ONE

INTRODUCTION TO INFECTION PREVENTION

KEY CONCEPTS you will learn in this chapter include:

- What the basic principles of infection prevention are
- What conditions allow infections to be transmitted to others
- How to stop the spread of infectious diseases
- What the role of the CDC isolation guidelines is in preventing nosocomial infections

BACKGROUND

People receiving health and medical care, whether in a hospital or clinic, are at risk of becoming infected unless precautions are taken to prevent infection. Nosocomial (hospital-acquired) infections are a significant problem throughout the world and are increasing (Alvarado 2000). For example, nosocomial infection rates range from as low as 1% in a few countries in Europe and the Americas to more then 40% in parts of Asia, Latin America and sub-Saharan Africa (Lynch et al 1997).

Most of these infections can be prevented with readily available, relatively inexpensive strategies by:

- adhering to recommended infection prevention practices, especially hand hygiene and wearing gloves;
- paying attention to well-established processes for decontamination and cleaning of soiled instruments and other items, followed by either sterilization or high-level disinfection; and
- improving safety in operating rooms and other high-risk areas where the most serious and frequent injuries and exposures to infectious agents occur.

How Risky is Working in a Hospital or Health Clinic

Healthcare workers, including support staff (e.g., housekeeping and maintenance and laboratory personnel), who work in these settings also are at risk of exposure to serious, potentially life-threatening infections. For example, in the US, more than 800,000 needlestick injuries occur each year despite continuing education and vigorous efforts aimed at preventing such accidents (Rogers 1997), including:

- reducing unnecessary and unsafe injections,
- training all staff to immediately dispose of needles and syringes in sharps containers without recapping—attempting to recap them accounts for one third of all needlesticks (Jagger et al 1988),[1]
- placing disposable sharps containers within arm's reach if possible, and
- increasing use of needleless injection systems and shielded syringes.

In many developing countries, however, the risk of needlestick injuries and accidental exposure to blood or body fluids is even higher (Phipps et al 2002). Moreover, because introduction of needleless injection systems is not feasible in countries with limited resources, it is important that healthcare staff **know** and **use** recommended infection prevention practices to minimize their risk of accidental exposure or injury (Tietjen 1997).

Purpose of This Chapter

The **purpose** of this chapter is to assist healthcare workers and hospital and clinic supervisors, managers and administrators understand the basic principles of infection prevention and recommended processes and practices. Also presented is an overview of the Centers for Disease Control and Prevention (CDC) isolation precaution guidelines for hospitals (Garner and HICPAC 1996). These guidelines replace both Universal Precautions and Body Substance Isolation Precautions and provide the framework on which **Part 1. Fundamentals of Infection Prevention** and **Part 2. Processing Instruments, Gloves and Other Items** are based.

DEFINITIONS

The terms **asepsis (aseptic technique)**, **antisepsis**, **decontamination**, **cleaning**, **high-level disinfection** and **sterilization** often are confusing. For the purposes of these guidelines, the following definitions will be used:

- **Asepsis** and **aseptic technique**. Combination of efforts made to prevent entry of microorganisms into any area of the body where they are likely to cause infection. The goal of asepsis is to **reduce to a safe level**, or **eliminate**, the number of microorganisms on both animate (living) surfaces (skin and mucous membranes) and inanimate objects (surgical instruments and other items).
- **Antisepsis**. Process of reducing the number of microorganisms on skin, mucous membranes or other body tissue by applying an antimicrobial (antiseptic) agent.
- **Decontamination**. Process that makes inanimate objects **safer** to be handled by staff **before** cleaning (i.e., inactivates HBV, HCV and HIV and reduces, but does not eliminate, the number of other contaminating microorganisms).

[1] If recapping must be done, health workers should be trained in the one-hand technique (see **Chapter 7**).

