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Contact Hours: **6**

Infection Control

Preventing and Controlling Infectious Diseases, including COVID-19

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LEARNING OUTCOME AND OBJECTIVES: Upon completion of this course, you will have increased your knowledge of current, evidence-based information on preventing and controlling the spread of infection. Specific learning objectives include:

- Discuss the impact of community-acquired and healthcare-associated infections.
- Define key terms related to infection prevention and control.
- Describe the chain of infection as it applies to infection prevention and control.
- Explain methods to prevent the spread of infection.
- Summarize the engineering, work practice, and environmental controls that protect against healthcare-associated infections.
- Identify barriers and personal protective equipment for protection from exposure to potentially infectious material.
- Discuss efforts designed to minimize the risk of occupational exposures to infectious diseases.
- Recognize suspected sepsis and methods to prevent it.

THE NEED FOR INFECTION PREVENTION AND CONTROL PRACTICES

Infection control was born in the mid 1800s when Ignaz Semmelweis, a Hungarian obstetrician, demonstrated that handwashing could prevent infection. Semmelweis was director of two obstetrical clinics, one staffed by medical students, the other by midwives. Disturbed by the fact that the maternal mortality rate from postpartum fever in the clinic staffed with medical students was almost six times greater than in the clinic staffed by midwives, he set about analyzing the difference and found that medical students often performed autopsies prior to assisting with deliveries without washing their hands.

Semmelweis came to the conclusion that the medical students performing autopsies (which midwives did not do) were carrying some invisible poisonous material on their hands to the women they were assisting in the delivery room, and he instituted a policy requiring medical students to wash their hands in a solution of chlorinated lime prior to assisting in any obstetrical procedure. As a result of this practice, the mortality rate dropped nearly 90% in the medical students' clinic, and in a period of two months, the death rate dropped to zero (Zoltán, 2020).

Later in that same century, Florence Nightingale described the relationship between the diseases that were killing her patients during the Crimean war and the conditions in which they were cared for. Nightingale instituted ways to improve overall hygiene and prevent contamination that led to reductions in infections and mortality. Her greatest influence has been on hospital infection control, and many modern healthcare practices (e.g., isolation, ventilation, routine cleaning, medical and human waste disposal) are attributed to her (Nightingale, 2017).

Today, we know about pathogenic microorganisms and how they are transmitted, and we have a great deal of knowledge of the principles of infection control. Despite these advances, preventable infections continue to occur. Why, on any given day, does 1 in 31 patients in United States hospitals have at least one healthcare-associated infection? Why, on average, do healthcare providers clean their hands less than half as often as they should, despite it being known that hand hygiene is the most effective way to prevent healthcare-acquired infections (CDC, 2020a)?

These questions indicate that infection control is not just a matter of knowing what is effective but that there is a strong behavioral element involved in the process of carrying out infection control practices. Both factors must be addressed if the absence of healthcare-acquired infections is the goal. To accomplish this, each healthcare worker should have the necessary knowledge, skills, and abilities to implement effective infection control practices, which then may influence their perceptions and provide motivation to change behavior.

It is also essential to reinforce continual improvement in infection control and prevention, recognizing that in the current healthcare environment there are factors that increase the need for ever more vigilance. Such factors include:

- A growing population of individuals who are immunocompromised and/or vulnerable (e.g., older adults, patients undergoing chemotherapy or transplants)



- An increase in the severity and acuity of illness among hospitalized patients
- The complexity of healthcare settings that are more difficult to clean and easier to transmit infections from the environment
- Medical care that has become more invasive, with patients being exposed to long-term invasive devices (urinary catheters, heart valves, implantable defibrillators, central venous catheters, tracheostomy tubes, etc.)
- The rising rate of multidrug-resistant organisms (MDROs) (e.g., methicillin-resistant *Staphylococcus aureus* [MRSA])
- The rise of organisms with high propensity for transmission within healthcare facilities (e.g., *Clostridioides difficile*)
- Changes in how and where healthcare is delivered, reinforcing the need for improved infection control and prevention efforts not only in hospitals and healthcare settings but in the community as well

TERMINOLOGY

Healthcare-associated infection (HAI)

A healthcare-associated infection is an infection acquired while receiving healthcare in any setting (e.g., hospital, long-term care facility, outpatient clinic, ambulatory setting, home care). These infections occur in patients who do not have infections and are not incubating an infection at the time of entry into the healthcare system but acquire them while receiving treatment for other conditions. Healthcare workers also can be the recipients of HAIs. Other common terms for HAIs are *nosocomial* (originating in a hospital) and *iatrogenic* (caused by medical treatment).

Healthcare worker (HCW)

Any person who has contact with patients, body fluids, or supplies used for patient care as part of their job. This includes physicians, nurses, occupational therapists, and physical therapists as well as administrative, environmental hygiene, and laboratory staff in medical facilities. HCWs also include interns, volunteers, and paid workers/employees who are involved in any aspect of healthcare in any setting. All healthcare workers should be trained in basic infection prevention and control regardless of whether they deliver direct or indirect care to patients.

Outbreak

An outbreak is a sudden increase in the occurrence of a particular infectious disease in a particular place and time. An epidemic is an outbreak in which a disease is actively spreading over a wide geographic area and affecting a high proportion of the population. A pandemic is an epidemic that has spread to multiple countries or regions of the world.



Surveillance

Surveillance is the continuous, systematic collection, analysis, and interpretation of health-related data needed for the planning, implementation, and evaluation of public health practice. It can serve as an early warning system for impending public health emergencies, document the impact of an intervention, or track progress toward specific goals.

(WHO, 2020a)

Healthcare-Associated Infections (HAIs)

The CDC (2019a) reports that on any given day approximately 1 in 31 hospital patients has at least one healthcare-associated infection.

COMMON TYPES OF HAIs

More than 80% of HAIs are caused by four types of infection, including:

- **Catheter-associated urinary tract infections (CAUTIs).** These infections involve any part of the urinary system, including urethra, bladder, ureters, and kidney, and result from incorrect insertion, failure to maintain asepsis, and leaving a catheter in place for too long.
- **Surgical site infections (SSIs).** These can involve the skin, tissues and organs under the skin, or implants such as material inserted or grafted into the body (e.g., prosthetic joints).
- **Central line–associated bloodstream infections (CLABSIs).** These are bloodstream infections unrelated to an infection at another site that develops within 48 hours of central line placement. Of all HAIs, these are associated with increased care costs and mortality.
- **Ventilator-associated events (VAEs) or pneumonias (VAPs).** These events or pneumonias are caused by a wide variety of pathogens, can be polymicrobial, and can be due to multidrug-resistant organisms.

The impact of HAIs infections may be greater when they are due to drug-resistant organisms, which include:

- **Methicillin-resistant *Staphylococcus aureus* (MRSA).** This type of bacteria is resistant to many antibiotics.
- ***Clostridioides difficile* (*C. difficile*)** (formerly known as *Clostridium difficile*). When antibiotics are taken, “good” bacteria are destroyed for several months, during which time infection with *C. difficile* bacteria can cause life-threatening diarrhea.



- **Carbapenem-resistant Enterobacteriaceae (CRE).** This family of organisms, which includes *Escherichia coli* (*E. Coli*) and *Klebsiella pneumoniae*, has a high level of antibiotic resistance.

The United States has made significant progress toward the collective goal of eliminating HAIs and is safer now than it was in years past. Nationally, among acute care hospitals there has been an 8%–12% decrease in CAUTIs, CLABSIs, and hospital-onset MRSA infections since 2015 (CDC, 2020b).

HAIs IN OUTPATIENT SETTINGS

Increasingly, healthcare delivery, including complex procedures, is being shifted to outpatient (ambulatory) settings. These settings often have limited capacity for oversight and infection control compared to hospital-based settings. Because patients with HAIs, including those caused by antibiotic-resistant organisms, often move between various types of healthcare facilities, prevention efforts must expand across the continuum of care.

Examples of outpatient settings include:

- Medical group practices
- Clinics at hospitals or other facilities
- Surgery centers
- Imaging centers
- Mental health centers
- Lab centers
- Physical therapy and rehabilitation facilities
- Chemotherapy and radiation therapy centers
- Dialysis centers
- Birthing centers
- Hospice homes
- Home care

Surveillance for infection in outpatient or ambulatory settings is inherently difficult, as detecting infections among outpatients typically requires retrospective reviews of medical records and/or prospective audits. However, intelligent information technology may serve as a meaningful tool. Such automated systems can be used to perform prospective surveillance for infections following outpatient procedures, such as a reference database designed to document surgical site infections in ambulatory surgery and linking institutional databases to detect bloodstream infections (Anderson & Kanafani, 2020).



ACCREDITATION FOR AMBULATORY HEALTHCARE FACILITIES

The Centers for Medicare and Medicaid Services has granted several organizations, along with itself, the authority to determine whether or not ambulatory healthcare facilities are in compliance with Medicare's conditions for coverage and provide accreditation for them. While there is no federal requirement for accreditation, some states and private payers require it. Organizations granted authority to accredit include:

- Accreditation Association for Ambulatory Health Care
- Accreditation Commission for Health Care, Inc.
- American Osteopathic Association/Healthcare Facilities Accreditation Program
- Center for Improvement in Healthcare Quality
- Community Health Accreditation Partner
- DNV GL-Healthcare
- National Dialysis Accreditation Commission
- The Compliance Team
- The Joint Commission
(CMS, 2020)

HAI's IN LONG-TERM CARE FACILITIES

Long-term care settings include nursing homes, skilled nursing facilities, and assisted living facilities. Over 4 million Americans are admitted to or live in nursing homes and skilled nursing facilities each year, and nearly 1 million live in assisted living facilities. While reporting is limited, the CDC (2020c) provides the following data about infections in these facilities:

- 1 to 3 million serious infections occur each year.
- Infections include urinary tract infections, diarrheal diseases, antibiotic-resistant staph infections, and many others.
- Infections are a major cause of hospitalization and death.

As many as 380,000 people die of infections in long-term care facilities every year.

Development of Infection Control and Prevention Standards and Guidelines

Standards and guidelines are designed to proactively prevent the spread of infection in healthcare settings. The development of these standards and guidelines came about through the collaborative efforts of the Centers for Disease Control and Prevention, the Joint Commission, the World Health Organization, and the Occupational Safety and Health Administration.



Although much has been accomplished thus far, there are always new challenges that must be faced. Challenges of concern include the growth of antibiotic-resistant and antifungal-resistant organisms. Antibiotic resistance is one of the biggest public health challenges today. Every year in the United States, about 2.8 million people get an antibiotic-resistant infection and more than 35,000 die from it. Combating this threat is a priority that requires global collaboration (CDC, 2020d).

Significant infection control challenges include:

- SARS-CoV-2 (COVID-19)
- SARS-CoV (severe acute respiratory syndrome)
- HIV infection
- Lyme disease
- *Escherichia coli*
- West Nile virus
- Zika virus
- *Candida auris*

Reemerging infectious diseases include:

- Tuberculosis
- Pertussis
- Influenza
- Pneumococcal disease
(Johns Hopkins, 2020)

MILESTONES IN INFECTION CONTROL EFFORTS	
Year	Milestone
1946	The Communicable Disease Center (later changed to the Centers for Disease Control and Prevention) is founded with the primary tasks of field investigation, training, and control of communicable diseases and encouragement of the development of formal infection control programs.
1951	The Joint Commission is founded with the goal of continuously improving safe and effective healthcare for the public.
1953	The CDC National Surveillance Program is developed to maintain constant vigilance over communicable diseases so as to respond immediately should an outbreak occur.



1970	<ul style="list-style-type: none"> • The National Communicable Disease Center is established in response to the increasing numbers of HAIs in hospitals. • The Occupational Safety and Health Administration is created to assure safe and healthful working conditions by setting and enforcing standards and by providing training, outreach, education, and assistance.
1970s	<ul style="list-style-type: none"> • The infection control movement moves toward mandated infection control policies following the publication of the Study of Effectiveness of Nosocomial Infection Control. This study provides evidence that infection control practices are effective. • The CDC establishes the Hospital Infections Program to provide guidance in HAI prevention. • The new field of hospital epidemiology emerges, and infection control becomes a profession.
1976	The Joint Commission institutes the requirement that a hospital have an infection control program in place based on CDC recommendations as a requirement for receiving accreditation.
1980s	The CDC initiates the National Nosocomial Infections Surveillance System to provide a mechanism for reporting HAIs. This evolves into the current National Health Safety Network in 2005.
1985	The CDC publishes guidelines on handwashing practices in hospitals.
1991	The Occupational Safety and Health Administration (OSHA) releases the Bloodborne Pathogens Standard, meant to minimize occupational exposures to bloodborne pathogens.
1996	The Joint Commission adopts a formal Sentinel Event Policy encouraging (but not requiring) hospitals to report serious adverse events that cause death or major disability, including HAIs, in order to learn from the events and improve safety.
2000	The Institute of Medicine publishes <i>To Err Is Human: Building a Safer Health System</i> , which draws the attention of the public as well as the healthcare industry to preventable medical errors, including HAIs.
2003	The Joint Commission issues its first-ever National Patient Safety Goals, a series of specific actions accredited organizations are required to take in order to prevent medical errors.
2008	Centers for Medicare and Medicaid Services begins withholding reimbursement for treatment of HAIs.
2009	The World Health Organization issues the WHO Guidelines on Hand Hygiene in Health Care, intended to be used in all settings, including home care.
2010	The Patient Protection and Affordable Care Act of 2010 creates an effective national mandate for public reporting of HAIs.
2014	Global Health Security Agenda is initiated to promote global health security to detect and mitigate outbreaks early.



2015	The National Action Plan for Combating Antibiotic-Resistant Bacteria (CARB Action Plan) is published.
(CDC, 2016a)	

Goals of Infection Control and Prevention

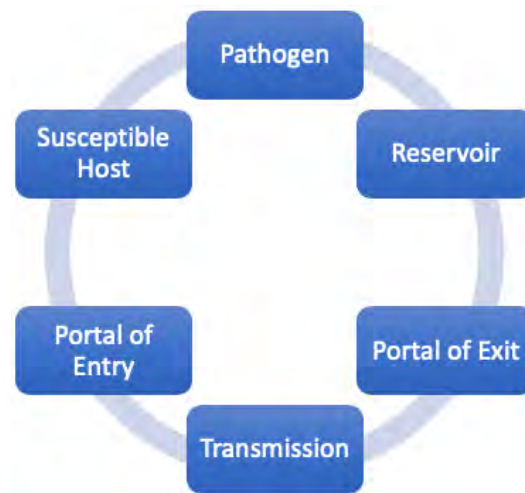
The goals of infection control and prevention training are to:

- Assure that health professionals understand how pathogens can be transmitted in the work environment from patient to healthcare worker, healthcare worker to patient, and patient to patient
- Apply current scientifically accepted infection prevention and control principles as appropriate for the specific work environment
- Minimize opportunity for transmission of pathogens to patients and healthcare workers

Periodically reinforce knowledge through continued training to ensure high understanding of how to prevent infection transmission

THE CHAIN OF INFECTION

Epidemiology involves knowing how disease spreads and how it can be controlled. Infection can only spread when conditions are right. This set of conditions is referred to as the “chain of infection,” which consists of six links. When all the links are connected, infection spreads. Infection control and prevention training provides the knowledge and skills that healthcare professionals can use to break the links in the chain and prevent the occurrence of new infections. Thus, understanding the chain of infection is at the foundation of infection prevention (APIC, 2020).



The six links in the chain of infection. (Source: Wild Iris Medical Education, Inc.)



CHAIN OF INFECTION	
Link	Examples
1. Pathogen: Micro-organisms capable of causing disease or illness	<ul style="list-style-type: none"> • Bacteria • Fungi • Parasites • Prions
2. Reservoir: Places in which infectious agents live, grow, and reproduce	<ul style="list-style-type: none"> • People • Water • Food
3. Portal of exit: Ways in which infectious anagent leaves the reservoir	<ul style="list-style-type: none"> • Blood • Secretions • Excretions • Skin
4. Transmission: Ways in which the infectious agent is spread from reservoir to susceptible host	<ul style="list-style-type: none"> • Physical contact • Droplets • Airborne
5. Portal of entry: Ways in which the infectious agent enters the susceptible host	<ul style="list-style-type: none"> • Mucous membrane • Respiratory system • Digestive system • Broken skin
6. Susceptible host: Individuals with traits that affect their susceptibility and severity of disease	<ul style="list-style-type: none"> • Immune deficiency • Diabetes • Burns • Surgery • Age
(Genieieiop, 2017)	



Pathogens

A pathogen is any biological agent that can cause disease or illness in its host.

BACTERIA

Bacteria are single-celled organisms present everywhere, some of which can cause disease. Humans are host to numerous bacteria—referred to as “normal flora” or “resident bacteria.” These usually do not cause disease unless their balance is disturbed or they are moved to a part of the body where they do not belong or to a new susceptible host. Important bacteria causing human disease include:

- *E. coli* (urinary tract infection, diarrhea)
- *Streptococci* (wound infection, sepsis, death)
- *Clostridioides difficile* (severe diarrhea, colitis, death)
- *Mycobacterium* (tuberculosis)
- *Staphylococcus* (skin boils, pneumonia, endocarditis, sepsis, death)
- *Chlamydia trachomatis* (sexually transmitted disease)
- *Pseudomonas* (infections in any part of the body)
- *Rickettsia* (spotted fever, typhus)
- *Mycoplasma pneumoniae* (“walking pneumonia”)

Bacterial spores (endospores) are thick-walled cells formed by bacteria to preserve the cell’s genetic material when conditions exist that are not conducive to bacterial growth and reproduction. This allows them to remain in a dormant state until conditions for multiplying return. Endospores can survive for extreme lengths of time. Most types of bacteria cannot change to the endospore form. Examples of bacteria capable of forming endospores include *Bacillus* and *Clostridium*. Bacterial spores are resistant to disinfectant and drying conditions. Infectious diseases transmitted to humans by endospores include:

- Anthrax
- Tetanus
- Gas gangrene
- Botulism
- Pseudomembranous colitis
(OSU, 2020)



VIRUSES

Viruses are not considered living organisms because they are acellular, i.e., they do not consist of cells. They contain either an RNA or DNA genome surrounded by a protective protein coat, and they lack the metabolic and biosynthetic machinery to reproduce. For this reason, they must co-opt a host's cellular mechanisms in order to multiply and infect other hosts. Viruses can infect every type of host cell, but typically they infect only specific cell types within a host.

