CHAPTER 120

Infectious Disease Disasters: Bioterrorism, Emerging Infections, and Pandemics

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ABSTRACT

Infectious disease disasters are events that involve a biological agent/disease and that result in mass casualties, such as a bioterrorism attack, a pandemic, or an outbreak of an emerging infectious disease. Infectious disease disasters are different from other types of disasters because they increase the risk of communicable disease spread during and after the incident. Subsequently, they involve the need for specialized mitigation, planning, and response interventions to prevent and control the spread of disease. As experts in the fields of surveillance, epidemiology, and prevention of communicable disease spread, infection preventionists play a critical role in emergency management of infectious disease disasters at the personal, hospital/healthcare facility, and community level. Emergency management of infectious disease disasters is a multidepartmental and multi agency endeavor that encompasses the four principles of emergency management: mitigation, preparedness, response, and recovery.[1]

KEY CONCEPTS

- Infectious disease disasters consist of biological terrorism, emerging infectious disease outbreaks, and pandemics.
- Infectious disease disasters pose unique challenges to infection preventionists and disaster planners.
- There are a broad range of potential bioterrorism agents, including bacteria, viruses, and toxins (of microbial, plant, or animal origin). Common characteristics of this diverse group of agents include:
  - The ability to be dispersed in aerosols of 1 to 5 micron-sized particles, which can penetrate the distal bronchioles
  - The ability to deliver these aerosols with simple technology
  - The feasibility of these agents, if delivered from a line source (e.g., an airplane) upwind from the target, to infect large numbers of the population
  - The ability to spread infection, disease, panic, and fear.
- Infectious diseases continuously emerge and/or reemerge, resulting in epidemics of varying sizes and scope.
- Pandemics pose the biggest potential threat to the public's health in terms of morbidity and mortality, and there is a high likelihood of a pandemic occurring in the future.
- Infection preventionists must undertake preparedness activities to ensure that they and their healthcare facilities and communities are better prepared to effectively recognize and respond to an infectious disease disaster.
- Infectious disease disaster preparedness is an ever-evolving process that addresses the four principles of emergency management: mitigation, preparedness, response, and recovery.

BACKGROUND

Definitions of Bioterrorism, Emerging Infections, and Pandemics

Bioterrorism (also known as biological terrorism) is the intentional use of a biological agent or derivative of such an agent to inflict harm or death onto a civilian population. Biological warfare differs from bioterrorism in that the target of the attack is military personnel. For the purposes of this chapter, the term *bioterrorism* will encompass both attacks on military and civilians using a biological agent/weapon.

Emerging infections are those that are new to a population or geographical region, or have increased rapidly. Many emerging infections, such as methicillin-resistant *Staphylococcus aureus* (MRSA) and human immunodeficiency virus (HIV), routinely occur throughout the world and are not covered in this chapter. Information on MRSA and HIV can be found in Chapters 26 Antimicrobials and Resistance, and 81 HIV/AIDS. Only newly emerging (infections that are new in humans) or reemerging infections (infections that occurred in the past but are now increasing in number or changing geographical area)

are addressed in this chapter. For the purposes of this chapter, the term *emerging infection* is used in lieu of the terms *newly emerging* and *reemerging infections*.

Pandemics are global outbreaks of disease in humans that exceed expected rates or morbidity and mortality.

Historical Perspective of Infectious Disease Disasters and Future Potential Impact

Bioterrorism

The use of biological agents on populations to cause harm or death is not a new concept; countries have been conducting bioterrorism for hundreds of years. Bioterrorism dates back to the 14th century, when cadavers were dropped into enemy wells to poison the drinking water.[2] Another example of bioterrorism occurred during the French and Indian War, when Native Americans were given smallpox-laden blankets. This action is believed to have initiated smallpox in this previously unexposed population and resulted in a 40 percent mortality rate. More recent examples of bioterrorism include the intentional contamination of salad bars in The Dalles, Oregon, using *Salmonella*[2] and the 2001 attack using anthrax-laden letters mailed to media organizations and politicians.

Bioterrorism has the potential to result in high morbidity and mortality, because aerosolized biological agents can infect or kill many people in a short period of time. Even nonaerosolized attacks, such as the anthrax bioterrorism attack in the United States in fall 2001, can result in morbidity, mortality, and the need to formulate a significant healthcare, public health, and emergency management response. It is not known when or if another bioterrorism attack will occur. However, bioterrorism preparedness helps mitigate potential negative outcomes, and is required by healthcare and public health regulating agencies as part of a comprehensive emergency management program.[3] The future potential impact of bioterrorism depends on the agent used, the amount disseminated, the dispersal method, the weather/release conditions, the preexisting immunity of the exposed population, and how quickly the attack is identified. The 2001 bioterrorism attack caused 22 cases of anthrax and five deaths, required over 10,000 doses of postexposure prophylaxis to be distributed, and cost more than $2.5 billion, yet was, essentially, a small event involving only the use of 2 to 3 ounces of anthrax spores.[4,5] Researchers estimating the potential morbidity, mortality, and cost associated with a bioterrorism attack indicate that an aerosolized release of *Francisella tularensis* over London could result in 2.4 million exposures, 130,000 infections, and 24,000 deaths, with an overall case fatality rate of ~18 percent.[6]

Emerging Infections

Emerging infectious disease outbreaks have occurred throughout recorded history. Examples include the Black Death in Europe, severe acute respiratory syndrome coronavirus (SARS CoV), West Nile Virus, 2009 H1N1 influenza A, Middle East respiratory syndrome coronavirus (MERS CoV), and many others. Many factors affect the emergence of infectious diseases, including social (war, human migration, and urbanization), microbial (genetic mutation, recombination, and assortment), and environmental (earthquakes, floods, deforestation, changes in animal/insect populations) determinants.[7,8]

The impact of emerging infections depends on the agent involved and the size of the event. For example, the 2012 multi-state outbreak of *Escherichia coli* 0145 was a relatively small event; 18 individuals were infected, with only a single death.[9] In contrast, the 2009 H1N1 influenza A virus developed into a pandemic, resulting in ~575,000 deaths.[10] The future potential impact of emerging infections is unknown, but it is expected that infectious diseases will continue to emerge or reemerge, resulting in epidemics of varying sizes and scope.

Pandemics

Of all types of infectious disease disasters, pandemics pose the biggest potential threat to the public's health in terms of morbidity and mortality. Historically, influenza pandemics occur on a semiregular basis. During the 20th century, three influenza pandemics (in 1918/1919, 1957/1958, and 1968/1969) resulted in more than 779,000 deaths in the United States and approximately 53 million deaths worldwide.[11] In 2009, a new strain of influenza A (H1N1) emerged and quickly became a pandemic, resulting in 151,700 to 575,400 deaths worldwide.[10] In addition, there have been several incidents in the last 40 years in which an influenza strain had the potential of causing a pandemic, including scares or pandemic "threats" with swine, Russian, and avian influenza.[11]

The potential impact of a future pandemic is staggering. It has been estimated that an influenza pandemic could infect approximately 30 percent of U.S. citizens (~90 million individuals), require the need for 45 million additional outpatient visits to healthcare agencies and 865,000 to 9,900,000 hospitalizations, result in 89,000 to 207,000 deaths, and cost between $71 and $166 billion in the United States alone.[12–14]

As experts in the fields of communicable diseases, infection prevention, and epidemiology, infection preventionists (IPs) are poised to be at the forefront during an infectious disease disaster. As such, IPs must embrace their role as experts in infectious disease emergency management and assist their healthcare facility or community in becoming better prepared to rapidly, appropriately, and effectively respond to an infectious disease disaster.

BASIC PRINCIPLES

Bioterrorism

Bioterrorism refers to the use of biological agents on civilian or military populations, animals, or crops. A combination of factors have all raised concerns about the actual use of bioterrorism agents, including the breakup of the former Soviet Union and the concomitant dispersal of scientists and agents involved in bioterrorism research, the rise of radical groups

focused on destroying what they believe to be evil forces, and the discovery of Iraq's stockpiled anthrax, botulinum toxin, and other biological warfare agents.

There are a broad range of potential bioterrorism agents, including bacteria, viruses, and toxins (of microbial, plant, or animal origin). Common characteristics of this diverse group of agents include (1) the ability to be dispersed in aerosols of 1 to 5 μm particles, which can penetrate the distal bronchioles; (2) the ability to deliver these aerosols with simple technology; (3) the feasibility of these agents, if delivered from a line source (e.g., an airplane) upwind from the target, to infect large numbers of the population; and (4) the ability to spread infection, disease, panic, and fear.[15]

The most likely route of dissemination is an aerosolized release of 1- to 5-μm particles. Other methods of dissemination include oral (intentional contamination of food/water supply), percutaneous, infected animal vector (e.g., release of infected fleas), and human-to-human spread (individual infected with communicable disease walking among a crowd of healthy people). As the anthrax attacks of 2001 proved, even physical objects, such as letters, can be used to help spread biological agents.

Pandemics

Unlike a bioterrorism attack or outbreak of an emerging infection, a pandemic is usually not an event that occurs suddenly. The World Health Organization (WHO) describes six phases of a pandemic, starting with the period in which there are few to no human cases from the organism/disease to the period in which there is efficient and sustained disease spread from person to person. The six WHO pandemic phases are outlined in Table 120-1. It is expected that a pandemic will hit communities in multiple waves. Each wave will last approximately 6 to 8 weeks, making response a more prolonged event than with other types of disasters.[12] During an influenza pandemic, attack rates will likely be about 30 percent across all populations; young children are expected to be disproportionately affected and have attack rates close to 40 percent.[12] It should be noted that not all pandemics will have a slow onset. The 2009 H1N1 pandemic illustrated that a pandemic can occur suddenly and without warning.

Table 120-1. The Six Phases of a Pandemic

Phase	Description of the Phase
1	Low risk of human cases
2	Higher risk of human cases
3	No or very limited human-to-human transmission
4	Evidence of increased human-to-human transmission
5	Evidence of significant human-to-human transmission
6	Efficient and sustained human-to-human transmission

Adapted from World Health Organization (WHO). Current WHO phase of pandemic alert. WHO website. 2013. Available at: http://www.who.int/influenza/preparedness/pandemic/h5n1phase/en/index.html.

There are a number of agents that could cause a pandemic, including MERS CoV, SARS, and plague. Historically, influenza has caused the most pandemics and is expected to cause others in the future.[11] Recent pandemic threats include H5N1 and H7N9, both avian strains of influenza A.

Nature of the Pandemic Threat

As of September 6, 2013, WHO indicates that we are in pandemic phase 3: There is an agent with the capacity to cause a pandemic (influenza A/H5N1), but there is currently no or very limited human-to-human transmission. As of August 2013, there have been 637 human cases of H5N1 avian influenza, 378 of whom have died.[16] As of August 22, 2013, there have been 135 cases of H7N9, 44 of whom died.[17] It is not known whether H5N1 and/or H7N9 will continue to mutate and adapt to become more easily spread from person to person, resulting in a pandemic. It is also possible that another strain or organism could emerge and cause a pandemic. A future influenza pandemic is considered inevitable, but it is not known what strain will be involved or when the event will occur.[12]

PREPAREDNESS FOR INFECTIOUS DISEASE DISASTERS

Many of the interventions needed to detect, prevent, and control infectious disease disasters are identical to those for other types of mass casualty events (see Chapter 119 Emergency Management, for more information). However, infectious disease disasters pose unique challenges to IPs, healthcare and public health agencies, response organizations, and businesses. These differences are discussed in this chapter.