Ideally, soiled surgical instruments, gloves and other items should always be handled by staff wearing gloves or using forceps. Because this is not always possible, it is safer first to soak these soiled items for 10 minutes in 0.5% chlorine solution, especially if they will be cleaned by hand (Nyström 1981). Metal objects should then be rinsed to prevent corrosion before cleaning (Lynch et al 1997). Other objects that should be decontaminated, by wiping with the 0.5% chlorine solution, include large surfaces (e.g., pelvic examination or operating tables) and equipment that come in contact with patients' blood or body fluids, secretions or excretions (except sweat).

- **Cleaning**. Process that physically removes all visible dust, soil, blood or other body fluids from inanimate objects as well as removing sufficient numbers of microorganisms to reduce risks for those who touch the skin or handle the object. (It consists of thoroughly washing with soap or detergent and water, rinsing with clean water and drying.[2])
- **High-level disinfection (HLD)**. The process that eliminates **all** microorganisms **except some** bacterial endospores from inanimate objects by boiling, steaming or the use of chemical disinfectants.
- **Sterilization**. Process that eliminates **all** microorganisms (bacteria, viruses, fungi and parasites) **including** bacterial endospores from inanimate objects by high-pressure steam (autoclave), dry heat (oven), chemical sterilants or radiation.

IMPORTANT CONCEPTS

Microorganisms are the causative agents of infection. They include bacteria, viruses, fungi and parasites. For infection prevention purposes, bacteria can be further divided into three categories: vegetative (e.g., staphylococcus), mycobacteria (e.g., tuberculosis) and endospores (e.g., tetanus). Of all the common infectious agents, endospores are difficult to kill due to their protective coating.[3]

Colonization means that pathogenic (illness or disease causing) organisms are present in a person (i.e., they can be detected by cultures or other tests) but are not causing symptoms or clinical findings (i.e., cellular changes or damage). **Infection** means that the colonizing organisms now are causing an illness or disease (cellular response) in the person. Coming in contact with and acquiring new organisms, while increasing the risk of infection, usually does not lead to infection because the body's natural defense mechanisms, including the immune system, are able to tolerate and/or destroy them. Thus,

[2] If tap water is contaminated, use water that has been boiled for 10 minutes and filtered to remove particulate matter (if necessary), or use chlorinated water—water treated with a dilute bleach solution (sodium hypochlorite) to make the final concentration 0.001% (see **Chapter 26**).

[3] Prions, which are protein-containing infectious agents present in brain, spinal column and eye tissue of patients with Creutzfeldt-Jakob disease, are even harder to kill (see **Chapter 11**).

when organisms are transmitted from one person to another, colonization rather than infection generally is the result. Colonized persons, however, can be a major source of transfer of pathogens to other persons (cross-contamination), especially if the organisms persist in the person (chronic carrier), such as with HBV, HCV and HIV.

Infection prevention largely depends on placing barriers between a **susceptible host** (person lacking effective natural or acquired protection) and the microorganisms. **Protective barriers** are physical, mechanical or chemical processes that help prevent the spread of infectious microorganisms from:

- person to person (patient, healthcare client or health worker); and/or
- equipment, instruments and environmental surfaces to people.

WHICH PROCESS TO USE

In 1968, Spaulding proposed three categories of potential infection risk to serve as the basis for selecting the prevention practice or process to use (e.g., sterilization of medical instruments, gloves and other items) when caring for patients. This classification has stood the test of time and still serves as a good basis for setting priorities for any infection prevention program. The Spaulding categories are summarized below:

- **Critical**. These items and practices affect normally sterile tissues or the blood system and represent the highest level of infection risk. Failure to provide management of sterile or, where appropriate, high-level disinfected items (e.g., surgical instruments and gloves), is most likely to result in infections that are the most serious.

- **Semicritical**. These items and practices are second in importance and affect mucous membranes and small areas of nonintact skin. Management needs are considerable and require knowledge and skills in:

  - handling many invasive devices (e.g., gastrointestinal endoscopes and vaginal specula),
  - performing decontamination, cleaning and high-level disinfection, and
  - gloving for personnel who touch mucous membranes and nonintact skin.

- **Noncritical**. Management of items and practices that involve intact skin and represent the lowest level of risk. Some (e.g., hand hygiene) are more important than others. Poor management of noncritical items, such as overuse of examination gloves, often consumes a major share of resources while providing only limited benefit.

