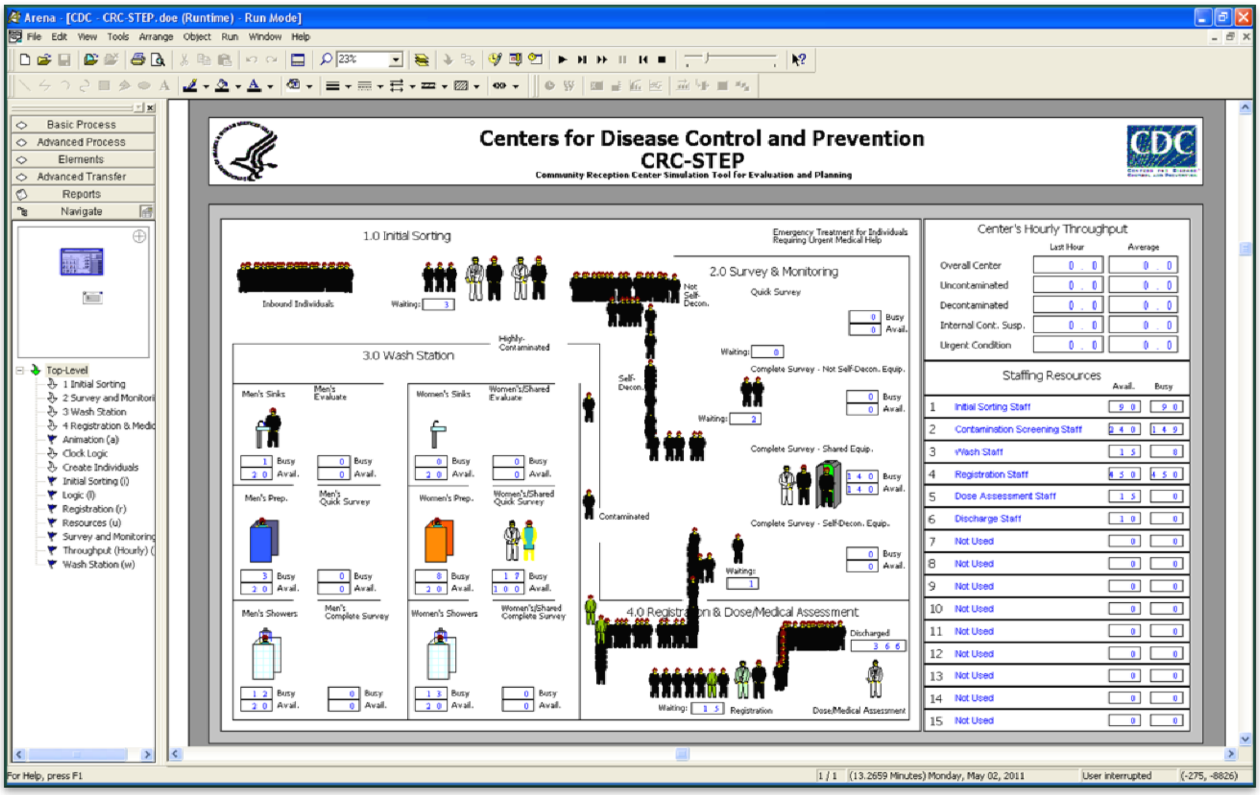


**Figure 13: CRC-STEP Interface**

CRC-STEP is a planning tool that enables users to run CRC simulations to generate throughput statistics (e.g., total throughput per hour, station wait times) and identify potential bottlenecks or resource shortages. This information enables planners to refine their CRC plans prior to drills, exercises, or activation. CRC-STEP is preset with default service times and simulation parameters. However, users can customize these parameters for each simulation, further tailoring the results to their particular planning specifications. Table 2 lists basic and advanced input parameters that users can adjust.

More information about CRC-STEP and instructions for using the program can be found online at: http://emergency.cdc.gov/radiation/crc/simulation.asp.



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40 CRC-STEP can be accessed at http://emergency.cdc.gov/radiation/crc/simulation.asp.

