2 INFECTION, ASEPSIS, AND STERILE TECHNIQUE

CORE CONCEPTS

- Discuss microorganisms and their effects in health care.
- Define pathogen.
- Identify the components of the chain of infection.
- Describe the basic procedures of infection control and state why they are used.
- Define asepsis.
- State the single most effective measure in preventing the spread of disease.
- Use proper sterile technique.
- Demonstrate the procedures for patient care hand washing, donning sterile gloves, and removing gloves.

INTRODUCTION

Preventing infection is vital to a health care facility's operation. Practicing techniques of medical and surgical **asepsis** will help protect health care workers and patients from infection. In ancient times, demons and evil spirits were thought to cause pestilence and infection. Hippocrates (460–377 BCE), the great healer of his time, irrigated wounds with wine or boiled water, foreshadowing asepsis. Galen (130–200 CE), a Greek man who practiced medicine in Rome, was the most distinguished physician after Hippocrates. He was also an early pioneer of asepsis because he boiled used surgical instruments after caring for wounded gladiators. In the early to mid-1800s, people such as Louis Pasteur introduced the world of microorganisms. Since that time, humans witnessed the invention of the steam sterilizer (1886), the practice of passive and active immunization, and the use of antibiotics.

MICROORGANISMS

Microorganisms or **microbes** are minute living cells not visible to the human eye. They are so small that they can only be seen with the aid of a microscope (Figure 2-1). The vast number of species that exist are found in many locations, including those in hostile environments previously thought to be incapable of sustaining life. Many species reside in or on humans and other animals. Some species are beneficial, others are harmful, and some are simply present (neither helpful nor harmful). Microorganisms that add the

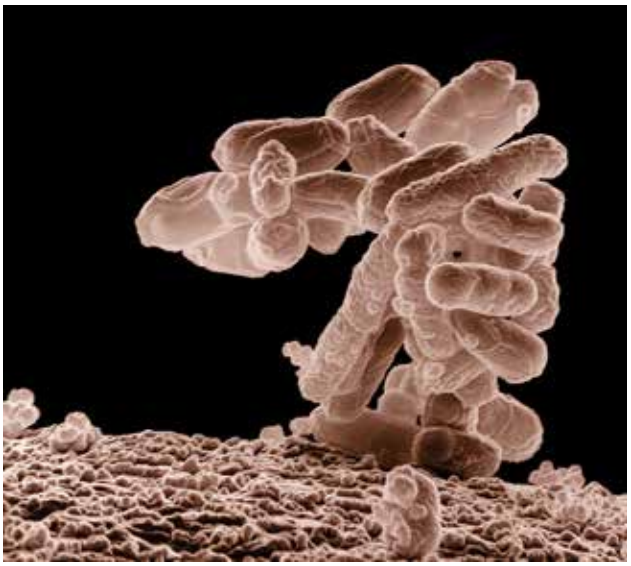


Figure 2-1. Electron micrograph of a cluster of *Escherichia coli* bacteria magnified 10,000 times. Each individual bacterium is oblong shaped. Photomicrograph by Eric Erb. Digital colorization by Christopher Pooley.
Reproduced from US Department of Agriculture, Agricultural Research Service. https://www.ars.usda.gov/oc/images/photos/mar05/k11077-1/

flavor and character to cheeses and yogurt or fermenting beer are considered beneficial. Harmful microorganisms produce disease, such as bacteria that cause Lyme disease.

Most microorganisms do not cause disease under normal conditions; those that do are called **pathogens**. Understanding pathogen physiology, ecology, and disease transmission helped create technology for disease prevention, especially for health care providers caring for potentially infected patients. Many microorganisms have their own metabolism (eg, bacteria take in oxygen, burn food for energy and growth, and excrete waste). They can increase in size, divide, and mutate, as well as react in different ways to environmental changes. Many are able to move on their own and some form protective capsules. These characteristics can all be exploited to prevent disease.

At the beginning of a bacterial infection, pathogens usually invade the body in small numbers. As the bacteria reproduce, they form groups of millions of individual cells, called **colonies**. Certain environmental factors such as oxygen, nutrients, temperature, moisture, **pH**, and light affect the metabolism and growth of microorganisms. Most microorganisms grow at normal body temperature; cold temperatures often slow growth, while high temperatures usually kill most organisms. Steam sterilization and boiling water are two common techniques used to kill pathogenic microorganisms.

Figure 2-2. *Codium fragile,* a type of algae. Photograph by Flyingdream. Reproduced from Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Codiumfragile.jpg

Figure 2-3. Photograph of a patient with ringworm of the toes (tinea pedis), also known as athlete's foot, a fungus. Content provided by CDC/Dr. Lucille K. Georg. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=2939

The following are the different types of microorganisms and their defining characteristics:

- **Algae**—resemble plant cells, are primarily found on sunlit water, and rarely cause human disease **(**Figure 2-2).
- **Fungi**—include yeasts (eg, *Candida albicans*, which causes thrush and vaginitis) and molds (eg, tinea pedis, or "athlete's foot") (Figure 2-3).
- **Protozoa**—single-celled microscopic microorganisms (eg, *Trichomonas vaginalis,* which causes vaginal infection in women and urinary tract infection in males) (Figure 2-4).
- **Bacteria**—single-celled organisms without nuclei. Some bacteria form **spores** that are able to survive extreme conditions of light and drying, as well as exposure to many chemicals. Spore-forming bacteria such as *Bacillus anthracis* (Figure 2-5) are the most difficult to control and destroy. Pathogenic bacteria cause diseases such as gonorrhea, pneumonia, and infectious meningitis. An increasing number of bacteria are resistant to certain antibiotic therapies (eg, methicillin-resistant *Staphylococcus aureus*) (Figure 2-6).
- **Viruses**—biological agents that reproduce inside the cells of living hosts (Figure 2-7). Immunization is the most effective means of preventing viral infections (eg, polio, measles).