Viruses can be transmitted through direct contact, indirect contact with fomites, or through a vector (another living entity, such as a tick or mosquito). There are a wide variety of viruses that cause infections and disease. Some of the deadliest emerging pathogens in humans are viruses; however, we have few treatments or drugs to deal with them. Some of the more common diseases caused by viruses include:

- COVID-19 (SARS-CoV-2)
- Chicken pox (varicella)
- Common cold (200+ types of rhinoviruses)
- Croup (parainfluenza virus)
- Ebola (Ebolavirus)
- Influenza (influenza A, B, and C viruses)
- Mumps (paramyxovirus)
- Polio (poliovirus)
- German measles (rubella virus)
- Rabies (rabies virus)
- HIV (human immunodeficiency viruses)
- Severe acute respiratory syndrome (SARS-CoV)
(OSU, 2020)

FUNGI

Fungi are prevalent throughout the world, but only a few cause disease in healthy people. Fungi are most closely related to animals and more distantly to plants. Fungi can be single cells or very complex multicellular organisms. Fungi can occur as yeasts, molds, or as a combination of both forms, some of which can cause superficial, cutaneous, subcutaneous, systemic, or allergic diseases.

In humans, most fungi affect skin, nails, and superficial mucosa. These are commonly caused by a group of at least 40 species of fungi called *dermatophytes*, but they can also be caused by common molds such as *Aspergillus* and the yeast *Candida albicans*. In persons with



weakened immune systems, *Candida* can cause life-threatening invasive bloodstream or systemic infections.

Candida auris is an emerging fungus that presents a serious global health threat because it is often multidrug-resistant; it is difficult to identify with standard laboratory methods; and it has caused outbreaks in healthcare settings, including bloodstream, wound, and ear infections (MS, 2020; CDC, 2020e).

PRIONS

A prion is a nonliving disease agent similar to a virus in that it is unable to self-propagate. A prion is a misfolded rogue form of normal protein found in the cells. This prion protein may be caused by a genetic mutation, or it may occur spontaneously and can stimulate other endogenous normal proteins to become misfolded also, forming plaques.

Prions are known to cause various forms of transmissible spongiform encephalopathy in humans (Creutzfeldt-Jakob disease) and animals (mad cow disease, chronic wasting disease in elk and deer). They are extremely difficult to destroy because they are resistant to heat, chemicals, and radiation (OSU, 2020).

PROTOZOA (PROTISTS)

Protozoa are single-celled microorganisms that are larger than bacteria. They are neither plants, animals, nor fungi. They are very diverse, some being free-living, others parasitic. Most are harmless, but some can cause disease in animals and humans. Examples of diseases caused by protozoa include:

- Severe diarrhea (*Giardia lamblia*)
- Sleeping sickness (*Trypanosoma*)
- Malaria (*Plasmodium protozoa*)
- Pneumonia (*Pneumocystis carinii*)
- Primary amebic meningoencephalitis (*Naegleria*)
- Toxoplasmosis (*Toxoplasma gondii*)

In individuals with weakened immune systems, untreated toxoplasmosis can lead to seizures and life-threatening illness such as encephalitis, which is fatal in those with AIDS (OSU, 2020).

Protozoa that live in a human's intestine are transmitted through the fecal-oral route, and those that live in the blood or tissue are transmitted by arthropod vectors (e.g., mosquitoes) (CDC, 2020f).



HELMINTHS

Helminths are large, multicellular organisms that are generally visible to the naked eye in their adult states. They infect humans primarily through ingestion of eggs or when the larvae penetrate the skin or mucous membranes. These organisms can cause anemia, chronic pain, diarrhea, and undernutrition. There are four main groups of helminths that are human parasites:

- Flatworms (platyhelminths) (include flukes and tapeworms)
- Thorny-headed worms (acanthocephalins)
- Roundworms (nematodes) (immature/larval states can cause infection of various body tissues)
- Hookworms (*Necator americanus*)
(CDC, 2020f)

Reservoirs

The next link in the chain of infection is the reservoir, the usual “habitat” in which the infectious agent (pathogen) lives and multiplies. It is defined as any person, animal, arthropod, plant, soil, substance, or a combination of these on which it depends primarily for survival and where it reproduces itself in such a way that it can be transmitted to a susceptible host.

A reservoir, however, is not the same thing as the “source.” For example, in typhoid fever, the reservoir may be a person with the infection, but the source of infection may be the feces or urine of those who are infected or contaminated food, milk, or water (Aryal, 2020).

HUMAN RESERVOIRS

The most important reservoir of infection for humans are other humans, and humans are also the most important reservoir for healthcare-associated infections. The nose (nostrils, nares) may harbor bacteria and viruses. The skin is another natural reservoir for yeast and bacteria, and both healthcare workers and patients may carry pathogenic MRSA and *Staphylococcus* on their skin. The gastrointestinal tract is a reservoir for many different types of organisms, including viruses, bacteria, bacterial spores, and parasites.

People who are sick can release microbes into the environment through infected body fluids and substances. For example, sneezing releases influenza virus in secretions from the respiratory tract. Coughing releases tuberculosis bacteria from the lungs. Diarrhea releases *C. difficile* and many pathogens from the bowel. Exudates from skin lesions release *Staphylococcus* in pus from boils or herpes virus from fluid in sores around the mouth, hands, or other body areas.

Two types of human or animal reservoirs are generally recognized. These are (1) symptomatic persons who have a disease (**cases**) and (2) **carriers** who are asymptomatic and can still transmit the disease. Carriers are individuals who have been **colonized** by a pathogen. Colonization is the presence of a microorganism on or in a host with growth and multiplication of the organism but no clinical expression or immune response from the host.



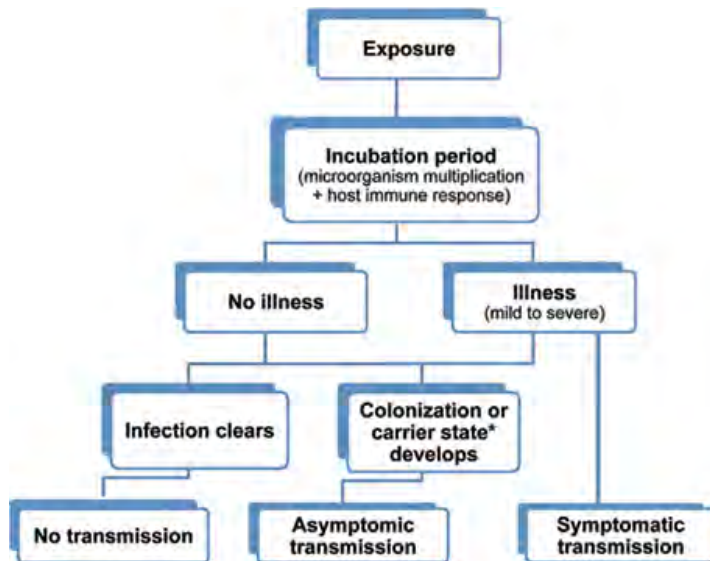
There are five types of carriers:

- **Healthy or passive carrier:** A person exposed to and harboring a pathogen but who has not become ill or has no symptoms
- **Active carrier:** A person who has been exposed to and harbors a pathogen, even though the person may have recovered from the disease
- **Incubatory carrier:** A person exposed to and harboring a pathogen in the beginning stages of the disease (e.g., the incubation period for HIV can last for many years before symptoms occur, but the person is able to transmit HIV to others during that time period)
- **Intermittent carrier:** A person exposed to and harboring a pathogen who can spread the disease in different places or at different intervals
- **Convalescent carrier:** A person who harbors the pathogen and, although in the recovery phase, is still infectious
(Merrill, 2021)

The important point to remember is that **infectious agents are transmitted every day from people who are sick as well as from those who appear to be healthy**. In fact, those individuals who are carriers may present more risk for disease transmission than those who are sick because:

- They are not aware of their infection.
- Their contacts are not aware of their infection.
- Their activities are not restricted by illness.
- They do not have symptoms and, therefore, do not seek treatment.





Possible outcomes of exposure to an infectious agent.

(Source: Wild Iris Medical Education, Inc.)

* The term *carrier state* is used to describe the presence of a microorganism on or in a host with growth and multiplication of the organism but no clinical expression or immune response from the host.

ANIMAL/INSECT RESERVOIRS

Animal reservoirs transmit infectious diseases from animal to animal, with humans as incidental hosts. An infectious disease caused by a pathogen transmitted from birds, rodents, reptiles, amphibians, insects, and other domestic and wild animals is called a **zoonosis**. A common way for these pathogens to spread are via a **vector**, usually a bite from a mosquito, mite, or tick. Examples of zoonoses include:

- Rabies (from bats, skunks, raccoons, and other mammals, transmitted directly through a bite)
- SARS (believed to originate from horseshoe bats that transmitted the virus to small mammals called civets, which are trapped and eaten, exposing humans to blood or organs during butchering or food preparation; now capable of being transmitted from human to human in respiratory secretions)
- Lyme disease (from deer mice to deer ticks to humans)
- Bubonic plague (from rats or prairie dogs to fleas to humans)
- West Nile virus (from birds to mosquito to humans)
- Zika (from monkeys to domestic animals and humans)
- Scabies (mites transmitted from humans to humans)
(Merrill, 2021)



ENVIRONMENTAL RESERVOIRS

Environmental reservoirs are certain environmental conditions or substances (e.g., food, feces, decaying organic matter) that are conducive to the growth of pathogens. Pathogens may survive in such a reservoir but may or may not multiply or cause disease. These reservoirs can include soil, water, and air, as well as inanimate objects, referred to as *fomites*, that convey infection because they have been contaminated by pathogenic organisms. Examples include facial tissues, doorknobs, telephones, bed linens, toilet seats, and clothing.

Environmental reservoirs in healthcare facilities can include:

- Contaminated medical devices (e.g., central venous catheters, urinary catheters, endoscopes, surgical instruments, ventilators, needles/sharps)
- Contaminated water sources
- Contaminated medications
- Air from heating, ventilation, or air conditioning systems
- Hospital textiles (e.g., linens, privacy curtains)
- Patient care equipment (BP cuffs, gloves)
(Christenson & Fagan, 2018)

Portal of Exit

The portal of exit is the route (or routes) by which a pathogen leaves the reservoir.

PORTALS OF EXIT FROM THE HUMAN BODY		
Portal	How the Pathogen Exits	Infectious Diseases
Respiratory tract	Coughing, sneezing	Influenza, tuberculosis, common cold, SARS, COVID-19
Skin	Draining skin lesions or wounds	Scabies, staph infection, MRSA
Blood	Insect bite, needles, syringes	HIV/AIDS, hepatitis B, hepatitis C
Digestive tract	Feces, saliva	Hepatitis A, cholera, salmonella infection, parasites, typhoid
Genitourinary tract	Urine, semen, vaginal secretions	HIV/AIDS, herpes, cytomegalovirus
Placenta	Mother to fetus	Herpes, malaria, rubella, Zika*
* The Zika virus has been found to cross the maternal-fetal barrier in the placenta, which viruses normally cannot do, and to infect the fetus, resulting in the birth defect microencephaly (small head with incomplete brain development).		
(CDC, 2019b)		



Modes of Transmission

In order for an organism to travel from one person to another or from one place in the body to another, it must have a way of getting there, or a mode of transmission. For any single agent, there are often many different means by which it can be transmitted. The modes of HAI transmission include:

Contact transmission, the most important and frequent mode of HAI transmission, is divided into three subgroups: direct contact, indirect contact, and droplet.

- **Direct contact** transmission involves skin-to-skin direct contact and the physical transfer of pathogens between a susceptible host and an infected or colonized person. Examples include scabies, sexually transmitted diseases, mononucleosis, and MRSA. Direct contact can include:
 - Childbirth
 - Medical procedures
 - Injections of drugs
 - Airborne, propelled a short distance (3–6 feet) via droplets, coughing, or sneezing and deposited on the host’s conjunctivae, nasal mucosa, or mouth
 - Transfusion (blood)
 - Transplacental
- **Indirect contact** transmission occurs by:
 - **Vehicle transmission** involves contact of a susceptible host with a contaminated inanimate object (fomite), such as food, water, medications, contaminated instruments, patient-care equipment, needles, dressings, gloves, or hands. Contaminated hands are often responsible for transmission of HAIs.
 - **Vector-borne transmission** usually refers to insects; however, a vector can be any living creature that transmits an infectious agent to humans. Vector-borne transmission is not a common source of HAIs.
 - **Airborne, long-distance transmission** involves generation of aerosolized particles from droplet nuclei that remain infectious when suspended in air over long distances and time. Aerosolized particles may also be generated from biological waste products.
(Ather et al., 2020)

The mode of **transmission is the weakest link in the chain of infection**, and it is the only link that healthcare providers can hope to eliminate entirely. Therefore, a great many infection control efforts are aimed at avoiding carrying pathogens from the reservoir to the susceptible host.



Because people touch so many things with their hands, **hand hygiene is still the single most important strategy for preventing the spread of infection.**

HIGH-RISK SETTINGS FOR INFECTION TRANSMISSION

Every area of the healthcare facility and every type of patient care holds the potential for exposure to pathogens, but some settings and practices present greater risk than others. High-risk settings include:

- Intensive care units
- Burn units
- Pediatric units and newborn nurseries
- Operating rooms
- Long-term care facilities

Transmission risks within the various healthcare settings are influenced by the characteristics of the population (e.g., immunocompromised patients, exposure to indwelling devices and procedures), intensity of care, exposure to environmental sources, length of stay, and interaction among and between other patients as well as healthcare providers.

Intensive Care Units

More than 20% of all HAIs are acquired in ICUs. In an international study, 60% of ICU patients were considered infected, and the risks of infection in general and with a resistant pathogen in particular increased with the length of stay. Infections and sepsis are the leading cause of death in noncardiac ICUs and account for 40% of all ICU expenditures. The most important HAIs are catheter-related bloodstream infections, ventilator-associated pneumonias, and catheter-associated urinary tract infections.

Risk factors for HAIs in ICU patients include:

- Chronic comorbid illnesses such as diabetes, predisposing to colonization and infections by MDROs
- Immunosuppression
- Frequent presence of invasive devices
- High frequency of invasive diagnostic and therapeutic procedures
- Presence of traumatic injuries and/or burns
- Age (older adults and neonates being more susceptible to infection)



- Frequent manipulations and contact with healthcare workers who are concurrently caring for multiple ICU patients
- Longer lengths of stay
- Colonization pressure (the proportion of patients colonized with a particular organism in a defined geographic area within a hospital during a specified time period)
(Marchaim & Kaye, 2020)

Burn Units

The incidence rate of infections in burn units has been found to be 21.8 events per 1,000 patient-days. Burn patients are at higher risk for many types of infections because of the loss of skin barrier and immunosuppression that occurs as a result of systemic inflammatory response due to injured tissue (Escandón-Vargas et al., 2020). Burn wound infections are often the source of systemic infections, including bloodstream infections and pneumonia, which can result in sepsis, multisystem organ failure, and death.

Hydrotherapy equipment is an important environmental reservoir, and its use is discouraged. Advances in burn care—specifically early excision and grafting of the burn wound, use of topical antimicrobial agents, and institution of early enteral feeding—have led to decreased infections, but no studies exist that define the most effective combination of infection control precautions for use in burn settings (Siegel et al., 2019).

Patients in burn units have additional risk factors for developing infections:

- Comorbidities such as obesity and diabetes
- Presence of invasive devices
- Large burn areas
- Full-thickness burns
- Inhalation injury
(Strassle et al., 2017)

Newborn Nurseries and Pediatric Units

Pediatric intensive care unit patients and those with lowest birthweight have high rates of central venous catheter-associated bloodstream infections. There is a high prevalence of community-acquired infections among hospitalized infants and young children who have not yet become immune either by vaccination or by natural infection.

Close physical contact between healthcare personnel and infants and children offers many opportunities for transmission of infectious material. Children congregating in play



areas with toys where bodily secretions are easily shared and family members rooming in can further increase risk of transmission (Siegel et al., 2019).

Other risk factors for infection in young patients include:

- Gestational age
- Low birth weight
- Age
- Presence of single or multiple invasive devices
- Invasive interventions and medical treatments
- Insufficient immune system development
- Insufficient mechanical barriers
- Lack of protective flora
- Permeable skin
- Parenteral nutrition
(Nandy, 2019)

Operating Rooms

This setting places both the patient and provider at higher risk for transmission of infectious pathogens. Factors that increase risk include:

- Invasive procedures with instruments (scalpel and other sharps) and tissue and blood exposure
- Quality of ventilation system
- Number of people present and their movements
- Rate of door opening
- Duration of surgery
- Classification of intervention as “dirty” (e.g., exposure to fecal material)
(Alfonso-Sanchez et al., 2017)

Long-Term Care Settings

Patients in these settings are at increased transmission risk due to:

- Advanced age
- Decreased immunity
- Underlying chronic diseases



- Decreased mobility
- Urinary catheter use
- Recent hospitalization
- Previous antibiotic use
- Colonization with multidrug-resistant pathogens
(Richards & Stuart, 2018)

Portals of Entry

The term *portal of entry* refers to the anatomical route or routes by which a pathogen gains entry into a susceptible host. The portal of entry is often the same as the portal of exit from the reservoir.

PORTALS OF ENTRY TO THE HUMAN BODY		
Portal	How the Pathogen Enters	Infectious Diseases
Skin	Conjunctivae, hair follicles, sweat ducts, cuts, nicks, abrasions, punctures, insect bites	Hookworm, tinea pedis, herpes simplex, folliculitis, sepsis
Respiratory tract	Inhalation	Influenza, tuberculosis, common cold, coronaviruses
Gastrointestinal tract	Food, drink, contaminated fingers	Diarrheal illnesses, salmonella infection, gastric and duodenal ulcers, gastroenteritis
Genitourinary tract	Skin or mucous membrane of penis, vagina, cervix, urethra, external genitalia	Cystitis, gonorrhea, chlamydia, genital herpes, HPV, HIV/AIDS
Across placenta to fetus	Vascular access	Zika, rubella, syphilis

Medical and surgical procedures often introduce new portals or facilitate the entry of pathogens. Examples include IV catheters, surgical wounds, urinary catheters, endotracheal tubes, and percutaneous injuries. Healthcare workers may develop dermatitis from frequent handwashing or allergy to latex gloves. They may receive needlestick injuries that allow pathogens access to their bloodstream. Any invasive procedure may facilitate entry of pathogens into the host.

INVASIVE DEVICES

An invasive device provides a portal of entry for pathogens. It is a device that, in whole or part, penetrates inside the body either through a body orifice or through the body surface.

Examples include:



- Vascular access devices
- Urinary catheters
- Wound drains
- Gastrostomy tubes
- Endotracheal tubes or tracheostomy
- Fracture fixation devices
- Traction pins
- Dental implants
- Joint prostheses
- Cardiac pacemakers
- Mammary implants
- Mechanical heart valves
- Penile implants

Susceptible Host

The final link in the chain of infection is the susceptible host. In healthcare settings, susceptible hosts abound. Susceptibility to infections depends on the genetic or constitutional factors, physiologic and immunological condition of the host, and the virulence of the pathogen. Host factors that influence the outcome of an exposure include the presence or absence of natural barriers, the functional state of the immune system, and the presence or absence of an invasive device.

