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Contact Hours: **6**

Infection Control

Preventing and Controlling Infectious Diseases and Healthcare-Associated Infections

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LEARNING OUTCOME: 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.

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 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, 2017).

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. But despite these advances, preventable infections continue to occur. Why, on any given day, does 1 in 25 patients in United States hospitals have at least one healthcare-associated infection (CDC, 2018a)? And 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, 2017a)?

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 individual 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 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., the elderly, 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., *Clostridium 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 his or her 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 disease in a particular place and time.

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, 2018).

Healthcare-Associated Infections

The CDC (2018a) reports that on any given day approximately 1 in 25 hospital patients has at least one healthcare-associated infection. Common types of HAIs include:

- **Catheter-associated urinary tract infections (CAUTIs).** Among UTIs acquired in the hospital, about 75% are associated with a urinary catheter, and the most important risk factor is prolonged use.

- **Surgical site infections (SSIs).** These can be superficial incisional, deep incisional, or organ or space SSIs.

- **Central line–associated bloodstream infections (CLABSIs).** Central lines pose the greatest risk of device-related infections among all types of medical devices. They are the main source of bacteremia and septicemia in hospitalized patients and a major cause of morbidity and mortality.

- **IV catheter–related bloodstream infections (CRBSIs).**

- ***Clostridium difficile (C. diff)* infections (CDIs).** Those most at risk are patients, especially older adults, who take antibiotics and also get medical care. They are related to poor antibiotic prescribing practices. Many studies have shown that 39% to 50% of antibiotics prescribed in hospitals are unnecessary or prescribed inappropriately, e.g., for an illness caused by a virus, or the use of broad-spectrum antibiotics such as azithromycin or cefuroxime instead of first-line antibiotics such as penicillin or amoxicillin.

- **Pneumonias.** Healthcare-acquired pneumonia (HAP) and ventilator-associated pneumonia (VAP) both may be caused by a wide variety of pathogens, can be polymicrobial, and can be due to multidrug-resistant organisms. Among all hospital-acquired infections, HAP is the leading cause of death.
  (CDC, 2017b; File, 2017)

Efforts have been made to reduce these infections, and research shows that when healthcare facilities and teams, individual physicians, and nurses become aware of the issue and take steps to prevent them, rates of some HAIs can decrease by more than 70%. For instance, in 2017, the CDC reported a national decrease of 50% in central line–associated bloodstream infections since 2008 as a result of those efforts. The financial benefit of this decrease was estimated to be $25 billion to $31 billion in medical cost savings (CDC, 2017b).

HAIs IN OUTPATIENT SETTINGS

Healthcare delivery is increasingly occurring in outpatient settings, but surveillance for infection in those settings has been difficult, as detection of infections requires retrospective reviews of medical records and/or prospective audits based on collecting information about patients during the process of care. Much of what is known about HAIs in outpatient settings comes from outbreaks of infections.

OUTPATIENT SETTINGS

- Medical group practices
- Clinics at hospitals or other facilities
- Surgery centers
- Imaging centers
- Mental health centers
- Lab centers
- Physical therapy clinics
- Chemotherapy and radiation therapy centers
- Dialysis centers

The Accreditation Association for Ambulatory Health Care accredits more than 6,000 ambulatory organizations, and since 2014 the Centers for Medicare and Medicaid Services has mandated that accrediting organizations report infection control breaches (not infections) to public health authorities in an effort to learn the extent of healthcare infection risk in those settings (AAAHC, 2017).

Control breaches are events that occur and that could result in transmission of infection to patients or require notification exposure to patients. Such breaches may include:

- Reuse of syringes to access medication vials used for more than one patient
- Failure to properly reprocess reusable medical equipment
- Improper reprocessing of dental instruments
- Failure to wear surgical masks and gowns consistently
- Visibly dirty equipment
- Failure to follow aseptic technique when preparing injections
  (CDC, 2015a)

HAIs IN LONG-TERM CARE FACILITIES

Long-term care settings include nursing homes, skilled nursing facilities, and assisted living facilities. While reporting is limited, the CDC (2017c) provides the following data about infections in these facilities:

- 1 to 3 million serious infections occur each year.
- 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 Prevention and Control, 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 currently of concern include the growth of antibiotic resistance, which may develop into a situation where there are patients with infections for which there is no effective antibiotic. In 2017 the CDC and the National Quality Forum released a guide to help hospitals set up programs to combat this issue (NQF, 2018).

Other challenges are emerging diseases and new outbreaks, such as the Ebola and Zika viruses and the emerging deadly yeast (a unicellular fungus) infection *C. auris* that has made its way into the United States for the first time (CDC, 2017d).

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	• 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	• 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 were 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 *To Err Is Human: Building a Safer Health System,* 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.

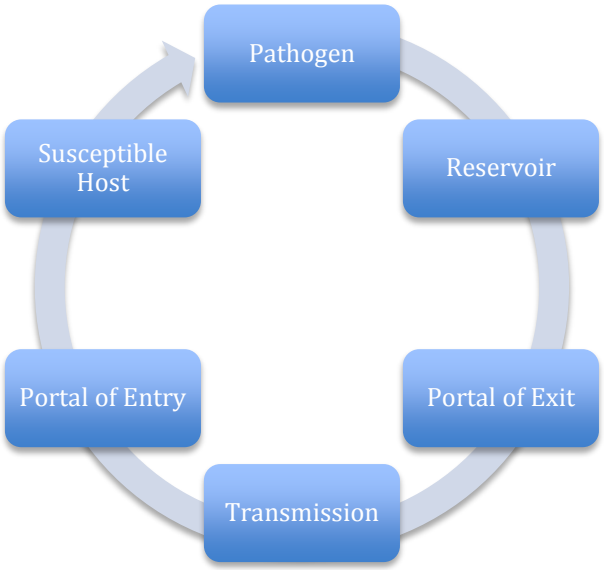
Goals of Infection Control and Prevention

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, patient to patient, and within the same patient (endogenous infection)
- Apply current scientifically accepted infection control principles as appropriate for the specific work environment
- Minimize opportunity for transmission of pathogens to patients and healthcare workers

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, 2018).



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

Pathogens

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

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)
- *Clostridium difficile* (severe diarrhea, colitis, death)
- *Mycobacterium* (tuberculosis)
- *Staphylococcus* (skin boils, pneumonia, endocarditis, sepsis, death)

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.

Viruses are intracellular parasites, that is, they can only reproduce inside a living cell. Viruses such as human immunodeficiency virus (HIV), hepatitis B virus (HBV), and hepatitis C virus (HCV) have the ability to enter and survive in the body for years before symptoms of disease occur. Such viruses can be transmitted to others even when the source person appears to be healthy. Other viruses, such as influenza and those that cause the common cold, quickly announce their presence through characteristic symptoms. All of these viruses are of concern in healthcare settings.

Fungi are prevalent throughout the world, but only a few cause disease in healthy people. Most of these commonly affect the skin, nails, and subcutaneous tissue. Yeasts (*Candida)* are fungi that can cause infections which can be life threatening in critically ill patients. Fungi such as *Aspergillus*, which usually causes infection of the lung, can be life threatening to people with HIV/AIDS or other immunological impairment. Molds can produce toxins that cause disease.

Prions are a form of infectious protein believed to be the cause of several neurodegenerative diseases such as Creutzfeldt-Jakob, a severe brain disease. Like viruses, prions are not considered living. They multiply by inducing the host's proteins to refold into an abnormal shape, accumulate in, and destroy neurons.

Protozoa are single-celled microorganisms that are larger than bacteria. Examples of disease-causing protozoa include amoebas and *Giardia*, which cause diarrhea.

Parasites are larger organisms that can infect or infest people. Infestation with arthropods such as ticks, mites, and body lice occurs by direct contact with the arthropod or its eggs. Diseases caused by these parasites include the plague, Lyme's disease, scabies, and epidemic typhus.

Helminths include roundworms, tapeworms, and flukes. They infect humans primarily through ingestion of eggs or when the larvae penetrate the skin or mucous membranes. Helminths can cause direct damage to internal organs physically and chemically, can modulate the host's immune response, and can result in anemia and malnutrition (Lin-Cereghino, 2017).

Reservoirs

The next link in the chain of infection is the reservoir, the usual "habitat" in which the infectious agent (pathogen) lives and multiplies. Reservoirs can be human, animal/insect, and/or environmental (such as plants, soil, and water).

Microbes often require moisture to grow and reproduce, so infectious agents often require a moist or wet habitat. However, many important human pathogens survive in dry conditions,

including those that live on the skin (e.g., yeast, strep, staph, MRSA) and in the environment. For example:

- Bacterial spores survive in dry environments but often require moisture to multiply (e.g., *C. difficile* spores survive long periods on dry surfaces in medical environments; tetanus and anthrax spores survive in soil).

- Hepatitis B virus has been demonstrated to survive in dried blood at room temperature on environmental surfaces for at least 7 days and still be capable of causing infection (CDC, 2018b).

- *Acinetobacter* commonly colonizes irrigating and intravenous solutions, can survive in a dry inanimate environment for several days, and causes infections most exclusively in hospitalized patients (Cunha, 2016).

