Advanced Emergency Nursing Journal
Vol. 44, No. 3, pp. E10–E26

NCPD

Disaster Response—A Global Concern

Are You Prepared to Care for Victims of Chemical, Biological, Radiological, and Nuclear Attacks?

Melanie Gibbons Hallman, DNP, CRNP, FNP-BC, ACNP-BC, ENP-C, CNS, FAEN, FAAN
M. Allen McCullough, PhD, ENP-C, FNP-C, NRP, CEM, MS, MPA, MSN

Abstract
The threat of bioterrorism is increasing in lethality and numbers of events globally. Weapons of mass destruction include devices of chemical, biological, radiological, and nuclear origin and are often selected by terrorists because they are capable of causing widespread destruction, harm, and panic. Emergency personnel are often first to recognize and report potential terrorist activities. It is essential that emergency personnel maintain a high index of suspicion for symptom patterns that correspond with effects of bioterrorism agents. Health care providers must have a solid understanding of personal protective equipment for specific categories of bioterrorism agents to protect themselves and others while providing care to victims in the emergency department. A clear understanding of disaster protocols, established communication systems, reporting requirements, and available resources to aid in patient management following a bioterrorism event is crucial for optimal, safe, quality care to be administered. **Key words:** bioterrorism, disaster communication and reporting, emergency department personnel, personal protective equipment, weapons of mass destruction

ON SEPTEMBER 11, 2001, monumental terrorist attacks took place on American soil, targeting the World Trade Center and the Pentagon. It is suspected that United Airlines Flight 93 was en route to attack the U.S. White House or Capitol but crashed before arriving at the intended destination after brave passengers fought against the terrorists. The series of events resulted in nearly 3,000 lives lost (Fink, 2021). Since then, terrorist attacks continue to increase in lethality and numbers across the globe (Atakro et al., 2019). The United States is particularly susceptible to terrorist plots employing weapons of mass destruction (WMD) to harm multitudes of Americans (U.S. Department of Homeland Security [DHS], 2018). The world continues to navigate through an evolving global pandemic still undetermined whether accidental or intentional but known to be from a biological source, a virus that continues to replicate and surge. Bioterrorism is the intentional use of microorganisms or toxins from living organisms with purpose to cause harm and death to humans and the water supplies, plants, and animals they depend on for

Author Affiliations: *Emergency Nurse Practitioner Program, The University of Alabama at Birmingham School of Nursing (Dr Hallman); and Emergency Nurse Practitioner Program, Nell Hodgson Woodruff School of Nursing, Emory University, Atlanta, Georgia (Dr McCullough).*

Disclosure: *The authors report no conflicts of interest.*

Corresponding Author: *Melanie Gibbons Hallman, DNP, CRNP, FNP-BC, ACNP-BC, ENP-C, CNS, FAEN, FAAN, Department of Family, Community & Health Systems, The University of Alabama at Birmingham School of Nursing, 1701 University Blvd, Birmingham, AL 35294 (MelanieGHallman@uab.edu).*

DOI: 10.1097/TME.0000000000000396

food and sustenance (Wagar, 2016). Biological agents are widely accessible and relatively inexpensive to harness for creation of WMD. They are found naturally occurring in the environment and can be weaponized for use against populations and countries for warfare and terrorism. Even simple fertilizer used in agricultural settings provides necessary components to develop select WMD. Health care workers in hospitals and clinics and prehospital providers are often the first to identify and initiate response to potential bioterrorism activities and accidental biological agent exposures. Emergency department (ED) personnel in particular must be prepared to manage care for victims of bioterrorism as well as other WMD (Atakro et al., 2019).

In response to increasing concerns that bioterrorism is an imminent threat to the United States, the American Association of Colleges of Nursing, the voice of academic nursing, included in its 2021 publication "The Essentials: Core Competencies for Professional Nursing Education" under Domain 3.6 Population Heath the newly introduced competencies "Advance preparedness to protect population health during disasters and public health emergencies." It is now expected that nursing curricula in both undergraduate and graduate programs address the essential role and responsibilities of professional nurses in disaster care and emergency preparedness, planning, response, mitigation, and recovery from such events that impact our populations and community.

In addition, several state boards of nursing require nurses to complete a prescribed number of approved continuing education hours focused on bioterrorism for nursing license renewal. The Nevada Nurse Practice Act (NRS 632.343.3) mandates that 4 hr of bioterrorism education be completed by nurses biannually. The education must include a description of acts of terrorism, medical effects and treatment of agents used as WMD, appropriate categories of personal protective equipment (PPE) necessary for health care response to these agents, syndromic surveillance mechanisms, official reporting procedures, and an overview of the Health Alert Network ([HAN]; Nevada Nurse Practice Act, 2020). This article reviews important content prescribed within these mandates.

OVERVIEW

WMD include devices of chemical, biological, radiological, or nuclear (CBRN) origin intended for use by terrorists to cause mass harm to targeted populations (DHS, 2018). Attacks on the World Trade Center and Pentagon in 2001 used chemicals in the form of jet fuel for incendiary and explosive properties and to evoke widespread public panic from the horror and destruction that ensued. The physical harm caused by terrorist events can be represented by the acronym TRACEM: Thermal, Radioactive, Asphyxiation, Chemical, Etiological, and Mechanical (Adalja, 2018).

Biological agents consist of naturally occurring viruses, bacteria, fungi, chemicals, protozoa, parasites, and plant- or animal-derived toxins naturally occurring in the environment that cause immediate or delayed symptoms in humans, animals, or flora upon exposure. They are useful weapons of terror assaults because symptoms often take time to evolve, therefore not raising immediate suspicion (Janik, Ceremuga, Saluk-Bijak, & Bijak, 2019; Williams, Armstrong, & Sizemore, 2021). Many biological agents are infectious and can readily spread from person-to-person, reaching epidemic levels in populations.

Chemical agents used in bioterrorism are classified as nerve agents, choking agents, blister agents (BlisAs), and blood agents. These chemicals are present in the forms of gases, solids, and liquids. Chemicals are often selected for terrorist attacks because they can quickly incapacitate victims and be fatal. A person may be exposed to these agents through inhalation, ingestion, absorption, or injection (Mishra & Geiling, 2019). Access to chemicals, and development of methods to disperse them, often requires minimal effort and expense. They can easily contaminate

food and water sources and be discretely disseminated by spraying or within explosives. If a large number of wildlife or multiple people become ill or die within a short period of time, chemical or biological terrorism should be suspected. Reports of fumes or peculiar odors in conjunction with patient illness or demise also suggest the potential for a chemical source of injury (Madsen, 2020).

Radionucleotides can be deployed as WMD using widely available explosives such as dynamite or makeshift bombs. Contamination of food and water sources by radiation can effectively impact large numbers of unsuspecting individuals in a short period of time. Radioactive material cannot be detected visually and can easily spread by wind or other means of transport (Allen, Dainiak, & Wingard, 2021). Nuclear weapons spread radioactive material on a wider scale. Terrorists are most likely to select improvised nuclear detonation bombs (IND), but radiation exposures may also accompany destruction of nuclear reactors that may or may not result from terrorist activity (Allen, Dainiak, et al., 2021, National Institute for Occupational Safety and Health [NIOSH], 2008). Severity of contamination with radioactive material depends upon external or internal involvement and the specific contaminating radionucleotide. Internal contamination increases the risk of death.

