

Chapter 1: Introduction to Infectious Diseases

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Objectives

After completing this chapter, participants should be able to:

1. Define *infectious disease*.
2. Describe the primary routes of transmission for infectious diseases.
3. Name an example of a recent or historic outbreak of an infectious disease.
4. List at least three infectious diseases, their symptoms, and how they are transmitted.
5. Describe the NIAID Category A, B, and C priority pathogens/agents.
List occupations that are at risk from infectious disease exposure.
6. Define *biosafety*.
7. Explain the key elements in assessing risks for occupational exposure to infectious diseases.

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Introduction

Recent news on the Zika virus and less recent but more frightening accounts of Ebola spreading beyond Africa, can make workers wonder if their job has infectious disease risks. To some degree, every job carries risk. Simply working around other people, animals (birds, bats, etc.), and contaminated environments can increase disease risk.

Healthcare workers face greater risk of exposure to infectious diseases than others but even construction craft laborers (CCLs) may have disease hazards on the job. For example, maintenance, housekeeping or renovation workers in a healthcare facility may risk exposure to disease-carrying viruses and bacteria. Workers on jobsites where many different people come and go, such as airports, universities, and government buildings also have greater chances of exposure. Anyone who responds to disasters also risks contact with bacteria and viruses from the dead and injured, contaminant releases, and unsanitary conditions.

There are a huge number of contagious diseases, and new ones appear at an alarming frequency. Even old diseases such as polio and yellow fever seem to be coming back, increasing worker health hazards.

The high potential for exposure is the bad news. The good news is that there are ways workers can protect themselves and reduce the risk of contracting an infectious disease. This course introduces infectious diseases, identifies potential work hazards, and provides ways that workers and employers can create a safer, healthier work environment. It is for all workers who could come into contact with any disease, both known and unknown.

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What are Infectious Diseases?

Infectious diseases are illnesses, infections, or other health disorders that are caused by organisms that enter the body and multiply. These small organisms (microorganisms) include bacteria, viruses, fungi, and parasites. They may also be called pathogens or biological agents.

Microorganisms are everywhere in nature. They are found in water, soil, plants, and animals. Many reproduce rapidly and require little to survive. Most are harmless and sometimes even helpful. Under some circumstances they cause diseases. Some also evolve and adapt to new environments, making them potentially hazardous to human health, even if they didn't start out that way.

HOW ARE INFECTIOUS DISEASES SPREAD?

Organisms that carry or cause infectious diseases can easily spread, causing outbreaks of an illness. They may spread from person to person, from insect or animal bites, from eating contaminated food/water, or simply by contacting the organism in the environment. Learning how infectious diseases are transmitted is important for determining proper infection prevention and control measures, and must be considered in risk assessment.

The different ways diseases spread are called routes of transmission. Some pathogens have multiple routes of transmission. The primary means include:

- **Direct contact:** (A susceptible person physically contacts an infected person and transfers the organism; for example, by kissing, sexual contact, touching open wounds/sores, etc.) Ebola is a very serious, deadly disease transmitted by direct contact. Direct contact diseases are most hazardous to family members and healthcare workers.
- **Indirect contact:** Transmission occurs when an individual touches a contaminated surface and then becomes infected by touching his or her mouth, eyes, or nose. Influenza is typically transmitted through indirect contact.
- **Airborne:** Transmission occurs through droplets or aerosols. With aerosols, the organism gets into the air and is breathed in by another person. (Breathing in a contaminant or organism is called inhalation.) When they are inhaled by a susceptible individual, they enter the respiratory tract and can cause infection. Since air currents can disperse these particles or droplet nuclei over long distances, airborne transmission does not require face-to-face contact with an infected individual.



Pathogens = Biological agents



aerosols: A suspension of tiny particles or droplets in the air.

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Table 1: Routes of transmission for infectious diseases.