HUMAN RESERVOIRS

Many common infectious diseases have human reservoirs, the most important reservoirs for HAIs. 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.

Human reservoirs, however, do not need to be sick (symptomatic) to transmit infection to others, and human reservoirs may or may not show any effects of an illness.

- **Asymptomatic carriers** are persons who never have signs or experience symptoms of infection despite being infected.

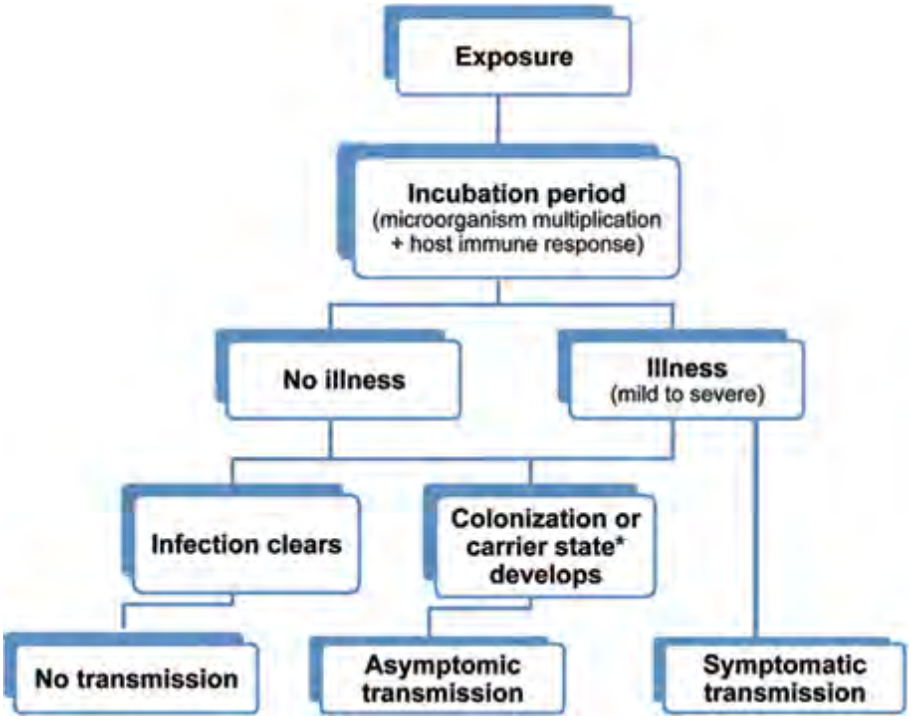
- **Incubatory carriers** are persons who can transmit the pathogen during the period when the infectious agent is incubating (developing) before signs and symptoms of illness begin. For example, the incubation period for HIV can last for many years before symptoms occur, but the person is able to transmit HIV to others during that time period.

- **Convalescent carriers** are persons who have recovered but remain capable of transmitting the pathogen to others.

- **Chronic carriers** are persons who continue to harbor a pathogen for months or even years after initial infection and are often referred to as being "**colonized**." Common bacteria that colonize include *Staphylococcus* and *Clostridium difficile* (Merrill, 2017).

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, colonized persons and persons who are incubating an infection may present more risk for disease transmission than persons 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 loosely to include the persistence of the microorganism in the body, including latent and clinically unapparent (subclinical) infections. These types of infections may remain asymptomatic or may become apparent at a later time. Carriers and colonized persons may "shed" an infectious agent chronically or intermittently and may be a source of infection when that occurs.

ANIMAL/INSECT RESERVOIRS

Animal reservoirs (referred to as *vectors*) include mammals, insects, and many other species that may transmit infections to humans, such as deer ticks (which may carry Lyme disease bacteria), raccoons (which may carry the rabies virus), or fish (which may carry parasites that humans ingest). Because animals and insects are not usually present in healthcare environments, they are not important causes of HAIs.

ENVIRONMENTAL RESERVOIRS

Environmental reservoirs provide favorable conditions for survival and multiplication of infectious agents. Such reservoirs 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 tissues, doorknobs, telephones, bed linens, toilet seats, and clothing.

Environmental reservoirs in healthcare facilities can include:

- Soil in plants
- Water from fish tanks or flower vases, which may contain pathogens and are especially dangerous for compromised patients
- Air filters that have not been properly maintained
- Sinks
- Soiled linens
- Soiled gloves
- Urinary catheters
- Intravenous catheters
- Needles or sharps
- Inadequately sterilized instruments
- Blood pressure cuffs
- Contaminated medical equipment

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
Skin	Cells, lesions	Scabies, staph infection, MRSA
Blood	Insect bite, needles, syringes	HIV, hepatitis B, hepatitis C
Digestive tract	Feces, saliva	Hepatitis A, cholera, salmonella infection, parasites, typhoid
Genitourinary tract	Urine, semen, vaginal secretions	HIV, 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, 2017e).		

Modes of Transmission

In order for an organism to get 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 ways 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 in healthcare include providing direct-contact patient-care activities such as bathing, turning a patient, assisting with toileting, and other direct-contact activities.

- **Indirect contact** transmission may happen in two primary ways:

    - **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.

- **Droplet transmission** occurs when very small drops of liquid are propelled from a human reservoir, mainly during coughing or sneezing, talking, or during the performance of medical procedures, such as bronchoscopy or during dental treatment. Droplets have been found to travel up to 25 feet into the air (Geri et al., 2017), and transmission occurs when the droplets are deposited upon a susceptible host (IFIC, 2016).

Airborne transmission occurs when evaporated droplet particles, dust particles, or shed skin cells containing pathogens are broadcasted, suspended in the air for long periods of time, and transmitted by air current. They may be inhaled by a susceptible person who is in the same room with the infected person or over a longer distance, depending on environmental factors.

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 hold greater risk than others. High-risk settings include:

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

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

Patients hospitalized in ICUs are 5 to 10 times more likely to acquire nosocomial infections than other hospitalized patients (Dasgupta et al., 2015). Risk factors for HAIs in ICU patients include:

- Chronic comorbid illnesses such as diabetes, predisposing to colonization and infections with MDR
- Immunosuppression
- Frequent presence of invasive devices
- High frequency of invasive diagnostic and therapeutic procedures
- Presence of traumatic injuries and/or burns
- Age (elderly and neonate are more susceptible to infection)
- Frequent manipulations and contact with healthcare workers who are concurrently caring for multiple ICU patients
- Longer lengths of stay

(Rao, 2014)

Burn Units

Patients in burn units have the following risk factors for developing infections:

- Comorbidities such as obesity and diabetes
- Presence of invasive devices
- Large burn areas
- Full-thickness burns
- Prolonged hospital stay
  (Rao, 2016)

Newborn Nurseries and Pediatric Units

These young patients are at high risk related to:

- Gestational age
- Low birth weight
- Presence of single or multiple invasive devices
- Invasive interventions and medical treatments
- Insufficient immune system development
- Insufficient mechanical barriers
- Lack of protective flora
- Longer duration of stay
  (Ertugrul et al., 2016)

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)

Clinical Laboratories

Healthcare workers in laboratory settings are at risk of infection from:

- Inhalation of aerosols
- Needlestick injury
- Broken glass injury
  (Coelho & Diez, 2015)

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
Respiratory tract	Inhalation	Influenza, tuberculosis, common cold
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

Medical and surgical procedures often introduce new portals or facilitate the entry of pathogens. Examples include IV catheters, surgical wounds, intubation, 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
- Dental implants
- Joint prostheses
- Cardiac pacemakers
- Mammary implants
- Mechanical heart values
- 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 physiologic and immunological condition of the host and on 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.

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), barriers such as 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. Inside the gastrointestinal tract are 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.** A localized response that occurs when several types of white blood cells flood an area that has been invaded by pathogens, which allows for the removal of damaged and dead cells, and begins 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)

Factors Affecting Natural Barriers

Several important factors affect an individual'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., Alaskan 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 that 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)

CASE

Robert Turner, an 80-year-old patient, was admitted to the general medical unit for treatment of a pressure ulcer on his sacrum and the onset of new delirium and urinary incontinence. To protect the healing ulcer 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 ulcer 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 UTI, 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

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. Methods to prevent the spread of infection include:

- Standard Precautions
- Transmission-based precautions
- Clinical management of temporary invasive medical devices
- Occupational health strategies

Standard Precautions

Standard Precautions are an infection control strategy to prevent transmission of pathogens and are **recommended for all patient-care delivery settings.** They are based on the concept that all blood, body fluids, secretions, excretions (except sweat), nonintact skin, and mucous membranes may contain transmissible pathogens.

Standard Precautions are intended to address all modes of transmission by any type of organism. They are based on a risk assessment and make use of practices and personal protective equipment that protect healthcare providers from infection and prevent the spread of infection from patient to patient.

Standard Precautions include:

- Performing hand hygiene
- Use of personal protective equipment 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, 2017f)

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 OPIM.

