Bioterrorism and Weapons of Mass Destruction

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Contact hours: 4

Course price: $35

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Course Summary

Defines terrorism, bioterrorism, and weapons of mass destruction and summarizes the diseases and agents most commonly used as chemical, biologic, radiologic, and nuclear weapons. Outlines CDC recommendations and best practices.

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Course Objectives

When you finish this course you will be able to:

- Define terrorism, bioterrorism, and weapons of mass destruction (WMD) and list four main types of WMD.
- For a chemical weapons event, summarize the agents most commonly used, the epidemiologic clues to and symptoms of a chemical release, and the appropriate first-receiver actions.
- For a bioterrorism event, outline the CDC's three categories of agents, the clinical features of high-priority agents, and the best practices and reporting procedures for first receivers.
- Describe the clinical features and treatment of exposure or injury from radiation, including acute radiation syndrome (ARS), and demonstrate ways to protect staff and patients during a radiation incident.

Defining Terrorism, Bioterrorism, and WMD

Terrorism and Bioterrorism

The Federal Bureau of Investigation (FBI) uses a definition of terrorism that includes "the unlawful use of force and violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives" (28 C.F.R. Section 0.85).

From the Centers for Disease Control and Prevention (CDC) comes a comprehensive definition of bioterrorism:

> A bioterrorism attack is the deliberate release of viruses, bacteria, or other germs (agents) used to cause illness or death in people, animals, or plants. These agents are typically found in nature, but it is possible that they could be changed to increase their ability to cause disease, make them resistant to current medicines, or to increase their ability to be spread into the environment. Biological agents can be spread through the air, through water, or in food. Terrorists may use biological agents because they can be extremely difficult to detect and do not cause illness for several hours to several days. Some bioterrorism agents, like the smallpox virus, can be spread from person to person and some, like anthrax, can not. (CDC, 2007).

While the use of violence lies at the heart of most definitions of terrorism, arriving at a more nuanced definition often depends on the political, ethnic, or religious perspective of those doing the defining. In addition, terrorism is sometimes categorized as either "domestic" or "international," referring not to where the terrorist act takes place, but to the origin of the individuals or groups responsible for it. For healthcare professionals facing the medical consequences of such an act, this distinction may not seem particularly relevant.

There is much debate over the motivations for terrorism. They have traditionally been thought to reflect religious, political, or ideological beliefs, and the targets of attacks to be symbolic in some way. Sparking fear in victims and the wider public is often an element of motivation. Recent research suggests motivations may include a personal desire on the part of perpetrators to further their membership in the terrorist community and can be affected by various internal structural issues within terrorist groups (Abrahms, 2015, 2008). However, the bottom line for healthcare professionals is that debates over definitions, motivations, and other factors are not necessarily relevant to understanding how to care for victims of terrorist acts.

Terrorist acts have occurred throughout history, but after the Oklahoma City bombing in 1995 and the events of September 11, 2001 in the United States, such behavior became an ongoing element of the public consciousness. Acts of terrorism and the means by which they might be carried out are of special concern to healthcare professionals, who would be called upon to treat people following a terrorist attack. In fact, several states have mandated training for nurses and other healthcare professionals to ensure they have a basic knowledge of potential terrorist threats and how to respond to them.

Man covered with ashes assisting a woman who is holding a particle mask to her face following the September 11 terrorist attack on the World Trade Center, New York City. Photographer: Don Halasy. Source: Wikimedia Commons.

The effects of terrorist acts are not only physical, and fear may loom large among citizens. Healthcare workers need to be prepared to address this fear, even in patients who have sustained little or no physical injury. Additional psychological effects are recognized consequences of certain types of injuries and will be discussed in the sections that follow.

The U.S. government was already actively working to combat terrorist threats before September 11, 2001, and has since stepped up its efforts. For the general public and for healthcare workers, education about the proper responses to terrorist activities, along with thorough emergency preparedness, are the best available defense. Absent shocking new events close to home, it can be tempting to relegate emergency preparedness for terroristic events to the back of the mind, but all sorts of things can happen, both small and large, that would require quick thinking and proper training.

Events since 2001 have resulted in a large body of useful information and many resources for individuals and organizations seeking to educate and prepare themselves. The changing nature of the Internet means that some of these resources may come and go, but websites maintained by the Department of Homeland Security, the Department of Health and Human Services (DHHS), and the CDC remain up-to-date and valuable resources for individuals and institutions. (See Resources at the end of this course for relevant links.)

Weapons of Mass Destruction

Weapons of mass destruction (WMD) is a term that has become increasingly familiar through its use in the media. Not everyone means precisely the same thing when they use the term, but the definition used by the U.S. military may be the simplest and most generally understood. WMD are:

> . . .chemical, biological, radiological, or nuclear weapons capable of a high order of destruction or causing mass casualties. (DOD, 2010/2015)

The possibility that terrorists might resort to the use of WMD is of grave concern. The types of WMD vary in their ability to cause damage, in their ease of production and use, in the kinds of physical and human damage they can be expected to cause, and in their likelihood of use by terrorist organizations.

Chemical and Biological Weapons

Chemical weapons use the toxic properties of chemicals to cause harm, up to and including death. Only a relatively small amount of a chemical agent is needed to produce significant physical and psychological effects. Historically, chemical weapons have been the most widely used and proliferated type of WMD, but they receive far less attention than do biological and nuclear weapons (NTI, 2015b).

Biological weapons utilize microorganisms and natural toxins to produce disease in humans, animals, or plants, and "gram for gram. . . are the deadliest weapons ever produced." Derived from a variety of sources, these compounds, when paired with a delivery system, become weapons. The potential danger of a given weapon is measured by its lethality, or how effectively it kills; its infectivity, or how easily it spreads; and its virulence, or how likely it is to cause disease. Other important considerations include how easily is it dispersed, whether it can be treated medically, whether there is a vaccine, what dose is needed to cause disease, and how stable the compound is (NTI, 2015a).

Chemical and biological weapons are financially and logistically easier to acquire than radiologic or nuclear weapons. They will cause more casualties and have a greater psychological impact than conventional weapons, but cause less destruction than devices involving radiation. Chemical weapons are somewhat easier than other weapons for terrorist groups (or even individuals) to manufacture because the manufacturing knowledge is readily available, many precursor chemicals have legitimate uses and are thus legally available, there is poor security around these chemicals in some countries, and small chemical manufacturing equipment is commonly available.

Radiologic and Nuclear Weapons

Radiologic and nuclear weapons rely on the same sources for damage—explosive power and radiation—but there is a distinction in their forms. In addition, true nuclear weapons produce tremendous heat, which can cause burns and start fires. In the last fifty years, most radiation injuries have been the result of accidents; however, the intentional deployment of a nuclear or radiologic device is a potential terrorist threat.

Modern nuclear threats can be divided into five general categories:

- An attack on nuclear power plants
- A malevolent act using simple radiologic devices
- Terrorist use of a radiologic dispersal device
- Detonation of an improvised nuclear device
- Detonation of a sophisticated nuclear weapon (Waselenko et al., 2004)

Both radiologic and nuclear devices can damage and contaminate. Incidents involving simple devices and radiological dispersal devices (RDDs)—any device that causes intentional dissemination of radioactive material without a nuclear detonation—would probably cause a limited number of casualties; however, those involving improvised nuclear devices and small nuclear weapons would result in mass casualties (ORISE, 2013; Waselenko et al., 2004; CISAC, n.d.-a).

Radiologic dispersal devices—commonly known as dirty bombs—are seen as more likely to be used by terrorists. These devices require little more skill than is needed to make a conventional bomb and their components are easier to acquire. RDDs utilize conventional explosives to disperse a radioactive material packaged in the device, as opposed to a nuclear device, which creates radiation with its explosion.

While it is unlikely that many people would die from radiation poisoning as a result of the explosion of an RDD, there would be some deaths and injuries and the costs of cleanup could be considerable. These devices are attractive to some groups because they are relatively easy to create and they will not generally do a great deal of damage, but they will play on the heightened fear of radiation among the general public to cause widespread panic and disruption, which is often a group’s real goal. Because of this, public education and good response preparation are important counter measures (CISAC, n.d.-a; NTI, 2015c,d; ORISE, 2013).

Nuclear weapons present significantly higher obstacles in terms of the skill needed to produce them and the financial and logistical support needed to acquire materials, prepare the device, and transport it (Weiss, 2015). However, the potential for damage, injuries, and death is much higher because they are significantly more powerful weapons.

Chemical Terrorism

Modern chemical warfare can be traced to World Wars I and II. Since then, there has been research and stockpiling of chemicals by many countries but mutual deterrence has generally prevailed. A modern exception was the use of chemical weapons in 2013 by Syrian president Bashar al-Assad against Syrian citizens who were rebelling against his autocratic government. Through intense negotiating, the United Nations was able to persuade Assad to allow outsiders to come into Syria and remove or destroy the chemical weapons he had stockpiled and by 2014 they had been reported destroyed or removed.

The techniques for making very destructive chemical weapons are well understood and the necessary equipment is commonly available. Once made, weapons can be easily concealed. In 1995 a Japanese cult group known as Aum Shinrikyo made and dispersed the nerve agent sarin several times in the Tokyo subway, killing twelve people on one occasion. These incidents made it clear that even small groups could manage the manufacture and dispersal of deadly chemical weapons (NTI, 2015b).

Chemical Weapons

Chemical weapons agents are classified as either nonpersistent or persistent. Nonpersistent agents dissipate within a few hours and are most threatening to the lungs. Persistent agents may take up to one month to dissipate if they have been deposited on soil, vegetation, or objects. They are most threatening to the skin.

Scientists often categorize hazardous chemicals by the type of chemical or by the effects a chemical would have on people exposed to it. The categories/types used by CDC are as follows:

Biotoxins

Poisons that come from plants or animals

- Abrin, Brevetoxin, Colchicine
- Digitalis
- Nicotine
- Ricin
- Saxitoxin
- Strychnine
- Tetrodotoxin, Trichothecene

Blister Agents/Vesicants

Chemicals that severely blister the eyes, respiratory tract, and skin on contact

- Mustards
  - Mustard gas (H) (sulfur mustard)
  - Mustard/lewisite (HL)
  - Nitrogen mustard (HN-1, HN-2, HN-3)
  - Sesqui mustard
  - Sulfur mustard (H) (mustard gas)
- Lewisites/chloroarsine agents
  - Lewisite (L, L-1, L-2, L-3)
  - Mustard/lewisite (HL)
- Phosgene oxime (CX)

Blood Agents

Poisons that affect the body by being absorbed into the blood

- Arsine (SA)
- Carbon Monoxide
- Cyanide
  - Cyanogen chloride (CK)
  - Hydrogen cyanide (AC)
  - Potassium cyanide (KCN)
  - Sodium cyanide (NaCN)
- Sodium monofluoroacetate (compound 1080)

Caustics (Acids)

Chemicals that burn or corrode people's skin, eyes, and mucus membranes (lining of the nose, mouth, throat, and lungs) on contact

- Hydrofluoric acid (hydrogen fluoride)
- Hydrogen chloride

Choking/Lung/Pulmonary Agents

Chemicals that cause severe irritation or swelling of the respiratory tract (lining of the nose, throat, and lungs)

- Ammonia

- Bromine (CA)
- Chlorine (CL)
- Hydrogen chloride
- Methyl bromide
- Methyl isocyanate
- Osmium tetroxide
- Phosgene
  - Diphosgene (DP)
  - Phosgene (CG)
- Phosphine
- Phosphorus, elemental, white or yellow
- Sulfuryl fluoride

Incapacitating Agents

Drugs that make people unable to think clearly or that cause an altered state of consciousness (possibly unconsciousness)

- BZ
- Fentanyls and other opioids

Long-Acting Anticoagulants

Poisons that prevent blood from clotting properly, which can lead to uncontrolled bleeding

- Super warfarin

Metals

Agents that consist of metallic poisons

- Arsenic
- Barium
- Mercury
- Thallium

Nerve Agents

Highly poisonous chemicals that work by preventing the nervous system from working properly

- G agents
  - Sarin (GB)
  - Soman (GD)
  - Tabun (GA)
- V agents
  - VX

Organic Solvents

Agents that damage the tissues of living things by dissolving fats and oils

- Benzene

Riot Control Agents/Tear Gas

Highly irritating agents normally used by law enforcement for crowd control or by individuals for protection (for example, mace)

- Bromobenzylcyanide (CA)
- Chloroacetophenone (CN)
- Chlorobenzylidenemalononitrile (CS)
- Chloropicrin (PS)
- Dibenzoxazepine (CR)

Toxic Alcohols

Poisonous alcohols that can damage the heart, kidneys, and nervous system

- Ethylene glycol

Vomiting Agents

Chemicals that cause nausea and vomiting

- Adamsite (DM) (CDC, 2013)

Covert Chemical Release

Since September 11, 2001, concern has increased about potential terrorist attacks involving the use of chemical agents. In addition, recent cases involving intentional or inadvertent contamination of food with chemicals have highlighted the need for healthcare providers and public health officials to be alert for patients in their communities who have signs and symptoms consistent with chemical exposures (CDC, 2003).