Preparedness for infectious disease disasters begins at the personal level. This means that it is the responsibility of all IPs to have a personal/family emergency management plan that will enable him/her to continue working during the infectious disease disaster. For infectious disease disasters, this includes the need to have personal protective equipment (PPE) stored at home in case the need arises for its use in community settings.[18] The United States Department of Health and Human Services (DHHS) recommends that all families stockpile respiratory protection as part of their personal pandemic plan.[19] See Chapter 119 Emergency Management, for more information on personal emergency management plans.

It is critical for healthcare facilities to become better prepared for infectious disease disasters. Infectious disease disasters will result in a large number of patients requiring hospitalization for mechanical ventilation, isolation, or highly specialized treatment in intensive care beds. Studies indicate that most healthcare facilities do not have adequate resources or the infrastructure needed to manage all aspects of patient care during an event that lasts longer than a few days, let alone the 6 to 8 weeks that may be necessary during a pandemic.[3] Deficiencies in hospital preparedness for infectious disease disasters include a lack of ventilators, antibiotics or antiviral medications, respiratory protection (N95 respirators and masks), negative pressure

rooms/areas, laboratory support/supplies, and linens.[3,20] Two studies conducted during the early part of the 2009 H1N1 pandemic found that many U.S. hospitals lacked infection prevention supplies, including respirators and anti-infective therapy.[20,21] Another study reported that almost a quarter of all U.S. hospitals lack 24/7 infection prevention coverage, which would make responding to an infectious disease disaster very challenging.[3]

At the community level, it is vital that healthcare agencies become better prepared for infectious disease disasters. Hospital surges during an infectious disease disaster will trickle down into community healthcare services and cause response challenges for these agencies. Potentially contagious patients will likely be discharged to alternate care sites, long-term care, and home care during an infectious disease disaster, requiring the need for surge capacity and infection prevention strategies/programs in these settings. Despite this, a 2010 study conducted during the H1N1 pandemic found that almost a third of all home health agencies lack any surge capacity, which would not allow hospitals to discharge patients to home health as planned.[22] Infection prevention strategies described in this chapter apply to all settings that administer healthcare services.

IPs play an important role in becoming prepared for infectious disease disasters at the personal, facility, and community levels. Preparedness activities must be undertaken by IPs to ensure that they and their healthcare facilities and communities are better prepared to effectively recognize and respond to an infectious disease disaster. As experts in infectious diseases, infection prevention, and epidemiology, IPs play a critical role in helping healthcare facilities/agencies and communities become better prepared to recognize and respond to an infectious disease disaster.

Infectious disease disaster preparedness is an ever-evolving process that addresses the four principles of emergency management: mitigation, preparedness, response, and recovery.[23] In addition, preparedness means that individuals and facilities develop an emergency management plan, practice the plan, and evaluate their level of preparedness. IPs must become better prepared not only to personally recognize and respond to an event but also to aid their healthcare facilities/agencies and communities in doing the same.

Assessment

Assessment is the first step in preparing a healthcare facility, healthcare agency, or community for an infectious disease disaster. Facility, agency, and community assessments are multidepartmental, multi agency endeavors that should not be undertaken alone. Information on emergency management plan assessment may be found in Chapter 119 Emergency Management.

Planning for Infectious Disease Disasters

Emergency management plans must address all hazards, including infectious disease disasters. For most hospitals and healthcare agencies, this will mean having an annex or section of their emergency management plan that is specific to infectious disease disasters.

Various planning guides exist to aid in preparing for infectious disease disasters, and each is aimed at a specific group/agency. For example, the Pandemic Influenza Plan written by the DHHS is designed to be used by local and state disaster planners and public health departments.[24]

In 2009, a planning checklist was developed for hospitals to assess the infection prevention components of their emergency management plan.[25] Emergency medical services (EMS) agencies can obtain guidance from the DHHS in the Emergency Medical Services and Non-Emergency (Medical) Transport Organizations Pandemic Influenza Planning Checklist.[26] In 2012, Volkman et al.[27] published a guidance document for long-term care facilities to use when developing emergency management plans, including addressing planning for bioterrorism and pandemics. A planning checklist was published in 2011 that describes the infection prevention components needed in a home health agency emergency management plan.[28] In addition, DHHS has published a number of pandemic planning checklists for businesses, schools, and faith-based organizations.[29]

The above are just a few examples of planning guides for infectious disease disasters. Other documents are available through state health departments and healthcare agencies.

Identification of an Infectious Disease Disaster

Morbidity and mortality related to many agents that could be involved in an infectious disease disaster can be decreased if treatment, isolation, and prophylaxis are provided as soon as possible. A rapid response depends on the foundation of the plan that is in place before the event occurs and the participants' familiarity with the emergency management plan.

When even a single case of an unusual disease is suspected or identified, bioterrorism or an emerging infectious disease should be considered. Groups of nonspecific illnesses clustered in time or place should also be strongly considered for bioterrorism or an outbreak of an emerging infectious disease. This includes the clustering of flulike syndrome in patients. All cases of unusual disease, including even a single case of any of the diseases mentioned in this chapter, should be reported immediately to local public health officials; if cases are recognized during evenings or weekends, after-hours or emergency numbers should be used.

Specific diagnosis of the agents discussed in this chapter has historically relied heavily on the presence of appropriate epidemiologic exposure (e.g., exposure to infected animals during meat rendering for anthrax, ingestion of home-canned foods for botulism, or travel to an area where an emerging infectious disease is endemic). Dissemination of biological agents via an aerosol route will require diagnosis of these generally uncommon diseases without the aid of usual exposure history. Furthermore, many of these syndromes can only be diagnosed on the basis of clinical knowledge of presenting symptoms

and expected disease progression. Maintaining a high level of suspicion and clinical knowledge about these diseases is essential to timely diagnosis. Assays/tests for bioterrorism agents and emerging infectious diseases are often only available in specific research laboratories (state public health laboratories, Centers for Disease Control and Prevention [CDC], or United States Army Medical Research Institute of Infectious Diseases [USAMRIID]); consult your local/state health department to arrange for appropriate testing or for consultation.

Early Recognition of an Infectious Disease Disaster

IPs may be the first to detect an infectious disease disaster, and early detection decreases morbidity and mortality. The sooner the incident and at-risk patients are identified, the higher the likelihood of decreasing morbidity, mortality, and cost associated with the event. The difference between infectious disease disasters and other mass casualty events is that infectious disease disasters are more difficult to detect. With natural disasters, and even traditional or chemical terrorism, there is an obvious sign that something unusual has happened. This can range from damaged buildings in an earthquake to a huge influx of patients immediately after a chemical attack.

In a bioterrorism event, however, an explosion is unlikely, and we may not know that there has been an attack unless the perpetrators announce it (i.e., it is an overt event), because aerosolized biological particles are odorless, colorless, and tasteless. In the case of a covert bioterrorism attack, a few days or weeks after the release, patients will begin to show symptoms and will access the medical system at that point. These patients will probably go to an emergency department or some other primary care facility. Detection will be difficult because it is unlikely that all the patients will go to the same facility or primary care provider. In this scenario, surveillance is essential to early detection of the event.

Like a bioterrorism attack, an outbreak of an emerging infectious disease may be difficult to detect. Clinicians rarely see these diseases, and the outbreak could even involve a novel strain or organism, making diagnosis very difficult. If the outbreak involves a new organism, such as the appearance of the coronavirus that causes MERS (MERS Co-V) in 2012, there may not be a laboratory test readily available for confirmation testing. Surveillance will be essential to detect a new outbreak and identify new cases once an outbreak is underway.

Early identification of a pandemic will be easier than that for bioterrorism or an outbreak of an emerging infectious disease. This is because pandemics tend to occur gradually over time, following the phases identified by WHO (see Table 120-1 for a list of the six WHO pandemic phases).[12] However, even pandemics can occur quite suddenly, as was the case with the 2009 H1N1 influenza A pandemic.[21] As the threat of a pandemic rises, IPs should continue to communicate with public health officials regarding the current status of the event.

Early recognition of an infectious disease disaster can occur by one of two methods: passive or active surveillance. See Chapter 11 Surveillance, for more information on surveillance.

Passive surveillance for infectious disease disasters refers to clinicians maintaining a high index of suspicion for potential diseases caused by bioterrorism or unusual disease presentation that may signal an emerging infectious disease. Clinicians who suspect bioterrorism may have occurred or an emerging infectious disease must report this incident to the infection prevention/infectious disease department and local health department immediately.

Active surveillance refers to surveillance activities implemented to detect bioterrorism incidents or other infectious disease disasters. However, emerging infectious diseases and most of the potential bioterrorism agents cause uncommon illnesses, such as inhalational anthrax, tularemia, monkeypox, and MERS CoV, and most facilities do not have the laboratory capability to test for these agents. This makes case finding very difficult.

An example of an active surveillance program would be one in which the data collector would contact specified people or groups in the community and ask for predetermined information or collect such information from hospitalized patients. Traditional active surveillance involves the collection of clinical information, usually in the form of laboratory tests, but can include other relevant clinical data such as chest radiograph results and patient symptoms. It is not feasible to conduct active surveillance using laboratory tests to detect an infectious disease disaster because there are too many possible causative agents. A study by Kaplan[30] examined the feasibility of conducting surveillance for bioterrorism using blood donation samples tested for a series of bioterrorism-related agents (e.g., anthrax, plague), just as donated blood is routinely tested for HIV and hepatitis. This study found that not only would detection of the event be delayed using this type of surveillance methodology, but it would also be prohibitively expensive. To screen all blood donations for bioterrorism-related agents would cost approximately $10/donor, totaling $139 million per year.[30]

BioWatch

BioWatch is an environmental monitoring program that is managed in coordination by the CDC, Environmental Protection Agency (EPA), and the United States. Department of Homeland Security. This program uses air samplers to test for aerosolized biological agents around the United States, with the goal of rapidly identifying biological events. Rapid detection of an infectious disease disaster would help minimize morbidity, mortality, and costs. The BioWatch air samplers are located in undisclosed cities and monitor the air 24 hours a day, 7 days a week. The specimens collected by BioWatch are sent to the Laboratory Response Network (LRN) and tested for various agents. When biological particles are detected in the air, a report is sent to emergency managers and public health professionals in the communities in which the agents were detected. These reports are termed “BioWatch Actionable Results” (BARs).

Communities must decide how to respond to these BARs in terms of the extent to which an investigation is conducted or interventions are implemented.

Although BioWatch has not detected a single bioterrorism attack (because no aerosolized attacks have occurred since the start of the program), BioWatch has been credited with strengthening the United States' existing biosurveillance program and enhancing coordination between public health agencies and healthcare systems as a means of increasing community resilience.[31] BioWatch is currently considered a complementary system to existing biosurveillance programs established in communities.

Syndromic Surveillance

Instead of conducting traditional active surveillance to detect an infectious disease disaster, a different approach must be used. Active surveillance for infectious disease disasters involves the use of syndromic surveillance. Historically, syndromic surveillance referred to the collection and analysis of syndrome-related data. A few examples of traditional syndromic surveillance indicators include (1) severe flulike illness indicating a new emerging pathogen (e.g., MERS CoV), pandemic influenza, or a bioterrorism attack involving the release of *Bacillus anthracis* (inhalational anthrax), *Yersinia pestis* (pneumonic plague), variola (smallpox), or other agents; (2) flaccid muscle paralysis indicating that a neurotoxin, such as botulism toxin, may have been released; (3) bleeding disorders indicating the use of a viral hemorrhagic fever agent; (4) rash indicating the release of variola virus (the cause of smallpox); or (5) gastrointestinal (GI) symptoms that present similarly to food- and waterborne illnesses, possibly indicating an intentional release on a water or food source or vendor.

