Chapter 32

Infection Prevention and Control

Nurses are directly involved in providing a biologically safe environment. Microorganisms exist everywhere in the environment: in air, in water, in soil, and on body surfaces. The skin, intestinal tract, and mucous membranes lining other areas open to the outside (e.g., mouth, upper respiratory tract, vagina, and lower urinary tract) have different types of **normal** or **resident flora** (the collective bacteria in a given area). See Table 32.1 for common resident organisms. Most microorganisms are harmless, and some are even beneficial. An important role of resident flora, for example, is to prevent a potential **pathogen**, a microorganism with the potential to cause disease, from taking up residence. Bacteria on the skin or mucous membranes produce toxic metabolites, or alter local pH, thus repressing the growth of other species. Some microorganisms found in the intestines (e.g., enterobacteria) produce substances that are lethal to related strains of bacteria. Other gut flora produce B vitamins and vitamin K.

OBJECTIVES

After studying this chapter, you should be able to

1. Identify risks for health-care-associated infections
2. Describe the specific and nonspecific body defences against microorganisms
3. Outline the pathophysiology of infection and describe the characteristics of the five major types of microorganisms that can cause an infection
4. Describe the six links in the chain of infection and identify measures that break each link
5. Describe the six routes of transmission of microorganisms
6. Describe factors that place people at risk for developing an infection
7. List indications for hand hygiene and describe cough etiquette
8. Correctly perform aseptic practices, including performing hand hygiene, donning and removing a face mask, gowning, donning and removing disposable gloves (clean versus sterile), bagging articles, and managing equipment used for clients
9. Describe the system of routine practices and additional precautions, and compare these with other systems
10. Identify nursing responsibilities in infection prevention and control
11. Outline relevant nursing diagnoses and contributing factors for clients at risk for infection and those who have an infection
12. Explain the measures to take to prevent or manage a potential exposure to a blood-borne pathogen

TABLE 32.1 Examples of Common Resident Organisms

Body Area	Organisms
Skin	*Coagulase-negative staphylococci* *Propionibacterium acnes* *Staphylococcus aureus* *Corynebacterium xerosis* *Pityrosporum ovale (yeast)*
Nasal passages	*Staphylococcus aureus* Coagulase-negative staphylococci
Oropharynx	*Streptococcus pneumoniae*
Bronchi, lungs	None
Mouth	*Streptococcus mutans* *Lactobacillus* *Bacteroides* *Actinomyces* None
Stomach	None
Esophagus	*Bacteroides*
Intestine	*Fusobacterium* *Eubacterium* *Lactobacillus* *Streptococcus* *Enterobacteriaceae* *Shigella* *Escherichia coli*
Urethral orifice	Coagulase-negative staphylococci
Urethra (lower)	*Proteus*
Bladder, ureters, kidneys	None
Vagina	*Lactobacillus* *Bacteroides* *Clostridium* *Candida albicans*
Blood, lymph system	None

An **infection** is an invasion of body tissue by microorganisms and their subsequent proliferation there, with damage to host tissue. Such a microorganism is called an **infectious agent**. Some infections are caused by normal resident flora when they move to a different part of the body. For example, *Escherichia coli* is a normal inhabitant of the large intestine but a common cause of infection of the urinary tract. Other infections are caused by microorganisms that are acquired from the environment or from another person.

Infectious diseases are a major cause of death worldwide and a leading cause of illness in Canada. The control of the spread of microorganisms and the protection of people from communicable diseases and infections are carried out on international, national, provincial or territorial, community, and individual levels. The World Health Organization (WHO) is the major regulatory agency at the international level. In Canada, the Public Health Agency of Canada (PHAC) is the principal public health agency at the national level, with its Nosocomial and Occupational Infections section concerned with infection prevention and control. At the provincial and territorial level, health departments track epidemics and illnesses as reports are made throughout a particular area. At the local level, hospitals and continuing-care facilities have infection-control practitioners who are responsible for monitoring infection rates and implementing appropriate education, prevention and control strategies, or other programs.

The Community and Hospital Infection Control Association—Canada (CHICA-Canada) has articulated core competencies in infection prevention and control for health-care workers (Henderson and CHICA-Canada Education Committee, 2006). Required knowledge and skills relate to the transmission of microorganisms, hand hygiene, routine practices and additional precautions, personal protective equipment, personal safety, sterilization and disinfection, and critical assessment of risk. Key strategies for the prevention and control of infections involve eliminating microorganisms, reducing transmission of organisms to an individual, and reducing the susceptibility of that individual. **Asepsis** is freedom from disease-causing microorganisms. To decrease the possibility of transferring microorganisms from one place to another, aseptic technique is used in such procedures as dressing changes and insertion of intravenous lines. Handwashing is another method used to reduce transmission of organisms.

Health-Care-Associated Infections

Infections that are associated with the delivery of health-care services in a health-care facility were traditionally called **nosocomial infections**. Nosocomial infections can either develop during a client's stay in a facility or manifest after discharge. Standard definitions are available for different sites of infection (e.g., pneumonia, surgical site infection). The broader term of **health-care-associated infections** is now preferred as it includes infections in all settings, including hospitals, long-term-care or continuing-care facilities, community, home care, health-care professionals' offices, or test centres. Health-care-associated infections are not limited to clients; microorganisms may also be acquired by health-care personnel working in

Evidence-Informed Practice

How Well Do Health-Care Workers Wash Their Hands?

In this study, Raboud and colleagues (2004) assessed the handwashing behaviour of nurses. A research assistant observed seven nurses for one shift each (day or night) on a medical ward in a tertiary care hospital in a large Canadian city, for a total of 379 client visits. In 24% of the visits, the nurse had no direct contact with the clients or their immediate environment; handwashing occurred in 4% of these visits. Eleven percent of the visits involved contact with body fluids; handwashing occurred in 81% of these visits and the nurse wore gloves 86% of the time. Forty percent of the visits involved contact with skin; handwashing occurred after 61% of these visits and the nurse wore gloves 33% of the time. Twenty-four percent of the visits involved contact with environment; handwashing occurred for 38% of these visits and the nurse wore gloves 15% of the time.

The key limitation of the study is the small number of observations over a short time in a single setting. However, these results are consistent with other similar studies.

NURSING IMPLICATIONS: Hand hygiene after higher-risk situations (e.g., exposure to body fluids or skin contact) should be reinforced. More importantly, the role of the environment in transmission and the need for hand hygiene after contact with the client's immediate environment need to be emphasized. Besides education about when and how to perform hand hygiene, work environments need to be structured so as to facilitate hand hygiene (e.g., easy access to sinks or alcohol-based hand rub).

Source: "Patterns of Handwashing Behavior and Visits to Patients on a General Medical Ward of Health-Care Workers," by J. Raboud, R. Saskin, K. Wong, C. Moore, G. Parucha, J. Bennett, K. Green, D. Low, M. Leob, A. Simor, and A. McGeer, 2004, *Infection Control and Hospital Epidemiology, 25*(3), pp. 198–202.

the facility (e.g., hepatitis B infection and HIV infection) and can cause significant illness and time lost from work.

Health-care-associated infections are receiving increasing attention. The most common settings in which health-care-associated infections develop are surgical or medical intensive care units in hospitals. Infections of the urinary tract, surgical site, and lower respiratory tract are the most common types of health-care-associated infections. Although less common, line-associated bacteremias, infections with antibiotic-resistant organisms, and *Clostridium difficile*–associated diarrhea are associated with higher mortality and health-care costs.

The microorganisms that cause health-care-associated infections can originate from an endogenous (internal) source or from an exogenous (external) source. Most health-care-associated infections appear to have endogenous sources, and many factors contribute to health-care-associated infections. A number of infections are the direct result of diagnostic or therapeutic procedures. One example of such an infection is **bacteremia** (bacteria in the bloodstream) that results from contamination of an intravascular line. Not all health-care-associated infections are procedure-related, and not all infections are preventable. A key factor contributing to the development of health-care-associated infections is the *presence of compromised hosts,* that is, clients whose normal defences have been lowered by surgery or illness. The hands of personnel serve as a common vehicle for the spread of microorganisms. *Insufficient handwashing* is thus an important factor contributing to the spread of organisms in health-care settings.

A point prevalence study conducted by the Canadian Nosocomial Infection Surveillance Program (2002) found that 10.5% of hospitalized adults and 9.1% of children had a health-care-associated infection. The cost of health-care-associated infections to the client, the facility, and the funding sources (e.g., insurance companies and federal, provincial and territorial, or local governments) is great. These infections extend hospitalization time, increase clients' time away from work, cause disability and discomfort, and even result in loss of life. See Table 32.2 for common health-care-associated infections.

TABLE 32.2 Health-Care-Associated Infections

Most Common microorganisms	Causes
Urinary Tract	
Escherichia coli	Catheterization technique
Enterococcus species	Contamination of closed drainage system
Pseudomonas aeruginosa	Inadequate hand hygiene
Surgical Sites	
Staphylococcus aureus (including methicillin-resistant strains [MRSA]	Inadequate hand hygiene
Enterococcus species (including vancomycin-resistant strains [VREJ])	Inadequate preparative skin reparation or antibiotic prophylaxis
Pseudomonas aeruginosa	Contaminated water
Bloodstream	
Coagulase-negative staphylococci	Inadequate hand hygiene
Staphylococcus aureus	Improper intravenous fluid, tubing, and site care technique
Enterococcus species	Inadequate hand hygiene, contamination from feces
Hepatitis B	Needle puncture
Pneumonia	
Staphylococcus aureus	Inadequate hand hygiene
Pseudomonas aeruginosa	Improper suctioning technique
Enterobacter species	
Gastrointestrial	
Norovirus	Inadequate hand hygiene

Types of Organisms Causing Infections

Five major categories of microorganisms cause infection in humans: bacteria, viruses, fungi, protozoa, and helminths. **Bacteria**, by far the most common infection-causing microorganisms, are large enough to be seen with a light microscope, can replicate outside of host cells, and are fairly easily grown in a laboratory. Several hundred species can cause disease in humans and can live and be transported through air, water, food, soil, body tissues and fluids, and inanimate objects. Most of the organisms in Table 32.2 are bacteria.

Viruses consist primarily of nucleic acid and lipoproteins and therefore must enter living cells in order to reproduce. They can be seen only with an electron microscope and cannot easily be grown in most hospital laboratories. Common viruses include rhinoviruses (which cause the common cold), influenza, hepatitis, herpes, and human immunodeficiency virus (HIV). **Fungi** include yeasts and moulds. *Candida albicans* is a yeast considered to be normal flora in the human vagina.

Protozoa are single-celled organisms, while **helminths** (worms) are multicelled organisms. Both are classified as **parasites** as they live on other living organisms with benefit only to themselves. Few cause health-care-associated infections, although some, such as the protozoa that cause malaria, present enormous public health challenges.

Bacteria, some fungi, and some protozoa are susceptible to antibiotics, while viruses are not. A limited number of available antiviral drugs are effective for certain viral infections. Other classes of drugs are used to treat infections caused by protozoa and helminths.

Some microorganisms affect only specific tissues, resulting in a predictable clinical picture. For example, rhinoviruses infect the nasopharynx causing signs and symptoms of the common cold, while the hepatitis B virus infects only the liver, resulting in the jaundice of hepatitis. Other microorganisms can infect a variety of tissues. For example, *Staphylococcus* species can cause skin infections, pneumonia, and gastroenteritis. Many different microorganisms can therefore cause a similar disease, such as pneumonia or diarrhea. Health assessment and laboratory testing are necessary to determine the exact infectious agent in any particular case of infection.

Microorganisms also vary in the severity of the diseases they produce and their degree of **communicability**, that is, their ability to be spread from one person to another. For example, the common cold virus is more readily transmitted than the bacillus that causes leprosy (*Mycobacterium leprae*). If the infectious agent can be transmitted to an individual by direct or indirect contact, through a vector or vehicle, or as an airborne infection, as described later in the chapter, the resulting condition is called a **communicable disease**.

Pathogenicity is the ability to produce disease. Many microorganisms that are normally harmless can cause disease under certain circumstances. A *true pathogen* causes disease or infection in a healthy individual. An **opportunistic pathogen** causes disease only in a susceptible individual. Pathogens vary in their **virulence**, that is, their power to overcome the host's defences. Different species have different **virulence factors** or evasion mechanisms, such as proteins that strengthen adherence to target cells, affect motility, or promote resistance to acid, enzymes, or antibiotics. Bacteria that acquire resistance to certain antibiotics frequently become resistant to many classes of antibiotics, reducing treatment options and effectiveness. Some microorganisms, such as the measles virus, have the ability to infect almost all susceptible people after exposure. By contrast, such microorganisms as the tuberculosis bacillus infect a relatively small number of the population who are susceptible and exposed, usually people who are poorly nourished or immunocompromised.

Body Defences against Infection

Individuals normally have defences that protect the body from infection when exposed to an infectious agent. These defences can be categorized as nonspecific and specific. **Nonspecific defences** protect the person against all microorganisms, regardless of prior exposure. The **specific defences** of the immune system, by contrast, are directed against identifiable bacteria, viruses, fungi, or other infectious agents recognized by the host from prior exposure.

Nonspecific Defences

Nonspecific body defences include anatomical and physiological barriers and the inflammatory response.

ANATOMICAL AND PHYSIOLOGICAL BARRIERS

Intact skin and mucous membranes are the body's first line of defence against microorganisms. Unless the skin and mucosa become cracked and broken, they are effective barriers against bacteria. Fungi can live on the skin, but they cannot penetrate it. The dryness of the skin also acts as a deterrent to bacteria, which are most plentiful in moist areas of the body, such as the perineum and axillae. Resident bacteria of the skin also prevent other bacteria from multiplying. They use up the available nourishment, and the end products of their metabolism inhibit other bacteria. Normal secretions make the skin slightly acidic; acidity also inhibits bacterial growth.

The nasal passages have a defensive function. As entering air follows the tortuous route of the passage, it comes in contact with moist mucous membranes and *cilia* (tiny hairs). These trap microorganisms, dust, and

foreign materials. The *lungs* have alveolar **macrophages** (large phagocytes). **Phagocytes** are cells that ingest microorganisms, other cells, and foreign particles.

Each body orifice also has protective mechanisms. The oral cavity regularly sheds mucosal epithelium to rid the mouth of colonizers. The flow of saliva and its partial buffering action help prevent infections. Saliva contains microbial inhibitors, such as lactoferrin, lysozyme, and secretory IgA.

The *eye* is protected from infection by tears, which continually wash microorganisms away and contain inhibiting lysozyme. The gastrointestinal tract also has defences against infection. The high acidity of the stomach normally prevents microbial growth. The resident flora of the large intestine helps prevent the establishment of disease-producing microorganisms. Peristalsis also tends to move microbes out of the body.

The *vagina* also has natural defences against infection. When a girl reaches puberty, lactobacilli ferment sugars in the vaginal secretions, creating a vaginal pH of 3.5 to 4.5. This low pH inhibits the growth of many disease-producing microorganisms. The entrance to the urethra normally harbours many microorganisms. These include coagulase-negative staphylococci (from the skin) and *Escherichia coli* (from feces). It is believed that the urine flow has a flushing and bacteriostatic action that keeps the bacteria from ascending the urethra. An intact mucosal surface also acts as a barrier.

INFLAMMATORY RESPONSE **Inflammation** is a local and nonspecific defensive response of the tissues to injury or infection. It is an adaptive mechanism that destroys or dilutes the injurious agent, prevents further spread of the injury, and promotes the repair of damaged tissue. Five signs characterize inflammation: (1) pain, (2) swelling, (3) redness, (4) heat, and (5) impaired function of the body part, if the injury is severe. Commonly, words with the suffix *-itis* describe an inflammatory process. For example, *appendicitis* means inflammation of the appendix; *gastritis* means inflammation of the stomach lining.

Injurious stressors to body tissues can be categorized as physical agents, chemical agents, and microorganisms. *Physical agents* include mechanical objects causing trauma to tissues, excessive heat or cold, and radiation. *Chemical agents* include external irritants (e.g., strong acids, alkalis, poisons, and irritating gases) and internal irritants (substances manufactured within the body, such as excessive hydrochloric acid in the stomach). *Microorganisms* include the broad groups of bacteria, viruses, fungi, protozoa, and helminths.

The inflammatory response involves a series of dynamic events commonly referred to as the three stages of the inflammatory response:

1. *First stage:* Vascular and cellular responses
2. *Second stage:* Exudate production
3. *Third stage:* Reparative phase

VASCULAR AND CELLULAR RESPONSES At the start of the first stage of inflammation, the damage to tissue cells caused by the infectious agent leads to synthesis of prostaglandins and leukotrienes from the damaged cell membranes, release of serotonin and histamine from platelets and mast cells or basophils, respectively, and activation of bradykinin. These chemical mediators cause constriction of the blood vessels at the site of injury, lasting only a few moments. This initial vasoconstriction is rapidly followed by dilation of small blood vessels, caused by the same chemical mediators. Thus, more blood flows to the injured area. This marked increase in blood supply is referred to as **hyperemia** and is responsible for the characteristic signs of redness and heat as warm blood flows to the surface.

Most of these chemical mediators also cause increased vascular permeability at the injured site. The result of this altered permeability is an outpouring of fluid, proteins, and leukocytes into the interstitial spaces, clinically manifested by the characteristic inflammatory signs of edema (swelling) and pain. The pain is caused by the pressure of accumulating fluid on local nerve endings and by stimulation of pain receptors by the chemical mediators. Too much fluid pouring into such areas as the pleural or pericardial cavity can seriously affect organ function. In other areas, such as joints, mobility is impaired. Chemical mediators will also stimulate mucous production if the site of infection involves a mucous membrane (e.g., infection of the bronchi) or stimulate smooth muscle contraction if the site of infection has smooth muscle. For example, in the lung, smooth muscle contraction leads to bronchospasm, while in the gastrointestinal tract, smooth muscle contraction leads to increased peristalsis and thus diarrhea.

Blood flow slows in the dilated vessels, allowing more **leukocytes** (white blood cells) to arrive at the injured tissues. When the blood flow slows, leukocytes aggregate or line up along this inner surface of the blood vessels. This process is known as **margination**. Leukocytes then move between the cells of the now permeable blood vessel wall into the affected tissue spaces, a process called **emigration.**

The actual passage of blood corpuscles through the blood vessel wall is referred to as **diapedesis**. Leukocytes are attracted to injured cells by **chemotaxis.**

In response to the exit of leukocytes from the blood vessels, the bone marrow produces large numbers of leukocytes and releases them into the bloodstream (**leukocytosis**). A number of **cytokines** (chemical mediators) produced by the leukocytes are responsible for stimulating this increase. An increase in white blood cell count is a sign associated with inflammation. A normal leukocyte count of 4.5×10^9/L to 11×10^9/L of blood can rise to 20×10^9/L or more when extensive inflammation occurs. Cytokines released from the leukocytes or molecules associated with bacterial cell walls also act as **pyrogens**, stimulating the production of fever.

Exudate Production In the second stage of inflammation, the inflammatory **exudate** is produced, consisting of fluid that escaped from the blood vessels, dead phagocytic cells, dead bacteria and dead tissue cells, and the products that they release. Exudate that contains leukocytes is called **pus**; it is frequently yellow because of the colour of the cells as they age. The nature and amount of exudate vary according to the tissue involved and the intensity and duration of the inflammation. The major types of exudate are *serous* (clear, containing serum but no cells), *sanguinous* (containing red blood cells), and *purulent* (containing pus).

Thromboplastin (a product released by injured tissue cells) initiates the coagulation pathway, resulting in a plasma protein called **fibrinogen** being converted to fibrin. Threads of fibrin and platelets together form an interlacing network to make a barrier, wall off the area, and prevent spread of the injurious agent. During the second stage, the injurious agent is destroyed by leukocytes, and the exudate is cleared away by lymphatic drainage.

Reparative Phase The third stage of the inflammatory response involves the repair of injured tissues by regeneration or replacement with fibrous tissue (scar) formation. **Regeneration** is the replacement of destroyed tissue cells by cells that are identical or similar in structure and function. It involves not only replacement of damaged cells one by one but also organization of these cells so that the architectural pattern and function of the tissue are restored. The ability to reproduce cells varies considerably from one type of tissue to another. For example, epithelial tissues of the skin and of the digestive and respiratory tracts have a good regenerative capacity, provided that their underlying support structures are intact. The same holds true for osseous, lymphoid, and bone marrow tissues. Tissues that have little regenerative capacity include nervous, muscular, and elastic tissues.