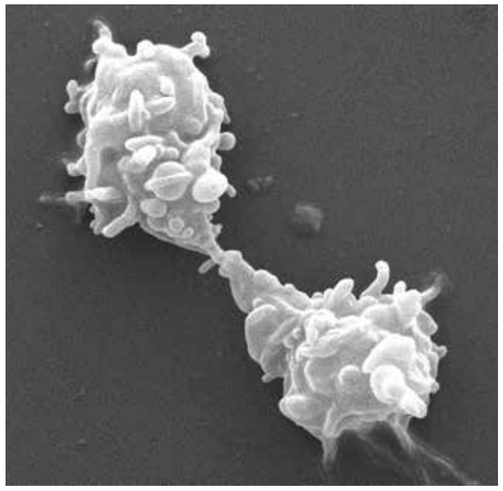


Figure 2-4. Scanning electron micrograph showing two protozoa interacting through their projecting pseudopodia. These pseudopodia enable the amoebae to move about and grasp objects in their environment. Photomicrograph by CDC/Janice Haney Carr. Content provided by CDC/Catherine Armbruster; Margaret Williams. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=11901

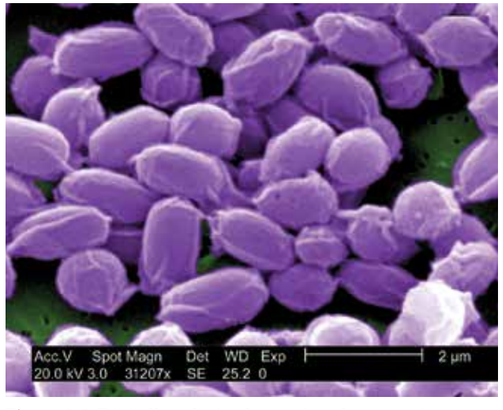


Figure 2-5. Digitally colorized scanning electron microscope image of endospores of *Bacillus anthracis* bacteria. Photomicrograph by Laura Rose. Content provided by CDC/ Janice Haney Carr. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=10123

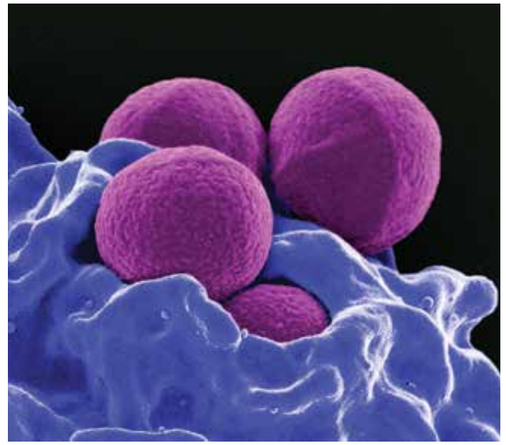


Figure 2-6. Digitally colorized scanning electron microscope image showing four magenta-colored spherical, methicillin-resistant *Staphylococcus aureus* (MRSA) bacteria being phagocytized by a blue-colored white blood cell called a neutrophil. Photomicrograph by the National Institute of Allergy and Infectious Diseases. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=18167

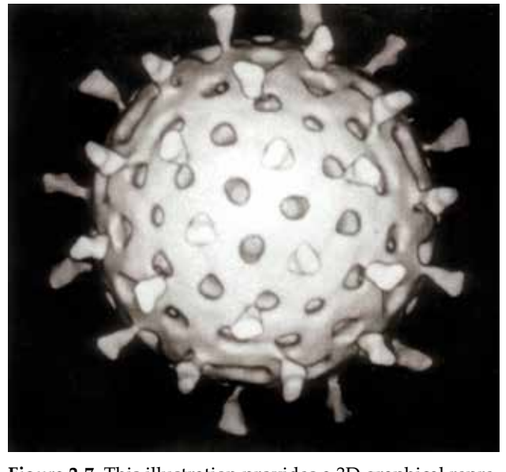


Figure 2-7. This illustration provides a 3D graphical representation of a rotavirus. Note the characteristic wheel-like appearance that gives the rotavirus its name. Rota means "wheel" in Latin. Illustration by Alissa Eckert. Content provided by CDC/Jessica A. Allen. Reproduced from the Centers for Disease Control and Prevention. https://phil.cdc.gov/Details.aspx?pid=21351

Check on Learning

1. What is a pathogen?
2. What type of microorganism is the most difficult to control and destroy?
3. What type of microorganism reproduces inside the cells of living hosts?