Intentional release of chemical agents may be an overt event, one whose nature reveals itself, such as release of a nerve agent in a subway or a large explosion of a chemical container. On the other hand, a chemical release might be a covert event, an unrecognized release in which the presence of sick people could be the first sign of an exposure; this could include deliberate contamination of food, water, or a consumer product.

To increase the likelihood that healthcare providers recognize a chemical release-related illness, and that public health authorities will implement the appropriate emergency response and public health actions, the CDC has identified examples of chemical-induced illness (see table below under "Identifying Chemical Agents") and created appropriate guidance for healthcare providers and public health personnel (CDC, 2003).

The CDC recognizes that the covert release of a chemical agent might not be easily identified, for at least five reasons:

1. Symptoms of exposure to some chemical agents (eg, ricin) might be similar to those of common diseases (eg, gastroenteritis).
2. Immediate symptoms of certain chemical exposures might be nonexistent or mild despite the risk for long-term effects (eg, neurocognitive impairment from dimethyl mercury, teratogenicity from isotretinoin, or cancer from aflatoxin).
3. Exposure to contaminated food, water, or consumer products might result in reports of illness to healthcare providers over a long period and in various locations.
4. People exposed to two or more agents might have symptoms not suggestive of any one chemical agent (ie, a mixed clinical presentation).
5. Healthcare providers might be less familiar with clinical presentations suggesting exposure to chemical agents than they are with illnesses that are treated frequently (CDC, 2003).

Epidemiologic Clues

Identifying a covert release of a chemical agent may depend on alert healthcare professionals as they begin to see victims of the release. First receivers (eg, hospital-based emergency staff), may be in the best position to observe epidemiologic clues that suggest such a release. These clues include:

1. An unusual increase in the number of patients seeking care for potential chemical release-related illness
2. Unexplained deaths among young or healthy persons
3. Emission of unexplained odors by patients

4. Clusters of illness in persons who have common characteristics, such as drinking water from the same source
5. Rapid onset of symptoms after an exposure to a potentially contaminated medium (eg, parasthesias and vomiting within minutes of eating a meal)
6. Unexplained death of plants, fish, or animals (domestic or wild)
7. A syndrome (ie, a constellation of clinical signs and symptoms in patients) suggesting a disease associated commonly with a known chemical exposure (eg, neurologic signs or pinpoint pupils in eyes of patients with a gastroenteritis-like syndrome or acidosis in patients with altered mental status) (CDC, 2003)

Identifying Chemical Agents

Because various chemical agents could be used as covert weapons, the actual clinical syndrome varies depending on the type of agent, the amount and concentration of the chemical, and the route of the exposure. However, some clinical presentations may be more common with a covert chemical release. Certain syndromes are associated with groups of chemical agents with similar toxic properties that have been used previously, have high toxicity, or are easily available (see table) (CDC, 2003).

Clinical Syndromes and Potential Chemical Etiologies*		
Category	Clinical syndrome	Potential chemical etiology
Cholinergic crisis	▪ Salivation, diarrhea, lacrimation, bronchorrhea, diaphoresis, and/or urination ▪ Miosis, fasciculations, weakness, bradycardia or tachycardia, hypotension or hypertension, altered mental status, and/or seizures	▪ Nicotine** ▪ Organophosphate insecticides**—decreased acetylcholinesterase activity ▪ Carbamate insecticides ▪ Medicinal carbamates (eg, physostigmine)
▪ Generalized muscle rigidity	▪ Seizure-like, generalized muscle contractions or painful spasms (neck and limbs) and, usually, tachycardia and hypertension	▪ Strychnine—intact sensorium
Oropharyngeal pain and ulcerations	▪ Lip, mouth, and pharyngeal ulcerations and burning pain	▪ Paraquat**—dyspnea and hemoptysis secondary to pulmonary edema or hemorrhage; can progress to pulmonary fibrosis over days to weeks ▪ Diquat ▪ Caustics (acids, alkalis) ▪ Inorganic mercuric salts ▪ Mustards (sulfur)

Clinical Syndromes and Potential Chemical Etiologies*		
Category	Clinical syndrome	Potential chemical etiology
Cellular hypoxia	▪ Mild: nausea, vomiting, and headache ▪ Severe: altered mental status, dyspnea, hypotension, seizures, and metabolic acidosis	▪ Cyanide** (hydrogen cyanide gas, sodium cyanide)—bitter almond odor*** ▪ Sodium monofluoroacetate (SMFA)**—hypocalcemia or hypokalemia ▪ Carbon monoxide ▪ Hydrogen sulfide ▪ Sodium azide ▪ Methemoglobin-causing agents
Peripheral neuropathy and/or neurocognitive effects	▪ Peripheral neuropathy signs and symptoms: muscle weakness and atrophy, "glove and stocking" sensory loss, and depressed or absent deep-tendon reflexes ▪ Neurocognitive effects: memory loss, delirium, ataxia, and/or encephalopathy	▪ Mercury (organic)**—visual disturbances, paresthesias, and/or ataxia ▪ Arsenic (inorganic)**—delirium and/or peripheral neuropathy ▪ Thallium—delirium and/or peripheral neuropathy ▪ Lead—encephalopathy ▪ Acrylamide—encephalopathy and/or peripheral neuropathy
Severe gastrointestinal illness, dehydration	▪ Abdominal pain, vomiting, profuse diarrhea (possibly bloody), and hypotension, possibly followed by multisystem organ failure	▪ Arsenic** ▪ Ricin**—inhalation an additional route of exposure; severe respiratory illness possible ▪ Colchicine ▪ Barium—hypokalemia common

*Not intended as a complete differential diagnosis for each syndrome or as a list of all chemicals that might be used in a covert chemical release.
**Potential agents for a covert chemical release based on historic use (ie, intentional or inadvertent use), high toxicity, and/or ease of availability.
***Unreliable sign.
Source: CDC, 2003.

As noted above, it is likely that a covert chemical release would be first recognized by healthcare providers, public health agencies, and poison control centers as they become aware of patterns while assessing illness and treating patients. Familiarity of healthcare professionals with the general characteristics of a covert chemical release, plus recognition of epidemiologic clues and related clinical syndromes, could reduce morbidity and mortality as these workers implement the appropriate emergency response.

Public health agencies and healthcare providers might render the most appropriate, timely, and clinically relevant treatment possible by using treatment modalities based on syndromic categories (eg, burns, respiratory depression, neurologic damage, shock). Because of the hundreds of new chemicals introduced globally each month, it is more pragmatic to treat exposed persons by clinical syndrome rather than specific agent (CDC, 2003; CDC, 2000).

Recognizing Specific Chemical Agents

The Centers for Disease Control and Prevention (CDC) provide many reference materials for recognizing and treating the effects of all types of chemical compounds. These include "reference cards" for dozens of individual chemical compounds that outline essential information for emergency and hospital personnel, including the type of personal protective clothing and equipment needed when treating victims. While personal protective equipment and clothing is necessary for treating virtually anyone who has been exposed to a chemical agent, specifics vary according to the agent involved. It is critical to have this information on hand and for staff to be trained to consult it.

Following are the CDC guidelines for two of the common categories of chemical agents—vesicants and nerve agents. These guidelines provide information on recognizing signs and symptoms, initial treatment, and alternative diagnoses. Remember that the details will differ for other agents and you should always know how to access reference materials quickly at your facility.

Vesicant (Blister Agent) Poisoning

Vesicants, also referred to as "blister agents," were the most commonly used chemical warfare agents during World War I. Likely routes of exposure are inhalation, dermal contact, and ocular contact. Vesicants are highly reactive chemicals that combine with proteins, DNA, and other cellular components to result in cellular changes immediately after exposure.

Depending on the vesicant, clinical effects may occur immediately (as with phosgene oxime, lewisite) or may be delayed for 2 to 24 hours (as with mustards). Following exposure, the most commonly encountered clinical effects include dermal (skin erythema, blistering), respiratory (pharyngitis, cough, dyspnea), ocular (conjunctivitis, burns), and gastrointestinal (nausea, vomiting).

The amount and route of exposure to the vesicant, the type of vesicant, and the premorbid condition of the person exposed contribute to the time of onset and the severity of illness. For example, ingestion of a vesicant leads to gastrointestinal symptoms more prominent than those that would result from inhalation exposure to the same dose and type of vesicant (CDC, 2013ca).

Signs and Symptoms

The following is a more comprehensive list of signs and symptoms that may be encountered in a person exposed to a vesicant. Signs and symptoms are not listed in order of presentation or specificity. Also, partial presentations (an absence of some of the following signs/symptoms) do not necessarily imply less severe disease.

Respiratory signs and symptoms include:

- Chest tightness
- Clear rhinorrhea
- Cough
- Dyspnea (shortness of breath)
- Hemoptysis
- Nasal irritation/pain
- Sore throat
- Tachypnea

Dermal signs and symptoms include:

- Blisters (within 1 hour with phosgene oxime, delayed for 2 to 12 hours with lewisite, delayed for 2 to 24 hours with mustards)
- Erythema (immediate with lewisite and phosgene oxime, may be delayed for 2 to 24 hours with mustards)
- Immediate blanching (phosgene oxime)
- Itching
- Necrosis and eschar (over a period of 7 to 10 days)

Ocular signs and symptoms include:

- Blindness
- Blurred vision
- Corneal ulceration
- Conjunctivitis
- Eyelid edema
- Eye pain/burning
- Lacrimation
- Photophobia

Cardiovascular signs include:

- Atrioventricular block and cardiac arrest (with high-dose exposure)
- Hypotension (with high-dose exposure to lewisite)

Gastrointestinal signs and symptoms (prominent if ingestion is a route of exposure) include:

- Abdominal pain
- Diarrhea (sometimes bloody)
- Hematemesis
- Nausea and vomiting

Central nervous system signs and symptoms (with exposure to high doses) include:

- Ataxia
- Coma
- Convulsions
- Tremors

Hematological signs and symptoms:

- Anemia
- Bleeding/hemorrhage
- Bone marrow suppression
- Increased susceptibility to infection
- Leukocytopenia

- Thrombocytopenia (CDC, 2013ca)

Laboratory Findings

Although it is a nonspecific finding, leukopenia can indicate vesicant exposure. It usually begins 3 to 5 days after exposure. With a white blood cell count <500, the prognosis is poor.