When regeneration is not possible, repair occurs by *fibrous tissue formation*. **Fibrous (scar) tissue** has the capacity to proliferate under the unusual conditions of ischemia and altered pH. The inflammatory exudate with its interlacing network of fibrin provides the framework for this tissue to develop. Damaged tissues are replaced with the connective tissue elements of collagen, blood capillaries, lymphatics, and other tissue-bound substances. In the early stages of this process, the tissue is called **granulation tissue**. It is a fragile, gelatinous tissue, appearing pink or red because of the many newly formed capillaries. Later in the process, the tissue shrinks (the capillaries are constricted, even obliterated) and the collagen fibres contract so that a firmer fibrous tissue remains. This is called **cicatrix** or scar.

Specific Defences

Specific defences of the body involve the immune system, which responds to foreign proteins in the body (e.g., bacteria or transplanted tissues). In some cases, the immune system even responds to the body's own proteins. Foreign proteins in the body are called **antigens** and are considered invaders. If the proteins originate in a person's own body, the antigen is called an **autoantigen**. Immunity is the specific resistance of the body to infection (pathogens or their toxins). Acquired immunity has two major types: active and passive. See Table 32.3. In **active immunity**, the host produces its own antibodies in response to natural antigens (e.g., infection) or artificial antigens (e.g., vaccines). With **passive immunity**, the host receives antibodies produced by another source, either natural (e.g., from a nursing mother) or artificial (e.g., from an injection of immune serum).

ANTIBODY-MEDIATED DEFENCES Another name for the *antibody-mediated defences* is **humoral (circulating) immunity**. **Antibodies**, also called **immunoglobulins**, are

TABLE 32.3 Types of Acquired Immunity

Type	Antigen or Antibody Source	Duration
1. Active	Antibodies are produced by the body in response to an antigen.	Long
a. Natural	Antibodies are formed in the presence of active infection in the body.	Lifelong
b. Artificial	Antigens (vaccines or toxoids) are administered to stimulate antibody production.	Many years: the immunity must be reinforced by booster inoculations
2. Passive	Antibodies are produced by another source, animal or human.	Short
a. Natural	Antibodies are transferred naturally from an immune mother to her baby through the placenta or in colostrum.	6 months to 1 year
b. Artificial	Immune serum (antibody) from an animal or another human is injected.	2 to 3 weeks

part of the body's plasma proteins. B lymphocytes are activated when they recognize a foreign invader, an antigen. They then differentiate into plasma cells, which secrete antibodies that bind specifically to the foreign antigen. This results in *neutralization* of a virus or toxin so it cannot enter or injure the target host cell, or *opsonization* (coating) of a bacterial cell to make it more attractive to leukocytes. The antigen-antibody complex also activates the complement system, which initiates inflammation and further helps eliminate the foreign invader. The antibody-mediated responses defend primarily against bacterial infection by opsonizing bacteria that are replicating in tissue and against viral infection by neutralizing viruses in the bloodstream before they enter host cells (i.e., in the extracellular phase).

Immunoglobulins (Ig) are divided into five classes, written as follows: IgM, IgG, IgA, IgD, and IgE. IgM, IgG, and IgA act in the protective function just described. They differ in that IgM and IgG are found in the bloodstream, while IgA is generally found in mucous membrane secretions. IgM is produced early and lasts only a short time; IgM to measles virus infection, for example, lasts about 1 month after the infection. The presence of IgM in a laboratory analysis therefore shows current or very recent infection. IgG or IgA are produced later and can last a very long time (years or decades for some infectious agents). On second or subsequent exposure to the same antigen, only IgG or IgA are produced, at a much faster rate than occurs after the initial infection.

IgD has no direct protective function. It acts as an antigen receptor for B lymphocytes. IgE is also not involved in the protective response to infectious agents. It is the key mediator in allergic reactions.

CELL-MEDIATED DEFENCES The **cell-mediated defences**, or **cellular immunity**, occur through the T-cell system. On exposure to an antigen, the lymphoid tissues release large numbers of activated T cells into the lymph system. These T cells pass into the general circulation. T cells come in three main groups: (1) *helper T cells*, which help in the activation of both B cells and cytotoxic T cells; (2) *cytotoxic T cells*, which attack and kill microorganisms and sometimes the body's own cells; and (3) *suppressor T cells*, which can suppress the functions of the helper T cells and the cytotoxic T cells. The cytotoxic T cells act against their specific antigen, which may be a part of a bacterial cell wall or an altered host cell (e.g., virus-infected host cell). Prostaglandins are synthesized from the cell membrane damaged by the cytotoxic T cells, initiating inflammation. The cytotoxic T-cell mediated response defends against bacterial infections and against the intracellular phases of viral infections. When cell-mediated immunity is lost, as occurs with HIV infection, an individual is defenceless against most viral, bacterial, and fungal infections.

Pathophysiology of Infection

When an infection occurs, the infectious agent enters the host body, moves to its preferred target site, and overcomes the host defences. It will encounter defences at the site of entry as well as when moving to its target site (e.g., moving in the bloodstream to the liver in the case of hepatitis B virus). At the site of infection, the infectious agent multiplies, causing physical damage to the host cells. Bacteria replicate outside host cells within the tissue, taking up space and putting physical pressure on host cells, thereby damaging them. Some bacteria also produce a toxin that gets absorbed into the bloodstream and moves to other cells, damaging them. Viruses enter host cells and take over their protein-synthesizing machinery (ribosomes) so that the host cell then produces **virions** (new virus particles). The virions exit the host cell through *exocytosis* (budding from the cell membrane) or by causing *lysis* (destruction) of the host cell. The virions move into neighbouring cells to infect them, repeating the cycle.

Damage to the host cell initiates the inflammatory response, while recognition of the infectious agent by the immune system leads to antibody-mediated or cytotoxic T-cell-mediated immune responses, both of which ultimately also promote inflammation. The white blood cells called in by the inflammatory and immune responses destroy the infectious agents and initiate phagocytosis and repair of the damaged tissue.

Clinical manifestations of infection result from both altered function of the damaged tissue and from the inflammatory response that is initiated in defence. Classic signs and symptoms of infection related to inflammation are redness and swelling at the site of infection, local pain, presence of purulent exudate, fever, and elevated leukocyte count. The clinical manifestations associated with altered tissue function depend on the tissue involved. For example, mucous production and edema of the airways with pneumonia lead to altered gas exchange and thus hypoxia, while with hepatitis, the damage that occurs to the ability of liver cells to conjugate bilirubin leads to the accumulation of bilirubin and results in jaundice.

The Clinical Spectrum of Infection

Colonization is the process by which strains of microorganisms become resident flora. In this state, the

microorganisms may grow and multiply but do not cause physiological changes in host tissue. The presence of colonizing bacteria does not mean the person has an infection. Infection occurs when newly introduced or resident microorganisms succeed in invading a part of the body in which the host's defence mechanisms are ineffective and the pathogen causes tissue damage. If tissue damage is localized to a few cells or a small part of the tissue, then changes may not be noticeable unless they are looked for specifically with relevant types of testing. When this occurs and there is no clinical evidence of disease, the infection is called *asymptomatic* or *subclinical*. Some subclinical infections can cause significant damage, however. For example, cytomegalovirus infection in a pregnant woman can lead to significant disease in the unborn child. When a detectable alteration in normal tissue function occurs, the infection is called *overt* and presents as disease.

Infections can be local or systemic. A **local infection** is limited to the specific part of the body in which the microorganisms remain. If the microorganisms spread and damage different parts of the body, it is a **systemic infection**. When a culture of the person's blood reveals microorganisms, the condition is called *bacteremia*. When bacteremia results in systemic infection, it is referred to as **septicemia.**

Infections are also acute or chronic. Acute infections generally appear suddenly or last a short time. A chronic infection may occur slowly, over a very long period, and can last months or years.

A **carrier** is a person or an animal that harbours a specific infectious agent and serves as a potential source of infection yet does not manifest any clinical signs of disease. The carrier state can also exist in the incubation period, convalescence, and post-convalescence of an individual with a clinically recognizable disease. This type of carrier is referred to as an *incubatory* or *convalescent carrier*. Under either circumstance, the carrier state can be of short duration (*temporary* or *transient carrier*) or long duration (*chronic carrier*).

Infection: An Imbalance between Microorganisms and Defences

Given the defence mechanisms available, it should be clear that the very presence of a microorganism entering the body is not enough to determine that an infection will occur. For an infection to occur, the microorganisms have to overcome the defences. This defeat can occur in the following cases:

- The microorganisms are highly virulent (even if present in small numbers) and so are able to overcome normal defence mechanisms.
- The **microbial load** (number of infectious agents present) is greater than the number that the available defence mechanisms can handle quickly, so the microorganisms are able to proliferate.
- Defence mechanisms are reduced or compromised, and thus host resistance is low, so that the host cannot overcome a microbial load that he or she would be expected to normally be able to handle.

Reducing the risk of infection therefore involves ensuring that defences are greater than the microorganisms' ability to overcome them. This goal can be accomplished by either reducing microbial load or strengthening host resistance. Both can be accomplished in clinical practice, while it is not possible to directly affect virulence.

The chain of infection is an important framework for understanding how microorganisms enter a host or move from one to another. Breaking any link in the chain is the key to infection prevention and control.

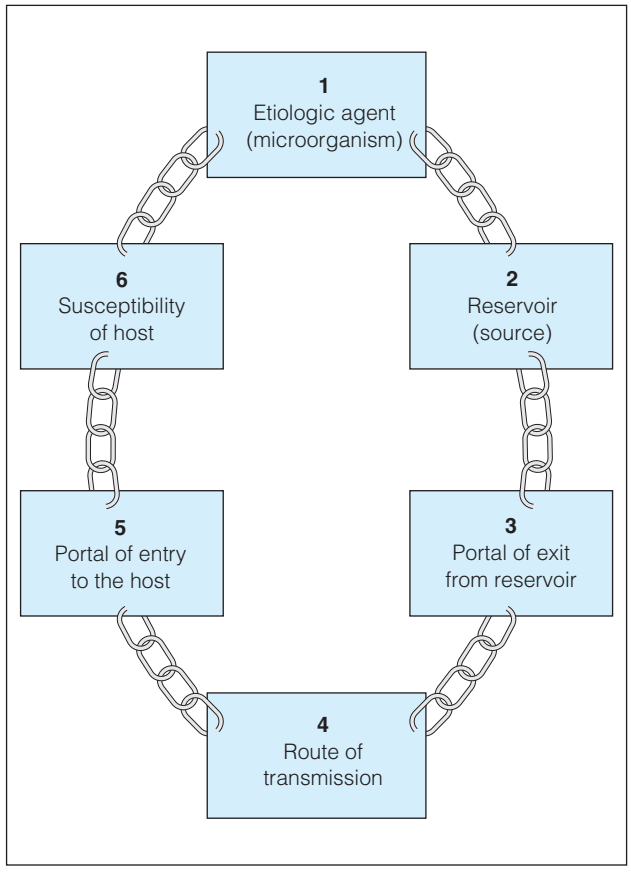


FIGURE 32.1 The chain of infection

The Chain of Infection

Six links make up the chain of infection (Figure 32.1): (1) the etiological agent or microorganism, (2) the place in which the organism naturally resides (reservoir), (3) a portal of exit from the reservoir, (4) a route (mode) of transmission, (5) a portal of entry into a host, and (6) the susceptibility of the host.

Etiological Agent

The extent to which any microorganism is capable of producing an infectious process depends on the number of organisms present, the virulence and pathogenicity of the organisms, the ability of the organisms to enter the body, the susceptibility of the host, and the ability of the organisms to live in the host's body. The presence of an infectious agent is a necessary condition for an infection to occur, but alone, the mere presence of an infectious agent is insufficient to ensure that an infection will develop.

Reservoir

Many **reservoirs**, or sources of microorganisms, exist. Common sources are other humans, the client's own microorganisms, plants, animals, or the general environment. People are the most common source of infection for others and for themselves. For example, the person with an influenza virus frequently spreads it to others. When resistance is lowered by fatigue and other factors, an infection may develop.

Insects, birds, and other animals are common reservoirs of infection. For example, the *Anopheles* mosquito carries the malaria parasite. Food, water, milk, and feces also can be reservoirs. In hospitals, urinary catheters, wound dressings contaminated with purulent exudates, oxygen humidity canisters, and contaminated bedside surfaces are all examples of reservoirs.

Portal of Exit from Reservoir

Before an infection can establish itself in a host, the microorganisms must leave the reservoir. Common human reservoirs and their associated portals of exit are summarized in Table 32.4.

Route of Transmission

After a microorganism leaves its source or reservoir, it requires a route of transmission to reach another person or host through a *receptive portal of entry*. There are six possible routes: (1) direct contact, (2) indirect contact,

TABLE 32.4 Human Reservoirs, Common Infectious Microorganisms, and Portals of Exit

Body Area (Source)	Common Infectious Organisms	Portals of Exit
Respiratory tract	Parainfluenza virus *Mycobacterium tuberculosis* *Staphylococcus aureus*	Nose or mouth through sneezing, coughing, breathing, or talking; endotracheal tubes or tracheostomies
Gastrointestinal tract	Hepatitis A virus *Salmonella* species	Mouth: saliva, vomitus; anus: feces; ostomies; drainage tubes (e.g., nasogastric or T-tubes)
Urinary tract	*Escherichia coli* enterococci Enterococci *Pseudomonas aeruginosa*	Urethral meatus and urinary diversion ostomies
Reproductive tract (including genitals)	*Neisseria gonorrhoeae* *Treponema pallidum* Herpes simplex virus type 2 Hepatitis B virus	Vagina: vaginal discharge; urinary meatus: semen, urine; urethral discharge; contaminated urine
Blood	Hepatitis B virus Human immunodeficiency virus (HIV) *Staphylococcus aureus* Coagulase-negative staphylococci	Open wound, needle puncture site, any disruption of intact skin or mucous membrane surfaces
Tissue	*Staphylococcus aureus* *Escherichia coli* *Proteus* species Beta-hemolytic *streptococcus* group A or B	Drainage from cut or wound

(3) droplet transmission, (4) airborne transmission, (5) vehicle-borne transmission, and (6) vector-borne transmission.

DIRECT CONTACT TRANSMISSION **Direct contact transmission** involves immediate and direct transfer of microorganisms from person to person through touching, biting, kissing, or sexual intercourse, that is, body surface to body surface.

INDIRECT CONTACT TRANSMISSION **Indirect contact transmission** involves passive transfer from the reservoir to an intermediate inanimate object in the recipient's immediate environment and then to the recipient (e.g., hands touch a contaminated doorknob, pick up microorganisms, and transfer them to the recipient's mucous membrane). The length of time that the microorganism remains infectious on inanimate surfaces depends on the microorganism and the relative humidity and temperature of the environment.

DROPLET TRANSMISSION **Droplet transmission** is also a form of direct contact but is usually considered separately as it requires different interventions. Droplets are large droplets of respiratory secretions, larger than 5 microns in diameter. They are generated from sneezing (see Figure 32.2), coughing, spitting, singing, talking, or procedures, such as suctioning. Droplets can be projected a short distance but do not remain suspended in air for long. The larger the particle, the faster it falls. About 85% of the droplets generated by an average sneeze or closed-mouth cough, and 92% of those generated by an open-mouth cough, are larger than 20 microns and will take less than 4 minutes to fall 3 metres (Evans, 2000). If the source and the recipient are within this distance of each other, the droplet spray can be deposited into the conjunctiva or onto the mucous membranes of the eye, nose, or mouth of the recipient. This route transmits the majority of agents causing respiratory infections. Droplets also contaminate the local environment, contributing to indirect contact transmission.

AIRBORNE TRANSMISSION **Airborne transmission** can involve droplet nuclei, which have an average size of less than 5 microns, or dust. **Droplet nuclei**, the residue of evaporated droplets emitted from an infected host, such as someone with tuberculosis, can remain in the air for long periods. Dust particles containing an infectious agent (e.g., varicella virus) can also become airborne. The material is transmitted by air currents to a suitable portal of entry, usually the respiratory tract, of another person. The droplet nuclei are inhaled into the lower respiratory tract and are also deposited on the person's mucous membranes. Very few infectious agents are spread by airborne transmission: tuberculosis, varicella, measles, and smallpox.

VEHICLE-BORNE TRANSMISSION In **vehicle-borne transmission**, a *vehicle* is any substance that serves as an intermediate means to transport and introduce an infectious agent into a susceptible host through a suitable portal of entry. *Fomites* (inanimate materials or objects), such as handkerchiefs, toys, soiled clothes, cooking or eating utensils, and surgical instruments or dressings, can act as vehicles. Water, food, milk, blood, serum, and plasma are other vehicles. For example, a food handler who carries the hepatitis A virus may contaminate food or water with fecal particles. A susceptible host then ingests the food. This is called the **fecal-oral route** of transmission, with the contaminated food acting as the vehicle.

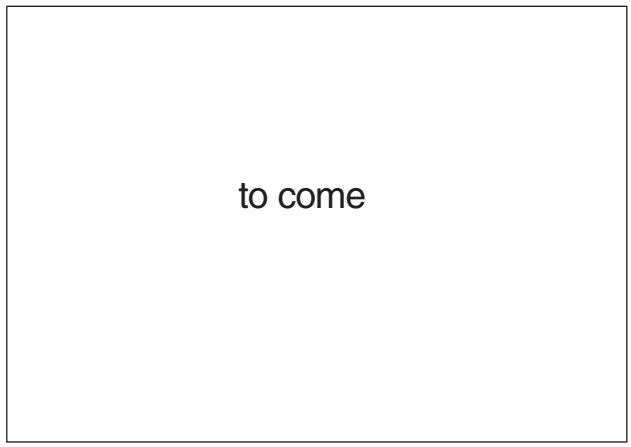


FIGURE 32.2 Droplet dispersion from a sneeze

VECTOR-BORNE TRANSMISSION A *vector* is an animal or insect that serves as an intermediate means of transporting the infectious agent. **Vector-borne transmission** can occur when salivary fluid is injected during biting or when feces or other materials are deposited on the skin through the bite wound or a traumatized skin area.

Portal of Entry to the Host

Before a person can become infected, microorganisms must enter the body. The skin is a barrier to infectious agents; however, any break in the skin can readily serve as a portal of entry. Other examples of portals of entry are the mucous membranes of the eyes, the respiratory tract, the gastrointestinal tract, or the bloodstream (e.g., with intravenous administration). Often, microorganisms enter the body of the host by the same route they used to leave the source.

Susceptibility of the Host

A **susceptible host** is any person who is at risk for infection. **Compromised hosts** are persons at increased risk, individuals who, for one or more reasons, are more likely than others to develop an infection. Impairment of the body's natural defences and a number of other factors can affect susceptibility to infection.

FACTORS INCREASING SUSCEPTIBILITY TO INFECTION Whether a microorganism causes an infection depends on a number of factors previously mentioned. One of the most important factors is host susceptibility, which is affected by age, immune status, heredity, level of stress, nutritional status, current medical therapy, obesity, smoking, existing disease processes, and some past or recent surgical interventions.

Age influences the risk of infection (see the Lifespan Considerations box). Newborns and older adults have reduced defences against infection. Infections are a major cause of death among newborns, who have immature immune systems and are protected only for the first 2 or 3 months by immunoglobulins passively received from the mother. Between 1 and 3 months of age, infants begin to synthesize their own immunoglobulins. Immunizations against diphtheria, tetanus, pertussis, and polio are usually started at 2 months, when the infant's immune system can respond. Immunizations are discussed later in the chapter.

Lifespan Considerations

Infections

CHILDREN

Infections are an expected part of childhood, with most children experiencing some kind of infection from time to time. The majority of these infections are caused by viruses and, for the most part, are transient, relatively benign, and overcome by the body's natural defences and supportive care. In some cases, severe, even life-threatening, infections occur. Considerations related to children include the following:

- Newborns may not be able to respond to infections because of an underdeveloped immune system. As a result, in the first few months of life, infections may not be associated with typical signs and symptoms (e.g., an infant with an infection may not have a fever).
- Newborns have some naturally acquired immunity transferred from the mother across the placenta.
- Breast-fed infants enjoy higher levels of immunity against infections than formula-fed infants do.
- Fevers lower than 39°C in children should not be treated, except for comfort of the child.
- Children between 6 months and 5 years are at higher risk for febrile (fever-induced) seizures. Febrile seizures are not associated with neurological seizure disorders (e.g., epilepsy).
- Children who are immune compromised (e.g., leukemia, HIV) or have a chronic health condition (e.g., cystic fibrosis, sickle-cell anemia, congenital heart disease) need extra precautions to prevent exposure to infectious agents.
- Hand hygiene, comprehensive immunizations, good nutrition, adequate hydration, and appropriate rest are essential to preventing and treating infections in children.
- Handwashing and good hygiene in daycare and schools are important to prevent the spread of infections
- Adolescents are at high risk for sexually transmitted infections and should be well educated about how to prevent infections.