SPREADING INFECTIOUS DISEASE

Disease Movement

Infectious diseases can be:

- **Communicable.** Spread from one person to another.
- **Contagious.** Capable of being transmitted from one individual to another.
- **Epidemic.** Occurring above the expected number in a particular geographic area; an outbreak.
- **Zoonotic.** Transmitted from animals to humans.
- **Arthropod borne**. Transmitted to humans from vectors such as ticks and mosquitoes.

Chain of Infection

Scientists and health care workers use knowledge gained from **epidemiology** to help control diseases. For example, the use of **Standard Precautions** by all health care personnel is an important factor in controlling the spread of infection (Figure 2-8). In fact, proper hand washing is the single most useful and effective means of preventing disease transmission.

The chain of infection is another key factor in disease prevention and control, learned through the application of epidemiology. It contains the elements described in Figure 2-9.

A **reservoir** is any living thing or inanimate object in or on which microorganisms can multiply or survive before moving to a susceptible host. Microorganisms can leave an animal or human reservoir through body orifices via natural discharges such as mucus, semen, sputum, saliva, urine, feces, vomit, drainage, or blood. These are called **portals of exit**. Direct contact spreads pathogens from one person to another through touch, kissing, hand shaking, or sexual intercourse. Indirect contact implies that an intermediary object harbors the pathogens and carries them from an infected person to a new victim. Such objects include patient bedding,

Figure 2-8. A combat medic dons gloves prior to performing a Combat Casualty Assessment.

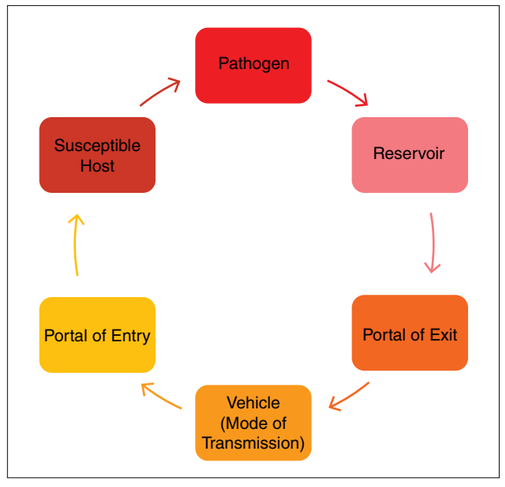


Figure 2-9. The chain of infection.

dressings, used syringes, and drinking cups. A human carrier is someone who does not exhibit the symptoms of a disease but carries the pathogens and transmits them to others. Vectors are animal or arthropod carriers of pathogens. Examples of vectors are rodents, mosquitoes, flies, ticks, and fleas (Figures 2-10 to 2-14). They can spread disease to humans in the following ways:

- directly from feet, wings, bodies, or mouthparts to food that is then consumed (eg, shigellosis, salmonella);

Figure 2-10. This image depicts a black rat, *Rattus rattus*, which is one of the hosts associated with the spread of the "Black Death" plague. Rats infected with the plague virus, *Yersinia pestis*, host fleas, which transmitted the plague from the rats to humans. Content provided by Centers for Disease Control and Prevention. Reproduced from the Centers for Disease Control and Prevention. https://phil.cdc.gov/Details.aspx?pid=14282

Figure 2-11. This female *Aedes albopictus* mosquito is in the process of inserting its needle-like proboscis through the skin surface of its human host. This type of mosquito transmits West Nile virus and Zika virus. Photograph by CDC/James Gathany. Reproduced from the Centers for Disease Control and Prevention. https://phil.cdc.gov/Details.aspx?pid=4487

Figure 2-12. House fly. Photograph by USDA-ARS/Stephen Ausmus. Reproduced from Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Common_house_fly,_Musca_domestica.jpg

Figure 2-13. Adult deer tick. Photograph by USDA, ARS/Scott Bauer. Reproduced from Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Adult_deer_tick(cropped).jpg

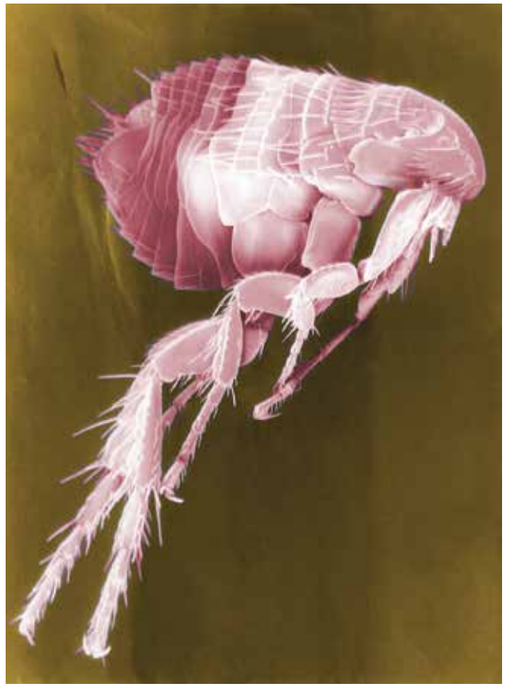


Figure 2-14. Electron micrograph of a flea. Photograph by CDC/Janice Haney Carr. Reproduced from Public Health Image Library. https://phil.cdc.gov/details.aspx?pid=11436

- through bites (eg, leishmaniasis, yellow fever); and
- from exposure to rodent saliva, urine, or feces (eg, leptospirosis, hantavirus).