**Table 2: CRC-STEP Input Parameters**

| Basic Input Parameters | Advanced Input Parameters |
|---|---|
| Arrival Rate<br>- How many people arrive each hour<br>Available Staff<br>- Number of CRC staff<br>Available Instrumentation and Facilities<br>- Number of handheld radiation survey meters<br>- Number of portal monitors<br>- Number of showers/cleaning stations<br>Concurrent Registrations<br>- How many people can be registered at the same time by one staff member | Service Times<br>- Time allotted for each step of the process<br>Staffing Category<br>- Worker type (e.g., radiation staff, medical staff, general staff)<br>- Contamination rates<br>- Percent of arrivals who are contaminated<br>Activate/Deactivate Processes<br>- Turn specific steps on/off depending on CRC layout and staffing |

### *RealOpt-CRC*

RealOpt-CRC is an optimization program for CRC operations developed by CDC and the Georgia Institute of Technology.[41] RealOpt-CRC allows emergency planners to analyze resource allocation in real-time and run trials to identify optimum staffing for the CRC.

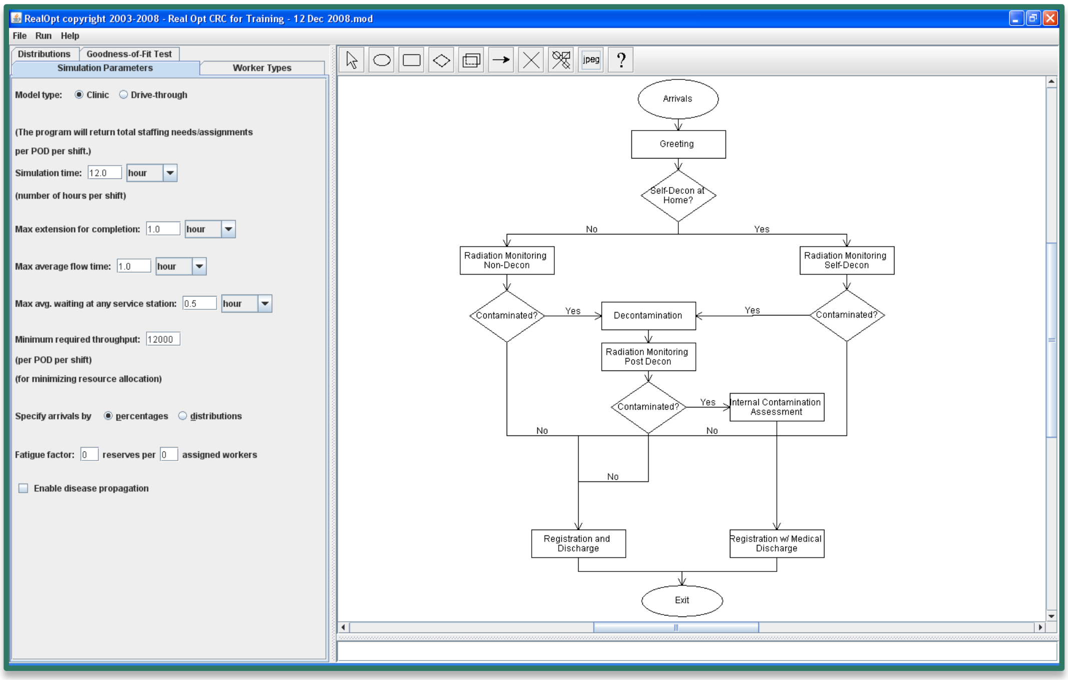


**Figure 14: RealOpt-CRC Interface**

RealOpt-CRC allows emergency planners to

- design customized and efficient CRC process flows.
- assess current resources and determine minimum needs to conduct population monitoring.
- determine optimal labor and instrumentation resources, and provide the most efficient placement of staff throughout the process.
- determine the number of centers and number of shifts needed to complete the screening for the affected population.
- determine the best operations performance under a given resource limitation (e.g., limited radiation survey meters, limited personnel).
- conduct virtual drills and design emergency exercises with a variety of screening scenarios.

More information about RealOpt-CRC and instructions for using the program can be found online at: http://emergency.cdc.gov/radiation/crc/simulation.asp.



[41] RealOpt-CRC can be accessed at http://emergency.cdc.gov/radiation/crc/simulation.asp.