Contact	Direct	<p>Direct physical contact between the source and the susceptible person, including exposure to skin and body secretions.</p> <p>Examples: Influenza virus; touching a wound; Infectious mononucleosis; chlamydia</p>
	Indirect	<p>Infectious agent deposited onto an object or surface (fomite) and survives long enough to transfer to another person who subsequently touches the object. These may include medical equipment, clothing, bedding or even drinking cups.</p> <p>Examples: Influenza; Norwalk, rhinovirus; gram-positive bacteria; gram-negative bacteria; a typical bacteria.</p>
	Droplet	<p>Transmission expelled from respiratory secretions by coughing, sneezing or talking. Droplets are large particles that rapidly settle on surfaces or come in contact with the nose, mouth, or eyes.</p> <p>Examples: Meningococcus; influenza; respiratory syncytial virus (RSV)</p>
Non-Contact	Airborne	<p>Transmission via aerosols (microscopic airborne particles) that stay suspended in the air. Can be spread via ventilation systems.</p> <p>Examples: Tuberculosis (TB); measles; chickenpox</p>
	Vehicle	<p>Infection spreads from a single contaminated source to multiple hosts. This can be either a point source or a common source.</p> <p>Point source examples: Food-borne outbreak; medical equipment</p> <p>Common source examples: The cyanide poisoning of Tylenol in 1982; cases may be widespread due to transportation and distribution of the source (in this case, the medication).</p>
	Vector-borne	<p>Infectious agents are transmitted to humans by insect or animal vectors</p> <p>Examples: Zika virus from mosquitoes; lyme disease from ticks; hantavirus from rodent feces and urine</p>
Aerosol Transmissible		<p>Infectious agents are suspended or present in particles or droplets and contact the eyes, nose, mouth, or are inhaled.</p> <p>Examples: Ebola, influenza, mumps, pertussis</p>

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Droplets containing infectious agents are generated when an infected person coughs, sneezes, or speaks. They usually do not stay in the air very long. Transmission occurs when droplets come into contact with a person's eyes, nose, or mouth. Droplet transmission does not occur through the air over long distances.

Droplet transmission more frequently occurs when a person touches the droplet after it settles onto a surface. Good examples of airborne diseases are tuberculosis and whooping cough.

- **Vector-borne:** Carried by another species; "vector" usually refers to an insect, and transmission occurs via a bite from the vector. For example, Zika and West Nile virus are transmitted by mosquitos. Construction workers are at greater risk from vector transmitted illness.
- **Non-contact vehicle transmission:** Infection spreads from a contaminated source to the individual. Often the contaminant is ingested (enters through the mouth). Pathogens may be found on food or in water. Recent food-borne outbreaks include illness from E. coli and salmonella. Janitorial workers in public buildings and environmental services personnel in healthcare facilities are at higher risk, as are disaster relief workers.
- **Bloodborne:** (From contact with an infected person's blood or sometimes other body fluids) Contaminated needle sticks often transmit these diseases. HIV and hepatitis B are bloodborne illnesses. Healthcare workers and emergency responders are at higher risk for these diseases.



Droplets are one form of airborne transmission of infectious agents.

Any of these means of transmission can happen in the workplace. The risk of becoming ill from an infectious disease depends on the opportunity for exposure, the overall health or susceptibility of the person, and the virulence of the disease.

Virulence means how harmful the organism is, or its ability to cause disease. It also refers to the severity of the disease after it is contracted. Basically virulence describes how effective a pathogen is at making a person sick. Ebola is an example of a highly virulent disease.

Some people are more likely to get diseases than others. Those who have compromised immune systems (a weakened ability to fight off diseases) are at greater risk. If a person is already sick with something else, he or she is more susceptible to (likely to get) another

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virulence (VEER-uh-lens): How harmful an organism is.

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immunocompromised (im-myoon-oh-COM-pro-mizd):
Unable to develop a normal immune response because of disease, malnutrition, or immunosuppressive therapy.

disease. The medical term for a weakened immune system is immunocompromised. Very young and very old people are also more likely to get sick.

Sometimes people can become immune to a disease, either by having already had the illness or by getting a vaccination against the illness. Immunity means that you will not get, or have a very low probability of getting, a disease even if you are exposed to it. To protect against some diseases, workers who are at high-risk (workers in healthcare settings or unsanitary environments) should make sure that they are vaccinated against likely diseases if the vaccinations are available.

INFECTIOUS DISEASE OUTBREAKS

Infectious disease outbreaks have occurred many times throughout history. Some of the most significant and some with the potential to remain or become a problem are described below.