Microbes and spores can blow from place to place, spreading disease through airborne transmission. For example, sneezing can spread the common cold. Public water, such as pools and lakes, can be contaminated with feces and transmit disease via waterborne transmission. Raw, undercooked, or contaminated food can be responsible for foodborne transmission. Blood-borne disease transmission can occur through contaminated medical devices during transfusions, kidney dialysis (Figure 2-15), and injections. Body orifices both natural and created (eg, by intravenous or urinary catheters) serve as **portals of entry** through which a microorganism can enter a host.

Infection is not inevitable just because a pathogen comes in contact with a host; the host must be susceptible. Healthy people have a variety of nonspecific (skin, fever) and specific (immunity) defenses. More susceptible are people with compromised immune systems such as hospitalized patients, ill or inactive people, those with chronic fatigue or poor nutrition, infants, young children, older adults, those who are injured or have wounds, and those who sustain shock and trauma. Side effects of some medications can also compromise the immune system, as can emotional factors such as anxiety.

Figure 2-15. Patient receiving dialysis. Photograph by Anna Frodesiak. Reproduced from Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Patient_receiving_dialysis_03.jpg

Check on Learning

4. What is the single most useful and effective means of preventing disease transmission?
5. What are the six elements of the chain of infection?

INFECTION CONTROL

Combat medics must know the meanings and infection control implications of a variety of terms. Dirty is a term for any object or person that has not been cleaned or sterilized for removal of microorganisms. A **contaminated** object was clean or sterile before it touched a dirty object. Clean implies that many or most harmful microorganisms have been removed. **Disinfectants** destroy most pathogens, but not necessarily spores. **Sterile** means that the item is free of all microorganisms and spores. Sterilization involves complete removal or destruction of microorganisms and spores in or on an object. For example, sterilization of instruments in an autoclave (a pressure steam sterilizer)

Figure 2-16. A combat medic demonstrates medical asepsis by cleaning the IV site with an alcohol prep pad prior to administering a saline lock.

Figure 2-17. A combat medic applying exam gloves prior to treating simulated casualty.

raises their surface temperature high enough and long enough to kill all microorganisms and spores. Some medical instruments are very sensitive and would be damaged or destroyed if sterilized by standard sterilization methods such as autoclave. These types of heat-sensitive instruments should undergo **high-level disinfection** by being submerged into microbicidal fluids like glutaraldehyde, orthophthalaldehyde, or concentrated hydrogen peroxide. Each high-level disinfectant requires the instrument to be submerged for a specific period of time, such as 20 minutes for 2% glutaraldehyde, in order to achieve a high level of disinfection. High-level disinfection will rid the instruments of small levels of bacteria spores, fungi, mycobacteria, or viruses. **Asepsis** refers to practices that minimize or eliminate organisms that can cause infection and disease.

Medical Asepsis

There are two kinds of asepsis: medical and surgical. Medical asepsis is a clean technique; surgical asepsis is a sterile technique that aims to destroy all microorganisms and is used only in certain situations. Medical asepsis is the practice of minimizing the number of microorganisms or preventing the transmission of microorganisms from one person or source to another (Figure 2-16). Because it is impossible to know which patients are carrying communicable diseases, the Centers for Disease Control and Prevention (CDC) established a set of guidelines to be used in the delivery of all health care encounters. These guidelines require standard precautions in the care of **ALL** patients. A combination of **universal precautions** (designed to reduce transmission of **blood-borne pathogens**) and **body substance isolation** (designed to reduce transmission of pathogens from moist body substances) reduce risk from both known and unknown sources of infection. CDC officials recommend that health care workers handle all blood, body fluids (including secretions, excretions, and drainage), tissues, and contact with mucous membranes and broken skin as if they contain infectious agents, regardless of the patient's diagnosis.

Standard Precautions

Required standard precautions include wearing gloves for any known or anticipated contact with blood, body fluids, tissues, mucous membranes, or non-intact skin (Figure 2-17). If the task or procedure being performed could result in splashing or splattering of blood or body fluids to the face or body, wear a mask, goggles or face shield, and a fluid-resistant gown or apron. Additional protective clothing, such as shoe covers, may be appropriate in situations that may expose health care workers to large amounts of blood or body fluids (or both). Discard gloves after each patient contact. To prevent transfer of pathogens between patients or between patients and the environment, wash your hands and skin surfaces immediately and thoroughly after each patient contact, and after

removing gloves. Do not recap or break needles. Place needles and sharp objects into a special, puncture-resistant "sharps" container after use. When available, use a needleless system or safety syringes. Immediately notify supervisors of any exposure to blood or body fluids. Cover skin breaks and wounds that are draining and change dressings when they are wet. Disinfect tubes and ports before collecting specimens from drainage tubes or intravenous lines. When possible, provide clean, dry, wrinkle-free linen. Remove linen without shaking it or allowing it to touch your clothing. Place contaminated linen into a leak-proof bag. Avoid talking, sneezing, or coughing directly over open wounds or a sterile field. Treat a patient's underlying condition so the patient does not become a susceptible host. Isolate patients with contagious diseases. Patients who have airborne infections may need to wear masks or receive medications that prevent coughing.