OLDER ADULTS

Normal aging may predispose older adults to increased risk of infection and delayed healing. Anatomical and physiological agents that are protective when a person is younger often change in structure and function with increasing age, and the protective ability of those agents decreases. Changes take place in the skin, respiratory tract, gastrointestinal system, kidneys, and immune system. If unchallenged, these systems work well to maintain homeostasis for the individual, but if compromised by stress, illness, infections, treatments, or surgeries, they often cannot keep up and therefore are not able to provide adequate protection. Special considerations for older adults are as follows:

- Nutrition can be poor in older adults and certain components, especially adequate protein, are necessary to build up and maintain the immune system.
- Diabetes mellitus, which occurs more frequently in older adults, increases the risk of infection and delayed healing by causing an alteration in nutrition and impaired peripheral circulation, which decrease the oxygen transport to the tissues.
- The immune system reacts slowly to the introduction of antigens, allowing the antigen to reproduce itself several times before it is recognized by the immune system. T-cell effectiveness is often decreased because of immaturity.
- The normal inflammatory response is delayed. This delay often causes atypical responses to infections with unusual presentations. Instead of displaying redness, swelling, and fever usually associated with infections, atypical symptoms, such as confusion and disorientation, agitation, incontinence, falls, lethargy, and general fatigue, are often seen first.

Recognizing these changes in older adults is important in early detection and treatment of infections and to avoid delayed healing. The following nursing interventions promote prevention:

- Provide and teach ways to improve nutritional status.
- Use strict aseptic technique to decrease chance of infections (especially health-care-associated infections in health-care facilities).
- Encourage older adults to have regular immunizations for influenza and pneumonia.
- Be alert to subtle atypical signs of infection and act quickly to diagnose and treat.

With advancing age, the immune responses again weaken. Although much is still to be learned about aging, it is known that immunity to infection decreases with age. Because of the prevalence of influenza and pneumonia and their potential for causing death, the National Advisory Committee on Immunization (2007a) recommends annual immunization against influenza for older adults, for the very young, and for persons with chronic cardiac, respiratory, metabolic, and renal diseases, and those capable of transmitting influenza to these individuals.

Immune status is an important factor for host susceptibility or resistance to a specific infectious agent. The presence of antibodies from prior exposure, either by natural infection or vaccination, will act to destroy the infectious agent when encountered again before it can lead to infection. **Immunization** or **vaccination** is therefore an important strategy for decreasing host susceptibility, although not all infections are vaccine preventable.

Heredity influences the development of infection in that some people have a genetic susceptibility to certain infections. For example, some may be deficient in serum immunoglobulins, which play a significant role in the internal defence mechanism of the body.

The nature, number, and duration of physical and emotional *stressors* can influence susceptibility to infection. Stressors elevate blood cortisol. Prolonged elevation of blood cortisol decreases inflammatory and immune responses, depletes energy stores, leads to a state of exhaustion, and decreases resistance to infection. For example, a person recovering from a major operation or injury is more likely to develop an infection than is a healthy person.

Resistance to infection depends on adequate *nutritional status.* Because antibodies are proteins, the ability to synthesize antibodies can be impaired by inadequate nutrition, especially when protein reserves are depleted (e.g., as a result of injury, surgery, or debilitating diseases, such as cancer).

Some *medical therapies* predispose a person to infection. Radiation treatments for cancer destroy not only cancerous cells but also some normal cells, thereby damaging normal defences or barriers. Some *diagnostic procedures* can also predispose the client to an infection, especially when the skin is broken or sterile body cavities are penetrated during the procedure. Certain *medications* also increase susceptibility to infection. Antineoplastic (anticancer) medications can depress bone marrow function, resulting in inadequate production of white blood cells necessary to combat infections. Anti-inflammatory medications, such as corticosteroids, inhibit the inflammatory response that is an essential defence against infection. Even some antibiotics that are used to treat infections can have adverse effects. Antibiotics may kill resident flora, allowing the proliferation of strains that would not grow and multiply in the body under normal conditions. *Clostridium difficile* infection, for example, is associated with antibiotic use. Certain antibiotics can also induce antibiotic resistance in some strains of organisms, making such infections difficult to treat.

Obesity contributes to infection because it is associated with decreased blood flow to skin and underlying tissue. Delivery of oxygen, nutrients, and leukocytes is therefore compromised, interfering with both rapid elimination of infectious agents and tissue repair.

Smoking increases susceptibility to infection by damaging respiratory defences and by impairing tissue oxygenation. Oxygen is important to tissue maintenance and repair, and to the energy production required for the inflammatory and immune responses. Any situation that leads to tissue hypoxia, such as smoking, compromised blood flow, or *anemia,* will increase susceptibility to infection.

Any *disease* that lessens the body's defences against infection places the client at risk. Examples are chronic pulmonary disease, which impairs ciliary action and weakens the mucous barrier; peripheral vascular disease, which restricts blood flow; burns, which impair skin integrity; chronic or debilitating diseases, which deplete protein reserves; and such immune system diseases as leukemia and aplastic anemia, which alter the production of white blood cells. *Diabetes mellitus* is a major underlying disease predisposing clients to infection for a number of reasons. For example, glycosylation of hemoglobin and other proteins impairs oxygenation of tissues and disrupts leukocyte function (critical to phagocytosis). Increased serum glucose levels also provide a source of energy that will support bacterial growth.

Previous surgery at the same site can increase risk of infection because scar tissue has reduced blood supply, interfering with delivery of leukocytes, oxygen, and nutrients.

Breaking the Chain: Prevention and Control of Health-Care-Associated Infections

The key to the prevention and control of infection is breaking one of the links in the chain of infection. Doing so can either prevent a new infection from occurring or realign an imbalance between the numbers of microorganisms and the host defence mechanisms to promote more rapid recovery from an existing infection. Many health-care-associated infections can be disrupted by (1) eliminating microorganisms and their reservoirs; (2) reducing transmission through the use of proper hand

hygiene, the use of personal protective equipment to protect portals of entry, and the use of aseptic and sterile technique when warranted; and (3) supporting host defences or reducing susceptibility. Identification of clients at risk and implementation of appropriate strategies are essential aspects of infection prevention and control. Tables 32.5 and 32.6 summarize nursing interventions that break the chain of infection.

Elimination of Microorganisms and Reservoirs

The first links in the chain, the etiological agent (i.e., microorganism) and the reservoir, are interrupted by a variety of strategies. Some reservoirs can be physically eliminated or reduced, for example, through removal and proper disposal of contaminated dressings, frequent emptying of catheter bags, or replacement of contaminated oxygen equipment. Other reservoirs can be affected through decontamination or antimicrobial agents.

DECONTAMINATION Decontamination has three levels: cleaning, disinfecting, and sterilizing. These are important for reducing infections caused by exogenous flora from the environment or transmitted through equipment or other materials. Items usually should be cleaned before being disinfected or sterilized. Items intended for single-use should be discarded and not processed for reuse.

Cleaning Cleaning physically removes contaminants (e.g., fluids and microorganisms) with detergent and mechanical removal. Cleaning is the lowest level of decontamination and is appropriate for items used on intact skin. When cleaning visibly soiled objects, nurses must always wear gloves to avoid direct contact with infectious microorganisms. Most objects used in the care of clients, whether forceps or draw sheets, can be cleaned by rinsing them in cold water to remove any organic material, washing them with hot soapy water, then rinsing them again to remove the soap. The following steps should be followed when cleaning objects in a hospital or in a home:

1. Rinse the article with cold water to remove organic material. Hot water coagulates the protein of organic material and tends to make it adhere. Examples of organic material are blood, pus, and respiratory secretions.

TABLE 32.5 Nursing Interventions That Break the Chain of Infection: Infectious Agent and Reservoir

Link	Interventions	Rationale
Etiologic agent (microorganism)	Ensure that articles are correctly cleaned and disinfected or sterilized before use.	Correct cleaning, disinfecting, and sterilizing reduce or eliminate microorganisms.
	Educate clients and support persons about appropriate methods to clean, disinfect, and sterilize articles.	Knowledge of ways to reduce or eliminate microorganisms is a step in the direction of gaining compliance with aseptic practices.
Reservoir (source)	Change dressings and bandages when they are soiled or wet.	Moist dressings are ideal environments for microorganisms to grow and multiply.
	Assist clients to carry out appropriate skin and oral hygiene.	Hygiene measures reduce the numbers of resident and transient microorganisms and the likelihood of infection.
	Dispose of damp, soiled linens appropriately.	Damp, soiled linens provide an environment for microorganism growth.
	Dispose of feces and urine in appropriate receptacles.	Urine and feces contain many microorganisms. Feces may also be the source of certain microorganisms, such as the hepatitis A virus, in asymptomatic carriers.
	Ensure that all fluid containers, such as bedside water jugs and suction and drainage bottles, are covered or capped.	Prolonged exposure increases the risk of contamination by airborne pathogens.
	Empty suction and drainage bottles at the end of each shift or before they become full or according to agency policy.	Drainage harbours microorganisms that, if left for long periods, proliferate and are at risk for transmission to others.
Portal of exit from the reservoir	Avoid talking, coughing, or sneezing over open wounds or sterile fields, and cover the mouth and nose when coughing and sneezing.	These measures limit the number of microorganisms that escape from the respiratory tract.

TABLE 32.6 Nursing Interventions That Break the Chain of Infection: Transmission and Susceptible Host

Link	Interventions	Rationale
Route of transmission	Perform hand hygiene as per guidelines, for example, between client contacts; after touching blood, any body fluids, or contaminated items; and before performing invasive procedures or touching open wounds. Instruct clients and support persons to perform hand hygiene before handling food or eating, after eliminating, and after touching infectious material.	Hand hygiene is an important means of controlling and preventing the transmission of microorganisms.
	Place discarded soiled materials in moistureproof refuse bags.	Moistureproof bags prevent the spread of microorganisms by capillary action.
	Steadily hold used bedpans away from clothing to prevent spillage, and dispose of urine and feces in appropriate receptacles.	Feces in particular contain many microorganisms.
	Place used bedpans on disposable bed pad, not directly on patient-use surfaces (e.g., overbed table). Avoid splashing when emptying.	Preventing contamination of the patients' environment can reduce transmission of organisms.
	Use routine practice for *all* clients at *all* times, regardless of their diagnosis or presumed infection status.	All clients can harbour potentially infectious microorganisms that can be transmitted to others.
	Wear masks and eye protection when in close contact with clients who have infections transmitted by droplets from the respiratory tract.	Masks and eyewear reduce the spread of droplet-transmitted microorganisms.
	Wear masks and eye protection when sprays of body fluid are possible (e.g., during irrigation procedures).	Masks and eye protection provide protection from microorganisms in clients' blood, body fluids, nonintact skin, and mucous membranes.
	Wear gloves when handling secretions and excretions. Wear gowns if there is danger of soiling clothing with blood, any body fluids, nonintact skin, and mucous membranes.	Gloves and gowns prevent soiling of the hands and clothing.
	Use sterile technique (see p. 898) for invasive procedures (e.g., injections, catheterizations).	Invasive procedures penetrate the body's natural protective barriers to microorganisms.
Portal of entry to the susceptible host	Use sterile technique when exposing open wounds or handling dressings.	Open wounds are vulnerable to microbial infection.
	Place used disposable needles and syringes in puncture-resistant containers for disposal.	Injuries from needles contaminated by blood or body fluids from an infected client or carrier are a primary cause of hepatitis B virus (HBV) and HIV transmission to health-care workers.
	Provide all clients with their own personal care items.	People have less resistance to another person's microorganisms than to their own.
Susceptible host	Maintain the integrity of the client's skin and mucous membranes.	Intact skin and mucous membranes protect against invasion by microorganisms.
	Ensure that the client receives a balanced diet.	A balanced diet supplies proteins and vitamins necessary to build or maintain body tissues.
	Educate the public about the importance of immunizations.	Immunizations protect people against some infectious diseases.

2. Wash the article in hot water and soap. The emulsifying action of soap reduces surface tension and facilitates the removal of dirt. Washing dislodges the emulsified dirt.
3. Use an abrasive, such as a stiff-bristled brush, to clean equipment with grooves and corners. Friction helps dislodge foreign material.
4. Rinse the article well with warm to hot water.
5. Dry the article. It is now considered clean.
6. Clean the brush and sink. These are considered soiled until they are cleaned appropriately, usually with a disinfectant.

Disinfecting **Disinfection** reduces the number of microorganisms but will not eliminate them all, and it does not kill most spores. It provides a medium level of decontamination and is appropriate for items that have contact with mucous membranes or are contaminated by microorganisms that are easily transmitted. A **disinfectant** is a chemical preparation, such as phenol or iodine compounds, used on inanimate objects. In comparison, an **antiseptic** is a chemical preparation used on skin or tissue. Disinfectants are frequently caustic and toxic to tissues. Disinfectants and antiseptics often have similar chemical components, but the disinfectant is a more concentrated solution. Disinfectants are able to destroy a variety of pathogens but are ineffective against spores. Table 32.7 lists commonly used antiseptics and disinfectants.

Both antiseptics and disinfectants are said to have bactericidal or bacteriostatic properties. A *bactericidal* preparation destroys bacteria, whereas a *bacteriostatic* preparation prevents the growth and reproduction of some bacteria.

When disinfecting articles, nurses need to follow agency protocols and manufacturer recommendations and consider the following:

1. The type and number of infectious organisms. Some microorganisms are readily destroyed, whereas others require longer contact with the disinfectant.
2. The recommended concentration of the disinfectant and the duration of contact.
3. The temperature of the environment. Most disinfectants are intended for use at room temperature.
4. The presence of soap. Some disinfectants are ineffective in the presence of soap or detergent.
5. The presence of organic materials. The presence of saliva, blood, pus, or excretions can readily inactivate many disinfectants.
6. The surface areas to be treated. The disinfecting agent must come into contact with all surfaces and areas.

Sterilizing **Sterilization** is a process that destroys *all* microorganisms, including spores and viruses. It provides the highest level of decontamination and is indicated for items that penetrate skin or mucous membranes, or enter sterile body areas. Four commonly used methods of sterilization are moist heat, gas, boiling water, and radiation.

Moist Heat For sterilizing, moist heat (steam) can be employed in two ways: as steam under pressure or as free steam. Steam under pressure (autoclave) attains temperatures higher than the boiling point. The time required to sterilize an item relates to how long it takes to destroy spores at the temperature of the autoclave, which varies from 15 minutes at 121°C to 3 minutes at 134°C.

Free steam, 100°C, is used to sterilize objects that would be destroyed at the higher temperature and pressure of the autoclave. Usually, it is necessary to steam the article for 30 minutes on three consecutive days. The intervals are required so that unkilled spores will return to their vegetative state and again become vulnerable to the heat.

Gas Ethylene oxide gas destroys microorganisms by interfering with their metabolic processes. It is also effective against spores. Its advantages are good penetration and effectiveness for heat-sensitive items. Its major disadvantage is its toxicity to humans.

Boiling Water Boiling water is the most practical and inexpensive method for sterilizing in the home. The main disadvantage is that spores and some viruses are not killed by this method. The water temperature rises no higher than 100°C. Boiling a minimum of 15 minutes is advised for disinfection of articles in the home.

TABLE 32.7 Commonly Used Antiseptics and Disinfectants, Effectiveness, and Use

	Effective Against					
Agent	**Bacteria**	**Tuberculosis**	**Spores**	**Fungi**	**Viruses**	**Use on**
Isopropyl and ethyl alcohol	X	X		X	X	Hands, vial stoppers
Chlorine (bleach)	X	X	X	X	X	Blood spills
Hydrogen peroxide	X	X	X	X	X	Surfaces
Iodophors	X	X	X	X	X	Equipment; intact skin and tissues if diluted
Phenol	X	X		X	X	Surfaces
Chlorhexidine gluconate (Hibiclens)	X				X	Hands
Triclosan (Bacti-Stat)	X					Hands, intact skin

Radiation Both ionizing and nonionizing radiation can be used for disinfection and sterilization. Ultraviolet light, a type of nonionizing radiation, can be used for disinfection. Its main drawback is that the ultraviolet rays do not penetrate deeply. Ionizing radiation is used effectively in industry to sterilize foods, drugs, and other items that are sensitive to heat. Its main advantage is that it is effective for items that are difficult to sterilize; its chief disadvantage is that the equipment is very expensive.

Nurses should be familiar with the cleaning, disinfecting, and sterilizing protocols of the agency in which they practise.

ANTIMICROBIAL AGENTS **Antimicrobial agents** kill or slow the growth of infectious agents. Antibiotics or antiviral drugs can reduce the number of infectious agents present in the host, allowing the body's defences to eliminate them. Antibiotics, for example, are given at the start of surgery to reduce the number of bacteria at the surgical site at the time of the incision, thereby reducing surgical site infection. **Antiseptics**, antimicrobial agents that remove both transient and resident flora on living tissue (e.g., skin), are also used to reduce the number of infectious agents present near the site of a surgical incision or insertion point (e.g., for an intravenous line or chest tube). Their use reduces the number of infections caused by the client's endogenous flora.

Reduction of Transmission

The transmission of microorganisms can be reduced through the use of proper hand hygiene, the use of personal protective equipment to protect portals of entry, and the use of aseptic technique when warranted.

HAND HYGIENE The importance of hand hygiene in every setting, including hospitals, cannot be overemphasized. It is considered the single most effective infection prevention and control measure. Any person can harbour microorganisms that are currently harmless yet potentially harmful to that person or to others *if they find a portal of entry.* As a health-care worker's hands are in continuous contact with patients and their environments, those hands are most at risk for contamination with organisms. Subsequent transfer of the organisms to other patients and health-care personnel, to the environment, or to the health-care worker involved might then occur. It is critical that hands be cleaned frequently and correctly. The term **hand hygiene** refers to both handwashing and the use of hand sanitizers.

Handwashing with soap and water physically removes transient microorganisms carried on the hands but not resident flora. Skill 32.1 describes correct handwashing techniques. Using an adequate amount of soap, rubbing the hands together to create friction, covering all surfaces of the hand, ensuring that rinsing occurs under running water, and turning off the tap with a paper towel are essential components of a handwashing procedure. Plain soap will successfully remove most transient microbial flora, whereas antimicrobial (antiseptic) soap is designed for use under conditions of heavy microbial soiling or if antimicrobial-resistant organisms are a factor or a possibility. Soap and sink manufacturers' recommendations should be adhered to for proper use.

SKILL 32.1

HAND WASHING

PURPOSES

- To reduce the number of microorganisms on the hands
- To reduce the risk of cross-contamination among clients
- To reduce the risk of transmission of microorganisms to clients
- To reduce the risk of transmission of infectious organisms to oneself

ASSESSMENT

Determine the client's

- Presence of factors increasing susceptibility to infection and possibility of undiagnosed infection (e.g., HIV)
- Use of immunosuppressive medications
- Recent diagnostic procedures or treatments that penetrated the skin or a body cavity
- Current nutritional status
- Signs and symptoms indicating the presence of an infection:
  - Localized signs, such as swelling, redness, pain or tenderness with palpation or movement, palpable heat at site, loss of function of affected body part, presence of exudate
  - Systemic indications, such as fever, increased pulse and respiratory rates, lack of energy, anorexia, enlarged lymph nodes

Planning

Determine the location of running water and soap or soap substitutes.

Equipment

- Soap
- Warm running water
- Disposable or sanitized towels
- Hand brush (if necessary)

(continued)

SKILL 32.1

HAND WASHING (*continued*)

IMPLEMENTATION

Preparation

Assess the hands.