Instrument Processing

Decontamination is the first step in processing soiled (contaminated) surgical instruments, gloves and other items, especially if they will be cleaned by hand (Nyström 1981). For example, briefly soaking contaminated items in 0.5% chlorine solution, or other locally available disinfectants, rapidly kills HBV[4] and HIV, thereby making the instruments and other items safer to be handled during cleaning (AORN 1990; DHMH 1990; Lynch et al 1997). Larger surfaces, such as examination and operating tables, laboratory bench tops and other equipment that may have come in contact with blood or other body fluids also should be decontaminated. Wiping with a suitable disinfectant (e.g., 0.5% chlorine solution or 1–2% phenol) is a practical, inexpensive way to decontaminate them.

After instruments and other items have been decontaminated, they need to be cleaned and finally either sterilized or high-level disinfected (Lynch 1997; Rutala 1993; Tietjen and McIntosh 1989). As outlined in **Table 1-1,** the process selected for final processing depends on whether the items will touch intact mucous membranes or broken skin or tissue beneath the skin that normally is sterile (Spaulding 1968).

Table 1-1. Final Processing for Surgical Instruments, Gloves and Other Items

TISSUE	FINAL PROCESSING	EXAMPLES
Intact mucous membranes or broken skin	**High-level disinfection** (HLD) destroys all microorganisms except some endospores.[a]	Uterine sounds, vaginal specula and plastic cannulae for suction curettage
Blood stream or tissue beneath the skin which normally is sterile	**Sterilization** destroys all microorganisms, including endospores.	Surgical instruments such as scalpels, trocars for insertion/removal of Norplant® implants and surgical gloves

[a] Bacterial endospores are forms of bacteria that are very difficult to kill because of their coating. Types of bacteria that make endospores include those causing tetanus (*Clostridium tetani*), gangrene (*Clostridium perfringens*) or anthrax (*Bacillus anthracis*).

Adapted from: Spaulding 1968.

When Is Sterilization Absolutely Essential? When Is HLD an Acceptable Alternative?

Most authorities recommend sterilization as the final step in processing instruments and other items used for surgical procedures. Some guidelines, however, are more flexible, and state that when sterilization equipment is **not** available, HLD can be used. In fact, the use of sterilization is not possible or practical in certain situations (Rutala, Weber and HICPAC 2002). For example, laparoscopes, which would be damaged if submitted to either high-pressure steam (autoclaving) or dry heat sterilization, usually are processed between cases by HLD (i.e., soaking in a chemical high-level disinfectant for

[4] Throughout this manual, when hepatitis B (HBV) is mentioned, hepatitis C (HCV) and Delta hepatitis (HDV) also are referred to because their occurrence is worldwide and mode of transmission or prevention is similar.

20 minutes). When correctly performed, sterilization clearly is the safest and most effective method for the final processing of instruments. If it is neither available nor suitable, however, HLD is the **only** acceptable alternative for final processing.

High-level disinfection kills all microorganisms but does **not** reliably kill bacterial endospores. Staff must be aware of this limitation if tetanus, a disease caused by endospores produced by bacteria called *Clostridium tetani*, is a significant risk. The information in **Table 1-2** will assist healthcare providers and managers in determining when sterilization is preferable to HLD in processing surgical instruments and other reusable items. In addition, as a further guide, throughout this manual frequent reference is made to the limitations of HLD (i.e., does not reliably kill some endospores).

Table 1-2. Which Final Process to Use

PROCEDURE	STERILIZATION	HLD
Cesarean section	Preferred	Acceptable
Abdominal laparotomy	Preferred	Acceptable
Vaginal delivery	Preferred	Acceptable
Norplant implants insertion and removal	Preferred	Acceptable
Laparoscopy	Preferred (chemical only)	Acceptable
MVA cannulae[a]	Acceptable	Acceptable
IUD insertion and removal	Acceptable	Acceptable
Pelvic examination	Acceptable	Acceptable

[a] MVA: manual vacuum aspiration (for treatment of incomplete abortion)

Adapted from: Tietjen, Cronin and McIntosh 1992.