The concept of syndromic surveillance has evolved over time to encompass more than simply syndrome-related data. It now consists of collecting and analyzing any nontraditional data for early detection of an infectious disease disaster. Syndromic surveillance now includes any indicator that might signal an increase in illness in the community. Some examples of data that could be collected and analyzed as part of a syndromic surveillance program include (1) number of patients seen in an emergency department; (2) number of patients presenting to the emergency department with flulike illness as their chief symptom; (3) number of patients admitted to a hospital; (4) number of EMS or ambulance runs performed each day, week, month, or other time period; (5) number of purchases of over-the-counter flu remedies; (6) number of purchases of over-the-counter diarrhea medications; or (7) other data available from healthcare facilities or agencies that may indicate a change or trend in the community. In studies, International Classification of Diseases Ninth Revision (ICD-9) codes and GI syndromes have high sensitivity and specificity in syndromic surveillance, whereas respiratory syndromes, chief symptom as an indicator, and fever alone were less sensitive measures. A 2011 study by Bellazzini and Minor[32] found that emergency department syndromic surveillance indicators, such as chief complaint or ICD-9 diagnostic codes are significantly faster at identifying an upward trend compared to laboratory-based data. Medication sales have been found to be useful indicators when used in conjunction with clinical syndrome indicators.[33] Combining multiple indicators has been found to yield the most accurate and sensitive information during syndromic surveillance, but can be expensive and resource intensive.[34,35]

Some communities are now collaborating with veterinarians and incorporating animal and insect surveillance data in the community syndromic surveillance program. Animal syndromic surveillance is important because more than 60 percent of human emerging infectious diseases are zoonotic;[36] an infectious disease outbreak among animals may be the precursor to human illness in a community. Animal syndromic surveillance began with cattle and livestock surveillance, but has expanded over time into also collecting data on companion animals. Examples of animal syndromic surveillance indicators include cattle mortality rates at farms and rendering plants, the number of visits at animal hospitals, and the number of laboratory tests requested by veterinary clinics, regardless of the results.[37] An innovative approach to public health syndromic surveillance is to combine animal and human data indicators. By doing this, it increases the sensitivity and specificity of the syndromic surveillance data being analyzed. Examples of parallel syndromic surveillance data indicators that have been collected include the following: (1) rate of influenza-like illness (ILI) in humans and in domestic cats, and (2) number of emergency room visits per day or per week at human and animal hospitals.[37]

Syndromic surveillance indicators must be evaluated in relation to facility and community illness baselines and current trends. Any upward trend or sharp increase must be evaluated as soon as possible to determine if an infectious disease disaster has occurred.

Syndromic surveillance data collection and analysis must be a component of facility and community emergency management. It should be a multiagency endeavor, including coordination and communication between hospitals, healthcare agencies (long-term care, home health), and public health.

Table 120-2 outlines syndromic surveillance indicators that healthcare facilities, schools, businesses, and veterinary clinics may consider collecting as part of their syndromic surveillance program for infectious disease disasters. All healthcare agencies, including long-term care and home health, should consider conducting syndromic surveillance. In addition, public health officials should consider partnering with schools and businesses to collect syndromic surveillance data, such as absenteeism rates related to ILI. Many syndromic surveillance programs exist (a 2004 study identified 115 such systems).[38] Facilities and agencies will need to decide which program or indicators work best for them. The CDC indicates that all hospitals should implement, at the least, a syndromic surveillance system that identifies patients with ILI; recommended sites for implementing this surveillance program include the emergency department, hospital clinics, and occupational health.[39] Syndromic surveillance programs should be coordinated with local public

Table 120-2. Syndromic Surveillance Indicators

Indicator
Flu like illness*
Flaccid muscle paralysis
Severe bleeding disorder with no discernable source
Rash
Gastrointestinal symptoms
Number of patients seen in an emergency department
Chief symptom (i.e., number of patients presenting with flulike illness as their chief symptom)
Number of patients admitted to a hospital
Number of EMS or ambulance runs
Number of calls to nurse or physician help lines triage centers
Over-the-counter pharmaceuticals sales (i.e., nonprescription medications to treat flu or gastrointestinal symptoms)
Number of individuals who use an Internet search engine (e.g., Google or Yahoo!) to look up information about flulike symptoms
Cattle or livestock morbidity or mortality rates
Domestic animal morbidity or mortality rates
Number of laboratory tests conducted at veterinary clinics
School absenteeism rates
Staff absenteeism rates at local businesses

*The CDC indicates that all hospitals should implement, at the least, a syndromic surveillance system that identifies patients and staff with influenza-like illness.[39]

health agencies to provide consistency in data collection and ensure adequate coverage across regions.

BioSense

BioSense is a national syndromic surveillance program for the United States that is run by the CDC. BioSense allows healthcare and public health agencies to quickly access and share data across regions or the nation. It was originally designed to assist with rapid identification of a bioterrorism attack but also has the opportunity to recognize an outbreak of an emerging infectious disease or pandemic, allowing for a more rapid response to the event. Data for BioSense derives from at least hundreds of hospitals, multiple state syndromic surveillance programs, and thousands of pharmacies and laboratories across the United States.[40] Most data submitted to BioSense are sent in real time, but a few sources have delayed reporting. BioSense tracks data by categorizing it into syndromes, such as ILI. Similar to other surveillance programs, spikes in BioSense data necessitate an investigation to determine whether it is a false alarm or a true infectious disease outbreak/anomaly. Most spikes in indicator rates result from predicable variation, inaccurate information provided to BioSense, misclassification of data, short-term anomalies, or a change in the community that is unrelated to an outbreak (e.g., a sale on over-the-counter pharmaceuticals that prompts increased sales). If the data spike is determined to be a potential legitimate threat, the CDC contacts the community from which the data derived to do an in-depth analysis. This may necessitate the involvement of hospitals, healthcare agencies, and local public health authorities to determine the source of the data anomaly. Although BioSense did not help in identifying the 2009 H1N1 pandemic, BioSense data was used by the CDC Emergency Operations Center and CDC's Influenza Division to determine H1N1 vaccine prioritization schedules, inform decisions related to school and public building closures, and aid in assessing the overall severity of the pandemic in the United States.[40] Between 2010 and 2012, BioSense data was used to monitor the impact of the 2010 Gulf of Mexico oil spill, enhance surveillance for dengue, and assess the health impacts related to the 2011 Japanese tsunami and subsequent nuclear incident as well as the 2011 U.S. heat wave.[40] BioSense data has also been used to enhance hospital epidemiology studies, including studies examining healthcare-associated pneumonia and *Clostridium difficile*.[41,42]

Vulnerable Populations

Certain groups of individuals are more at risk from morbidity and mortality during an infectious disease disaster. These individuals are known as vulnerable populations. Meeting the needs of vulnerable groups must be addressed as part of infectious disease disaster planning and included in the emergency management plan at the facility and community level. General disaster planning for vulnerable populations is covered in Chapter 119 Emergency Management. Only issues that are specific to infectious disease disasters are covered in this chapter.

Pediatrics

Children, especially newborns and young children are at an increased risk for infection during most types of infectious disease disasters. Neonates may be at risk from infection during an infectious disease disaster in two ways: vertical transmission from the mother during pregnancy and healthcare-associated transmission after birth.[43] Although newborns may be provided some protection by passive immunity (receipt of antibodies from the mother while in utero), they may be susceptible to certain diseases if the mother develops an infection during pregnancy. Neonates are also more at risk from infection than adults and even older children because of their relative state of immunosuppression, which predisposes them to many types of infections. Babies who are born prematurely are also at high risk from a variety of infections.

During a bioterrorism attack involving the release of an aerosolized agent, children are at higher risk from exposure than adults because of children's increased respiratory rate, which would result in their inhalation of more infectious particles.[44] In addition, newborns and young children have more permeable skin than adults, increasing the risk of toxin absorption through the skin.[44] Children are also at higher risk during a smallpox bioterrorism incident because they have never been immunized against variola. Although most adults do not have active immunity against smallpox because their initial immunization was more than 30 years ago, individuals who receive a booster of smallpox vaccines (i.e., most adults born before 1972) are much more likely to have a sustained immune response compared with primary vaccinees (i.e., children). In addition, children infected

with smallpox are more likely than adults to be misdiagnosed with chickenpox because of the increased incidence of this disease in children. Children are also expected to be at higher risk of infection and fatality during an influenza pandemic.[12]

Attending school or a childcare agency also puts infants and children at increased risk for infection during biological events. Research indicates that schools and childcare agencies are often associated with communicable disease spread among children.[45,46] Epidemiological studies indicate that school openings have been associated with spikes in cases during outbreaks and pandemics, including the 2009 H1N1 pandemic, and school closure (whether intentional event-specific closure or natural closure due to breaks/holidays) is associated with sudden drops in cases.[47,48] Close interaction at school or childcare puts children at risk from disease spread unless control measures are implemented.

Elderly

The number of elderly individuals in the United States is growing, and the fastest growing group among the elderly are those who are 85 years or older. Normal declines in physiological function that occur with aging put the elderly at higher risk for infection. In addition, many older adults have comorbidities, which put them at higher risk for infection at all times, and this risk can be magnified during an infectious disease disaster. Infectious diseases currently account for 40 percent of deaths among the elderly, and rates are expected to be even higher during a pandemic or bioterrorism attack.[49]

Diagnosing infectious diseases among the elderly can be complicated. Most elderly individuals have a pulse/temperature dissociation that masks the signs of infection, making diagnosis much more difficult in the elderly than in adults or children.[49] Therefore, triaging algorithms need to take this pulse/temperature dissociation into account and use a lower temperature as a potential indicator of infection among the elderly (see "Triage" section of this chapter). In addition to having a pulse/temperature dissociation, the elderly commonly have atypical disease presentation because of normal organ system changes and comorbidities. These factors can make diagnosis of infectious diseases very difficult among the elderly, especially during an infectious disease disaster.

Immunocompromised

Immunosuppression results in an increased risk for infectious disease, even during nondisaster times. Immunocompromised individuals can be expected to have increased complications and mortality rates after an infectious disease disaster compared with healthy adults.[50] Immunocompromised individuals with comorbidities are at an increased risk.

Very little is known about bioterrorism-related disease presentation in immunocompromised hosts, but it is believed that these individuals will likely have unusual disease presentation, which will complicate and possibly delay diagnosis.[50] In addition, disease is expected to be more severe for immunocompromised patients during an infectious disease disaster compared with healthy adults, especially among patients with HIV and cancer.

