CHAPTER
INFECTION CONTROL AND BARRIER PRECAUTIONS
(7 CONTACT HOURS)

Learning objectives
- Adhere to scientifically accepted practices and principles of infection control.
- List the precautions recommended by the CD to prevent transmission of HIV to health care personnel in the workplace.
- Describe and employ proper hand hygiene techniques that help reduce the risk of transmitting microorganisms.
- Use workplace practices and engineering techniques to reduce the risk of infectious disease transmission.
- List the five main routes of microorganism transmission in hospital-acquired (nosocomial) infections.

The education law requires that every four years since July 1, 1994, every dental hygienist, dentist, licensed practical nurse, optometrist, podiatrist and registered professional nurse practicing in New York state complete approved infection control and barrier precautions course work appropriate to the professional’s practice. The goal of this law is to prevent the transmission of the human immunodeficiency virus (HIV) and the hepatitis B virus (HBV) in the course of professional practice. Each professional was required to document compliance to the Education Department at the time of his/her first registration after July 1, 1994, and must do so for every subsequent reregistration.

Physicians, physician assistants (PAs), and specialist assistants (SAs), while needing to meet the same requirement and deadlines, must document their completion of approved course work either to the Department of Health-regulated health care facilities at which they are credentialed or, if not so credentialed, to the New York State Department of Health. Such individual’s compliance with the course work requirement has no effect on the Education Department’s licensure or registration in these three professions.

Physicians, PAs and SAs should direct any questions to:
The Department of Health, Bureau of Communicable Disease Control P.O. Box 2051 Empire State Plaza Albany, NY 12220-0051 Phone:1-518-486-2938 Fax: 1-518-474-7381.

Adherence to infection control
Infection control is an essential component of any health care delivery. Infection control measures can be as simple as hand washing and as sophisticated as high-level disinfection of surgical instruments. Implementing these measures can prevent transmission of disease in health care settings and the community.

Infection control is a key concept in achieving the New York State Department of Health mission to protect and promote the health of New Yorkers through preventive science and the assurance of quality health care delivery. [2]

Infection control objectives should be an integral part of a health care organization’s general program for infection control. The objectives usually include the following:
- Educating personnel about the principles of infection control and stressing individual responsibility for infection control.
- Collaborating with the infection control department in monitoring and investigating potentially harmful infectious exposures and outbreaks among personnel.
- Providing care to personnel for work-related illnesses or exposures.
- Identifying work-related infection risks and instituting appropriate preventive measures containing costs by preventing infectious diseases that result in absenteeism and disability.

These objectives cannot be met without the support of the health care organizations’ administration, medical staff and other health care personnel.

Certain elements are necessary to attain the infection control goals of a personnel health service:
- Coordination with other departments.
- Medical evaluations.
- Health and safety education.
- Immunization programs.
- Management of job-related illnesses and exposures to infectious diseases, including policies for work restrictions for infected or exposed personnel.
- Counseling services for personnel on infection risks related to employment or special conditions.
- Maintenance and confidentiality of personnel health records.

The organization of a personnel health service may be influenced by the size of the institution, the number of personnel and the services offered. To ensure that contractual personnel who are not paid by the health care facility receive appropriate personnel health services, contractual agreements with their employers should contain provisions consistent with the policies of the facility that uses those employees. Personnel with specialized training and qualifications in occupational health can help ensure effective services.

Employees are more likely to comply with an infection control program if they understand its rationale. Thus, personnel education is a cardinal element of an effective infection control program. Clearly written policies, guidelines and procedures ensure uniformity, efficiency and effective coordination of activities. Training should comply with existing federal, state and local regulations regarding requirements for employee education and training. All health care personnel need to be educated about the organization’s infection control policies and procedures. [3]

HIV
Preventing occupational HIV transmission to health care personnel [1]
The human immunodeficiency virus (HIV) is not spread easily. You can only get HIV if you get infected blood or sexual fluids into your system. You can’t get it from mosquito bites, coughing or sneezing, sharing household items or swimming in the same pool as someone with HIV. There have been no documented cases of HIV transmission by sweat, saliva or tears. However, even small amounts of blood in your mouth might transmit HIV during kissing or oral sex. Blood can come from flossing your teeth, sores caused by gum disease or by eating very hot or sharp, pointed food.

To infect someone, the virus has to get past the body’s defenses, which include skin and saliva. If your skin is not broken or cut, it protects you against infection from blood or sexual fluids. Saliva contains chemicals that can help kill HIV in your mouth.

If HIV-infected blood or sexual fluid gets inside your body, you can get infected. This can happen through an open sore or wound, during sexual activity, or if you share equipment to inject drugs.

HIV can also be spread from a mother to her child during pregnancy or delivery. This is called “vertical transmission.” A baby can also be infected by drinking an infected woman’s breast milk. Adults exposed to breast milk of an HIV-infected woman may also be exposed to HIV.

Health care personnel and exposure [6]
An exposure that might place health care personnel (HCP) at risk for HIV infection is defined as a percutaneous injury (i.e., a needle stick or cut with a sharp object) or contact of mucous membrane or nonintact skin (i.e., exposed skin that is chapped, abraded or afflicted with dermatitis) with blood, tissue or other body fluids that are potentially infectious. In addition to blood and visibly bloody body fluids, semen and vaginal secretions also are considered potentially infectious. Although semen and vaginal secretions have been implicated in the sexual transmission of HIV, they have not been implicated in occupational transmission from patients to health care workers.

The following fluids also are considered potentially infectious: cerebrospinal fluid, synovial fluid, pleural fluid, peritoneal fluid, pericardial fluid and amniotic fluid. The risk for transmission of HIV infection from these fluids is unknown; the potential risk to health care workers from occupational exposures has not been assessed by epidemiologic studies in health care settings. Feces, nasal secretions, saliva, sputum, sweat, tears, urine and vomitus are not considered potentially infectious unless they are visibly bloody; the risk for transmission of HIV infection from these fluids and materials is low.