- Nails should be kept short. **Rationale: Short, natural nails are less likely to harbour microorganisms, scratch a client, or puncture gloves.**
- Remove all jewellery. Some nurses prefer to slide their watches up above their elbows. Others pin the watch to the uniform. **Rationale: Microorganisms can lodge in the settings of jewellery and under rings on fingers. Removal facilitates proper cleaning of the hands and arms.** The jewellery itself also needs to be washed. It is better to not wear it at all.
- Check hands for breaks in the skin, such as hangnails or cuts. Use lotions to prevent hangnails and cracked, dry skin. **Rationale: A nurse who has broken skin areas may have to change work assignments with decreased risk for transmission of infectious organisms or wear gloves for protection.**
- Do not apply fingernail polish or artificial nails. **Rationale: Both can harbour microorganisms.**

Performance

1. If you are washing your hands where the client can observe you, introduce yourself and explain to the client what you are going to do and why it is necessary.
2. Turn on the water, and adjust the flow.
   - Faucet controls have five common types:
     a. Hand-operated handles
     b. Knee levers. Move these with the knee to regulate flow and temperature (see 1).
     c. Foot pedals. Press these with the foot to regulate flow and temperature (see 2).
     d. Elbow controls. Move these with the elbows instead of the hands.
     e. Infrared controls. The water runs when motion is detected at a preset distance.
   - Adjust the flow so that the water is warm. **Rationale: Warm water removes less of the protective oil of the skin than does hot water.**
3. Wet the hands thoroughly by holding them under the running water, and apply soap to the hands. Hold the hands lower than the elbows so that the water flows from the arms to the fingertips. **Rationale: The water should flow from the least contaminated to the most contaminated area; the hands are generally considered more contaminated than the lower arms.**
   - If the soap is liquid, apply 2 mL to 5 mL. If it is bar soap, rub it firmly between the hands.
4. Thoroughly wash and rinse the hands.
   - Using firm, rubbing, and circular movements, wash the palm, back, and wrist of each hand. Interlace the fingers and thumbs and move the hands back and forth (see 3), continuing this motion for *at least* 15 seconds. **Rationale: Friction and brisk action help remove microorganisms mechanically. Interlacing the fingers and thumbs cleans the interdigital spaces.**
   - Rub the fingertips against the palm of the opposite hand. **Rationale: The nails and fingertips are commonly missed during handwashing.**
   - Rinse the hands for at least 10 seconds by using a rubbing motion. **Rationale: This ensures removal of microorganisms.**
5. Thoroughly pat dry the hands and arms.
   - Dry hands and arms thoroughly from fingertips to wrist, without scrubbing, by using a separate paper towel for each arm. **Rationale: Moist skin becomes chapped readily, as does dry skin that is rubbed vigorously; chapping produces lesions.**
   - Discard each paper towel in the appropriate container.

1 A knee-lever faucet control

2 A foot-pedal faucet control

3 Interlacing the fingers during hand washing

(continued)

SKILL 32.1

HAND WASHING (*continued*)

6. Turn off the water.

- Use a dry, clean paper towel to grasp a hand-operated control (see 4). **Rationale: This prevents the nurse from picking up microorganisms from the faucet handles.**

Variation: Handwashing before Sterile Techniques

- Apply the soap and wash as described in steps 3 and 4, but hold the hands higher than the elbows during this hand wash. Wet the hands and forearms under the running water, letting it run from the fingertips to the elbows so that the hands become cleaner than the elbows (see 5). Ensure that at least 2 minutes of friction is used for surgical handwashing. **Rationale: In this way, the water runs from the area with the fewest microorganisms to areas with a relatively greater number.**
- After washing and rinsing, use a towel to dry one hand thoroughly in an encircling motion from the fingers to the elbow. Use a clean towel to dry the other hand and arm. **Rationale: A clean towel prevents the transfer of microorganisms from one elbow (least clean area) to the other hand (cleanest area).**

4 Using a paper towel to grasp the handle of a hand-operated faucet

5 The hands are held higher than the elbows during a handwash before sterile technique.

EVALUATION

No traditional evaluation exists of the effectiveness of the individual nurse's handwashing. Institutional quality control departments monitor the occurrence of client infections and investigate those situations in which health-care providers are implicated in the transmission of infectious organisms.

Waterless *alcohol-based hand rubs* kill microorganisms on the hands and are more effective than soap and water in reducing hand contamination. They facilitate hand hygiene compliance because of ease of accessibility, reduced time required to perform, and reduced skin irritation. They are therefore the preferred method of hand hygiene.

CHICA-Canada (2008) recommends the following steps when alcohol-based hand rub products are used for hand hygiene:

1. *Remove hand and arm jewellery.*
2. *Apply enough product to cover all surfaces of the hands; follow manufacturer's instructions for the amount of product to use.*
3. *Use a rubbing motion to evenly distribute the antiseptic product over all surfaces of the hands, particularly between fingers, fingertips, back of hands and base of thumbs.*
4. *Rub hands until your hands feel dry (minimum 15 to 30 seconds). Do not use paper towels.*

However, alcohol-based hand rubs have reduced effectiveness when there is physical material on the hands, such as secretions. When there is visible soiling, hands should be washed before or instead of using an alcohol-based hand rub.

The decisions as to what product to use, the amount of soap or alcohol-based hand rub to use, the frequency of performing hand hygiene, as well as the actual technique implemented remain with the health-care worker. They are decisions that must be made with an unrelentingly conscientious attitude. The indications for hand hygiene are shown in Box 32.1.

PERSONAL PROTECTIVE EQUIPMENT Personal protective equipment (PPE) acts a barrier to reduce a health-care worker's exposure to microorganisms and reduce carriage of microorganisms by the health-care worker. PPE includes gloves, gowns, face masks, respirators, and eyewear.

BOX 32.1 RECOMMENDATIONS FOR HAND HYGIENE

Indications for the frequency of hand hygiene depend on the following:

- The type, intensity, duration, and sequence of activity
- The degree of contamination associated with the contact
- The susceptibility to infection of the health-care recipient

Hand hygiene must be performed at these times:

- Between direct contact with individual patients, residents, or clients
- Before performing invasive procedures
- Before caring for patients in intensive care units and immunocompromised patients
- After contact with blood or body fluids, or items known or considered likely to be contaminated with blood, body fluids, secretions, or excretions
- Between certain procedures on the same patient where soiling of hands is likely, to avoid cross-contamination of body sites
- After situations or procedures in which microbial or blood contamination of hands is likely
- Immediately after removing gloves
- Before preparing, handling, serving, or eating food, and before feeding a patient when hands are soiled after personal body functions (e.g., using the toilet, blowing the nose)
- Whenever the health-care provider is in doubt about the necessity for doing so
- Before entering the unit or agency at the beginning of a work period and when leaving at the end of a work period

Gloves Gloves are worn for three reasons. First, they protect the hands when the nurse is likely to handle any body substances, for example, blood, urine, feces, sputum, mucous, and nonintact skin. Second, gloves reduce the likelihood of nurses transmitting their own endogenous microorganisms to individuals receiving care. Nurses who have open sores or cuts on the hands must wear gloves for protection. Third, gloves reduce the chance that the nurse's hands will transmit microorganisms from one client or a fomite to another client. In all situations, gloves are changed between client contacts. The hands are washed each time gloves are removed for two primary reasons: (1) the gloves may have imperfections or be damaged during wearing so that they could allow microorganisms to pass through to the skin and (2) the hands may become contaminated during glove removal. For most activities, disposable *clean* gloves are used. No special technique is required to don clean disposable gloves.

If a gown is worn, the nurse pulls up the gloves to cover the cuffs of the gown. If a gown is not worn, the nurse pulls up the cuffs to cover the wrists. Sterile gloves are used when the hands will come in contact with an open wound or when the hands might introduce microorganisms into a body orifice that is normally considered sterile.

Many of the gloves used in infection control are made of latex rubber, as are various other items used in health care (e.g., catheters, blood pressure cuffs, rubber sheets, intravenous tubing, stockings and binders, adhesive bandages, and dental dams). As a result of the frequent use of gloves, health-care workers and clients with chronic illnesses have increasingly reported allergic reactions to latex. In addition, latex gloves lubricated by powder or cornstarch are particularly allergenic because the latex allergen adheres to the powder, which is aerosolized during glove use and inhaled by the user. Latex gloves that are labelled *hypoallergenic* still contain measurable latex and should not be used by or on persons with known latex sensitivity. The people at greatest risk for developing latex allergies are those with other allergic conditions and those who have had frequent or long-term exposure to latex.

Latex allergies can be either local or systemic and may take the form of dermatitis, urticaria (hives), bronchospasm, or anaphylaxis. Clients and health-care workers should be assessed for possible allergies by taking a thorough history. Clients should be asked if they have had any adverse reactions to such items as balloons, condoms, and dishwashing or utility gloves. Strategies to avoid sensitization or exposure to latex include use of nonlatex products, nonlatex barriers between latex products and the skin, and gloves that are unpowdered. People with significant allergies should have no contact with latex products. Health-care agencies are striving to provide alternatives to latex equipment and supplies.

Skill 32.2 describes application and removal of nonsterile gloves.

Gowns Clean or disposable impervious (water-resistant) gowns or plastic aprons are worn during procedures when the nurse's uniform is likely to become soiled. *Single use of a gown* (using a gown only once before it is discarded or laundered) is the usual practice in health-care agencies. After the gown is worn, the nurse discards it (if it is paper) or places it in a laundry hamper. Before leaving the client's room, the nurse makes sure that hands are washed.

Sterile gowns may be indicated when the nurse changes the dressings of a client with extensive wounds (e.g., burns).

A gown worn for protection is always assumed to have become contaminated during use. Skill 32.2 provides guidelines for donning and removing a gown.

Face Masks and Respirators During certain techniques requiring sterile technique, masks are worn to prevent droplet contact transmission of exhaled microorganisms to the sterile field or to a client's open wound. Masks are also worn as part of routine practices to protect the nurse from splashes of body substances from the client. Surgical and procedure masks protect the

SKILL 32.2

DONNING AND REMOVING PERSONAL PROTECTIVE EQUIPMENT (GLOVES, GOWN, MASK, EYEWEAR)

PURPOSES

To protect health-care workers and clients from transmission of potentially infective materials

ASSESSMENT

Consider which activities will be required while the nurse is in the patient's room.

Planning

- Application and removal of personal protective equipment (PPE) can be time consuming. Prioritize care and arrange for personnel to care for your other clients if indicated.
- Determine which supplies are present within the patient's room and which must be brought to the room.
- Consider whether special handling is indicated for removal of any specimens or other materials from the room.

Equipment

As indicated, according to which activities will be performed. Ensure that extra supplies are easily available.

- Gown
- Mask
- Eyewear
- Clean gloves

IMPLEMENTATION

Preparation

Remove and secure all loose items, such as name tags or jewellery.

Performance

1. Before performing the procedure, introduce yourself and verify the client's identity by using agency protocol. Explain to the client what you are going to do, why it is necessary, and how he or she can cooperate.
2. Perform proper hand hygiene.
3. Don a clean gown.
   - Pick up a clean gown, and allow it to unfold in front of you without allowing it to touch any area soiled with body substances.
   - Slide the arms and the hands through the sleeves.
   - Fasten the ties at the neck to keep the gown in place.
   - Overlap the gown at the back as much as possible, and fasten the waist ties or belt (see 1). **Rationale: Overlapping securely covers the uniform at the back. Waist ties keep the gown from falling away from the body, which can cause inadvertent soiling of the uniform.**
4. Don the face mask.
   - Locate the top edge of the mask. The mask usually has a narrow metal strip along the edge.
   - Hold the mask by the top two strings or loops.
   - Place the upper edge of the mask over the bridge of the nose, and tie the upper ties at the back of the head or secure the loops around the ears. If glasses are worn, fit the upper edge of the mask under the glasses. **Rationale: With the edge of the mask under the glasses, clouding of the glasses is less likely to occur.**
   - Secure the lower edge of the mask under the chin, and tie the lower ties at the nape of the neck (see 2). **Rationale: To be effective, a mask must cover both**

1 Overlapping the gown at the back to cover the nurse's uniform

2 A face mask and eye protection covering the nose, mouth, and eyes

(continued)

SKILL 32.2

DONNING AND REMOVING PERSONAL PROTECTIVE EQUIPMENT (GLOVES, GOWN, MASK, EYEWEAR) (*continued*)

the nose and the mouth, because air moves in and out of both.

- If the mask has a metal strip, adjust this firmly over the bridge of the nose. **Rationale: A secure fit prevents both the escape and the inhalation of microorganisms around the edges of the mask and the fogging of eyeglasses.**
- Wear the mask only once, and do not wear any mask longer than the manufacturer recommends or once it becomes wet. **Rationale: A mask should be used only once because it becomes ineffective when moist.**
- Do not leave a used face mask hanging around the neck.

5. Don protective eyewear if it is not combined with the face mask.
6. Don clean disposable gloves.
   - No special technique is required.
   - If wearing a gown, pull up the gloves to cover the cuffs of the gown. If not wearing a gown, pull up the gloves to cover the wrists.
7. To remove soiled PPE, remove the gloves first since they are the most soiled.
   - If wearing a gown that is tied at the waist in front, undo the ties before removing gloves.
   - Remove the first glove by grasping it on its palmar surface, taking care to touch only glove to glove (see ❸). **Rationale: This keeps the soiled parts of the used gloves from touching the skin of the wrist or hand.**
   - Pull off the first glove completely by inverting or rolling the glove inside out.
   - Continue to hold the inverted removed glove by the fingers of the remaining gloved hand. Place the first two fingers of the bare hand inside the cuff of the second glove (see ❹). **Rationale: Touching the outside of the second soiled glove with the bare hand is avoided.**
   - Pull off the second glove to the fingers by turning it inside out. This pulls the first glove inside the second glove. **Rationale: The soiled part of the glove is folded to the inside to reduce the chance of transferring any microorganisms by direct contact.**
   - By using the bare hand, continue to remove the gloves, which are now inside out, and dispose of them in the refuse container (see ❺).
8. Perform proper hand hygiene.
9. Remove protective eyewear and dispose of properly or place in the appropriate receptacle for cleaning.
10. Remove the gown when preparing to leave the room. Unless a gown is grossly soiled with body substances, no special precautions are needed to remove it. If a gown is grossly soiled,

❸ Plucking the palmar surface below the cuff of a contaminated glove

❹ Inserting fingers to remove the second contaminated glove

❺ Holding contaminated gloves, which are inside out

(continued)

SKILL 32.2

DONNING AND REMOVING PERSONAL PROTECTIVE EQUIPMENT (GLOVES, GOWN, MASK, EYEWEAR) (*continued*)

- Avoid touching soiled parts on the outside of the gown, if possible. **Rationale: The top part of the gown may be soiled, for example, if you have been holding an infant who has a respiratory infection.**
- Grasp the gown along the inside of the neck and pull down over the shoulders.
- Roll up the gown with the soiled part inside, and discard it in the appropriate container.

11. Remove the mask.

- Remove the mask at the doorway to the client's room. If using a respirator mask, remove it after leaving the room and closing the door.
- If using a mask with strings, first untie the *lower* strings of the mask. **Rationale: This prevents the top part of the mask from falling onto the chest.**
- Untie the top strings and, while holding the ties securely, remove the mask from the face. If side loops are present, lift the side loops up and away from the ears and face. Do not touch the front of the mask. **Rationale: The front of the mask through which the nurse has been breathing is contaminated.**
- Discard a disposable mask in the waste container.
- Perform proper hand hygiene again.

EVALUATION

- Conduct any follow-up indicated during your care of the client. If any failure of the equipment has occurred and exposure to potentially infective materials is suspected, follow the steps in Box 32.4 later in this chapter.

Ensure that an adequate supply of equipment is available for the next health-care provider.

wearer's mouth and nose and thus are worn to reduce the risk for transmission of organisms by droplet contact and by splatters of body substances. In addition to health-care personnel, family members and others who are close to the client should wear masks if the infection (e.g., mumps or acute respiratory diseases in children) is transmitted by droplet transmission.

Various types of masks differ in their filtration effectiveness and fit. Single-use disposable surgical masks are effective for use when the nurse provides care to most clients but should be changed if they become wet or soiled. These masks are discarded in the waste container after use.

Surgical masks do not create a tight seal around the mouth and nose so that not all of the air breathed by the wearer is filtered through the mask itself. They are therefore not considered effective against smaller droplets and droplet nuclei. Disposable particulate **respirators** are masks made of a high-filtration material and are designed to create a tight seal around the mouth and nose. An N95-level respirator filters out at least 95% of airborne particles under standard conditions, excluding oil particles (the *N* of N95 stands for *not resistant to oil*). Respirators need to be fitted—health-care providers need to choose a size and style of respirator mask that allows a good seal. Most institutions provide a selection of respirators; assessing an individual for an appropriate respirator is called **fit testing**.

Fit testing is done by an appropriately trained individual. While done in some places on an annual basis, regulations vary by jurisdiction as to the frequency with which fit testing must occur. *Fit checking* means assessing the adequacy of the seal and should be done each time a respirator is worn (Public Health Agency of Canada, 2003).

Respirators should be worn by all persons entering the room when the infection (e.g., pulmonary tuberculosis) is transmitted by the airborne route. Respirators should also be worn during aerosol-generating procedures (e.g., bronchoscopy or suctioning).

Guidelines for donning and removing a facemask are found in Skill 32.2. Special care must be taken to avoid self-contamination when removing the mask or respirator.

EYEWEAR Protective eyewear (goggles, glasses, or face shields) and masks may be indicated in situations in which body substances may splatter the face, thereby allowing entry of microorganisms through the eyes or respiratory tract. If the nurse wears prescription eyeglasses, goggles must still be worn over the glasses because the protection must extend around the sides of the glasses. Guidelines for donning and removing eyewear are found in Skill 32.2.

ASEPTIC AND STERILE TECHNIQUE *Asepsis* means "without infection" and implies the absence of disease-causing microorganisms. To decrease the possibility of transferring microorganisms from one place to another, aseptic technique or sterile technique is used. The two terms are not the same. **Aseptic technique** is sometimes referred to as **clean technique**, where clean denotes the absence of almost all, but not all, microorganisms. While efforts are made to reduce transfer of microorganisms, items in use may not be sterile (e.g., use of clean forceps) and activity occurs outside of a sterile field (e.g., a wound

during a dressing change). **Sterile technique** employs stricter measures to maintain sterility throughout the procedure. It refers to using sterile items within a sterile field, such as an operative site in an operating room, or in an intensive care unit when a sterile drape is applied for insertion of a central venous access device.

Approaches to asepsis will vary, depending on the procedure and setting. For example, before an operating room procedure, the scrub nurse generally puts on a mask and cap, performs a surgical hand scrub, and then dons a sterile gown and gloves. In a general care area, the nurse may only perform a handwash and don sterile gloves. In both areas, the nurse works with sterile equipment and a sterile field. The basic principles of sterile technique appear in Table 32.8, with examples from nursing practice that relate to each principle.

TABLE 32.8 Principles and Practices of Establishing and Maintaining a Sterile Field

Principle	Practices
All objects used in a sterile field must be sterile.	All articles are sterilized appropriately by dry or moist heat, chemicals, or radiation before use. Sterile articles can be stored for only a prescribed time; after that, they are considered unsterile. Always check a package containing a sterile object for intactness, dryness, and expiration date. Any package that appears open, torn, punctured, or wet is considered unsterile. Never assume an item is sterile; if in doubt, consider the item unsterile. Storage areas should be clean, dry, off the floor, and away from sinks. Always check chemical indicators of sterilization before using a package. The indicator is often a tape used to fasten the package or contained inside the package. The indicator changes colour during sterilization, indicating that the contents have undergone a sterilization procedure. If the colour change is not evident, the package is considered unsterile. Commercially prepared sterile packages may not have indicators but are marked with the word *sterile*.
Sterile objects become unsterile when touched by unsterile objects.	Handle sterile objects that will touch open wounds or enter body cavities only with sterile forceps or sterile gloved hands. Discard or resterilize objects that come into contact with unsterile objects. Whenever the sterility of an object is questionable, assume the article is unsterile.
Sterile items that are out of vision or below the waist level of the nurse are considered unsterile.	Once left unattended, a sterile field is considered unsterile. Sterile objects are always kept in view. Nurses should not turn their backs on a sterile field. Only the front part of a sterile gown (from the waist to the shoulder) and 5 cm above the elbows to the cuff of the sleeves are considered sterile. Always keep sterile gloved hands in sight and above waist level; touch only objects that are sterile. Sterile draped tables are considered sterile only at surface level. Once a sterile field becomes unsterile, it must be set up again before proceeding.
Sterile objects can become unsterile by prolonged exposure to air-borne microorganisms.	Keep doors closed and traffic to a minimum in areas where a sterile procedure is being performed; moving air can carry dust and microorganisms. Keep areas in which sterile procedures are carried out as clean as possible by frequent damp cleaning with detergent germicides to minimize contaminants in the area. Keep hair clean and short, tied back, or enclosed in a net to prevent hair from falling on sterile objects. Microorganisms on the hair can make a sterile field unsterile. Wear surgical caps in operating rooms, delivery rooms, and burn units. Refrain from sneezing or coughing over a sterile field. This can render the field unsterile because of the spray of droplets containing microorganisms from the respiratory tract. Some nurses recommend that masks covering the mouth and the nose be worn when working over a sterile field or an open wound. Nurses with mild upper respiratory tract infections should refrain from carrying out sterile procedures, or should wear masks. When working over a sterile field, talking should be kept to a minimum. Turn the head from the field if talking is necessary. To prevent microorganisms from falling over a sterile field, refrain from reaching over a sterile field, unless sterile gloves are worn, and refrain from moving unsterile objects over a sterile field.

continued

TABLE 32.8 Principles and Practices of Establishing and Maintaining a Sterile Field (*continued*)

Principle	Practices
Fluids flow in the direction of gravity.	Hold instruments with the tips below the handles. When the tips are held higher than the handles, fluid can flow onto the handle and become contaminated by the hands. When the forceps are again pointed downward, the fluid flows back down and contaminates the tips. During a surgical handwash, hold the hands higher than the elbows to prevent contaminants from the forearms from reaching the hands.
Moisture that passes through a sterile object draws microorganisms from unsterile surfaces above or below to the sterile surface by capillary action.	Sterile moistureproof barriers are used beneath sterile objects. Liquids (sterile saline or antiseptics) are frequently poured into containers on a sterile field. If they are spilled onto the sterile field, the barrier keeps the liquid from seeping beneath it. Keep the sterile covers on sterile equipment dry. Damp surfaces can attract microorganisms in the air. Replace sterile drapes that do not have a sterile barrier underneath when they become moist.
The edges of a sterile field are considered unsterile.	A 2.5 cm margin at each edge of an opened drape is considered unsterile because the edges are in contact with unsterile surfaces. Place all sterile objects more than 2.5 cm inside the edges of a sterile field. Any article that falls outside the edges of a sterile field is considered unsterile.
The skin is unsterile and cannot be sterilized.	Use sterile gloves or sterile forceps to handle sterile items. Prior to a surgical aseptic procedure, wash the hands to reduce the number of microorganisms on them.
Conscientiousness, alertness, and honesty are essential qualities in maintaining surgical asepsis.	When a sterile object becomes unsterile, it does not necessarily change in appearance. The person who sees a sterile object become contaminated must correct or report the situation. Do not set up a sterile field ahead of time for future use.