# APPENDIX H: SAMPLE COMMUNITY RECEPTION CENTER STAFFING PLAN

# Appendix H

## Sample Community Reception Center Staffing Plan

Community Reception Centers (CRCs) must have sufficient staff, both technical and nontechnical, to manage the centers for several days or weeks. Each CRC must have staff members and equipment capable of

- detecting contamination through beta/gamma portal monitors.
- monitoring for general contamination using handheld radiation survey meters.
- fielding questions and addressing all concerns.
- distributing incident and follow-up information.

Technical staff members who are competent in the use of radiation survey meters must be available for monitoring. Additional staff will be necessary for processing and decontamination. One or more clinicians will likely be needed at each CRC to provide medical assessments and refer those who need it for additional medical care.

Many community public health departments have established relationships with local Medical Reserve Corps (MRC) units. The MRC is comprised of both medical and nonmedical volunteers capable of providing assistance during public health emergencies.[42] MRC volunteers are usually trained to staff PODs, and they can also assist with staffing CRCs. It is prudent for MRC units to also recruit health physicists or other radiation safety professionals as volunteers.

The *Planning Guidance for Response to a Nuclear Detonation* recommends that planners should identify radiation protection professionals in their community and encourage them to volunteer and register in a local or state health volunteer program.[43] Through a program administered by the Conference of Radiation Control Program Directors, Inc. (CRCPD), a number of states have established a Radiation Response Volunteer Corps (RRVC) to assist local responders with population monitoring and public shelter operations.[44] The RRVC units work closely with the state health volunteer programs.

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### *An Example*

Consider the following staffing needs for each shift. For certain positions (e.g., contamination screening staff), consider shorter (4–6 hour) shifts to minimize physical and mental fatigue. The following staffing and equipment requirements were developed using CRC-STEP (see Appendix G) and are recommended for processing 350 people per hour. The staffing table does not include CRC

[42] For more information on the Medical Reserve Corps, see www.medicalreservecorps.gov/HomePage. For information on POD operations, see *Point of Dispensing (POD) Operations Manual*, Philadelphia Department of Public Health, Division of Disease Control, Emergency Preparedness and Bioterrorism Program, 2008, available at www.naccho.org/toolbox/_toolbox/POD%20operations%20manual_1.pdf. Also see archived CDC Webcasts, *Mass Antibiotic Dispensing: Streamlining POD Design and Operations*, available at http://www2a.cdc.gov/tceonline/registration/detailpage.asp?res_id=1863, and *Mass Antibiotic Dispensing: Taking the Guesswork out of POD Design*, available at http://www2a.cdc.gov/tceonline/registration/detailpage.asp?res_id=1518.

[43] Homeland Security Council (HSC) Interagency Policy Coordination Subcommittee for Preparedness & Response to Radiological and Nuclear Threats (SubIPC). *Planning Guidance for Response to a Nuclear Detonation*: Second Edition. June 2010. Washington, D.C.

[44] Conference of Radiation Control Program Directors, Inc. (CRCPD). *A Plan for Incorporating Local Volunteer Radiation Professionals into Existing Health Volunteer Programs to Assist in Population Monitoring*. March 2011, available at www.crcpd.org/Homeland_Security/RRVC_FinalReport.pdf.

management or incident command staff, and the simulation assumes registration staff can accommodate two concurrent registrations at a time.

**Table 3: CRC Staffing Chart**

| Name | Staff |
|---|---|
| Initial Sorting Staff | 10 |
| Contamination Screening Staff | 14 |
| Wash Staff | 10 |
| Registration Staff | 21 |
| Radiation Dose Assessment Staff | 5 |
| Discharge Staff | 5 |
| **TOTAL** | **65** |

This simulation assumes 10% of the people arriving at the CRC are contaminated and that staff are equipped with adequate contamination screening and decontamination resources, as listed in Table 4. Each CRC should have protocols in place for transporting patients in need of urgent medical care to hospitals or alternate care sites. In addition, it is prudent to plan for buses and bus drivers who can provide transportation on a priority schedule to and from the CRCs for those who need such transportation.