HOST NATURAL BARRIERS

There are many natural barriers against the penetration of pathogens into the human host. They are categorized as physical, mechanical, chemical, and cellular.

Three “Lines of Defense”

The **first line** of defense against the entry of pathogens includes physical, mechanical, and chemical barriers, which are considered functions of innate (natural or inborn) immunity.

- **Physical barriers** (or anatomical barriers) include the skin and associated accessories, such as nails and hair within the nose.
- **Mechanical barriers** include the eyelashes and eyebrows, cilia (tiny hairs in the respiratory tract), eyelids, and intact skin-mucous membranes. Coughing, sneezing, urinating, defecating, and vomiting are also mechanical barriers.



- **Chemical barriers** include tears, perspiration, sebum (oily substance produced by the skin), mucus, saliva, earwax, gastrointestinal secretions, and vaginal secretions. Tears contain active enzymes that attack bacteria. Mucus in the respiratory tract traps pathogens and contains enzymes that serve as antibiotics. The gastrointestinal tract contains various chemicals, including acid in the stomach, bile, and pancreatic secretions. The normal acidic environment of the vagina protects from most pathogens.

The **second line** of defense comes into play when pathogens make it past the first line. Cellular defensive processes include:

- **Phagocytes.** Two types of white blood cells, macrophages and neutrophils, destroy and ingest pathogens that enter the body.
- **Inflammation.** Several types of white blood cells flood a localized area that has been invaded by pathogens, allowing for the removal of damaged and dead cells and beginning the repair process.
- **Fever.** Elevated temperature inhibits the growth, and is even lethal, to some bacteria and viruses; it also facilitates the host's immune response and increases the rate of tissue repair.
- **Lymphatic system.** Lymph nodes, spleen, tonsils, and adenoids collect and filter tissue fluids of harmful pathogens.

The **third line** of defense against invading pathogens is the immune system response, which involves lymphocytes.

- **T cells** send out an alarm and cause white blood cells to divide and multiply.
- **B cells** secrete antibodies that stick to antigens on the surface of pathogens and destroy them.
- **Memory T and B cells** store information about the invading pathogen to be used against a future invasion.

(Lindh et al., 2018)

The protective antibodies resulting from this process can be the result of:

- Past infection
- Vaccination or toxoid
- Indirectly through the placenta from mother to child
- Administration of antitoxin or immunoglobulin



Factors Affecting a Host's Natural Barriers

Several important factors affect a host's susceptibility to infection:

- **Age.** The very young and the very old are more susceptible to infection. The older adult often has comorbid conditions such as diabetes, renal insufficiency, or a decrease in immune function, and the young do not as yet have an immune system as efficient as adults.
- **Genetics.** Genetic background causes variations in innate immunity, e.g., Alaska Natives, Native Americans, and Asians are more susceptible to tuberculosis.
- **Stress level.** Stress increases the release of cortisol from the adrenal cortex, causing a suppression of the inflammatory response, which facilitates infection.
- **Nutritional status.** The function of the cells that make up the first, second, and third lines of defense are dependent upon specific nutrients without which the system weakens.
- **Current medical therapy.** Patients undergoing chemotherapy or radiation are more susceptible to infections since these agents also destroy cells that make up the immune system. Transplant patients on immunosuppressant medications to prevent rejection are also more susceptible, as are patients taking corticosteroids.
- **Pre-existing disease.** Patients with chronic diseases such as diabetes or AIDS are more susceptible.
- **Gender.** Anatomical differences of the genitourinary tract allow bacteria to more easily traverse the shorter female urethra to reach the bladder.

(Paustian, 2017)

INFECTIOUS AGENT FACTORS

It is only when a pathogen has been successful in establishing a site of infection in the host that disease occurs, and little damage will result if the pathogen is unable to spread to other parts of the body. There are a number of factors that are important in this process.

Specific to the pathogen itself are its:

- Infectivity, or the ability of an infectious agent to invade and replicate in a host
- Pathogenicity, or the capacity of the agent to cause disease
- Virulence, or the extent of disease that the pathogen can cause

Another important factor includes the number of organisms that are transferred to the host (the **inoculum**). Some organisms require only a few to cause disease while others require many. The



route of exposure, or the portal of entry of the pathogen, also influences the ability to cause infection, as does the **duration** or amount of time the host is exposed to the pathogenic reservoir.

ENVIRONMENTAL FACTORS

Environmental factors are those extrinsic elements that affect the infectious agent and the opportunity for exposure. In a healthcare setting, these factors involve contamination of the environment and equipment.

Environmental contamination involves inanimate objects (fomites) such as air, water, food supply, floors, and surfaces around patients. Proper sanitation prevents the spread of infectious organisms from the environment to patients.

Contamination of equipment occurs when it is not cleaned and disinfected between patients. Equipment that has been contaminated can spread infectious agents from patient to patient.

CASE

Robert Turner, an 80-year-old patient, was admitted to the general medical unit for treatment of a pressure injury on his sacrum and the onset of new delirium and urinary incontinence. To protect the healing injury from urine, the medical team ordered placement of an indwelling urinary catheter. Mr. Turner is a susceptible host at risk of infection because of his advanced age, the fact that he is in the hospital, and because of the indwelling urinary catheter.

During the first three days of Mr. Turner's hospital stay, the medical assessment revealed that a new medication was causing his delirium. The medication was stopped on the third day, and on the fifth day his delirium began to decrease. He slowly began to participate in activities of daily living. It was decided, however, to leave the indwelling urinary catheter in place until his pressure injury had sufficiently begun healing.

On day seven, his nurse noticed an abrupt change in the patient. He was more confused, agitated, and felt warm to the touch. On assessment, his temperature was 100.5 °F and he was slightly hypotensive. The medical team suspected the cause most probably was a urinary tract infection, and the urinary catheter was removed. Cultures confirmed infection with *E. coli*. Mr. Turner was started on antibiotics and IV fluids and recovered over the next three days.

METHODS FOR PREVENTING THE SPREAD OF PATHOGENS IN HEALTHCARE SETTINGS

Preventing the spread of pathogens involves breaking one of the links of the chain of infection, and the link most amenable to actions by healthcare workers are modes of transmission.



Standard Precautions

One of the most effective infection control practices is Standard Precautions. Standard Precautions are a set of infection control practices used to prevent transmission of pathogens and are based on the concept that all blood, body fluids, nonintact skin (including rashes), and mucous membranes may contain transmissible pathogens. Standard Precautions are implemented for all patient care settings and include:

- Performing hand hygiene
- Use of personal protective equipment (PPE) whenever there is an expectation of possible exposure to infectious material
- Following respiratory hygiene/cough etiquette principles
- Ensuring appropriate patient placement
- Proper handling and proper cleaning and disinfecting of patient-care equipment and instruments or devices
- Cleaning and disinfecting the environment appropriately
- Handling textiles and laundry carefully
- Following safe injection practices
- Wearing a surgical mask when performing lumbar punctures
- Ensuring healthcare worker safety, including handling of needles and other sharps (CDC, 2019c)

BLOOD AND OTHER POTENTIALLY INFECTIOUS MATERIAL (OPIM)

All occupational exposures to blood or other potentially infectious materials place healthcare providers at risk for infection with bloodborne pathogens. Standard Precautions are designed to eliminate exposure to blood and other potentially infectious material.

OSHA defines blood as:

- Human blood
- Human blood components
- Products made from human blood

OPIM include:

- Semen
- Vaginal secretions



- Cerebrospinal fluid
- Synovial fluid
- Pleural fluid
- Pericardial fluid
- Peritoneal fluid
- Amniotic fluid
- Saliva in dental procedures
- Any body fluids that are visibly contaminated with blood
- All body fluids in situations where it is difficult or impossible to differentiate between them
- Any unfixed tissue or organ (other than intact skin) from a human (living or dead)
- HBV- and HIV-containing cell or tissue cultures, organ cultures, and HBV- or HIV-containing culture medium or other solutions
- Blood, organs, or other tissues from experimental animals infected with HBV or HIV

(OSHA, 2012; CDC, 2020g)

HAND HYGIENE

Hand hygiene is the single most important practice to reduce transmission of infectious agents and means cleaning hands by using handwashing with soap and water, antiseptic hand wash, antiseptic hand rub, or surgical hand antisepsis.

During delivery of healthcare, the CDC (2020h) advises healthcare workers to avoid unnecessary touching of surfaces in close proximity to the patient and requires performance of hand hygiene in accordance with the following recommendations:

Wash hands **with soap and water**:

- When hands are visibly soiled
- After caring for a person with known or infectious diarrhea
- After known or suspected exposure to spores (e.g., *B. anthracis*, *C. difficile* outbreaks)

Unless hands are visibly soiled, an **alcohol-based hand sanitizer** is the method of choice for hand hygiene. Alcohol-based hand rubs come in gel, rinse, wipe, and foam form. They are less drying and have superior microbicidal activity in comparison to soap and water.

Indications include:



- Immediately before having direct contact with a patient's intact skin (e.g., taking a pulse)
- Before performing an aseptic task (e.g., placing an indwelling device) or handling invasive medical devices
- Before moving from work on a soiled body site to a clean body site on the same patient
- After touching a patient or the patient's immediate environment
- After contact with blood, body fluids or excretions, mucous membranes, nonintact skin, or wound dressing
- After contact with inanimate objects in the immediate vicinity of the patient, including medical equipment
- Before donning gloves
- Immediately after glove removal

Skin and Nails

The CDC offers the following recommendations to maintain hand skin health:

- Use lotions and creams to prevent and decrease healthcare provider skin dryness related to frequent hand hygiene.
- Use only hand lotions approved by the healthcare facility so as to avoid interfering with hand sanitizing products.

Recommendations regarding **fingernails** state:

- Healthcare providers should not wear artificial fingernails or extensions when having direct contact with patients at high risk (e.g., those in ICU or ORs). Pathogens can live under artificial fingernails both before and after use of an alcohol-based hand sanitizer and handwashing.
- Keep natural nail tips less than 1/4-inch long.
(CDC, 2020h)

Some studies have shown that more pathogens are present on the skin underneath **rings** than comparable areas of skin on fingers without rings. Rings may also increase the risk of glove tears. However, further studies are needed to determine if wearing rings results in an increased spread of pathogens (CDC, 2020h).

Studies regarding the issue of wearing **nail polish** remain inconclusive. Bacterial burden increases over time for natural nails, standard nail polish, and gel polish. However, reductions in the bacterial burden of natural nails and standard polish, but not gel polish,



has occurred following hand hygiene, indicating that gel polish may be more difficult to clean using alcohol hand gel (Hewlett et al., 2018).

It appears that wearing a simple finger band and unchipped nail polish may be acceptable, although removal of all rings and wearing no nail polish may be the safest prevention option.

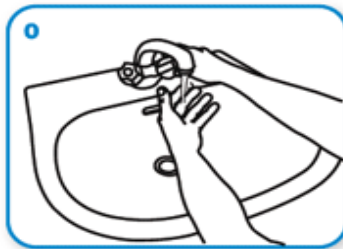
Hand Cleansing Techniques

Both the CDC and the World Health Organization provide guidelines in the techniques of handwashing as well as hand rub cleansing using an alcohol hand sanitizer.

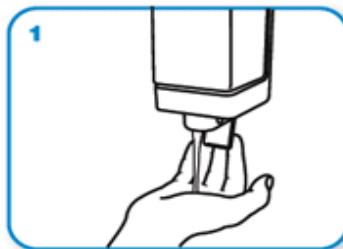
Handwashing requires 15 to 20 seconds to be effective (about as long as it takes to sing “Happy Birthday” twice).



Technique for handwashing with soap and water (WHO, 2020b):



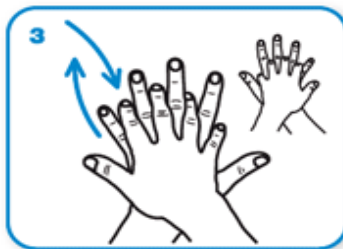
Wet hands with water



apply enough soap to cover all hand surfaces.



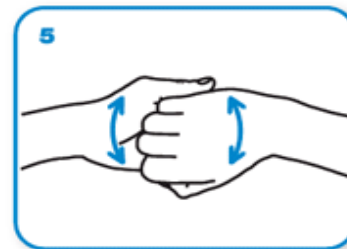
Rub hands palm to palm



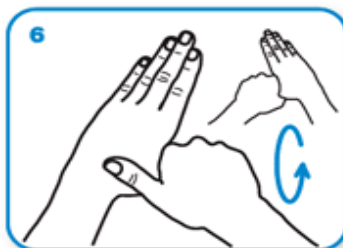
right palm over left dorsum with interlaced fingers and vice versa



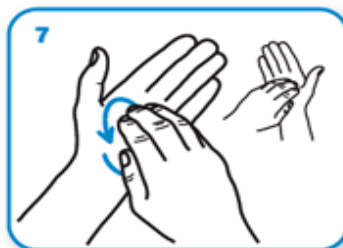
palm to palm with fingers interlaced



backs of fingers to opposing palms with fingers interlocked



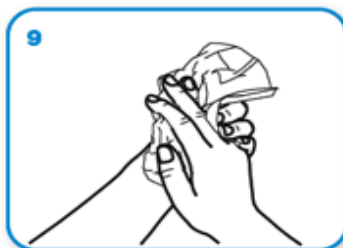
rotational rubbing of left thumb clasped in right palm and vice versa



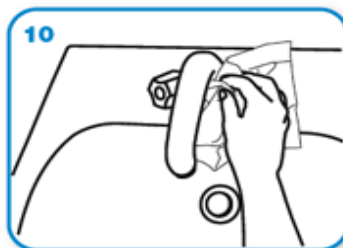
rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and vice versa.



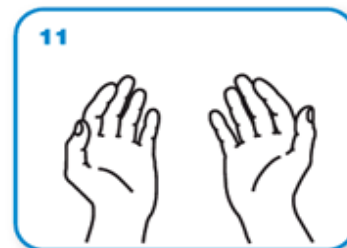
Rinse hands with water



dry thoroughly with a single use towel



use towel to turn off faucet



...and your hands are safe.



Handrub technique using alcohol hand sanitizer (WHO, 2009):



Apply a palmful of the product in a cupped hand.



Rub hands palm to palm.



Rub palm over left dorsum with interlaced fingers and vice versa.





Rub palm to palm with fingers interlaced.



Rub backs of fingers to opposing palms with fingers interlocked.



Rub left thumb rotationally clasped in right palm and vice versa with right thumb in left palm.





Rub clasped fingers of right hand rotationally, backwards, and forwards in left palm and vice versa with left fingers in right palm.



Once dry, hands are safe.

Surgical Hand Antisepsis

Performing surgical hand antisepsis using either an antimicrobial soap or an alcohol-based hand sanitizer with persistent activity is recommended before donning sterile gloves when performing surgical procedures.

- Remove rings, watches, and bracelets before beginning to scrub.
- Clean under nails using a nail cleaner under running water.
- When using antimicrobial soap, scrub hands and forearms for 2 to 6 minutes. Long scrub times (e.g., 10 minutes) are not necessary.
- When using an alcohol-based surgical hand-scrub product with persistent activity, follow the manufacturer's instructions.
- When using an alcohol-based surgical hand-scrub, prewash hands and forearms with a nonantimicrobial soap and dry hands and forearms completely before donning sterile gloves.



- Double gloving is advised during invasive procedures that pose an increased risk of exposure to blood.
(CDC, 2020h)

GLOVES

The CDC recommendations state that gloves should be worn according to Standard Precautions, as described below:

- Make sure that gloves fit properly before performing any tasks.
- Wear disposable medical examination gloves for providing direct patient care.
- Wear disposable medical examination gloves or reusable utility gloves for cleaning the environment or medical equipment.
- Gloves should be worn when it can be reasonably anticipated that contact with blood or other potentially infectious materials, mucous membranes, nonintact skin, potentially contaminated skin, or contaminated equipment could occur.
- Wearing gloves is not a substitute for hand hygiene.
- Hand hygiene should be performed immediately after removing gloves.
- Prior to a task that requires gloves, perform hand hygiene before donning them and before touching the patient or the patient environment.
- Change gloves and perform hand hygiene during patient care if:
 - Gloves become damaged
 - Gloves become visibly soiled with blood or body fluids following a task
 - Moving from work on a soiled body site to a clean body site on the same patient or if another clinical indication for hand hygiene occurs
- Never wear the same pair of gloves in the care of more than one patient.
- Do not touch the face when wearing gloves.
- Do not wear gloves in the halls, except as approved by facility.
(CDC, 2020h)

EYE PROTECTION, MASKS, FACE SHIELDS, AND GOWNS

Appropriate barriers include personal protective equipment used alone or in combination to protect the mucous membranes, airway, skin, and clothing from contact with infectious materials. These barriers include eye protection, face masks, and gowns.



- Eye protection (goggles and face shields) should be worn when there is a potential of a splash or spray of blood, respiratory secretions, or other body fluids. Personal eyeglasses and contact lenses are **not** considered adequate eye protection.
- Select masks, goggles, face shields, and combinations of each according to the need anticipated by the task to be performed.
- A mask should be worn to protect patients from exposure to infectious agents carried in the mouth or nose of healthcare personnel. A mask should be worn when placing a catheter or injecting material into the spinal canal or subdural space, or to perform intrathecal chemotherapy.
- A fluid resistant, nonsterile gown should be worn to protect skin and clothing during procedures or activities where contact with blood or body fluids is anticipated.
- A new gown should be worn for the care of each individual patient.
- A gown should be worn prior to direct patient contact that may generate splashes or sprays of blood, body fluids, secretions, and excretions.
- Remove gown and perform hand hygiene before leaving the patient's environment.
- Do not reuse gowns, even for repeated contacts with the same patient.
(WDHS, 2018; CDC, 2019c)

CASE

Sharon is a nurse working the night shift in respiratory ICU. Her assignment for the night includes three patients. As her shift begins, Sharon must first check in on her patient who is intubated and perform tracheotomy care and suctioning. Sharon recognizes that the suctioning procedure may expose her to the patient's secretions. Considering which level of Standard Precautions to apply, she dons appropriate PPE, which includes a gown, gloves, mask, and goggles. After caring for the patient, she disposes properly of all PPE and washes her hands prior to moving on to care for her next patient.

RESPIRATORY HYGIENE/COUGH ETIQUETTE

To prevent transmission of all respiratory infections in healthcare settings, Standard Precautions require that the following infection control measures be implemented at the point of initial encounter with patients or accompanying individuals who have signs and symptoms of respiratory infection:

- Educate healthcare workers on the importance of source-control methods to contain respiratory secretions, especially during outbreaks of respiratory illness such as influenza, measles, or coronavirus.