Pregnancy

Normal physiological changes during pregnancy, such as a somewhat compromised immune system, decreased ventilatory capacity, and increased respiratory tract bacterial growth, put women at an increased risk for disease.[43] Influenza infection during pregnancy may cause poor outcomes, such as longer hospital stays, more frequent hospitalization not related to delivery, and maternal death.[43] These risks were amplified in past pandemics and are expected to hold true during future influenza pandemics.[12] Mortality rates were higher for pregnant women than for nonpregnant individuals during the 1918 influenza pandemic, and influenza was the leading cause of maternal death in the 1957 pandemic.[43] Pregnant women are also at higher risk for fatality during outbreaks of emerging infectious diseases and bioterrorism; mortality rates were higher for pregnant women than for nonpregnant individuals during the SARS outbreak in 2003 and during past smallpox outbreaks.[51]

Fetuses are at risk from infection and death while the mother is pregnant. Infections women develop during pregnancy, such as SARS or smallpox, can lead to spontaneous abortion or preterm birth.[43] In addition, many medications or vaccinations that might be needed during an infectious disease disaster to treat or prevent disease in pregnant women could cause potential harm to the fetus.[52] Examples include smallpox vaccination and live attenuated vaccines.[52]

Some women with high-risk pregnancies will require specialized care/treatment while in labor and delivery, even during an infectious disease disaster. However, most women with normal pregnancies may be better served by giving birth in an alternate care site or the home to prevent exposure to communicable diseases during an infectious disease disaster.[52] Communities will need to make arrangements for continuing to provide prenatal care, labor and delivery services, and newborn care in the community during infectious disease disasters as part of emergency management.[52] Hospitals and healthcare facilities need to develop triaging algorithms for determining which women require hospitalization and which can be managed in another setting.[52] During the 2003 SARS outbreak in Canada, pregnant women delivered their babies in nonhospital settings as a way of physically separating pregnant women from potentially contagious patients; this was effective at decreasing disease transmission during labor and delivery.[43]

Reporting Infectious Disease Disasters

All cases of unusual disease or syndrome clusters should be reported immediately to local public health officials, including even a single case of any of the diseases mentioned in this chapter. If cases are recognized during evenings or weekends, after-hours or emergency numbers should be used. Phone trees should be developed as part of emergency management planning to ensure that reporting can take place around the clock. Staff

should be educated to report any known or suspected patients with bioterrorism-related diseases or an emerging infectious disease to the infection prevention, infectious disease, and/or hospital epidemiology department(s). During an infectious disease disaster, reporting should occur through the facility incident command system (see Chapter 119 Emergency Management, for information on the hospital incident command system).

Epidemiology of Bioterrorism or Outbreak of an Emerging Infectious Disease

It is difficult to predict and delineate the epidemiology of a bioterrorism attack or emerging infectious disease outbreak before it occurs, but the general principles of epidemiology, infection prevention, and outbreak investigation apply. An outbreak investigation may be warranted if a communicable disease is involved or epidemiological information, such as risk factor data, needs to be collected and analyzed.

In the event of an unannounced bioterrorism attack, the epidemiological investigation will be critical to mounting an effective response. If terrorists covertly release an aerosolized biological weapon, the event will not be detected until days to weeks after the incident, when patients become ill and begin infiltrating the medical system. When this occurs, a rapid and focused epidemiological investigation will be needed to identify the possible date and location of the release. Victims' histories will be taken and examined for shared activities, such as attendance at a mutual event. It is essential that the release date and location be identified to determine other people/groups who are potentially at risk. This information can guide distribution of treatment, prophylaxis, and vaccination.

If a contagious agent is used in a bioterrorism attack, the epidemiological investigation will be even more critical. Not only will the date and location of release need to be identified, but a list of contacts (i.e., people who came into contact with infected patients since the onset of infectiousness) must be identified as well. For instance, if smallpox is released as a biological weapon, there are two distinct groups at risk of exposure: (1) those exposed to the initial release (which will be identified when the date and location of the release is determined) and (2) those exposed to infected individuals during periods of contagiousness (which will be identified in a thorough epidemiological investigation of potential contacts). These same principles will apply if the infectious disease disaster is an outbreak of a contagious emerging pathogen, although the source or potential vector may need to be identified rather than a release point.

As with any outbreak or epidemiological investigation, the three primary factors of contextual concern are person, place, and time. The basic information that will need to be determined as soon as possible after a bioterrorism attack or outbreak of an emerging infectious disease is detected includes the following: (1) identification of the causative agent, (2) establishment of the case definition, (3) determination of date of release, (4) location of release, (5) assessment of the approximate length of exposure time, and (6) determination of the potentially exposed groups. The response to an infectious disease disaster will depend on the answers to these questions. If a contagious agent (e.g., aerosolized plague or smallpox) was involved, the epidemiological investigation will be quite different from an investigation if a noncontagious agent (e.g., anthrax) was involved. In addition, the date, location, and approximate length of exposure time will affect the response needed. The epidemiological investigation and necessary response will be different for a small release in a contained area versus a large release in an open area or if the outbreak involves an insect or animal vector.

Causative Agent Identification

Regardless of whether the infectious disease disaster is a bioterrorism attack or outbreak of an emerging pathogen, it will be imperative to establish the causative agent as quickly as possible. Treatment, prophylaxis, and control measures all depend on the causative agent. Time is of the essence because patients with diseases caused by some of these agents can progress to death very rapidly without appropriate treatment. For example, untreated pneumonic plague usually progresses to death within 36 to 72 hours.[53] Although diagnosis will not be a direct responsibility of the IP, it is likely that the IP's infectious disease expertise will be consulted in the evaluation process and in deciding which, if any, isolation precautions should be implemented while awaiting confirmatory diagnosis.

Agent identification and patient diagnosis will depend a great deal on the effectiveness of the passive surveillance system used by the facility or agency. If clinicians have maintained a high index of suspicion and have a good knowledge foundation regarding the potential diseases that could be involved in an infectious disease disaster, it is more likely that the event/outbreak will be rapidly identified.

Identification of the Date and Location of Agent Release or Potential Source of Pathogen

An IP's epidemiological skills will be necessary to identify when and where the release of the biological agent(s) occurred, or the source/vector of an emerging pathogen. The date and location of release or potential source are critical to determine at-risk groups, control measures, and, depending on the agent, may determine who needs to be vaccinated and/or receive prophylaxis. To determine when and where the exposure took place, a thorough patient history of any and all victims of the bioterrorism attack must be taken. This history should focus on (1) past and current symptoms, (2) date of symptom onset, (3) severity of illness, (4) possible source of exposure, (5) route of exposure (body site affected), and (6) date and location of exposure. For example, a new painless necrotic lesion on the arm might indicate cutaneous anthrax, whereas respiratory symptoms with an accompanying widened mediastinum on chest radiograph would suggest inhalational anthrax. Both diseases result from exposure to the same agent, but the route of exposure is different.

Determining the source of exposure may be the most challenging component of the epidemiological investigation. However,

it will also be one of the most critical components because it will help determine at-risk groups that might benefit from prophylaxis or vaccination. Determining the date and location of the exposure will be aided by listing all the places the patient had been during the incubation period of their illness; a travel history will be an essential component. The time period for which a history needs to be collected (i.e., the incubation period) will depend on the agent used; this time period can range from 1 day to weeks before symptom onset. If the date and location of release can be quickly determined and at-risk persons identified, a targeted prophylaxis or vaccination program can be initiated. If the date and location cannot be rapidly determined, consider mass prophylaxis or immunization to protect the community at large. Occupational risk exposures should also be assessed, especially if the person is a laboratory, healthcare, or sanitation professional, or if the person works with animals (e.g., in a veterinary clinic, meat rendering plant, or poultry or swine farm).

Potential Bioterrorism Agents

The CDC provides a list of the most likely agents to be used in a bioterrorism attack. These agents are divided into three categories (A, B, and C) with category A agents being the most likely to be used.[15] Table 120-3 reviews the most likely agents of bioterrorism.

Table 120-3. Centers for Disease Control and Prevention Bioterrorism Agents

Category A
Anthrax (*Bacillus anthracis)*
Botulism (*Clostridium botulinum toxin*)
Plague (*Yersinia pestis*)
Smallpox (variola major)
Tularemia (*Francisella tularensis*)
Viral hemorrhagic fevers (filoviruses [e.g., Ebola, Marburg] and arenaviruses [e.g., Lassa, Machupo])
Category B
Brucellosis (*Brucella species*)
Epsilon toxin of *Clostridium perfringens*
Food safety threats (e.g., *Salmonella species, Escherichia coli* O157:H7, *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 [e.g., Venezuelan equine encephalitis, eastern equine encephalitis, western equine encephalitis])
Water safety threats (e.g., *Vibrio cholerae, Cryptosporidium parvum*)
Category C
Emerging infectious diseases such as Nipah virus and hantavirus

Adapted from Centers for Disease Control and Prevention (CDC). CDC bioterrorism agents. CDC website. 2013. Available at: http://emergency.cdc.gov/agent/agentlist-category.asp

Clinical Manifestations of Bioterrorism-related Diseases or Emerging Pathogens

The diseases produced by bioterrorism agents could be incapacitating or lethal. Because these agents would most likely be released via an aerosol route, resulting in pulmonary infection, many of the clinical syndromes include a febrile syndrome with accompanying respiratory symptoms. Agents causing GI symptoms (e.g., nausea, vomiting, and diarrhea) are also likely to be used, and have been used in past bioterrorism attacks.[2] Other possible clinical syndromes related to bioterrorism include fever with a centrifugal rash (smallpox), a rapidly descending flaccid muscle paralysis (botulism), or a severe bleeding disorder (viral hemorrhagic fever virus).[53]

Emerging infectious diseases can demonstrate a variety of clinical manifestations, from ILI to GI disorders. Many emerging infectious diseases can be expected to be zoonotic in nature.[36] The exact clinical picture of an emerging infectious disease will be specific to the pathogen.

Triage and Screening

Triage is an important component of emergency management to quickly identify those individuals who need medical treatment first. Severely ill or injured patients need to be transferred to a medical facility as soon as possible. During an infectious disease disaster, triage involves assessment for not only disease/injury severity, but also screening for potential contagiousness. Patients and visitors may need to be screened before they are allowed entry into healthcare facilities, points of dispensing or distribution (PODs), or alternate care sites (ACS). Healthcare personnel may need to be screened before each shift, depending on the event and the associated morbidity and mortality. Table 120-4 is a generic assessment/screening form that can be used to identify potentially contagious individuals during an infectious disease disaster. This table/tool would need to be modified to be event-specific during an infectious disease disaster; screening items should be based on the case definition for the disease/condition involved in the incident. For example, a screening tool for MERS CoV might include a question related to a recent travel history to an area in which cases of MERS CoV have occurred.

Healthcare facilities, PODs, and ACS should encourage informal screening of patients, visitors, and staff for potentially contagious conditions/diseases. Posters describing signs and symptoms that should be reported to healthcare personnel should be strategically located around the facility.

Screening Area

If formal screening is to be conducted during a biological disaster, a screening area will need to be set up. Research indicates that it is most effective to limit the number of formal screening areas (to maximize available resources) by locking off extra entrances during the infectious disease disaster, provided that fire and safety codes are not violated by doing so.[21] The screening area should be set up either outside or immediately inside the entrance to the healthcare facility, and it should be manned by a

Table 120-4. Sample Generic Screening Form for Infectious Disease Disasters

Screening/Triage Form*		
Name _____		
Temperature: _____ (in degrees Fahrenheit)		
Do you currently have any of the following symptoms?		
Yes	No	
☐	☐	Cough
☐	☐	If you have a cough, is your sputum bloody?
☐	☐	Runny nose
☐	☐	Loose or unformed stools
☐	☐	Watery or explosive diarrhea stools
☐	☐	Bloody stools
☐	☐	Rash
☐	☐	If you have a rash, is it itchy?
☐	☐	Stiff/sore neck
☐	☐	Red eye or drainage from eye(s)
☐	☐	Wound or lesion
☐	☐	Have you been hospitalized within the past 3 months?
☐	☐	Have you been told that you have a multidrug-resistant organism (MRSA, VRE, etc.)?
☐	☐	Are you currently on any antibiotics/treatment? If Yes, list.
Name of person completing the form		Date

*Adapted from: Rebmann T, Hilley S, McCaulley M, et al. Infection prevention for ambulatory care centers during disasters. Association of Professionals in Infection Control and Epidemiology website. 2013. Available at: http://apic.org/Resource_/TinyMceFileManager/Emergency_Prep/2013_Ambulatory_Care_during_Disasters_FINAL.pdf.

trained screener. The screening area should have hand hygiene and PPE available for the screener(s) and visitors.