OSHA defines blood as:

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

Other potentially infectious materials include:

- Semen
- Vaginal secretions
- Cerebrospinal fluid
- Synovial fluid
- Pleural fluid

- Pericardial fluid
- Peritoneal fluid
- Amniotic fluid
- Saliva in dental procedures
- Any body fluid that is visibly contaminated with blood
- All body fluids in situations where it is difficult or impossible to differentiate between body fluids
- 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
- Human breast milk (implicated in transmitting HIV and HBV from mother to infant) (OSHA, 2012; CDC 2015b)

HAND HYGIENE

During delivery of healthcare, the CDC (2017g) 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 dirty
    - After known or suspected exposure to *Clostridium difficile*
    - After known or suspected exposure to patients with infectious diarrhea during norovirus outbreaks
    - If exposure to *Bacillus anthracis* is suspected or proven
    - Before eating
    - After using a restroom
- Use an alcohol-based hand sanitizer for everything else.

Perform hand hygiene in the following **clinical situations**:

- Before having direct contact with patients
- Before handling medication

- Before donning sterile gloves to insert an invasive device
- Before and after handling respiratory devices, urinary catheters, and intravascular catheters
- After contact with blood, body fluids or excretions, mucous membranes, nonintact skin, or wound dressing
- After contact with a patient's intact skin (e.g., when taking a pulse)
- If hands will be moving from a contaminated body site to a clean body site during care
- After contact with inanimate objects (including medical equipment) in the immediate vicinity of the patient
- After removing gloves

Skin and Nail Care

CDC recommendations to maintain hand skin health include:

- Lotions and creams can 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.

CDC recommendations regarding nail care 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).
- An organizational policy should be in place regarding wearing of non-natural nails by healthcare personnel who have direct contact with patients outside of the groups specified above.
- Keep natural nail tips less than 1/4-inch long.
- Studies are inconclusive at this time regarding the wearing of rings as a source of contamination.
  (CDC, 2017g)

Evidence and guidelines support not wearing artificial nails and either not using nail polish or ensuring the polish is intact. Newer gel polish products are widely available, but very few studies have been done regarding them, and evidence does not support their safe use. Based on evidence and recommendations, some hospitals are going to a "clean, short, natural nails" policy for all patient-care area workers. The Association of periOperative Registered Nurses states: "Artificial nails, including extensions or tips, gels

and acrylic overlays, resin wraps, or acrylic fingernails, should not be worn by perioperative personnel" (Wood & Van Wicklin, 2015).

Hand Cleansing Techniques

Both the CDC and the World Health Organization provide guidelines in the technique of handwashing as well as handrub 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, 2009)**:**

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.

For surgical hand antisepsis:

- 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, prewash hands and forearms with a non-antimicrobial soap and dry hands and forearms completely before applying. Allow product to dry thoroughly before donning sterile gloves.
- Double gloving is advised during invasive procedures that pose an increased risk of exposure to blood.
  (CDC, 2017g)

GLOVES

The CDC describes when and how to wear gloves and states that wearing gloves is not a substitute for hand hygiene and that hands should always be cleaned after removing gloves.

Steps for glove use:

- Choose the right size and type of gloves for the task.
  - 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.
- Put on gloves before touching a patient's nonintact skin, open wounds, or mucous membranes, such as the mouth, nose, and eyes.
- Change gloves during patient care if the hands will move from a contaminated body site (e.g., perineal area) to a clean body site (e.g., face).
- Remove gloves after contact with a patient and/or the surrounding environment (including medical equipment) using proper technique to prevent hand contamination.
- Clean hands before putting on gloves for a sterile procedure.
- Change gloves between tasks and procedures on the same patient after contact with material that may contain a high concentration of microorganisms.
- Wear gloves in hemodialysis settings for any contact with the patient or the patient’s equipment.
- Remove gloves promptly after use and perform hand hygiene immediately before touching noncontaminated items and environmental surfaces and before going to another patient.
  (CDC, 2017g)

The Association for Professionals in Infection Control and Epidemiology (APIC, 2016) add the following instructions:

- Do not reuse or wash gloves (except for utility gloves after being properly cleaned).
- Do not use nonapproved hand lotions.
- Do not use gloves if they are damaged.
- Do not touch your face when wearing gloves.
- Do not wear gloves in the hall. Consult facility’s policy for exceptions.

MASK, EYE PROTECTION, FACE SHIELD

CDC recommendations state:

- Wear a mask and eye protection or a face shield to protect mucous membranes of the eyes, nose, and mouth during activities that are likely to generate splashes or sprays of blood or body fluids, secretions, and excretions. Select masks, goggles, face shields, and combinations of each according to the need anticipated by the task.

- During procedures that generate aerosols (e.g., bronchoscopy, suctioning of the respiratory tract, endotracheal intubation) in patients who are not suspected of being infected with an agent for which respiratory protection is otherwise recommended (e.g., tuberculosis, SARS, or hemorrhagic fever viruses), wear one of the following:
    - A face shield that fully covers the front and sides of the face
    - A mask with attached shield
    - A mask and goggles

  (CDC, 2017g)

GOWNS

- Wear a gown that is appropriate to the task to protect skin and prevent soiling or contamination of clothing during procedures and patient-care activities when contact with blood, body fluids, secretions, or excretions is anticipated.

- Wear a gown for direct patient contact if the patient has uncontained secretions or 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.

- Routine donning of gowns upon entrance into a high-risk unit (e.g., ICU, NICU, HSCT unit) is not indicated.

  (CDC, 2017g)

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.

- 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 with symptoms of respiratory infection to:
    - Cover mouths/noses when coughing or sneezing
    - Use and dispose of tissues
    - Perform hand hygiene after contact with respiratory secretions
- Provide tissues and no-touch receptacles (e.g., foot pedal–operated lid or open, plastic-lined waste basket) for disposal of tissues.

- Provide resources and instructions for performing hand hygiene in or near waiting areas; provide conveniently located dispensers of alcohol-based handrubs and, where sinks are available, supplies for handwashing.

- During periods of increased prevalence of respiratory infections in the community, offer masks to coughing patients and other symptomatic persons upon entry into the facility or medical office and encourage them to maintain a separation, ideally of at least 3 feet in common waiting areas.

  (CDC, 2017g)

PATIENT-CARE EQUIPMENT AND INSTRUMENTS/DEVICES

Policies and procedures should be established for containing, transporting, and handling patient-care equipment and instruments/devices that may be contaminated with blood or body fluids.

- Remove organic material from instruments/devices that penetrate soft tissue and bone (**critical**) and those that do not penetrate (**semicritical**), using recommended cleaning agents to enable effective disinfection and sterilization processes.

- Wear PPE (personal protective equipment), 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, 2017g)

CARE OF THE ENVIRONMENT

Establish policies and procedures for routine and targeted cleaning of environmental surfaces as indicated by the level of patient contact and degree of soiling.

- Clean and disinfect surfaces likely to be contaminated with pathogens, including those in close proximity to the patient (e.g., bed rails, over-bed tables) and surfaces in the patient-care environment that are frequently touched (e.g., door knobs) on a more frequent schedule compared to that for other surfaces such as horizontal surfaces in waiting rooms.

- Use EPA-registered disinfectants that have microbicidal activity against the pathogens most likely to contaminate the patient-care environment. Use according to manufacturer's instructions.

    - Review the effectiveness of disinfectants being used when evidence of continuing transmission of a pathogen, such as *C. diff.*, suggests resistance to the in-use product. Change to a more effective disinfectant as indicated.

In facilities providing healthcare to pediatric patients or that have waiting areas with child play toys, establish policies and procedures for cleaning and disinfecting toys at regular intervals using the following 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 multi-use electronic equipment for preventing contamination and for cleaning and disinfection, 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 (e.g., daily) (CDC, 2017g).

TEXTILES AND LAUNDRY

- Handle used textiles and fabrics with minimum agitation to avoid contamination of air, surfaces, and persons.

- If laundry chutes are used, ensure they are properly designed, maintained, and used so as to minimize dispersion of aerosols from contaminated laundry.

(CDC, 2017g)

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, 2017g)

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.
- Use IV bags, tubing, and connectors for one patient only.
- Do not use bags or bottles of intravenous solution as common source of supply for multiple patients.
- Consider a syringe or needle/cannula 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, both the needle/cannula and syringe used to access them must be sterile.
- Do not keep multidose vials in the immediate patient-care areas. Store as recommended by the manufacturer and discard if sterility is compromised.

  (CDC, 2017g)

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

INFECTION CONTROL PRACTICES FOR SPECIAL LUMBAR PUNCTURE PROCEDURES

Wear a surgical mask to prevent droplet spread of oral flora when placing a catheter or injecting material into the spinal canal or subdural space (i.e., during myelograms, lumbar puncture, and spinal or epidural anesthesia) (CDC, 2017g).

Transmission-Based Precautions

In addition to Standard Precautions, which are used with all patients, some patients require additional precautions known as transmission-based precautions. 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. 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.
  - 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).
    - 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 factors 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

- Put gloves on upon entry into the room or cubicle.
- 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., BP cuffs) or implement patient-dedicated use. If common use is unavoidable, clean and disinfect before use on another patient.
- 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. 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, 2017g)

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 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.

Hand hygiene, including handwashing with soap and water versus using hand sanitizer, is a recognized precaution to be taken by all providers who will be caring for Mrs. Alberts.