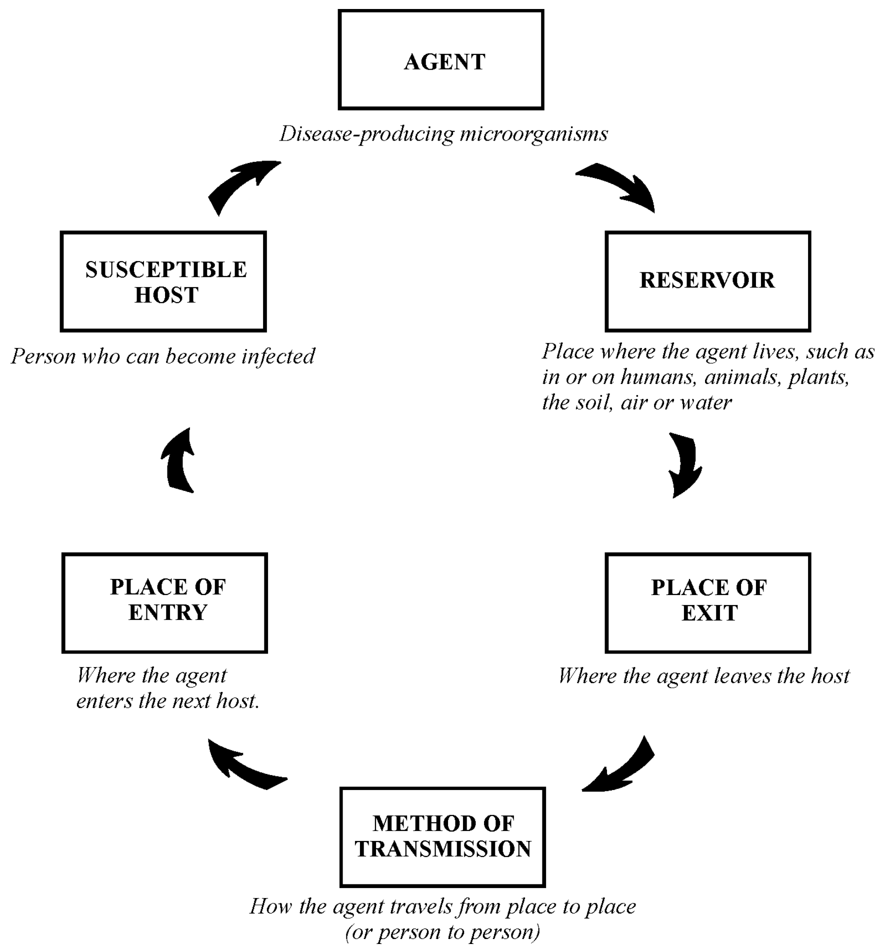
THE DISEASE TRANSMISSION CYCLE

Microorganisms live everywhere in our environment. Humans normally carry them on their skin and in the upper respiratory, intestinal and genital tracts. In addition, microorganisms live in animals, plants, soil, air and water. Some microorganisms, however, are more **pathogenic** than others, that is, they are more likely to cause disease. Given the right circumstances, **all** microorganisms may cause infection, such as when transmitted to an immunocompromised patient with AIDS (Burke 1977).

All humans are susceptible to bacterial infections and also to most viral agents. The dose of organisms (inoculum) necessary to produce infection in a susceptible host varies with the location. When organisms come in contact with bare skin, infection risk is quite low, and all of us touch materials that contain some organisms every day. When the organisms come in contact with mucous membranes or nonintact skin, infection risk increases. Infection risk increases greatly when organisms come in contact with normally sterile body sites, and the introduction of only a few organisms may produce disease.

For bacteria, viruses and other infectious agents to successfully survive and spread, certain factors or conditions must exist. The essential factors in the transmission of disease-producing microorganisms from person to person are illustrated and defined in **Figure 1-1** (APIC 1983; WPRO/WHO 1990).