Potentially contagious individuals identified through screening should be moved immediately to an isolation room/area. A temperature of 100°F should be used as the identifier for potential infection to identify the elderly or immunocompromised individuals whose physiological changes tend to mask normal signs of infection.[49]

Anti-infective Therapy, Prophylaxis, and Vaccination

Several of the potential bioterrorism agents and emerging infectious diseases have effective treatment regimens, when such therapy is initiated early in the disease process. Immediate recognition of the disease process and rapid administration of appropriate treatment modalities are essential to decreasing the morbidity and mortality of an infectious disease disaster.

In most situations, chemoprophylaxis will be important during an infectious disease disaster. Several of the bacterial and viral agents of bioterrorism have effective postexposure prophylaxis (PEP) available in the form of either medical treatment or vaccination. Some emerging infectious diseases, such as pandemic influenza, also have identified PEP regimens. Exceptions to the need for PEP would be diseases for which there is no known effective prophylaxis available, such as viral hemorrhagic fever, SARS, or MERS CoV. PEP should be offered to all those with a known exposure to a potentially contagious patient/person. This includes patients, visitors, staff, and volunteers. Immediate recognition of the disease involved in the infectious disease disaster and clearly defining the population exposed will be crucial for dispensing appropriate PEP to those most at risk. Information on what constitutes an exposure and contact tracing are part of the epidemiological investigation and should be coordinated with local public health officials. PEP should be offered as soon as an exposure is suspected. Delayed PEP can decrease effectiveness of the medication or vaccine and result in increased morbidity and mortality.

The DHHS currently recommends that communities and healthcare facilities consider offering preexposure prophylaxis to high-risk healthcare personnel (those with direct high-risk exposures) and front-line workers (emergency department workers, first responders, EMS personnel) during a pandemic.[55] Preexposure prophylaxis would consist of taking antiviral medications for the duration of the outbreak in the community. This strategy is expected to decrease disease transmission among the highest risk individuals and allow these groups to continue working during a pandemic by preventing illness associated with the event. Preexposure prophylaxis will require large numbers of doses of medication (a 6- to 12-week regimen/provider); the decision to allocate medication to preexposure prophylaxis needs to be examined in light of the facility's ability to provide ongoing PEP and treatment. Treatment and PEP are higher priority than preexposure prophylaxis, and this needs to be incorporated into healthcare facility/agency prioritization plans.[55] If a healthcare facility/agency's supplies of antiviral medications start to dwindle, even if supplemented from the CDC's Strategic National Stockpile (SNS), medications need to be reserved for treating cases and providing PEP.

Vaccination can be an important component of responding to an infectious disease disaster, depending on the agent/disease involved in the event. For some diseases/agents (e.g., viral hemorrhagic fever viruses, SARS, MERS CoV, and others), there is no available vaccine. Others have a vaccine, but it is only available to laboratory workers (i.e., tularemia), not approved by the U.S. Food and Drug Administration (FDA) for PEP use (i.e., anthrax), or not feasible for use as PEP because it takes months to develop immunity (i.e., botulism). Vaccination during a pandemic may be possible, but will likely be delayed. It could take weeks to months to identify the causative strain and develop an effective vaccine against it. Even after the strain is identified, it may take months to ramp up vaccine production to create enough vaccine for the entire United States or world. As of fall 2013, there were multiple FDA-approved vaccines against the current circulating strain of avian influenza A (H5N1).[56] Other vaccines against H5N1 avian influenza and other strains of influenza (H7N9 and H3N2 to name just two) are also under development. These vaccines may provide limited protection during a pandemic but would likely not be completely effective. This is

because the current H5N1 avian influenza vaccines are effective against the current circulating strain. However, the influenza strain must mutate to become more easily transmissible from person to person and thus able to cause a pandemic. This mutation may render the current avian influenza vaccine less effective or ineffective. It is anticipated that vaccine distribution during a pandemic may be delayed by 9 months or more because of the time needed to develop and produce a new vaccine.[12]

In the event of a large-scale infectious disease disaster, mass distribution of medical countermeasures may be required in the form of antimicrobial therapy/prophylaxis distribution or vaccination administration. Mass distribution of medical countermeasures requires extensive upfront planning to accommodate large numbers of exposed individuals in a short period of time. Mass distribution is generally accomplished through PODs. There are two types of PODs: open and closed. Open PODs are distribution sites that dispense medical countermeasures to all community members; these sites are coordinated by local public health officials. Closed PODs are distribution sites that are located within a workplace or other private employer setting and only dispense medical countermeasures to employees and/or employees' family members. Open POD development and implementation is a multiagency endeavor, as it will need to be a communitywide effort. Healthcare agencies should consider becoming closed PODs, so as to be able to quickly distribute medical countermeasures to their own employees, patients, visitors, and volunteers. This may ensure faster service and enable healthcare employees to continue working throughout the infectious disease disaster. If healthcare facilities or agencies want to be a closed POD site, they should work with public health officials prior to an event, as formal arrangements need to be in place in order for an agency to become a closed POD.

During an infectious disease disaster, medical countermeasures may be limited. The CDC's SNS is a national repository of medications and supplies needed for a disaster. The SNS is intended as a supplement for situations in which local resources are exceeded by need. Medications and supplies in the SNS are located throughout the United States and can be delivered to any state within 12 hours. Healthcare facilities/agencies and communities need to remember that the SNS is supplemental only. In the event of a large-scale infectious disease disaster, especially a pandemic, the current SNS supplies will not be sufficient to cover all communities. The United States experienced this during the 2009 H1N1 pandemic when many hospitals reported running out of N95 respirators early on in the pandemic, and the supplies they received from the SNS were inadequate in number or size/type.[21] Healthcare facilities/agencies and communities need to be as proactive as possible in preparing for infectious disease disasters to ensure the best response. One way to do this is to stockpile or make arrangements to obtain additional supplies during a disaster. Although this is widely regarded as an essential component of emergency management, a recent study of U.S. hospitals found that only 63 percent of hospitals are stockpiling or have arrangements to obtain additional medications (e.g., antibiotics, antivirals) during an infectious disease disaster.[3] Healthcare facilities and communities need to prioritize who will receive limited supplies. This should be done as part of emergency management planning and not wait until supplies are insufficient or depleted. Guidance on allocating scarce resources ethically can be obtained from the Institute of Medicine.[57]

Anti-infective Therapy, Prophylaxis, and Vaccination for Elderly and Immunocompromised Individuals

Anti-infective therapy, chemoprophylaxis, and vaccination will be the same for the elderly and immunocompromised as it is for healthy adults for most diseases, but there may be more adverse effects in the elderly and immunocompromised. The elderly will be at high risk from drug-to-drug interactions and adverse events from anti-infective therapy and chemoprophylaxis during an infectious disease disaster because of their likelihood of having comorbidities.[49] Immunocompromised individuals are at increased risk from adverse events related to administration of live vaccines, such as the smallpox vaccine.

Anti-infective Therapy, Prophylaxis, and Vaccination for Pediatrics

Anti-infective therapy for children will differ from adults for most diseases. These differences range from smaller doses that are based on weight to elimination of certain medications because of adverse effects in children (e.g., teeth stain due to tetracycline in children younger than 8 years).[58] One example is that infants younger than 6 months may not be vaccinated against influenza, which would put them at risk from infection during an influenza pandemic.[43] However, infants may receive some passive immunity protection up to 6 months after birth from the mother's vaccination during pregnancy. There are identified therapies and pediatric-specific doses for most bioterrorism-related bacterial infections; antiviral therapy for pandemic influenza, SARS, and other viral illnesses; antitoxin for botulism; and vaccines for some diseases that could cause an infectious disease disaster.[58] However, there are not a lot of data available on the efficacy and safety of these medical therapies in children; further research is needed in this area.

Infection Prevention Procedures

The amount of IP involvement in disaster response depends on the agent involved. In an infectious disease disaster, IP involvement will be critical, especially if the agent is communicable. Many agents of bioterrorism are not transmitted from person to person, but some are. Most emerging infectious diseases are communicable, but a few are not. Bioterrorism agents and emerging infectious diseases that are communicable pose the greatest risk to society and will require the most involvement from an IP. Examples of potential infectious disease disasters that involve communicable diseases include pneumonic plague, smallpox, viral hemorrhagic fever viruses, SARS CoV, MERS CoV, and pandemic influenza. In these instances, infection prevention will be essential to control the outbreak, prevent future cases, and decrease morbidity and mortality associated with the event.

Isolation and Personal Protective Equipment Use

In addition to pharmacological interventions (anti-infective therapy, chemoprophylaxis, and vaccination), nonpharmacological interventions should be implemented to prevent and control disease spread during an infectious disease disaster. The primary nonpharmacological intervention involves isolation and PPE use. Standard Precautions should always be used when caring for patients, patient care equipment, and environmental controls. Respiratory etiquette (also known as respiratory or cough hygiene) should be implemented as part of routine infection prevention activities, but are especially important during infectious disease disasters. Information on Standard Precautions, isolation, and respiratory etiquette are outlined in Chapter 29 Isolation Precautions. These simple measures are very important during an infectious disease disaster, but research indicates that many healthcare personnel do not follow them correctly during biological events. An epidemiological study found that 40 percent of healthcare personnel who developed SARS after exposures to coughing patients had not been wearing a mask when exposed; many, if not all of these infections may have been prevented if the healthcare personnel had been wearing respiratory protection.[59] A study conducted in New York City during the 2009 H1N1 pandemic examined unprotected staff exposures to H1N1 patients and found that there were 277 unprotected staff exposures from 26 H1N1 patients, 65 percent (179) of which were preventable if staff had correctly followed Transmission-based Isolation Precautions.[60] Hand hygiene is also an important component of respiratory etiquette and response to an infectious disease disaster. See Chapter 27 Hand Hygiene, for more information. The final component of respiratory hygiene is spatial separation. Spatial separation for infectious disease disasters involves physically separating potentially contagious patients from noncontagious people. Approximately 3 feet is needed to prevent the spread of respiratory diseases, including those involved in infectious disease disasters, such as SARS and pneumonic plague.

The exact necessary infection prevention procedures needed for a bioterrorism attack cannot be estimated before an attack occurs. It depends on many factors, including (1) how soon the release is detected (i.e., whether decontamination and prophylaxis are necessary), (2) how soon the diagnosis is made, (3) how soon appropriate isolation was initiated (i.e., the number of potential contacts of an infected case), (4) the size of the release (i.e., the number of affected individuals), and (5) the agent used (i.e., whether the agent is contagious). However, the basic principles of infection prevention still apply. Infection prevention principles and recommendations are not altered for bioterrorism; they are the same whether the event is intentionally inflicted (bioterrorism) or a naturally occurring incident (emerging infectious disease outbreak or pandemic).