Transmission-Based Precautions

Transmission-based precautions are used in addition to standard precautions during treatment of patients with a suspected or known communicable disease. They are based on the disease's route of transmission and are intended to interrupt the chain of infection. The three types are listed below.

Airborne Precautions

Pathogens from evaporated droplets remain suspended in the air or are carried on dust particles and inhaled. Airborne precautions (Figure 2-18) help prevent the spread of diseases such as tuberculosis, measles, and chickenpox. Use a high-filtration particulate respirator such as an N95 mask (Figure 2-19) when caring for tuberculosis patients. They should also have private rooms with monitored negative air flow pressure (with air discharged outdoors or specially filtered before circulating to other areas). Doors to these rooms should remain closed.

Droplet Precautions

Pathogens are propelled through the air from an infected person who is sneezing, coughing, talking, or being suctioned and are deposited on a host's eyes, nose, or mouth. Droplet precautions (Figure 2-20) help prevent the spread of diseases such as meningitis, pneumonia, diphtheria, streptococcal pharyngitis, influenza, mumps, and rubella. Patients with these diseases should have private rooms or share with another patient with the same infection. Doors may remain open. Wear an N95 mask when working within 3 feet of these patients, and require the patients to wear masks if they are transported outside of the room.

Figure 2-18. An airborne precaution sign placed at the doors of infectious patients' hospital rooms.

Figure 2-19. A combat medic demonstrating how to wear an N95 respirator.

Figure 2-20. A droplet precaution sign placed at the doors of infectious patients' hospital rooms.

Figure 2-21. A contact precaution sign placed at the doors of infectious patients' hospital rooms.

Contact Precautions

The most frequent mode of disease transmission occurs when there is direct contact between a susceptible host's body surface and an infected or colonized person (who may or may not exhibit clinical signs or symptoms). Contact precautions (Figure 2-21) help prevent the spread of drug-resistant gastrointestinal, respiratory, skin, and wound infections; hepatitis A; herpes simplex virus; and acute diarrhea. Patients with these illnesses should have private rooms or share with another patient with the same infection. The doors may remain open. Use of noncritical equipment should be restricted to one patient only. If equipment is shared, it must be disinfected before use on other patients. Wear gloves when entering the room and remove them before leaving. Wear a gown if you anticipate contact with infectious matter. Remove the gown before leaving the room and wash your hands with an antimicrobial or waterless antiseptic agent.

Neutropenic Precautions

Unlike other types of precaution procedures, **neutropenic** (protective or **reverse isolation**) precautions guard a patient who is at increased risk for infection against contact with potential pathogens. Patients with weakened immune responses must be protected from the outside environment and from microorganisms that may be carried by others. This level of immunosuppression may occur with burns, bone marrow transplants, human immunodeficiency virus infection, chemotherapy, or low resistance due to other reasons. Health care workers and visitors with communicable diseases must not enter the patient's private room. No fresh fruits and vegetables, gifts, or flowers are allowed. Healthy individuals who enter the room must wear masks and wash their hands before entering.

Surgical Asepsis

Surgical asepsis is a sterile technique used when performing dressing changes, administering **parenteral** (the introduction of substance into the body via a route other than the digestive tract) medications, and during surgery and other invasive procedures such as urinary catheterization. The technique destroys microorganisms on surfaces before they can enter the body and prevents them from being carried to the patient. Sterilized instruments and dressings are used during sterile procedures, and equipment is sterilized or discarded after use. Articles must first be sterilized, then prevented from coming into contact with any unsterile objects. When a sterile article touches an unsterile article, it becomes contaminated and is no longer sterile. Sterile-to-sterile remains sterile, yet sterile-to-clean

Figure 2-22. Surgical asepsis being displayed by a surgical team. Note the sterile field being displayed. Reproduced from Nessen S, Lounsbury D, Hetz S, eds. *War Surgery in Afghanistan and Iraq: A Series of Cases, 2003-2007*. Washington, DC: Department of the Army, Office of the Surgeon General, Borden Institute; 2012: 114.

becomes contaminated (Figure 2-22). Think before you touch anything. Never touch sterile articles with unsterile articles. Discard an article if you contaminate it or are unsure whether it is contaminated. Do not risk using a contaminated article.

Check on Learning

6. What are the three types of transmission-based precautions?
7. What is the most frequent mode of disease transmission?

Patient Care Hand Wash

Correct and thorough hand washing reduces the number of resident and transient microorganisms that are transmitted from hospital environment to patient and from patient to health care provider. Wash hands before and after patient contact and after contact with dirty or contaminated materials (eg, used linens or thermometers). Proper hand washing requires running water (sink and faucets) and hand soap (usually a germicidal agent in a dispenser) in accordance with local standard operating procedure (SOP). When performing a patient care hand wash, warm water is preferable to cold because it reduces chapping skin and removes skin oils, which can retain bacteria.

Patient Care Hand Wash Procedures

1. Stand in front of the sink and avoid leaning against it. Turn on the water and adjust the temperature.
2. Thoroughly wet your hands and forearms under running water, keeping your hands lower than your elbows.

Note: When performing a patient care hand wash, give particular attention to creases and folds in the skin where microorganisms are difficult to dislodge. To reduce areas that are difficult to clean, do not wear rings in any patient care area.