**Table 4: CRC Equipment Resources**

| Equipment | Purpose | Location | Number |
|---|---|---|---|
| Alarming Dosimeters | High Contamination Screening | Initial Sorting | 10<br>(1 per staff) |
| Handheld Radiation Survey Meters | Partial-Body Contamination Screening | Contamination Screening | 4 |
| | Post-Decon Screening | Wash Station | 4 |
| Portal Monitors | Whole-Body Contamination Screening | Contamination Screening | 2 |
| Showers/Cleaning Stations | Decontamination | Wash Station | 6 |

### *Supplies*

The following list contains some suggested items that would be needed at a CRC. This is not intended to be a complete listing of all needed supplies.

#### *Contamination control supplies*

- Materials for constructing signs or instruction posters
- Barriers (stanchions and rope)
- Step-off pads (tacky mats)
- Plastic bags (variety of sizes)
- Butcher paper (or absorbent floor covering such as disposable painting drop cloths)
- Plastic sheeting

#### *Personal protective equipment (PPE)*

- Scrubs
- Coveralls (e.g., Tyvek®) or waterproof surgical gowns
- Plastic (vinyl, nitrile) examination gloves
- Disposable shoe covers
- Surgical masks
- N-95 masks
- Face shields
- Duct tape
- Masking tape

#### *Personal decontamination equipment*

- Moist towels or disposable wipes
- Paper towels
- Large plastic bags (a variety of sizes to hold clothing)
- Zipper-type bags for small personal items
- Adhesive labels
- Soap (mild)
- Shampoo (no conditioner)
- Baby shampoo
- Waterless hand cleaner
- Plastic sponges
- Soft nail brushes
- Towels
- Clothing items, such as coveralls or scrubs for people to wear as they exit showers (Various sizes are needed including very large and children's sizes.)
- Sanitary garments, such as diapers for children of various ages.
- Shoes, sandals, or shoe coverings
- Blankets or heaters for warmth (Note: Heaters should not blow air across a potentially contaminated area.)

### *Forms and telecommunications equipment*

- Informational fact sheets to distribute to people at the CRC
- Record forms
- Notebooks
- Telephones, cell phones, and fax machines
- Computers (laptops) and Internet connectivity (if possible)
- Photocopiers or scanners (Copying driver licenses or other forms of photo identification with current information may expedite the registry process.)

### *Sample collection*

- Appropriate administrative forms (e.g., consent forms)
- Urine sample collection kits
- Blood sample collection kits
- Chain-of-custody documentation

### *Radiation detection and measurement equipment*

Note: These instruments require periodic calibration and maintenance. For specific information on these instruments and their maintenance requirements, consult with health physics experts in your state radiation control program.

- Geiger-Mueller (GM) pancake survey meters
- Handheld alpha contamination monitors (only if alpha contamination is suspected)
- Beta/gamma portal monitors

### *Miscellaneous supplies*



- Large garbage bags
- 55-gallon waste drums
- Folding chairs (At various places in the facility, folding chairs should be available in temporary waiting areas. Some people, particularly the elderly, may find it difficult to stand for an hour or more until they get cleared through the monitoring process.)
- Drinking water
- First aid kits
- Defibrillator
- Portable toilet facilities (outside area only)
- Portable sinks or tubs (outside area only)

# APPENDIX I: PHARMACEUTICAL COUNTERMEASURES

# Appendix I

## Pharmaceutical Countermeasures

There are several drugs that can be used to treat patients who are internally contaminated with certain radionuclides or who are externally exposed to radiation.  The decision to administer such drugs is a medical one that must be made by appropriate medical authorities.  However, public health planners can benefit from a basic understanding of what these drugs can do and what their limitations are.

As part of the planning process, public health authorities should consult with other experts and evaluate the need, logistical requirements, and priority for administration of prophylactic or decorporation agents.  Most importantly, planners should review the decision-making process needed to make these clinical judgments in a mass casualty radiation emergency.