Any time a bioterrorism-related or emerging infectious disease is suspected, infection prevention guidelines for that specific agent/disease should be followed. During the beginning of an infectious disease disaster when the agent may not have been identified or when there is not enough evidence regarding the disease transmission route, IPs need to base infection prevention decisions on syndromes and symptomatology. This is referred to as syndrome-based isolation/control measures. This will be especially important during an infectious disease disaster involving a newly emerging infection because there may be limited or no information available on the causative agent. MERS CoV was an example of this situation. When MERS CoV first emerged in 2012, the transmission route and control measures needed to prevent disease spread were unknown. Infection prevention decisions were made on the basis of patients' symptoms, epidemiological information as it became available, and basic infection prevention principles.

Some general guidelines to follow when the causative agent is unknown include the following: (1) if the patient has respiratory-type symptoms (e.g., cough, sneezing, fever), Droplet Isolation Precautions should be used; (2) if the patient is severely ill with rapidly progressing respiratory symptoms and an airborne spread disease is suspected (i.e., SARS or avian influenza), Airborne Precautions should be considered; (3) if the patient has GI symptoms (e.g., nausea, vomiting, diarrhea), Contact Precautions should be used; (4) if the patient has an unusual rash (especially if it is centrifugal in pattern), smallpox should be considered and Contact and Airborne Isolation Precautions should be used; (5) if the patient is bleeding profusely from multiple orifices for no logical reason (i.e., no history of recent trauma, surgery), viral hemorrhagic fever should be considered and Contact and Airborne Isolation Precautions should be used; (6) if the patient has any type of unusual or severe lesion or wound for no logical reason (i.e., no recent history of surgery, injury), Contact Precautions should be implemented; (7) if the patient has an enlarged and very painful lymph node, bubonic plague should be suspected and Contact Precautions should be used if the skin is broken or there is draining fluid; and (8) if the patient has descending flaccid paralysis and botulism is suspected, no isolation is necessary. Table 120-5 provides an outline of syndrome-based isolation precautions that can be used during an infectious disease disaster until the causative agent is identified and/or event-specific isolation guidelines are provided by the CDC. PPE use should follow standard healthcare facility procedures, including recommendations provided as part of respiratory hygiene/cough etiquette. In the event of an outbreak of an emerging infectious disease in which the causative agent is not known, healthcare personnel should be told to follow official recommendations from their infection prevention/hospital epidemiology department, their local public health authorities, or the CDC. Healthcare personnel should be encouraged to wear PPE that is appropriate to the situation and the task that they are performing.

During routine activities, isolation is generally only implemented in hospitals. However, during an infectious disease disaster in which hospitals will be full and potentially contagious patients may be triaged to alternate care sites or home health, communities should consider educating the public regarding how to implement basic infection prevention strategies in nonhospital settings. This may include isolation and PPE use in long-term care, alternate care sites, home health, medical clinics,

Table 120-5. Syndrome-Based Isolation Categories/Control Measures for Infectious Disease Disasters in Which the Causative Agent is Unknown

Symptoms/Syndrome	Isolation Precaution Category*†
Respiratory	
Cough, runny nose, watery eyes	Droplet
Fever (>101.1°F) and cough in adults**	Droplet
Fever (>101.1°F) and cough in children	Droplet and Contact
Fever (>101.1°F), cough with bloody sputum, and weight loss or with upper lobe pulmonary infiltrate in an HIV-negative patient or any lobe of an HIV-positive patient	Airborne and Contact, plus eye protection when performing aerosol-generating procedure
Fever (>101.1°F), cough, and pulmonary infiltrate in any lobe in patient with a travel history to country with active cases of SARS or avian influenza within past 10 to 21 days**	Airborne and Contact, plus eye protection
Diarrhea or vomiting	
Vomiting	Standard
Acute diarrhea with a likely infectious cause in an incontinent or diapered patient	Contact
Watery or explosive stools, with or without blood	Contact
Skin	
Fever (>101.1°F) and rash	Airborne
Fever (>101.1°F), upper chest rash, and stiff/sore neck	Droplet
Eye infections (drainage from eye)	Standard
Draining wound/lesion that cannot be covered	Contact
Rash	
—Itchy rash without fever	Contact
—Petechial/ecchymotic with fever	Droplet for 24 hours of antimicrobial therapy
—Rash and positive history of travel to an area with a current outbreak of very high frequency in the 10 days before fever onset	Droplet and Contact, plus eye protection (goggles or face shield). Add N95 or equivalent when performing aerosol-generating procedures
—Maculopapular with cough, coryza, and fever	Airborne
—Vesicular, especially if centrifugal in pattern	Airborne and Contact

*Always use Standard Precautions.

†If the causative agent is known, the appropriate isolation precautions for that disease should be used.

**A temperature of 100°F should be used as the identifier for potential infection to identify the elderly or immunocompromised individuals whose physiological changes tend to mask normal signs of infection.[49] In addition, clinical judgment should always be used.

Adapted from Rebmann et al.[61] and Siegel et al.[64]

community-based evacuation shelters, and any other site that administers healthcare services or houses potentially contagious patients.[61] Home isolation may also be recommended for individuals who are ill and contagious but do not require inpatient treatment.

PPE and other medical supplies are expected to be insufficient or depleted during an infectious disease disaster. Guidelines for stockpiling PPE for biological events have been proposed,[62] and are summarized in Table 120-6. If supplies of respirators become insufficient during disasters, despite local and regional stockpiling efforts, healthcare agencies should implement crisis standards of care related to extending the use or reuse of respirators. Guidance for developing a respirator crisis standard-of-care policy should be based on existing guidelines.[63] See Chapter 119 Emergency Management, for more information on how to manage a shortage of PPE and other medical equipment.

Social distancing practices may also be implemented during an infectious disease disaster as a nonpharmacological intervention. Social distancing refers to a set of practices that aim to reduce disease transmission through physical separation of individuals in community settings. These practices have been outlined in DHHS' document *Community Strategy for Pandemic Influenza Mitigation*.[65] Examples of social distancing include (1) home quarantine (staying at home after exposure to a potentially contagious person); (2) closing schools and childcare programs; (3) keeping children and teenagers out of public places, such as malls, movie theaters, and other common gathering areas; (4) canceling large public gatherings of any kind; (5) encouraging people to work from home when their jobs allow or adjusting schedules to decrease the number of workers in the same place at the same time; (6) arranging for community-based medical services that keep noncontagious individuals away from potentially contagious people (e.g., setting up prenatal classes in community sites rather than at hospitals, encouraging home birth); and (7) implementing other interventions that decrease interaction between individuals in communities as a way of decreasing the risk of disease transmission.[52,65]

Quarantine

Quarantine is the separation of individuals who are not yet symptomatic but have been exposed to a contagious person and are believed to be at risk of developing an infection. These exposed individuals are quarantined or separated from others

Table 120-6. Estimated Numbers of Postexposure Prophylaxis Needed for an Infectious Disease Disaster*

Category of Staff	Respirator	Gown (disposable)	Gloves (disposable)	Goggles/Eye Protection
Little to no exposure	1 disposable per contact/exposure	1 per exposure	1 pair per contact	None
Prolonged exposure	1 **reusable** per outbreak (plus 2 cartridges/month**)	1 per exposure	1 pair per contact	1 per outbreak
Infrequent exposure(s)	1 **reusable** per outbreak (plus 2 cartridges/month**)	1 per shift	1 pair per contact	1 per outbreak

Estimates are based on staff's expected exposure risk during the event.

*Adapted from: Radonovich LJ, Magalian PD, Hollingsworth MK, et al. Stockpiling supplies for the next influenza pandemic. *Emerg Infect Dis* 2009;15(6):e1.

**Disposable respiratory cartridges are needed for reusable respirators.

as a way to rapidly identify onset of illness if it occurs and keep them away from susceptible people. Once a person in quarantine develops signs or symptoms of disease, it would be assumed that they are infected and they would need to be isolated. Quarantine also implies exclusion of healthy individuals from areas that are known or suspected of being contaminated or housing infected patients. Time periods for quarantine depend on the disease to which the person was exposed. Generally, the quarantine time is equal to the length of the incubation period for the disease to which the person was exposed. Quarantines can be voluntary or enforced.

Quarantine is only to be considered in drastic circumstances, such as the emergence of a new highly pathogenic infectious disease or the use of smallpox as a biological weapon. Quarantine can be implemented in a variety of places, including community settings (e.g., a hotel or convention center), the home, or even in hospitals (i.e., work quarantine).[43] Interventions used as part of home and work quarantine are outlined in Table 120-7. Monitoring (either self-monitoring or external) must be in place for all quarantined individuals, regardless of where they are quarantined, to identify rapidly potentially infected or contagious individuals and institute appropriate therapy. It is generally recommended that quarantined individuals be housed in separate rooms; however, a study conducted in China during the 2009 H1N1 pandemic found that there was no increased risk of infection for quarantined students housed two to a room compared to those in single-person rooms.[66] Therefore, double-occupancy quarantine housing may be considered if space is limited.

Table 120-7. Interventions for Implementing Home or Work Quarantine as Used during the Severe Acute Respiratory Syndrome Outbreak

Home Quarantine
Individual is instructed to: —Wear mask when in contact with household members. —Monitor and record temperature twice daily. —Report any elevated temperature or other symptoms to public health. —Stay physically separated from others in the home whenever possible, including having a separate sleeping area/room and bathroom when feasible. —Keep separate linens (towels, sheets, pillowcases) and eating utensils (i.e., dishes, silverware) that are not shared with other household members. —Do not have visitors. —Do not go to any public gatherings or community activities, including shopping. —Stay in the house at all times. If the individual must leave the house (e.g., to get the mail), he/she should take a mask to put on if someone comes into the yard. —Walk dogs or other pets in the backyard only.
Work Quarantine (used after an individual had been exposed to illness during an occupational exposure)
Individual is instructed to: —Work at only the healthcare facility at which the worker was exposed, and then only if symptoms are not present. —See only essential patients in community-based clinics (if the healthcare personnel has a community practice in addition to hospital duties) and refer nonessential patients to other medical facilities. Wear a mask and have office staff wear a mask at all times. —Monitor and record temperature and symptoms before beginning work; elevated temperatures or other symptoms should be reported to the health department. —Drive to work alone in a private vehicle (i.e., do not use public transportation). —Wear mask at all times when at work. —Adhere to hand hygiene practices meticulously. —Eat in a room that is physically separated from others if possible; if not feasible, individual should stay at least 6 feet away from others. —Do not go to other medical centers, clinics, or hospitals unless authorized by the health department before visit. —When not at work, the individual must follow home quarantine guidelines.