3. Apply soap and wash your hands, wrists, and lower forearms using a circular scrubbing motion. The duration of the patient care hand wash should be a minimum of 10 to 15 seconds and up to 2 minutes (or longer), depending on the potential for contamination with microorganisms.
4. Insert your fingernails from one hand under those of your other hand using a sweeping motion. Repeat with the other hand. Repeat the procedure if your hands are very dirty.
5. Rinse your hands, wrists, and forearms, keeping your hands and wrists lower than your elbows so that water flows from elbows to fingers. Do not touch any part of the contaminated sink or faucets.
6. Finish by drying your hands, wrists, and forearms thoroughly using clean paper towels. Once your hands are dry, turn off the water with the towel used for hand drying. Discard the towel in accordance with local SOP (usually trash container disposal is sufficient) without dropping your hands below waist level.

Check on Learning

8. What is the purpose of the patient care hand wash?
9. When is a patient care hand wash performed?
10. How long should the patient care hand wash last?

Donning and Removing Sterile Gloves

Sterile gloves establish a barrier to microorganisms between health care worker and patient. They maintain a sterile field during hands-on procedures such as the following:

- during invasive procedures (eg, surgery, urinary catheterization),
- when sterility must be maintained (eg, handling sterile instruments while assisting during sterile procedures),
- when changing sterile dressings, and
- when irrigating wounds.

Donning Sterile Gloves

1. Select and obtain the proper size sterile gloves and inspect the glove package for signs of contamination and damage.
2. Perform a patient care hand wash, then open the sterile package.
3. Place the package on a flat, clean, and dry surface in the area where the gloves are to be worn. Peel the outer wrapper open to completely expose the inner package. Remove the inner package, touching only the folded side of the wrapper, and position it so the cuff end is nearest to you. Unfold the inner package by opening it to a fully flat position without touching the gloves. Expose both gloves. Grasp the lower inside corners or designated areas on the folder and pull gently to the side without touching the gloves.
4. Grasp the cuff at the folded edge and remove it from the wrapper with one hand, then step away from the table or tray.
5. Keeping both hands above your waist, insert the fingers of your other hand into the glove and pull the glove on, touching only the exposed inner surface of the glove. If it is difficult fitting your fingers fully into the glove fingers, make adjustments after donning both gloves.
6. When preparing to put on the second glove, first insert the fingertips of the gloved hand under the edge of the folded-over cuff. The gloved thumb may be kept up and away from the cuff area or may be inserted under the edge of the folded-over cuff with your fingertips. Keeping both hands above the waist, insert the fingers of your ungloved hand into the glove.
7. Pull the glove on and adjust the gloves to fit properly. Be careful not to contaminate either glove. Avoid dropping your hands below waist level once your gloves are on; anything below the waist is considered contaminated. Grasp and pick up the glove surfaces on the individual fingers to adjust them. Pick up the palm surfaces and work your fingers and hands into the gloves.
8. Interlock your gloved fingers and work your hands around until the gloves are firmly on your fingers.

Removing Gloves

1. To remove gloves, grasp the glove at the heel of one hand with the other gloved hand and peel the glove off, retaining it in the palm of the gloved hand.
2. Reach under the cuff of the remaining glove with one or two fingers of the ungloved hand and peel the glove off over the glove being held in the palm, being careful not to contaminate yourself.
3. Discard the gloves according to local SOP and perform a patient care hand wash.

Check on Learning

11. Why do we use sterile gloves for patient care?
12. Name four medical care procedures that require the use of sterile gloves.

RESPONSES TO INFECTION

Whether or not a pathogen produces an active infection depends on both the organism and the host. There are four phases of normal infection. First is the incubation period, which begins when the pathogen enters the body and lasts until the first symptoms of illness appear. The second phase is the prodromal stage, which lasts from the onset of initial symptoms, such as fatigue or low-grade fever, to the beginning of more severe symptoms. The third phase is the full stage of illness, when symptoms are acute and specific to the type of infection, such as lesions covering the body or high fever (Figure 2-23). The final phase is convalescence, when acute symptoms of the infection subside and the person recovers.

When dealing with patients who suffer from infection, combat medics should realize that the severity

Figure 2-23. Very sick person from cholera. Note the wrinkling of the fingers indicating severe dehydration. Content provided by Centers for Disease Control and Prevention. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=1939

of infection is determined by several factors. Factors that influence infection are the strength of the body's immune system, the specific **portal** of entry, the number of microorganisms, the pathogen's **virulence**, and host resistance.

A patient who has a weakened immune system will be more susceptible to infection when exposed to microorganisms. An example of a condition that results in a weakened immune system would be a patient who has contracted human immunodeficiency virus (HIV). This virus reduces the number of white blood cells known as T helper or CD4 white blood cells, which results in the body being more susceptible to infection.

Some disease states require that a specific microorganism enter the body through a specific portal of entry. An example of this factor of infection is the *Streptococcus pneumoniae* bacteria. In order for a patient to contract pneumococcal pneumonia, they must be exposed to *Streptococcus pneumoniae* through the respiratory portal of entry.

Another factor that can influence the development of infection in a patient is the number of microorganisms the patient is exposed to. If a patient is exposed to few microorganisms, in most cases the immune system has a better chance of fighting them off and thus preventing infection. However, if a patient is exposed to many microorganisms, the sheer number may overwhelm the patient's immune system.