Figure 1-1. The Disease Transmission Cycle



Adapted from: APIC 1983; WPRO/WHO 1990.

As shown in this figure, a disease needs certain conditions in order to spread (be transmitted) to others:

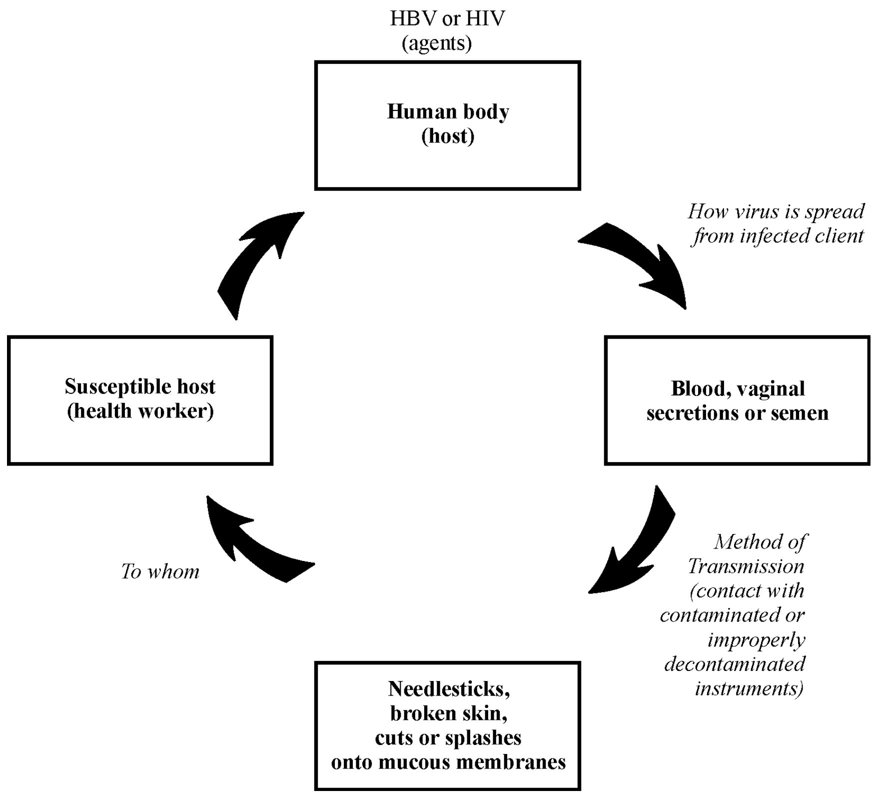
- There must be an **agent**—something that can cause illness (virus, bacteria, etc.).
- The agent must have a place it can live (**host** or **reservoir**). Many microorganisms that cause disease in humans (pathogenic organisms) multiply in humans and are transmitted from person to person. Some are transmitted through contaminated food or water (typhoid), fecal matter (hepatitis A and other enteric viruses) or the bites of infected animals (rabies) and insects (malaria from mosquitoes).
- The agent must have the right environment outside the host to survive. After the microorganism leaves its host, it must have a suitable environment in which to survive until it infects another person. For example, the bacteria that cause tuberculosis can survive in sputum for weeks, but will be killed by sunlight within a few hours.
- There must be a person who can catch the disease (**susceptible host**). People are exposed to disease-causing agents every day but do not always get sick. For a person to catch an infectious disease (e.g., mumps, measles or chicken pox,) s/he must be susceptible to that disease. The main reason most people do not catch the disease is that they have been previously exposed to it (e.g., vaccinated for it or previously had the disease) and their body's immune system now is able to destroy the agents when they enter the body.
- An agent must have a way to move from its host to infect the next susceptible host. Infectious (communicable) diseases are spread mainly in these ways:

    - **Airborne**: through the air (chicken pox or mumps).
    - **Blood or body fluids**: if blood or body fluids contaminated with HBV or HIV comes in contact with another person, such as through a needlestick, s/he may become infected.
    - **Contact**: either **direct** (touching an open wound or draining pustule), or **indirect** (touching an object contaminated with blood or other body fluids).
    - **Fecal-oral**: swallowing food contaminated by human or animal feces (e.g., putting your fingers in your mouth after handling contaminated objects without first washing your hands).
    - **Foodborne**: eating or drinking contaminated food or liquid that contains bacteria or viruses (hepatitis A from eating raw oysters).
    - **Animal- or insect-borne**: contact with infected animals or insects through bites, scratches, secretions or waste.