DROPLET PRECAUTIONS

Droplet Precautions are designed to prevent transmission of diseases easily spread by large-particle droplets produced when the patient coughs, sneezes, or talks, or during the performance of procedures. 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.
    - Ensure patients are physically separated greater than 3 feet and draw a privacy curtain between beds to minimize close contact.
- In long-term care and other residential settings, make decisions on a case-by-case basis.
- In ambulatory settings, place patients in an examination room or cubicle as soon as possible.
- Instruct 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 patient to wear a mask and follow respiratory hygiene/cough etiquette.
- No mask is required for persons transporting patients.
  (CDC, 2017g)

AIRBORNE PRECAUTIONS

Airborne Precautions are designed to prevent transmission of diseases spread by the true airborne route. Airborne Precautions are the only type that requires a negative-pressure airborne infection isolation room (AIIR) with door kept closed and use of an N-95 respirator. 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 a negative-pressure environment.
- 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.

- 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.

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 infectious 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

- 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, 2017g)

Clinical Management of Temporary Invasive Medical Devices

- During each healthcare encounter, assess the medical necessity of any invasive medical device (e.g., vascular catheter, indwelling urinary catheter, feeding tube, ventilator, surgical drain) in order to identify the earliest opportunity for safe removal.
- Ensure that healthcare personnel adhere to recommended insertion and maintenance practices.

  (CDC, 2017g)

Occupational Health

- Ensure that healthcare personnel either receive immunizations or have documented evidence of immunity against vaccine-preventable diseases as recommended by the CDC and/or ACIP and as required by federal, state, or local authorities.

- Implement processes and sick leave policies to encourage healthcare personnel to stay home when they develop signs or symptoms of acute infectious illness.

- Implement a system for healthcare personnel to report to their supervisor or healthcare facility staff responsible for occupational health signs, systems, and diagnosed illnesses that may represent a risk to patients and coworkers.

- Adhere to federal and state standards and directives applicable to protecting healthcare workers against transmission of infectious agents including OSHA's Bloodborne Pathogens Standard, Personal Protective Equipment Standard, Respiratory Protection Standard, and TB compliance directive.
  (CDC, 2017g)

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

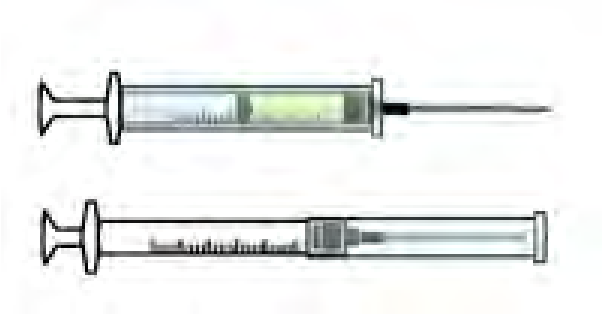
Engineering controls refers to measures that isolate or remove a hazard from the workplace and that must be used when feasible. These include:

- 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.

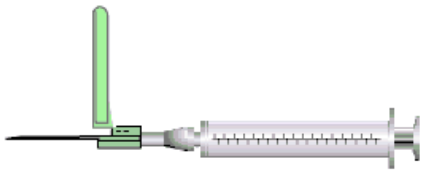
ENGINEERING CONTROL DEVICE EXAMPLES

Syringe with retractable needle.



Self-resheathing needle.

Resheathing disposable scalpel.



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

Source: OSHA, 2017.

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:

- General housekeeping
- Cleaning and disinfecting strategies
- Sterilizing patient equipment
- Handling of laundry and bedding
- Disposal of regulated medical waste
  (CDC, 2017h)

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 from April 2012.

OSHA requirements for handling sharps states 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.
- 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.
- 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 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.

Healthcare providers are required to follow CDC (2017i) recommended practices for injection and/or IV therapy:

- To the extent possible, prepare medications in pharmacy settings and dedicated medication rooms.
    - Draw up medications in the medication room or a designated clean area free of any items potentially contaminated with blood or body fluids (e.g., syringes, needles, IV tubing, blood collection tubes, and needle holders).
    - Multi-dose vials should not be accessed in the immediate patient treatment area. If a multi-dose vial enters the immediate patient-care area, it should be dedicated to that patient and discarded after use.
    - Bags or bottles of intravenous solution should not be used for more than one patient.
- Use an aseptic technique to access parenteral medications.
- Perform hand hygiene before handling the medication.
- Disinfect the rubber septum with alcohol and allow alcohol to dry prior to piercing.
- Always use a new sterile syringe and sterile needle to draw up the medication and avoid contact with a nonsterile environment during the process.
- Never leave a needle inserted into the septum of a vial for multiple draws.
- Ensure that any device inserted into the septum is used in accordance with manufacturer's instructions and does not compromise the integrity of the remaining vial contents.
- Minimize multiple entries into bags of fluid to add medications; if more than one entry is required, use a new sterile syringe and sterile needle and access the bag using aseptic technique.
- Discard medications:
    - According to the manufacturer's s expiration date (even if not opened) and whenever sterility is compromised or questionable.

  - 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.
  - Multi-dose vials that have been opened or accessed should be dated and discarded within 28 days unless the manufacturer specifies a different date.

- Never administer medications from the same syringe to more than one patient, even if the needle is changed.
- After a syringe or needle has been used to enter or connect to a patient's IV, it is contaminated and should not be used on another patient or to enter a medication vial.
- Never enter a vial with a used syringe or needle.
- Never use medications packaged as single-dose vials for more than one patient.
- Assign medications packed as multi-dose vials to a single patient whenever possible.
- Wear a surgical mask when placing a catheter or injecting material into the spinal canal or subdural space.

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

GENERAL ENVIRONMENTAL SURFACE CLEANING

Environmental cleaning is critical for reducing pathogen contamination of surfaces and the subsequent risk for HAIs. Environmental cleaning involves physical action of cleaning surfaces to remove organic and inorganic material, application of a disinfectant, and employing monitoring strategies to ensure that these practices are carried out appropriately.

Healthcare environment surfaces can be divided into two groups: 1) those with minimal hand contact, such as floors and ceilings, and 2) those with frequent hand contact, such as doorknobs, bedrails, light switches, and edges of privacy curtains, that require cleaning and/or disinfecting more frequently than those with minimal hand contact.

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)

Horizontal surfaces with infrequent hand contact (e.g., window sills, hard-surface flooring) in routine patient-care areas require cleaning on a regular basis, when soiling or spills occur, and when a patient is discharged from the facility.

Extraordinary cleaning and decontamination of floors in healthcare settings have been found to be unwarranted. Disinfection of floors offers no advantage over regular detergent/water cleaning and has minimal or no impact on the occurrence of HAIs. However, facilities may elect to use an EPA-registered detergent/disinfectant in patient areas because of the possibility a spill may contain blood or body fluids or when a multi-drug resistant organism is likely to be present.

Disinfectants used in environmental cleaning are not sporicidal or tuberculocidal but can kill most other microorganisms. Hospital-level disinfectants (e.g., quaternary ammonium germicidal detergent solution) have been shown to be capable of killing *Staphylococcus aureus, Pseudomonas aeruginosa,* and *Salmonella cholerae.*

Cleaning solutions should be replaced frequently, and soiled cloths and mop heads should be replaced each time a bucket of detergent/disinfectant is emptied and refilled (CDC, 2017h).

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 disinfectant or disinfectant wipes
- Using care when wet dusting equipment and surfaces above the patient to avoid patient contact with the detergent/disinfectant
- Avoiding the use of cleaning equipment that produces mists or aerosol
- Equipping vacuums with HEPA filters, especially for the exhaust
- Regular cleaning and maintenance of equipment to ensure efficient particle removal
  (CDC, 2017h; Anderson & Friedman, 2018)

All disinfectants and sterilizing chemicals have a degree of toxicity necessary to kill the microorganisms. In general, the lowest level of product that will do the job should be used to minimize exposure of healthcare workers to toxic chemicals.

CLEANING UP BLOOD SPILLS

All environmental and working surfaces must be cleaned and decontaminated after contact with blood or OPIM. Protective gloves and other PPE should be worn as necessary, and an appropriate disinfectant should be used. Such disinfections can be a diluted bleach solution or EPA-registered antimicrobial products such as tuberculocides, sterilants, or products registered against HIV/HBV.

After putting on personal protective equipment:

- Block off the area to protect patients and other staff if the spill is large.
- Wipe up the spill with paper towels or other disposable absorbent material and discard the contaminated materials in an appropriate, labeled container.
- Use a spill kit to clean up the spill if it contains sharps such as needles, scalpels, broken glass, blood tubes, or capillary tubes, or if there is a large volume of liquid.
- Clean up all blood thoroughly before applying the disinfectant.
- Apply the disinfecting solution onto all contaminated areas of the surface.
- Let surface remain in contact with disinfectant for the number of minutes based on the manufacturer's directions. (When using a diluted bleach solution, contact time is the length of time it takes for the solution to dry.)
  (CDC, 2017h)

LOW-LEVEL DISINFECTION

Items that come in contact with intact skin for a brief period of time are usually considered noncritical surfaces. **Noncritical items** include environmental surfaces and:

- Bedpans
- Blood pressure cuffs
- Pneumatic tourniquet cuffs
- Stethoscopes
- Hydrotherapy tanks
- Computers

Most noncritical reusable items may be decontaminated where they are used. Virtually no risk has been documented for transmission of infectious agents to patients through noncritical items as long as they do not contact nonintact skin and/or mucous membranes.