- Post signs at entrances and in strategic places, such as elevators and cafeterias, in both ambulatory and inpatient settings in languages appropriate to the population served, with instructions to patients and other persons on cough etiquette.
- Make the following supplies readily available:
 - Tissues
 - No-touch waste containers
 - Hand hygiene supplies and instructions (alcohol-based hand rub, sinks when available)
- For patients with signs and symptoms of respiratory infection, offer a mask to contain their secretions.
- Separate patients with symptoms of respiratory infection from the general patient population by 6 feet.
- For healthcare workers, wear a surgical or procedural mask whenever in close proximity to a patient with signs or symptoms of respiratory infection.
(CDC, 2019c)

COUGH ETIQUETTE

- Cover the mouth and nose when coughing and/or sneezing with a tissue; if no tissue is available, cough or sneeze into the elbow, not the hands.
- Immediately dispose of the tissue into the nearest waste container.
- Perform hand hygiene after coughing, sneezing, or using a facial tissue.
(CDC, 2019c)

PATIENT-CARE EQUIPMENT AND INSTRUMENTS/DEVICES

The following policies and procedures are recommended for containing, transporting, and handling patient-care equipment and instruments/devices that may be contaminated with blood or body fluids.

- Meticulously clean patient-care items with water and detergent or with water and enzymatic cleaners before high-level disinfection or sterilization procedures.
- Remove visible organic residue (e.g., blood and tissue) and inorganic salts with appropriate effective cleaning agents.
- Clean medical devices as soon as practical after use to avoid soiled materials drying onto the instruments. Dried or baked materials make the removal process more difficult and disinfection or sterilization less effective or ineffective.



- Wear PPE, such as gloves and gown, according to the level of expected contamination when handling patient-care equipment and instruments/devices that are visibly soiled or may have been in contact with blood or body fluids.
(CDC, 2019d)

CARE OF THE ENVIRONMENT

Policies and procedures for keeping the environment clean include using facility-approved disinfectants to clean patient equipment and to clean high-touch surfaces on a more frequent schedule, including:

- Bedrails
- IV poles
- Sink handles
- Bedside tables
- Counters where medications and supplies are prepared
- Edges of privacy curtains
- Patient monitoring equipment (keyboards, control panels)
- Transport equipment (wheelchair handles)
- Call bells
- Doorknobs
- Light switches
- Surfaces in and around toilets in patients' rooms

Spills of blood or other potentially infectious materials must be promptly cleaned and decontaminated following proper procedures and using protective gloves and other personal protective equipment appropriate for the task (CDC, 2019d).

In facilities providing healthcare to **pediatric patients** or that have waiting areas with child play toys, policies and procedures for cleaning and disinfecting toys at regular intervals should follow these principles:

- Select play toys that can easily be cleaned and disinfected and avoid use of stuffed, furry toys if they will be shared.
- Clean and disinfect large stationary toys (e.g., climbing equipment) at least weekly and whenever visibly soiled.
- If toys are likely to be put in the mouth, rinse with water after disinfection; alternatively, wash in a dishwasher.



- When a toy requires cleaning and disinfection, do so immediately or store in a designated, labeled container separate from toys that are clean and ready for use.

Include multiuse electronic equipment in environmental cleaning and disinfection policies, especially those items used by patients, those used during delivery of patient care, and mobile devices that are moved in and out of patient rooms frequently (CDC, 2019d).

TEXTILES AND LAUNDRY

Recommendations include:

- Handle used textiles and fabrics with minimum agitation to avoid contamination of air, surfaces, and persons.
- Bag or otherwise contain contaminated textiles and fabrics at the point of use.
- Use lead-resistant containment for textiles and fabrics contaminated with blood or body substances.
- If laundry chutes are used, ensure they are properly designed, maintained, and used so as to minimize dispersion of aerosols from contaminated laundry.
(CDC, 2019d)

PATIENT PLACEMENT

Include the potential for transmission of infectious agents in patient-placement decisions.

- Place patients who pose a risk for transmission to others in a single-patient room when available (e.g., those with uncontained secretions, excretions, or wound drainage; infants with suspected viral respiratory or gastrointestinal infections).
- Determine patient placement based on the following principles:
 - Route(s) of transmission of known or suspected pathogen
 - Risk factors for transmission in the infected patient
 - Risk factors for adverse outcomes resulting from an HAI in other patients in the area or room being considered for patient placement
 - Availability of single-patient rooms
 - Patient options for room sharing (e.g., cohorting patients with the same infection)
(CDC, 2019c)

SAFE INJECTION PRACTICES

The following recommendations apply to the use of needles, cannulas that replace needles, and where applicable, intravenous delivery systems.



- Use aseptic technique to avoid contamination of sterile injection equipment.
- Do not administer medications from a syringe to multiple patients.
- Needles, cannulas, and syringes are single-patient-use items; they should not be reused to access a medication or solution that might be used for a subsequent patient.
- Use IV bags, tubing, and connectors for one patient only and dispose appropriately after use.
- Do not use bags or bottles of intravenous solution as a common source of supply for multiple patients.
- Consider a syringe or needle/cannula to be contaminated after it has entered an IV bag or administration set.
- Use single-dose vials whenever possible.
- Do not use one single-dose vial or ampule for several patients or combine contents of several vials.
- If multidose vials must be used, use only a sterile needle/cannula and syringe to access them.
- Do not keep multidose vials in the immediate patient-care areas; store as recommended by the manufacturer and discard if sterility is compromised. (CDC, 2019c)

(See also “Sharps- and Injection-Related Practices and Controls” later in this course.)

INFECTION CONTROL PRACTICES FOR LUMBAR PUNCTURE PROCEDURES

Healthcare workers should wear a surgical mask when placing a catheter or injecting material into the epidural or subdural spaces to prevent infection caused by the transfer through normal breathing or coughing of oral flora to the central nervous system of the patient during the procedure (CDC, 2019c).

Transmission-Based Precautions

In addition to Standard Precautions, which are used with all patients, patients with documented or suspected infection or colonization with highly transmissible or epidemiologically important pathogens require additional precautions known as transmission-based precautions. The duration of these precautions is to be extended for immunosuppressed patients with viral infections due to prolonged shedding of viral agents that may be transmitted to others. There are three types of transmission-based precautions: Contact, Droplet, and Airborne.



CONTACT PRECAUTIONS

Contact Precautions are designed to minimize transmission of organisms that are easily spread by contact with hands or objects. Conditions requiring Contact Precautions may include:

- Enteric infections (*C. diff.*, *E. coli*)
- Viral infections (rhinovirus, COVID-19)
- Scabies
- Impetigo
- Enteric infections
- Noncontained abscesses or decubitus ulcers (*S. aureus*, Group A *Streptococcus*) (Anderson, 2020)

CDC Contact Precautions are summarized below:

Patient Placement

In acute care hospitals, place the patient in a single-patient room when available. When a single-patient room is not available:

- Prioritize patients with conditions that may facilitate transmission (e.g., stool incontinence) for single-patient-room placement.
- Place together in the same room (cohort) patients who are infected or colonized with the same pathogen and are suitable roommates.
- If necessary to place the patient in a room with a patient who is not infected or colonized with the same pathogen:
 - Avoid placement in rooms with patients whose conditions increase risk of adverse outcome or that may facilitate transmission (e.g., immunocompromised, open wounds, or have anticipated prolonged lengths of stay).
 - Ensure physical separation of greater than 3 feet. Draw privacy curtain between beds.
 - Change protective attire and perform hand hygiene between contacts with patients in the same room.

In long-term care and other residential settings, make decisions about placement on a case-by-case basis, balancing risk to other patients in the room, presence of risk factors increasing likelihood of transmission, and potential adverse psychological impact on infected or colonized patient.

In ambulatory settings, place patients in an examination room or cubicle as soon as possible.



Use of Personal Protective Equipment

- Don gloves upon entry into the room or cubicle.
- Wear gloves whenever touching the patient's intact skin or surfaces and articles in close proximity to the patient.
- Wear a gown when anticipating clothing will have direct contact with the patient or potentially contaminated environmental surfaces or equipment in close proximity to the patient.
- Don a gown upon entry and remove and perform hand hygiene before leaving the patient-care area.
- After removal of gown, ensure clothing and skin do not contact environmental surfaces in the patient-care area.

Patient Transport

- In acute care hospitals and long-term care and other residential settings, limit transport and movement of patients outside of the room to medically necessary purposes.
- If necessary to transport or move, ensure infected or colonized areas of the patient's body are contained and covered.
- Remove and dispose of contaminated PPE and perform hand hygiene prior to transporting.
- Don clean PPE to handle the patient at the transport destination.

Patient-Care Equipment and Instruments/Devices

- Handle equipment and instruments/devices according to Standard Precautions.
- In acute care hospitals, long-term care, and other residential settings, use disposable equipment (e.g., blood pressure cuffs) or implement patient-dedicated use. If common use is unavoidable, clean and disinfect before use on another patient.
- Limit the amount of nondisposable patient-care equipment brought into the patient's home. Whenever possible, leave equipment in the home until discharge from home services.
 - If noncritical equipment (e.g., stethoscope) cannot remain, clean and disinfect items before taking them from the home using a low- to intermediate-level disinfectant. Alternatively, place in a plastic bag for transport and later cleaning and disinfection.



- In ambulatory settings, place contaminated reusable noncritical patient-care equipment in a plastic bag for transport to a soiled utility area for reprocessing.
- Ensure that rooms of patients are prioritized for frequent cleaning and disinfection (at least daily), with a focus on frequently touched surfaces (e.g., bed rails, over-bed table, bedside commode, lavatory, doorknobs) and equipment in the immediate vicinity of the patient.

(CDC, 2019c)

CASE

Mrs. Alberts is a patient on the hospital surgical unit who is recovering from a complicated hip replacement surgery. She has been on antibiotics during the pre- and post-operative periods. On day four, she develops watery diarrhea, which tests positive for *C. difficile*.

The nurse initiates Contact Precautions and communicates with Mrs. Albert's physician to confirm the order. Contact Precautions require all visitors and care providers to wear a gown and gloves when entering the patient's room. Mrs. Alberts will also need to have disposable or dedicated equipment that is used only for her, such as a blood pressure cuff, stethoscope, and other equipment that may be needed for her care.

DROPLET PRECAUTIONS

Droplet Precautions are designed to prevent transmission of diseases easily spread by large-particle droplets (>5 microns in size) produced when the patient coughs, sneezes, or talks, or during the performance of procedures. Conditions requiring Droplet Precautions may include:

- *Neisseria meningitidis* infection
- *Mycoplasma pneumoniae* infection
- Pertussis (whooping cough) (*Bordetella pertussis*)
- Influenza
- Rubella
- Mumps
- Adenovirus infection
- Parvovirus B19 infection
- Rhinovirus infection
- Certain coronavirus infections (e.g., MERS-CoV, SARS-CoV, and SARS-CoV-2) (Anderson, 2020)



CDC Droplet Precautions are summarized below:

Patient Placement

In acute care hospitals, place the patient in a single-patient room when available. When a single room is not available:

- Prioritize patients who have excessive cough and sputum production for single-room placement.
- Place together in the same room (cohort) patients who are infected with the same pathogen.
- If necessary to place a patient in a room with another patient who does not have the same infection:
 - Avoid placing in the same room with patients who have conditions that may increase risk of adverse outcome or who may facilitate transmission (e.g., those who are immunocompromised or have anticipated prolonged lengths of stay).
 - Ensure patients are physically separated greater than 3 feet and draw a privacy curtain between beds to minimize close contact.
 - Change protective attire and perform hand hygiene between contact with patients in the same room, regardless of whether one patient or both patients are on Droplet Precautions.

In long-term care and other residential settings, make decisions on a case-by-case basis following consideration of infection risks to other patients in the room and available alternatives.

In ambulatory settings, place patients in an examination room or cubicle as soon as possible.

Instruct all patients to follow respiratory hygiene/cough etiquette.

Use of Personal Protective Equipment

Wear a mask upon entry into the patient room or cubicle.

Patient Transport

- In acute care hospitals, long-term care facilities, and other residential settings, limit transport and movement outside the room to medically necessary purposes.
- If transporting or moving is necessary, instruct the patient to wear a mask and follow respiratory hygiene/cough etiquette.



- No mask is required for persons transporting patients.

(CDC, 2019c)

RECOMMENDED INFECTION PREVENTION AND CONTROL PRACTICES FOR COVID-19

The CDC recommends using additional infection prevention and control practices along with Standard and Transmission-Based Precautions when caring for patients with suspected or confirmed SARS-CoV-2 infection. These include, but are not limited to:

- Implement telehealth and nursing-directed triage protocols.
- Screen and triage everyone entering a healthcare facility for signs and symptoms of COVID-19.
- Perform screening assessments of all admitted patients on a daily basis.
- Implement universal source control measures (cloth face coverings or facemask) for everyone in a healthcare facility.
- Ensure all healthcare personnel wear a facemask at all times in all places within the healthcare facility.
- Ensure all healthcare personnel wear eye protection in addition to a facemask during patient care encounters to ensure protection.
- Encourage physical distancing (6 feet) between people.
- Limit visitors to only those essential for patients' physical and emotional well-being and care.

(Due to the rapidly growing body of knowledge concerning SARS-CoV-2 infection, it is recommended that all healthcare professionals review the most recent infection control guidelines provided by the CDC. See "Resources" at the end of this course.)

(CDC, 2020i)

AIRBORNE PRECAUTIONS

Airborne Precautions are designed to prevent transmission of small particles of respiratory secretions that contain infectious microbes over time and long distances. Airborne Precautions are the only type that requires a negative-pressure airborne infection isolation room (AIIR) with door kept closed and use of an N95 respirator.

Conditions requiring Airborne Precautions may include:

- Tuberculosis
- Varicella
- Measles



- Smallpox
- Certain coronavirus infections (e.g., MERS-CoV, SARS-CoV, and SARS-CoV-2)
- Ebola
(Anderson, 2020)

CDC Airborne Precautions are summarized below:

Patient Placement

- In acute care hospitals and long-term care settings, place patients in an AIIR that has been constructed in accordance with current guidelines.
- Keep the AIIR door closed except for entry and exit.
- When an AIIR is not available, transfer patient to a facility that has an available AIIR.
- In the event of an outbreak or exposure involving large numbers of patients requiring Airborne Precautions:
 - Consult infection control professionals.
 - Cohort patients presumed to have the same infection in areas away from other patients.
 - Use temporary portable solutions (e.g., exhaust fan) to create negative pressure in the converted environment, and discharge air directly to the outside or through HEPA filters before it is introduced to other air spaces.
- In ambulatory settings:
 - Develop a system (e.g., signage, triage) to identify patients requiring Airborne Precautions.
 - Place in an AIIR as soon as possible. If not available, put a surgical mask on the patient, instruct in respiratory hygiene/cough etiquette, and place in an examination room. Once the patient leaves, the room should remain vacant for about one hour to allow full exchange of air.
 - Instruct patients to wear a surgical mask and observe respiratory hygiene/cough etiquette. Once in an AIIR, mask may be removed.
- Restrict susceptible healthcare personnel from entering rooms of patients known to have measles (rubeola), varicella (chickenpox), disseminate zoster, or smallpox if other immune healthcare personnel are available.
- Respiratory protection is recommended for all healthcare personnel, vaccinated and unvaccinated.



Use of Personal Protective Equipment

- Wear a fit-tested NIOSH-approved N95 or higher-level respirator when entering the room or home of a patient with known or confirmed infectious pulmonary tuberculosis and when procedures for treating tuberculosis skin lesions are performed that would aerosolize viable organisms.

Patient Transport

- In acute care hospitals, long-term care, and other residential settings, limit transport and movement outside of the room to medically necessary purposes.
- If transport or movement is necessary, instruct patients to wear a surgical mask and observe respiratory hygiene/cough etiquette. Cover infectious skin lesions.
- Transporting healthcare personnel do not need to wear a mask or respirator during transport if patient is wearing a mask and infectious skin lesions are covered.

Exposure Management

- Healthcare workers are encouraged to be vaccinated against common childhood illnesses to prevent outbreaks in vulnerable populations such as neonates.
- Annual influenza vaccination reduces the incidence of institutional outbreaks.
- Healthcare workers should receive periodic boosters against pertussis.
- Immunize or provide appropriate immune globulin to susceptible persons as soon as possible following unprotected exposure to a patient with measles, varicella, or smallpox.

(CDC, 2019c)

PRACTICES AND CONTROLS

In addition to the precautions described above, other practices and controls can be employed to prevent and control infection. These include:

- Engineering controls
- Work practice controls
- Environmental controls



Types of Practices and Controls

Engineering controls are measures that protect workers by removing hazardous conditions or by placing a barrier between the worker and the hazard. Examples include:

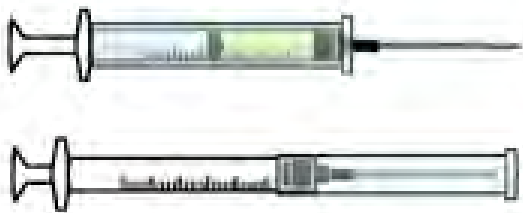
- Sharps disposal containers
- Self-sheathing needles
- Sharps with engineered sharps injury protections
- Needleless systems

According to the Occupational Safety and Health Administration (OSHA, 2012), engineering controls shall be examined and maintained or replaced on a regular schedule to ensure their effectiveness.

ENGINEERING CONTROL DEVICE EXAMPLES



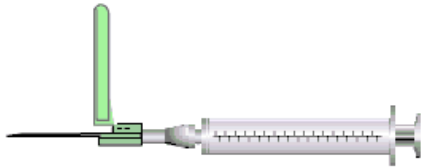
Syringe with retractable needle.



Self-resheathing needle.



Resheathing disposable scalpel.



Phlebotomy needle with hinged shield as an add-on safety feature.

(OSHA, 2020)

Work practice controls reduce the likelihood of exposure to pathogens by changing the way a task is performed, such as:

- Practices for handling and disposing of contaminated sharps
- Handling specimens
- Handling laundry
- Cleaning contaminated surfaces and items
- Performing hand hygiene

(OSHA, 2012)

Environmental controls help prevent the transmission of infection by reducing the concentration of pathogens in the environment. Such measures include but are not limited to:

- Appropriate ventilation
- Environmental cleaning (housekeeping)
- Cleaning and disinfecting strategies (including food service areas)
- Cleaning, disinfection, and sterilization of patient care equipment
- Proper linen and laundry management
- Disposal of regulated medical waste

(CDC, 2019e)



Sharps- and Injection-Related Practices and Controls

Engineering, work practice, and environmental controls have all been developed to prevent and control the spread of infection related to the use of needles and other sharps in the healthcare setting.