This appendix provides an overview of four (4) pharmaceutical radiation countermeasures:

- Potassium iodide
- Prussian blue
- DTPA[45] (calcium and zinc)
- Filgrastim (Neupogen®)

Potassium iodide (KI) is used to keep the thyroid from taking up radioactive iodine and must be taken before or immediately after exposure to radioactive iodine. KI is approved by the U.S. Food and Drug Administration (FDA) for this use.  Prussian blue and DTPA are used to treat internal contamination and are approved by the FDA for this use.  Filgrastim can be used to treat acute radiation syndrome (ARS).  Although this drug is commonly used to treat patients undergoing radiotherapy and chemotherapy procedures, its use to treat ARS patients is not yet approved by the FDA.

For more detailed descriptions of these drugs, dosing requirements, and other clinical information and related fact sheets, you may refer to the following websites:

- U.S. Food and Drug Administration:
  http://www.fda.gov/Drugs/EmergencyPreparedness/BioterrorismandDrugPreparedness/ucm063807.htm
- Radiation Emergency Medical Management (REMM) – Guidance on Diagnosis and Treatment for Healthcare Providers
  www.remm.nlm.gov/
- U.S. Centers for Disease Control and Prevention:
  http://emergency.cdc.gov/radiation/
- REAC/TS
  http://orise.orau.gov/reacts/

In addition, the National Council on Radiation Protection and Measurements (NCRP) has published an authoritative report on medical management of internal contamination.[46]  This NCRP report includes prophylaxis and decorporation therapy recommendations for an extended list of radionuclides.

[45] Diethylenetriamene pentaacetate.

[46] NCRP (2008). National Council on Radiation Protection and Measurements, *Management of Persons Accidentally Contaminated with Radionuclides,* Report No. 165, December 2008.

### *Potassium Iodide (KI)*

KI is a prophylactic or blocking agent that comes in the form of a tablet. It protects the thyroid gland against absorption of radioactive iodine. It is important to note that KI can be effective only when radioactive iodine is a contaminant of concern. It offers no protection for other radionuclides. It also does not protect against external exposure to radiation, even that from radioactive iodine.

There is a finite period of time immediately before and after inhaling or ingesting radioactive iodine during which KI can be effective. Often, the best measure of protection is to avoid the radioactive material in the first place. Protective measures that public health authorities may recommend include evacuation or seeking shelter. When it is warranted, they may advise against consumption of milk or other food products that could be contaminated with radioactive iodine. KI is usually regarded as a potential *supplementary* measure of protection, not a primary one, even in cases of radioactive iodine contamination.

Public health officials in states with operating nuclear power plants and communities surrounding nuclear power plants are already familiar with KI and its potential use in case of an off-site release of radioactive iodine from the power plants. Planners in states without nuclear power plants can consult colleagues in other states about how to incorporate KI in their emergency plans. The National Academy of Sciences has published guidance for the distribution of KI in a nuclear incident.[47]

### *Prussian Blue*

Prussian blue is used to treat people internally contaminated with radioactive cesium and thallium.[48] It binds to radioactive cesium or thallium in the gut and speeds up its excretion from the body through feces. Prussian blue is administered orally and comes in the form of a capsule.

Prussian blue is not effective for radionuclides other than cesium or thallium. It also does not protect against external radiation, including radiation from cesium and thallium.

Prussian blue is technically a dye, and some formulations have industrial or artistic applications in the form of paint, dye, or stain. For administrating to people, use only the FDA-approved formulations.



### *DTPA*

DTPA is used to treat people internally contaminated with plutonium, americium, and/or curium. It acts by chelating (or binding) these radionuclides in the blood stream and speeding up their excretion from the body through urine. Although an oral formulation of DTPA is under development, the only formulation available at this time needs to be administered by intravenous injection. Therefore, providing this drug to a large number of contaminated or presumptively contaminated people may present logistical challenges, especially in a resource-depleted environment.

DTPA comes in two forms: calcium (Ca-DTPA) and zinc (Zn-DTPA). When given within the first day after internal contamination has occurred, Ca-DTPA is about 10 times more effective than Zn-DTPA at chelating plutonium, americium, and curium. After 24 hours have passed, Ca-DTPA and Zn-DTPA are equally effective in chelating these radioactive materials. As is usual with these types of drugs, there are additional considerations for children and pregnant or breastfeeding women.