Noncritical items are disinfected using low- or intermediate-level disinfectants, which include:

- Ethyl or isopropyl alcohol
- Sodium hypochlorite
- Diluted household bleach solution
- Phenolic germicidal detergent
- Iodophor germicidal detergent
- Quaternary ammonium germicidal detergent solution (low level only)
  (CDC, 2017h)

INTERMEDIATE-LEVEL DISINFECTION

Intermediate-level disinfection kills most viruses, bacteria, and mycobacteria using a chemical germicide registered as a tuberculocide by the EPA. It does not kill bacterial spores. It is often used to clean blood spills and other environmental cleaning and is **not** licensed for disinfection of patient-care equipment that touches mucous membranes. These disinfectants are typically labeled as tuberculocidal to give evidence that they kill the bacterium that causes tuberculosis as well as HBV and HIV. They may be available as a liquid or as disposable wipes.

Intermediate-level disinfectants include:

- Ethyl or isopropyl alcohol
- Sodium hypochlorite

- Diluted household bleach solution
- Phenolic germicidal detergent
- Iodophor germicidal detergent
  (CDC, 2017h)

Some situations, such as care of the patient on Contact Precautions, may require specified patient-care items to be either dedicated to one patient or patient cohort or subjected to special disinfection procedures between patient uses. This includes items used for patients infected with organisms that are difficult to treat, highly virulent, or easily spread, such as:

- Patients infected with MRSA, vancomycin-resistant enterococci (VRE), *C. diff,* and other microorganisms of special concern
- Patients infected with highly virulent microorganisms such as viruses causing hemorrhagic fever (e.g., Ebola or Lassa)

Knowing facility policies and/or consulting with infection control staff is important in these situations.

HIGH-LEVEL DISINFECTION

High-level disinfection is required for disinfecting semicritical items, i.e., those that come in contact with intact mucous membranes (e.g., lungs, gastrointestinal tract) or nonintact skin. Such items include:

- Respiratory therapy equipment
- Anesthesia equipment
- Some endoscopes
- Laryngoscope blades
- Esophageal manometry probes
- Cystoscopes
- Anorectal manometry catheters
- Diaphragm fitting rings

Semicritical objects should be free from all pathogens; however, a small number of bacterial spores are permissible. These items should be cleaned and then receive at least high-level disinfection between patients by chemical germicides when sterilization is not feasible, using:

- Glutaraldehyde
- Stabilized hydrogen peroxide

- Ortho-phthalaldehyde
- Peracetic acid with hydrogen peroxide

The most appropriate chemical germicide for a particular situation should be chosen on the basis of the object to be disinfected, its composition, and intended use.

Recommendations for disinfecting semicritical items include:

- Use a probe cover or condom, when available, to reduce the level of microbial contamination. However, do not use a lower category of disinfection or cease to follow the appropriate disinfectant recommendations when using probe covers, as these sheaths and condoms can fail.
- Wear appropriate PPE when handling and cleaning contaminated items.
- Clean items thoroughly before reprocessing. First rinse with cold water to remove blood or body fluids, then wash with hot soapy water and rinse again to remove the soap before disinfecting or sterilizing. Cleaning methods may be manual or mechanical and may require a rinse or presoak depending on the nature and amount of blood or body fluids. Once cleaned, avoid cross contamination by other articles or surfaces.
- Rinse all items after high-level disinfection using sterile water, filtered water, or tap water followed by an alcohol rinse of equipment that will have contact with mucous membranes of the upper respiratory tract.
- Wipe clean tonometer tips and then disinfect them by immersing for 5 to 10 minutes in either 5,000 ppm chlorine or 70% ethyl alcohol, which are not listed as FDA-cleared high-level disinfectants.
- Monitor methods for verifying contact with all internal channels and components of devices with internal lumens, such as endoscopes.
- Follow the recommendations of the device/equipment manufacturers of both the device to be disinfected and the disinfectant to be used to ensure that the method chosen is compatible with the components and materials.
  (CDC, 2017h)

Reprocessing Medical Devices

Reusable devices become soiled and contaminated when used and must undergo reprocessing, which is a detailed, multistep process to clean and then disinfect or sterilize them. Reprocessing correctly following labeled instructions results in a device that can be safely used more than once.

Reprocessing involves three steps:

1. Initial decontamination and cleaning at point of use to prevent drying of blood, tissue, other biological debris, and contaminants
2. Transfer of the device to the reprocessing work area, where it is thoroughly cleaned
3. Either disinfection or sterilization, depending on the intended use of the device, and the materials from which it is made

The device is then stored or routed back into use (U.S. FDA, 2017).

STERILIZATION

Sterilization is required for reusable patient-care instruments that touch sterile tissue or the vascular system (e.g., surgical instruments, implants) and require the absence of microbial contamination. Most of these should be purchased as sterile or be sterilized with steam.

Steam sterilization is the most widely used and the most dependable method. It is used whenever possible on all critical and semicritical items that are heat- and moisture-resistant. Steam sterilization is rapidly microbicidal, sporicidal, and rapidly heats and penetrates fabrics. Each item is placed in a steam sterilizer (autoclave) and exposed to direct steam at the required temperature and pressure for a specific time. Portable steam sterilizers are used in outpatient, dental, and rural clinics.

Low-temperature sterilization technologies include:

- Ethylene oxide (EtO) has been widely used for sterilizing temperature- and moisture-sensitive medical devices and supplies.
- Hydrogen peroxide gas plasma is used for materials and devices that cannot tolerate high temperature and humidity, such as some plastics, electrical devices, and corrosion-susceptible metal.
- Peracetic acid sterilization is used to chemically sterilize medical (e.g., GI endoscope) and surgical (e.g., flexible endoscope) instruments. Lumened endoscopes must be connected to an appropriate channel connector to ensure that the sterilants have direct contact with the contaminated lumen.

Other sterilization methods include:

- Ionizing radiation is used for medical devices and other products such as pharmaceutical and tissue for transplantation.
- Dry-heat sterilization is used for materials that might be damaged by moist heat or that are impenetrable to moist heat (e.g., sharp instruments).

- Microwaves are used for disinfection of soft contact lenses, dental instruments, dentures, and urinary catheters for intermittent self-catheterization. Microwaves must be used with products that do not melt.

- Ozone is a new sterilization process for use with reusable medical devices and has been shown to be effective against the most resistant pathogen, *Geobacillus stearothermophilus*, a bacteria commonly found in the soil, on human skin, and in the intestines. It is compatible with a range of commonly used materials, including stainless steel, titanium, anodized aluminum, ceramic, glass, silica, and PVC.
  (CDC, 2017h)

MEASURING EFFECTIVENESS

Effectiveness of reprocessing depends upon:

- Thorough cleaning before either disinfection or sterilization
- Choice of the right disinfectant product (high-level disinfectants require immersion, while surface disinfectants are for environmental use)
- 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 of 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 of 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 indicators** include gauges, thermometers, timers, records, and/or other devices. Most sterilizers have automatic control and locking devices as well as alarm

systems in the event of a failure to operate correctly. Records are maintained and reviewed for each cycle.

- **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. Several types are available:
    - Tape, labels, and paper strips printed with ink that changes color
    - Glass tube with pellets that melt
    - Integrating or wicking paper with ink or chemical tablet at one end that melts and wicks along a color bar to reach the "accept" area

- **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. A biological indicator that has been inactivated by the sterilization process indicates that other potential spores or bacteria in the sterilizer load have been killed. Biological indicators should be used for every load containing implantable items and quarantine items, whenever possible, until the biologic indicator is negative. (CDC, 2017h; URMC, 2018)

PACKAGING, HANDLING, AND STORAGE OF PROCESSED ITEMS

Medical devices that are prepared for sterilization must be packaged so their sterility is maintained to the point of use.

- Ensure that packaging materials are compatible with the sterilization process and have received FDA clearance.

- Ensure that packaging is sufficiently strong to resist punctures and tears to provide a barrier to pathogens and moisture.

- Types of packaging:
    - Textiles
    - Nonwoven
    - Pouch packaging
    - Rigid container systems

Once devices/equipment have been disinfected, proper handling and storage are required to maintain these items in ready-to-use condition. Proper handling and storage after sterilization recommendations include:

- Ensure the storage area is well-ventilated and protects against dust, moisture, insects, and temperature and humidity extremes.
- Store sterile items so the packaging will not be compromised.
- Label sterilized items with a load number indicating the sterilizer used, date of sterilization, and if applicable, expiration date. Some sterile items have day-to-day expiration and may be labeled "sterile unless the integrity of the package is compromised."
- Shelf life depends on quality of packing material, storage conditions, transport conditions, and amount of handling or moisture.
- Evaluate packaging before use for loss of integrity; if integrity is compromised, repack and reprocess.
- If time-related storage is used, label the pack at time of sterilization with expiration date. Once date expires, reprocess.
  (CDC, 2017h)

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 the CDC to identify the source and prevent further transmission to other patients.