Differential Diagnosis

- Barbiturates
- Bullous pemphigoid
- Chemotherapeutic agents
- Carbon monoxide
- Other chemical burns (eg, with strong acids, bases, corrosives)
- Pemphigus vulgaris
- Stevens-Johnson syndrome
- Staphylococcus scalded skin syndrome
- Toxic epidermal necrolysis

Note: The actual clinical manifestations of a vesicant exposure may be more variable than the syndrome described above (CDC, 2013ca).

Nerve Agents and Organophosphate (OP) Pesticide Poisoning

Nerve agents are chemical warfare agents that have the same mechanism of action as organophosphate (OP) pesticides. They are potent inhibitors of acetylcholinesterase. Inhibition of acetylcholinesterase leads to an accumulation of acetylcholine in the central and peripheral nervous system. Excess acetylcholine produces a predictable cholinergic syndrome consisting of copious respiratory and oral secretions, diarrhea and vomiting, sweating, altered mental status, autonomic instability, and generalized weakness that can progress to paralysis and respiratory arrest.

The amount and route of exposure to the nerve agent or OP pesticide, the type of nerve agent or pesticide, and the premorbid condition of the exposed person contribute to the time of onset and the severity of illness. For example, inhalation of a nerve agent or an OP pesticide leads to a quicker onset of poisoning with more severe symptoms than dermal exposure, given the same amount of agent (CDC, 2013cb).

Signs and Symptoms

The following are more comprehensive lists of signs and symptoms that may be encountered in a person exposed to a nerve agent or OP pesticide. Signs and symptoms are not listed in order of presentation or specificity. Also, partial presentations (an absence of some of the following signs/symptoms) do not necessarily imply less severe disease.

Central nervous system signs and symptoms include:

- Miosis (unilateral or bilateral)
- Headache
- Restlessness
- Convulsions
- Loss of consciousness
- Coma

Respiratory signs and symptoms include:

- Rhinorrhea (perfuse watery runny nose)
- Bronchorrhea (excessive bronchial secretions)
- Wheezing
- Dyspnea (shortness of breath)
- Chest tightness
- Hyperpnea (increased respiratory rate/depth)—early
- Bradypnea (decreased respiratory rate)—late

Cardiovascular signs include:

- Tachycardia (increased heart rate)—early
- Hypertension (high blood pressure)—early
- Bradycardia (decreased heart rate)—late
- Hypotension (low blood pressure)—late
- Arrhythmias Dysrhythmias (prolonged QT on EKG, ventricular tachycardia)

Gastrointestinal signs and symptoms include:

- Abdominal pain
- Nausea and vomiting

- Diarrhea
- Urinary incontinence, frequency

Musculoskeletal signs and symptoms include:

- Weakness (may progress to paralysis)
- Fasciculations (local or generalized)

Skin and mucous membrane signs and symptoms include:

- Profuse sweating (local or generalized)
- Lacrimation (tear formation)
- Conjunctival injection

Laboratory Findings

- Decreased plasma or red blood cell (RBC) cholinesterase activity.

Limitations:

- Wide normal range for enzyme activity makes interpretation difficult without a baseline measurement.
- Cholinesterase activity correlates poorly with severity of local effects after vapor exposures.
- Plasma or RBC cholinesterase may be disproportionately inhibited depending on the particular nerve agent, amount of exposure, and time interval since exposure.

Interpreting cholinesterase activity:

Plasma Cholinesterase

- Usually declines faster than RBC cholinesterase
- Is easier to assay than RBC cholinesterase
- Regenerates faster than RBC cholinesterase
- May have a day-to-day variation in enzyme activity as high as 20%
- Is less specific than RBC cholinesterase
- Can show false depression from liver disease, malnutrition, pregnancy, genetic deficiency, or drugs (eg, codeine, morphine, cocaine, succinylcholine)

Red Blood Cell Cholinesterase

- Is a better reflection of CNS cholinesterase activity

- Is more specific test than plasma cholinesterase
- May have a day-to-day variation in enzyme activity as high as 10%
- Can show false depression from antimalarial therapy or pernicious anemia

Differential Diagnosis

- Carbamate insecticides
- Medicinal carbamates (eg, pyridostigmine, neostigmine, physostigmine)
- Cholinomimetic compounds (eg, pilocarpine, methacholine, bethanechol)
- Nicotine alkaloids (eg, nicotine, coniine)
- Muscarine-containing mushrooms
- Neuromuscular blocking drugs (eg, atracurium, vecuronium)

Note: The actual clinical manifestations of an exposure to a nerve agent or an OP pesticide may be more variable than the syndrome described in this document (CDC, 2013cb).

Biological Weapons

From a scientific and medical perspective, bioterrorism—using biological weapons to produce disease in humans—can be viewed as a variation of the problem of emerging infectious diseases, the only difference being that increased virulence or intentional release are deliberate acts. The United States public health system and primary healthcare providers must be prepared to address various biological agents, including pathogens that are rarely seen in this country.

Covert vs. Overt Bioterrorism

As with chemical agents, the intentional release of biological agents can be either covert or overt. A covert release is unannounced and hidden, and may go unnoticed for days or even weeks. The presence of ill individuals may be the first sign of a release, and those infected may have inadvertently infected others. An infected person may seek medical care anywhere within the healthcare system, possibly at a distance from the release area.

An overt release is immediately apparent and may even be announced. In an overt release, the healthcare system and public health officials may be overwhelmed by requests for information and treatment. Hospitals, clinics, emergency responders, and communication systems will be pressed into immediate service. An overt release has the potential to cause widespread panic.

Whether the release is covert or overt, healthcare providers should be alert to illness patterns and diagnostic clues that indicate an unusual infectious disease outbreak that could be associated with intentional release of a biological agent. In addition that should watch for increases in unexpected or unexplained illnesses and know how to activate the public health response system if an outbreak is suspected (CDC, 2001). Well-trained and educated first responders, first receivers, and public health personnel are essential to an organized and successful response.

Improving Response to Biologically Induced Illness

Healthcare providers, clinical laboratory personnel, infection control professionals, and public health departments play critical and complementary roles in the recognition and response to illness caused by the intentional release of biological agents. Syndrome descriptions, epidemiologic clues, and laboratory recommendations provide basic guidance that can improve recognition of these events (CDC, 2001).

Since 9/11, state and local health departments have initiated activities to improve recognition, reporting, and response, ranging from enhancing communications to conducting special surveillance projects. This includes active tracking for changes in the number of hospital admissions, emergency department visits, and occurrence of specific syndromes. Bioterrorism preparedness activities and work with emerging infectious diseases have helped public health agencies prepare for the intentional release of a biological agent (CDC, 2001). The CDC's Emergency Preparedness and Response website has links to and information on the various tools available, as well as other resources.

Recognizing Clinical Syndromes

Work continues on syndromic surveillance projects and the CDC maintains current data on this research. The term syndromic surveillance means watching for health-related data that signal sufficient probability of a case or an outbreak to warrant further public health response. Historically, syndromic surveillance was used in investigating potential cases, but its utility for detecting outbreaks associated with bioterrorism is increasingly being explored by public health officials. Technology changes and the plethora of programs and data have also affected these efforts (CDC, 2004b, 2012; Dembek, 2004). (See also the CDC resource website).

The release of a biological agent may not have an immediate impact because of the delay between exposure and onset of illness, and because outbreaks associated with intentional releases may resemble naturally occurring ones. Nevertheless, healthcare workers should be familiar with indications of intentional release of a biological agent and know when, and to whom, to report a suspected outbreak.

These indications include unusual clustering of illness, patients presenting with clinical signs and symptoms that suggest an infectious disease outbreak, unusual age distribution for common diseases, and a large number of cases of acute flaccid paralysis with prominent bulbar palsies, which is suggestive of a release of botulinum toxin (CDC, 2001).

Epidemiologic Clues That May Signal a Covert Bioterrorism Attack

- Large number of ill persons with similar disease or syndrome.
- Large number of unexplained disease, syndrome or deaths.
- Unusual illness in a population.
- Higher morbidity and mortality than expected with a common disease or syndrome.
- Failure of a common disease to respond to usual therapy.
- Single case of disease caused by an uncommon agent.
- Multiple unusual or unexplained disease entities coexisting in the same patient without other explanation.
- Disease with an unusual geographic or seasonal distribution.
- Multiple atypical presentations of disease agents.
- Similar genetic type among agents isolated from temporally or spatially distinct sources.
- Unusual, atypical, genetically engineered, or antiquated strain of agent.
- Endemic disease with unexplained increase in incidence.
- Simultaneous clusters of similar illness in non-contiguous areas, domestic or foreign.
- Atypical aerosol, food, or water transmission.
- Ill people presenting near the same time.
- Deaths or illness among animals that precedes or accompanies illness or death in humans.
- No illness in people not exposed to common ventilation systems, but illness among those people in proximity to the systems (CDC, 2001a)

As noted earlier, a variety of factors affect the potential public health impact of an intentionally released biological agent:

- Lethality—how effectively it kills
- Infectivity—how easily it spreads
- Virulence—how likely it is to cause disease

- How easily is it dispersed
- Availability of medical treatment and/or vaccine
- Dosage needed to cause disease
- Stability of the compound (NTI, 2015a)

It may be difficult to pinpoint the time and location of a biological agent's release because of the variation in incubation period among organisms. Some diseases show a rapid onset of symptoms and early treatment is critical. For example, plague has a rapid onset and is potentially fatal within 12 to 24 hours if untreated; botulism toxin also has a rapid onset and requires immediate supportive treatment. On the other hand, smallpox can be treated effectively by vaccination within 2 to 3 days of symptom onset. But smallpox, like plague, is highly contagious and has the potential to cause widespread panic, and in the case of smallpox, which is believed to have been eradicated, not enough vaccine exists should a widespread outbreak occur. Conversely, plague and anthrax, despite their potential for causing serious illness and death, are effectively treated with antibiotics.

Categories of Diseases and Biological Agents

Bioterrorism agents can be separated into three categories, depending on how easily they can be spread and the severity of illness or death they cause. Category A agents are considered the highest risk and Category C agents are those that are considered emerging threats for disease (CDC, 2007).

Category A Diseases or Agents

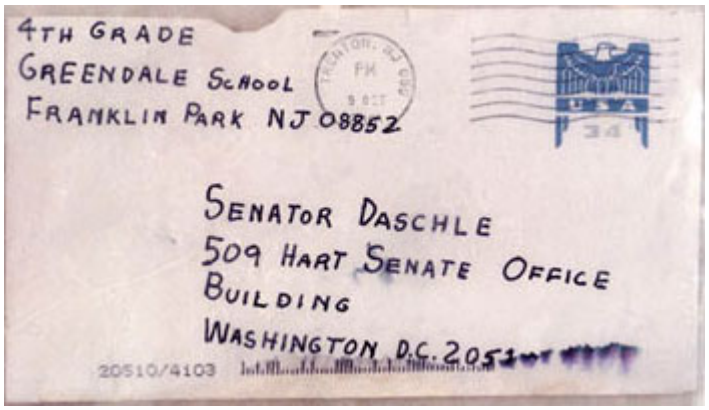
Category A diseases or agents are high priority and include organisms that pose the highest risk to the public and national security because they:

- Are easily spread or transmitted from person to person
- Result in high mortality rates and have the potential for major public health impact
- May cause public panic and social disruption
- Require special action for public health preparedness (CDC, 2007)

Category A bioterrorism agents are:

- Anthrax
- Botulism
- Plague
- Smallpox

- Tularemia
- Viral hemorrhagic fevers (VHF) (CDC, 2013a)



A letter sent in 2001 to Senate Majority Leader Tom Daschle contained anthrax powder. Beginning one week after the September 11 attacks, letters containing anthrax spores were mailed to several news media offices and two U.S. Senators, killing five people and infecting 17 others. Source: Wikimedia Commons.