Adapted from Reynolds et al.[67]

Home quarantine can be considered a means of social distancing and it was used as one such intervention in Canada during the SARS outbreak,[67] and in China,[68] Australia,[69] and Japan[70] during the 2009 H1N1 pandemic. A study conducted in Japan during the 2009 H1N1 pandemic aimed to assess the effectiveness of voluntary home quarantine among car production company personnel. This study found that voluntary home quarantine with paid time off was effective at lowering the overall incidence of infection among workers (reduced risk of infection by 20 percent); however, those who stayed home and obeyed the quarantine were two times more likely to get infected themselves compared to those who went to work.[70] This is believed to be because the workers who followed the quarantine probably had more close contact with their sick family member while they were at home. Another study conducted during the H1N1 pandemic had different findings; that study found that home quarantine may have been effective at decreasing the transmission rate early on during the pandemic, but it became significantly less effective as the rate of community transmission increased.[68]

Home quarantine should be considered if a young child requires quarantine so that the child can stay with the parent/primary caregiver. Multiple studies have found that U.S. citizens strongly prefer home quarantine over quarantine in a separate facility.[71,72] In contrast, research indicates that citizens from Hong Kong, Singapore, and Taiwan (who had experienced home quarantine during the SARS outbreak or had known individuals who had) reported that they strongly prefer quarantine in a separate facility.[72] The reasons for this difference are not known, but it is believed to be associated with the reality of home quarantine (i.e., fear of infecting household members, protective measures that needed to be implemented in the home, such as wearing a mask when around others, not sleeping in the same room). Research also indicates that U.S. citizens are more willing to comply with quarantine when it is voluntary versus when the government requests or orders it.[71]

Individuals in home quarantine may develop signs of infection and become too ill to stay at home, which would require transfer to a healthcare facility. Communication must be provided to quarantined individuals regarding: (1) why they are being quarantined, (2) how long their quarantine will last, (3) protective measures they must take while being quarantined, (4) how to monitor themselves for illness or how they will be monitored, (5) symptoms that need to be reported, (6) to whom they report symptoms or changes in health status, (7) how psychological support will be provided, (8) how compliance will be monitored, and (9) consequences for noncompliance.

Work quarantine was implemented during the SARS outbreak in Canada; results regarding its effectiveness as a means of controlling disease spread are conflicting.[73,74] In addition,

hospital/work quarantines implemented during the SARS outbreak were found to be expensive and had a negative psychological effect on healthcare personnel.[67] Future use of work quarantine as a nonpharmacological intervention needs to be evaluated. If a hospital-based work quarantine is to be implemented, provisions must be made to provide sleeping arrangements, food, water, and other essential services to those quarantined.

Regardless of the setting used for quarantine, one major potential obstacle to quarantine effectiveness is a lack of compliance. Research from the SARS outbreak indicates that only about half of all quarantined individuals were compliant with all community protective measures while on home quarantine;[67] these measures included such things as not going out of the house to socialize, not attending public events, not going on vacation, not running errands, and not allowing visitors into the home. Compliance with household protective measures was even lower: Only 38.4 percent complied with household protective measures, such as using separate towels and utensils, sleeping in a separate room, and using a mask when around others in the home.[67] A study conducted in Australia during the 2009 H1N1 pandemic had similar findings; compliance with home quarantine was only 53 percent.[69] A 2010 study[71] found that those who have a higher perceived susceptibility to avian influenza are more likely to report willingness to comply with home quarantine; education campaigns could be used to increase home quarantine compliance by focusing on the risk of disease development.

When considering the implementation of quarantine, one factor that needs to be considered is the potential for psychological stress associated with being quarantined. Two studies conducted with individuals who had been quarantined during the 2003 SARS outbreak found that quarantine causes a lot of psychological stress.[67,75] Quarantined individuals report feeling frightened, lonely, bored, frustrated, angry, and fearful of becoming infected, infecting their family or friends, and losing income while being quarantined.[67,75] Research indicates that there was also a certain level of stigma associated with being quarantined during the SARS outbreak, and this contributed to psychological distress among the quarantined.[67] However, the same level of psychological distress associated with quarantine was not found during the 2009 H1N1 pandemic. A study conducted with college students who had been quarantined for 7 to 10 days found that there were no negative psychological consequences from the quarantine.[76] The researchers postulated that the higher psychological impact during the SARS outbreak may have been related to the high mortality rate seen during the SARS outbreak, which could have caused more stress among those who were quarantined compared to those who were quarantined during the H1N1 flu pandemic that had a much lower mortality rate (10 percent mortality during the SARS outbreak versus <1 percent during the H1N1 pandemic).[76] If this is true, then a future event that involves an infectious disease with a fairly high mortality rate would be expected to result in higher rates of negative psychological stress while individuals are quarantined, and this should be factored into the decision-making process and/or addressed in mental health interventions among the quarantined.

Discussions regarding quarantine policies and procedures should include all of the following groups: (1) local law enforcement, (2) public health agencies, (3) facility administration, (4) security, (5) facility law representatives, (6) infection prevention, and (7) hospital epidemiologist or infectious disease physician/department. Other groups may need to be included, depending on the community and the agency/group that intends to implement quarantine. Current quarantine policies and procedures for healthcare facilities or agencies should be evaluated. In addition, healthcare facilities should partner with local public health officials to evaluate and update existing quarantine laws as needed.

Food Safety

For most infectious disease disasters, food safety will not be a primary concern. Pandemics, for example, will not pose a huge risk of foodborne illness, unless staffing shortages lead to poor food handling or inadequate environmental decontamination in food service industries. However, food safety will be critical if the infectious disease disaster involves a foodborne illness outbreak. Examples might include a bioterrorism attack using a foodborne illness agent, such as botulism, *Salmonella*, or *Shigella*, an agroterrorism attack that involves the infection of livestock or poultry, or if the event involves an emerging infectious disease that is linked to food sources, such as livestock.

An important aspect of biosecurity is ensuring that military and civilian food sources do not become compromised. This is one reason why veterinarians have started collaborating with public health officials to conduct surveillance of livestock: to monitor for potential bioterrorism attacks or emerging infectious zoonotic diseases. If food supplies do become compromised or contaminated, an investigation would need to be conducted. One possible intervention would include conducting environmental sampling; samples would be needed from the food involved, the processing or rendering plant or factory where the animals or food was processed, food preparation areas (if it's a restaurant), and utensils or other equipment that may be involved in the outbreak. Any facility that might be involved in the outbreak may need to be closed down temporarily. Examples include restaurants, rendering plants, dairy or animal farms, or food processing factories. Food safety education and training will be essential during foodborne outbreaks to ensure that workers understand how to safely handle food and decontaminate food preparation areas and equipment.

Water Safety

Water safety will not pose a major challenge for most infectious disease disasters. However, if terrorists were able to infiltrate and contaminate military or civilian water supplies, then water safety would be critical. In the past, military forces have deliberately contaminated wells and reservoirs as a means of poisoning civilians.[2,77] In addition, in the 1970s, two terrorist

groups attempted to use biological weapons to poison water supplies.[2] Intentional contamination of a municipal water system could lead to serious medical, public health, and economic consequences. Early recognition, timely outbreak investigations, accurate diagnosis, and rapid reporting by the medical and public health community of suspected waterborne terrorism disease cases will be essential to maintaining water security and safety.

An important aspect of biosecurity is ensuring that military and civilian sources of drinking water do not become compromised. Researchers have identified multiple ways in which our water systems could become contaminated during a bioterrorism attack, including before, during, or after water treatment at water treatment plants.[77] Some have argued that contaminating water before or at the water treatment plant would be ineffective because our current water treatment mechanisms would eliminate any infectious disease risk. However, water could easily be contaminated after it leaves water treatment facilities, such as at water bottling facilities, water supply connections at buildings or in communities, or deliberate contamination of recreational water, such as swimming pools.[77]

If water supplies do become contaminated, an investigation would need to be conducted. One possible intervention would include conducting environmental sampling; samples would be needed from the area or building known to be involved, plus moving backward through the water supply chain to determine the point at which the water first became contaminated. Sampling would identify if the water was only contaminated in a single facility/building or if it became contaminated at a water bottling factory that supplies drinking water to the facility/agency. Waterborne outbreaks can be very challenging to investigate because both animals and humans need water to survive, and animals and humans can get sick from waterborne diseases and then spread them animal to animal, animal to human, or human to human. It might be very complicated to determine that a bioterrorism attack was actually an attack on a water source, if the event involves sick animals and humans. It might look like an aerosol attack on animals, or a foodborne attack on animals that then spread to humans. Any facility that might be involved in a waterborne illness outbreak may need to be closed down temporarily, including healthcare facilities. Public health officials should be notified immediately if waterborne illness is suspected within a healthcare agency.

Healthcare Personnel Surge Capacity

Agencies, organizations, and businesses, including healthcare, should expect high absenteeism rates during an infectious disease disaster. Absenteeism is expected to be higher during an infectious disease disaster than other types of mass casualty events. Up to 20 percent of the workforce may be affected by illness at the same time during a pandemic, and others will be unable or unwilling to work due to family obligations or fear.[12] WHO recommends that emergency managers plan for a 40 percent absenteeism rate during the peak of a pandemic.[12] Healthcare personnel are expected to be infected at the same rate as the general population during an infectious disease disaster, which will further reduce healthcare facilities' and agencies' abilities to respond to such an event.[78] Healthcare facilities and agencies, including long-term care, home health, and community-based medical clinics, need to plan for this increase in healthcare personnel absenteeism. Some recommended ways for increasing healthcare personnel surge capacity include (1) having back-up contracts for obtaining extra staff; (2) providing incentives to get and keep staff; (3) prioritizing healthcare personnel for anti-infective therapy, prophylaxis, and vaccination; (4) offering anti-infective therapy, prophylaxis, and vaccination to healthcare personnel family members; (5) cohorting patients to decrease staff workload; (6) cohorting staff (dedicating healthcare personnel to provide care for potentially contagious individuals and restrict these staff from working with noninfectious individuals); and (7) cross-training staff to provide patient care outside their routine area/specialty to allow for staff resource distribution. One example of effectively using cross-trained staff to help with patient surge during an infectious disease disaster was the Children's Hospital of Philadelphia's use of nonboard-certified pediatric emergency medicine physicians and medical unit nurses in an emergency department during the 2009 H1N1 pandemic; this increased the emergency department's surge capacity when it was most needed.[79]

A variety of incentives should be considered to encourage employees to work during an infectious disease disaster. Examples include monetary bonuses, transportation, housing and subsistence, child/adult family member care, and pet care.[3] Many of the available interventions for increasing worker surge capacity are not currently being implemented in U.S. hospitals. For example, a recent study of U.S. hospitals found that less than a quarter have cross-trained their employees, less than 40 percent have plans to cohort staff, and less than half currently offer incentives to encourage staff to work during an infectious disease disaster.[3] Of U.S. hospitals that do offer incentives, the three most common incentives offered are free child or adult family member care, temporary housing and subsistence, and healthcare personnel prioritization for anti-infective therapy, prophylaxis, and vaccination.[3] There is no evidence regarding the status of healthcare personnel surge capacity during infectious disease disasters for long-term care, medical clinics, or home health, although it is assumed that surge capacity is no better for these healthcare agencies/groups than for hospitals.

One important incentive to provide healthcare personnel to encourage them to work during infectious disease disasters is to provide them safety measures. This includes prioritizing healthcare personnel for pharmaceutical interventions, such as vaccine and pre- and postexposure prophylaxis, when they are available. Research indicates that providing pharmaceutical interventions to healthcare and public health professionals and their family members significantly increases providers' willingness to work during infectious disease disasters.[80] Despite this, although approximately 80 percent of U.S. hospitals prioritize healthcare personnel to receive anti-infective therapy, prophylaxis, and vaccination during an infectious disease

disaster, less than half include healthcare personnel family members in the prioritization plan for pharmacological benefits.[3]

Research indicates that providing adequate supplies of PPE for providers so they can reduce their risk of occupational exposure to infectious diseases also increases the likelihood of healthcare professionals' being willing to work during a biological event.[80] Having adequate supplies of hygiene products and negative pressure rooms for infected patients will also help in limiting the risk of exposure to healthcare personnel and maximize the chances that they will be willing and able to work during a biological event. These issues need to be addressed in healthcare facility disaster planning for infectious disease disasters, so that healthcare personnel surge capacity can be maximized.