Chelating agents work best when given shortly after radioactive materials have entered the body. The more quickly the radioactive material is removed from the body, the fewer and less serious the

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[47] *Distribution and Administration of Potassium Iodide in the Event of a Nuclear Incident*, National Academies Press, 2004, available at http://books.nap.edu/catalog.php?record_id=10868.

[48] Prussian blue has also been used to treat contamination with nonradioactive thallium (once an ingredient of rat poison).

health effects will be.  After 24 hours, plutonium, americium, and curium are more difficult to chelate.  However, DTPA can still work to remove these radioactive materials from the body several days or even weeks after a person has been internally contaminated.

DTPA does not protect against external radiation, including that from plutonium, americium, and curium.

### *Filgrastim (Neupogen®)*

This drug is different from the previous three drugs in that it is not used to treat internal contamination with any radionuclide.  Filgrastim belongs to a class of drugs known as colony stimulating factors, or CSF, and it is used to treat an adverse effect of acute radiation syndrome—bone marrow suppression.  This is a condition in which the body is not producing enough blood cells (red cells, white cells, and platelets). A low white blood cell count makes people susceptible to infections.

Filgrastim can stimulate the bone marrow to produce more white blood cells.  It is administered intravenously.

Public health officials should know that although Filgrastim is stored in the Strategic National Stockpile for this purpose, it has not been approved by the FDA for the treatment of bone marrow suppression following acute radiation exposure.  Filgrastim could be administered to victims of acute radiation syndrome if an Emergency Use Authorization is issued by the FDA.[49]

None of these pharmaceutical countermeasures are needed for low levels of exposure to radiation or low levels of internal contamination.  When the amount of internal contamination is deemed medically significant (see Appendix E), medical treatment is considered.  The estimation of the levels of exposure or contamination is made by the appropriate radiation protection and control authority.  The decision whether to treat people with any of these pharmaceutical countermeasures needs to be made only by appropriate medical authorities.

In the aftermath of a nuclear or radiological incident, the emphasis should be on minimizing public exposure to radiation and minimizing the chances of radionuclides entering the body by providing timely and appropriate recommendations for protective actions the public can take.  When prevention of exposure or contamination is possible, the need for pharmaceutical countermeasures can potentially be avoided.

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[49] For more information on the FDA's Emergency Use Authorization of medical products, see www.fda.gov/RegulatoryInformation/Guidances/ucm125127.htm.

# APPENDIX J: ADDITIONAL RESOURCES

# Appendix J

## Additional Resources

This resource list is not intended to be all-inclusive. A number of websites are identified that may be helpful to public health planners as they address the issue of population monitoring in their communities:

**Centers for Disease Control and Prevention (CDC)**

http://emergency.cdc.gov/radiation

770-488-3800 (for questions about this guide)

770-488-7100 (for emergencies only)

**ATSDR Rapid Response Registry**

http://www.atsdr.cdc.gov/rapidresponse/

**U.S. Department of Health and Human Services, Office of the Assistant Secretary for Preparedness and Response (ASPR)**

http://www.phe.gov/preparedness/pages/default.aspx

**U.S. Environmental Protection Agency.**

http://www.epa.gov/radiation/index.html

**U.S. Food and Drug Administration (FDA)**

http://www.fda.gov/Drugs/EmergencyPreparedness/BioterrorismandDrugPreparedness/ucm063807.htm

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**Conference of Radiation Control Program Directors, Inc. (CRCPD)**

http://www.crcpd.org/

To identify the radiation control authority in your state, contact CRCPD at 502-227-4543 or visit:

http://www.crcpd.org/Map/default.aspx.

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

http://orise.orau.gov/reacts/default.aspx

865-576-3131

865-576-1005 (after hours)

### Radiation Emergency Medical Management (REMM)

http://www.remm.nlm.gov/

### Responder Knowledge Base (RKB)

RKB is a Web-based information service for the emergency responder community funded by the U.S. Department of Homeland Security (DHS).

https://www.llis.dhs.gov/knowledgebase

### National Alliance for Radiation Readiness (NARR)

The NARR is an interagency collaboration among key stakeholders in public health preparedness, radiation control, and emergency management that maintains a clearing house of documents and resources used in radiation emergency planning and exercises.

http://www.radiationready.org