Sterile Field A **sterile field** is a microorganism-free area. Nurses often establish a sterile field by using the innermost side of a sterile wrapper or by using a sterile drape. When the field is established, sterile supplies and sterile solutions can be placed on it. Sterile forceps are used in many instances to handle and transfer the sterile supplies.

So that their sterility can be maintained, supplies are wrapped in a variety of materials. Commercially prepared items are frequently wrapped in plastic, paper, or glass. In the past, it was not unusual for sterile liquids (e.g., sterile water for irrigations) to be supplied in large containers. This practice is considered undesirable today because once a container has been opened, there can be no guarantee that it is sterile. Liquids are preferably packaged in amounts adequate for single use only; leftover liquid is discarded.

The Home Care Considerations box contains information that the nurse should teach the client to maintain a sterile field at home.

Skill 32.3 describes how to establish and maintain a sterile field.

Home Care Considerations

Sterile Field

Creating a sterile field is essential in many procedures conducted in the home:

- Clean and wipe dry a flat surface for the sterile field.
- Keep pets and uninvolved small children out of the area when setting up for and performing sterile procedures.
- Dispose of all soiled materials in a waterproof bag. Check with the agency as to how to dispose of medical refuse.
- Remove all instruments from the home or other setting in which others might accidentally find them. *New or used instruments can be sharp or capable of causing injury. Used instruments may transmit infection.* Check with the agency for instructions on the cleansing of reusable supplies and disposal of single-use instruments.
- If appropriate, teach the client and family members the principles and rationale underlying use of a sterile field.

SKILL 32.3

ESTABLISHING AND MAINTAINING A STERILE FIELD

PURPOSE

- To maintain the sterility of supplies and equipment

ASSESSMENT

Review the client's record or discuss with the client or other health-care team members exactly what procedure will be performed that requires a sterile field. Determine the client's presence or risk for infection and ability to cope with the procedure.

Determine, if possible, what supplies and techniques have been used in the past to perform the procedures for this client. Attempt to determine if the procedure will be performed again in the future, so appropriate client teaching can be done and adequate supplies will be available.

Schedule the procedure at a time consistent with the order, the need for the procedure, and the client's other activities.

Equipment

- Package containing a sterile drape
- Sterile equipment as needed (e.g., packaged gauze, wrapped sterile bowl, antiseptic solution, sterile forceps)

IMPLEMENTATION

Preparation

- Ensure that the package is clean and dry; if moisture is noted on the inside of a plastic-wrapped package or the outside of a cloth-wrapped package, it is considered contaminated and must be discarded.
- Check the sterilization expiration dates on the package, and look for any indications that it has been previously opened. Spots or stains on cloth-wrapped or paper-wrapped objects may indicated contamination and should not be used.
- Follow agency practice for disposal of possibly contaminated packages.

Performance

1. Before performing the procedure, introduce yourself and verify the client's identity by using agency protocol. Explain to the client what you are going to do, why it is necessary, and how he or she can cooperate.
2. Observe other appropriate infection prevention and control procedures (see Skills 32.1 and 32.2).
3. Provide for client privacy.
4. Open the package. If the package is inside a plastic cover, remove the cover.

To Open a Wrapped Package on a Clean Surface

- Place the package in the centre of the work area so that the top flap of the wrapper opens away from you. **Rationale: This position prevents the nurse from reaching directly over the exposed sterile contents, which could contaminate them.**
- Reaching from the side of the package (not over it), pinch the first flap on the outside of the wrapper between the thumb and index finger (see 1). **Rationale: Touching only the outside of the wrapper maintains the sterility of the inside of the wrapper**. Pull the flap open, laying it flat on the far surface.
- Repeat for the side flaps, opening the top one first. Use the right hand for the right flap, and the left hand for the left flap (see 2). **Rationale: By using both hands, the nurse avoids reaching over the sterile contents.**
- Pull the fourth flap toward you by grasping the corner that is turned down (see 3). Make sure that the flap does not touch any object. **Rationale: If the inner surface touches any unsterile article, it is contaminated.**

1 Opening the first flap of a sterile wrapped package

2 Opening the second flap to the side

3 Pulling the last flap toward you by grasping the corner

(continued)

SKILL 32.3

ESTABLISHING AND MAINTAINING A STERILE FIELD (*continued*)

Variation: Opening a Wrapped Package while Holding It

- Hold the package in one hand with the top flap opening away from you.
- By using the other hand, open the package as described above, pulling the corners of the flaps well back and not reaching across the contents of the package (see 4). **Rationale: The hands are considered contaminated, and at no time should they touch the contents of the package.**

4 Opening a wrapped package while holding it

Variation: Opening Commercially Prepared Packages

Commercially prepared sterile packages and containers usually have manufacturer's directions for opening.

- If the flap of the package has a peel back corner, hold the container in one hand and pull back on the flap with the other hand (see 5).

5 Opening a sterile package that has a peel back corner

- If the package has a peel back edge, grasp both sides of the edge, one with each hand, and pull apart gently (see 6).

5. Establish a sterile field by using a sterile drape.
   - Open the package containing the drape as described above.
   - With one hand, pluck the corner of the drape that is folded back on the top touching only one side of the drape.

6 Opening a sterile package that has a partially sealed edge

- Lift the drape out of the cover and allow it to open freely without touching any objects (see 7). **Rationale: If the drape touches the outside of the package or any unsterile surface or object, it is considered contaminated.**
- Discard the cover.
- With the other hand, carefully pick up another corner of the drape, holding it well away from you, and again, touching only the same side of the drape as the first hand.

7 Allowing a drape to open freely without touching any objects

(continued)

SKILL 32.3

ESTABLISHING AND MAINTAINING A STERILE FIELD (*continued*)

- Lay the drape on a clean and dry surface, placing the bottom (i.e., the freely hanging side) farthest from you (see 8). **Rationale: By placing the lowermost side farthest away, the nurse avoids leaning over the sterile field and contaminating it.**

6. Add necessary sterile supplies, being careful not to touch the drape with the hands.

To Add Wrapped Supplies to a Sterile Field

- Open each wrapped package as described in the preceding steps.
- With the free hand, grasp the corners of the wrapper and hold them against the wrist of the other hand (see 9). **Rationale: The unsterile hand is now covered by the sterile wrapper.**
- Place the sterile bowl, drape, or other supply on the sterile field by approaching from an angle, rather than holding the arm over the field.
- Discard the wrapper.

Variation: Adding Commercially Packaged Supplies to a Sterile Field

- Open each package as previously described.
- Hold the package 15 cm above the field, and allow the contents to drop on the field (see 10). Keep in mind that 2.5 cm around the edge of the field is considered contaminated. **Rationale: At a height of 15 cm, the outside of the package is not likely to touch and contaminate the sterile fields.**

Adding Solution to a Sterile Container

Liquids (e.g., normal saline) may need to be poured into containers within a sterile field. Unwrapped bottles or flasks that contain sterile solution are considered sterile on the inside and contaminated on the outside because the bottle has been handled. Bottles used in an operating room may be sterilized on the outside as well as the inside, however, and these are handled with sterile gloves.

- Before pouring any liquid, read the label three times to ensure you have the correct solution and concentration (strength).
- Obtain the exact amount of solution, if possible. **Rationale: Once a sterile container has been opened, its sterility cannot be ensured for future use unless it is used again immediately.**
- Remove the lid or cap from the bottle and invert the lid before placing it on a surface that is not sterile. **Rationale: Inverting the lid maintains the sterility of the inside surface because it is not allowed to touch an unsterile surface.**

8 Placing a drape on a surface

9 Adding wrapped sterile supplies to a sterile field

10 Adding commercially packaged gauze to a sterile filed

(continued)

SKILL 32.3

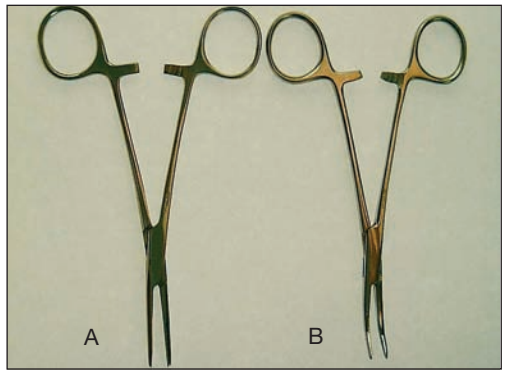
ESTABLISHING AND MAINTAINING A STERILE FIELD (*continued*)

- Hold the bottle at a slight angle so that the label is uppermost (see ⓫). **Rationale: Any solution that flows down the outside of the bottle during pouring will not damage or obliterate the label.**
- Hold the bottle of fluid at a height of 10 cm to 15 cm over the container and to the side of the sterile field so that as little of the bottle as possible is over the field. **Rationale: At this height, there is less likelihood of contaminating the sterile field by touching the field or by reaching an arm over it.**
- Pour the solution gently to avoid splashing the liquid. **Rationale: If the sterile drape is on an unsterile surface, any moisture will contaminate the field by facilitating the movement of microorganisms through the drape.**
- Tilt the neck of the bottle back to vertical quickly when done pouring so that none of the liquid flows down the outside of the bottle. **Rationale: Such drips would contaminate the sterile field if the outside of the bottle is not sterile.**
- If the bottle will be used again, replace the lid securely on the bottle and provide the date and time of opening according to agency policy. **Rationale: Replacing the lid immediately maintains the sterility of the inner aspect of the lid and the solution.**
- Depending on agency policy, a sterile container of solution that is opened may be used only once and then discarded (such as in the operating room). In other settings, policy may permit recapped bottles to be reused within 24 hours.
- If bottle of solution is used again, the lip of the container should be cleansed by pouring a small amount of solution (and then discarding) before pouring solution into the sterile container.

8. Use sterile forceps to handle certain sterile supplies.

- Forceps are commonly used for such techniques as changing a sterile dressing and shortening a drain. Transfer forceps are used to move a sterile article from one place to another, for example, transferring sterile gauze from its package to a sterile dressing tray. Forceps may be discarded or resterilized after use. Commonly used forceps include hemostats, or artery forceps (see ⓬), and tissue forceps (see ⓭).
- Keep the tips of wet forceps lower than the wrist at all times unless you are wearing sterile gloves (see ⓮). **Rationale: Gravity prevents liquids on the tips of the forceps from flowing to the handles and later back to the tips, thus making the forceps unsterile. The handles are unsterile once they are held by the bare hand.**
- Hold sterile forceps above waist level. **Rationale: Items held below waist level are considered contaminated.**
- Hold sterile forceps within your visual field. **Rationale: While out of sight, forceps may, unknown to the user, become contaminated. Any forceps that go out of sight should be considered unsterile.**

⓫ Adding liquid to a sterile bowl



⓬ Hemostats: A: straight; B: curved

⓭ Tissue forceps: A: plain; B: toothed

(continued)

SKILL 32.3

ESTABLISHING AND MAINTAINING A STERILE FIELD (*continued*)

- When using forceps to lift sterile supplies out of a commercially prepared package, be sure that the forceps do not touch the edges or outside of the wrapper. **Rationale: The edges and outside of the package are exposed to the air and are handled and are, thus, unsterile.**
- Deposit a sterile item on a sterile field without permitting moist forceps to touch the sterile field when the surface under the sterile field is unsterile and a barrier drape is not used. A *barrier drape* is resistant to moisture and should be used whenever a procedure involves moisture. **Rationale: Made of chemically treated cotton or synthetic materials, barrier drapes prevent a sterile field from becoming contaminated when the drape becomes wet. It is known that a sterile cloth becomes unsterile when dampened (even with sterile water) if it is on an unsterile surface or has contact with any unsterile object. Microorganisms can move through a damp sterile cloth from an unsterile surface by capillary action.**
- When placing forceps whose handles were in contact with the bare hand, position the handles outside the sterile area. **Rationale: The handles of these forceps harbour microorganisms from the bare hand.**

14 Holding forceps with an ungloved hand, keeping the tips pointing downward

EVALUATION

- Conduct any follow-up indicated during your care of the client. Ensure that adequate numbers and types of sterile supplies are available for the next health-care provider.

Sterile Gloves Sterile gloves are worn during many procedures to maintain the sterility of equipment and protect the client. Sterile gloves are packaged with a cuff of about 5 cm and with the palms facing upward when the package is opened. The package usually indicates the size of the glove (e.g., size 6 or 7 1/2).

Sterile gloves can be donned by the open or the closed method. The open method is most frequently used outside the operating room because the closed method requires that the nurse wear a sterile gown. Skill 32.4 describes how to don and remove sterile gloves by using the open method.

SKILL 32.4

DONNING AND REMOVING STERILE GLOVES (OPEN METHOD)

PURPOSES

- To enable the nurse to handle sterile objects freely
- To prevent clients at risk (e.g., those with open wounds) from becoming infected by microorganisms on the nurse's hands

ASSESSMENT

Review the client's record and orders to determine exactly what procedure will be performed that requires sterile gloves. Check the client record and ask about latex allergies. Use nonlatex gloves whenever possible.

Planning

Think through the procedure, planning which steps need to be completed before the gloves can be applied. Determine what additional supplies are needed to perform the procedure for this client. Always have an extra pair of sterile gloves available.

Equipment

- Package of sterile gloves

(continued)

SKILL 32.4

DONNING AND REMOVING STERILE GLOVES (OPEN METHOD) (*continued*)

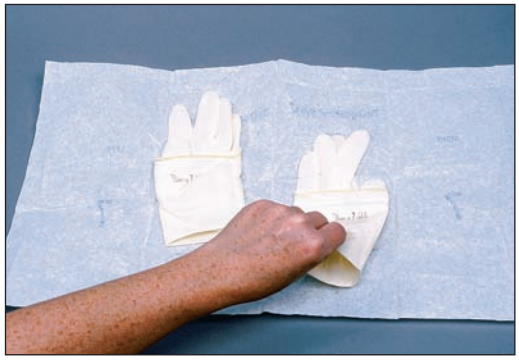
IMPLEMENTATION

Preparation

Ensure the sterility of the package of gloves.

Performance

1. Before performing the procedure, introduce yourself and verify the client's identity by using agency protocol. Explain to the client what you are going to do, why it is necessary, and how he or she can cooperate.
2. Observe other appropriate infection prevention and control procedures (see Skill 32.1, Skill 32.2, and Skill 32.3).
3. Provide for client privacy.
4. Open the package of sterile gloves.
   - Place the package of gloves on a clean dry surface. **Rationale: Any moisture on the surface could contaminate the gloves.**
   - Some gloves are packed in an inner as well as an outer package. Open the outer package without contaminating the gloves or the inner package. See Skill 32.3.
   - Remove the inner package from the outer package.
   - Open the inner package as in step 4 of Skill 32.3 or according to the manufacturer's directions. Some manufacturers provide a numbered sequence for opening the flaps and folded tabs to grasp for opening the flaps. If no tabs are provided, pluck the flap so that the fingers do not touch the inner surfaces. **Rationale: The inner surfaces, which are next to the sterile gloves, will remain sterile.**
5. Put the first glove on the dominant hand.
   - If the gloves are packaged so that they lie side by side, grasp the glove for the dominant hand by its cuff (on the palmar side) with the thumb and first finger of the nondominant hand. Touch only the inside of the cuff (see 1). **Rationale: The hands are not sterile. By touching only the inside of the glove, the nurse avoids contaminating the outside.**
   - *Or* if the gloves are packaged one on top of the other, grasp the cuff of the top glove as above, using the opposite hand.
   - Insert the dominant hand into the glove and pull the glove on. Keep the thumb of the inserted hand against the palm of the hand during insertion (see 2). **Rationale: If the thumb is kept against the palm, it is less likely to contaminate the outside of the glove.**
   - Leave the cuff turned down. **Rationale: Attempting to further unfold the cuff is likely to contaminate the gloves.**
6. Put the second glove on the nondominant hand.
   - Pick up the other glove with the sterile gloved hand, inserting the gloved fingers under the cuff and holding the gloved thumb close to the gloved palm (see 3). **Rationale: This helps prevent accidental contamination of the glove by the bare hand.**



1 Picking up the first sterile glove

2 Putting on the first sterile glove

3 Picking up the second sterile glove

(continued)

SKILL 32.4

DONNING AND REMOVING STERILE GLOVES (OPEN METHOD) (*continued*)

- Pull on the second glove carefully. Hold the thumb of the gloved first hand as far as possible from the palm (see 4). **Rationale: In this position, the thumb is less likely to touch the arm and become contaminated.**
- Adjust each glove so that it fits smoothly, and carefully pull up the cuffs by sliding the fingers under the cuffs.

7. Remove and dispose of used gloves.

- Remove them by turning them inside out. See Skill 32.2.

4 Putting on the second sterile glove

EVALUATION

Conduct any follow-up indicated during your care of the client. Ensure that adequate numbers and types of sterile supplies are available for the next health-care provider.

Latex and latex-free (e.g., nitrile and vinyl) sterile gloves are available to protect the nurse from contact with blood and body fluids. Latex and nitrile are more flexible than vinyl, mould to the wearer's hands, allow freedom of movement, and have the added feature of resealing tiny punctures automatically. Therefore, wear latex or nitrile gloves when performing tasks (1) that demand flexibility, (2) that place stress on the material (e.g., turning stopcocks, handling sharp instruments or tape), and (3) that involve a high risk of exposure to pathogens. Vinyl gloves should be chosen for tasks unlikely to stress the glove material, requiring minimal precision, or with minimal risk of exposure to pathogens.

Sterile Gowns Sterile gowning and closed gloving are chiefly carried out in operating or delivery rooms. The closed method of gloving can be used only when a sterile gown is worn because the gloves are handled through the sleeves of the gown. Before these procedures, the nurse dons a hair cover and a mask, and performs a surgical handwash.

Skill 32.5 describes the steps in donning a sterile gown and sterile gloves by the closed method.

SKILL 32.5

DONNING A STERILE GOWN AND STERILE GLOVES (CLOSED METHOD)

PURPOSES

- To enable the nurse to work close to a sterile field and handle sterile objects freely
- To protect clients from becoming contaminated with microorganisms on the nurse's hands, arms, and clothing

ASSESSMENT

Review the client's record and orders to determine exactly what procedure will be performed that requires sterile gloves. Check the client record and ask about latex allergies. Use nonlatex gloves whenever possible.

Planning

Think through the procedure, planning which steps need to be completed before the gown and gloves can be applied.

Determine what additional supplies are needed to perform the procedure for this client. Always have an extra pair of sterile gloves and an extra sterile gown available.

Equipment

- Sterile pack containing a sterile gown
- Sterile gloves

IMPLEMENTATION

Ensure the sterility of the gown and gloves.

Performance

1. Before performing the procedure, introduce yourself and verify the client's identity by using agency protocol.

(continued)

SKILL 32.5

DONNING A STERILE GOWN AND STERILE GLOVES (CLOSED METHOD) (*continued*)

Explain to the client what you are going to do, why it is necessary, and how he or she can cooperate.

2. Observe other appropriate infection prevention and control procedures (see Skills 32.1, 32.2, and 32.3).
3. Provide for client privacy.