SHARPS HANDLING

The Occupational Safety and Health Administration (OSHA), part of the U.S. Department of Labor, first published the Occupational Exposure to Bloodborne Pathogens Standard in 1991. In 2001, in response to the Needlestick Safety and Prevention Act, OSHA revised the Bloodborne Pathogens Standard. The Bloodborne Pathogens Standard is updated regularly, with the most recent update being April 2012.

OSHA requirements for handling sharps state that **contaminated sharps** are needles, blades (such as scalpels), scissors, and other medical instruments and objects that can puncture the skin. Contaminated sharps must be properly disposed of immediately or as soon as possible in containers that are closable, puncture-resistant, leak-proof on the sides and bottom, and color-coded or labeled with a biohazard symbol.

- Discard needle/syringe units without attempting to recap the needle whenever possible.
- If a needle must be recapped, **never** use both hands. Use the single-hand “scoop” method by placing the cap on a horizontal surface, gently sliding the needle into the cap with the same hand, tipping the needle up to allow the cap to slide down over the needle, and securing the cap over the needle with the same hand.
- Never break or shear needles.
- To move or pick up needles, use a mechanical device or tool, such as forceps, pliers, or broom and dustpan.
- Use blunt-tip suture needles to decrease risk of percutaneous injury.
- Dispose of needles in labeled sharps containers only. Sharps containers must be accessible and maintained upright.
- When transporting sharps containers, close the containers immediately before removal or replacement to prevent spillage or protrusion of contents during handling or transport.
- Fill a sharps container up to the fill line or two thirds full. Do not overfill the container. (OSHA, 2012)

CASE

Joanne is a circulating nurse assigned to the operating room (OR) procedure room. She has just finished caring for a patient who required a lumbar epidural steroid injection. The anesthesiologist performing the procedure left the lumbar puncture procedure tray for Joanne



to clean up, as he was needed on another case in another room. Joanne is under pressure to turn over the procedure room quickly because there is a full patient schedule for the day.

As Joanne is cleaning up the tray, she sticks herself with the used lumbar puncture needle, not realizing that the syringe was left in the open wrapper of the disposable tray. As per well-publicized policy, the needle should have been discarded in a sharps container by the anesthesiologist after use.

Joanne promptly flushes the needlestick injury and reports the incident to her immediate supervisor. The report includes the fact that the injury occurred in the procedure room of the OR while cleaning up after a lumbar puncture. Her supervisor starts the process of investigation and exposure management.

The infection control team is also alerted and assists with formal reporting, feedback to the anesthesiologist on duty, and recommended postexposure protocols. The infection control team works with the entire OR team to review and reinforce safe handling of sharps and needlestick prevention as a result of this incident.

SAFE INJECTION PRACTICES

Unsafe injection practices put patients and healthcare providers at risk for infection. Safe injection practices are part of Standard Precautions and are aimed at maintaining a basic level of patient safety and provider protections. A good rule to remember regarding safe injections is **“One Needle, One Syringe, One Time.”**

Healthcare providers are required to follow **CDC-recommended practices** for injection and/or IV therapy:

- Draw up medications in a designated clean medication preparation area that is not adjacent to potential sources of contamination, including sinks or other water sources. Clean and disinfect the medication preparation area on a regular basis and any time there is evidence of soiling.
- Perform proper hand hygiene prior to handling medications.
- Access parenteral medications in an aseptic manner, using a new sterile syringe and sterile needle.
- Prepare an injection as close as possible to the time of administration to prevent compromised sterility.
- Disinfect the rubber septum with alcohol and allow to dry.
- Do not leave a needle inserted into a medication vial septum for multiple use.
- Always enter a medication vial with a sterile needle and sterile syringe, even when obtaining additional doses of medication for the same patient, and discard after use.



- Use a syringe and needle only once to administer a medication to a single patient. Do not use the same syringe to give an injection to more than one patient.
- Do not use a syringe for patient after using it to inject medications into an IV tubing port of another patient, even if that tubing port is several feet away from the IV catheter site.
- Vials labeled as single-dose or single-use should be used for only a single patient as part of a single case, procedure, or injection.
- If a single-dose or single-use vial appears to contain multiple doses or more medication than needed for a single patient, do not use for another patient or store for future use for the same patient.
- If a single-dose or single-use vial will be entered more than once for a single patient as part of a single procedure, use a new needle and new syringe each time. Discard the vial at the end of the procedure; do not store for future use.
- Do not combine (pool) leftover contents of single-dose or single-use vials or store single-dose or single-use vials for later use.
- Multi-dose vials should be dedicated to a single patient whenever possible. If used for more than one patient, keep and access in a dedicated clean medication preparation area.
- If a multi-dose vial enters an immediate patient treatment area (operating room, procedure room, anesthesia and procedure carts, and patient rooms or bays) it should be dedicated for single-patient use only.
- Discard medications according to the manufacturer's expiration date (even if not opened) and whenever sterility is compromised or questionable.
- If a multi-dose vial has been opened or accessed, the vial should be dated and discarded within 28 days unless manufacturer specifies a different length of time or date.
- Single-dose vials that have been opened or accessed should be discarded according to the manufacturer's time specifications or at the end of the case/procedure for which it is being used. Do not store for future use.
(CDC, 2019f)

Safe injection practices are also described by **OSHA**. They include:

- Contaminated needles and other contaminated sharps shall not be bent, recapped, or removed except as noted below. Shearing or breaking of contaminated needles is prohibited.
- If an employer can demonstrate that no alternative is feasible or that such an action is required by a specific medical or dental procedure, bending, recapping, or needle removal



must be accomplished through the use of a mechanical device or one-handed “scoop” technique (see above).

- Immediately or as soon as possible after use, contaminated reusable sharps shall be placed in appropriate containers until properly reprocessed. Reusable sharps that are contaminated with blood or OPIM shall not be stored or processed in a manner that requires employees to reach by hand into the container.
(OSHA, 2012)

Cleaning, Disinfecting, and Sterilizing

The healthcare environment can easily become contaminated with pathogens. The potential for contamination exists in every area of the hospital or other healthcare facility. Contaminated patient-care equipment (e.g., wet or soiled dressings), invasive devices that were used in diagnosis and treatment (e.g., surgical instruments or endoscopes), and environmental surfaces (e.g., doorknobs, floors, toilets) can act as vehicles for the transmission of infection to healthcare workers and/or patients. In addition, contamination depends on:

- The potential for external contamination (e.g., presence of hinges, crevices)
- The potential for internal contamination (e.g., presence of lumens)
- The physical composition, design, or configuration of an instrument, medical device, equipment, or environmental surface

GENERAL ENVIRONMENTAL SURFACE CLEANING

Transmission of infections to either staff or patients is largely via hand contact with a surface. Thus, cleaning and disinfecting environmental surfaces is fundamental to reducing the incidence of HAIs.

The number and type of pathogens present on environmental surfaces are affected by:

- Number of people in the environment
- Amount of activity
- Amount of moisture
- Presence of material able to support microbial growth
- Rate at which organisms suspected in the air are removed
- Type of surface and orientation (horizontal or vertical)

Cleaning is the first step of any sterilization or disinfection process and requires the physical action of scrubbing with detergents and surfactants and rinsing with water.

Cleaning is followed by disinfection. The following are factors that influence the choice of disinfection procedure for environmental surfaces:



- The nature of the item to be disinfected
- The number of microorganisms present
- The innate resistance of those microorganisms to the inactivating effects of a germicide
- The amount of organic soil present
- The type and concentration of germicide used
- The duration and temperature of germicide contact

Environmental surfaces can be divided into medical equipment surfaces (e.g., knobs or handles on equipment) and housekeeping surfaces (e.g., floors, walls, and tabletops).

Manufacturers of **medical equipment** provide care and maintenance instructions specific to their equipment. These instructions include information about:

- The equipment's compatibility with chemical germicides
- Whether the equipment is water-resistant or can be safely immersed for cleaning
- How the equipment should be decontaminated if servicing is required

Use barrier protective coverings as appropriate for equipment surfaces that are:

- Touched frequently with gloved hands during the delivery of patient care
- Likely to become contaminated with blood or body substances
- Difficult to clean (e.g., computer keyboards)

Most, if not all, **housekeeping surfaces** (e.g., floors, walls, tabletops) must be cleaned on a regular basis using only soap and water or a detergent/disinfectant, depending on the nature, type, and degree of contamination. Spills must be cleaned up promptly. Walls, blinds, and window curtains in patient-care areas are cleaned when visibly dusty or soiled.

High-touch housekeeping surfaces in patient-care areas (e.g., doorknobs, bedrails, light switches, wall areas around the toilet in the patient's room, and the edges of privacy curtains) are cleaned and/or disinfected more frequently than surfaces with minimal hand contact.

Disinfectant/detergent formulations registered by the EPA are used for environmental surface cleaning, but the most important step is the physical removal of microorganisms and soil by scrubbing and/or wiping.

A one-step process and an EPA-registered hospital disinfectant/detergent designed for general housekeeping purposes should be used in patient-care areas when:

- The nature of the soil on these surfaces is uncertain
- The presence or absent of multi-drug resistant organisms on such surfaces is uncertain



Follow facility policies and procedures for effective handling and use of mops, cloths, and solutions (CDC, 2019e).

CLEANING IMMUNOSUPPRESSED PATIENT AREAS

In areas where immunosuppressed patients are cared for, cleaning/disinfecting involves:

- Wet dusting of horizontal surfaces daily with cleaning cloths premoistened with detergent or an EPA-registered hospital detergent/disinfectant
- Avoiding the use of cleaning equipment or methods that disperse dust or produce mists or aerosol
- Equipping vacuums with HEPA filters
- Regular cleaning and maintenance of equipment to ensure efficient particle removal
- Closing the doors of immunocompromised patients' rooms when vacuuming, waxing, or buffing corridor floors to minimize exposure to airborne dust
(CDC, 2019e)

CLEANING UP BLOOD SPILLS

All environmental and working surfaces must be promptly cleaned and decontaminated after contact with blood or OPIM. Protective gloves and other appropriate PPE should be worn, and an appropriate disinfectant should be used.

After putting on personal protective equipment:

- If the spill contains large amounts of blood or body fluids, clean the visible matter with disposable absorbent material, and discard in an appropriate, labeled container.
- Swab the area with a cloth or paper towels moderately wetted with disinfectant and allow the surface to dry.
- Use EPA-registered hospital disinfectants labeled tuberculocidal or registered germicides with specific label claims for HIV or HBV.
- Use an EPA-registered sodium hypochlorite product; if not available, general versions (e.g., household chlorine bleach) may be used.
- Use a 1:100 solution of hypochlorite product or chlorine bleach to decontaminate nonporous surfaces after cleaning a spill in patient-care settings.
(CDC, 2019e)



Reprocessing Healthcare Equipment and Devices

Depending on the intended use, reusable medical and surgical equipment and devices must undergo reprocessing that involves:

- Cleaning alone, for **noncritical** items
- Cleaning followed by disinfection, for **semi-critical** items
- Cleaning followed by sterilization, for **critical** items

REPROCESSING EQUIPMENT/DEVICES		
Classification/Intended Use	Goal of Process	Appropriate Process
<p>Non-critical items Objects that come into contact with intact skin but not mucous membranes, e.g.:</p> <ul style="list-style-type: none"> • BP cuffs • Tabletops • Bedpans • Crutches • Computers 	<p>Clean of:</p> <ul style="list-style-type: none"> • Soil • Blood • Protein substances • Other debris 	<ul style="list-style-type: none"> • Cleaning (manual or mechanical) • Low-level disinfection
<p>Semi-critical items Items that make contact, directly or indirectly, with intact mucous membranes or nonintact skin, e.g.:</p> <ul style="list-style-type: none"> • Endoscopes • Anesthesia equipment • Respiratory therapy equipment 	<p>Free of all microorganisms, with exception of high numbers of bacterial spores</p>	<p>High-level disinfection (thermal, chemical)</p>
<p>Critical items Items entering sterile tissue, body cavity, vascular system, nonintact mucous membranes, e.g., surgical instruments</p>	<p>Free of all microorganisms, including bacterial spores</p>	<ul style="list-style-type: none"> • Steam sterilization • Low temperature sterilization
(CDC, 2019e)		

CLEANING

Cleaning involves removal of foreign material (e.g., soil, organic material) from objects and is normally accomplished using water with detergents or enzymatic products. Thorough cleaning is required before high-level disinfection and sterilization because inorganic and organic material remaining on the surfaces of instruments interfere with the effectiveness of these process. If



soiled materials dry or bake onto the instruments, the removal process becomes more difficult and the disinfection or sterilization process less effective or ineffective.

Perform either manual cleaning (using friction) or mechanical cleaning (using ultrasonic cleaners, washer-disinfector, or washer-sterilizer).

When a washer-disinfector is used, care should be taken in loading instruments: hinged instruments should be opened fully to allow adequate contact with the detergent solution; stacking of instruments in washers should be avoided; and instruments should be disassembled as much as possible.

There are no real-time tests that can be used in a clinical setting to verify cleaning. The only way to ensure adequate cleaning is to conduct a reprocessing verification test (e.g., microbiologic sampling), but this is not routinely recommended (CDC, 2019e).

DISINFECTION

Disinfection describes a process that eliminates many or all pathogenic microorganisms, except bacterial spores, on inanimate objects. In healthcare settings, objects usually are disinfected by liquid chemicals or wet pasteurization. Factors that can affect the effectiveness of either method include:

- Organic and inorganic load present
- Type and level of microbial contamination
- Concentrations of an exposure time to the germicide
- Physical nature of the object
- Presence of biofilm
- Temperature and pH of the disinfection process
- Relative humidity of the sterilization process

There are three levels of disinfection, as described in the table below.

LEVELS OF DISINFECTION	
Level	Disinfection/Process
Low	<ul style="list-style-type: none"> • Ethyl or isopropyl alcohol • Sodium hypochlorite • Phenolic germicidal detergent solution • Iodophor germicidal detergent solution • Quaternary ammonium germicidal detergent solution



Intermediate	<ul style="list-style-type: none"> • Ethyl or isopropyl alcohol • Sodium hypochlorite • Phenolic germicidal solution • Iodophor germicidal detergent solution
High	<ul style="list-style-type: none"> • Glutaraldehyde-based formulation • Ortho-phthalaldehyde • Hydrogen peroxide • Hydrogen peroxide and peracetic acid • Wet pasteurization at 70 degrees for 30 minutes with detergent cleaning • Hypochlorite
(CDC, 2019e)	

STERILIZATION

Sterilization destroys all microorganisms on the surface of an article or in a fluid to prevent disease transmission. Medical devices that have contact with sterile body tissues or fluids must be sterile when used. The use of inadequately sterilized items represents a high risk of transmitting pathogens; however, documented transmission of pathogens associated with an inadequately sterilized critical item is exceedingly rare.

FDA-approved sterilization methods are described in the table below.

STERILIZATION METHODS		
Sterilization Process	Description	Uses
Steam under pressure (moist heat)	<ul style="list-style-type: none"> • Uses four parameters: steam, pressure, temperature, time • Most widely used • Most dependable 	<ul style="list-style-type: none"> • Heat-stable medical and surgical devices • Can corrode some materials
Flash steam	Modification of conventional steam sterilization where item is placed on an open tray or in a container for rapid penetration of steam	<ul style="list-style-type: none"> • Cleaned patient-care items that cannot be packaged, sterilized, and stored before use • When there is insufficient time to sterilize an item by preferred method • Not recommended for implantable devices



Low-temperature ethylene oxide (ETO) gas	Parameters: <ul style="list-style-type: none"> • Gas concentration • Temperature • Relative humidity • Exposure time 	Temperature- and moisture-sensitive medical devices and supplies
Hydrogen peroxide gas plasma	Inactivates microorganisms by the combined use of hydrogen peroxide gas and the generation of free radicals	High temperature- and humidity-intolerant materials and devices, including: <ul style="list-style-type: none"> • Some plastics • Electrical devices • Corrosion-susceptible metal alloys
Peracetic acid	<ul style="list-style-type: none"> • Chemical sterilant • Biocidal oxidizer • Effective in presence of organic soil 	Medical and surgical instruments (e.g., endoscopes, arthroscopes)
Dry heat	Static or forced air penetrates material	Materials damaged by moist heat or impenetrable to moist heat (e.g., powders, sharp instruments, petroleum products)
Ozone	Created from: <ul style="list-style-type: none"> • Oxygen • Steam-quality water • Electricity 	Compatible with a wide range of commonly used materials and effective for rigid lumen devices
(CDC, 2019e)		

MONITORING REPROCESSING EFFECTIVENESS

Effectiveness of reprocessing depends on:

- Thorough cleaning before either disinfection or sterilization
- Choice of the right disinfectant product
- Presence of organic matter (inadequate cleaning), which can inactivate many disinfectants
- Use of mechanical scrubbing. In general, biofilms are not readily removed by chemicals alone but require mechanical scrubbing. (Biofilms are constructed by some bacteria to protect themselves from hostile environments such as disinfectants. An example of a biofilm is the film on teeth in the morning, not removed by mouthwash, requiring brushing.)



Monitoring disinfection is essential to document the effectiveness of reprocessing. Factors to be documented include:

- Activity (concentration) of the disinfectant
- Contact time with internal and external components
- Recordkeeping and tracking of equipment usage and reprocessing
- Handling and storage after disinfection to prevent contamination

Monitoring sterilization involves maintaining records of each sterilizer load, routinely evaluating the sterilizing conditions, and indirectly evaluating the microbiological status of the processed items. This is accomplished by using a combination of mechanical, chemical, and biological indicators.

- **Mechanical monitors** for both steam sterilization and ETO sterilization provide data on cycle time, temperature, and pressure. However, two essential elements for ETO sterilization (gas and humidity) cannot be monitored in healthcare ETO sterilizers.
- **Chemical indicators** are affixed on the outside of each pack to indicate that the item has been exposed to the sterilization process. It does not, however, prove sterilization has been achieved. A chemical indicator should also be placed on the inside of each pack to verify sterilant penetration. Chemical indicators are either heat-or chemical-sensitive inks that change color when one or more sterilization parameters are present. Chemical indicators should be used in conjunction with biological indicators.
- **Biological indicators** are considered to be the closest to ideal because they measure the sterilization process directly by using a preparation of the most resistant pathogen (*Bacillus* spores) as an indicator of sterility. These preparations are added to a carrier and then packaged. Biological indicators specifically designed for monitoring flash sterilization are now available, and a new rapid-readout ETO biological indicator has been designed for rapid and reliable monitoring of the process.

Periodic infection control rounds to areas using sterilizers for the purpose of standardizing use may identify correctable variances in operator competence, documentation of sterilization records, sterilizer maintenance and wrapping, and load numbering of packs (CDC, 2019e).

PACKAGING, STORAGE, AND HANDLING OF PROCESSED ITEMS

Written and illustrated procedures for preparation of items to be packaged should be readily available and used by personnel when packing procedures are performed.