The investigators work with Jennifer and the center to review the histories of all patients and discover that each patient had undergone a similar invasive procedure using an endoscope. On reviewing the center's procedures, CDC officials find that the center has been cleaning and reprocessing the endoscopes according to manufacturer-recommended procedures for disinfecting. However, one endoscope is cultured and found to contain the resistant strain of *E. coli.* Investigators recommend to Jennifer and the center that they switch to a liquid chemical, high-level disinfection system that is 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 meet 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 are able to make recommendations to the management team of their procedure center regarding equipment acquisitions and policy/procedure changes.

After the center changes its disinfection procedures, no additional cases of *E. coli* occur and patient safety is maintained. The center invests 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

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.

Regulated medical waste includes:

- Liquid or semiliquid blood or other potentially infectious materials
- Items contaminated with blood or OPIM and which would release these substances in a liquid or semiliquid state if compressed
- Items that are caked with dried blood or OPIM and are capable of releasing these materials during handling
- Contaminated sharps
- Pathological and microbiological wastes containing blood or OPIM

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 should be placed in containers that are 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:

- 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.

Recommendations from the CDC 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.

Treatment methods developed in recent years include grinding/shredding/chemical disinfection methods, energy-based technologies (e.g., microwave or radio wave), and disinfection/ encapsulation methods. State medical waste regulations specify appropriate treatment for each category of regulated waste.

WARNING LABELS

Warning labels are to be affixed to containers of regulated waste; refrigerators and freezers containing blood or OPIM; and other containers used to store, transport, or ship blood or OPIM. 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.

Biohazard warning label.
(Source: OSHA.)

Linens and Laundry

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, 2017h)

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 appropriate PPE donned prior to starting cleanup. All surfaces that are 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 as well. Each team member monitors his or her 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

Types of Personal Protective Equipment

Personal protective equipment is defined by OSHA (2012) as specialized clothing or equipment worn by a healthcare worker for protection against hazards including infectious materials. Employers are required to provide and maintain clean, appropriate PPE and clothing free of charge to employees. Latex-free PPE must be made available on request.

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 versus 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 needs to 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.

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, as they are sometimes worn for several hours, and need to 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.

Environmental service personnel often wear reusable heavy-duty gloves to work with caustic disinfectants.

Proper glove use includes:

- 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 use if torn or when heavily soiled and after use on each patient
- Disposing of gloves in proper receptacle
- Performing hand hygiene before putting on and following removal of gloves
- Never washing or reusing disposable gloves
  (CDC, 2017g)

GOWNS/APRONS/COVERALLS

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

Clean gowns are generally used for isolation precautions. Sterile gowns are only needed when performing invasive procedures.

A waterproof apron is often worn during surgical or obstetrical procedures when a large volume of blood or body fluids are anticipated.

Coveralls provide 360-degree protection and are designed to cover the whole body, including back and lower legs and sometimes head and feet as well (CDC, 2017g).

FACE AND EYE PROTECTION

Face and eye protection is used during patient-care activities likely to generate splashes or sprays of blood, body fluids, secretions, or excretions.

Masks protect the nose and mouth and should fully cover them to prevent fluid penetration.

Goggles protect the eyes and should fit over and around them snuggly. 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 (CDC, 2017g).

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

Respirators protect the healthcare worker from inhalation of infectious aerosols, such as tuberculosis. These include:

- **Particulate respirators** (N-95, N-99 or N-100) protect against particles (dust and infectious agents) but not vapor or gas. Most particulate respirators are disposable (single-use) and not designed for repeated or extended use.

- Half- or full-face **elastomeric respirators** (EHFRs) protect against particulates as well as gases and vapors. They are reusable, durable, and maintain fit over time. One EHFR is assigned to each worker.

- **Powered air purifying respirators** (PAPRs) are typically loose-fitting, hooded or helmeted, and use a battery-powered blower to force air through a high-efficiency particulate air (HEPA) filter for the wearer to breathe. They exceed the capability of

an N95 and EHFR in reducing airborne exposures. PAPRs are assigned to individual workers and are reusable and durable (CDC, 2017h).

Respirators require medical evaluation to determine if it is safe for the healthcare worker to wear a respirator and to fit the worker with the appropriate respirator size and type. The healthcare worker must also be trained on how and when to use the respirator. Following training, the healthcare worker is responsible for checking the respirator before use to ensure it has a proper seal (CDC, 2017h).

PPE IN THE OPERATING ROOM

To protect patients undergoing surgical procedures, sterile drapes are used to establish a sterile field and to provide a barrier to minimize passage of pathogens from unsterile to sterile areas.

Surgical gowns are intended to be worn by healthcare personnel during surgical procedures to protect both the patient and personnel from transfer of pathogens, body fluids, and particulate matter. Surgical caps minimize risk of hair falling into the sterile area during surgery.

In the OR, a facemask is worn as a barrier to protect the patient against the transfer of pathogens present in the healthcare professional's saliva, nasal discharge, and facial hair, and to protect the healthcare professional from pathogens present in a patient's pus, blood, and other body fluids, secretions, or excretions (Burlingame et al., 2018).

Putting On and Removing PPE

Specific procedures to be followed when putting on and removing PPE include:

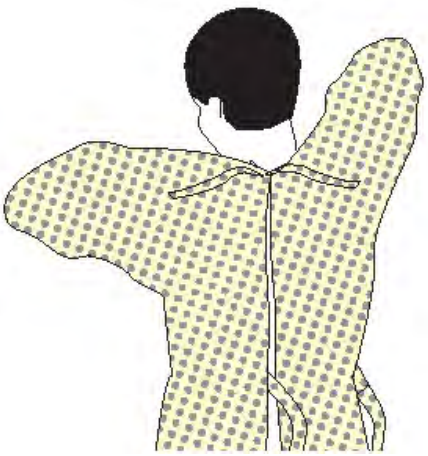
PUTTING ON PPE

PPE should be put on (donned) in the following sequence:

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

How to put on a gown:

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



How to put on a mask:

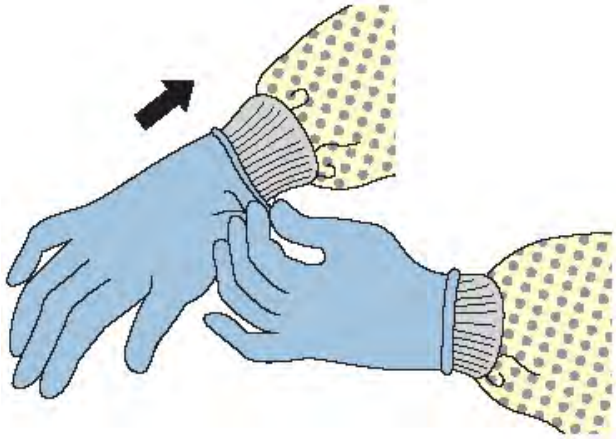
1. Place over nose, mouth and chin.
2. Fit flexible nose piece over bridge of nose.
3. Secure on head with ties or elastic.

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.



Source: CDC, 2016a.

REMOVING PPE

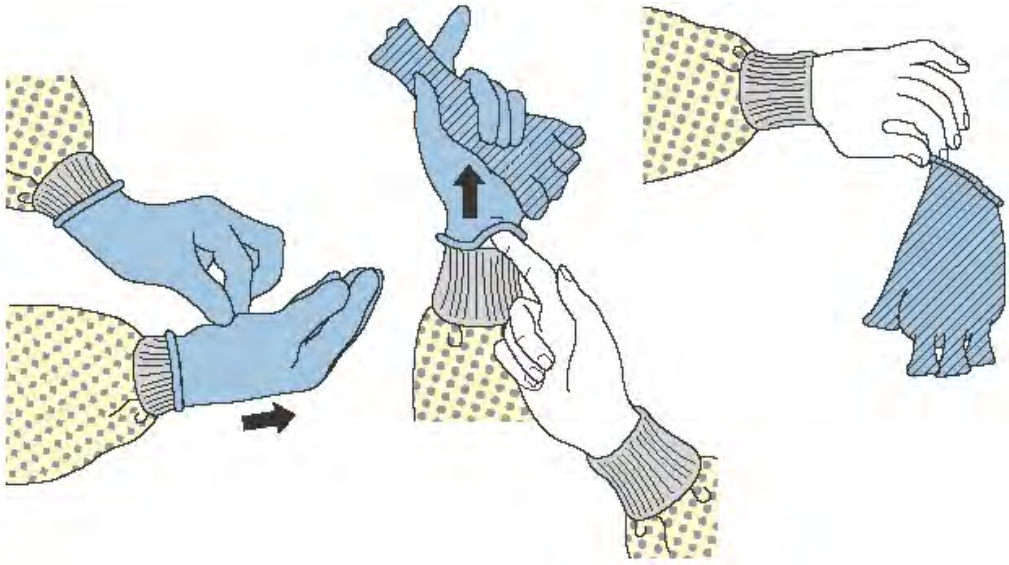
Contaminated PPE should be removed in the following sequence:

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

They should be removed at the doorway before leaving the patient room or in the anteroom. Respirators should be removed outside the room after the door has been closed.