Donning a Sterile Gown

4. Open the package of sterile gloves.
   - Remove the outer wrap from the sterile gloves and leave the gloves in their inner sterile wrap on the sterile field. **Rationale: If the inner wrapper is not touched, it will remain sterile**. See Skill 32.3, step 4.
5. Unwrap the sterile gown pack.
6. Perform proper hand hygiene. (See "Variation" at the end of Skill 32.1 and review agency practice.)
7. Put on the sterile gown.
   - Grasp the sterile gown at the neck, hold it away from you, and permit it to unfold freely without touching anything, including the uniform. **Rationale: The gown will be unsterile if its outer surface touches any unsterile objects**.
   - Put the hands inside the shoulders of the gown, and work the arms partway into the sleeves without touching the outside of the gown (see 1).
   - If donning sterile gloves by using the *closed* method (see below), work the hands down the sleeves only to the proximal edge of the cuffs.
   - *Or* if donning sterile gloves by using the *open* method, work the hands down the sleeves and through the cuffs.
   - Have a co-worker wearing a hair cover and mask grasp the neck ties without touching the outside of the gown and pull the gown upward to cover the neckline of your uniform in front and back. The co-worker ties the neck ties. Gowning continues at step 11.

Donning Sterile Gloves (Closed Method)

8. Open the sterile glove wrapper while the hands are still covered by the sleeves (see 2).

1 Putting on a sterile gown

2 Opening the sterile glove wrapper

9. Put the glove on the nondominant hand (see 3).
   - With the *dominant* hand, pick up the *opposite* glove with the thumb and index finger, handling it through the sleeve.
   - Lay the glove on the opposite gown cuff, thumb side down, with the glove opening pointed toward the fingers. Position the dominant hand palm upward inside the sleeve.

3 Positioning the first sterile glove for the nondominant hand

(continued)

SKILL 32.5

DONNING A STERILE GOWN AND STERILE GLOVES (CLOSED METHOD) (*continued*)

- Use the nondominant hand to grasp the cuff of the glove through the gown cuff, and firmly anchor it.
- With the dominant hand working through its sleeve, grasp the upper side of the glove's cuff, and stretch it over the cuff of the gown.
- Pull the sleeve up to draw the cuff over the wrist as you extend the fingers of the nondominant hand into the glove's fingers (see 4).

10. Put the glove on the dominant hand.

- Place the fingers of the gloved hand under the cuff of the remaining glove.
- Place the glove over the cuff of the second sleeve.
- Extend the fingers into the glove as you pull the glove up over the gown cuff (see 5).

Completion of Gowning

11. Complete gowning as follows:

- Have a co-worker wearing a hair cover and mask hold the waist tie of your gown by using sterile gloves or a sterile forcep or drape. **Rationale: This approach keeps the ties sterile.**
- Make a three-quarter turn, then take the tie from the co-worker and secure it in front of the gown.
- *Or* have a co-worker wearing sterile gloves take the two ties at each side of the gown and tie them at the back of the gown, making sure that your uniform is completely covered. **Rationale: Both methods ensure that the back of the gown remains sterile.**
- When worn, sterile gowns should be considered *sterile* only in front from the waist to the shoulder. The sleeves should be considered sterile from the cuff to 5 cm above the elbow, since the arms of a scrubbed person must move across a sterile field. Moisture collection and friction areas, such as the neckline, shoulders, underarms and back, should be considered unsterile.

12. Remove and dispose of used gown and gloves.

- If soiled, remove the attire by turning it inside out. See removal of disposable gowns and gloves in Skill 32.2 for the sequence of removing the gown.

4 Pulling on the first sterile glove

5 Extending the fingers into the second glove of the dominant hand

EVALUATION

- Conduct any follow-up indicated during your care of the client. Ensure that adequate numbers and types of sterile supplies are available for the next health-care provider.

Support of the Defences of a Susceptible Host

People are constantly in contact with microorganisms in the environment. Normally, a person's natural defences ward off the development of an infection. *Susceptibility* is the degree to which an individual can be affected, that is, the likelihood of an organism causing an infection in that person. Factors affecting a person's susceptibility have previously been identified. Although it is not possible to specifically manipulate age or heredity as risk factors, a number of strategies can support host defences.

CLINICAL ALERT
A person does not need to have an identified infection in order to pass potentially infective microorganisms to another person. Even normal microorganisms for one person can infect another person.

HYGIENE Maintaining the intactness of the skin and mucous membranes retains a barrier against microorganisms entering the body. In addition, oral care, including flossing the teeth, reduces the likelihood of an oral infection. Regular and thorough bathing and shampooing remove microorganisms, and the dirt that contains them, that can cause an infection.

NUTRITION A balanced diet enhances the health of all body tissues, helps keep the skin intact, and promotes the skin's ability to repel microorganisms. Adequate nutrition enables tissues to maintain and rebuild themselves and helps keep the immune system functioning well.

FLUID An adequate fluid intake permits a fluid output that flushes out the bladder and urethra, removing microorganisms that could cause an infection. Adequate hydration also helps maintain the natural barriers since dehydrated skin or mucous membranes have breaks through which microorganisms can enter. Adequate rest and sleep are essential to health and to renewing energy. See Chapter 37.

STRESS Excessive stress predisposes people to infections. Nurses can assist clients to learn stress-reducing techniques. See Chapter 47.

OPTIMIZING TISSUE OXYGENATION AND BLOOD FLOW Optimizing blood flow allows sufficient numbers of leukocytes to reach a given tissue; these are key cells for reducing the number of microorganisms locally. Adequate tissue oxygenation will promote production of ATP (adenosine triphosphate) for use by the leukocytes and either replacement or strengthening of the tissue. Reducing smoking, ensuring adequate hydration, managing pain, reducing stress, reducing obesity, and correcting anemia are all strategies that promote blood flow and tissue oxygenation.

GLYCEMIC CONTROL Uncontrolled diabetes is a major risk factor for a variety of infections. Maintaining glycemic control can reduce the physiological changes that increase risk. Studies have shown that hemoglobin A1C levels of less than 7%, the target indicator of glycemic control, are significantly associated with lower rates of infection in surgical patients (Dronge et al., 2006). Diabetic clients need to be taught to monitor their blood glucose levels and appropriate diet, exercise, and medication strategies for controlling them.

IMMUNIZATIONS Immunizations have dramatically decreased the incidence of infectious diseases. It is recommended that immunizations begin shortly after birth and be completed in early childhood, except for boosters (see Table 32.9 for recommended immunizations for Canadian children). Immunizations are frequently given in combination to minimize multiple injections. Because immunization schedules change frequently, it is advisable to update immunization schedules yearly. The information can be obtained from the Public Health Agency of Canada National Advisory Committee on Immunization. Similar committees exist in other countries, including the United States, Australia, and the United Kingdom, and as part of the World Health Organization.

All adults should ensure they are adequately immunized, by completion of childhood vaccination or by booster doses, as appropriate, against the following diseases: diphtheria, tetanus, pertussis, polio, measles, mumps, and rubella (see Table 32.10). Immunization

TABLE 32.9 Routine Immunization Schedules for Infants and Children

Age at vaccination	DTaP-IPV	Hib	MMR	Var	HB	Pneu-C-7	Men-C	Tdap	Inf
Birth					Infancy 3 doses ★				
2 months	⊖	✦				⊠	⊙		
4 months	⊖	✦				⊠	(⊙)		
6 months	⊖	✦				⊠	⊙		6–23 months ☢ 1–2 doses
12 months			■	●		⊠ 12–15 months	⊙ or if not yet given		
18 months	⊖	✦	■ or ■						
4–6 years	⊖								
14–15 years					Pre-teen/teen 2–3 doses		⊙ if not yet given	▲	

⊖ Diphtheria, tetanus, acellular pertussis and inactivated polio virus vaccine (DTaP-IPV)
✦ *Haemophilus influenzae* type b conjugate vaccine (Hib)
■ Measles, mumps, and rubella vaccine (MMR)
● Varicella vaccine (Var)
★ Hepatitis B vaccine (HB)
⊠ Pneumococcal polysaccharide : 23-valent (Pneu-P-23)
⊙ Meningococcal C conjugate vaccine (Men-C)
▲ Diphtheria, tetanus, acellular pertussis vaccine: adult/adolescent formulation (Tdap)
☢ Influenza vaccine (Flu)

Source: *Canadian Immunization Guide* (7th ed., 2006). © Minister of Public Works and Government Services Canada, 2006.

Notes: There are provincial and territorial variations to this immunization schedule.

TABLE 32.10 Adult Immunization Schedule: Routine and Specific Risk Situations

Vaccine or Toxoid	Dosing Schedule If No Record or Unclear History of Immunization	Booster Schedule If Primary Series Completed
Tetanus and diphtheria given as Td; and pertussis given as Tdap	Doses 1 and 2, 4 to 8 weeks apart and dose 3 at 6 to 12 months later; one of the doses should be given as Tdap for pertussis protection	Td every 10 years; 1 dose should be given as Tdap if not previously given in adulthood
Measles, mumps, and rubella given as MMR	1 dose for adults born in or after 1970 without a history of measles or those individuals without evidence of immunity to rubella or mumps; second dose for selected groups	Not routinely required
Varicella	Doses 1 and 2 at least 4 weeks apart for susceptible adults (no history of natural disease or seronegativity)	Not currently recommended
Influenza	Adults ≥ 65 years; adults < 65 years at high risk of influenza-related complications, their household contacts, health-care workers, and all those wanting to be protected against influenza	Every autumn by using current recommended vaccine formulation
Pneumococcal polysaccharide	Adults ≥ 65 years; adults < 65 who have conditions putting them at increased risk of pneumococcal disease	1 dose

Source: *Canadian Immunization Guide,* 7th ed., 2006, by the Public Health Agency of Canada, Ottawa: Minister of Public Works and Government Services Canada.

programs are also available for high-risk groups, such as health-care personnel, people who have had a splenectomy, and people travelling, each of which require individual assessment. In view of the increased risk of exposure to communicable diseases, the following vaccines are also recommended for all health-care workers and others providing personal care: hepatitis B, influenza, and varicella if seronegative.

New vaccines are reviewed as they appear and may be recommended for very specific populations. For example, Gardasil, a vaccine against the human papilloma virus (HPV), is recommended for girls 9 to 13, before they commence sexual intercourse, and females between 14 and 26 years of age, even if they are already sexually active, have had previous pap abnormalities, or have had a previous HPV infection (National Advisory Committee on Immunization, 2007b).

Routine Practices and Additional Precautions

History of Isolation Precautions

Isolation precautions refer to measures designed to prevent the spread of infections or potentially infectious microorganisms to health-care personnel, clients, and visitors. A variety of infection prevention and control measures are used to decrease the risk of transmission of microorganisms in hospitals.

The history of Canada's isolation guidelines, under the guidance of the Laboratory Centre for Disease Control (LCDC), which has been replaced by the Public Health Agency of Canada, parallels that of the United States' Centers for Disease Control and Prevention (CDC).

Historically, health-care workers applied PPE and other measures when a client or resident was known to have or suspected of having an infection or communicable disease. To facilitate implementation, recommendations were written as systems of either category-specific or disease-specific isolation.

Category-specific isolation precautions were based on the presumed major mechanism of transmission and included seven categories: (1) strict isolation, (2) contact isolation, (3) respiratory isolation, (4) tuberculosis isolation, (5) enteric precautions, (6) drainage or secretions precautions, and (7) blood or body fluid precautions.

Disease-specific isolation precautions provided precautions for specific diseases. These precautions delineated using private rooms with special ventilation, having the client share a room with other clients infected with the same organism, and gowning to prevent gross soiling of clothes for specific infectious diseases.

In the 1980s, it became increasingly recognized that a number of people carried blood-borne infectious

agents without being identified as carriers. In 1987, the CDC and LCDC therefore presented recommendations (revised in 1988) for *universal precautions* (*UP*) on *all clients* to decrease the risk of transmitting unidentified pathogens. Universal precautions applied to those body fluids associated with *blood-borne pathogens,* namely, hepatitis B virus, hepatitis C virus, and HIV. This included blood and other body fluids containing visible blood. The recommendation did not imply that universal precautions replaced disease-specific or category-specific precautions but that they should be used in conjunction with them.

The *body substance isolation* (BSI) system, introduced in the early 1990s, employed generic infection prevention and control precautions for *all* clients, except those with the few diseases transmitted through the airborne route. This system was based on three premises:

1. All people have an increased risk for infection from microorganisms placed on their mucous membranes and nonintact skin.
2. All people are likely to have potentially infectious microorganisms in all of their moist body sites and substances.
3. An unknown portion of clients and health-care workers will always be colonized or infected with potentially infectious microorganisms in their blood and other moist body sites and substances.

The term *body substance* included blood and some body fluids but also urine, feces, wound drainage, oral secretions, and any other body substance. Barrier precautions addressed the activity performed as opposed to the diagnosis.

Recommendations evolved further in the mid-1990s, with selection of the best recommendations from all previous work being merged into standard precautions and three categories of transmission-based precautions. This framework was directed at acute-care facilities and did not address specific needs of long-term-care, ambulatory care, and home care agencies. To this end, Canadian authorities advocated the terms *routine practices* and *additional precautions* in place of *standard precautions* and *transmission-based precautions,* to emphasize the need to apply precautions to all patients, no matter the venue of health care. This system of routine practices and additional precautions, first published in 1999, remains current today and provides recommendations that include these settings, as well as include special considerations for the prevention of transmission of tuberculosis, blood-borne pathogens, hemorrhagic fevers, and certain multidrug-resistant organisms, such as vancomycin-resistant enterococci (VRE).

Routine Practices

Routine practices are used in the care of all clients regardless of their diagnosis or possible infection status. They apply to blood, all body fluids, secretions, and excretions (*except sweat*), nonintact skin, and mucous membranes whether or not blood is present or visible. Routine practices combine the major features of universal precautions and body substance isolation. Recommended practices for routine practices are shown in Box 32.2.

BOX 32.2 RECOMMENDED ROUTINE PRACTICES FOR ROUTINE PRACTICES

- These recommendations are designed for *all* clients (i.e., in hospital, long-term-care facilities, community, and any other care setting).
- These precautions apply to blood; all body fluids, excretions, and secretions except sweat; nonintact (broken) skin; and mucous membranes.
- They are designed to reduce risk of transmission of microorganisms from recognized and unrecognized sources.

1. Wash hands after contact with blood, body fluids, secretions, excretions, nonintact skin, mucous membranes, and contaminated objects whether or not gloves are worn. If hands are not visibly soiled, then hand hygiene may be performed with an alcohol-based hand rub. Hand hygiene is performed between client contacts.
   a. Perform hand hygiene immediately after removing gloves.
   b. Use a plain soap for routine handwashing.
   c. Use an antimicrobial agent or an antiseptic agent for the control of specific outbreaks of infection.
2. Wear clean gloves when touching blood, body fluids, secretions, excretions, nonintact skin and mucous membranes, and contaminated items (e.g., soiled gowns).
   a. Clean gloves can be unsterile unless their use is intended to prevent the entrance of microorganisms into the body. See the discussion of sterile gloves in this chapter.
   b. Remove gloves before touching uncontaminated items and surfaces.
   c. Perform hand hygiene immediately after removing gloves.
3. Wear a mask, eye protection, or a face shield if splashes or sprays of blood, body fluids, secretions, or excretions can be expected.
4. Wear a clean, nonsterile gown if client care is likely to result in splashes or sprays of blood, body fluids, secretions, or excretions. The gown is intended to protect clothing.
   a. Remove a soiled gown carefully to avoid the transfer of microorganisms to others (i.e., clients, other health-care workers, or yourself).
   b. Perform hand hygiene after removing gown.

(continued)

BOX 32.2 RECOMMENDED PRACTICES FOR ROUTINE PRACTICES (*continued*)

5. Handle client care equipment that is soiled with blood, body fluids, secretions, or excretions carefully to prevent the transfer of microorganisms to others and to the environment.
   a. Make sure reusable equipment is cleaned and reprocessed correctly.
   b. Dispose of single-use equipment correctly.
6. Handle, transport, and process linen that is soiled with blood, body fluids, secretions, or excretions in a manner to prevent contamination of clothing and the transfer of microorganisms to others and to the environment.
7. Prevent injuries from used scalpels, needles, or other equipment, and place in puncture-resistant containers.

Additional Precautions

Additional precautions are used in addition to routine practices for clients with *known* or *suspected* infections that are spread in one of three ways: by airborne transmission, by droplet transmission, or by contact (direct or indirect). The three types of additional precautions can be used alone or in combination with each other but they are always used *in addition* to routine practices. They encompass all the conditions or diseases previously listed in the category-specific or disease-specific classifications. Recommended practices for additional precautions are shown in Box 32.3.

BOX 32.3 RECOMMENDED ADDITIONAL PRECAUTIONS

The following are additional precautions:

AIRBORNE PRECAUTIONS

Use the routine practices as well as the following:

1. Place the client in a private room that has negative air pressure, six to nine air changes per hour, and either discharge of air to the outside or a filtration system for the room air. Keep doors closed.
2. If a private room is not available, place the client with another client who is infected with the same microorganism.
3. Wear a respirator (e.g., N95) when entering the room of a client who is known or suspected of having primary tuberculosis.
4. Susceptible people should not enter the room of a client who has rubella (measles) or varicella (chickenpox). If they must enter, they should wear a respirator.
5. Limit movement of client outside the room to essential purposes. Place a surgical mask on the client during transport.
6. Perform hand hygiene after removing a respirator.

DROPLET PRECAUTIONS

Use the routine practices as well as the following:

1. Place the client in private room.
2. If a private room is not available, place the client with another client who is infected with the same microorganism.
3. Wear a mask if working within 1 to 2 metres of the client.
4. Limit movement of the client outside the room to essential purposes. Place a surgical mask on the client during transport.
5. Perform hand hygiene after removing mask.

CONTACT PRECAUTIONS

Use the routine practices as well as the following:

1. Place the client in private room.
2. If a private room is not available, place the client with another client who is infected with the same microorganism.
3. Wear gloves on entering the client's room.
   a. Change gloves after contact with infectious material.
   b. Remove gloves before leaving the client's room.
   c. Perform hand hygiene immediately after removing gloves.
   d. After hand washing, do not touch possibly contaminated surfaces or items in the room.
4. Wear a gown when entering a room if there is a possibility of contact with infected surfaces or items, or if the client is incontinent, or has diarrhea, a colostomy, or wound drainage not contained by a dressing.
   a. Remove gown in the client's room.
   b. Make sure uniform does not contact possible contaminated surfaces.
5. Limit movement of the client outside the room.
6. Dedicate the use of noncritical client care equipment to a single client or to clients with the same infecting microorganisms.

Source: Summarized from "Routine Practices and Additional Precautions for Preventing the Transmission of Infection in Health Care," by Health Canada, 1999, *Canada Communicable Disease Report, 25S4* (July), pp. 1–155.

Airborne precautions are used for clients known or suspected to have serious illnesses transmitted by airborne droplet nuclei smaller than 5 microns. Examples of such illnesses include measles, rubeola, varicella (including disseminated zoster), and tuberculosis.

Droplet precautions are used for clients known or suspected to have serious illnesses transmitted by particle droplets larger than 5 microns. Examples of such illnesses are diphtheria (pharyngeal); pertussis (whooping cough); mumps; rubella; influenza, pneumonia, scarlet fever in infants and young children; and pneumonic plague.

Contact precautions are used for clients known or suspected to have serious illnesses easily transmitted by direct client contact or by contact with items in the client's environment. Such illnesses include gastrointestinal, respiratory, skin, or wound infections or colonization with multidrug-resistant bacteria; specific enteric infections, such as *Clostridium difficile,* enterohemorrhagic *Escherichia coli* O157:H7, *Shigella,* and hepatitis A in diapered or incontinent clients; respiratory syncytial virus, parainfluenza virus, or enteroviral infections in infants and young children; and highly contagious skin infections, such as herpes simplex virus, impetigo, pediculosis, and scabies.

SPECIAL CONSIDERATIONS: COUGH ETIQUETTE To further reduce transmission by droplets, respiratory secretions should be contained as much as possible. **Cough etiquette** involves coughing or sneezing into tissues or cloth (e.g., sleeves) rather than hands, which become contaminated. Used tissues should be immediately discarded, not saved for reuse, and hands washed or decontaminated with an alcohol-based hand rub. Further containment of infection can be achieved by recognizing when you pose a risk to others and staying home from work and not socializing.

SPECIAL CONSIDERATIONS: MULTI-DRUG RESISTANT ORGANISMS AND EMERGING PATHOGENS In addition to the preceding precautions, additional measures can be used for specific communicable diseases caused by multi-drug or antibiotic-resistant organisms, such as vancomycin-resistant enterococci (VRE) or methicillin-resistant *Staphylococcus aureus* (MRSA). Nurses should follow their agency's guidelines with respect to these pathogens, as protocols vary by jurisdiction. Additional precautions may also be warranted for newly emerging infectious agents, such as severe acute respiratory syndrome (SARS), or microorganisms that are difficult to eliminate from the environment, such as *Clostridium difficile* or norovirus.