Category B Diseases or Agents

Category B diseases or agents are the second highest priority because they:

- Are moderately easy to disseminate
- Result in moderate illness rates and low mortality rates
- Require specific enhancements of CDC's laboratory capacity and enhanced disease surveillance (CDC, 2007)

Category B diseases or agents include:

- Brucellosis (Brucella species)
- Epsilon toxin of Clostridium perfringens
- Food safety threats (Salmonella species, Escherichia coli O157:H7, and Shigella)
- Glanders (Burkholderia mallei)
- Melioidosis (Burkholderia pseudomallei)
- Psittacosis (Chlamydia psittaci)
- Q fever (Coxiella burnetii)
- Ricin toxin from Ricinus communis (castor beans)
- Staphylococcal enterotoxin B
- Typhus fever (Rickettsia prowazekii)

- Viral encephalitis (alphaviruses—Venezuelan equine encephalitis, eastern and western equine encephalitis)
- Water safety threats (Vibrio cholerae, Cryptosporidium parvum) (CDC, 2008)

Category C Diseases or Agents

Category C diseases or agents are the third highest priority and include emerging pathogens that could be engineered for mass dissemination in the future because:

- Are easily available
- Are easily produced and spread
- Have potential for high morbidity and mortality rates and major health impact (CDC, 2007)

Clinical Features of High-Priority Agents

Four category A diseases have been the focus of the CDC's efforts to educate the healthcare community about bioterrorism potential: anthrax, botulism, plague, and smallpox. The CDC does not prioritize these agents in any order of importance or likelihood of use. Other agents with bioterrorism potential include those that cause tularemia and viral hemorrhagic fevers (category A), brucellosis, Q fever, viral encephalitis, and disease associated with staphylococcal enterotoxin, category B. Other important category B agents include any organism that threatens the water or food supply.

Anthrax

Anthrax has been recognized as an infectious disease of animals and humans for millennia. Within the United States, animal anthrax is reported in most years, but naturally occurring human anthrax is rare. Worldwide, however, the disease is common in wild and domestic animals and not uncommon among persons who interact with animals in agricultural regions of South and Central America, sub-Saharan Africa, central and southwestern Asia, and southern and eastern Europe (Hendricks, et al. [CDC], 2014).

Bacillus anthracis, the causative agent of anthrax, is a nonmotile spore-forming, gram-positive, rod-shaped bacterium. Biodefense experts often place *B. anthracis* at or near the top of the list for potential threat agents. Inhalation anthrax is particularly deadly, as demonstrated by the 1979 accidental release of *B. anthracis* from a military microbiology facility in the Sverdlovsk region of Russia; 88% (66/75) of patients reported with inhalation anthrax died. More recently, humans have acquired disease from exposure to spores released purposefully as a bioterrorist weapon and accidentally from naturally occurring sources (Hendricks, et al. [CDC], 2014).

If a bioterrorist attack were to happen, Bacillus anthracis would be one of the biological agents most likely to be used. Biological agents are germs that can sicken or kill people, livestock, or crops. Anthrax is one of the most likely agents to be used because:

- Anthrax spores are easily found in nature, can be produced in a lab, and can last for a long time in the environment.
- Anthrax makes a good weapon because it can be released quietly and without anyone knowing. The microscopic spores could be put into powders, sprays, food, and water. Because they are so small, you may not be able to see, smell, or taste them.
- Anthrax has been used as a weapon before. (CDC, 2014)

Anthrax has been used as a weapon around the world for nearly a century. In 2001, powdered anthrax spores were deliberately put into letters that were mailed through the U.S. postal system. Twenty-two people, including 12 mail handlers, got anthrax, and five of these 22 people died.

A subset of select agents and toxins have been designated as Tier 1 because these biological agents and toxins present the greatest risk of deliberate misuse with significant potential for mass casualties or devastating effect to the economy, critical infrastructure, or public confidence, and pose a severe threat to public health and safety. Bacillus anthracis is a Tier 1 agent.

An **anthrax attack** could take many forms. For example, it could be placed in letters and mailed, as was done in 2001, or it could be put into food or water. Anthrax also could be released into the air from a truck, building, or plane. This type of attack would mean the anthrax spores could easily be blown around by the wind or carried on people's clothes, shoes, and other objects. It only takes a small amount of anthrax to infect a large number of people.

If anthrax spores were released into the air, people could breathe them in and get sick with anthrax. Inhalation anthrax is the most serious form and can kill quickly if not treated immediately. If the attack were not detected by one of the monitoring systems in place in the United States, it might go unnoticed until doctors begin to see unusual patterns of illness among sick people showing up at emergency rooms (CDC, 2014).

There are four clinical forms of anthrax: cutaneous or skin, respiratory tract or inhalation, gastrointestinal, and injection anthrax (has occurred in Europe but not in the US) (CDC, 2013b).

Cutaneous Anthrax

When anthrax spores get into the skin, usually through a cut or scrape, a person can develop cutaneous anthrax. This can happen when a person handles infected animals or contaminated animal products like wool, hides, or hair. Cutaneous anthrax is most common on the head, neck, forearms, and hands. It affects the skin and tissue around the site of infection.

Cutaneous anthrax is the most common form of anthrax infection, and it is also considered to be the least dangerous. Infection usually develops from 1 to 7 days after exposure. Without treatment, up to 20% of people with cutaneous anthrax may die. However, with proper treatment, almost all patients with cutaneous anthrax survive (CDC, 2013b).

Cutaneous anthrax symptoms can include:

- A group of small blisters or bumps that may itch
- A painless skin sore (ulcer) with a black center that appears after the small blisters or bumps
- Most often the sore will be on the face, neck, arms, or hands
- Swelling can occur around the sore (CDC, 2013b)

Inhalation Anthrax

When a person breathes in anthrax spores, they can develop inhalation anthrax. People who work in places such as wool mills, slaughterhouses, and tanneries may breathe in the spores when working with infected animals or contaminated animal products from infected animals. Inhalation anthrax starts primarily in the lymph nodes in the chest before spreading throughout the rest of the body, ultimately causing severe breathing problems and shock.

Inhalation anthrax is considered to be the most deadly form of anthrax. Infection usually develops within a week after exposure, but it can take up to 2 months. Without treatment, only about 10% to 15% of patients with inhalation anthrax survive. However, with aggressive treatment, about 55% of patients survive (CDC, 2013b).

Inhalation anthrax symptoms can include:

- Fever and chills
- Chest discomfort
- Shortness of breath
- Confusion or dizziness
- Cough

- Nausea, vomiting, or stomach pains
- Headache
- Sweats (often drenching)
- Extreme tiredness
- Body aches (CDC, 2013b)

Gastrointestinal Anthrax

When a person eats raw or undercooked meat from an animal infected with anthrax, they can develop gastrointestinal anthrax. Once ingested, anthrax spores can affect the upper gastrointestinal tract (throat and esophagus), stomach, and intestines.

Gastrointestinal anthrax has rarely been reported in the United States. Infection usually develops from 1 to 7 days after exposure. Without treatment, more than half of patients with gastrointestinal anthrax die. However, with proper treatment, 60% of patients survive (CDC, 2013b).

Gastrointestinal anthrax symptoms can include:

- Fever and chills
- Swelling of neck or neck glands
- Sore throat
- Painful swallowing
- Hoarseness
- Nausea and vomiting, especially bloody vomiting
- Diarrhea or bloody diarrhea
- Headache
- Flushing (red face) and red eyes
- Stomach pain
- Fainting
- Swelling of abdomen (stomach) (CDC, 2013b)

Injection Anthrax

Recently, another type of anthrax infection has been identified in heroin-injecting drug users in northern Europe. This type of infection has never been reported in the United States.

Symptoms may be similar to those of cutaneous anthrax, but there may be infection deep under the skin or in the muscle where the drug was injected. Injection anthrax can spread throughout the body faster and be harder to recognize and treat. Lots of other more common bacteria can cause skin and injection site infections, so a skin or injection site infection in a drug user does not necessarily mean the person has anthrax (CDC, 2013b).

Injection anthrax symptoms can include:

- Fever and chills
- A group of small blisters or bumps that may itch, appearing where the drug was injected
- A painless skin sore with a black center that appears after the blisters or bumps
- Swelling around the sore
- Abscesses deep under the skin or in the muscle where the drug was injected
- Keep in mind
  - Symptoms are similar to those of cutaneous anthrax, but injection anthrax can spread throughout the body faster and be harder to recognize and treat than cutaneous anthrax.
  - Skin and injection site infections associated with injection drug use are common and do not necessarily mean the person has anthrax. (CDC, 2013b)

Botulism

Botulism is a neuroparalytic (muscle-paralyzing) disease whose agent is the toxin produced by *Clostridium botulinum*—an encapsulated, anaerobe, gram-positive, spore-forming, rod-shaped bacterium (CDC, 2006). Botulism neurotoxin is an extremely potent organism; less than 1 microgram causes fatality in adults. It causes paralysis by inhibiting the release of acetylcholine at the neuromuscular junction; respiratory paralysis and death result if left untreated. There are four forms of naturally occurring botulism:

Foodborne Botulism

- Caused by ingestion of pre-formed toxin

Infant Botulism

- Caused by ingestion of C. botulinum, which produces toxin in the intestinal tract

Wound Botulism

- Caused by wound infection with C. botulinum that secretes the toxin

Adult Intestinal Colonization

- Rare, caused when *C. botulinum* colonizes the intestinal tract of children or adults, usually with gastrointestinal abnormalities (CDC, 2006)

Botulinum toxin as a biological weapon

- Aerosolized botulinum toxin is a possible mechanism for a bioterrorism attack
- Inhalational botulism does not occur naturally
- Inhalational botulism cannot be clinically differentiated from the three naturally occurring forms
- Indications of intentional release of a biologic agent may include:
  - An unusual geographic clustering of illness (eg, persons who attended the same public event or gathering)
  - A large number of cases of acute flaccid paralysis with prominent bulbar palsies, especially if occurring in otherwise healthy persons (CDC, 2006)

Botulism is not transmissible from person to person. For foodborne botulism, symptoms begin within 6 hours to 10 days after exposure (often within 12–36 hours), and could be shorter in inhalational botulism (CDC, 2006b).