There is a caveat to encouraging healthcare personnel to work during an infectious disease disaster: It is imperative that healthcare agencies use a liberal sick leave policy during biological events. Sick healthcare personnel can contribute to the spread of disease during infectious disease disasters, as was seen during the SARS outbreak in which one staff member who worked a single shift while ill was linked to 137 cases of SARS, 45 of whom were other healthcare personnel.[43] Sick healthcare personnel should be furloughed until they are no longer contagious, and the policy should not be punitive.

Decontamination

Decontamination may or may not be an issue after an infectious disease disaster, depending on the following factors: (1) type of event (bioterrorism vs. emerging infectious disease outbreak or pandemic), (2) causative agent, (3) how soon the event is identified, and (4) source of concern (environment or patient). Most infectious disease disasters, including bioterrorism attacks, will likely not require patient or animal decontamination. Pandemics and outbreaks of emerging infectious diseases will not require patient or animal decontamination. In the event of a covert release of a biological agent, patients will not become symptomatic and present to healthcare institutions until days to weeks after the exposure; in this instance, they will most likely have bathed and changed their clothes, thus decontaminating themselves. Only in the event of an announced bioterrorism attack (within 12 to 24 hours after the release) will exposed individuals need to be decontaminated. Patient decontamination consists of bathing, including shampooing of hair, with plain soap and water, and changing their clothing.

Given existing knowledge, environmental decontamination is not considered necessary for outside sources, such as streets, cars, or the outside of buildings after a bioterrorism attack. This is because weather plays a key role in rapidly disseminating biological agents in outside air.

Indoor environmental sources may require extensive decontamination strategies after an infectious disease disaster, but the interventions vary according to the agent involved and the nature of the event. For example, more stringent decontamination methods are necessary for a bioterrorism attack using anthrax (because of the hardy nature of spores). As the 2001 bioterrorism attacks illustrated, equipment or areas may require specialized decontamination strategies, such as contained buildings, ventilation systems, or machinery with small parts. The costs of decontamination following the 2001 anthrax bioterrorism attack are estimated at $320 million.[4]

Other agents, such as smallpox, require diligent environmental decontamination as well. Smallpox can be spread through direct hand-to-hand contact or indirect contact with fomites, making decontamination of environmental surfaces imperative to prevent secondary transmission. Only EPA-registered, healthcare facility-approved germicides are required for environmental decontamination of smallpox, although a 0.5 percent hypochlorite solution may be used (this solution is made by mixing one part household bleach with nine parts water). In the event of a single smallpox case, scrupulous attention to contact precautions, including good housekeeping with EPA-approved germicides, would be critical to prevent secondary spread. Other potential bioterrorism agents and emerging infections that can be spread by hand-to-hand contact, such as viral hemorrhagic fevers and SARS, would require stringent environmental decontamination as well. Additional information on decontamination can be found in Chapter 119 Emergency Management.

Animal Control

Animal control may be an important nonpharmacological intervention during an infectious disease disaster, depending on the event. Contact with animals, both domesticated and nondomesticated, can lead to the spread of zoonotic illness. Management of service animals for disabled individuals or those that are used for healthcare-related procedures are covered in Chapter 122 Animals Visiting Healthcare Facilities.

Management of animals is less likely to be needed during an infectious disease disaster compared to a natural disaster that results in the displacement of individuals from their homes, but animal control may be essential during biological events that involve an animal vector, such as a West Nile virus, swine flu, or avian flu outbreak. Animal control interventions necessary for infectious disease disasters will primarily be a public health concern. Examples include surveillance of swine and poultry during avian or swine influenza pandemics, education of employees at meat rendering plants or poultry farms, and education of the general public about safe handling of animals while hunting. Animal control should not be an issue for healthcare agencies during infectious disease disasters, unless the animals are vermin.

Pest Control

Natural disasters, especially hurricanes and floods, are likely to result in an increase in insects and other pests in or around the affected community due to rain and high water levels. Healthcare facilities may become infested with insects and/or

vermin seeking warmth, moisture, and food. This is less of a concern for infectious disease disasters because there most likely will not be a significant environmental disruption that will cause pests to seek out medical facilities. However, if the biological event involves a vectorborne disease, then pest control will be vital. An example would be a bioterrorism attack involving the release of fleas carrying *Yersinia pestis*, the bacteria that causes plague. If carrier fleas were released, they could easily move throughout the community on animals, such as rats, cats, or dogs, and lead to human illness. If such an event occurs, vector control interventions will be vital to stop the outbreak.

The pest control interventions needed will depend on the disease involved. In the example of a bioterrorism attack involving the release of fleas carrying *Yersinia pestis*, pest control might involve spraying the facility for fleas, or trapping and killing rats if the plague-carrying fleas get into the rat population and rats invade medical facilities. Other pest control interventions would be needed if the vector was mosquitos. Mosquito control measures would include spraying the community for mosquitos, eliminating sources of standing water, and educating the public about mosquito prevention, such as using DEET and wearing long sleeves and pants.

Pest control services should be obtained as needed during an infectious disease disaster, including spraying for mosquitos or setting traps for mice. In addition, the facility's physical structure should be evaluated for any possible entrances for pests, and if found, should be eliminated. Examples include windows with torn or missing screens, unclosed doors that lead to the outside of the building, or sources of standing water.

Postmortem Care

There is a pervasive fear about potential infectious disease outbreaks caused by exposure to disaster victims' dead bodies. However, epidemiological data indicate that there is very little risk of an epidemic related to managing the dead bodies of disaster victims—even infectious disease disasters.[81] However, some infectious disease disasters do pose a threat of disease spread from managing the dead bodies of disaster victims. Examples include outbreaks of cholera, viral hemorrhagic fevers, or smallpox, any of which could put people at risk from disease from exposure to victims' dead bodies if precautions are not taken.[81]

Most of the risk related to handling the bodies of dead victims would be to medical examiners and those involved in conducting an autopsy, because this is an aerosol-generating procedure that could expose those in the room to infectious particles. All of the CDC category A bioterrorism agents could potentially be transmitted during autopsy; in practice, tularemia, viral hemorrhagic fevers, smallpox, glanders, and Q fever have been transmitted to medical examiners while performing autopsy.[82] Therefore, it is essential that pathology departments, medical examiners, coroners, funeral directors, and morgues be informed when the hospital or community is experiencing an infectious disease disaster. This communication should be done before submission of specimens or delivery of bodies. However, past outbreaks of anthrax and smallpox have been first identified from medical examiner autopsy findings.[82] Therefore, infection prevention is essential for all autopsies and pathology procedures.

All autopsies should be performed using Standard Precautions and following routine departmental practices for infection prevention. Standard Precautions for autopsies includes the use of scrubs, a hair bonnet/cap, impervious gown that covers arms, eye protection (face shield or goggles), shoe covers, double gloves, and respiratory protection.[82] Standard respiratory protection for autopsies consists of an N95 respirator or powered air-purifying respirators (PAPR) because of the aerosols routinely generated during the autopsy procedure (e.g., the use of an oscillating saw).[82] Autopsies should also be performed in a negative pressure room/area.[82] Additional biosafety recommendations for medical examiners and autopsy personnel can be found in "Medical Examiners, Coroners, and Biological Terrorism."[82]

Cremation is recommended for handling the bodies of smallpox and viral hemorrhagic fever victims, but mass cremation or mass burial should not be necessary.[81]

Exercises and Drills

Chapter 119 Emergency Management, outlines the need to perform exercises/drills to assess emergency management plans and how to conduct such exercises. As part of infectious disease disaster preparedness, it is vital that IPs ensure that emergency management drills regularly include a biological agent scenario. These exercises need to involve healthcare facilities, healthcare agencies (including long-term care and home health), and community response agencies to obtain a true sense of the community's preparedness for this type of event. It is also helpful to involve local businesses and schools to fully assess community preparedness for a biological event. A recent study found that although most U.S. hospitals had participated in a disaster drill involving a biological agent scenario in the previous year, approximately 15 percent had not.[3] Many of the hospitals had included community involvement in the exercise and compiled lessons learned from the exercise, but approximately 35 percent had not communicated emergency management plan changes to staff after the exercise.[3] A study conducted after the 2009 H1N1 pandemic found that less than half of all home health agencies engage in regular disaster drills of any kind.[22] A 2011 study[83] found that only 13.6 percent of U.S. businesses overall and 31.3 percent of healthcare agencies have used an infectious disease scenario in a drill or exercise during the past 2 years. Another study found that only 4 percent of schools have incorporated an infectious disease scenario into a disaster drill in the last 2 years.[84]

CONCLUSIONS

After the bioterrorism attack using anthrax-laden letters in the United States in 2001 and the numerous outbreaks of emerging infectious diseases that have occurred, including the 2009 H1N1 pandemic, preparedness for biological events has

become a necessity for healthcare, public health, businesses, and schools. The world remains always poised for the next pandemic or large-scale infectious disease outbreak. Infectious disease disaster management encompasses the four principles of emergency management—mitigation, preparedness, response, and recovery—and is a multidepartmental and multiagency endeavor. As experts in the fields of surveillance and epidemiology, IPs play a critical role in hospital/healthcare facility and community preparedness, and are responsible for becoming better prepared to effectively recognize and respond to an infectious disease disaster.

Infectious disease disaster preparedness is an ever-evolving process in which facilities and IPs become better prepared to effectively recognize and respond to a mass casualty event involving a biological agent. This is accomplished through facility assessment, development of a response plan, exercise of the response plan, evaluation of the exercise and the facility's and community's level of preparedness, and incorporation of lessons learned from the evaluation into the plan (i.e., emergency management process).

FUTURE TRENDS

Many issues related to infectious disease disaster preparedness are still being debated, and response strategies are being continuously planned and updated. A few such issues include (1) status of quarantine laws, (2) reimbursement issues related to adverse events associated with the smallpox vaccine, and (3) plan for mass prophylaxis or vaccination distribution. In addition, new guidelines related to avian influenza, smallpox, and other potential infectious disease disaster agents are being evaluated and updated. It is critical for IPs to stay abreast of the ever-changing knowledge base related to infectious disease disaster preparedness and the etiological agents of concern.

INTERNATIONAL PERSPECTIVE

Infectious disease disaster preparedness is an international concern. With the ease and frequency of international travel, it is conceivable for infectious diseases to have a major global impact. SARS is a good example of this phenomenon. Whether intentionally inflicted or a natural event, an outbreak involving an infectious disease is a global issue of concern. Few countries currently have the resources to respond to an infectious disease disaster involving mass casualties.[85] Many countries are working on infectious disease disaster management strategies, both alone and in conjunction with the United States.

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SUPPLEMENTAL RESOURCES

Many resources are available for education and training on infectious disease disasters preparedness and the clinical description of potential infectious disease disaster agents. APIC offers many educational opportunities for infectious disease disaster related education. A few examples include multiple webinars provided through the APIC website: http://webinars.apic.org/; the APIC Position Paper, *Extending the Use and/or Reusing Respiratory Protection in Healthcare Settings During Disasters*[63]; and numerous other educational initiatives. Please see the APIC Emergency Preparedness website for additional infectious disease disaster training opportunities: http://www.apic.org/Professional-Practice/Emergency-Preparedness .

Other website sources include the following:

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

U.S. Army Medical Department. Available at: http://www.usamriid.army.mil/.

Johns Hopkins Center for Biodefense: http://www.jhsph.edu/news/news-releases/2003/preparedness-tips.html/

In addition, many public health departments offer infectious disease disaster educational opportunities; check with your local and state public health department(s) for further information.