Historic Outbreaks

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gangrene (gan-GREEN): *The death of body tissue due to a lack of blood flow or a bacterial infection. It usually affects your toes, fingers, and limbs.*

The Bubonic Plague

The plague in the 14th century, was so devastating that some estimate nearly half of the European population was wiped out in four years. The plague is believed to have been a vector transmitted disease, usually transmitted to humans through fleas. Symptoms included chills, high fever, muscle cramps, seizures, gland swelling, and gangrene.

pandemic (pan-DE-mic):
Widespread, across the whole country or the world.

The 1918 Spanish Flu

This influenza pandemic spread quickly around the world and was helped by the movement of troops engaged in World War I. After ending in 1919, one fifth of the world's population was infected. The mortality rate was as high as one in five. This influenza is a particularly good example of a highly virulent disease and was unusual because it was particularly devastating to individuals aged 20 to 40. These individuals are normally more resistant to the influenza.

Many different strains of the influenza virus continue to cause outbreaks every year. Some are more serious than others. Serious outcomes of flu infection can result in hospitalization or death. The best way to prevent the flu is by getting vaccinated each year, although flu strains change each year, and vaccines have varying levels of success in preventing the flu. Risk of catching the flu can be reduced by following standard precautions such as hand

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washing, covering the mouth and nose when sneezing and coughing, disinfecting soiled/contaminated surfaces, and limiting exposure to affected individuals.

People who have the flu often feel some or all of these signs and symptoms:

- fever or feeling feverish/chills
- cough
- sore throat
- runny or stuffy nose
- muscle or body aches
- headaches
- fatigue (very tired)
- some people may have vomiting and diarrhea

Influenza can be transmitted through direct contact, contact with an infected object, or inhalation of infected aerosols.

Recent or Frequent Outbreaks

HIV/AIDS

We still battle this disease. The first documented case was in 1959 in the Congo. As of 2011 over 60 million people were affected and 25 million had died. In sub-Saharan Africa one in five adults were infected. HIV is an example of a bloodborne pathogen that is extremely virulent.

Although you might not see them for years, symptoms can include flu-like symptoms; rapid weight loss; night sweats; extreme exhaustion; swollen lymph glands; prolonged diarrhea; sores on the mouth, anus, or genitals; pneumonia; skin blotches; memory loss; and depression.

Cholera

This disease affects millions of people each year, killing over a hundred thousand. This disease is an example of the impact of harmful organisms transmitted by eating food or drinking

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water contaminated with the cholera bacterium. It is transmitted through ingestion; it doesn't usually spread from person to person. It is characterized by diarrhea, vomiting, and leg cramps. Rapid loss of body fluids can lead to dehydration and shock. Without treatment death can occur within hours. A vaccine is now available for protection against cholera but is not 100% protective. Standard prevention and control measures are still needed.

E. coli

Escherichia coli are bacteria found in the environment, foods, and intestines of people and animals. E. coli has been transmitted to the general population through contaminated food, often from inadequately washed fruit and vegetables. A recent example involved food served at Chipotle restaurants in 2015.

E. coli are a large and diverse group of bacteria. Some kinds of E. coli can cause diarrhea, while others cause urinary tract infections, respiratory illness and pneumonia, and other illnesses. The symptoms of E. coli infections vary for each person but often include severe stomach cramps, diarrhea (often bloody), and vomiting. Most people get better within 5–7 days. Some infections are very mild, but others are severe or even life-threatening. It is important to stay hydrated when suffering from E. coli infections. Workers in the food industry and disaster workers who may be exposed to unsanitary conditions are particularly at risk for transmission of E. coli.

SARS

Severe Acute Respiratory Syndrome (SARS) was notable in the way it is believed to have spread. It started in China in 2002 and spread to 37 countries worldwide through airplane travel. Experts believe that this virus was spread by droplets expelled from an infected person's cough or sneeze and then breathed in by others. It also spread indirectly from contact with infected surfaces. SARS demonstrated how quickly viruses spread in a world that is so interconnected by international travel. This virus rapidly spread from person to person, however it was controlled by maintaining rigid isolation controls. SARS most likely originated from infected bats, then transferred to civet cats and livestock, and finally to humans. It provides an example of how a disease can sometimes jump from one species to another.