Once items are cleaned, dried, and inspected, those requiring sterilization must be wrapped or placed in rigid containers and arranged in instrument trays/baskets according to guidelines.



There are several choices in **packaging methods** to maintain sterility of surgical instruments, including:

- Rigid containers
- Peel-open pouches, (e.g., self-sealed or heat-sealed plastic and paper pouches)
- Roll stock or reels (i.e., paper-plastic combinations of tubing designed to allow the user to cut and seal the ends to form a pouch)
- Sterilization wraps (woven and nonwoven)

The packing material must:

- Allow penetration of the sterilant
- Provide protection against contamination during handling
- Provide an effective barrier to microbial penetration
- Maintain the sterility of the processed item after sterilization

Wrapped surgical trays remain sterile for varying periods depending on the type of material used to wrap the trays. **Safe storage times** for sterile packs vary with the porosity of the wrapper and storage conditions.

Heat-sealed, plastic peel-down pouches and wrapped packs sealed in 3 mil polyethylene overwrap have been reported to be sterile for as long as nine months after sterilization. The polyethylene is applied after sterilization to extend the shelf life for infrequently used items. Supplies wrapped in double-thickness muslin comprising four layers remain sterile for at least 30 days.

Any sterilized item should not be used after the expiration date has been exceeded or if the sterilized package is wet, torn, or punctured. Although some hospitals continue to date every sterilized product and use the time-related shelf-life practice, many hospitals have switched to an event-related practice. This practice recognizes that the product should remain sterile until some event causes it to become contaminated (e.g., tear in packaging, packaging becomes wet, or seal is broken).

Following the sterilization process, **handling** of medical and surgical devices must use aseptic technique in order to prevent contamination (CDC, 2019e).

REPROCESSING AND REUSE OF SINGLE-USE DEVICES

Reusing single-use medical devices (SUDs) has been occurring since the late 1970s. Single-use medical devices can be reprocessed within healthcare organizations or by outside vendors (third-party reprocessors). Specifically, the FDA requires third-party reprocessors to meet the same criteria for the reprocessed devices as the original equipment manufacturer.



The FDA (2020) is proposing to prioritize its enforcement of premarket requirements for reprocessed SUDs on the basis of the risk that is likely to be posed by the reuse of the device.

The public health risk presented by a reprocessed SUD varies. Some that are low risk when used only one time may present an increased risk to a patient upon reprocessing. Others that are low risk when used for the first time may remain low risk after reprocessing, provided the reprocessor conducts cleaning and sterilization/disinfection in the appropriate manner.

CASE

Jennifer is a nurse and manager of an outpatient procedure center that performs colonoscopies and endoscopies on a regular basis. In the past three months, the center has had reports of six patients with a diagnosis of a strain of Carbapenem-resistant *Enterobacteriaceae* (CRE) *Escherichia coli* (*E. coli*) that occurred within a few weeks of their GI procedures. An investigation was initiated by public health authorities to identify the source and prevent further transmission to other patients.

The investigators worked with Jennifer and the center to review the histories of all patients. They discovered that each patient had undergone a similar invasive procedure using an endoscope. On reviewing the center's procedures, public health investigators found that the center has been cleaning and reprocessing the endoscopes according to manufacturer-recommended procedures for disinfecting. However, one endoscope was cultured and found to contain the resistant strain of *E. coli*.

Investigators recommended to Jennifer and the center that they switch to a liquid chemical, high-level disinfection system appropriate to their endoscope inventory and monitor the effectiveness by following the recommendations of the manufacturers of both the disinfection system and the endoscopes.

Jennifer and her instrument processing personnel met with their counterparts and an infection preventionist at the hospital with whom their physicians have privileges. Using the expertise and experience of their colleagues, they made recommendations to the management team of their procedure center regarding equipment acquisitions and policy/procedure changes.

After the center changed its disinfection procedures, no additional cases of *E. coli* occurred and patient safety has been maintained. The center invested a significant amount of its capital improvement and inventory budgets to purchase and install the disinfection system and acquire additional endoscopes and accessory instruments because of this outbreak.

Waste Management

Treatment of regulated medical waste reduces the microbial load in or on the waste and renders the by-products safe for further handling and disposal. Regulated medical waste treatment methods include:

- Chemical disinfection



- Grinding/shredding/disinfection methods
- Energy-based technologies (e.g., microwave, radio wave treatments)
- Disinfection/encapsulation methods

Medical wastes require careful disposal and containment. OSHA requirements are designed to protect workers who generate medical waste and who manage the wastes from point of generation to disposal. Personnel responsible for waste management must receive appropriate training in handling and disposal methods in accordance with facility policy.

State medical waste regulations specify appropriate treatment for each category of regulated waste. **Major categories of medical waste** requiring special handling and disposal precautions include:

- Microbiology laboratory wastes (e.g., cultures and stocks of microorganisms)
- Bulk blood, blood products, blood, and bloody body fluid specimens
- Pathology and anatomy waste
- Sharps (e.g., needles and scalpels)

Of all the categories of regulated medical waste, microbiologic wastes pose the greatest potential for infectious disease transmission, and sharps pose the greatest risk for injuries.

CONTAINERS AND DISPOSAL METHODS

In addition to any state rules for disposing of regulated waste, **OSHA rules** state that regulated waste must be placed in containers that are:

- Closable
- Constructed to contain all contents and prevent leakage of fluids during handling, storage, transport, or shipping
- Labeled or color-coded
- Closed prior to removal to prevent spillage or protrusion of contents during handling, storage, transport, or shipping

If outside contamination of the regulated waste container occurs, it must be placed in a second container meeting the above standards.

Sharps containers must be puncture-resistant and located as close as possible to point of use. The container must be labeled with the universal biohazard symbol and the word *biohazard* or be color-coded red. Sharps containers must be maintained upright throughout use, replaced routinely, and not be allowed to overfill. Also, containers must be:

- Capable of maintaining impermeability after waste treatment



- Closed immediately prior to removal or replacement to prevent spillage or protrusion of contents during handling, storage, transport, or shipping
- Placed in a secondary container if leakage is possible; the second container must be:
 - Closeable
 - Constructed to contain all contents and prevent leakage during handling, storage, transport, or shipping
 - Labeled or color-coded
- Reusable containers must not be opened, emptied, or cleaned manually or in any other manner that would expose employees to risk of percutaneous injury
- Upon closure, duct tape may be used to secure the lid of a sharps container as long as the tape does not serve as the lid itself.

CDC recommendations state:

- On-site incineration is an option for microbiologic, pathologic, and anatomic waste.
- Waste generated in isolation areas should be handled using the same methods used for waste from other patient-care areas.
- Containers with small amounts of blood remaining after laboratory procedures, suction fluids, or bulk blood can either be inactivated or carefully poured down a utility sink drain or toilet. No evidence indicates that bloodborne diseases have been transmitted from contact with raw or treated sewage.
- If treatment options are not available at the site of waste generation, transport in closed, impervious containers to the on-site treatment location or to another facility for treatment as appropriate.
- Store regulated medical wastes awaiting treatment in a properly ventilated area inaccessible to vertebrate pests. Use waste containers that prevent development of noxious odors.
- Regulated waste that has been decontaminated need not be labeled or color-coded.
(CDC, 2019e)

WARNING LABELS

Warning labels that include the universal biohazard symbol, followed by the term “biohazard,” must be included on:

- Bags and containers of regulated waste
- Refrigerators and freezers containing blood or OPIM



- Other containers used to transport or ship blood or OPIM
- Contaminated equipment that is to be serviced or shipped (must also contain a statement relating to which portions of the equipment remain contaminated)

These labels are fluorescent orange, red, or orange-red. Bags used to dispose of regulated waste must be red or orange-red, and they too must have the biohazard symbol in a contrasting color readily visible upon them.

Red bags or red containers may be substituted for the biohazard labels.



Biohazard warning label. (Source: OSHA.)

Linens and Laundry Management

The risk of actual disease transmission from soiled laundry is negligible. However, the hands of healthcare workers may be contaminated by contact with patient bed linens. Thus, common sense hygienic practices for handling, processing, and storage of textiles are recommended. These practices include:

- Do not shake items or handle them in any way that may aerosolize the infectious agents.
- Avoid contact of one's own body and personal clothing with the soiled items being handled.
- Wear gloves and other protective equipment, as appropriate, when handling contaminated laundry.
- Contain soiled items in a laundry bag or designated bin at the location where they were used, minimizing leakage.
- Do not sort or rinse textiles in the location of use.
- Label or color-code bags or containers for contaminated waste.

- If laundry chutes are used:
 - Ensure that laundry bags are securely closed before they are placed in the chute.
 - Do not place loose items in the laundry chute.
- For textiles heavily contaminated with blood or other body fluids, bag and transport in a manner that will prevent leakage.
- Do not use dry cleaning for routine laundering in healthcare facilities.
- For clean textiles, handle, transport, and store by methods that will ensure their cleanliness.
- If healthcare facilities require the use of uniforms, they should either make provisions to launder them or provide information to the employee regarding infection control and cleaning guidelines for the item based on the tasks being performed at the facility.
(CDC, 2019e)

OSHA's Bloodborne Pathogens Standard requires employers to ensure that employees who have contact with contaminated laundry wear protective gloves and other appropriate PPE.

Employers are responsible for laundering reusable PPE. Work clothes such as uniforms are not considered to be PPE. Provided gowns or other PPE should be used to prevent soiling of uniforms.

Training healthcare workers who are responsible for housekeeping and management of linen and waste in appropriate infection control for their particular duties is essential for safe patient care.

CASE

David is a charge nurse in the emergency department (ED) in a rural hospital and is working with a team caring for a trauma patient, a farmer who was transported after an accident involving harvesting equipment. The patient is bleeding out from a partially severed arm on arrival, and the ED team stabilizes the patient prior to transfer to the OR.

Once the patient is transferred to the OR, David returns to the ED to work with housekeeping to ensure proper cleanup of the room. The housekeeping team has had the required infection control training but has had little experience with this type of trauma cleanup. Cleaning this room is doubly complex for them: There is the sheer volume and complexity of the work itself and the unavoidable thoughts about what caused it. As the charge nurse on duty, David is responsible for supervising the team and ensuring that proper procedure is followed.

David confirms that the housekeeping team has donned appropriate PPE prior to starting cleanup. Surfaces contaminated with blood are first cleaned with recommended disinfectant. All soiled items are contained, placed in biohazard bags, and secured for disposal. David also takes a second look to make sure that any sharps are placed in sharps containers and secured for disposal. Laundry that is contaminated with blood is also secured according to hospital procedures.



After cleanup, PPE is removed and discarded by the team in biohazard bags. Each team member monitors their uniform for any soiled items and performs hand hygiene as a final step prior to moving on to the next work assignment.

Because David considers the housekeeping personnel part of the team involved in this patient's care, he coordinates with his manager to ensure that they are offered the same postincident care as those directly involved.

BARRIERS AND PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment (PPE) includes a variety of barriers and respirators used alone or in combination to protect mucous membranes, airways, skin, and clothing from contact with infectious agents. The selection of PPE is based on the nature of the patient interaction and/or the likely mode or modes of transmission.

Types of Personal Protective Equipment

PPE must be readily accessible to employees and available in appropriate sizes. It is important to know which type of PPE is available at work and where it is stored. To protect themselves, healthcare providers must have a barrier between them and any potentially infectious material.

Types of **PPE used in healthcare settings** include:

- Gloves
- Gowns/aprons/coveralls
- Face and eye protection
- Head coverings
- Boots/shoe covers
- Respirators

Factors that influence the **selection of appropriate PPE** include:

- Type of exposure anticipated:
 - Blood or body fluid splash/spray vs. touch
 - Contact with minimal bleeding/drainage/body substances
 - Contact with large volume bleeding/drainage/body substances that are likely to soak through the contact area
 - Category of isolation precautions (Contact, Droplet, Airborne)



- Durability and appropriateness for the task. This affects whether a gown or fluid-proof apron is selected, or if a gown is selected, whether it must be fluid-resistant, fluid-proof, or neither.
- Fit of the equipment. The employer must ensure that all PPE are available in sizes appropriate for the workforce to be protected.

(See also “Standard Precautions” earlier in this course for additional information related to PPE.)

GLOVES

Gloves are the most common type of PPE. They are used for patient care as well as environmental service. Gloves can be sterile or nonsterile and single use or reusable. Because of allergy concerns, latex products have been eliminated in many facilities, and materials used for gloves are mostly synthetics such as vinyl or nitrile.

Gloves can protect both patients and healthcare personnel from exposure to infectious material that may be carried on the hands. Nonsterile disposable medical gloves are available for routine patient care. The selection of glove type for nonsurgical use is based on the task that is to be performed and anticipated contact with chemicals and chemotherapeutic agents.

For contact with blood and body fluids during nonsurgical patient care, a single pair of gloves provides adequate barrier protection. However, there is considerable variability among gloves, and studies have shown repeatedly that vinyl gloves have higher failure rates than latex or nitrile gloves. For this reason, either latex or nitrile gloves are preferable for clinical procedures that require manual dexterity and/or will involve more than brief patient contact.

Most patient-care activities require the use of a single pair of nonsterile gloves. Vinyl gloves are frequently available and work well if patient contact is limited. However, some gloves do not provide a snug fit on the hand, especially around the wrist, and should be not used if extensive contact is likely. Gloves should not tear or damage easily and must stand up to the task.

Sterile surgical gloves are worn when performing invasive patient procedures. At times, two pairs of gloves may be worn during surgical procedures for additional protection.

Heavier, reusable utility gloves are indicated for non-patient-care activities such as handling or cleaning contaminated equipment or surfaces. Environmental service personnel often wear reusable heavy-duty gloves to work with caustic disinfectants.

Proper glove use includes:

- Performing hand hygiene before putting on gloves
- Putting gloves on last when being worn in combination with other PPE
- Working from clean to dirty



- Limiting touch contamination (e.g., adjusting eyeglasses, touching light switches, etc.) when wearing gloves that have been in contact with a patient
- Changing gloves during the care of a single patient to prevent cross-contamination of body sites or if patient interaction also involves touching portable keyboards or other mobile equipment that is transported from room to room
- Changing gloves during use if torn or when heavily soiled and after use on each patient
- Discarding gloves between patients and disposing of gloves in proper receptacle
- Performing hand hygiene following glove removal
- Never washing or reusing disposable gloves
(CDC, 2019c)

GOWNS/APRONS

Clinical and laboratory coats or jackets worn over personal clothing are not considered PPE.

Isolation gowns are preferred, but aprons occasionally are used where limited contamination is expected. Gowns must fully cover the torso, fit comfortably over the body, and have long sleeves that fit snugly at the wrist.

The type of protection is based on the nature of the patient interaction, including the anticipated degree of contact with infectious material and potential for blood and body fluid penetration of the barrier. Clean gowns are generally used for isolation precautions. Sterile gowns are needed only when performing invasive procedures.

For prevention of transmission of an infectious agent, donning of both gown and gloves upon room entry is indicated. Gowns are always worn in combination with gloves and with other PPE when indicated, and are usually the first piece of PPE to be donned. Full coverage of arms and body front from neck to the mid-thigh or below ensures that clothing and exposed body areas are protected.

FACE AND EYE PROTECTION

Face and eye protection are used during patient-care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, or excretions. Two mask types are available for use: surgical masks and procedure or isolation masks.

Masks are used for three primary purposes:

- Worn by healthcare personnel to protect from contact with infectious material from patients



- Worn by healthcare personnel who are engaged in procedures requiring sterile technique to protect patients from exposure to infectious agents carried in the healthcare worker's mouth or nose
- Placed on patients to limit potential dissemination of infectious respiratory secretions from the patient to others

Eye protection depends on the circumstances of exposure, other PPE used, and personal vision needs. Goggles protect the eyes and should fit over and around them snugly. Personal prescription glasses are not a substitute for goggles. Some goggles have antifog features that improve clarity, and many styles of goggles fit adequately over prescription lenses with minimal gaps.

Face shields protect the face, nose, mouth, and eyes. A face shield should cover the forehead, extend below the chin, and wrap around the sides of the face. Face shields can be worn along with face masks.

Removal of a face shield, goggles, and mask can be performed safely after removing gloves and performing hand hygiene (CDC, 2019c).

HEAD COVERINGS

Head coverings such as surgical caps are worn when gross contamination is expected, such as during orthopedic surgery or autopsies (OSHA, 2012).

BOOTS/SHOE COVERS

Theater boots are waterproof boots worn by surgical personnel as a protective measure from contamination with blood and other body fluids. Shoe covers protect the wearer from accidental spills and body fluids (OSHA, 2012).

RESPIRATORY PROTECTION

Respiratory protection includes both surgical and standard N95 or higher-level respirators. Respirators require medical evaluation to determine if it is safe for the healthcare worker to wear one and to fit the worker with the appropriate respirator size and type. Healthcare workers are responsible for performing a user-seal check (formerly called a “fit check”) each time a respirator is donned to minimize air leakage around the face piece.

A surgical N95 respirator is recommended only for use by healthcare personnel who need protection from both airborne and fluid hazards such as splashes and sprays.

The CDC currently recommends standard N95 or higher-level respirators for healthcare personnel who are exposed to patients with suspected or confirmed tuberculosis and COVID-19 (Siegel et al., 2019; CDC, 2020j).



Putting On and Removing PPE

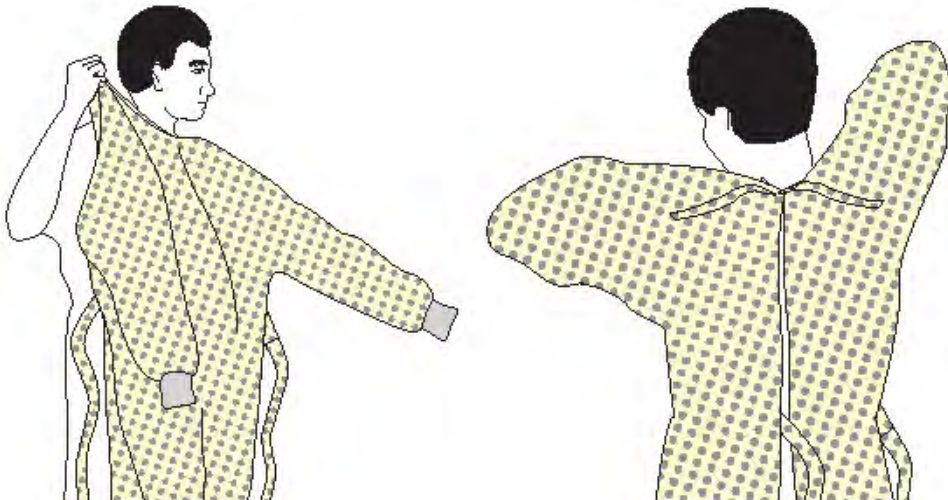
PUTTING ON PPE

There are various ways to put on PPE. Training and practice using the healthcare facility's procedure is critical. The CDC recommends that PPE be put on (donned) in the following sequence:

1. Gown
2. Mask or N95 filtering respirator
3. Face shield or goggles
4. Gloves

How to put on a gown:

1. Select appropriate type and size.
2. Perform hand hygiene using hand sanitizer.
3. Put on with opening in the back.
4. Secure at neck and waist.
5. If gown is too small, use two gowns, with the first tied in front and the second tied in back.