PROTECTING HEALTH CARE PROVIDERS RESPONDING TO VICTIMS OF TERRORISM

The DHS endorsed performance standards for PPE used during response to acts of terrorism involving CBRN hazards. PPE must meet or surpass minimum requirements for use in CBRN incidents in both durability and physical properties (NIOSH, 2008). PPE used by health care providers when responding to victims of bioterrorism is categorized into three levels signified by letters A–C. The selection of PPE level is determined by the suspected hazard and the effects that the hazard may impart on the wearer in their specific role of response to the hazard. Level D PPE as recognized by the Occupational Safety and Health Administration (OSHA) and the U.S. Environmental Protection Agency (EPA) is standard work apparel plus gowns, gloves, and eye and face shields and is not appropriate for bioterrorism incidents (NIOSH, 2008). Dissemination of a biological WMD may be followed by distribution of a chemical WMD. This should be considered when selecting PPE for first responders and health care workers. If in doubt, advance to a more protective category of PPE.

Category A PPE provides the greatest level of protection from gases, vapors, aerosols, liquids, and solids and consists of a totally enveloping suit equipped with a self-contained breathing apparatus (SCBA).

Category B PPE protects the wearer from vapors, aerosols, liquids, and solids and consists of chemical-resistant outer clothing combined with an independent breathing apparatus.

Category C PPE is the minimum accepted protection for providing care to victims of WMD in the ED setting. Chemical-resistant clothing and an air purifier offer the wearer protection from vapors, aerosols, liquids, and solids.

The Hazardous Waste Operations and Emergency Response Standard (HAZWOPER), Title 29, Code of Federal Regulations (C.F.R.), Part 1920.120, defines categories of PPE for first responders and potentially to ED personnel stationed outside of the hospital more generally than those established by the OSHA and the EPA (NIOSH, 2008; OSHA, 2005). HAZWOPER Level A PPE is selected for the greatest anticipated hazards and is necessary when the highest level of skin, respiratory, and eye protection is needed. Level B PPE is appropriate when maximum respiratory protection is required, but skin protection is not as important. Level C PPE is selected when the airborne substance concentration and type are identified, and it is known that air-purifying respirators can protect the wearer from the substance (NIOSH, 2008).

The protection supplied by PPE is only as good as the quality of donning and doffing employed in its use. Recommended best practices for donning include a qualitative mask-fit test for respirators and shaving facial hair (if hair causes a break in seal), use of extended-cuff gloves to securely cover gown sleeve cuffs, and allowing adequate time to don PPE ensuring proper application (Munoz-Leyva & Niazi, 2020). Before donning PPE, hydrate sufficiently and use the lavatory. With assistance from an observer colleague, remove all personal items including jewelry before donning PPE outside of the patient care area (Richard & Kanchi, 2020). Increased care to avoid potential breaches in doffing procedures is critical. These may include ensuring that contact between the ungloved hand and the sleeve of the gloved hand be minimized and snapping of gloves be avoided. Avoid touching the front of the contaminated gown with bare hands. Do not touch the front of the mask or the face shield with the hands. Use alcohol-containing sanitizer for a minimum of 15 s following removal of each component of PPE (Munoz-Leyva & Niazi, 2020). It is crucial to only doff in a designated area with a skilled observer present. Discard used PPE into designated receptacles (Richard & Kanchi, 2020).

MANAGEMENT OF EXPOSURES TO CBRN AGENTS

Biological Agents

Biological agents are derived from toxins naturally occurring in the environment that can be weaponized and used as WMD. These toxins consist largely of bacteria, viruses, and rickettsia. Biological agents are categorized into three classes (A, B, C) according to their severity, degree of risk to public health, momentum for transmission, degree of resulting illness, and morbidity and mortality potential. Category A biological agents pose the highest priority threat and the greatest likelihood for mass casualties. Category B biological agents pose less potential for morbidity and mortality than category A biological agents and are less dependent on public health resources; Category C includes agents with potential for future threats and is the least acute risk level of the three categories but presents extraordinary potential for significant impact on health (Hallman, 2021). The number of biological agents potentially used for bioterrorism is expansive, with selection typically based on availability to the terrorist. Biological agents are ideal WMD because of their lethality, debilitating quality, resilience, and transmissibility. The following examples of biological agents are discussed by category.

Category A Biological Agents (Anthrax, Smallpox, Others)

Anthrax is caused by an aerobic, gram-positive, spore-producing bacterium (*Bacillus anthracis*) found in soil, mostly affecting animals. It is easily aerosolized and can enter the victim by inhalation, ingestion, absorption, and injection. Mechanism of entry is usually by the respiratory route. Spores enter and are transported to lymphoid tissue where they incubate for up to a week, resulting in bacteremia. Symptoms may include a dry cough, chest pain, and fever accompanied by anxiety and confusion. Cutaneous anthrax may cause fever and myalgias similar to influenza and produce vesicles that evolve to blackened lesions with associated lymphadenopathy. Hemorrhagic pleural effusions and a widened mediastinum on chest radiograph may present following anthrax inhalation. Infection by ingestion causes mouth lesions and symptoms of gastroenteritis with bloody stools and significant abdominal pain. Tachycardia may present, especially in cases of significant fever and dehydration. A combination of these symptoms may be found in anthrax entry by any route. PPE for aerosolized powder consists of universal precautions including face shield combined with N95 or powered air-purifying respirator (PAPR). The patient should be placed in respiratory and contact isolation. Remove contaminated clothing and jewelry and irrigate the skin with copious water. Anticipate

treatment with supplemental oxygen, early intubation and intravenous rehydration, and possibly pleural fluid drainage for significant effusions. Antibiotics effective in treating anthrax include ciprofloxacin, doxycycline, tetracyclines, and penicillin (Green, LeDuc, Cohen, & Franz, 2019).

Smallpox is caused by an extremely infectious virus (*Variola major*) that spreads easily as an aerosol. The infection can spread from person-to-person by inhalation of droplets from sneezes and coughs. Cutaneous absorption may occur following contact with contaminated surfaces and tissues. The virus replicates in epithelial cells within the respiratory tract. The incubation phase may last 7–19 days often without symptoms. High fever, chills, headache, lethargy, fatigue, abdominal pain, back pain, nausea, and vomiting develop and last about 4 days. As fever subsides, papular oral lesions develop in the oropharynx and then extend to the face and extremities, spreading centrifugally to the trunk, palms, and soles of the feet. Lesions evolve uniformly across the body, progressing from macules to papules and then to vesicles over 4–5 days. Vesicles evolve to pustules within the following 2 days. By Day 9, crusting and scabbing develop. Scabs slough off about 14 days after onset of the rash (Centers for Disease Control and Prevention [CDC], 2016). Secondary pneumonia may develop during the illness. An effective smallpox vaccine is available and may prevent severe symptoms if administered up to 7 days postexposure. Once a rash develops, effectiveness of the vaccine is greatly reduced (CDC, 2016). PPE consists of standard precautions, contact/droplet isolation, and NIOSH-approved N95 respirator. Decontamination is not usually required unless gross external exposure occurs. Personal decontamination consists of removal of contaminated clothing and thorough washing exposed skin with soap and water. Care is mostly supportive including supplemental oxygen and intravenous rehydration. Secondary bacterial infections including pneumonia should be treated with an appropriate antibiotic per facility protocol. Only personnel having previously received smallpox immunization should collect diagnostic specimens from vesicles. Any person having contact with the victim within the preceding 4 weeks before symptoms developed should be notified and placed in quarantine (CDC, 2016). Smallpox presents a significant risk to public health. Brisk reporting to both the local and state health departments and the CDC is mandatory.