Symptoms include fever, dry cough, shortness of breath, headache, muscle aches, sore throat, fatigue, and diarrhea.

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Ebola

The Ebola virus disease (EVD) is a severe and often fatal disease. The 2014 Ebola outbreak was the largest Ebola outbreak in history and the first in West Africa. It most commonly spreads by direct contact with blood, secretions, organs, or other body fluids of infected individuals. The fatality rate is around 50%.



The Ebola virus under an electron microscope.

EVD is usually marked by fever, muscle pain, headache, and sore throat. The illness progression includes nausea, vomiting, diarrhea, and impaired organ function. In some cases, rash, internal and/or external bleeding, and death may occur.

Family members and healthcare workers have the highest risk of contracting the virus, but other workers who clean linens and other materials used by the patient and individuals who decontaminate their hospital and living quarters are also at risk.

Because Ebola is so infectious after the incubation period is over, individuals who work in public buildings, especially travel-related areas such as airports, train stations, vehicles, etc. should also take precautions when working during a known outbreak.

Zika

Zika virus disease is caused by the Zika virus, which is spread to people primarily through the bite of an infected mosquito. It can also be sexually transmitted. Zika most frequently occurs in tropical and subtropical regions. In 2016, Zika outbreaks occurred in South and Central America, the Caribbean and in areas of Miami-Dade County, Florida. Symptoms of Zika include mild fever, rash, joint/muscle pain, and headache. The virus is also spread from a pregnant mother to her fetus and may cause severe fetal brain defects. During the colder winter months the virus is not as common in North America.

To date over 5,000 cases have been reported in the United States mostly by travelers returning from affected areas outside the U.S. It remains to be seen if it will spread further

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incubation period:
The time between exposure to a pathogen and when the signs/symptoms first become apparent.

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within the United States, but it is likely since mosquitos are difficult to control. Outdoor workers, such as construction craft laborers, are at higher risk of contracting Zika. Precautions include wearing long sleeve shirts and pants, using insect repellent, and eliminating standing water from the work area.

CATEGORIZATION OF PATHOGENS AND BIOLOGICAL AGENTS

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NIAID: National Institute of Allergy and Infectious Diseases

NIH: National Institutes of Health

The National Institute of Allergy and Infectious Diseases (NIAID) is part of the National Institutes of Health (NIH), which falls under the U.S. Department of Health and Human Services. NIAID is an organization that supports research to understand, treat, and ultimately prevent infectious diseases.

NIAID maintains and regularly revises a pathogen priority list. This list includes diseases that emerge naturally as well as those that may be deliberately introduced as an act of bioterrorism. The NIAID pathogen priority list includes three risk levels:

- **Category A Priority Pathogens:** Organisms/biological agents that pose the highest risk to national security and public health.
- **Category B Priority Pathogens:** The second-highest priority organisms/biological agents.
- **Category C Priority Pathogens:** The third-highest priority, including emerging pathogens that could be engineered for mass dissemination in the future.

Category A Priority Pathogens

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disseminate: Spread widely.

Category A pathogens pose the highest risk to national security and public health because they:

- Can be easily disseminated or transmitted from person to person.
- Result in high mortality rates and have the potential for major public health impact.
- Might cause public panic and social disruption.
- Require special action for public health preparedness.
- Cannot be transported without special permissions unless the virus is inactivated.

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Category A infectious agents are capable of causing permanent disability or life-threatening or fatal disease. Some of the Category A pathogens include:

- anthrax
- bloodborne pathogens
- HIV/AIDS
- hepatitis B
- hepatitis C
- botulism
- dengue
- Ebola
- hantaviruses
- plague
- smallpox
- tularemia
- viral hemorrhagic fevers



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hemorrhagic (hem-or-A-jic): characterized by profuse bleeding

autoclave: a strong, heated container used for chemical reactions and other processes using high pressures and temperatures

Autoclave sterilization renders Category A infectious substances into Category B medical waste. An autoclave is a strong, heated container that is used for chemical reactions and other processes using high pressures and temperatures. Not all hospitals have autoclaves.