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.

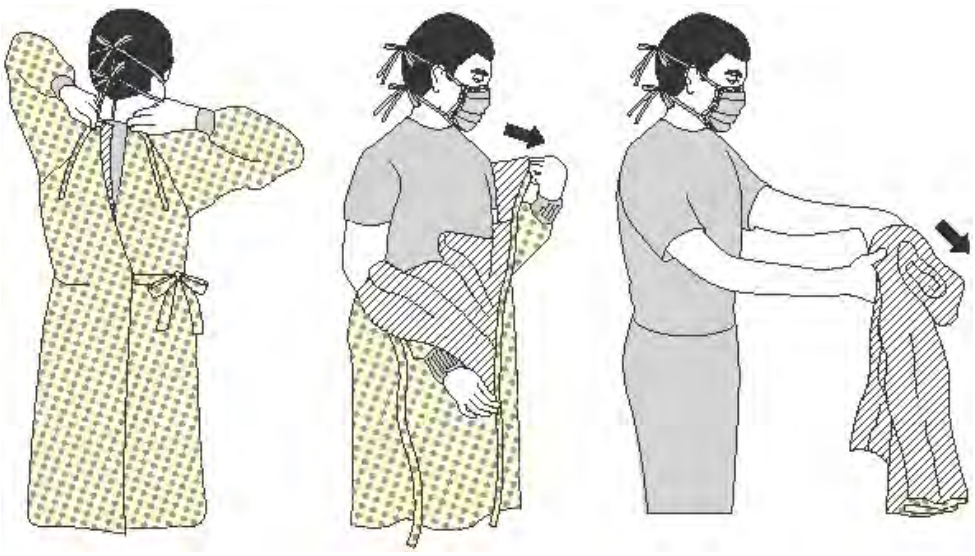


How to remove goggles or face shield:

1. Outside of goggles or face shield are contaminated.
2. Remove from the back by lifting head band or ear pieces.
3. Lift away from face.
4. Place in designated receptacle for reprocessing or disposal.

How to remove gown:

1. Gown front and sleeves are contaminated.
2. Unfasten ties.
3. Pull 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.



How to remove mask or respirator:

1. Front of mask is contaminated; do not touch.
2. Grasp bottom ties or elastics of the mask/respirator, then the ones at the top.
3. Remove without touching the front.
4. Discard.

Source: CDC, 2016a.

ENHANCED PRECAUTIONS AGAINST EBOLA VIRUS TRANSMISSION

The CDC provides guidance for healthcare workers who are caring for a person with confirmed Ebola or persons under investigation for Ebola. This guidance recommends:

1. Healthcare workers caring for patient with Ebola or persons under investigation for Ebola are required to receive comprehensive training and have demonstrated competency in performing Ebola-related infection control practices and procedures.

2. Personal protective equipment that covers the clothing and skin and completely protects mucous membranes is required:

    - A disposable **impermeable gown** extending to at least mid-calf or **coverall**, preferably without a hood. Coveralls with or without integrated socks are acceptable.

    - Disposable **apron** covering the torso to level of mid-calf should be used over the gown or coveralls if the patient is vomiting or has diarrhea. An apron should be used routinely if the facility is using a coverall that has an exposed, unprotected zipper in the front.

    - Disposable **examination gloves** with extended cuffs. Two pairs of gloves should be worn so that a heavily soiled outer glove can be removed and replaced safely during care.

- Disposable **boot covers** that extend to at least mid-calf. Disposable ankle-high **shoe covers** worn over boot covers may also be considered. It is acceptable to use disposable shoe covers if they are used in combination with a coverall with integrated socks.

- An **N-95 respirator** with a disposable surgical hood extending to the shoulders and fully covering the neck. Alternatively, a **PAPR** can be used that includes a full face shield, helmet, or headpiece and disposable hood.

- Full **face shield.**

3. When personnel are providing care to patients with Ebola, they must be supervised by an on-site manager at all times, and a **trained observer must supervise each step** of every PPE donning/doffing procedure to make certain established PPE protocols are completed correctly.

4. Individuals who are unable or unwilling to adhere to infection control and PPE use procedures should not provide care for patients with Ebola.

(CDC, 2017j)

INFECTIOUS DISEASES AND OCCUPATIONAL HEALTH STRATEGIES

Several **standards and directives** are directly applicable to protecting workers against transmission of infectious agents. These include:

- Bloodborne pathogens standard
- Personal protective equipment standard
- Respiratory protection standard
- CDC guidelines

Protecting healthcare workers from disease is accomplished in many ways, including:

- Use of Standard Precautions with all patients, especially hand hygiene
- Use of additional transmission precautions (e.g., Contact, Airborne, Droplet)
- Vaccination (e.g., influenza, hepatitis B)
- Postexposure control plan and prophylaxis
- Environmental hygiene to reduce exposure to pathogens in healthcare settings

If a healthcare worker has been exposed on the job to a communicable disease, the supervisor and infection control practitioner should be notified without delay. This will allow evaluation of the circumstances and prevent exposure of others, management of the exposure, and appropriate medical follow-up as needed. For some diseases, postexposure prophylaxis (preventive medication) is available (see below).

Protection of patients and others from the risk of infections from health professionals includes:

- Vaccination programs
- Evaluation of acute symptoms
- Evaluation of safety to work and reassignment or furlough when unsafe
- Strict adherence to infection control guidelines

Preventing transmission of infection is the responsibility of the facility and the individual HCW.

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 that should be reported and evaluated typically include:

- Fever
- Unusual rash
- Skin infections, such as boils, impetigo, and herpetic whitlow
- Exudative (weeping) dermatitis
- Sore throat with fever
- Gastrointestinal symptoms (vomiting, diarrhea)
- Recent onset of unexplained cough
- Recent onset of congestion suggesting an acute respiratory infection
- Jaundice
- Symptoms suggesting active tuberculosis (chronic productive cough with unexplained weight loss, fever, night sweats, or hemoptysis)

Other occupational health strategies for **preventing transmission** of bloodborne pathogens and other communicable diseases to and from healthcare workers include:

- Pre-employment evaluation to screen for:
    - Tuberculosis
    - Rubella (German measles) immunity
    - Measles immunity
- Annual assessment of staff (including surveillance for TB)
- Annual influenza immunization programs
- Removal from work or modification or limitation of work practices

WORKERS WITH HBV, HCV, HIV INFECTION

The following standards are based on recommendations in the Society for Healthcare Epidemiology of America Guidelines (2014).

Healthcare workers who have or may have HBV, HCV, or HIV should be evaluated for the ability to work safely. This evaluation should be based on the premise that HBV, HCV, or HIV alone is not sufficient justification to limit the worker's professional duties. Case-by-case evaluation should be done to determine whether an individual healthcare worker poses a risk to patients that warrants job modifications, limitations, or restrictions. If a patient is exposed to the blood of a healthcare worker, that patient must be informed of the exposure and appropriate follow-up offered.

Periodic re-evaluation of a healthcare worker infected with HBV, HCV, or HIV may be appropriate if the disease progression alters physical or mental functioning. Other factors that may affect the ability of healthcare workers to provide quality healthcare include:

- Lack of compliance with established infection control guidelines
- Appropriateness of techniques as related to performance of procedures
- Any health condition that would pose a significant risk to others

IMMUNIZATIONS

Vaccinating healthcare workers protects both themselves and patients.

Influenza

Since 1981 the CDC has recommended healthcare workers receive influenza vaccination, and the coverage among healthcare workers during the 2014–15 flu season was 78.7%.

Coverage was highest (85.5%) among healthcare personnel working in settings in which flu vaccination was a requirement for employment (CDC, 2017k).

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 is to have 90% compliance for healthcare workers by 2020.

Many facilities have enacted policies requiring mandatory influenza vaccination for all healthcare workers. There is great controversy, however, over the issue of mandatory vaccination, with strong arguments for differing points of view regarding individual rights versus the right of patients to be protected from disease transmitted by a healthcare worker. The CDC does not issue any requirements or mandates for state agencies, health systems, or healthcare workers regarding infection control practices, including influenza vaccination or the use of masks.

Hepatitis B

Federal OSHA law requires that all employees whose jobs involve participation in tasks or activities with potential exposure to blood/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.

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	All healthcare personnel at risk of exposure to blood and body fluids if they do not have evidence of immunity
Influenza	All healthcare personnel, including volunteers and students
MMR (measles, mumps, and rubella)	All healthcare personnel who do not have documented evidence of immunity; healthcare personnel born in or after 1957 without documentation of 1) receipt of two doses of live vaccine on or after their first birthday, 2) physician-diagnosed measles, or 3) laboratory evidence of immunity; should be considered for all personnel, including those born before 1957, who have no proof of immunity

Varicella (chickenpox)	All healthcare personnel who do not have documented evidence of immunity: 1) documentation of two doses of varicella vaccine given at least 28 days apart, 2) history of chickenpox or shingles based on physician diagnosis, 3) laboratory evidence of immunity, or 4) laboratory confirmation of disease
Tetanus, diphtheria, and pertussis (Td/Tdap)	All healthcare personnel who have not or are unsure if they have received a dose of Tdap (boosters needed every 10 years)
Meningococcal	One dose for those who are routinely exposed to isolates of *N. meningitides*
Source: CDC, 2017l.	