Category B Biological Agents (Q-Fever, Ricin, Others)

Q-fever is caused by the bacterium *Coxiella burnetii* and is a resilient bacterial infection that occurs naturally in cattle, sheep, and goats and can persist in the environment for long periods. The bacteria attaches to macrophages for transport into cells where it fuses with lysosomes, replicates, and eventually ruptures host cells. This agent can be dispersed as an aerosol, as a contaminant in the food supply, or transported within a vector such as a mosquito. Diseased animals excrete the infection in body fluids and tissues. Entry to victims may be by inhalation, ingestion, or direct contact. Early symptoms of infection include persistent high fever, chills, tachycardia, myalgias, excessive headache, dry cough, and gastroenteritis, and a truncal maculopapular rash may develop. Symptoms of pneumonia, heart failure, hepatitis, and nuchal rigidity may evolve. PPE consists of standard precautions including gloves, gown, mask, and eye protection. Supportive therapies such as intravenous rehydration are determined by patient condition. Antibiotics may be used to treat Q-fever including doxycycline (first line), ciprofloxacin, tetracycline, moxifloxacin, clarithromycin, and rifampin. Trimethoprim/sulfamethoxazole may be administered to pregnant women up to 32 weeks' gestation and children younger than 8 years (Hallman, 2021; Raoult, 2020).

Ricin is a noncontagious, rapid-acting, and deadly poison derived largely from castor (*Ricinus communis*) beans. The poison is

disseminated in solid, liquid, and aerosol forms, entering by inhalation, ingestion, and injection, and quickly incapacitates victims. This toxin is not absorbed through intact skin. Ricin harbors two toxins that bind to host cells and inhibit cell protein synthesis, thus killing cells. PPE includes standard precautions including gown, gloves, mask, and eye covering. Decontamination of the victim is achieved by clothing removal and gently washing the skin with copious amounts of water and mild soap. Fever, nausea, chest tightness, and dyspnea accompanied by cough are common symptoms of inhalation entry. Abdominal pain, nausea, vomiting, and diarrhea that may be bloody are seen in ricin ingestion. General symptoms of poisoning are flu-like including malaise, fatigue, myalgias, and arthralgias. Dizziness, blurred vision, dehydration, tachycardia, hypotension and hypoxia, tachypnea, evolving cyanosis, and respiratory failure follow. There is no antidote for ricin poisoning. Patient management includes supplemental oxygenation with likely intubation, intravenous rehydration, and administration of blood products (Adalja, 2020). The CDC must be notified immediately of ricin poisoning.

Category C Biological Agents (Nipah Virus, Hantaviruses, Others)

Category C biological agents include an infinite number of emerging infectious pathogens that can be used for terrorism and are capable of widespread civil disruption. Examples of Category C agents include Hantaviruses, tick-borne viruses, Nipah virus (NiV), West Nile virus, coronaviruses, and influenzas. In order for an infectious agent to be used as a WMD, it must be stable, be capable of producing high morbidity and mortality, and be easily disseminated. Hantaviruses are rodent-borne and endemic to varied regions worldwide, including the Four Corners region of the western United States. The virus is disseminated by aerosol from saliva, urine, and feces of infected rodents and is transmitted to humans by inhalation and less often by ingestion. The Viral Special Pathogens Branch (VSPB) of the CDC provides diagnostics and surveillance when notified of an occurrence of human Hantavirus infection (CDC, 2020a). The disease cannot be transmitted from person-to-person. PPE for patient care activities includes gloves, gown, goggles, and a fit-tested respirator with HEPA filter or PAPR. Decontamination for overt exposures can be accomplished with 1% sodium hypochlorite, 2% glutaraldehyde, or 70% ethanol (Adalja, 2020). Symptoms usually present within 45 days of exposure to Hantavirus. Early symptoms of infection include fever, violent chills, fatigue, and severe myalgias, especially of large muscle groups, headaches, and gastrointestinal symptoms. Late symptoms include chest tightness, a smothering sensation, advancement to renal and pulmonary syndromes with thrombocytopenia, hemorrhage, and developing shock, likely leading to death. The virus can be detected in urine early in illness. Ribavirin is an effective treatment of Hantavirus if administered early in treatment. Other supportive therapies include dialysis and sustaining blood volume throughout recovery (Hjelle, 2020).

Nipah virus is a zoonotic virus thought to be transmitted by direct exposure to tissue or body fluids of infected animals or humans. The first acknowledged Nipah outbreaks in Malaysia and Singapore occurred in 1999 and were traced to direct contact with infected pigs. Fruit bats (*Pteropus* species) are a natural host of NiV, and other bat species are noted to have Nipah antibodies. Fruit contaminated by urine and saliva from fruit bats was suspected as the source of a 2001 outbreak of Nipah virus in Bangladesh and India (WHO, 2018). Early symptoms may be mild or flu-like with severe fever and myalgias, usually presenting within 4–18 days after exposure. Headache, cough, dyspnea, pharyngitis, and vomiting may be present. The disease advances to encephalitis with central nervous system (CNS) symptoms of drowsiness, confusion, seizures, and coma (Kamarulzaman & Goh, 2020). PPE consists of standard infection control and barrier techniques used to prevent nosocomial infections. Chloroform is

effective for decontaminating victims (Adalja, 2020).

Supportive care consists of rest, hydration, and symptom management. Monoclonal antibody therapy, remdesivir, and ribavirin may be helpful treatments, but use of these therapies for NiV is still under clinical investigation (Kamarulzaman & Goh, 2020).

Chemical Agents

Nerve Agents

Nerve agents were developed in the 1930s prior to World War II and acquired from pesticides and organophosphates. Tabun, sarin, soman, and VX are more recent potent nerve agents with significant lethality (Candiotti, 2017; National Center for Environmental Health, 2018). Nerve agents exhibit the greatest toxicity and most rapid onset of all known chemical warfare agents (National Center for Environmental Health, 2018). They are characteristically without color or taste, which makes the chemicals demanding to detect (Mishra & Geiling, 2019). All nerve agents inhibit cholinesterase at the synapse causing acetylcholine to accumulate in the tissues, resulting in systemic muscarinic and nicotinic effects (Ciottone, 2018). Symptoms depend on dose of poison, length of contact, and mechanism of entry into the victim. Symptoms may not be apparent for up to 18 hr in less significant exposures (Hallman, 2021). Nerve agents enter by inhalation, ingestion, and absorption through skin and mucus membranes. Initially, nerve agents cause disorientation, confusion, and sometimes hallucinatory behavior (Ciottone, 2018). Complete paralysis may develop rapidly, and fever and diaphoresis may evolve. CNS depression and cardiopulmonary arrest may follow. Inhaled nerve agent gases can produce death in less than 2 min; however, if a victim can survive for 30 min or longer without respiratory collapse, they may be able to survive the poisoning (Candiotti, 2017). Health care providers must maintain caution to avoid secondary poisoning while evaluating patients, performing decontamination procedures, and administering care. Carefully donning prescribed PPE to avoid dermal or mucus membrane contamination is critical.