Symptoms, Diagnosis, and Treatment of Botulism

Symptoms/signs

- Symmetrical cranial neuropathies
  - Difficulty swallowing or speaking, dry mouth
  - Diplopia (double vision), blurred vision, dilated or non-reactive pupils, ptosis (drooping eyelids)
- Symmetric descending weakness respiratory dysfunction (requiring mechanical ventilation)
- Descending flaccid paralysis
- Intact mental state
- No sensory dysfunction
- No fever
- Constipation more common in infant botulism

Diagnosis/lab/ reporting

- **Clinicians should immediately contact their state health departments to report suspected cases and inquire about testing and treatment**
- Diagnosis: history and clinical exam
- Laboratory confirmation:
  - Demonstrating the presence of toxin in serum, stool, or food
  - Culturing *C. botulinum* from stool, wound, or food

Treatment

- Prompt diagnosis is essential
- Antitoxin is effective in reducing the severity of symptoms, if administered early
- A supply of antitoxin against infant botulism is maintained by the California Department of Public Health's Infant Botulism Treatment and Prevention Program, and a supply of antitoxin against other kinds of botulism is maintained by the CDC
- State health departments should contact CDC to arrange for a clinical consultation by phone, and (if indicated) the release of the antitoxin
- Supportive care as needed, including mechanical ventilation

Prophylaxis	▪ Botulism can be prevented by the administration of neutralizing antibody in the bloodstream ▪ Passive immunity can be provided by equine botulinum antitoxin or by specific human hyperimmune globulin, while endogenous immunity can be induced by immunization with botulinum toxoid

Source: CDC, 2006.

Plague (*Yersinia pestis*)

Plague is an acute and potentially fatal bacterial infection that affects humans and animals and is caused by *Y. pestis*. Plague usually presents as 1 of 5 principal clinical syndromes: bubonic, pneumonic, septicemic, plague meningitis, or pharyngeal. Plague is a naturally occurring disease that has been endemic in the United States since 1900. Approximately 5 to 15 cases occur per year, with the greatest concentration of cases in Arizona, Colorado, and New Mexico (CDC, 2004a).

An immediate and coordinated public health and medical response would be required in the event of the intentional use of plague. Therefore, **any case of plague should be reported to the state health department immediately**. Reporting is especially important when a case of plague occurs outside of a typically affected area (CDC, 2004a).

With bubonic plague, the infection is transmitted by the bite of an infected flea or exposure to infected material through a break in the skin. Bubonic plague cannot be transmitted from person to person. If bubonic plague is not treated, the bacteria can spread through the bloodstream and infect the lungs, causing a secondary infection of pneumonic or septicemic plague (CDC, 2004a).

Pneumonic plague is a pulmonary infection that occurs upon inhalation of plague bacteria. Pneumonic plague can be transmitted person to person through respiratory droplets with direct close contact, and without early treatment in less than 24 hours, pneumonic plague almost universally leads to respiratory failure, shock, and rapid death (CDC, 2004a).

Infection via inhalation of infective respiratory droplets or aerosols is rare with naturally occurring plague in the United States, but is the most likely route of transmission in a bioterrorist event. If *Y. pestis* were to be used as a bioweapon, it would be most dangerous if released as an aerosol. An aerosol release would be expected to result in an outbreak of the pneumonic form of plague and it may also cause the less common pharyngeal plague and ocular plague (CDC, 2004a).

The primary form of septicemic plague results from direct inoculation and multiplication of plague bacilli in the bloodstream, while the secondary form is a development of untreated pneumonic or bubonic plague (CDC, 2004a).

Bubonic Plague

- Incubation period: 2 to 6 days
- Symptoms
  - Lymphadenopathy and fever are both early symptoms of bubonic plague.
  - Patients develop buboes, which are grossly enlarged, extremely tender lymph nodes draining at the respective site of inoculation.
- Progression of disease: If bubonic plague is not treated, the bacteria can spread through the bloodstream, causing septicemia, or it can infect the lungs, causing a secondary case of pneumonic plague. Rarely, it can progress to meningitis. (CDC, 2004a)

Pneumonic Plague

- Incubation period: 2 to 4 days with range of 1 to 6 days
- Symptoms
  - Acute onset of fever, chills, malaise, and myalgias associated with progressive lethargy
  - A productive cough of copious watery mucoid sputum that may be bloody
  - Associated chest pain and increasing dyspnea
- Progression of disease: As the disease progresses, adult respiratory distress syndrome (ARDS) characterized by refractory pulmonary edema may occur. Signs of shock, including hypotension and eventual multi-organ failure, may also occur. Without early detection and treatment in less than 24 hours, pneumonic plague is almost universally fatal. (CDC, 2004a)

Septicemic Plague

- Incubation period: Occurs when plague bacteria multiply in the blood. Most commonly, septicemic plague presents as a complication of pneumonic or bubonic plague, but primary septicemic plague can occur.
- Symptoms: Acute onset of fever, chills, prostration, abdominal pain, nausea, and vomiting.
- Progression of disease: As the disease progresses, purpura may develop, as well as possible disseminated intravascular coagulation (DIC). Eventually, hypotension and

other signs of shock appear. Septicemic plague is often fatal even when treated. (CDC, 2004a)

Smallpox (Variola)

Smallpox is a serious, contagious, and sometimes fatal infectious disease. There is no specific treatment for smallpox disease, and the only prevention is vaccination. The pox part of *smallpox* is derived from the Latin word for "spotted" and refers to the raised bumps that appear on the face and body of an infected person (CDC, 2004c).

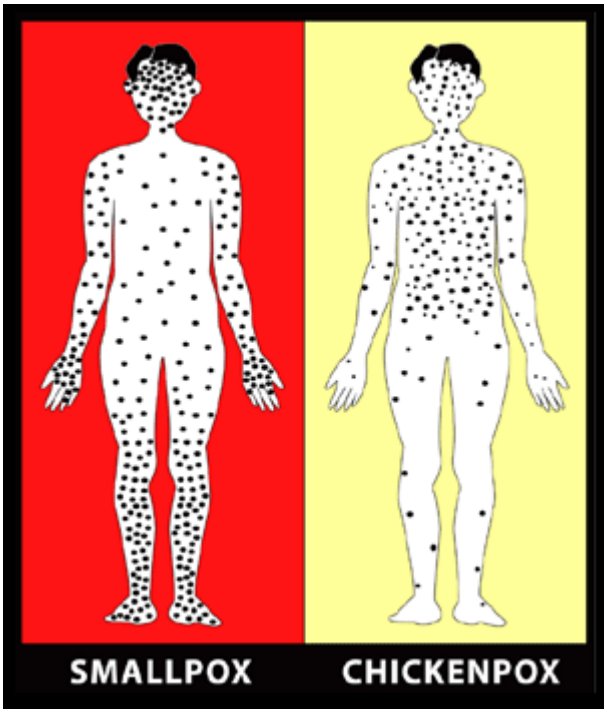
There are two clinical forms of smallpox. Variola major is the severe and most common form of smallpox, with a more extensive rash and higher fever. There are four types of variola major smallpox: ordinary (the most frequent type, accounting for 90% or more of cases); modified (mild and occurring in previously vaccinated persons); flat; and hemorrhagic (both rare and very severe). Historically, variola major has an overall fatality rate of about 30%; however, flat and hemorrhagic smallpox usually are fatal. Variola minor is a less common presentation of smallpox, and a much less severe disease, with death rates historically of 1% or less (CDC, 2004c).

Smallpox is caused by the variola virus, which emerged in human populations thousands of years ago, but the disease is now eradicated after a successful worldwide vaccination program. After the disease was eliminated from the world, routine vaccination against smallpox among the general public was stopped because it was no longer necessary for prevention. Except for laboratory stockpiles, the variola virus has been eliminated. However, in the aftermath of 9/11, there is heightened concern that the variola virus might be used as an agent of bioterrorism. For this reason, the U.S. government is taking precautions for dealing with a smallpox outbreak (CDC, 2004c).

Generally, direct and fairly prolonged face-to-face contact is required to spread smallpox from one person to another. Smallpox also can be spread through direct contact with infected bodily fluids or contaminated objects such as bedding or clothing. Rarely, smallpox has been spread by virus carried in the air in enclosed settings such as buildings, buses, and trains. Humans are the only natural hosts of variola. Smallpox is not known to be transmitted by insects or animals.

A person with smallpox is sometimes contagious with onset of fever (prodrome phase), but the person becomes most contagious with the onset of rash. At this stage the infected person is usually very sick and not able to move around in the community. The infected person is contagious until the last smallpox scab falls off (CDC, 2004c).

The acute clinical symptoms of smallpox resemble other acute viral illnesses, such as influenza, beginning with a 2- to 4-day nonspecific prodrome of fever and myalgias before rash onset. Several clinical features can help clinicians differentiate varicella (chickenpox) from smallpox. The rash of varicella is most prominent on the trunk and develops in successive groups of lesions over several days, resulting in lesions in various stages of development and resolution. In comparison, the vesicular/pustular rash of smallpox is typically most prominent on the face and extremities, and lesions develop at the same time (CDC, 2001; CDC, 2004c).



Source: CDC.

The only weapons against smallpox are vaccination and patient isolation. Those caring for a patient with smallpox should wear an N95 mask and follow airborne and contact isolation precautions. HEPA filters do remove smallpox virus, but proper procedures must be followed for their effective use. Vaccination before exposure, or within 3 days after exposure, affords almost complete protection against the disease. Vaccination as late as 4 to 7 days after exposure likely offers some protection from disease or may modify the severity of disease (CDC, 2009a,b).

The smallpox vaccine is made from a virus called vaccinia, which is a pox-type virus related to smallpox. The vaccine contains the live vaccinia virus (other vaccines containing live virus include measles, mumps, and German measles) and for that reason the vaccination site must be treated carefully to prevent the virus from spreading. The vaccine can have side effects; however, it does not contain the smallpox virus and cannot give you smallpox (CDC, 2009c).

Best Practices for First Receivers

Healthcare workers risk occupational exposures to biological materials when a hospital receives contaminated patients, particularly during mass casualty events. Hospital employees termed first receivers work at a site removed from where the hazardous release occurred. This means that their exposures are limited to the substances transported to the hospital on the skin, hair, clothing, or personal effects of the victims. The location and limited source of contaminants distinguishes first receivers from first responders such as firefighters, law enforcement, and ambulance service personnel, who typically respond to the incident site (OSHA, 2005).

Worst-case scenarios take into account challenges associated with communication, resources, and victims. During mass-casualty emergencies, hospitals can anticipate little or no warning before victims begin arriving. First receivers can anticipate that information regarding the hazardous agents may not be available immediately. Hospitals can also anticipate a large number of self-referred victims (as many as 80% of the total number of victims) and should assume victims will not have been decontaminated prior to arriving at the hospital (OSHA, 2005).

An employee's role at a facility and the corresponding hazards the employee might encounter dictate the level of training that must be provided to any individual first receiver. Selection of personal protective equipment (PPE) must be based on a hazard assessment that carefully considers both of these factors, along with the steps taken to minimize the extent of the employee's contact with hazardous substances (OSHA, 2005). Surge capacity, triage, decontamination, security, and disposal of contaminated wastewater must also be addressed.

Surge Capacity

In the event of a mass casualty event, healthcare organizations must be able to increase their services quickly in response to the crisis. This is an organization's surge capacity, "the ability to expand care capabilities in response to sudden or prolonged demand" (JCAHO, 2003; Kelen, 2008). Staffing levels, education and training, decontamination capabilities, vaccination programs for direct caregivers, volunteer resources, and stockpiling of supplies must be assessed while, in most cases, routine care continues.

Individual personnel on an emergency response team have slightly differing concerns and responsibilities when it comes to surge situations. While surge capacity planning is an administrative level concern, individual healthcare providers should understand the basic concept and the need for guidelines in order to participate effectively in training and any necessary implementation. The CDC's handbook, *Updated In a Moment's Notice: Surge Capacity in Terrorist Bombings*, and other good general resources are available at this website: http://stacks.cdc.gov/view/cdc/5713/ (CDC, 2010).