Virulence is described as the pathogen's strength to cause disease. There are many factors that affect virulence. For example, some bacteria form protective capsules to defend themselves against attack from the human immune system, while other bacteria produce enzymes that destroy blood cells, stop normal blood clotting, damage host cell membranes, or consume muscle fibers. These all may result in an increase in the pathogen's virulence.

Note: Ebola virus disease is caused by one of the most virulent agents to infect humans and it has a very high fatality rate. A related term is pathogenicity, or the ability of a microorganism to cause disease in a susceptible individual. These terms are commonly used interchangeably.

Finally, a host's resistance to pathogens will decrease the chance of infection. An example of host resistance is the natural body flora. Natural body flora have an antibiotic relationship with pathogens that will keep the pathogen in check. If a condition in the body reduces the normal floral bacteria or if the flora is introduced to an area of the body where it doesn't belong, then infection can occur.

Nosocomial infections, also known as **health care-associated infections (HCAI)**, are those that patients acquire while in a health care facility. They are a serious problem for health care facilities, which harbor a number of disease-causing microorganisms, many of which are resistant to antibiotics. Health care facilities house several potential pathogen reservoirs, including intravenous fluids, food, biological materials, and equipment. Nosocomial infections can lengthen a patient's hospital stay, increase the cost of treatment, promote further antibiotic resistance, and even cause death.

Check on Learning

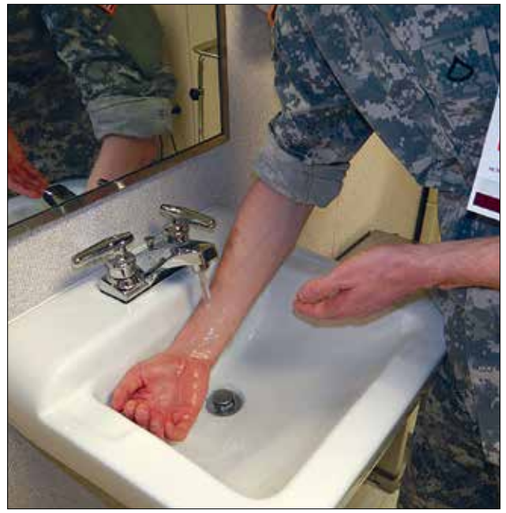
13. What is a nosocomial infection?
14. What is an example of host resistance?
15. What factors increase a pathogen's virulence?
16. What is the normal course of infection?

SUMMARY

Throughout the ages, diseases have resulted in more casualties than actual battle injuries. Understanding the chain of infection will aid you in implementing measures that will result in the reduction of disease, ensuring that the soldier arrives at the battle, ready to fight and win. Through the use of asepsis and sterile technique, medical procedures can be performed with a greatly reduced chance of the casualty developing an infection. Proper asepsis and sterile technique will speed up a casualty's recovery, reduce complications with healing, and return them to the fight.

PATIENT CARE HAND WASHING

STEP 1: Stand in front of the sink and avoid leaning against it. Turn on the water and adjust the temperature.



STEP 2: Thoroughly wet your hands and forearms under running water, keeping your hands lower than your elbows.

STEP 3: Apply soap and wash your hands, wrists, and lower forearms using a circular scrubbing motion for a minimum of 10–15 seconds and up to 2 minutes (or longer).

STEP 4: Insert your fingernails from one hand under those of your other hand using a sweeping motion. Repeat with the other hand.

PATIENT CARE HAND WASHING,CONT.

STEP 5: Rinse your hands, wrists, and forearms, keeping your hands and wrists lower than your elbows so that water flows from the elbows to the fingers.

STEP 6: Finish by drying your hands, wrists, and forearms thoroughly using clean paper towels. Once dry, turn off the water with the towel used for hand drying. Discard the towel in accordance with local SOP (usually trash container disposal is sufficient) without dropping your hands below waist level.

DONNING STERILE GLOVES

STEP 1: Select and obtain the proper size sterile gloves and inspect the glove package for signs of contamination and damage.

STEP 2: Perform a patient care hand wash, then open the sterile package.

STEP 3: Place the package on a flat surface. Peel the outer wrapper open. Remove and unfold the inner package. Grasp the lower inside corners or designated areas and pull gently to the side.

STEP 4: Grasp the cuff at the folded edge and remove it from the wrapper with one hand, then step away from the table or tray.

DONNING STERILE GLOVES,CONT.

STEP 5: Keeping both hands above the waist, insert the fingers of your other hand into the glove and pull the glove on, touching only the exposed inner surface of the glove.

STEP 6: Insert the fingertips of the gloved hand under the edge of the folded-over cuff. Insert the fingers of the un-gloved hand into the glove.

STEP 7: Pull the glove on and adjust to fit properly.

STEP 8: Interlock your gloved fingers and work your hands around until the gloves are firmly on your fingers.

REMOVING GLOVES

STEP 1: Grasp the glove at the heel of one hand with the other gloved hand and peel the glove off, retaining it in the palm of the gloved hand.

STEP 2: Reach under the cuff of the remaining glove with one or two fingers of the ungloved hand and peel the glove off over the glove being held in the palm, being careful not to contaminate yourself.

STEP 3: Discard the gloves according to local standard operating procedure.