Nerve agents affect nicotinic and muscarinic receptors and CNS cholinergic receptors. Clinical effects are dependent on the route and dose of exposure. Nicotinic effects of nerve agents impact striated muscle and sympathetic ganglia, resulting in fatigue, skeletal muscle defasciculation, generalized weakness, and flaccid paralysis. Initially, nerve agents affect muscarinic receptors of the pupils, ciliary body, nasal mucus membranes, bronchial tree, and gastrointestinal system. Following systemic absorption, sweat glands, salivary glands, lachrymal glands, heart, and bladder are affected (CDC, 2018a, 2018b; Huebner, 2021). The acronym SLUDGE (salivation, lacrimation, urination, defecation, gastric distress, and emesis) provides an easy recall of common muscarinic effects of nerve agents (Mishra & Geiling, 2019). Effects of nerve agents on CNS cholinergic receptors result in depressed levels of consciousness and mentation and cause respiratory and circulatory depression.

Respiratory effects commonly consist of profuse rhinorrhea, excessive respiratory secretions, dyspnea, hyperpnea and bradypnea, and complaints of chest tightness (CDC, 2018a, 2018b). Tachycardia and elevated blood pressure are early cardiovascular symptoms of poisoning. Bradycardia, declining blood pressure, and dysrhythmias, particularly a prolonged QT interval, are late symptoms of nerve agent poisoning. Patients may complain of abdominal pain with nausea, vomiting, diarrhea, and increased urination. Muscle twitching and weakness progressing to paralysis may also occur. Diaphoresis, excessive tearing, and injection of the corneas are common. A laboratory finding of decreased red blood cell cholinesterase raises suspicion for nerve agent poisoning (Hallman, 2021).

In preparation to treat victims of nerve agent exposure, health care workers should don at minimum a Level C PPE ensemble that

includes head and face covering with tight-fitting goggles and a chemical-resistant suit, double-layer chemical gloves, butyl rubber boots, and a NIOSH-approved PAPR with particulate air/organic vapor/acid gas respirator cartridges (Hallman, 2021). It is crucial that the PPE be sealed carefully to avoid exposure to chemical gases (Candiotti, 2017). Decontamination should be accomplished outside of the ED, preferably in the prehospital setting, prior to transport. The patients clothing and jewelry should be completely removed, and any dressings applied in the field must be removed and discarded. Liberal soap and water should be used to gently wash the patient's skin. Special care should be taken to avoid skin tears or breaks that would allow chemical entrance into body tissues. Flush eyes with normal saline or Ringer's lactate solution for at least 15 min (Bagheri, Wajda, Calvo, & Durrani, 2016). All contaminated materials must be double plastic bagged and disposed of in an area away from personnel and high ED traffic. After decontamination has been completed, health care providers may begin definitive care, which may include intubation, resuscitation, and provision of ongoing assessment coupled with supportive care. The goal in treatment of nerve agent exposure is to terminate symptoms including drying of excess secretions, reversal of nerve agent sequelae, and restoration of normal cardiopulmonary functions. Nerve agents are typically treated with a combination of three drug classes. Anticholinergics such as atropine may be useful in terminating bronchorrhea and life-threatening bradycardia. Oximes are administered to reverse muscarinic and nicotinic signs and symptoms. Benzodiazepines are useful for seizure prophylaxis and management. Specific antidotes such as pralidoxime (2-PAM, Protopam) can be administered once the patient is stabilized to regenerate enzyme activity and reverse paralysis (Candiotti, 2017; Hallman, 2021). Acetylcholinesterase (AChE) undergoes a biochemical process known as "aging" that may render the oxime class of drugs unable to regenerate AChE following nerve agent poisoning. Therefore, oximes should be given rapidly following nerve agent exposure to avoid irreversible inhibition of AChE (Newmark, 2019).

Choking Agents

Phosgene and chlorine are common choking agents disseminated by inhalation and commonly used for chemical warfare. Chlorine gas is an industrial agent that is easily produced and very effective as a chemical weapon (Zellner & Eyer, 2020). Chemical choking agents usually have characteristic appearances or noticeable odors, making them easier to identify. They dissipate rapidly, sometimes within an hour. Choking agents produce pulmonary capillary and alveolar damage at the cellular level, resulting in pulmonary edema and impaired oxygenation. Chlorine gas is an irritant and generates acids when it reacts with moisture of respiratory tract tissues, resulting in tracheobronchial constriction, significant inflammation, and increased mucus production (Zellner & Eyer, 2020). Chlorine as a liquid is capable of absorption, resulting in systemic toxicity. Chlorine affects vasculature, which may lead to cardiac injury with subsequent heart failure and hypotension (Zaky et al., 2015). Significant exposure to chlorine gas may result in neurotoxicity (Zellner & Eyer, 2020).

Symptoms of chlorine gas exposure are dependent on chemical concentration and length of exposure and usually begin immediately. Delayed symptoms of up to 24 hr are likely with phosgene exposure but may also occur with exposure to chlorine. Irritation of the eyes and pharynx, drooling, burning of the lips and mouth, and moderate upper respiratory tract irritation develop accompanied by dry cough and choking. Chemical pneumonitis and pulmonary edema may develop, resulting in death within minutes or may rapidly progress to acute respiratory distress syndrome. Sloughing of nasal and oral mucosa and the tracheal lining, chest pain, shortness of breath, bronchospasm, and tachypnea evolve. Swelling of the glottis and laryngospasms are potentially life-threatening

developments. Hemoptysis, nausea, vomiting, and headache are common symptoms of exposure. Asphyxiation is the ultimate cause of death from chorine gas exposure (Hallman, 2021; Zellner & Eyer, 2020).

Immediate removal of victims from the hazardous gas is the initial step in treatment. Decontamination is unnecessary for chlorine gas alone. Unless confirmed that no other biochemical agent exists, don Level C PPE and proceed with decontamination following the procedure for nerve agents discussed earlier. Inspect the eyes for conjunctival injection and corneal and oral tissues for erosion. Pulmonary evaluation may reveal bronchospasm and possibly stridor with impaired oxygen saturation levels. If stridor, glottic edema, or laryngospasm are present, laryngoscopy should be performed immediately to determine whether rapid intubation or a surgical airway is required. Continuous co-oximetry is essential, and a baseline chest radiograph and arterial blood gases should be obtained. There is no antidote for chlorine gas poisoning. Development of worsening airway edema leading to compromised oxygenation and ventilation will require intubation and mechanical ventilation with added positive end-expiratory pressure (PEEP). Consider antibiotic prophylaxis for secondary bacterial infection often accompanying chemical pneumonitis. High-flow oxygen and regular suctioning should also be initiated. If persistent hypotension is present, vasopressors may be initiated (Hallman, 2021; Zellner & Eyer, 2020).

Blister Agents

Blister agents are vesicants that are noxious to eyes and mucosa and can produce excessive chemical burns and significant damage to organs. These chemicals are categorized as mustards (most common), arsenicals, and urticants. The most common BlisAs are sulfur mustard, phosgene oxime, and lewisite (Hallman, 2021). Sulfur mustard, the most common BlisA, is thick, oily, and yellow–brown in color and has a recognizable smell of mustard, onion, or garlic. This agent is thought to cause alkylation of DNA, which results in strand breaking and ultimate cell death. Phosgene oxime is an urticant that is yellow–brown as a liquid with a very irritating odor. Its vapor is heavier than air, so it is low lying in the environment but degenerates quickly. Phosgene oxime causes substantial corrosion and insurmountable pain immediately on contact with eyes, skin, and the respiratory tract. Noteworthy is the ability of phosgene oximes to penetrate rubber and clothing more rapidly than any other agent used for chemical warfare (Ciottone, 2018; Mishra & Geiling, 2019). Lewisite is an arsenic compound that inhibits sulfhydryl enzymes, leading to cell necrosis (Mishra & Geiling, 2019). This agent is oily, but without a classic smell, and more volatile than sulfur mustard (Ciottone, 2018).