How to put on a respirator:

1. Respirator straps should be placed on the crown of the head (top strap) and base of the neck (bottom strap). Perform a user seal check each time putting on the respirator.



How to put on a mask:

1. Place over nose, mouth, and chin.
2. Fit flexible nose piece over bridge of nose using both hands. Do not bend or tent. Do not pinch the nosepiece with one hand.
3. Ensure facemask extends under the chin.
4. Mask ties should be secured on the crown of the head (top tie) and base of the neck. If the mask has loops, hook them appropriately around the ears.



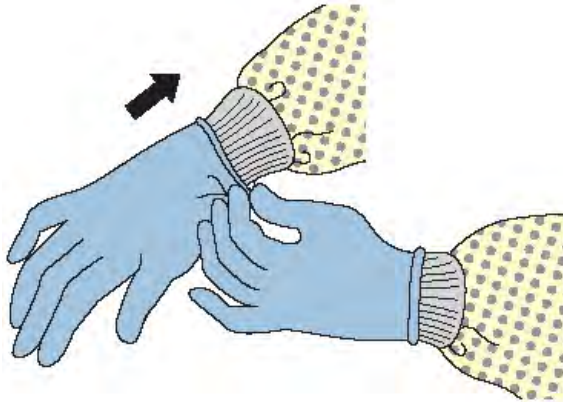
How to put on goggles and face shield:

1. Place over face and eyes.
2. Adjust to fit.



How to put on gloves:

1. Select correct type and size.
2. Insert hands into gloves.
3. Extend gloves over isolation gown cuffs (wrists).



(CDC, 2020k)

REMOVING PPE

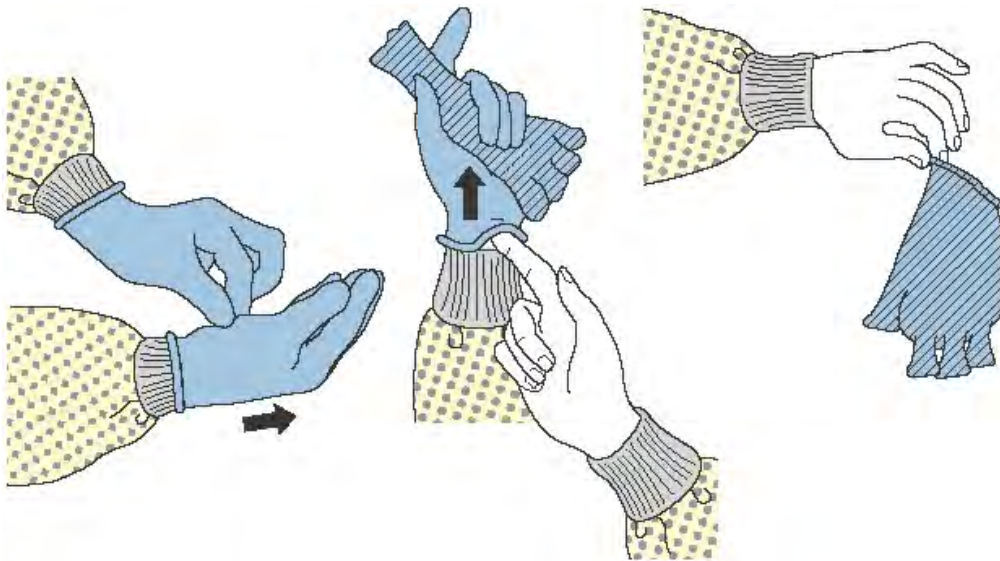
More than one doffing method may be acceptable. Training and practice using the healthcare facility's procedure is critical. The following is one example of doffing recommended by the CDC.

Contaminated PPE should be removed in the following sequence:

1. Gloves
2. Gown
3. Hand hygiene and exit patient room
4. Face shield or goggles
5. Mask or respirator
6. Hand hygiene

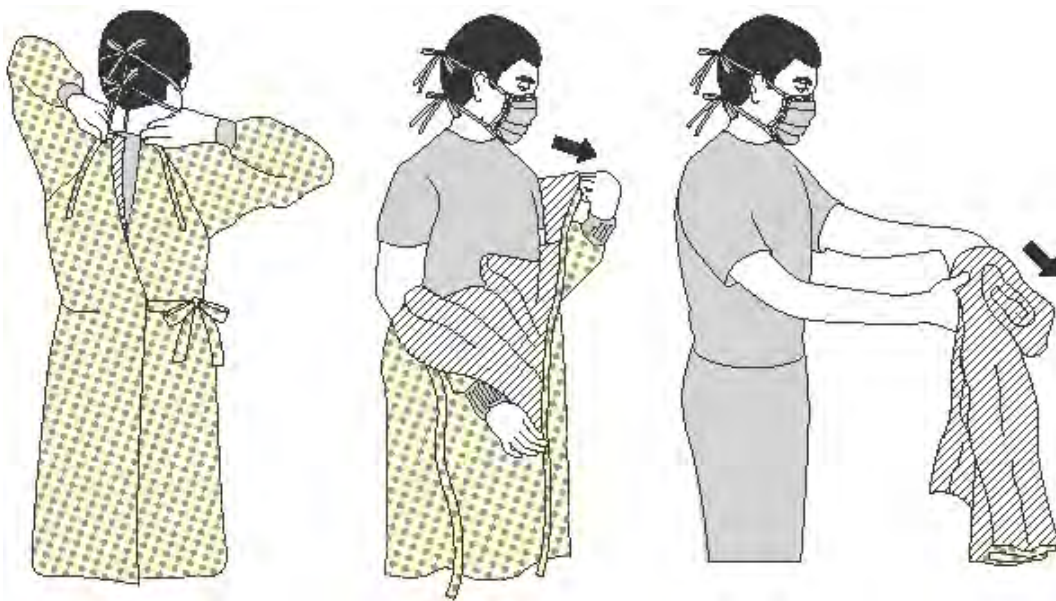
How to remove gloves:

1. Grasp outside edge near wrist.
2. Peel away from hand, turning glove inside out.
3. Hold in opposite gloved hand.
4. Slide ungloved finger under wrist of remaining glove.
5. Peel off from inside, creating a bag for both gloves.
6. Discard.
7. Perform hand hygiene if contamination occurs.



How to remove gown:

1. Consider gown front and sleeves to be contaminated.
2. Unfasten ties. (Some gown ties can be broken rather than untied.)
3. Peel gown away from neck and shoulders, touching inside of gown only.
4. Turn contaminated outside toward the inside.
5. Fold or roll into a bundle and discard.
6. Perform hand hygiene before exiting the patient area.



How to remove goggles or face shield:

1. Consider outside of goggles or face shield to be contaminated.
2. Grasp ear- or headpieces from the back with ungloved hands by lifting head band or ear pieces.
3. Lift away from face.
4. Place in designated receptacle for reprocessing or disposal.
5. Perform hand hygiene if contamination occurs.



How to remove mask or respirator:

1. Consider front of mask or respirator to be contaminated; do not touch.
2. Respirator: Remove the bottom strap of the respirator by touching only the strap and bringing it carefully over the head. Grasp the top strap and bring it carefully over the head. Then pull the respirator away from the face without touching the front of it.
3. Facemask: Carefully untie (or unhook from the ears) and pull away from face without touching the front.
4. Discard.
5. Perform hand hygiene.



(CDC, 2020k)



PERSONAL PROTECTIVE EQUIPMENT AND SARS-CoV-2 (COVID-19) PANDEMIC

1. Healthcare personnel should adhere to Standard and Transmission-based Precautions when caring for patients with SARS-CoV-2 infection.
2. Transmission-based Precautions for SARS-CoV-2 require the use of a filtering facepiece respirator (e.g., N95).
3. A study has found that SARS-CoV-2 is able to survive on materials such as plastic, stainless steel, and cardboard for up to 72 hours.
4. In the event of PPE shortages, the CDC recommends that each healthcare worker be issued five respirators. They will wear one respirator each day and store it in a breathable paper bag at the end of each shift. The order of use should be repeated with a **minimum of five days between each use**.
5. Ultraviolet germicidal irradiation, vaporous hydrogen peroxide, and moist heat have shown the most promise as methods to decontaminate respirators.
6. Reuse of respirators should only be practiced where shortages exist. (CDC, 2020)

(See also “Resources” at the end of this course for a link to the latest CDC guidance on PPE and COVID-19.)

INFECTIOUS DISEASES AND OCCUPATIONAL HEALTH STRATEGIES

Because healthcare workers have contact with patients and infectious material, and because vulnerable patients will be exposed to healthcare workers, healthcare organizations utilize various occupational health strategies to assess, prevent, and control infections and communicable diseases.

Occupational health services provide or refer potential healthcare employees for preplacement medical evaluation prior to taking on job duties and for periodic and episodic medical evaluations during the course of employment.

Preplacement assessments are done in order to:

- Document the employee’s baseline health status
- Implement measures to reduce the employee’s risk of acquiring or transmitting infections in the healthcare settings, such as:
 - Ensuring the individual has evidence of immunity to vaccine-preventable diseases, as recommended by the Advisory Committee on Immunization Practices



- Conducting tuberculosis screening, as required by OSHA
- Offering hepatitis B immunization before starting work, as required by the OSHA Bloodborne Pathogens Standard
- Providing or referring for medical clearance for respirator fit-testing, training, and medical re-evaluations, as required by the OSHA Respiratory Protection Standard
- Assess job placement and provide “clearance for duty”
- Inform the healthcare worker about occupational health services and expectations and confidentiality of health information

Periodic medical evaluations are done in order to:

- Provide additional doses of recommended vaccines
- Perform or refer for indicated follow-up testing
- Conduct periodic screening for tuberculosis as recommended by CDC
- Provide or refer for periodic respirator fit testing

Episodic medical evaluations are done in order to:

- Evaluate and manage potentially infectious exposures and illnesses
- Evaluate and manage new health conditions that may affect risk of acquiring or transmitting infections or ability to perform job functions
- Provide preplacement medical evaluation for those who are changing job duties
- Survey healthcare personnel for exposures and/or illness during outbreaks of infectious diseases in healthcare settings
(CDC, 2019g)

Healthcare Workers and Communicable Diseases

Healthcare workers are responsible for reporting to their supervisor or occupational health service when they have any **signs or symptoms of a communicable disease**. Symptoms requiring immediate evaluation by a licensed medical professional and possible restriction from patient care activities and return-to-work clearance may include:

- Fever or chills
- Sore throat
- Cough
- Shortness of breath or difficulty breathing



- Rash
 - Vesicular lesions
 - Draining wounds
 - New loss of taste or smell
 - Vomiting
 - Diarrhea
- (CDC, 2020i; NYDOH, 2018)

STRATEGIES FOR PREVENTION AND CONTROL OF BLOODBORNE PATHOGEN TRANSMISSION

Healthcare workers who have or may have HBV, HCV, or HIV should be evaluated for the ability to work safely. This evaluation is based on the premise that HBV, HCV, or HIV alone is not sufficient justification to limit the worker's professional duties.

Factors that may bear on the ability of the healthcare worker to provide healthcare include:

- Physical or mental condition that may interfere with ability to perform assigned tasks or regular duties
- Lack of compliance with established guidelines for prevention of disease transmission and/or documentation or evidence of previous transmission of bloodborne pathogens
- Lack of infection prevention and control techniques related to performance of procedures (e.g., poor hand hygiene or failure to follow Standard Precautions)
- Any health condition that would pose a significant risk to others

Notification of patients exposed to the blood of a healthcare worker should be based on documentation of an injury to a healthcare worker or negligent practice. In such cases, the patient should be advised to receive testing for potential bloodborne pathogen exposure.

IMMUNIZATIONS

Vaccinating healthcare workers protects both themselves and patients.

Influenza

The CDC conducts studies each year to determine how well the influenza vaccine protects against flu illness. While effectiveness can vary, recent studies show that the vaccine reduces the risk by between 40% and 60% among the overall population during seasons when most circulating flu viruses are well-matched to the flu vaccine (CDC, 2020m).



The CDC, the Advisory Committee on Immunization Practices (ACIP), and the Healthcare Infection Control Practices Advisory Committee recommend that all U.S. healthcare workers get vaccinated annually against influenza.

Beginning in 2015, the Affordable Care Act linked failure to meet certain percentages of a healthcare facility's employees vaccinated for influenza to federal reimbursement of Medicare and Medicaid funds. The goal was to have 90% compliance for healthcare workers by 2020 (CDC, 2019h). In 2018–19 flu vaccination coverage among healthcare personnel was 81.1%, similar to coverage during the past four seasons. As in previous seasons, coverage in the 2018–19 season was highest among healthcare workers in hospital settings (95.2%), followed by those working in ambulatory care (79.8%).

Hepatitis B

Federal law requires that all employees whose jobs involve participation in tasks or activities with potential exposure to blood or OPIM be offered hepatitis B vaccination. The vaccination is free, safe, and highly protective. This vaccine is given in three doses. Serologic testing after vaccination (to verify that the vaccination was effective) is recommended.

The vaccination schedule most often used is three intramuscular injections, the second and third doses administered 1 and 6 months, respectively, after the first dose. In 2018 a new formulation (Heplisav-B) was approved for two doses, one month apart (CDC, 2018).

Other Vaccines

Vaccinations recommended by the CDC for healthcare workers who do not have evidence of immunity are shown below.

CDC HEALTHCARE PERSONNEL VACCINATION RECOMMENDATIONS (For healthcare workers who do not have evidence of immunity)	
Vaccine	Recommendations in Brief
Hepatitis B	<ul style="list-style-type: none"> • Healthcare personnel without documented evidence of immunity • Healthcare personnel without documented evidence of completed vaccine series
Influenza	All healthcare personnel, including volunteers and students
MMR (measles, mumps, and rubella)	<ul style="list-style-type: none"> • Healthcare personnel without documented evidence of immunity • Healthcare personnel born in or after 1957 without documentation of MMR vaccine
Varicella (chickenpox)	All healthcare personnel who have never had chickenpox, never had a vaccination, or who lack evidence of immunity



Tetanus, diphtheria, and pertussis (Td/Tdap)	<ul style="list-style-type: none"> • All healthcare personnel who have not or are unsure if they have received a dose of Tdap (boosters needed every 10 years) • Pregnant healthcare workers (dose of Tdap needed during each pregnancy)
Meningococcal	One dose for those who are routinely exposed to isolates of <i>N. meningitides</i>
(CDC, 2020n)	

Bloodborne Pathogens Training

OSHA requires employers to provide bloodborne pathogens training for all workers who may come into contact with blood and OPIM in their jobs.

- This training includes information on bloodborne pathogens and diseases, methods used to minimize risk and control occupational exposure, hepatitis B vaccine, and medical evaluation and postexposure follow-up procedures.
- Employers must offer this training on initial assignment, at least annually thereafter, and when new or modified tasks or procedures affect a worker's occupational exposure.
- HIV and HBV laboratory and production facility workers must receive specialized initial training in addition to the training provided to all workers with occupational exposure. Workers must have the opportunity to ask the trainer questions. Training must be presented at an educational level and in a language that workers understand.

Although HBV and HIV are specifically identified in the OSHA Bloodborne Pathogens Standard, bloodborne pathogens include any pathogen present in human blood or OPIM that can infect and cause disease in people exposed to the pathogen. There are approximately 20 additional pathogens that can be transmitted by blood, including:

- HCV
- Malaria
- West Nile virus
- Syphilis
- Babesiosis
- Brucellosis
- Leptospirosis
- Arboviral infections
- Relapsing fever
- Creutzfeldt-Jakob disease (although not a microorganism)



- Adult T-cell leukemia/lymphoma (caused by HTLV-I)
- HTLV-I-associated myelopathy
- Diseases associated with HTLV-II
- Ebola (also known as Ebola hemorrhagic fever)
- Zika viral infection

It is yet unknown whether other nonrespiratory body fluids from an infected person, including blood, vomit, urine, breast milk, or semen, can contain viable infectious SARS-CoV-2 (NIEHS, 2020).

To prevent transmission of bloodborne pathogens to healthcare workers, the CDC recommends:

- Strict adherence to sharps safety guidelines and Standard Precautions
- Hepatitis B vaccination of healthcare workers
- Postexposure prophylaxis and counseling in the event of exposure incident

Exposure Control Plan

OSHA's Bloodborne Pathogens Standard (OSHA, 2012) requires employers to:

1. Establish a **written exposure control plan** designed to eliminate or minimize employee exposure to bloodborne pathogens. Employers must:
 - Prepare an exposure determination that contains a list of job classifications in which **all** workers have occupational exposure and a list of job classifications in which **some** workers have occupational exposure, along with a list of the tasks and procedures performed by those workers that could result in exposure
 - Ensure that a copy of the exposure control plan is accessible to employees
2. **Update the exposure control plan at least annually** to reflect changes in tasks, procedures, and positions that affect occupational exposure, and also technological changes implemented to eliminate or reduce occupational exposure. Employers must:
 - Annually document in the plan that they have considered and begun using appropriate, commercially available, and effective safer medical devices designed to eliminate or minimize occupational exposure
 - Document that they have solicited input from frontline workers in identifying, evaluating, and selecting effective engineering and work practice controls



The exposure control plan is a key document to assist in implementing and ensuring compliance with OSHA standards, detailing information about the ways an employer provides a safe and healthy work environment, including:

- Who is responsible for implementing the plan
- Determination of employee exposure incidents
- Methods of exposure control, such as Standard Precautions; environmental, engineering, and work practice controls; PPE; and housekeeping methods
- Hepatitis B vaccination programs
- Postexposure evaluation and follow-up, as well as the procedures for evaluating the circumstances surrounding an exposure incident
- Communication of hazards to employees
- Training and recordkeeping

Employers are required to implement these preventive measures to reduce or eliminate the risk of exposure to bloodborne pathogens.