KEY TERMS AND ACRONYMS

Arthropod borne. Disease that is transmitted by arthropods (invertebrate phylum Arthropoda), such as mosquitos, ticks, flies, fleas, and lice.
Asepsis. Practices that minimize or eliminate organisms that cause infections or disease.
Bacteria. A one-celled organism without a true nucleus or cell organelles, belonging to the kingdom Procaryotae (Monera).
Blood-borne pathogen. Infectious microorganisms in human blood that can cause disease in humans.
Body substance isolation. Isolation practice that emphasizes avoiding contact with all moist and potentially infectious body substances.
Colony. A growth of microorganisms in a culture; usually considered to have grown from a single organism.
Communicable. Transmitted from one person to another.
Contagious. Capable of being transmitted from one individual to another.
Contaminate. To soil, stain, or pollute.
Disinfectant. A substance that prevents infection by killing bacteria.
Epidemic. Pertaining to a disease affecting an exceptionally high percentage of people in a community or larger area at one time.
Epidemiology. The study of the distribution and determinants of health-related states and events in populations and the application of this study to the control of health problems.
HCAI. Health-care-associated infection.
High-level disinfection. Disinfection with the use of chemical sterilants that will kill all microorganisms except large numbers of bacterial spores.
Microbes. A unicellular or small multicellular organism including bacteria, protozoa, some algae and fungi, viruses, and some worms.
Microorganisms. A living organism too small to be perceived with the naked eye.
MRSA. Methicillin-resistant *Staphylococcus aureus.*
Neutropenia. The presence of an abnormally low number of neutrophils (a type of white blood cells) in the blood.
Neutropenic precautions. Precautions that are taken to prevent infection when a patient has neutropenia.
Nosocomial. Originating in a health care facility; a nosocomial infection.
Parenteral. Situated or occurring outside the digestive tract; introduced or administered other than by way of the digestive tract (eg, central venous catheter).
Pathogen. A disease-producing agent or organism.
Pathogenic. Causing or capable of causing disease.
pH. The symbol for hydrogen ion concentration. Use of the symbol with a number denotes whether a substance is acidic (< 7.0), neutral (7.0), or basic (> 7.0).
Portal. An entryway.
Portal of entry. The pathway by which infectious organisms gain access to the body.
Portal of exit. The pathway by which pathogens leave the body of a host.
Reservoir. A place or cavity for storage.
Reverse isolation. Isolation in which a vulnerable patient is protected from potentially harmful microorganisms in the environment.
Spore. A protective capsule formed by some microorganisms to safeguard them.
Standard precautions. Guidelines recommended by the Centers for Disease Control and Prevention to reduce the risk of the spread of infection in hospitals.
Sterile. Free of living organisms, especially microorganisms.
Transmission-based precautions. Measures suggested by the Centers for Disease Control and Prevention to reduce the risk of airborne, droplet, and direct contact transmission of infection in hospitals.
Universal precautions. Guidelines designed to protect workers with occupational exposure to blood-borne pathogens (such as HIV and hepatitis B).

Vector. Carrier; especially of a disease organism.
Virulence. Ability of a microorganism to cause disease; strength, potency, or severity.
Virus. A pathogen composed of nucleic acid core within a protein shell, which can grow and reproduce only after infecting a host cell.
Zoonotic. An infection that is common in animal populations and occasionally infects humans.

CHECK ON LEARNING ANSWERS

1. What is a pathogen?

   A microorganism that causes disease.

2. What type of microorganism is the most difficult to control and destroy?

   Spore-forming bacteria.

3. What type of microorganism reproduces inside the cells of living hosts?

   Virus.

4. What is the single most useful and effective means of preventing disease transmission?

   Hand washing.

5. What are the six elements of the chain of infection?

   Pathogen, reservoir, portal of exit, vehicle of transmission, portal of entry, susceptible host.

6. What are the three types of transmission-based precautions?

   Airborne, droplet, and contact.

7. What is the most frequent mode of disease transmission?

   Contact (direct).

8. What is the purpose of the patient care hand wash?

   To reduce the number of microorganisms that can be transmitted to a patient.

9. When is a patient care hand wash performed?

   Before and after patient contact and after contact with dirty or contaminated materials.

10. How long should the patient care hand wash last?

    A minimum of 10 seconds to as long as 2 minutes (or even longer). Length depends on the potential for contamination.

11. Why do we use sterile gloves for patient care?

    To establish a barrier against microorganism transfer from person to person.

12. Name four medical care procedures that require the use of sterile gloves.

    - *Invasive procedures—surgery, sterile procedures (urinary catheterization).*
    - *Handling sterile instruments while assisting during sterile procedures.*
    - *Changing sterile dressings.*
    - *Irrigating wounds.*

13. What is a nosocomial infection?

    An infection that is contracted in a health care facility.

14. What is an example of host resistance?

    Naturally occurring body microorganisms that have antibiotic relationships with pathogens and also may contribute to an individual's health.

15. What factors increase a pathogen's virulence?

    Some bacteria form protective capsules that increase their virulence. Other bacteria produce enzymes that destroy blood cells, stop normal blood clotting, damage host cell membranes, or consume muscle fibers.

16. What is the normal course of infection?

    Incubation period, prodromal stage, full stage of illness, and convalescence.

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