Symptoms of BlisA poisoning are specific to the offending chemical. Initially, sulfur mustard agents are not very painful. They cause anxiety, fatigue, redness, and swelling of the skin, irritated eyes, coughing, pulmonary edema, and eventual respiratory failure. The blisters from sulfur mustard may have a "string-of-pearls" appearance. Phosgene oxime and lewisite are very corrosive, significantly painful, and cause severe skin lesions. Phosgene oxime causes skin blanching that evolves to wheals but not blisters. Lewisite may cause symptoms within seconds to minutes, resulting in blinding, mucus membrane sloughing and hoarseness, and a painful, burning, blistering skin rash that is characteristic of individual vesicles with erythematous bases. Third-spacing and resulting hypotension is common with significant lewisite exposure. Sulfur mustard exposure usually does not result in death, and symptoms may be delayed up to 24 hr. Exposure to liquid sulfur mustard can produce extensive second- and third-degree burns, leading to significant scarring (CDC, 2018a, 2018b). Vesicles caused by BlisAs may evolve to bullae lasting for months; however, the fluid in these bullae does not contain the offending agent. Eventually, tremors,

seizures, and coma develop (Ciottone, 2018; Hallman, 2021; Mishra & Geiling, 2019).

Level A PPE with an SCBA is required for health care workers caring for victims of BlisA exposure. Treatment of BlisAs is similar to treatment of thermal burns. It is important to anticipate early intubation and ventilator support. Double antibiotic ointment and silver sulfadiazine cream may be used to treat topical wounds, with bandaging appropriate for the involved area. Administer ocular antibiotics for eye involvement. Systemic antibiotics may be required for larger areas of affected skin. Steroids may be necessary for pulmonary bronchospasms. Because BlisAs are typically very painful, pain management medications and other supportive therapies should be considered early in treatment. Lewisite poisoning may specifically be treated with an antidote, dimercaprol, or British anti-lewisite (BAL) intramuscularly. Topical and cutaneous BALs are not available in the United States. There are no antidotes for sulfur mustard or phosgene oxime (Hallman, 2021; Mishra & Geiling, 2019).

Blood Agents

Blood agents enter through the respiratory tract, ingestion, or absorption and act by blocking cellular respiration in organs and tissues. This results in anaerobic metabolism and lactic acidosis with eventual asphyxiation. Common examples of these substances include hydrogen cyanide and cyanogen chloride. The odor of hydrogen cyanide has been described as that of bitter almonds. Both of these blood agents can be distributed as WMD in the form of liquid, gas, or aerosol (Ciottone, 2018; Hallman, 2021).

Blood agents cause air hunger, symptoms of headache, confusion, cardiac dysrhythmias, syncope, seizures, and failure of respiratory and cardiac systems, culminating in death. Frothy sputum and complaints of metallic taste have been observed in many of these patients. Skin flushing may appear cherry red in color and may occur in cyanide poisoning with eventual transition to cyanosis as symptoms progress. Sweating, itching, and swelling are common symptoms of skin exposure to blood agents. Blood pressure and pulse may elevate initially but trend downward to bradycardia and atrioventricular block with associated hypotension as poisoning progresses.

Health care providers should don a chemical-resistant suit with head and face coverings, impermeable boots, and double-layer protective gloves, as well as a NIOSH-approved PAPR or a gas respirator with 99.97% high-efficiency particulate air/organic vapor/acid gas respirator cartridges before providing care to a victim contaminated by blood agents (Hallman, 2021). Decontamination consists of gentle cleansing with generous soap and water. Eyes may be flushed with water or saline for a minimum of 15 min if ocular contamination is present. Hydroxocobalamin is the preferred treatment of cyanide poisoning. Availability of pharmaceutical agents to treat cyanide poisoning may vary by region or hospital (Madsen, 2020).

Radiological/Nuclear Agents

Ionizing radiation may produce skin or tissue damage based on the type of radiation and whether the exposure is external or internal. Types of ionizing radiation include alpha and beta particles, gamma rays, neutrons, and x-rays. Alpha particles are only able to shallowly penetrate skin with an external exposure but may cause systemic damage with internal exposure such as ingestion. Beta particles, in comparison, can inflict much deeper injury to the dermal and subcutaneous tissues with an external exposure and cause more severe systemic insult with internal exposure. Gamma rays and x-rays can efficiently penetrate deep tissues and organs of the body even with an external exposure. Neutrons diffuse both alpha and beta particles and also gamma rays, giving neutron particles the ability to inflict injury at multiple tissue levels (Allen, Dainiak, et al., 2021; McCullough, 2021).

Nuclear incidents may occur unintentionally or may be intentionally induced in an act of terrorism. There are two essential threats

associated with intentional nuclear incidents: nuclear bomb explosion, and detonation of a device to distribute nuclear materials. A radiological dispersal device also known as a "dirty bomb" houses radioactive material as powder or pellets with conventional explosives to scatter radioactive material over small to expansive areas. Determining whether a bomb includes radiation particles is accomplished using a Geiger counter. Health care providers may be unaware of contaminated victims if they present to the ED from the vicinity of explosion before measurements are accomplished (Cangemi, 2002; McCullough, 2021). Impacted victims may be externally or internally irradiated or contaminated. Patients who are contaminated risk irradiating or contaminating others including the health care workers who care for them if not properly decontaminated.

Internal exposure to radiation results from inhalation, ingestion, or absorption through the mucous membrane or nonintact skin of radioactive liquid or dust (Allen, Dainiak, et al., 2021). Radiation is usually transmitted to victims as a liquid or dust and inhaled, ingested, or absorbed through mucosal surfaces and breaks in skin integrity, resulting in internal contamination (Allen, Dainiak, et al., 2021). Severity of symptoms is determined by radiosensitivity of the contaminated area, size of area irradiated, type of radiation, and the dose and duration of exposure. Cutaneous radiation injury may present rapidly, and death, if it results, may occur quickly or be extended over days or weeks. Acute radiation syndrome (ARS) may occur when victims sustain whole-body exposure to high-dose radiation. The syndrome evolves in four recognized stages: prodromal, latent, manifest illness, and recovery or death phases. In the prodromal phase, patients commonly present with nausea, vomiting, anorexia, and diarrhea that may occur within minutes of exposure or may be delayed for several days and may last episodically for several days. The latent phase lasts up to a few weeks during which the patient may be symptom free. During the illness phase, symptoms are dependent on the specific syndrome present (hematopoietic, gastrointestinal, cardiovascular, and CNS) based on the radiation dose. Multisystem organ failure and death are expected with high-dose exposures, but survival is possible with likely chronic sequelae (Williams et al., 2021). Local radiation exposure may result in burns progressing from redness to blisters and tissue necrosis. Fever, headache, dizziness, fatigue, anorexia, confusion, gastroenteritis, bleeding resulting from cytopenias, and alopecia occur in systemic exposures (Allen, Dainiak, et al., 2021).