The ability of the organization to "degrade gracefully" must also be considered. A healthcare organization should have a plan to deal with a reduction in services as the number of patients increases. The goal is to engineer and manage failures and thus to avoid "catastrophic failure" (JCAHO, 2003). During a state of emergency, it may be impossible to follow normal practice guidelines. The Joint Commission recommends that hospitals and oversight agencies "provide for waiver of regulatory requirements under conditions of extreme emergency" (JCAHO, 2003).

Triage

Pre-decontamination triage serves three purposes:

1. Distinguishes contaminated individuals from other patients arriving at the hospital by identifying symptoms and victim's proximity to a known chemical release
2. Identifies patients who require immediate stabilization before they enter the decontamination system
3. Identifies injuries or critical pre-hospital treatment materials that will require special handling inside the decontamination system (OSHA, 2005)

Post decontamination triage for medical treatment should occur in the hospital post-decontamination zone after victims are inspected and found to be free of contamination. Some hospitals combine decontamination and initial medical treatment (such as antidotes), which means either the healthcare worker attempts medical triage while wearing PPE (preferred) or the worker is at risk of exposure from victims who have not been adequately decontaminated (OSHA, 2005).

Decontamination Activities

Hospitals must identify spaces that will support decontamination activities (including equipment storage) and ensure that operations can continue in the event that one area of the hospital becomes contaminated. Hospitals planning additions or remodeling projects have a unique opportunity to design spaces appropriately. Other hospitals should use creative planning to identify existing architectural features that they can use to their advantage. Nonambulatory victims can require a substantial proportion of first receivers' time and efforts, and first receivers are likely to experience the greatest exposure while assisting these victims (OSHA, 2005).

If decontamination is necessary, numerous agencies and organizations recommend a shower time of approximately five minutes for contaminated victims brought to a hospital. Despite the fact that there is no empirical data, operational procedures deem this time to be adequate. Numerous agencies and programs recommend the use of water and a liquid soap with good surfactant properties (such as hand dishwashing detergent) to decontaminate victims during emergencies and for mass casualties involving hazardous substances (OSHA, 2005).

Isolation and Lockdown

Hospitals can use a variety of methods to limit unauthorized access to the emergency department until the victims have been decontaminated. The methods range from a guard at the locked door to sophisticated keycard systems controlled at a central command center. These more complex systems tend to be associated with urban or recently modernized hospitals and are intended for use in any type of disturbance. Hospitals can use these methods if situations suggest that an unruly crowd will force its way into the hospital (OSHA, 2005).

Security

Site security helps maintain order and control traffic around the decontamination facility and the hospital entrances. Security officers might need to control a contaminated individual to prevent other staff from becoming exposed and to protect equipment. Security officers also ensure contaminated victims do not bypass the decontamination hospital or enter the ED without passing inspection. In cases of civil disturbance, properly identified security officers protect the decontamination facility and staff so normal operations can continue (OSHA, 2005).

Personal Protective Equipment

Hospitals should select personal protective equipment (PPE) such as respirators, suits, gloves, and face and eye protection based on a hazard assessment that identifies the hazards to which employees might be exposed. Under OSHA's Personal Protective Equipment Standard, or the parallel State Plan standards, all employers, including hospitals, must certify in writing that the hazard assessment has been performed. For first-receiver PPE, hospitals may base the hazard assessment on OSHA's Best Practices document. Hospitals likely to respond to incidents involving a specific hazard should adjust the PPE accordingly (OSHA, 2005).

OSHA's Personal Protective Equipment Standard also requires that employees be provided with equipment that fits appropriately. Some hospitals assign a set of protective equipment to a specific individual, and that equipment is stored in a container marked with the individual's name. Other hospitals maintain general supplies of PPE, storing sets of equipment by size. In this case, the packages are clearly marked only with the size. Each first receiver tries on equipment in advance to determine what size group fits best so that, during an emergency, the employee can quickly locate an appropriate PPE set (OSHA, 2005).

Personal protective equipment selection for first receivers has been a topic of extensive discussion. At the root of this discussion is the need for hospitals to provide adequate protection for the reasonably anticipated worst-case scenario, despite having limited information regarding the nature of the substance with which victims may be contaminated. This lack of information challenges hospitals' abilities to conduct the hazard assessments on which PPE selection must be based (OSHA, 2005).

Infection Control

Heightened awareness by infection control (IC) professionals facilitates recognition of the release of a biological agent. Infection control professionals are involved with many aspects of hospital operations and several departments, and with their counterparts in other hospitals. As a result, they may recognize changing patterns or clusters in a hospital or in a community that might otherwise go unrecognized (CDC, 2001).

Infection control professionals should ensure that hospitals have current telephone numbers for notification of both internal and external contacts and that they are distributed to the appropriate personnel. They should work with clinical microbiology laboratories, on- or off-site, that receive specimens for testing from their facility to ensure that cultures from suspicious cases are evaluated appropriately (CDC, 2001).

Wastewater Management

Wastewater from decontamination showers can contain low-level concentrations of the substance(s) with which victims are contaminated. Given the opportunity to plan for decontamination activities (by designing and installing or purchasing decontamination facilities, developing procedures, and preparing staff), hospitals should consider the management of decontamination shower water as part of their emergency preparedness plan (OSHA, 2005).

Decontaminating Surfaces and Equipment

The hospital emergency management plan should include procedures for cleaning equipment and surfaces during and after an incident. Cleaning should be performed by employees who are properly protected and trained. Items that cannot be decontaminated safely should be processed for appropriate disposal. It is unlikely that portable gear could be adequately decontaminated after an incident involving a persistent or highly toxic agent (OSHA, 2005).

Reporting an Incident of Bioterrorism

In the event that an incident of bioterrorism occurs in your community, you should know what to report and to whom the report should be sent. First reporters should start at the healthcare organization or hospital level by reporting to the department supervisor, laboratory, and infection control department. Then contact the local health/regional departments, which will contact your state's health department and the CDC. Successful reporting of a bioterrorism event results from good planning, education, and awareness, as well as regular standardized testing before an occurrence.

In most cases telephone will still be the primary means for immediate reporting because it is direct, rapid, and easy-to-use. There should always be a backup communication plan (eg, cell phones or other means) in case of a telephone system failure. In every institution standards should be established to ensure a reliable and immediate response to notifiable diseases and health conditions.

Radiological and Nuclear Weapons

Radiation is any form of energy propagated as rays, waves, or energetic particles that travel (radiate) from their source. Radiation can travel through the air or through a material medium (CISAC, n.d.-b,c).

There are five primary types of radiation:

- Alpha particles
- Beta particles
- Gamma rays
- X-rays
- Neutrons (ORISE, 2013)

Radiation types vary in their size, charge, ability to travel, and ability to penetrate objects. These variations affect their uses, their current and future effects, what materials effectively shield against them, the parts of the body they can potentially damage, and the exposure restrictions mandated by the government (ORISE, 2013).

Radioactive materials are composed of atoms that are unstable. An unstable atom gives off its excess energy until it becomes stable. The energy emitted is radiation. The process by which an atom changes from an unstable state to a more stable state by emitting radiation is called radioactive decay or radioactivity (CISAC, n.d.-b,c).

Radiation is often divided into ionizing and non-ionizing radiation. Radiation that has enough energy to move atoms in a molecule or cause them to vibrate, but not enough to change them chemically, is referred to as non-ionizing radiation. Examples of this kind of radiation are radio waves and visible light (CISAC, n.d.-b).

Radiation that falls within the ionizing radiation range (alpha and beta particles and gamma rays) has enough energy to break the bonds that tie electrons into the atoms or molecules that make up ordinary substances. This is the type that people usually think of as "radiation" when dealing with nuclear dangers. Ironically, this is also the type of radiation that is used for medical treatment and in many manufacturing processes (CISAC, n.d.-b; ORISE, 2014).

Compared with other types of radiation that may be absorbed, ionizing radiation deposits a large amount of energy into a small area. All ionizing radiation is capable, directly or indirectly, of removing electrons from most molecules. This property of ionizing radiation lies at the root of both its usefulness and its dangers (CISAC, n.d.-c).

Radiation cannot be detected by the human senses. A radiologic survey conducted with specialized equipment is the only way to confirm the presence of radiation. If a terrorist event involves the use of radioactive material, both patient exposure and contamination must be assessed.

Exposure occurs when a person is near a radiation source. People exposed to a source of radiation can suffer radiation illness if the dose is high enough, but they do not become radioactive. For example, an x-ray machine is a source of radiation exposure, yet a person does not become radioactive or pose a risk to others following a chest x-ray (CDC, 2014e).

Measuring Radiation

When scientists measure radiation, they use different terms depending on whether they are discussing radiation coming from a radioactive source, the radiation dose absorbed by a person, or the risk that a person will suffer health effects (biological risk) from exposure.

Most scientists in the international community measure radiation using the Système International d'Unités (SI), a uniform system of weights and measures that evolved from the metric system. In the United States, however, the conventional system of measurement is still widely used.

Different units of measure are chosen depending on what aspect of radiation is being measured. For example, the amount of radiation being given off, or emitted, by a radioactive material is measured using the conventional unit curie (Ci), named for the famed scientist Marie Curie, or the SI unit becquerel (Bq).

The radiation dose absorbed by a person (the amount of energy deposited in human tissue by radiation) is measured using the conventional unit rad or the SI unit gray (Gy). The biologic risk of exposure to radiation (the risk that a person will suffer health effects from an exposure to radiation) is measured using the conventional unit rem or the SI unit sievert (Sv) (CDC, 2014g).

Types of Radiation Injury

The only non-test deployment of nuclear weapons was the 1945 dropping of the atomic bombs on Hiroshima and Nagasaki, Japan, near the end of World War II. Those at the center of impact were killed immediately by thermal and shock forces as well as intense radiation poisoning. Others at varying distances from the bomb's center were injured and died later. Still others are alive today, but many of them have suffered from the latent effects of radiation exposure. Patterns of aftereffects are known, as are the patterns of radiation illness and injury that follow closely upon exposure. Understanding these patterns will aid in diagnosis and treatment of radiation-induced injury or illness.

Radioactive contamination and radiation exposure could occur if radioactive materials are released into the environment as the result of an accident, an event in nature, or an act of terrorism. Such a release could expose people and contaminate their surroundings and personal property (CDC, 2014b).

Exposure

Radiation exposure occurs when all or part of the body absorbs penetrating ionizing radiation from an external radiation source. Exposure from an external source stops when a person leaves the area of the source, the source is shielded completely, or the process causing exposure ceases. During exposure, the body may absorb radiation or it may pass completely through the body. This is similar to what happens during an ordinary chest x-ray. An individual who has been exposed in this way is not radioactive and can be treated like any other patient (ORISE, 2014; CDC, 2014b; REMM, 2013).

Radiation exposure also occurs after internal contamination, ie, when a radionuclide is ingested, inhaled, or absorbed into the blood stream. This kind of exposure stops only if the radionuclide is totally eliminated from the body, with or without treatment (REMM, 2013).

An individual exposed only to an external source of radiation, is NOT radioactive or contaminated and may be approached without risk, just like after a chest x-ray or CT scan (REMM, 2013).

Radiation from external exposure alone is either absorbed without the body becoming radioactive, or it can pass through the body completely. Therefore, if a person is scanned with a radiation survey monitor after external exposure alone, the device will not register radiation above the background level (REMM, 2013).

Contamination: External or Internal

Contamination results when a radioisotope (as gas, liquid, or solid) is released into the environment and then ingested, inhaled, or deposited on the body surface. External contamination results when radioactive material is deposited on skin, hair, eyes, or other external structures, much like mud or dust. External contamination stops when the material is removed by shedding contaminated clothes and/or completely washing off the contamination (REMM, 2013).