Infection prevention deals primarily with preventing the spread of infectious diseases through the air, blood or body fluids, and contact, including fecal-oral and foodborne.

Figure 1-2 depicts the steps in the transmission of the hepatitis B (HBV) and human immunodeficiency (HIV) viruses from colonized persons (e.g., family planning client or pregnant woman attending an antenatal clinic) or patients to healthcare workers. Spread of these viruses from person to person can occur when staff (physician, nurse or housekeeping personnel) are exposed to the blood or body fluids of an infected person (e.g., needlestick injury).

Figure 1-2. Transmission of HBV and HIV from Patients to Healthcare Workers



Studies in the United States have shown that the risk of disease after exposure to HBV from a single needlestick injury ranges from 27–37% (Seeff et al 1978), while the risk following a single needlestick exposure to HIV is much lower, 0.2–0.4% (Gerberding 1990; Gershon et al 1995), and 3–10% for HCV (Lanphear 1994). The rate of transmission of HIV is considerably lower than for HBV, probably because of the lower concentration of virus in the blood of HIV-infected persons.

The efficiency for transmission of hepatitis B is high. For example, an accidental splash in the eye of as little as 10^{-8} mL (.00000001 mL) of infected blood can transmit HBV to a susceptible host (Bond et al 1982).

In nearly all cases, transmission of HBV or HIV to health workers has occurred through preventable accidents such as puncture wounds. Transmission can also occur through mucous membrane contact, such as a splash of blood or amniotic fluid into the surgeon's or assistant's eye. Also, skin damaged by a cut, scrape, chapped skin or contact dermatitis can be a point of entry for these viruses. While the risk of transmission is much lower from splashes of blood onto mucous membranes, they should be avoided. If splashing is anticipated, personal protective equipment such as face shields or glasses and plastic or rubber aprons, if available, is recommended. This protection is important because large mucous membrane exposures and prolonged skin contact may be associated with a higher risk of becoming infected (DHMH 1990).

Finally, because it is not always possible to know in advance whether or not a person may be infected with HBV or HIV, contaminated instruments, needles and syringes as well as other items from **all** persons (e.g., patients, pregnant women and other clients) must be handled as if they are contaminated. This practice is consistent with the recommendations in the new Standard Precaution Guidelines discussed in the next section (Garner and HICPAC 1996). For example, several studies have highlighted the inability to distinguish HBV- or HIV-infected people from noninfected individuals on clinical grounds (Baker et al 1987; Handsfield, Cummings and Swenson 1987; Kelen et al 1988).

PREVENTING INFECTIOUS DISEASES

Understanding the disease transmission cycle is important if healthcare workers are to:

- prevent transmission of microorganisms to patients during medical and surgical procedures;
- teach others the factors required for transmission to occur and, most importantly;
- teach others **how to** break the cycle.

Preventing the spread of infectious diseases requires removing one or more of the conditions necessary for transmission of the disease from host or reservoir to the next susceptible host by:

- inhibiting or killing the agent (e.g., applying an antiseptic agent to the skin before surgery);
- blocking the agent's means of getting from an infected person to a susceptible person (e.g., handwashing or using a waterless, alcohol-based antiseptic handrub to remove bacteria or viruses acquired through touching an infected patient or contaminated surface);
- making sure that people, especially healthcare workers, are immune or vaccinated; and

- providing health workers with the right protective equipment to prevent contact with infectious agents (e.g., heavy-duty gloves for housekeeping and waste removal staff).