Level A PPE should be worn if health care providers are responding and staged near the radiation disaster site. To reduce potential for caregiver exposure during decontamination and initial care phases for victims of radiation incidents, PPE minimally consisting of a waterproof suit, surgical cap, mask, face shield, shoe covers, and double-layer protective gloves. PPE may not provide complete protection from radiation exposure, but it can decrease potential for direct contamination by radiation-containing substances (Allen, Wingard, & Dainiak, 2021). Lead aprons or vests offer some protection from x-rays and gamma rays. It is essential that real-time dosimeters be worn by all health care personnel responding to the event to monitor total radiation exposure.

Decontamination of noncritical patients should be completed in a staged area outside and away from the ED to decrease the risk of facility contamination. Rotating personnel to decrease length of exposure is important. Pregnant workers should not be involved in the decontamination process but can assume care once decontamination is complete. Critical patients should be resuscitated while being decontaminated if possible. Remove clothing and gently wash the skin and hair with mild soap and water, with particular attention to open wounds and mucus membranes. Following decontamination, transfer the patient to a clean stretcher and move to a "clean area" of the ED or other designated area of the hospital (Allen, Wingard, et al.,

Table 1. Resources

Resource	Website	Documents/Searches
CDC Radiological Preparedness and Response	https://www.cdc.gov	Radiologic Threat Agents Radiologic Emergency Fact Sheet Radiologic Exposure Device Radiological Emergency Preparedness Program (REPP)
EPA Radiological Preparedness and Response	https://www.epa.gov	Radiological Emergency Preparedness and Response
Radiation Injury Treatment Network (RITN)	https://www.ritn.net	
Bioterrorism: CDC Emergency Preparedness and Response	https://www.cdc.gov	Bioterrorism
Bioterrorism: A Public Health Perspective National Institute of Health	https://www.ncbi.nlm.nih.gov	
Chemical Agents: CDC Emergency Preparedness and Response	https://www.cdc.gov	Chemical Agents
Chemical Warfare Agents: National Institutes of Health	https://www.ncbi.nlm.nih.gov	
CHEMTREC Emergency Response	https://www.chemtrec.com	

Note. CDC = Centers for Disease Control and Prevention; EPA = Environmental Protection Agency.

2021). Preparing an ED to accept patients following a radiation event requires detailed setup and safety measures. Instructions for preparation should be located in the hospital's disaster response plan. Life-threatening injuries must be stabilized before proceeding to treatment of radiation exposure. Intravenous rehydration and antiemetics are the mainstay of supportive care. Potassium iodide may be beneficial if administered within 4 hr of contamination. The CDC provides specific guidelines for the use of potassium iodide for infants, children, young adults, and pregnant and breastfeeding women (McCullough, 2021).

Various federal agencies are involved with preparedness education, policy, and response including the CDC and the EPA. Consistent messaging has been developed for the community by these agencies in the event of a radiological emergency. "Get inside, stay inside, stayed tuned." Consistent messaging for the community is vital during all disaster events. Refer to Table 1 for a list of resources.

The most current medical countermeasures and treatments of radiation exposure and contamination can also be found on the cdc.gov site under Radiation Emergencies, which includes potassium iodide (KI), Prussian blue, DTPA (diethylenetriamine pentaacetate), and Neupogen. The Radiation Injury Treatment Network (RITN) also provides valuable guidelines from medical specialist in managing acute radiation exposure (ARS). It is important to remember to follow your local protocols for reporting of incidents both within your agency or service and to governmental agencies having authority and

jurisdiction such as public health and the emergency management agency.

SYNDROMIC SURVEILLANCE

Syndromic surveillance systems monitor and detect natural outbreaks of disease and biological terrorism activities. The primary goal of these systems is to detect community patterns of symptoms with potential for epidemic illness early, even before the identity of the disease is determined (CDC, 2017; Green et al., 2019; Hopkins et al., 2017). Syndromic surveillance systems use existing health data in real time to provide immediate analysis and feedback to those charged with investigation and follow up of potential outbreaks (Atakro et al., 2019; CDC, 2021a, 2021b). The National Syndromic Surveillance Program (NSSP) is an alliance of agencies that gathers and inspects shared electronic information from health care encounters through the BioSense platform. The partnership includes the CDC, other federal agencies, health departments at both local and state levels, academic colleagues, and partners from the private sector. By working jointly, these agencies share information to improve syndromic surveillance systems. The data come from EDs, urgent care centers, ambulatory care center, inpatient agencies including hospitals and laboratories in Washington, DC, and 49 states across the nation (CDC, 2021a, 2021b). Other examples of active syndromic surveillance systems include Electronic Surveillance System for the Early Notification of Community-Based Epidemics (ESSENCE), Rapid Syndrome Validation Project (RSVP), and Real-Time Outbreak Disease Surveillance (RODS). These systems glean data from multiple sources including patient records and social media and have connected scientists globally and served to assist in monitoring epidemics such as severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS). Electronic symptom information collection must be adequate to recognize potential disease outbreaks, and accessing private information and patient records also poses obstacles for syndromic surveillance agencies. Their use globally requires additional exploration (Green et al., 2019). Other systems exist to monitor for potential outbreaks. Environmental surveillance systems such as Biowatch use specially placed air sensors that continually monitor for potential disease outbreaks in 31 major U.S. cities by detecting aerosolized biological substances and sending samples to special laboratories for analysis. There are wearable biosurveillance platforms in operation that use multiple technologies synchronously to monitor for disease outbreaks, communicating with higher level processors to identify threats. In situations where multiple security threats exist concurrently, these systems would not be as beneficial because they only recognize single-threat potential disease outbreaks (Green et al., 2019). In October 2021, the CDC announced new funding allocation for development of advanced infectious disease outbreak forecasting and analytics. This initiative will improve preparedness and response to future pandemics, support public health decision making, train future infectious disease modelers, and address health inequities during outbreaks (CDC, 2021a, 2021b).

REPORTING PROCEDURES AND AGENCY RESOURCES FOR PATIENT MANAGEMENT

Exceptional communication between health care providers and local, state, and government reporting agencies is crucial. Health care agencies are often first to be aware of bioterrorism incidents. A current list of emergency telephone numbers and contact information for required agencies and individual personnel to be notified in the event of a suspected bioterrorism incident should be part of the health care facility bioterrorism readiness plan. Rapid notification of health care agency administration and infection control personnel will facilitate active engagement in response. Local and state health departments,

the closest FBI field office, local police, the CDC, and surrounding emergency services agencies should be notified of the suspected incident (English, 1999). The CDC includes reporting requirements for many bioterrorism agents in its guidelines (CDC, 2020a, 2020b, 2020c). The U.S. Poison Control Network can be accessed to assist in determining a plan of care for victims of bioterrorism. There are 55 poison centers available at all times serving the United States (Arnold, Borger, & Nappe, 2020). In the known or suspected incidence of a radiological event, the emergency medical response plan should be activated. Expert workers from radiation services, such as nuclear medicine and radiology, and the radiation safety officer should be notified to offer guidance in managing victims of radiation exposure. The Radiation Emergency Assistance Center and Training Site (REAC/TS), a branch of the U.S. Department of Health and Human Services (U.S. DHHS, n.d.), provides numerous resources to assist in planning for radiation emergencies and is readily available to assist in guiding health care response to victims sustaining radiation exposure (U.S. DHHS, n.d.). A large cohort of U.S. academic medical centers created the Patient Evacuation Resource Classification (PERC) system in order to assist health system agencies and emergency medical systems to strategize use of resources including staffing during disasters (Ventura, 2020). The system also addresses risks involved in individual patient evacuation. The PERC system allows hospitals to collaborate and plan for off-loading of patients to other agencies expeditiously during a disaster or bioterrorism response.