An autoclave is a strong, heated container that is sometimes used to inactivate infectious agents.

Category B Priority Pathogens

Category B pathogens, the second-highest priority organisms/biological agents:

- Are moderately easy to disseminate.
- Are not generally capable of causing permanent disability, or life-threatening or fatal disease.
- Result in moderate morbidity (illness) rates and low mortality rates.
- Require CDC's diagnostic capacity and enhanced disease surveillance.

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CDC: U.S. Centers for Disease Control

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Category B pathogens include biological agents such as:

- typhus fever
- ricin toxin
- Staphylococcus
- food and waterborne pathogens:
 - bacteria (E. coli, salmonella)
 - viruses (hepatitis A)
- mosquito-borne encephalitis viruses, including:
 - West Nile virus
 - Eastern equine encephalitis virus

Category C Priority Pathogens

Category C pathogens are the third-highest priority, and include emerging pathogens that could be engineered for mass dissemination in the future because of:

- availability;
- ease of production and dissemination; and
- potential for high morbidity and mortality rates and major health impact.

Some of the Category C pathogens include:

- tuberculosis (TB),
- seasonal influenza virus,
- yellow fever, and
- hantaviruses.

Emerging Infectious Diseases

NIAID also lists several emerging infectious diseases. These are diseases that have newly appeared in a population or have existed previously but which are rapidly increasing in incidence or geographic range. Some emerging infectious diseases include:

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- rubella (German measles)
- Zika virus

OCCUPATIONAL EXPOSURE AND RISK ASSESSMENT FOR INFECTIOUS DISEASES

At-risk Occupations and Industries

Many industries and occupations have potential exposure to infectious diseases:

- building maintenance;
- healthcare;
- humanitarian aid;
- first responders, emergency personnel, security;
- laboratory;
- environmental services (cleanup and waste disposal);
- funeral and mortuary;
- travel: airline, rail, ship; and
- border, customs, and quarantine workers.

Prevention of occupational exposures to pathogens begins with employers performing a risk assessment and developing and implementing an exposure control plan. This plan helps ensure procedures are in place to protect all employees who have potential contact with infectious agents.

Exposure to infectious diseases will differ based on job tasks and sites, and hazard assessments. Control plans should be developed that meet the needs of the specific group, site, tasks, and potential exposures.

Only a few industries such as laboratories and healthcare have set up regular practices specifically for working around infectious diseases. Medical laboratories already have established protocols for biosafety – the discipline addressing the safe handling and containment of infectious microorganisms and hazardous biological materials. This industry

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biosafety: The discipline addressing the safe handling and containment of infectious microorganisms and hazardous biological materials.

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considers: type of pathogen, work tasks, primary barriers and safety equipment needed, and the type of facilities where the work is performed.

OSHA's standards on bloodborne pathogens, respiratory protection, and personal protective equipment all require employers to conduct an exposure assessment to protect workers from hazards. An effective risk assessment for workplace exposure to infectious agents should include these requirements and other site-specific exposure considerations into a site-specific exposure control plan. Traditionally exposure assessments consider:

- occupational exposure limits;
- virulence (the severity or harmfulness of a disease);
- airborne or surface concentration; and
- infectious dose.

However, the lack of information on these factors for many diseases makes development of the control plan very difficult. When circumstances are poorly defined and the risk may be high, then the most protective measures should be taken.

The Risk Assessment

Health and safety experts will conduct the risk assessment, but the involvement of front line workers is very important. Administrators, supervisors, maintenance personnel, and those working closest to the hazard will have the direct experience with the tasks and operations that have the potential for exposure. They can help develop effective interventions that workers can and will use to improve infection prevention and control.

Key Considerations in the Risk Assessment

The risk assessment must consider the sources and pathways for potential exposure to infectious pathogens. Some key considerations are:

- Will job tasks include potential exposure to infectious materials?
- What is the proximity of workers to the contagious individual, contaminated waste, surfaces/equipment, or animals?

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- Will workers be at risk for exposure through contact, splash, inhalation, ingestion, or injection?
- Will job tasks, work environment, fatigue, and related factors increase risk of exposure or illness?