Internal contamination results when radioactive material is taken into the body via inhalation or ingestion or open wounds. Internal deposition of radioisotopes in organs results in local exposure at that location. Internal contamination continues until the radioactive material decays, is flushed from the body by natural processes, or is removed by medical countermeasures (REMM, 2013).

Incorporation

After inhalation, ingestion, or wound contamination, small radioisotope particles may be transported via blood or lymphatics into cells, tissues, and organs. Isotopes can be alpha-, beta-, or gamma-emitting. Radioisotopes can be incorporated into one or more organs specific for that isotope, (eg, thyroid, lungs, kidneys, bones/bone marrow, or liver/spleen) resulting in exposure at that site. Medical countermeasures called decorporation agents or other procedures (eg, diuresis) may be needed to remove radioisotopes that have been incorporated into tissues. Toxic effects of radioisotopes may be due to their chemical and/or radiological properties (REMM, 2013).

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Radiation-Induced Illness

Acute Radiation Syndrome (ARS)

Acute radiation syndrome (ARS)—sometimes known as radiation toxicity or radiation sickness—is an acute illness caused by irradiation of the entire body, or most of the body, by a high dose of penetrating radiation in a very short period of time (usually a matter of minutes) (CDC, 2014c). The most probable terrorist events, such as a dirty bomb attack, will likely generate low levels of radiation exposure. If ARS cases are seen, it is likely that casualty numbers will be small (CDC, 2014e).

Basic symptomatic issues of ARS include:

- Time of exposure, distance from radioactive source, and duration of exposure
- Patients may present individually if exposed to radioactive sources that are hidden in the community.
- Symptoms can be immediate or delayed, mild or severe, based on radiation dose.
- Nausea and vomiting may occur minutes to days after exposure.
- Early onset of vomiting followed by symptoms of bone marrow suppression, gastrointestinal destruction, and/or cardiovascular/CNS effects are indicative of acute illness.
- Depending on the stage of illness, a patient may be asymptomatic. (CDC, 2014e)

The required conditions for ARS are:

- The radiation dose must be large (> 0.7 Gy, or >70 rads).
- The dose usually must be external (the source of radiation is outside of the patient's body).
- The radiation must be penetrating (able to reach the internal organs).
- The entire body (or a significant portion of it) must have received the dose.
- The dose must have been delivered in a short time (usually a matter of minutes). (CDC, 2014c)

The three classic ARS syndromes are:

- Bone marrow syndrome (hematopoietic syndrome)
- Gastrointestinal syndrome
- Cardiovascular (CV)/Central Nervous System (CNS) syndrome (CDC, 2014c)

The four stages of ARS are:

- **Prodromal stage** (N-V-D stage): Classic symptoms are nausea, vomiting, and anorexia—and possibly diarrhea, depending on dose—which occur from minutes to days following exposure. The symptoms may last episodically from minutes to several days.
- **Latent stage**: The patient looks and feels generally healthy, for a few hours to a few weeks.
- **Manifest illness stage**: The symptoms depend on the specific syndrome and last from hours to several months.
- **Recovery or death**: Most patients who do not recover will die within several months of exposure. The recovery process lasts from several weeks to 2 years. (CDC, 2014c)

Cutaneous Radiation Injury (CRI)

Injury to the skin and underlying tissues from acute exposure to a large external dose of radiation is referred to as **cutaneous radiation injury (CRI). Acute radiation syndrome (ARS)** will usually be accompanied by some skin damage; however, CRI can occur without symptoms of ARS. This is especially true with acute exposures to beta radiation or low-energy x-rays, because beta radiation and low-energy x-rays are less penetrating and less likely to damage internal organs than gamma radiation is. Most cases of CRI have occurred when people inadvertently came in contact with unsecured radiation sources from food irradiators, radiotherapy equipment, or well depth gauges (CDC, 2014a).

Basic symptomatic issues of CRI include:

- Skin damage that can manifest within hours, days, or weeks after radiation exposure.
- Transient itching, tingling, erythema, or edema within hours or days after exposure, usually followed by a latent period.
- Lesions may not be seen for weeks to months postexposure, but then can be debilitating or even life threatening.
- Delayed occurrence of lesions is a differentiating factor from thermal burns.
- It is important to note time of occurrence of signs and symptoms and progressive changes in appearance.
- Treat localized injuries symptomatically, focusing on pain and infection control. (CDC, 2014e)

Protecting Staff and Patients

The Centers for Disease Control and Prevention (CDC) has established general guidelines for managing patients and protecting staff in the event of radiation exposure. These guidelines are specifically designed for small-scale incidents not resulting from a large or nuclear device.

Hospitals and other agencies are also expected to have mass casualty strategies in place, and all appropriate staff should be trained in proper procedures and use of equipment. Many resources are available for establishing triage areas and managing mass casualties (OSHA, 2005).

According to the CDC, addressing contamination issues should not delay treatment of life-threatening injuries. It is highly unlikely that the levels of radioactivity associated with a contaminated patient would pose a significant health risk to care providers. In certain rare instances, the presence of imbedded radioactive fragments or large amounts of external contamination may require expedited decontamination, thus it is recommended to include in-house radiation professionals on the response team (CDC, 2014e). The CDC staff protection guidelines include the following.

Establish an ad hoc triage area:

- Base it on your hospital's disaster plan and the anticipated number of casualties.
- Establish a contaminated area and a clean area separated by a buffer zone.
- Remove your contaminated outer garments when leaving the contaminated area.
- Have your body surveyed with a radiation meter when exiting a contaminated area.

Use standard precautions to protect staff:

- Follow standard guidelines for protection from microbiologic contamination.
- Surgical masks should be adequate.
- N95 masks, if available, are recommended.
- Survey hands and clothing at frequent intervals with a radiation meter.
- Due to fetal sensitivity to radiation, assign pregnant staff to other duties. (CDC, 2014e)

Protective Clothing for Staff

The purpose of protective clothing is to keep bare skin and personal clothing free of external contamination. Paper coveralls, cloth coveralls, and surgical garb are all appropriate protective clothing. Because most people are not used to working in extra layers of clothing they should be monitored for heat stress. "Standard issue particulate protective masks (respirators) afford excellent protection from inhalation and ingestion of most radioactive material" (ORISE, 2013).

PPE in Radiation Emergencies

- In a radiation emergency, the choice of appropriate personal protective equipment (PPE) depends on
- Response role and specific tasks
- Risk of contamination
- PPE can protect against
  - External contamination
  - Internal contamination via inhalation, ingestion, absorption through open wounds
  - Other physical hazards (e.g., debris, fire/heat, or chemicals)
- PPE cannot protect against exposure from high energy, highly penetrating forms of ionizing radiation associated with most radiation emergencies.
  - Lead aprons worn in diagnostic radiology do not provide sufficient shielding against these kinds of radiation.
- PPE should include a personal radiation dosimeter whenever there is concern about exposure to penetrating ionizing radiation.
  - Direct-reading personal radiation dosimeters may be used to monitor radiation dose and can help workers stay within recommended Dose Limits for Emergency Workers.
  - Direct-reading dosimeters should be worn so that a worker can easily see the read-out and/or hear warning alarms.
- Recommended respiratory PPE includes a full-face piece air purifying respirator with a P-100 or High Efficiency Particulate Air (HEPA) filter.
  - Other respiratory protective equipment (e.g., a simple surgical facemask, N-95 respirators), non-fit tested respirators, or ad hoc respiratory protection do not deliver appropriate or sufficient respiratory protection.
  - Environmental testing and hazard assessment by a safety professional can help identify hazards and risk levels and direct choices

More detailed information about forms of PPE and their efficacy is available from the Radiation Emergency Medical Management website.

Decontamination Guidelines for Patients

The CDC offers the following guidelines for managing patients who are believed to have been contaminated either externally or internally with radiation. Before beginning treatment, staff should be sure to take care in following their agency's guidelines for donning protective clothing or equipment.

Survey the patient with a radiation meter:

- Perform surveys using consistent technique and trained personnel.
- Note exceptionally large amounts of surface or embedded radioactive material.
- Handle radioactive objects with forceps and store in lead containers.
- Record location and level of any contamination found. (CDC, 2014e)

Remove patient clothing:

- Carefully cut clothing and roll it away from the face to contain the contamination.
- Double-bag clothing using radioactive hazardous waste guidelines, label, and save as evidence.
- Repeat patient survey and record level. (CDC, 2014e)

Cleanse contaminated areas:

- Wash wounds first with saline or water.
- If facial contamination is present, flush eyes, nose, and ears, and rinse mouth.
- Gently cleanse intact skin with soap and water, starting outside the contaminated area and washing inward.
- Do not irritate or abrade the skin.
- Resurvey and note levels.
- Repeat washing until survey indicates radiation level is no more than twice background or the level remains unchanged.
- Cover wounds with waterproof dressing.
- Dispose of wastewater through normal channels.
- For mass casualties, consider establishing separate shower areas for ambulatory and nonambulatory patients. (CDC, 2014e)

Management of deceased:

- If exposed to a lethal dose of radiation without contamination, a patient is not radioactive and no special precautions are needed.
- Special precautions may be necessary for contaminated deceased. (CDC, 2014e) (CDC and REMM provided detailed guidelines.)

Initial Evaluation and Treatment

Treat vomiting immediately. Repeat CBC analysis with special attention to the lymphocyte count every 2 to 3 hours for the first 8 to 12 hours after exposure (and every 4 to 6 hours for the following 2 to 3 days). Precisely record all clinical symptoms, particularly nausea, vomiting, diarrhea, and itching, reddening, or blistering of the skin. Be sure to include time of onset.

Note and record areas of erythema. If possible, take color photographs of suspected radiation skin damage. Consider tissue and blood typing as well as initiation of viral prophylaxis. Promptly consult with radiation, hematology, and radiotherapy experts about dosimetry, prognosis, and treatment options. Call the Radiation Emergency Assistance Center to record the incident in the Radiation Accident Registry System (see numbers under Resources at the end of this course).

After consultation, begin the following treatment (as indicated):

- Supportive care in a clean environment (eg, burn unit)
- Prevention and treatment of infections
- Stimulation of hematopoiesis by use of growth factors
- Stem cell transfusions or platelet transfusions (if platelet count too low)
- Psychological support
- Careful observation for erythema (document locations), hair loss, skin injury, mucositis, parotitis, weight loss, or fever
- Confirmation of initial dose estimate, using chromosome aberration cytogenetic bioassay when possible (Although resource-intensive, this is the best method of dose assessment following acute exposures.)
- Consultation with experts in radiation accident management (CDC, 2014c)

Internal Contamination

Consider internal contamination if high survey readings persist following decontamination. Internal contamination generally does not cause early symptoms. Nose or mouth contamination may indicate inhalation or ingestion.

To check for internal contamination:

- Assessment may include analysis of urine, blood, and fecal samples or whole-body counts. Consult with radiation experts.
- Radiation experts may recommend early administration of radionuclide-specific decorporation agents such as Prussian blue, DTPA, or bicarbonate.
- Gastric lavage, antacids, and cathartics assist in clearing ingested contaminants. (CDC, 2014e)

Medical Management: Countermeasures

Treating internal contamination:

- During a radiological or nuclear emergency, radioactive materials may be released into the air and then breathed into the lungs, or may get into the body through open wounds. Radioactive materials can also contaminate the local food supply and get into the body through eating or drinking. This is called internal contamination.
- The sooner internal contamination is removed from the body, the fewer and less severe the health effects will be. Small amounts of internal contamination may not need treatment.