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, adult T-cell leukemia/lymphoma (caused by HTLV-I), HTLV-I-associated myelopathy, diseases associated with HTLV-II, and Ebola (also known as Ebola hemorrhagic fever).

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 do the following:

1. Establish a **written exposure control plan** designed to eliminate or minimize employee exposure to bloodborne pathogens. The employer:

    - 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

    - Shall 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 should 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, the employer is required to test the source's blood as soon as possible, provided the source individual consents.
- If the source individual does not consent, the employer must establish that legally required consent cannot be obtained.
- If state or local law allows testing without the source person's consent the employer must test the individual's blood, if it is available.
- The results of the tests must be made available to the exposed worker and the worker must be informed of the laws and regulations concerning disclosure of the source's identity and infectivity status.
- Employers must 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.
  (CCC, 2017; CDC, 2016c)

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 two 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 (CCC, 2017).

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 the supervisor and follow the 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, 2017e).

CASE

Robert is a nurse who works in the emergency department. He is in the trauma bay when a patient arrives who has been in a car accident. The patient is actively bleeding out from the abdomen. Robert dons a gown, gloves, mask, and goggles as he cares for the patient. During the process of care, Robert applies pressure to the traumatic wound prior to stabilizing the patient. His gown and gloves become covered in blood as he works with the patient.

Later, as he is taking off the gloves, Robert notices that there is a hole in his left-hand glove and that his hands have been exposed to the patient's blood. He also remembers that the day prior, he cut his left hand at home while he was chopping vegetables in his kitchen and forgot to cover the cut prior to starting his shift. The ED is so busy that he goes on with his shift and does not report the exposure.

The next day, the ED supervisor reports that the patient was found to be positive for HIV and asks the team to report any concerns. Robert is now faced with the possibility that he was exposed to HIV-positive blood. He immediately reports the blood exposure incident from the previous day. His supervisor takes all of the information and together they work closely with the infection control nurse to implement testing, postexposure prophylaxis, and surveillance. As Robert starts his medical care, he also receives counseling to understand his risk for developing HIV as a result of the exposure.

The supervisor reinforces to Robert that it was important for him to report the exposure as soon as it happened. The supervisor also debriefs the remainder of the team to do the same any time an exposure occurs. The supervisor stresses the importance of protecting employee health and well-being as well as reviews the reporting requirements of the OSHA Bloodborne Pathogens Standard.

CONCLUSION

During the past four decades, healthcare-associated infections 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 need to 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 2014 Ebola virus outbreak, there is a need to recognize unique situations requiring enhanced infection control precautions.

RESOURCES

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

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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1. Data shows that infections are a major cause of hospitalization and death among individuals in:

a. Outpatient surgical centers.
b. Physical therapy clinics.
c. Outpatient cancer centers.
d. Long-term care facilities.

2. 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. Eradicate communicable disease in all healthcare settings
d. Apply current scientifically accepted practices appropriately to the work environment

3. Which pathogen can survive for extreme lengths of time and is resistant to disinfectant and drying conditions?

a. Bacteria
b. Virus
c. Prion
d. Endospore

4. Which term refers to a person who continues to harbor a pathogen for months or even years after initial infection?

a. Incubatory
b. Colonized
c. Convalescent
d. Asymptomatic

5. Which person is **most likely** to be a source of asymptomatic transmission?

a. Mary, who was meticulous about handwashing while caring for her husband with food poisoning
b. Bill, a father caring for his sick 2-year-old son who does not cover his nose when he sneezes
c. Roberto, whose girlfriend has been too sick with a cold to see him for the past week
d. Lupe, whose mother has an infected foot ulcer that is covered with an occlusive dressing

6. Which mode of transmission in the chain of infection involves a fomite?

a. Airborne

b. Droplet

c. Direct contact

d. Indirect contact

7. What is the single most important infection control procedure to prevent the spread of infection?

a. Hand hygiene

b. Prompt and thorough reporting

c. The use of gloves

d. The isolation of infected patients

8. 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.

9. 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 are implemented.

10. Which is a **correct** statement concerning hand hygiene?

a. Handrub procedure with alcohol hand sanitizer should last 10 seconds.

b. Handwashing is not necessary prior to donning sterile gloves.

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.

11. Before administering an intramuscular injection to a patient with HIV, the nurse takes protection against which potential means of HIV transmission?

a. Touching the patient's skin

b. Receiving a needlestick injury

c. Touching the patient's blood with a gloved hand

d. Forgetting to wear a surgical gown

12. Which action does the CDC recommend regarding Contact Precautions?

a. Wear an N-95 respirator when entering a patient's room to provide direct patient care.

b. Put on a gown and gloves on when entering a patient's room to provide direct patient care.

c. Implement Contact Precautions only for patients with active skin infections.

d. Cohort patients infected with different microorganisms.

13. 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 N-95 respirator

c. The placement of a powered air-purifying respirator on the patient during his or her transport

d. The donning of a surgical face mask when entering the patient's room

14. Which is an example of an engineering control used in the healthcare setting to reduce the spread of infection?

a. A vaccination program for hospital staff

b. A nursing education program about infectious disease

c. A puncture-resistant container for the disposal of sharps

d. Gloves worn to prevent contact with body fluids

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

a. Bags or bottles of intravenous solution can be used for more than one patient.

b. A new sterile syringe and needle are not needed for additional entries into a bag of fluid.

c. A surgical mask is to be worn when injecting material into the spinal canal or subdural space.

d. Single-dose vials that have been opened can be stored for future use.

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

a. An EPA-registered antimicrobial product.

b. Soap and water, with chemical germicides added.

c. Strong detergents applied with protective gloves.

d. A full-strength bleaching agent.

17. Which is a **correct** statement regarding the processing, handling, and storage of sterilized equipment and devices?

a. Evaluate packaging before use for loss of integrity.

b. Shelf life does not depend on transport conditions.

c. Packaging materials do not require FDA clearance.

d. All sterilized items must be labeled with a specific expiration date.

18. 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.

19. Personal protective equipment is specialized clothing or equipment that:

a. Protects healthcare workers against percutaneous sharps injuries.

b. Assists in the safe physical restraining of a patient.

c. Protects a healthcare worker against infectious diseases.

d. Protects patients against infected healthcare workers.

20. Which is a **true** statement about glove use by healthcare workers?

a. The CDC does not recommend the use of gloves with patient contact.

b. Use gloves only when providing care to patients with open wounds.

c. The use of gloves precludes the need for hand hygiene.

d. Never wash or reuse disposable gloves.

21. The use of sterile gowns is indicated:

a. Whenever limited contamination is expected.

b. For any patient care involving body fluids.

d. When practicing isolation precautions.

d. During invasive procedures.

22. Which is a **true** statement regarding PPE guidance when working with patients infected with Ebola virus?

a. PPE donning/doffing must be supervised by a trained observer each time.

b. Respirators are not required.

c. Double gloving is not recommended.

d. PPE guidelines recommend frequent disinfection of gloved hands using an alcohol-based handrub.

23. Which is a recommended occupational health strategy designed to prevent the transmission of infectious disease?

a. Pre-employment screening for tuberculosis

b. Annual screening for drug use

c. Annual chest X-rays for all employees

d. Pre-employment determination of sexual preference and practices

24. The CDC recommends that all healthcare workers receive vaccination against hepatitis B, measles, mumps, rubella, and chickenpox if they:

a. Plan to work in epidemic areas.

b. Do not have laboratory or clinical evidence of immunity.

c. Have been exposed to a family member with any of these infections.

d. Have recently traveled outside the United States.

25. Bloodborne pathogens training for healthcare workers must include:

a. A thorough study of the physiology of pathogens.

b. Protective measures to minimize risk of occupational exposure.

c. A focus on the gastrointestinal tract, with its resident organisms.

d. Vaccination for all identified, vaccine-preventable disease.

26. Which is a **correct** statement about OSHA-required exposure control plans?

a. An employer is not required to make a copy accessible to employees.

b. Employees must be immunized against Hepatitis B.

c. Employers must communicate hazards to employees.

d. Employers must make known to employees any individual responsible for causing an exposure.

27. 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?

a. Reporting the incident to a supervisor before the end of the shift

b. Monitoring himself for any signs or symptoms of infection

c. Arranging for follow-up screening

d. Washing or irrigating his face and eyes

28. When administering an intramuscular injection to a patient, the clinician accidentally incurs a needlestick injury. The clinician's action is to:

a. Seek medical evaluation if the site becomes red, inflamed, or painful.

b. Report the exposure incident immediately to his or her supervisor.

c. Cleanse the injured area using alcohol swabs.

d. Report the injury only if the patient has tested positive for a bloodborne pathogen.