Once at-risk jobs and job tasks are identified, the assessment will consider the characteristics of the pathogens to establish risk level and determine effective controls. Key characteristics of the pathogen, potential exposure pathways, and effectiveness of existing controls should be documented, including:

- pathogenicity, virulence, and infectious dose;
- severity of potential health effects;
- environmental survivability and transmission;
- potential for sprays, splashes, and aerosols generated during work-related procedures; and
- effectiveness of existing controls.

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pathogenicity
(*path-o-gen-ih-sih-tee*):
Refers to the ability of an organism to cause disease (i.e., harm the host).

Completing the Risk Assessment

A completed risk assessment will include documentation of the following five steps:

Step 1: Identify hazards.

- Employers have a duty to assess the health and safety risks faced by their workers.

Step 2: Decide who may be harmed, and how.

- Identify who is at risk including employees, contract staff, visitors, and members of the public.
- Review work routines in all the different job locations and situations.
- Identify vulnerable workers such as young workers, disabled workers, and pregnant or breastfeeding women.

Step 3: Assess the risks and take action.

- Employers must consider how likely it is that each hazard could cause harm. Even after all precautions have been taken, some risk usually remains. For each remaining hazard determine whether the risk remains high, medium, or low.

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Step 4: Record the findings.

- Employers should record the main findings of the risk assessment, including details of any hazards and action taken to reduce or eliminate risk.

Step 5: Review the risk assessment.

- Employers should periodically review the assessment to ensure that safe practices are being followed; and
- To take into account any new conditions, equipment, technology, or hazards that may present themselves.

WORKER PROTECTION AND INFECTION CONTROL

Selection of Control Measures

Once the risk assessment is completed, the next step is to select appropriate control measures to prevent exposure to infectious pathogens. This control selection process considers:

- Likelihood of exposure.
- Consequences of exposure.
- Have exposures occurred?
- Routes of exposure?
- Does exposure result from specific job duties?
- How do Standard Precautions or Expanded Precautions apply?
- How does the Hierarchy of Controls apply?

Standard Precautions

Standard Precautions reduce the risk of disease transmission. They were initially developed for bloodborne pathogens to provide a basic, minimum level of infection control. Standard Precautions are designed to reduce the risk of transmission of microorganisms from both recognized and unrecognized sources of infection in hospitals. While standard precautions

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were developed with the healthcare setting in mind, workers in other settings who may be at risk of infectious disease exposure should observe as many of these precautions as possible.

Expanded Precautions

Expanded Precautions (formerly known as Transmission-Based Precautions) are designed for patients documented or suspected to be infected with highly transmissible or epidemiologically important pathogens for which additional precautions beyond Standard Precautions are needed to interrupt transmission in hospitals.

Standard and Expanded Precautions will be discussed further in *Chapter 2: Hazard Recognition and Control*.

Control Issues with Infectious Diseases

Numerous agencies and experts have published guidelines, recommendations, and orders with differing advice. Because of this, it is crucial that employers, unions, and health and safety experts work together and involve frontline employees in assessing hazards and selecting control measures and PPE that are appropriate to the setting and tasks.

A first step is to review CDC, OSHA, and best practice documents to have the best available information to assist in hazard identification and control activities. Involving frontline workers is important as they have intimate knowledge of the day-to-day job hazards, and also practical insight into what works and what doesn't.

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epidemiology: *The branch of medicine that deals with the incidence, distribution, and possible control of diseases and other factors relating to health.*

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Summary

Environmental service workers may be asked to perform cleanup operations on an infected site or transport infected waste. Other workers may need to perform maintenance operations in a workplace setting where infected equipment or materials are present. The diversity of workplaces where this might take place makes working around infectious diseases especially challenging.

A number of government agencies are working to provide guidelines and best practices for different industries so that people can work safely around infectious diseases. Because new diseases are constantly being identified, the information in this course is meant to serve as a foundation for learning about hazards, controls, and safety precautions to take around these types of situations. In practice, employers will need to provide information that is specific to the type of exposure present, based on comprehensive occupational risk assessments and their own safety and health plans, best practices, and standard operating procedures or safety protocols.

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