SPECIAL CONSIDERATIONS: IMMUNOCOMPROMISED CLIENTS Compromised clients are those who are highly susceptible to infection, such as those who

- Have diseases (e.g., leukemia) or have received treatments (e.g., cancer chemotherapy) that depress the resistance to infectious organisms
- Have extensive skin impairments, such as severe dermatitis or major burns that cannot be effectively covered with dressings

Such clients are often infected by their own microorganisms (endogenous source), but they can also be infected by microorganisms carried on the inadequately washed hands of health-care personnel, and by nonsterile items (food, water, air, and client care equipment). Guidelines for severely compromised (immunocompromised) clients include the use of routine practices and additional precautions appropriate to their condition. Additional cleaning and use of protective clothing are not necessary beyond routine practices. The need for a single room depends on the extent to which the individual is compromised. Handwashing by health-care workers and visitors, and protection from those with infection, are essential to reducing transmission of organisms.

Practical Issues for Implementation of Precautions

Disposal of Soiled Equipment and Supplies

Many pieces of equipment are supplied for single use only and are disposed of after use. Some items, however, are reusable. Agencies have specific policies and procedures for handling soiled equipment (e.g., disposal, cleaning, disinfecting, and sterilizing); the nurse needs to be familiar with these practices and with what items can be reused. Appropriate handling of soiled equipment and supplies is essential for these reasons:

- To prevent inadvertent exposure of health-care workers to articles contaminated with body substances
- To prevent contamination of the environment

See Skill 32.2 for removing soiled PPE. Information about cleaning, disinfecting, and sterilizing is presented earlier in this chapter.

BAGGING Most articles do not need to be placed in bags unless they are contaminated, or likely to have been contaminated, with infective material, such as pus, blood, body fluids, feces, or respiratory secretions. Contaminated articles need to be enclosed in a sturdy bag impervious to microorganisms before removal from the

client's room. Some agencies use labels or bags of a particular colour that designate them as infective wastes.

Follow agency protocol, or use the following guidelines to handle and bag soiled items:

- Use a single bag if it is sturdy and impervious to microorganisms, and if the contaminated articles can be placed in the bag without soiling or contaminating its outside.
- Double-bag if the above conditions are not met.
- Place garbage and soiled *disposable* equipment, including dressings and tissues, in the plastic bag that lines the waste container. Some agencies separate dry and wet waste material and incinerate dry items, such as paper towels and disposable items. No special precautions are required for disposable equipment that is not contaminated.
- Place *nondisposable* or *reusable* equipment that is visibly soiled in a labelled bag before removing it from the client's room or cubicle, and send it to a central processing area for decontamination. Some agencies may require that glass and metal items be placed in separate bags from rubber and plastic items. Glass and metal can be sterilized in an autoclave, but rubber and plastic are damaged by this process and must be cleaned by other methods, such as gas sterilization.
- Disassemble *special procedure trays* into component parts. Some components are disposable; others need to be sent to the laundry or central services for cleaning and decontaminating.
- Bag soiled *clothing* before sending it home or to the agency laundry.

LINENS Handle soiled linen as little as possible and with minimal manipulation before placing it in the laundry hamper. This prevents gross microbial contamination of the air and persons handling the linen. Close the bag before sending it to the laundry, in accordance with agency protocol.

LABORATORY SPECIMENS Laboratory specimens, if placed in a leakproof container with a secure lid, need no special precautions. Use care when collecting specimens to avoid contaminating the outside of the container. Containers that are visibly contaminated on the outside should be placed inside a sealable plastic bag before sending them to the laboratory. This prevents personnel from having hand contact with potentially infective material.

DISHES Dishes require no special precautions. Soiling of dishes can largely be prevented by encouraging clients to wash their hands before eating. Some agencies use paper dishes for convenience, which are disposed of in the refuse container.

BLOOD PRESSURE EQUIPMENT Other than routine cleaning, blood pressure equipment needs no special precautions unless it becomes contaminated with infective material. If it does become contaminated, follow agency practice. Cleaning procedures vary according to whether it is a wall or portable unit.

THERMOMETERS Nondisposable used thermometers are generally disinfected after use. Check agency practice.

DISPOSABLE NEEDLES, SYRINGES, AND SHARPS Place needles, syringes, and sharps (e.g., lancets, scalpels, and broken glass) into a puncture-resistant container. To avoid puncture wounds, do not detach needles from the syringe or recap the needle before disposal. See Chapter 31 for preventing needle-stick injuries.

TOYS Personal toys that are visibly contaminated are bagged and sent home. Agency toys, if visibly soiled, may require cleaning. Check agency practice. Depending on the type of microorganism, its transmission, and the child's hygiene behaviours, special precautions may be required. For example, a child who has an enteric infection that can be spread by contact transmission or by fomites may not be allowed to share toys with others.

HAZARDOUS MATERIAL In addition to precautions discussed in this chapter, significant emphasis is placed on avoiding injury caused by sharp instruments, measures to be taken in case of exposure to blood-borne pathogens, and communication of biohazards to employees. Health Canada (2008) requires that Workplace Hazardous Materials Information System (WHMIS) labels be affixed to containers of regulated waste and to refrigerators and freezers containing blood or other potentially infectious materials. The labels required are fluorescent orange or orange-red and feature the biohazard symbol shown in Figure 32.3.

Transporting Clients with Infections

Transporting clients with infections outside their own rooms is avoided unless absolutely necessary. If a client

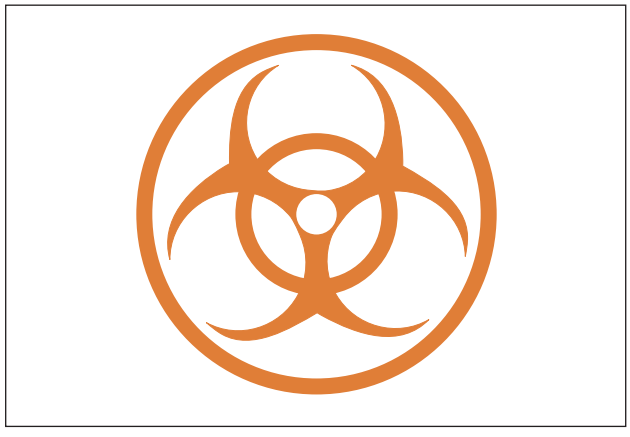


FIGURE 32.3 Biohazard infectious materials

(From Health Canada. Workplace Hazardous Materials Information System. http://www.hc-sc.gc.ca/hecs-sesc/whmis/whmis_symbols.htm)

must be moved, the nurse implements appropriate measures to prevent soilage of the environment. For example, the nurse ensures that any draining wound is securely covered or places a surgical mask on the client who has an airborne infection. In addition, the nurse notifies personnel at the receiving area of any infection risk so that they can maintain necessary precautions. Follow agency protocol.

Psychosocial Needs of Clients Requiring Isolation Precautions

Clients requiring isolation precautions can develop several problems as a result of the separation from others and of the special precautions taken in their care. Two of the most common are sensory deprivation and feelings of inferiority. *Sensory deprivation* occurs when the environment lacks normal stimuli for the client, for example, communication with others. Nurses should, therefore, be alert to common clinical signs of sensory deprivation: boredom, inactivity, slowness of thought, daydreaming, increased sleeping, thought disorganization, anxiety, hallucinations, and panic. Furthermore, nurses should be aware that staff members might contribute to sensory deprivation by spending less time with the client than might otherwise occur, especially if the client is in a single room, or if gowns and masks are required. Since the latter require additional time for client care, nurses may not be able to frequently or quickly check on a client.

A client's *feeling of inferiority* can be due to the perception of the infection itself or to the required precautions. In North America, many people place a high value on cleanliness, and the idea of being "soiled," "contaminated," or "dirty" can give clients the feeling that they are at fault and are substandard. Although this is inaccurate, the infected persons may feel they are not as good as others and blame themselves.

Nurses need to provide care that prevents these two problems or that deals with them positively. Nursing interventions include the following:

- Assess the individual's need for stimulation.
- Initiate measures to help meet the need, including regular communication with the client and diversionary activities, such as toys for a child and books, television, or radio for an adult; provide a variety of foods to stimulate the client's sense of taste; stimulate the client's visual sense by providing a view or an activity to watch.
- Explain the infection and the associated procedures to help clients and their significant others understand the situation.
- Demonstrate warm, accepting behaviour. Avoid conveying to the client any sense of annoyance about the precautions or any feelings of revulsion about the infection.
- Do not use stricter precautions than are indicated by the diagnosis or the client's condition.

Nursing Responsibility for Infection Prevention and Control

Initiation of practices to prevent the transmission of microorganisms is generally a nursing responsibility and is based on a comprehensive assessment of the client. This assessment takes into account the status of the client's normal defence mechanisms, the client's ability to implement necessary precautions, and the source and mode of transmission of the infectious agent. The nurse then decides whether to wear gloves, gowns, masks, or protective eyewear. In all client situations, nurses must *perform appropriate hand hygiene.* Nurses should be aware of resources in their practice setting, such as an infection prevention and control policy and procedure manuals or infection-control practitioners, and refer to these resources for guidance when necessary.

Besides initiating and maintaining routine practices and additional precautions, nurses have a responsibility for evaluating changes in the client's condition that could indicate a need for further precautions, or indicate that additional precautions are no longer warranted. In some agencies or practice settings, especially community health, nurses are responsible for notifying the local public health officials about notifiable diseases so that accurate incidence rates can be calculated and contacts managed, as appropriate. Nurses might also be responsible for alerting infection-control practitioners about incidence or clusters of infections, or situations that might increase risk of infection. Nurses share responsibility for ensuring visitors wash their hands and following posted instructions, and for assisting clients to clean their hands after using the toilet and before eating (see the Reflect on Primary Health Care box). Furthermore, nurses can demonstrate prevention behaviours by updating their immunizations and not reporting to work when ill.

In addition to the precautions cited within this chapter, the nurse implements specific actions relevant to infection prevention and control when performing many

REFLECT ON PRIMARY HEALTH CARE

Canadians have become increasingly aware of the importance of hand hygiene in the prevention and control of infection. Consider the role of *intersectoral collaboration* the next time you see a sign in a washroom reminding you to wash your hands. Automated wall mounted alcohol-based hand rub dispensers at entrance ways to public facilities and automatic sensor water faucets are examples of *appropriate technology* to limit the spread of infection. The next time a client or patient asks, "have you washed your hands?" consider that this person is a true *participant* in his or her health care.

specific therapies discussed throughout this book. The following are some examples:

- Use strict aseptic technique when performing any invasive procedure (e.g., inserting an intravenous needle or catheter, suctioning an airway, and inserting a urinary catheter) and when changing surgical dressings.
- Handle needles and syringes carefully to avoid needle-stick injuries. See Chapter 31.
- Change intravenous cannulae, tubing, and solution containers according to agency policy. See Chapter 43.
- Check all sterile supplies for expiry date and intact packaging before use.
- Prevent urinary infections by maintaining a closed urinary drainage system with a downward flow of urine. Do not irrigate a catheter unless ordered to do so. Provide regular catheter and perineal care. Keep the drainage bag and spout off the floor. See Chapter 41.
- Implement measures to prevent impaired skin integrity and to prevent accumulation of secretions in the lungs (for example, encourage the client to move, breathe deeply, and cough at least every two hours).

Assessing

NURSING HISTORY During the nursing history, the nurse assesses (1) the degree to which a client is at risk for developing an infection, and (2) any client complaints suggesting the presence of an infection. To identify clients at risk, the nurse reviews the client's chart and structures the nursing interview to collect data regarding the factors influencing the development of infection, especially existing disease process, history of recurrent infections, current medications and therapeutic measures, current emotional stressors, nutritional status, and history of immunizations. To obtain subjective data that may indicate the presence of an infection, the nurse asks whether the client has experienced loss of energy, loss of appetite, nausea, headache, or other signs associated with specific body systems (e.g., difficulty urinating, urinary frequency, or a sore throat). Specific questions to be asked depend on the clinical situation and should be directly related to what the suspected infection might be or the type of infection for which the client is likely at risk. See the Assessment: Interview box for sample assessment questions.

PHYSICAL ASSESSMENT Signs and symptoms of an infection vary according to the body area involved. For example, sneezing, watery or mucoid discharge from the nose, and nasal stuffiness commonly occur with an infection of the nose and sinuses; urinary frequency and sometimes cloudy or discoloured urine often occur with a urinary infection. Signs and symptoms of *localized infection* include the following:

- Localized swelling
- Localized redness
- Pain or tenderness with palpation or movement
- Palpable heat at the infected area
- Loss of function of the body part affected, depending on the site and extent of involvement
- Drainage from open wounds; exudate may be of various colours

Signs and symptoms of *systemic infection* are as follows:

- Fever
- Increased pulse and respiratory rate, if the fever is high
- Lassitude, malaise, and loss of energy
- Anorexia and, in some situations, nausea and vomiting
- Enlargement and tenderness of lymph nodes that drain the area of infection

LABORATORY DATA Laboratory data that indicate the presence of an infection include the following:

- Elevated leukocyte (white blood cell or WBC) count, if it is higher than 11×10^9/L.
- Increases in specific types of leukocytes as revealed in the differential white blood cell count. Specific

ASSESSMENT: INTERVIEW

Clients at Risk for Infections

The questions a nurse needs to ask will depend on the client, but the following provide a good guideline:

- When were you last immunized for diphtheria, tetanus, poliomyelitis, rubella, measles, influenza, hepatitis, and pneumococcal pneumonia?*
- When did you last have a tuberculin skin test?*
- What infections have you had in the past, and how were these treated?
- Have any of these infections recurred?
- Are you taking any antineoplastic, anti-inflammatory, or antibiotic medications?
- Do you smoke?
- Are you overweight?
- Do you have diabetes? If yes, how well controlled is it?
- Have you recently been exposed to someone with an infection?
- Have you had any recent diagnostic procedure or therapy that penetrated your skin or a body cavity?*
- What past surgeries have you had?
- How would you describe your nutritional status in terms of a well-balanced diet?
- On a scale of 0 to 10, how would you rate the stress you have experienced in the last 6 months?

* These questions would be tailored according to the nature of the infection the person is at risk for or suspected of having.

types of white blood cells are increased or decreased in certain infections.

- Urine, blood, sputum, or other drainage *cultures* that indicate the presence of pathogenic microorganisms. Culture and sensitivity testing involves laboratory cultivation of bacteria or yeast in a special growth medium. Laboratories report the specific species as well as its sensitivity or resistance to specific antibiotics. A Gram stain smear is also done, to identify the presence of bacteria, white blood cells, and epithelial cells in the original specimen. The presence of numerous white blood cells is indicative of infection, whereas the presence of numerous epithelial cells is indicative of a poor quality specimen (e.g., sputum may be contaminated with saliva). Collecting a good specimen is important if results are to be credible and useful. See also Skill 33.1 (page 949), "Obtaining a Wound Drainage Specimen for Culture."

Diagnosing

The NANDA International (2007) nursing diagnostic labels for problems associated with the transmission of microorganisms are (1) *Risk for Infection:* the state in which an individual is at risk for being invaded by an opportunistic or pathogenic microorganism from endogenous or exogenous sources; and (2) *Risk for Transmission of Infection*: the state in which an individual is at risk for transferring an opportunistic or pathogenic agent to others. Related factors may be pathophysiological in nature, treatment related, situational, or maturational.

Clients who have, or are at risk for, an infection are prime candidates for other physical and psychological problems. Examples of nursing diagnoses or collaborative problems that can arise from the actual presence of an infection include the following:

- *Potential Complication of Infection: Fever*
- *Imbalanced Nutrition Less Than Body Requirements* if the client is too ill to eat adequately
- *Acute Pain* if the client is experiencing tissue damage and discomfort
- *Impaired Social Interaction* or *Social Isolation* if the client is required to be separated from others during a contagious episode
- *Anxiety* if the client is apprehensive regarding changes in life activities resulting from the infection or its treatment, such as absence from work or inability to perform usual functions

Planning

The major goals for clients susceptible to infection are to

- Maintain or restore defences
- Avoid the spread of infectious organisms
- Reduce or alleviate problems associated with the infection

Desired health outcomes depend on the individual client's condition. Examples of desired health outcomes, although established in the planning phase, are provided in Table 32.11 in the "Evaluating" section later in this chapter.

Nursing strategies to meet the three broad goals stated above generally include the measures previously described for breaking the chain of infection, such as using meticulous hand hygiene and aseptic techniques to prevent the spread of potentially infectious microorganisms, implementing measures to support the defences of a susceptible host, and teaching clients about protective measures to prevent infections and the spread of infectious agents when an infection is present.

Examples of interventions related to clients at risk for infection include the following:

- Environmental management
- Infection prevention and control (e.g., minimizing the acquisition and transmission of infectious agents)
- Risk identification
- Teaching of individuals
- Wound care

Specific nursing activities associated with each of these interventions can be selected to meet the individual needs of the client.

PLANNING FOR HOME CARE Clients being discharged following hospital care for an infection often require continued care to completely eliminate the infection or to adapt to a chronic state. In addition, such clients may be at increased risk for reinfection or development of an opportunistic infection following therapy for existing pathogens.

In preparation for discharge, the nurse needs to know the clients and family's risks, needs, strengths, and resources. The nurse tailors the teaching plan for the client and family (see Teaching: Home Care).

Implementing

Whenever possible, the nurse invokes strategies to prevent infection. If infection cannot be prevented, the nurse works to prevent the spread of the infection within and between persons and to treat the existing infection. In the previous sections, specific nursing activities were described that interfere with the chain of infection to prevent and control transmission of infectious organisms and that promote care of the infected client. These activities were summarized earlier in Tables 32.5 and 32.6.

Evaluating

By using data collected during care—vital signs, breath sounds, skin status, characteristics of urine or other

TEACHING: HOME CARE

Environmental Management

The way the client takes care of an infection after going home is important. The nurse can help by teaching the client how to do it correctly:

- Discuss injury proofing the home to prevent the possibility of further tissue injury (e.g., use of padding, handrails, removal of hazards).
- Explore ways to control the environmental temperature and airflow (especially if client has an airborne pathogen).
- Determine the advisability of visitors and family members in close proximity to the client.
- Describe ways to manipulate the bed, the room, and other household facilities.

INFECTION CONTROL

- Based on assessment of client and family knowledge, teach proper hand hygiene (e.g. before handling foods, before eating, after toileting, before and after any required home care treatment, and after touching any body substances, such as wound drainage) and related hygiene measures to all family members.
- Promote nail care: keep fingernails short, clean, and well manicured to eliminate rough edges or hangnails, which can harbour microorganisms.
- Instruct not to share personal care items, such as toothbrush, washcloths, and towels, and describe the rationale of how infections can be transmitted from shared personal items.
- Discuss antimicrobial soaps and effective disinfectants.
- Ensure access to and proper use of gloves and other barriers as indicated by the type of infection or risk.
- Discuss the relationship among hygiene, rest, activity, and nutrition in the chain of infection.
- Instruct about proper administration of medication.
- Instruct about cleaning reusable equipment and supplies. Use soap and water, and disinfect with a chlorine bleach solution.

INFECTION PREVENTION

- Teach the client and family members how to avoid infections.
- Suggest techniques for safe food preservation and preparation (e.g., wash raw fruits and vegetables before eating them, refrigerate all opened and unpackaged foods).
- Remind to avoid coughing, sneezing, or breathing directly on others. Cover the mouth and nose with a tissue or the sleeve to prevent the transmission of airborne microorganisms.
- Inform of the importance of maintaining sufficient fluid intake to promote urine production and output. This helps flush the bladder and urethra of microorganisms.
- Emphasize the need for proper immunizations of all family members.

WOUND CARE

- Teach the client and family the signs of wound healing and of wound infection and why monitoring of the wound is important.
- Delineate the factors that promote wound healing.
- Explain the proper technique for changing the dressing and disposing of the soiled one. Reinforce need to place contaminated dressings and other disposable items containing body fluids in moisture-proof plastic bags.
- Advise to put used needles in a puncture-resistant container with a screw-top lid. Label so as not to discard in the garbage.

REFERRALS

- Provide appropriate information regarding how to access community resources, home care agencies, sources of supplies, and community or public health departments for immunizations.

drainage, laboratory blood values, and so on—the nurse judges whether client health outcomes have been achieved. Examples of client goals and related health outcomes are shown in Table 32.11.

If outcomes are not achieved, the nurse may need to consider such questions as the following:

- Were appropriate measures implemented to prevent skin breakdown and lung infection?
- Was strict aseptic technique implemented for invasive procedures?
- Are prescribed medications affecting the immune system?
- Is client placement appropriate to reduce the risk of transmission of microorganisms?
- Did the client and family misunderstand or fail to comply with necessary instructions?