Some medical treatments are available for limiting or removing internal contamination depending on the type of radioactive material involved. Medical professionals will determine if any of the following treatments are needed:

- Potassium Iodide (KI)
- Prussian Blue
- DTPA (Diethylenetriamine pentaacetate)
- Neupogen (CDC, 2014d)

Psychosocial Issues

In urban areas, hundreds to thousands may seek care. Most will self-refer to the nearest hospital. While many may need decontamination, others may seek radiologic screening even though not contaminated. Many simply seek reassurance. Mental health professionals should always be members of the response team and available in any first-receiver facility to provide such support.

When evaluating patients, healthcare workers need to understand that psychogenic symptoms, such as nausea or vomiting, may manifest. Keep in mind that vomiting due to radiation exposure is usually recurrent rather than episodic.

Have radiation exposure fact sheets available for patients and families and remember that pregnant patients require special counseling. It is likely that separate areas for radiation screening and counseling will be needed for patients with minimal risk of exposure or injury (CDC, 2014e).

Health Alert Network (HAN)

CDC's Health Alert Network (HAN) is CDC's primary method of sharing cleared information about urgent public health incidents with public information officers; federal, state, territorial, and local public health practitioners; clinicians; and public health laboratories.

CDC's HAN collaborates with federal, state, territorial, and city/county partners to develop protocols and stakeholder relationships that will ensure a robust interoperable platform for the rapid distribution of public health information (CDC, 2015).

A vast majority of the state-based HAN programs have over 90% of their population covered under the umbrella of HAN. The CDC website provides links to each connected state and local jurisdiction. Check with your state's HAN program to signup. In addition, persons who wish to sign up to receive HAN Update Alerts from CDC can do so on the CDC website.

Alert Message Types

CDC HAN messages range from informational updates of general interest to alerts that require immediate action. Examples of the different types of alerts listed below, as well as archives of past alerts, may be found on the CDC Health Alert Network website.

- Health Alert: provides vital, time-sensitive information for a specific incident or situation; warrants immediate action or attention by health officials, laboratorians, clinicians, and members of the public; and conveys the highest level of importance.
- Health Advisory: provides important information for a specific incident or situation; contains recommendations or actionable items to be performed by public health officials, laboratorians, and/or clinicians; may not require immediate action.
- Health Update: Provides updated information regarding an incident or situation; unlikely to require immediate action.
- Info Service: provides general public health information; unlikely to require immediate action. (CDC, 2015).

Resources and References

Resources

Centers for Disease Control and Prevention (CDC)

1600 Clifton Road
Atlanta, GA 30329-407
Phone: 800 232 4636 (CDC-INFO)
TTY: 888 232 6348
cdcinfo@cdc.gov
http://www.cdc.gov
Emergency Preparedness and Response
http://emergency.cdc.gov/

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

Oak Ridge Institute for Science and Education (ORISE)
PO Box 117, MS-39, Oak Ridge, TN 37831
865 576 3131 • 24-hour number 865 576 1005 (ask for REAC/TS)
http://orise.orau.gov/reacts/default.aspx

Ready.gov

http://www.ready.gov/

U.S. Department of Health and Human Services (HHS)

http://www.dhhs.gov/
Radiation Event Medical Management (REMM)
Comprehensive Resource Site for Healthcare Providers
http://www.remm.nlm.gov

U.S. Department of Homeland Security

http://www.dhs.gov

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Post Test

Use the answer sheet following the test to record your answers.

1. Terrorism is defined as:

    a. Threatening statements or actions in public settings.
    b. Threats of future violence for present gain.
    c. Use of violence to intimidate others for political or social objectives.
    d. Fear based upon imagined outcomes to civilian populations.

2. Bioterrorism is defined as:

    a. Destroying the environment in order to make a political statement.
    b. The threat posed by pesticides and herbicides.
    c. Tampering with products for sale on store shelves.
    d. The deliberate release of harmful biological agents to cause illness or death.

3. The four classifications of weapons of mass destruction (WMD) include which one of the following?:

    a. Biological.
    b. Geographical.
    c. Geological.
    d. Physiological.

4. Which one of the following statements is correct?:

    a. Dirty bombs are so-called because they disseminate harmful microbes.
    b. Chemical and biological weapons can cause more casualties than conventional weapons.
    c. Chemical weapons are harder for terrorists to manufacture than other types of WMD.
    d. Dirty bombs are unattractive to some terrorist groups because they have been successful only in war zones.

5. If deposited on soil, vegetation, or objects, persistent chemical weapons agents may take how long to dissipate?:

    a. Within a few minutes.

b. Within a few hours.

c. Up to one month.

d. Up to a year.

6. An example of a covert event is:

a. A situation generally covered by insurance.

b. The deliberate contamination of a consumer product.

c. An event where there is a charge at the door.

d. An explosion in a public school.

7. The most pragmatic initial response to a covert chemical release is to:

a. Treat patients by clinical syndrome.

b. Stay on the line with your poison control center until instructions are available.

c. Isolate patients who are symptomatic.

d. Call staff together to be sure all are following the same guidelines.

8. With vesicants (blister agents), symptoms:

a. Always manifest immediately.

b. May manifest immediately or be delayed for up to 24 hours.

c. May manifest immediately or be delayed, but never for more than 2 hours.

d. Manifest only after at least 24 hours.

9. With biological weapons, the term *syndromic surveillance* means:

a. Being aware of genetic or other variations in the patient population.

b. Asking security to be especially careful in lockdown situations.

c. Monitoring data for signs that an outbreak may warrant a public health response.

d. Doing background checks on patients with certain unexplained symptoms.

10. Category A agents and diseases are:

a. Moderately easy to disseminate.

b. Emerging pathogens that could be engineered for mass dissemination.

c. Agents that result in moderate morbidity rates and low mortality rates.

d. Easily disseminated or transmitted from person to person.

11. If *Y. pestis* were to be used as a bioweapon, it would be most dangerous if released:

a. As an aerosol.

b. In a water supply.

c. As a liquid.

d. In food.

12. Symmetrical cranial neuropathies and symmetric descending weakness respiratory dysfunction is suggestive of:

a. Anthrax.

b. Botulism.

c. Smallpox.

d. Cholera.

13. Acute onset of fever, chills, malaise, and myalgias associated with progressive lethargy, a productive cough of copious watery possibly bloody mucoid sputum, and chest pain are suggestive of:

a. Pneumonic plague.

b. Smallpox.

c. Ricin poisoning.

d. Bubonic plague.

14. The presence of a nonspecific fever and myalgias, followed by a pustular rash on the face and extremities, is suggestive of:

a. Chickenpox.

b. Cutaneous anthrax.

c. Smallpox.

d. Botulism poisoning.

15. Radioactivity is:

a. Any form of energy that radiates from a source.

b. Stable atoms moving through the air or through a material medium.

c. Lingering effects of atomic instability over long periods of time.

d. The process by which an atom changes from an unstable state to a more stable state by emitting radiation.

16. What type of radiation do people usually connect with a nuclear threat?:

    a. Ionizing radiation.
    b. Iatrogenic radiation.
    c. Nonunion radiation.
    d. Nosocomial radiation.

17. Which of the following statements is true?:

    a. Radiation can be detected by the human senses.
    b. Ionizing radiation deposits a large amount of radiation in a small area.
    c. Exposure to radiation from an x-ray machine can make a person slightly radioactive.
    d. Radioactive materials are composed of stable atoms.

18. Acute radiation syndromes (ARS) include all but which one of the following:

    a. Bone marrow syndrome.
    b. Cardiovascular syndrome.
    c. Pulmonary syndrome.
    d. Gastrointestinal syndrome.

19. The most critical Health Alert Network (HAN) message type is the:

    a. Health Warning.
    b. Health Advisory.
    c. Health Report.
    d. Health Alert.

Answer Sheet

Bioterrorism and Weapons of Mass Destruction

Name (Please print your name): _____

Date: _____

Passing score is 80%

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____

Course Evaluation

Please use this scale for your course evaluation. Items with asterisks * are required.

- 5 = Strongly agree
- 4 = Agree
- 3 = Neutral
- 2 = Disagree
- 1 = Strongly disagree

* Upon completion of the course, I was able to:

a. Define terrorism, bioterrorism, and weapons of mass destruction (WMD) and list four main types of WMD.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

b. For a chemical weapons event, summarize the agents most commonly used, the epidemiologic clues to and symptoms of a chemical release, and the appropriate first-receiver actions.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

c. For a bioterrorism event, outline the CDC's three categories of agents, the clinical features of high-priority agents, and the best practices and reporting procedures for first receivers.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

d. Describe the clinical features and treatment of exposure or injury from radiation, including acute radiation syndrome (ARS), and demonstrate ways to protect staff and patients during a radiation incident.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

* The author(s) are knowledgeable about the subject matter.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

* The author(s) cited evidence that supported the material presented.

○ 5 ○ 4 ○ 3 ○ 2 ○ 1

* This course contained no discriminatory or prejudicial language.

Yes No

* The course was free of commercial bias and product promotion.

Yes No

* As a result of what you have learned, do you intend to make any changes in your practice?

Yes No

If you answered Yes above, what changes do you intend to make? If you answered No, please explain why.

* Do you intend to return to ATrain for your ongoing CE needs?

- Yes, within the next 30 days.
- Yes, during my next renewal cycle.
- Maybe, not sure.
- No, I only needed this one course.

* Would you recommend ATrain Education to a friend, co-worker, or colleague?

- Yes, definitely.
- Possibly.
- No, not at this time.

* What is your overall satsfaction with this learning activity?

5 4 3 2 1

* Navigating the ATrain Education website was:

- Easy.
- Somewhat easy.

- ○ Not at all easy.

* How long did it take you to complete this course, posttest, and course evaluation?

- ○ 60 minutes (or more) per contact hour
- ○ 50-59 minutes per contact hour
- ○ 40-49 minutes per contact hour
- ○ 30-39 minutes per contact hour
- ○ Less than 30 minutes per contact hour

I heard about ATrain Education from:

- ○ Government or Department of Health website.
- ○ State board or professional association.
- ○ Searching the Internet.
- ○ A friend.
- ○ An advertisement.
- ○ I am a returning customer.
- ○ My employer.
- ○ Other
- ○ Social Media (FB, Twitter, LinkedIn, etc)

Please let us know your age group to help us meet your professional needs.

- ○ 18 to 30
- ○ 31 to 45
- ○ 46+

I completed this course on:

- ○ My own or a friend's computer.
- ○ A computer at work.
- ○ A library computer.
- ○ A tablet.
- ○ A cellphone.
- ○ A paper copy of the course.

Please enter your comments or suggestions here: _____

_____

_____

_____

Registration Form

Please print and answer all of the following questions (* required).

* Name: _____

* Email: _____

* Address: _____

* City: _____ * State: _____ * Zip: _____

* Country: _____

* Phone: _____

* Professional Credentials/Designations:

_____

Your name and credentials/designations will appear on your certificate.

* License Number and State: _____

* Please email my certificate:

○ Yes ○ No

(If you request an email certificate we will not send a copy of the certificate by US Mail.)

Payment Options

You may pay by credit card or by check.
Fill out this section only if you are **paying by credit card.**
4 contact hours: $35

Credit card information

* Name: _____

Address (if different from above): _____

* City: _____ * State: _____ * Zip: _____

* Card type:

○ Visa ○ Master Card ○ American Express ○ Discover

* Card number: _____

* CVS#: _____

* Expiration date: _____