COMMUNICATION DURING BIOTERRORISM EVENTS

Notification of the general public and activation of public health entities following a bioterrorism event require efficient coordination with law enforcement officials and prehospital emergency services personnel. Public messaging through the media can reach a large sector of the community (Adalja, 2020). The HAN is a communication network develop to promote advocacy by prioritizing development of information system development to improve terrorism preparedness within local, state, tribal, and territorial public health agencies (Baker & Porter, 2005; Martinez, Talbert, Romero-Steiner, Kosmos, & Redd, 2019). After September 11, 2001, the focus of the HAN, which consists of all local health departments, is to use information technology to electronically communicate for matters of public health awareness. Early on the system was more active as a national system but has evolved to be a richer state and local system for communicating infectious disease outbreaks and natural disasters (Baker & Porter, 2005). The CDC communicates timely details related to public health incidents through the HAN to public information officers, public health providers and workers, other health care workers who request notification, and laboratories associated with public health. Public health personnel are responsible for passing the information on to patients and the public, which can contribute to delay of information in an emergency (Sharma & Panigrahi, 2020).

CONCLUSION

Bioterrorism is a global threat that has impacted the United States on multiple occasions, most notably in the form of anthrax dispersal. However, all emergency disaster incidents begin in the local community, although they may expand into regional, state, national, and international problems with public health, political, economic, and social consequences. Nurses are among the first to respond and frequently must see communities through recovery. Syndromic surveillance systems provide monitoring to detect diseases and symptoms of illness in communities in real time. This allows for early detection of disease outbreaks and potential terrorist activities. A complex and structured network of agency and public communication that includes local and national response

plans is essential to protect public health and to reduce or mitigate new exposures. Maintaining a high index of suspicion and heightened awareness combined with specialized training that includes frequent simulation experiences to build retained knowledge is essential for emergency health care providers because these personnel are often the first to suspect and alert authorities that biological poisonings have occurred and to provide initial care. ED and other hospital personnel must carefully prepare to respond to bioterrorism events. A clear understanding of PPE necessary to care for patients contaminated by bioterrorism agents specific to agents and mechanisms of dispersal is essential to protect the provider as well as patients and other personnel. Basic knowledge of the pathophysiology, symptoms, assessment, management, and reporting requirements for agents commonly used in bioterrorism is essential in order to provide safe and quality care to patients during CBRN terrorism events.

REFERENCES

Adalja, A. A. (2018). Identifying and managing casualties of biological terrorism. In A. Bloom (Ed.), *UpToDate*. Retrieved August 1, 2018 from, https://www.uptodate.com/contents/identifying-and-managing-casualties-of-biological-terrorism

Adalja, A. A. (2020). Identifying and managing casualties of biological terrorism. *UpToDate*. Retrieved August 24, 2021, from https://www.uptodate.com/contents/identifying-and-managing-casualties-of-biological-terrorism

Allen, J. Y., Dainiak, N., & Wingard, J. R. (2021, July). Clinical manifestations, evaluation, and diagnosis of acute radiation exposure. *UpToDate*. Retrieved August 15, 2021, from https://www.uptodate.com/contents/clinical-manifestations-evaluation-and-diagnosis-of-acute-radiation-exposure

Allen, J. Y., Wingard, J. R., & Dainiak, N. (2021, April). Management of radiation injury. *UpToDate*. Retrieved August 15, 2021, from https://www.uptodate.com/contents/management-of-radiation-injury

Arnold, J. K., Borger, J., & Nappe, T. M. (2020). *Poison control in the United States*. Treasure Island, FL: StatPearls Publishing. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK537316/#_NBK537316_pubdet_

Atakro, C. A., Addo, S. B., Aboagye, J. S., Blay, A. A., Amoa-Gyarteng, K. G., Menlah, A., … Sarpong, L. (2019). Nurses' and medical officers' knowledge, attitude, and preparedness toward potential bioterrorism attacks. *SAGE Open Nursing*, *5*, 2377960819844378. doi:10.1177/2377960819844378

Bagheri, N., Wajda, B., Calvo, C., & Durrani, A. (Eds.). (2016). *The Wills eye manual: Office and emergency room diagnosis and treatment of eye disease* (7th ed.). Philadelphia, PA: Lippincott Williams & Wilkins.

Baker, E., & Porter, J. (2005). The Health Alert Network. *Journal of Public Health Management and Practice*, *11*(6), 574–576. Retrieved from https://oce.ovid.com/article/00124784-200511000-00017/HTML

Candiotti, K. (2017). A primer on nerve agents: What the emergency responder, anesthesiologist, and intensivist needs to know. *Canadian Journal of Anesthesia*, *64*, 1059–1070. doi:10.1007/s12630-017-0920-2

Cangemi, C. W. (2002). Occupational response to terrorism. *AAOHN Journal*, *50*(4), 190–198. doi:10.1177/216507990205000413

Centers for Disease Control and Prevention (CDC). (2016, June). *Smallpox signs and symptoms*. Retrieved December 10, 2021, from https://www.cdc.gov/smallpox/symptoms/index.html

Centers for Disease Control and Prevention (CDC). (2017). *National Syndromic Surveillance Program: Syndromic surveillance data in action*. Retrieved August 20, 2021, from https://www.cdc.gov/nssp/biosense/action.html

Centers for Disease Control and Prevention (CDC). (2018a, April). *Facts about sulfur mustard*. Retrieved December 11, 2021, from https://emergency.cdc.gov/agent/sulfurmustard/basics/facts.asp

Centers for Disease Control and Prevention (CDC). (2018b). *Nerve agent and organophosphate pesticide poisoning. Emergency preparedness and response, toxic syndrome description, nerve agent and organophosphate pesticide poisoning*. Retrieved August 2, 2021, from https://emergency.cdc.gov/agent/nerve/tsd.asp

Centers for Disease Control and Prevention (CDC). (2020a, December 1). *Diseases caused by high-consequence viruses*. Atlanta, GA: Viral Special Pathogens Branch, Division of High-Consequence Pathogens and Pathology, National Center for Emerging and Zoonotic Infectious Diseases, Centers for Disease Control and Prevention. Retrieved August 12, 2021, from https://www.cdc.gov/ncezid/dhcpp/vspb/diseases.html

Centers for Disease Control and Prevention (CDC). (2020b). *Bioterrorism. Emergency preparedness and response*. Retrieved August 2, 2021, from https://emergency.cdc.gov/bioterrorism

Centers for Disease Control and Prevention (CDC). (2020c, October). *Nipah virus, signs and symptoms in viral hemorrhagic fevers*. Retrieved September 4, 2021, from https://www.cdc.gov/vhf/nipah/symptoms/index.html

Centers for Disease Control and Prevention (CDC). (2021a). *Data modernization initiative: An urgent need to modernize*. Atlanta, GA: Center for Surveillance, Epidemiology, and Laboratory Services, Centers for Disease Control and Prevention. Retrieved September 3, 2021, from https://www.cdc.gov/surveillance/surveillance-data-strategies/dmi-investments.html

Centers for Disease Control and Prevention (CDC). (2021b, October 26). *CDC to invest $26 million in advanced outbreak forecasting and analytics* [Press release]. Retrieved from https://www.cdc.gov/media/releases/2021/p-1026-mill-funding.html