Occupational Health Issues Related to Infection

The Public Health Agency of Canada provides guidelines to protect health-care workers from occupational exposure to blood-borne pathogens in the workplace. **Occupational exposure** is defined as reasonably anticipated skin, eye, mucous membrane, or parenteral contact with blood or other potentially infectious materials that may result from the performance of an employee's duties.

The transmission of infectious fluids in the clinical setting has three major modes:

TABLE 32.11 Evaluation of Goals and Health Outcomes: Risk for Infection

Goal	Examples of Desired Health Outcomes
Maintain body defences	Skin integrity intact
	Mucous membranes intact
	WBC values within normal range
	T-cell levels within normal range
	Respiratory assessment findings within normal range (e.g., respiratory rate, rhythm, depth, and breath sounds)
	Urinary tract assessment findings within normal range (e.g., urine colour, clarity, odour, and consistency)
	Gastrointestinal tract assessment findings within normal range (e.g., stool colour, odour, and consistency, and emesis is absent)
	Immunizations recommended for age are current
Avoid spread of microorganisms	Describes mode of transmission of microorganism
	Demonstrates infection prevention and control practices that reduce transmission
	Follows prescribed treatment for diagnosed infection

1. *Puncture wounds* from contaminated needles or other sharps, commonly referred to as needle-stick injuries
2. *Skin contact,* which allows infectious fluids to enter through wounds and broken or damaged skin
3. *Mucous membrane* contact, which allows infectious fluids to enter through mucous membranes of the eyes, mouth, and nose

Conscientious use of routine precautions, appropriately using PPE (gloves, masks, gowns, goggles, face shields, shoe covers, special resuscitative equipment), and avoiding carelessness in the clinical area will reduce the risk of injury to the caregiver. Used needles and sharp items should be disposed of immediately after use, without recapping of needles. Puncture resistant containers need to be placed for easy access in areas where the items are used. Measures to be taken in case of possible exposure to blood-borne pathogens are outlined in Box 32.4. Nurses should follow their agency's specific protocols for managing exposure and for handling blood or body fluid spills.

Nurses who themselves are infected with a blood-borne pathogen must ensure that they practise in a manner that does not put their clients at risk (Canadian Nurses Association, 2006). Most health-care agencies and some nursing regulatory bodies have expert panels to advise nurses and other health-care professionals in these situations.

The *Canadian Immunization Guide* (Minister of Public Works and Government Services Canada, 2006) recommends that health-care employers make the hepatitis B vaccine and vaccination series available to all employees. Other vaccinations may also be made available (e.g., nurses working in an obstetric area should be vaccinated against rubella to protect pregnant clients and their fetuses).

Roles of the Infection-Control Practitioner

Infection-control practitioners (ICPs) are important in both acute-care and continuing-care facilities. Many organizations, however, do not meet the recommendation of one ICP per 100 to 150 beds for acute care, and one per 100 to 250 beds for long-term care (Dougherty, 2001; O'Boyle, Jackson, & Henley, 2002; Zoutman et al. 2003). The role of the ICP is less developed in community health settings, outside of control of communicable diseases. The majority of ICPs come from a nursing background, though some may have a background in microbiology or epidemiology.

Key roles and activities of ICPs relate to the following:

- Surveillance of infections to monitor rates and trends in order to identify problems or affirm success of interventions
- Outbreak identification and management
- Staff education related to infection prevention and control, for example, with respect to using routine practices and additional precautions, promoting hand hygiene, or addressing and preventing specific problems
- Consultation with staff on individual client management
- Development, implementation, and evaluation of policies and procedures with specific implications

BOX 32.4 STEPS TO FOLLOW AFTER EXPOSURE TO BLOOD-BORNE PATHOGENS

The following are important steps to follow after exposure to blood-borne pathogens:

- Report the incident immediately to appropriate personnel within the agency.
- Complete an injury report.
- Seek appropriate evaluation and follow-up. This includes the following:
  - Identification and documentation of the source individual when feasible and legal
  - Testing of the source individual's blood when feasible and consent is given
  - Making results of the test available to the source individual's health-care provider
  - Testing of blood of the exposed health-care personnel (with consent)
  - Postexposure prophylaxis if medically indicated (e.g., hepatitis B vaccine for hepatitis B virus, or recommended agents for HIV)
  - Medical counselling regarding personal risk of infection or risk of infecting others
- For a puncture or laceration,
  - Encourage bleeding.
  - Clean the area with soap and water.
  - Initiate first aid and seek treatment, if indicated.
- For a mucous membrane exposure (eyes, nose, mouth), flush with saline solution or water for 5 to 10 minutes.

HIV POSTEXPOSURE PROTOCOL (PEP)

- Treatment should be started as soon as possible, preferably within hours after exposure. Treatment may be less effective when started more than 24 hours after exposure. Starting treatment after a longer period (e.g., 1 week) should be considered for high-risk exposures previously untreated.
- For high-risk exposure (high blood volume *and* source with a high HIV titre), three-drug treatment is recommended.
- For increased risk exposure (high blood volume *or* source with a high HIV titre): three-drug treatment is recommended.
- For low-risk exposure (neither high blood volume nor source with a high HIV titre), two-drug treatment is considered.
- Drug prophylaxis continues for 4 weeks.
- Drug regimens vary and new drugs and regimens are continually being developed.
- HIV antibody tests are done shortly after exposure (baseline), and 6 weeks, 3 months, and 6 months thereafter.

HEPATITIS B

- Anti-HBs testing 1 to 2 months after last vaccine dose
- Hepatitis B immunoglobulin (HBIg) or hepatitis B vaccine (or both) within 1 to 7 days following exposure for nonimmunue workers

HEPATITIS C

- Anti-HCV and ALT (alanine aminotransferase) at baseline and 4 to 6 months after exposure

for infection prevention and control (e.g., IV insertion or maintenance, O.R. procedures, infection prevention and control manual)

- Acting as consultants to a variety of committees on issues related to, or that may have an impact on, infection prevention and control (e.g., policy and procedure committee, selection of products for purchase)

ICPs also collaborate with occupational health and safety staff on specific issues, such as prevention and management of sharps injuries, or annual influenza immunization campaigns. Finally, ICPs are an integral part of infection prevention and control committees, which all health-care organizations must have. Such committees are multidisciplinary, including representatives from the clinical laboratory, housekeeping, maintenance, dietary, pharmacy, nursing, medicine, and client care areas. Their mandate is to monitor the infection prevention and control programs, advise ICPs on direction, and facilitate consultation between key groups.

Infection Prevention and Control Is a Shared Responsibility

Nurses are key players in preventing and controlling infections, given the nature and extent of their contact with clients. Their focus is most commonly on individuals and small groups (e.g., by identifying risks, performing hand hygiene, minimizing exposure of portals of entry to microorganisms, and using routine practices and additional precautions). They also contribute to promoting a safe work environment. Administrators share responsibility in promoting a safe work environment by ensuring appropriate staffing (in numbers and skills), implementing evidence-informed guidelines, and advocating for adequate supplies and structures (e.g., ventilation or environmental controls). Use of PPE alone is insufficient for preventing and controlling infections in the absence of administrative

supports and engineering controls. Infection-control practitioners focus on larger groups and institutions, both helping to identify problems and intervening to resolve them. Together health-care providers, clients and families, administrators, and infection-control practitioners can reduce the incidence of infections and their impact.

Case Study 32

Mrs. Cortez is a 76-year-old woman who is independent, lives alone, and prefers not to rely on others unless absolutely necessary. She was active and healthy until about 6 months ago, at which time she developed a persistent upper respiratory tract infection. Because she was unable to obtain or prepare food, she lost weight and became very weak. She finally sought medical attention, but she has not yet fully recovered. Mrs. Cortez was admitted to the acute-care facility for fever, shortness of breath, productive cough, dehydration, and nutritional deficiency. An initial Gram stain of a sputum specimen suggests that she does not have tuberculosis but may have pneumococcal pneumonia.

Critical Thinking Questions

1. Mrs. Cortez's physician suspects that she has pneumonia, a serious lower respiratory tract infection. Identify factors that increase Mrs. Cortez's risk for such an infection, and explain how each factor contributes to the risk.
2. What assessment data would be helpful to the nurse when planning care for Mrs. Cortez?
3. What routine practices and additional precautions should be instituted for Mrs. Cortez? Explain your reasoning in terms of the chain of infection.
4. What should the nurse teach Mrs. Cortez and her visitors with respect to preventing infection?
5. The nurse notes that the housekeeping aide is leaving Mrs. Cortez's room. The aide stops to wash her hands, soaping them and rubbing them together under running water for about 5 seconds. She then turns off the water before reaching for the paper towels to dry her hands. Should the nurse intervene, and if so, in what way?

After working through these questions, go to the MyNursingLab at **http://www.mynursinglab.com** to check your answers.

KEY TERMS

normal flora
resident flora
pathogen
infection
infectious agent
asepsis
nosocomial infections
health-care-associated infections
bacteremia
bacteria
viruses
fungi
protozoa
helminths
parasites
communicability
communicable disease
pathogenicity
opportunistic pathogen
virulence
virulence factors
nonspecific defences
macrophages
phagocytes
inflammation
hyperemia
leukocytes
margination
emigration
diapedesis
chemotaxis
leukocytosis
cytokine
pyrogen
exudate
pus
fibrinogen
regeneration
fibrous (scar) tissue
granulation tissue
cicatrix
specific defences
antigens
autoantigens
active immunity
passive immunity
humoral (circulating) immunity
antibody (immunoglobulin)
cell-mediated defences (cellular immunity)
virions
colonization
local infection
systemic infection
septicemia
carrier
microbial load
reservoir
direct contact transmission
indirect contact transmission
droplet transmission
airborne transmission
droplet nuclei

vehicle-borne transmission
fecal-oral route
vector-borne transmission
susceptible host
compromised host
immunization (vaccination)
antimicrobial agent
antiseptic
disinfection
disinfectant
sterilization
hand hygiene
respirator
fit testing
aseptic technique
clean technique
sterile technique
sterile field
isolation precautions
routine practices
additional precautions
airborne precautions
droplet precautions
contact precautions
cough etiquette
occupational exposure

CHAPTER HIGHLIGHTS

- Microorganisms are everywhere. Most are harmless and some are beneficial; however, many can cause infection in susceptible persons.
- Some normal body flora produce toxic metabolites, alter local pH, or physically compete for space, thereby inhibiting growth of foreign bacteria.
- Effective control of infectious disease is an international, national, community, and individual responsibility.
- Health-care-associated infections have significant impact on morbidity, mortality, quality of life, and health-care costs. Major sites for these infections are the respiratory and urinary tracts, the bloodstream, and surgical or open wounds.
- Bacteria and viruses are responsible for most health-care-associated infections. They differ in their ability to be spread from individual to individual, and in their ability to produce disease.
- Humans have both specific and nonspecific defences that combat infectious agents.
- Intact skin and mucous membranes are the body's first line of defence against microorganisms.
- Some body secretions (e.g., saliva and tears) contain enzymes that act as antibacterial agents.
- The inflammatory response limits physical, chemical, and microbial injury and promotes repair of injured tissue.
- Immunity is the specific resistance of the body to infectious agents. Antibodies neutralize viruses or toxins so that they cannot enter or damage cells, while cytotoxic T cells target and kill specific bacteria or virus-infected cells.
- Acquired immunity is active or passive and, in either case, can be naturally or artificially induced.
- Clinical manifestations of infection result from both altered function of the damaged tissue and from the inflammatory response that is initiated in defence.
- In colonization, microorganisms grow and multiply but do not cause physiologic changes in host tissue. In infection, microorganisms cause tissue damage.
- Infection occurs when there is an imbalance between microorganisms and host defences (e.g., high microbial load or low resistance).
- An infection can develop if the six links in the chain of infection—infectious agent, reservoir, portal of exit, mode of transmission, portal of entry, and susceptible host—are not interrupted.
- The six routes of transmission are direct contact, indirect contact, droplet, airborne, vehicle-borne, and vector-borne.
- Factors that contribute to nosocomial infection risks are invasive procedures, medical therapies, the existence of susceptible persons, inappropriate use of antibiotics, and insufficient hand hygiene after client contact and after contact with body substances.
- Especially at risk of acquiring an infection are the very young or old; those with poor nutritional status, a deficiency of serum immunoglobulins, multiple stressors, insufficient immunizations, obesity, anemia, poorly controlled diabetes, or an existing disease process; those who smoke; and those receiving certain medical therapies.
- Infectious agents can be eliminated by physically removing reservoirs, by using antimicrobial drugs to kill microorganisms or slow their growth, by physically cleaning materials, by disinfecting, or by sterilizing.
- Hand hygiene, considered to be the single most effective infection control measure, includes both handwashing (to physically remove transient microorganisms) and use of an alcohol-based hand rub (to kill microorganisms), done correctly and at indicated times to reduce hand carriage of microorganisms.
- Personal protective equipment (gloves, gowns, face masks, respirators, and eyewear) disrupts transmission of microorganisms from patient to caregiver and from client to client via the caregiver.
- Surgical masks protect against infections transmitted via the droplet route, while respirators, if properly fitted and used, protect against infections transmitted by both the airborne and the droplet routes.
- Asepsis is the freedom from infection or infectious material.
- Clean technique keeps the area free from most microorganisms, whereas sterile technique refers to working within a sterile field, using sterile items,

and keeping an area or objects free of all microorganisms.

- Supporting host defences by addressing individual risk factors for infection is important in breaking the chain of infection.
- Routine practices rely on hand hygiene and use of appropriate personal protective equipment, and they are used to protect against exposure to all blood and body fluids from all clients, regardless of infection status.
- Additional precautions are used in addition to routine practices when clients have infections that are transmitted through the airborne, droplet, and contact routes.
- Cough etiquette involves containing respiratory secretions by coughing or sneezing into a tissue (which is then discarded) or cloth (e.g., sleeve), accompanied by hand hygiene.
- Additional protocols may be in effect, depending on the practice setting, for clients who are immunocompromised or who have infections caused by multidrug-resistant organisms.
- Clients requiring isolation precautions are susceptible to sensory depravation and decreased self-esteem.
- Nursing responsibilities for infection prevention and control include assessing clients' risks for infection or status of an infection and problems or complications associated with the infection; implementing routine practices and additional precautions and other interventions appropriate to the client's needs and situation; evaluating outcomes; and preventing the transmission of microorganisms from infected clients to others.
- The nurse must be knowledgeable about sources and modes of transmission of microorganisms.
- Nurses must also take measures to protect themselves and others from sharps injuries.
- Infection control practitioners are key personnel for infection prevention and control, helping to identify problems and intervene to resolve them. They are an excellent resource for nurses.
- Infection prevention and control is a shared responsibility.

ASSESS YOUR LEARNING

1. A patient is a chronic carrier of an infection. To prevent the spread of the infection to other patients or health-care providers, the nurse emphasizes interventions that do which of the following?

a. Eliminate the reservoir.
b. Block the portal of exit from the reservoir.
c. Block the portal of entry into the host.
d. Decrease the susceptibility of the host.

2. The most effective nursing action for controlling the spread of infection includes which of the following?

a. Performing hand hygiene before and after client contact
b. Wearing gloves and masks for all client care
c. Implementing isolation precautions
d. Administering broad-spectrum prophylactic antibiotics

3. In caring for a patient on contact precautions for a draining infected foot ulcer, the nurse should perform which of the following?

a. Wear a mask during dressing changes.
b. Provide disposable meal trays and silverware.
c. Follow routine practices in all interactions with the patient.
d. Use aseptic technique for all direct contact with the patent.

4. When caring for a single patient during one shift, it is appropriate for the nurse to reuse which of the following personal protective equipment?

a. Goggles
b. Gown
c. Surgical mask
d. Clean gloves

5. While donning sterile gloves (open method), the cuff of the first glove rolls under itself about 0.5 cm. Which is the best action for the nurse?

a. Remove the glove and start over with a new pair.
b. Wait until the second glove is in place and then unroll the cuff with the other sterile hand.
c. Ask a colleague to assist by unrolling the cuff.
d. Leave the cuff rolled under.

6. After evaluating a 69-year-old patient's chart, the nurse concludes that this patient's immunizations are up-to-date. What evidence supports this conclusion?

a. Had a tetanus booster at age 65
b. Receives the influenza vaccine every second year
c. Seeks a second dose of pneumococcal vaccine
d. Has not received the hepatitis B vaccine

7. The nurse has taught a client and family general infection prevention strategies. Which of the following statements by the client indicates effective learning has occurred?

a. "We will use antimicrobial soap and hot water to wash our hands at least three times per day."
b. "We must wash or peel all raw fruits and vegetables before eating."
c. "A wound or sore is not infected unless we see it draining pus."
d. "We should not share toothbrushes but it is OK to share towels and washcloths."

8. Which of the numbered areas in the following figure are considered sterile on a person in the operating room? Assume that all articles were sterile when applied.

9. The nurse determines that a field remains sterile if which of the following conditions exist?

- **a.** The tips of wet forceps are held upward when held in ungloved hands.
- **b.** The field was set up 1 hour before the procedure.
- **c.** Sterile items are kept at least 5 cm from the edge of the field.
- **d.** The nurse reaches over the field rather than around the edges.

10. Sue and Mary are co-workers who have desks beside each other and share a telephone. Sue comes to work with a cold. She is tired, has a low-grade fever, and is sneezing frequently. What can Sue do to minimize the risk that Mary will develop the same respiratory infection?

- **a.** She should stay a minimum of 0.5 metres from Mary.
- **b.** She should take an antipyretic agent to lower her fever.
- **c.** She should sneeze into a tissue or her sleeve.
- **d.** She should not come to work if the symptoms do not subside within 2 days.

After working through these questions, go to the MyNursingLab at ***http://www.mynursinglab.com*** *to check your answers and see explanations.*

SUGGESTED READINGS

Goering, R. V., Dockrell, H. M., Zuckerman, M., Wakelin, D., Roitt, I., Mims, C., & Chiodini, P. L. (2008). *Mims' medical microbiology* (4th ed.). Edinburgh, UK: Elsevier.

This text summarizes, in a reader friendly way, key details about microorganisms and the infections they cause.

Mayhall, C. G. (Ed.). (2004). *Hospital epidemiology and infection control.* Philadelphia, PA: Lippincott Williams & Wilkins.

This is a key reference text used by infection-control practitioners. It provides details on epidemiology, surveillance, common infections, and recommended practices for a variety of settings.

Phillips, N. (2007). *Berry & Kohn's operating room technique* (11th ed.). St Louis, MO: Mosby.

This text summarizes principles and procedures related to establishing, maintaining, and working within sterile fields.

Wilson J. (2006). *Infection control in clinical practice* (3rd ed.). Edinburgh, UK: Baillière Tindall Elsevier.

This text is targeted toward clinicians rather than infection-control practitioners. It covers key points related to basic principles and to specific practices for common sites of infection.

WEBLINKS

Public Health Agency of Canada: Nosocomial and Occupational Infections

http://www.phac-aspc.gc.ca/nois-sinp/index.html

This site has links to the Infection Control Guidelines Series as well as to the Canadian Nosocomial Infection Surveillance Program

Public Health Agency of Canada: Canadian Nosocomial Infection Surveillance Program

http://www.phac-aspc.gc.ca/nois-sinp/survprog_e.html

This site has links to the Canadian Nosocomial Infection Surveillance Program surveillance projects and publications.

Public Health Agency of Canada: Canadian Immunization Guide

http://www.phac-aspc.gc.ca/publicat/cig-gci/index.html

This site provides the most up-to-date recommendations for immunizing Canadians.

Public Health Agency of Canada

http://www.phac-aspc.gc.ca/new_e.html

This is the main website for the Public Health Agency of Canada. It includes links to a number of topics, including information about chronic diseases, emergency preparedness, health promotion, immunization and vaccines, infectious diseases, injury prevention, public health practice, surveillance, and travel health.

Community and Hospital Infection Control Association—Canada (CHICA-Canada)

http://www.chica.org

This website, while targeted primarily to infection-control practitioners, has links to information useful for education about infection control issues.

Centers for Disease Control and Prevention

http://www.cdc.gov

CDC is the American equivalent of the Public Health Agency of Canada.

Canadian Communicable Disease Report

http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/index-eng.php

The website contains this publication of the Public Health Branch of Health Canada.

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Zoutman, D. E., Ford, B. D., Bryce, E., Goudeau, M., Hebert, G., Henderson, E., Paton, S., et. al. (2003). The state of infection surveillance and control in Canadian acute care hospitals. *American Journal of Infection Control, 31*(5), 266–272; discussion: 272–273.