EMERGENCY STEPS FOLLOWING AN OCCUPATIONAL EXPOSURE

If an occupational exposure to blood or other body fluids occurs, the following steps must immediately be taken:

1. Wash needlestick injuries and open wounds with soap and water.
2. Flush splashes to nose, mouth, or skin with water.
3. If exposed, irrigate eyes with clean water, saline, or sterile irrigant.
4. Report the incident to the supervisor.
5. Immediately seek medical treatment.
(CDC, 2016b)

EMPLOYER FOLLOW-UP

Following an exposure incident, the employer is required to:

- Perform a timely evaluation of the circumstances surrounding the exposure incident to find ways of preventing such a situation from occurring again
- Identify the source individual (unless the employer can establish that identification is not possible or prohibited by state or local law), and determine the source's HBV and HIV infectivity status



- If the status of the source individual is not already known, test the source's blood as soon as possible, provided the source individual consents
- If the source individual does not consent, establish that legally required consent cannot be obtained
- If state or local law allows testing without the source person's consent, test the individual's blood if it is available
- Make the results of the tests available to the exposed worker and inform the worker of the laws and regulations concerning disclosure of the source's identity and infectivity status
- Provide a timely written report of the above information

Medical care as the result of an exposure is provided by the employer at no charge to the healthcare worker. All test records are confidential. The healthcare worker must be given a copy of the healthcare professional's written opinion within 15 days after the medical evaluation is finished. Postexposure prophylaxis may be administered if medically necessary, as recommended by the U.S. Public Health Service. The healthcare worker should also be offered counseling that includes recommendations for transmission and prevention of HIV (OSHA, 2012).

Postexposure Prophylaxis (PEP)

The CDC and the Clinician Consultation Center offer guidelines for occupational postexposure prophylaxis.

HEPATITIS B

Following an exposure to HBV, prophylaxis can prevent HBV infection and subsequent development of chronic liver infection. The central component of postexposure prophylaxis is hepatitis B vaccine. In certain circumstances, hepatitis B immune globulin is recommended in addition to vaccine for added protection.

HEPATITIS C

There is no postexposure prophylaxis currently available or approved for HCV prevention. Following exposure, initial management recommendations are:

- The exposed individual should receive initial follow-up testing for HCV viral load (HCV RNA) at 6 weeks postexposure if the source person is HCV positive or has potential HCV risk factors.
- The exposed individual should have baseline HCV antibody (HCV Ab) testing with final follow-up testing at 6 months or later if the source person's HCV status is unknown or if



the source person's status is known and has no known HCV risk factors. Optional testing can be done at 6 weeks for HCV viral load.
(NCCC, 2020)

HIV

Occupational exposures require urgent medical evaluation. Baseline HIV testing of the exposed worker should be done even if the exposed worker refuses PEP treatment.

PEP should be initiated as soon as possible, ideally within 2 hours of exposure. A first dose of PEP should be offered while evaluation is underway and should not be delayed while awaiting information about the source person or results of the exposed worker's baseline HIV test.

Whether the exposed worker accepts or declines PEP treatment, if postexposure evaluation shows that PEP is indicated, repeat HIV testing should be done at 4 and 12 weeks. If test results at 12 weeks are negative, HIV can reasonably be excluded in relation to an occupational exposure.

The preferred HIV three-drug occupational PEP regimen is Truvada orally once a day plus raltegravir orally twice a day or dolutegravir once a day for a duration of 28 days. If source person testing is found to be negative for HIV, PEP can be discontinued before 28 days (NCCC, 2020).

SARS-CoV-2/CORONAVIRUS

Higher-risk exposures generally involve exposure of the healthcare worker's eyes, nose, or mouth to material potentially containing SARS-CoV-2. Close contact of 15 minutes or longer is considered a prolonged exposure, but any duration should be considered prolonged if the exposure occurs during performance of an aerosol-generating procedure.

A record of healthcare workers exposed to the virus should be maintained and should include whether or not the worker was:

- Wearing a respirator or mask
- Wearing eye protection if the source person was not wearing a cloth face covering or mask
- Wearing all recommended PPE while performing an aerosol-generating procedure

Healthcare workers who experience prolonged close contact should be excluded from work for 14 days after last exposure and be advised to self-monitor for fever or symptoms consistent with COVID-19. If fever or symptoms develop, they should immediately contact occupational health to arrange for medical evaluation and testing (CDC, 2020o).

EBOLA VIRUS

There are no FDA-approved vaccines or therapeutics available for Ebola virus disease prevention or postexposure.

ZIKA VIRUS

Healthcare workers who believe an occupational exposure to Zika virus has occurred should report it immediately to their supervisor and follow their employer's procedures. This usually involves contacting the occupational health office for an assessment of the exposure with consideration of all bloodborne pathogens.

If it is determined that an occupational exposure did occur, testing might be indicated; however, this needs to be determined individually along with public health authorities and will depend on the type of exposure, infectious status of the source patient, and individual healthcare personnel factors, including pregnancy status (CDC, 2019b).

CASE

Hannah is a registered nurse who works in an assisted living facility. Her residents are largely independent but need assistance with some activities of daily living as well as medication administration at the correct times.

The COVID-19 pandemic has limited family visitation; however, last week, the facility held an outdoor picnic for residents and family members. There was a limit of four family member guests per resident. Screening of family members occurred upon their arrival. Physical distancing of 6 feet was maintained throughout the event, and everyone wore a mask except while eating.

Hannah was one of the RNs providing oversight for the picnic. As she circulated from family to family to ensure that all was well, she kept her mask on and performed hand hygiene between visiting each family. When Hannah had her mask down to get a drink of water, a family member who was eating got food caught in her throat and began to cough violently. Hannah rushed to help her, and the family member's sputum and some food was coughed onto Hannah's clothes and neck area.

After helping this family member, Hannah asked another nurse to take her place so that she could wash her neck and clean her scrub top. She reported this event to her supervisor, wrote up an exposure incident report, and completed her shift. Hannah worked the next day before being off for the next two days.

Three days after the picnic, the administrator at the assisted-living facility learned that the family member who coughed on Hannah tested positive for COVID 19 after showing mild symptoms, including a temperature of 100 °F, coughing, fatigue, headache, and a loss of taste. The administrator immediately contacted Hannah to inform her of the individual's positive COVID test. Per facility protocol, the administrator also instructed Hannah to undergo a



COVID screening test provided by the facility, to self-monitor for COVID signs and symptoms, to report any positive signs/symptoms immediately, and to self-quarantine for 14 days, even if the COVID test is negative. The administrator also reported this exposure to the local public health department for follow up.

SEPSIS

Scope of the Problem

Sepsis is the body's severe response to an infection. Sepsis happens when a person has an infection that triggers an extreme systemic response throughout the body, and without timely recognition and intervention, sepsis can rapidly lead to tissue damage, organ failure, and death.

Sepsis can range from mild to more severe. As sepsis worsens, blood flow to vital organs becomes impaired, leading to organ failure, or to tissue death. Blood clots can form in the arms, legs, fingers, and toes, resulting in gangrene and amputation.

Sepsis can progress to **septic shock** when the systemic infection leads to dangerously low blood pressure. Septic shock is more likely than sepsis to cause death. Most people recover from mild sepsis, but the average mortality rate for septic shock is about 40%. Also, an episode of severe sepsis may place the patient at higher risk for future infection (Mayo Clinic, 2020).

Each year, at least 1.7 million adults in the United States develop sepsis. Nearly 270,000 Americans die as a result of sepsis, and 1 in 3 patients who die in a hospital have sepsis (CDC, 2020p). As many as 87% of sepsis cases begin in the community, and up to 50% of sepsis survivors are left with long-term physical and/or psychological effects (Sepsis Alliance, 2019).

Causes of Sepsis

Sepsis is caused by **infection**—bacterial, viral, fungal, or parasitic. Anyone can get an infection, and almost any infection can lead to sepsis. The most likely include:

- Pneumonias
- Infections of the digestive system
- Infections of the urinary tract
- Bacteremia (bloodstream infections)

People who are higher risk for sepsis include:

- Adults 65 or older
- People with chronic medical conditions (e.g., diabetes, lung disease, cancer, kidney disease)



- Pregnant women
- People with weakened immune systems
- Children younger than 1 year
- Those with wounds or injuries, such as burns
- Those with invasive devices
- Those who previously received antibiotics or corticosteroids
(Mayo Clinic, 2020)

Early Recognition of Sepsis

There is no one sign or symptom of sepsis. Rather, sepsis can be recognized by a combination of symptoms, including any of the following:

- Tachycardia
- Fever usually $>101^{\circ}\text{F}$, shivering, or feeling very cold
- Confusion or disorientation, difficult to rouse
- Tachypnea, shortness of breath
- Hypotension
- Extreme pain or discomfort
- Clammy or sweaty skin
(CDC, 2020m)

Diagnosing Sepsis

Sepsis is diagnosed based on history, physical findings, and laboratory and other tests. Since the signs and symptoms of sepsis are the same as in many other conditions, sepsis may be hard to diagnose in its early stage.

Several tests may be ordered in order to determine underlying infection. A **blood** sample may be drawn to test for:

- Evidence of infection (peripheral blood cultures from two different sites)
- Clotting problems
- Abnormal liver or kidney function
- Impaired gas exchange
- Electrolyte imbalances



Depending on symptoms, other tests may be done on one or more **body fluids** including:

- Urine
- Wound secretions
- Respiratory secretions

If the site of infection is not obvious, one or more of the following **imaging tests** may be done to target a suspected site of infection:

- Chest, abdominal, or extremity X-ray
- CT scan of abdomen or head
- Abdominal ultrasound
- MRI

A **lumbar puncture** test is indicated when there is clinical evidence or suspicion of either meningitis or encephalitis.

A **venous or arterial blood lactate level** should be drawn early with suspected infection and sepsis, in the presence of mildly abnormal vital signs. A high lactate level places the patient at increased risk of adverse outcomes (ACEP, 2020; Mayo Clinic, 2020; Kaili, 2019).

Principles of Sepsis Treatment

Patients with sepsis and septic shock require admission to the hospital. Early and aggressive treatment boosts a patient's chances of surviving sepsis. Management principles of sepsis and septic shock include:

- Early recognition
- Early and adequate antibiotic therapy
- Treating the source of infection with antimicrobial therapy, surgery, or both
- Early hemodynamic resuscitation and continued support
- Proper ventilator management with low tidal volume in patients with acute respiratory distress syndrome
- Renal dialysis, if indicated
(Kaili, 2019)

Patient Education and Prevention

Sepsis and septic shock have serious consequences. Therefore, it is imperative that patients and families are educated about what it is and how to prevent it from happening to them. Since the



best way to prevent sepsis is to block pathogens from entering the body, education should include such measures as:

- Practicing good hygiene, such as handwashing
- Keeping scrapes and cuts clean and covered until healed
- Getting recommended vaccinations
- Having any serious cut or animal or human bite examined by a primary care provider
- Managing chronic medical conditions
- Recognizing early signs and symptoms of worsening infection and sepsis
- Seeking immediate care if signs and symptoms are present
- Ensuring relevant history is provided to clinicians
(CDC, 2019i)

CONCLUSION

During the past four decades, healthcare-associated infections (HAIs) have emerged as a significant risk to patient and healthcare provider safety. In order to ensure both patient and healthcare worker safety, infection control and prevention strategies are required in all healthcare settings. Outcomes of infection control programs should be continually assessed and reported for their effectiveness.

Healthcare workers must understand the chain of infection as it applies to basic infection prevention and control concepts and their role in breaking the links of the chain to prevent healthcare-associated infections. Effective infection control programs include an emphasis on Standard and transmission-based precautions, along with updates on the most current recommendations for PPE, work practices, and engineering controls.

As seen in recent infectious disease outbreaks, such as the 2019 SARS-CoV-2/Coronavirus pandemic, there is a need to recognize unique situations requiring enhanced infection control precautions and to respond in a timely and efficient manner.



RESOURCES

COVID-19: using personal protective equipment (PPE) (CDC)
<https://www.cdc.gov/coronavirus/2019-ncov/hcp/using-ppe.html>

Demonstration of donning (putting on) personal protective equipment (video) (CDC)
<https://www.youtube.com/watch?v=H4jQUBAlBrI>

Demonstration of doffing (taking off) personal protective equipment (video) (CDC)
<https://www.youtube.com/watch?v=PQxOc13DxvQ>

Healthcare-associated infections (CDC)
<http://www.cdc.gov/hai/>

Interim infection prevention and control recommendations during the COVID-19 pandemic (CDC)
<https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html>

Optimizing supply of PPE and other equipment during shortages (CDC)
<https://www.cdc.gov/coronavirus/2019-ncov/hcp/ppe-strategy/index.html>

OSHA Bloodborne Pathogens Standard
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10051

Postexposure prophylaxis (PEP) consultation
888-448-4911
<http://nccc.ucsf.edu/clinician-consultation/pep-post-exposure-prophylaxis/>

Selected EPA-registered disinfectants
<https://www.epa.gov/pesticide-registration/selected-epa-registered-disinfectants>

Society for Healthcare Epidemiology of America
<http://www.shea-online.org>

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TEST

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1. Which is a goal of infection control training?
 - a. Ensure that health professionals understand the chain of command
 - b. Be certain there is no discrimination in care based on ethnicity or race
 - c. Increase vaccination rates in order to eradicate communicable diseases
 - d. Minimize the transmission of pathogens to patients and healthcare workers

2. Which disease-causing organism is nonliving and similar to a virus in that it is unable to self-propagate?
 - a. Bacteria
 - b. Fungi
 - c. Protozoa
 - d. Prion

3. A person who harbors a pathogen and, although in recovery, is still infectious is referred to as a(n):
 - a. Active carrier.
 - b. Incubatory carrier.
 - c. Convalescent carrier.
 - d. Passive carrier.

4. What is the single most important infection control procedure to prevent the spread of infection?
 - a. Hand hygiene
 - b. Prompt and thorough reporting
 - c. Use of gloves
 - d. Isolation of infected patients

5. The first line of defense against the entry of pathogens into a susceptible host includes:
 - a. Physical and mechanical barriers.
 - b. Chemical barriers and fever.
 - c. Lymphatic system and phagocytes.
 - d. Memory T and B cells.



6. Which is a **true** statement about Standard Precautions?
- a. Standard Precautions are limited to settings where there is anticipated exposure to blood.
 - b. Determining that a patient is contagious is recommended prior to implementing Standard Precautions.
 - c. Standard Precautions are implemented for all patients in all patient-care settings.
 - d. Work practice controls are not required if Standard Precautions have been implemented.
7. Which is a **correct** statement concerning hand hygiene?
- a. The handrub procedure with alcohol hand sanitizer should last 5 to 10 seconds.
 - b. Handwashing is not necessary prior to donning sterile gloves for surgery.
 - c. Newer gel nail polish products have been proven safe to wear.
 - d. Duration of handwashing with soap and water should be 15 to 20 seconds.
8. Which action places the clinician at risk of HIV transmission when administering an intramuscular injection to a patient with HIV?
- a. Touching the patient's skin
 - b. Attempting to recap the needle before disposal
 - c. Touching the patient's blood with a gloved hand
 - d. Forgetting to wear a surgical gown
9. Which action does the CDC recommend regarding Contact Precautions?
- a. Wear an N95 respirator when entering a patient's room to provide direct patient care.
 - b. Remove a gown and perform hand hygiene before exiting the patient's room.
 - c. Implement Contact Precautions only for patients with active skin infections.
 - d. Cohort patients infected with different microorganisms.
10. Which is a **unique** infection control measure for a patient on Airborne Precautions?
- a. A single-patient room and the use of gown and gloves when entering the patient's room
 - b. A negative-pressure airborne infection isolation room and the use of an N95 respirator
 - c. The placement of a powered air-purifying respirator on the patient during their transport
 - d. The donning of a surgical face mask when entering the patient's room



11. Which is an example of an **engineering** control used in the healthcare setting to reduce the spread of infections?

- a. A vaccination program for hospital staff
- b. A nursing education program
- c. Sharps disposal container
- d. Personal protective equipment

12. Which is a **true** statement about safe injection practices?

- a. Leftover contents of single-dose or single-use vials can be combined for later use.
- b. A new sterile syringe and needle are not needed for additional entries into a multidose vial.
- c. Shearing or breaking of contaminated needles is prohibited.
- d. Single-dose vials that have been opened can be stored for future use.

13. Spills of blood or other potentially infectious materials (OPIM) are decontaminated by using:

- a. An EPA-registered disinfectant.
- b. Detergent and then rinsing with water.
- c. Disinfectant wipes.
- d. Soap and water.

14. Which form of monitoring of sterilization is considered to be the closest to ideal?

- a. Biological indicators
- b. Mechanical indicators
- c. Chemical indicators
- d. Periodic infection control rounds

15. Containers used to store, transport, and dispose of regulated waste must be identified with warning labels colored:

- a. Orange, red, or orange-red.
- b. Black, brown, or gray.
- c. Yellow or gold.
- d. Blue or blue-green.



- 16.** Personal protective equipment is specialized clothing or equipment that:
- Protects healthcare workers against percutaneous sharps injuries.
 - Assists healthcare providers in the safe physical restraint of a patient.
 - Provides a barrier between a healthcare worker and potentially infectious material.
 - Is used by patients to protect against contracting healthcare-associated infections.
- 17.** Which is a **true** statement about glove use by healthcare workers?
- The CDC does not recommend the use of gloves with patient contact.
 - Use gloves only when providing care to patients with open wounds.
 - The use of gloves precludes the need for hand hygiene.
 - Never wash or reuse disposable gloves.
- 18.** The use of sterile gowns is indicated:
- Whenever limited contamination is expected.
 - When caring for a patient with an infectious disease.
 - When practicing isolation precautions.
 - When performing invasive procedures.
- 19.** Which PPE should be removed last?
- Gloves
 - Face shield or goggles
 - Mask or respirator
 - Gown
- 20.** Which is a recommended occupational health strategy designed to prevent the transmission of infectious disease?
- Pre-employment screening for tuberculosis
 - Annual screening for drug use
 - Annual chest X-rays for all employees
 - Pre-employment determination of sexual preference and practices
- 21.** Which is a **correct** statement regarding CDC's recommended vaccinations for healthcare workers?
- Influenza vaccine is the only recommended vaccine.
 - Measles, mumps, rubella, and chickenpox vaccines are no longer recommended.
 - Pregnant healthcare workers require Tdap during each pregnancy.
 - Vaccination against diphtheria is no longer recommended.



- 22.** Bloodborne pathogens training for healthcare workers must include:
- A thorough study of the physiology of pathogens.
 - Protective measures to minimize risk of occupational exposure.
 - A focus on the gastrointestinal tract, with its resident organisms.
 - Vaccination for all identified, vaccine-preventable disease.
- 23.** While disconnecting a patient's blood transfusion, a clinician accidentally sprays his own face and eyes with blood. What is the clinician's **first** action?
- Report the incident to a supervisor before the end of the shift
 - Monitor himself for any signs or symptoms of infection
 - Arrange for follow-up screening
 - Wash or irrigate his face and eyes
- 24.** Which is an **early** sign or symptom of sepsis?
- Bradycardia
 - Hot, dry skin
 - Fever >101 °F
 - Hypertension