NEW ISOLATION GUIDELINES AND RECOMMENDATIONS

Since 1970, when CDC first introduced the disease-specific category system of isolation precautions, many different policies and practices to prevent the spread of infections in hospitals have been recommended. Traditionally, barrier precautions (e.g., hand hygiene and gloves) have been used to reduce the risk of transmission of nosocomial infections to and from hospitalized patients. The emergence of bloodborne diseases such as AIDS and hepatitis C (HCV) in the 1980s, coupled with the resurgence of tuberculosis, first led to the introduction of Universal Precautions (UP) in 1985 and subsequently Body Substance Isolation (BSI) (1987). While many hospitals quickly began using some or all of the recommendations, there was much local variation and confusion in the use and interpretation of both UP and BSI. Thus, in 1996 the CDC and the Hospital Infection Control Practices Advisory Committee (HICPAC) issued a new system of isolation precautions (Garner and HICPAC 1996). This system involves a two-level approach—**Standard Precautions** and **Transmission-Based Precautions—**and was developed to meet the following criteria:

- Be epidemiologically sound
- Recognize the pathogenic importance of all body fluids, secretions and excretions (except sweat)
- Contain adequate precautions for infections transmitted by airborne, droplet or contact routes
- Be as simple and user-friendly as possible
- Use new terms to avoid confusion with existing systems

The new system accomplishes the following:

- Incorporates the major features of both UP and BSI into a single set of precautions, called **Standard Precautions**, that are designed to be used in treating **all clients** and **patients** attending healthcare facilities regardless of their presumed diagnosis.
- Retains the recommendations that healthcare workers providing direct care, especially those working in surgical or obstetrical units, should be immune to rubella, measles, mumps, varicella (chicken pox) and hepatitis A and B, as well as receive tetanus toxoid.
- Collapses the old disease-specific isolation categories into three sets of precautions based on routes of transmission, called **Transmission-Based Precautions**. (These guidelines apply to **hospitalized patients** or those in nursing homes or other types of extended care facilities.)

- Lists specific clinical syndromes in **hospitalized adult** and **child patients** that are highly suspicious for infection (i.e., the so called "empiric use" of Transmission-Based Precautions).

The new isolation guidelines are yet another positive step intended to reduce the risk of transmitting infections not only to and from patients and clients using healthcare services, but also to the healthcare personnel caring for them. As such, healthcare administrators and staff will need to carefully review the recommendations to determine what is possible, practical and doable within their resource setting.

Standard Precautions

Standard Precautions are designed for use in caring for **all people**—both clients and patients—attending healthcare facilities. They apply to blood, all body fluids, secretions and excretions (except sweat), nonintact skin and mucous membranes. Implementing these precautions, however, will add additional cost for personal protective equipment, especially for new examination gloves, staff training and monitoring in order to be effective. Because no one really knows what organisms clients or patients may have at any time, it is essential that Standard Precautions be used all the time. The details of their use and issues related to implementing them are covered in **Chapter 2**.

Transmission-Based Precautions

The second level of precautions is intended for use in patients **known** or **highly suspected** of being infected or colonized with pathogens transmitted by:

- air (tuberculosis, chicken pox, measles, etc.);
- droplet (flu, mumps and rubella); or
- contact (hepatitis A or E and other enteric pathogens, herpes simplex, and skin or eye infections).[5]

> **Note**: In all cases, whether they are used alone or in combination, **Transmission-Based Precautions** must be used in conjunction with the **Standard Precautions**.

If there is any question of an infectious process in a patient without a known diagnosis, implementing Transmission-Based Precautions should be based on the patient's signs and symptoms (empiric basis) until a definitive diagnosis is made.

Use of Transmission-Based Precautions, including their empiric use, is designed to reduce the risk of spreading infections between hospitalized patients and healthcare staff. Occasionally, a patient may require isolation precautions involving more than one category. Their use is described in more detail in **Chapter 21**.

[5] Contact precautions also should be used for patients with wet or draining infections that may be contagious (e.g., draining abscesses, herpes zoster, impetigo, conjunctivitis, scabies, lice and wound infections).

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