Ciottone, G. R. (2018). Toxidrome recognition in chemical-weapons attacks. *The New England Journal of Medicine*, *378*(17), 1611–1620. doi:10.1056/NEJMra1705224

English, J. F. (1999). Overview of bioterrorism readiness plan: A template for health care facilities. *American Journal of Infection Control*, *27*(6), 468–469. doi:10.1016/S0196-6553(99)70022-2

Fink, J. (2021, September 11). What happened on 9/11: Facts, victims of attacks, on World Trade Center, Pentagon, United 93. *Newsweek 2021 Digital LLC*. Retrieved from https://www.newsweek.com/what-happened-9-11-facts-victims-attacks-world-trade-center-pentagon-united-93-1627265

Green, M. S., LeDuc, J., Cohen, D., & Franz, D. R. (2019). Confronting the threat of bioterrorism: Realities, challenges, and defensive strategies. *The Lancet Infectious Diseases*, *19*(1), e2–e13. Retrieved from https://www.sciencedirect.com/science/article/pii/S1473309918302986

Hallman, M. G. (2021). Chemical and biological weapons. In R. S. Holleran & T. M. Campo (Eds.), *Emergency nurse practitioner core curriculum* (pp. 551–573). New York: NY: Springer. doi:10.1891/9780826141477

Hjelle, B. (2020). Hantavirus cardiopulmonary syndrome. *UpToDate*. Retrieved August 30, 2021, from https://www.uptodate.com/contents/hantavirus-cardiopulmonary-syndrome

Hopkins, R. S., Tong, C. C., Burkom, H. S., Akkina, J. E., Berezowski, J., Shigematsu, M., … Streichert, L. C. (2017). A practitioner-driven research agenda for syndromic surveillance. *Public Health Reports*, *132*(1, Suppl.), 116S–126S. doi:10.1177/0033354917709784

Huebner, K. D. (2021). CBRNE: Nerve agents, G-series—Tabun, Sarin, Soman. *Medscape*. Retrieved from https://emedicine.medscape.com/article/831648-overview

Janik, E., Ceremuga, M., Saluk-Bijak, J., & Bijak, M. (2019). Biological toxins as the potential tools for bioterrorism. *International Journal of Molecular Sciences*, *20*(5), 1181. doi:10.3390/ijms20051181

Kamarulzaman, A., & Goh, K. J. (2020). Nipah and Hendra viral encephalitis. *UpToDate*. Retrieved August 30, 2021, from https://www.uptodate.com/contents/nipah-and-hendra-viral-encephalitis

Madsen, J. M. (2020). Chemical terrorism: Rapid recognition and initial medical management. *UpToDate*. Retrieved August 1, 2021, from https://www.uptodate.com/contents/chemical-terrorism-rapid-recognition-and-initial-medical-management

Martinez, D., Talbert, T., Romero-Steiner, S., Kosmos, C., & Redd, S. (2019). Evolution of the public health preparedness and response capability standards to support public health emergency management practices and processes. *Health Security*, *17*(6), 430–438. doi:10.1089/hs.2019.0076

McCullough, M. A. (2021). Radiation injuries. In R. S. Holleran & T. M. Campo (Eds.), *Emergency nurse practitioner core curriculum* (pp. 495–496). New York: NY: Springer. doi:10.1891/9780826141477

Mishra, R., & Geiling, J. (2019). Chemical agents in disaster. *Critical Care Clinics*, *35*(4), 633–645. doi:10.1016/j.ccc.2019.05.002

Munoz-Leyva, F., & Niazi, A. U. (2020). Common breaches in biosafety during donning and doffing of protective personal equipment used in the care of COVID-19 patients. *Canadian Journal of Anesthesia*, *67*(7), 900–901. doi:10.1007/s12630-020-01648-x

National Center for Environmental Health. (2018, April 4). *Facts about VX*. Atlanta, GA: Department of Health and Human Services, Centers for Disease Control and Prevention. Retrieved November 26, 2021, from https://emergency.cdc.gov/agent/vx/basics/facts.asp

National Institute for Occupational Safety and Health (NIOSH). (2008). *Guidance on emergency responder personal protective equipment (PPE) for response to CBRN terrorism incidents* (DHHS NIOSH Publication No. 2008-132). Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. Retrieved from https://www.cdc.gov/niosh/docs/2008-132/pdfs/2008-132.pdf?id=10.26616/NIOSHPUB2008132

Nevada Nurse Practice Act. (2020). *NRS 632.343.3*. Retrieved from https://nevadanursingboard.org/wp-content/uploads/2020/04/BIO-updated-003.pdf

Newmark, J. (2019). Therapy for acute nerve agent poisoning: An update. *Neurology Clinical Practice*, *9*(4), 337–342. doi:10.1212/CPJ.0000000000000641

Occupational Health and Safety Administration. (2005). *Best practices for hospital-based first receivers of victims from mass casualty incidents involving the release of hazardous substances* (OSHA 3249-O8N). Washington, DC: U.S. Department of Labor. Retrieved from https://www.osha.gov/sites/default/files/publications/osha3249.pdf

Raoult, D. (2020). Treatment and prevention of Q fever. *UpToDate*. Retrieved August 24, 2021, from https://www.uptodate.com/contents/clinical-manifestations-and-diagnosis-of-q-fever

Richard, V. S., & Kanchi, M. (2020). A practical guide to a safe sequence of donning and doffing of personal protective equipment in relation to COVID-19. *Journal of Critical Care*, *4*(1), 61–63. doi:10.1055/s-0040-1712804

Sharma, D., & Panigrahi, A. (2020). Health Alert Network. *Archives of Community Medicine and Public Health*, *6*(1), 26–27. doi:10.17352/2455-5479.000066

U.S. Department of Health and Human Services. (n.d.). *Emergency preparedness and subject matter expertise on the medical management of radiation incidents*. Oak Ridge, TN: Oak Ridge Institute for Science and Education–Radiation Emergency Assistance Center/Training Site-REAC/TS. Retrieved September 12, 2021, from https://orise.orau.gov/reacts/index.html

U.S. Department of Homeland Security (DHS). (2018, August). *Weapons of mass destruction*. Retrieved from https://www.dhs.gov/topic/weapons-mass-destruction

Ventura, G. (2020). Development of patient evacuation resource classification system (PERC) using systems engineering to assist hospital evacuations in a disaster. *Disaster Medicine and Public Health Preparedness*, *15*(3), 1–10. doi:10.1017/dmp.2020.92

Wagar, E. (2016). Bioterrorism and the role of the clinical microbiology laboratory. *Clinical Microbiology Reviews*, *29*(1), 175–189. doi:10.1128/CMR.00033-15

Williams, M., Armstrong, L., & Sizemore, D. C. (2021). *Biologic, chemical, and radiation terrorism review*. Treasure Island, FL: StatPearls Publishing. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK493217

World Health Organization. (2018, May 30). *Nipah virus*. Retrieved November 26, 2021, from https://www.who.int/news-room/fact-sheets/detail/nipah-virus

Zaky, A., Bradley, W. E., Lazrak, A., Zafar, I., Doran, S., Ahmad, A., … Ahmad, S. (2015). Chlorine inhalation-induced myocardial depression and failure. *Physiological Reports*, *3*(6), e12439. doi:10.14814/phy2.12439

Zellner, T., & Eyer, F. (2020). Choking agents and chlorine gas: History, pathophysiology, clinical effects and treatment. *Toxicology Letters*, *320*, 73–79. doi:10.1016/j.toxlet.2019.12.005