Any direct contact (i.e., contact without barrier protection) to concentrated virus in a research laboratory or production facility requires clinical
evaluation. For human bites, clinical evaluation must include the possibility that both the person bitten and the person who inflicted the bite were exposed to blood-borne pathogens. Transmission of HIV infection by this route has been reported rarely, but not after an occupational exposure.

**Preventive strategies [4]**

To prevent transmission of HIV to health care personnel in the workplace, the Centers for Disease Control and Prevention (CDC) offers the following recommendations. Health care personnel should assume that the blood and other body fluids from all patients are potentially infectious. They should therefore follow infection control precautions at all times. These precautions include:

- The routine use of barriers (such as gloves and goggles) when anticipating contact with blood or body fluids.
- Washing hands and other skin surfaces immediately after contact with blood or body fluids.
- The careful handling and disposal of sharp instruments during and after use.

Safety devices have been developed to help prevent needle-stick injuries. If used properly, these types of devices may reduce the risk of exposure to HIV. Many percutaneous injuries are related to sharps disposal. Strategies for safer disposal, including safer design of disposal containers and placement of containers, are being developed.

Although the most important strategy for reducing the risk of occupational HIV transmission is to prevent occupational exposures, plans for post-exposure management of health care personnel should be in place. CDC has issued guidelines for the management of health care worker exposures to HIV and recommendations for post-exposure prophylaxis (PEP), Updated U.S. Public Health Service Guidelines for the Management of Occupational Exposures to HBV, HCV, and HIV and Recommendations for Post-Exposure Prophylaxis (June 29, 2001).

**HIV prevention in medical care settings [4]**

Despite significant advances in the treatment of HIV infection, the estimated number of annual new HIV infections in the United States has remained at 40,000 for nearly 10 years [7]. Historically, HIV prevention in this country has generally focused on persons who are not HIV-infected, to help them avoid becoming infected. However, further reduction of HIV transmission will require new strategies, including an increased emphasis on preventing transmission by HIV-infected persons aware of their status [11,12]. This may be a highly cost-effective strategy in that prevention is targeted directly to potential sources of new infections. After testing positive for HIV, many people reduce behaviors that may transmit HIV to others [2, 16]. However, recent studies suggest that such behavioral changes are not maintained by all HIV-infected persons, and that some continue to engage in behaviors that place others at risk for HIV infection [3,8].

Routine HIV prevention programs and support are needed to help HIV-infected persons reduce behavioral risks and maintain safer behavior in the years after the diagnosis of HIV infection. Studies have tested interventions in this population and have demonstrated significant reductions in risky sexual and drug-use behaviors. For example, in a study at public HIV clinics of HIV-infected persons who had multiple sex partners at baseline, the prevalence of unprotected anal and vaginal intercourse was reduced 38 percent after brief, ongoing prevention counseling from primary care providers [5, 14]. Successful risk-reduction interventions for HIV-infected persons have also been conducted in group settings [6]. Further, interventions for HIV-infected persons who inject illicit drugs have reduced illicit drug use and unsafe sex in this population [13, 15]. A number of studies have demonstrated the beneficial effect of substance abuse treatment, particularly methadone maintenance treatment, on HIV risk behaviors among injection drug users (IDUs) [10].

Taken as a whole, the findings strongly suggest that a concerted, sustained effort to provide prevention counseling and appropriate referral to services can greatly benefit HIV-infected persons and help them maintain safer behaviors that prevent others from becoming infected with HIV. However, recent studies suggest the need for targeted training of health care personnel on the importance of HIV transmission prevention counseling [9].

**Antimicrobial resistance**

**Transmission**

Microorganisms are transmitted in hospitals by several routes, and the same microorganism may be transmitted by more than one route. There are five main routes of transmission – contact, droplet, airborne, common vehicle and vector borne. For the purpose of this guideline, common vehicle and vector-borne transmission will be discussed only briefly, because neither play a significant role in typical nosocomial infections.

1. **Contact transmission**, the most important and frequent mode of transmission of nosocomial infections, is divided into two subgroups: direct-contact transmission and indirect-contact transmission.
   i. Direct-contact transmission involves a direct body surface-to-body surface contact and physical transfer of microorganisms between a susceptible host and an infected or colonized person, such as occurs when a person turns a patient, gives a patient a bath or performs other patient-care activities that require direct personal contact. Direct-contact transmission also can occur between two patients, with one serving as the source of the infectious microorganisms and the other as a susceptible host.
   ii. Indirect-contact transmission involves contact of a susceptible host with a contaminated intermediate object, usually inanimate, such as contaminated instruments, needles or dressings, or contaminated hands that are not washed and gloves that are not changed between patients.

2. **Droplet transmission**, theoretically, is a form of contact transmission. However, the mechanism of transfer of the pathogen to the host is quite distinct from either direct- or indirect-contact transmission. Therefore, droplet transmission will be considered a separate route of transmission in this guideline. Droplets are generated from the source person primarily during coughing, sneezing and talking and during the performance of certain procedures such as suctioning and bronchoscopy. Transmission occurs when droplets containing microorganisms generated from the infected person are propelled a short distance through the air and deposited on the host’s conjunctivae, nasal mucosa or mouth. Because droplets do not remain suspended in the air, special air handling and ventilation are not required to prevent droplet transmission; that is, droplet transmission must not be confused with airborne transmission.

3. **Airborne transmission** occurs by dissemination of either airborne droplet nuclei (small-particle residue {5 um or smaller in size} of evaporated droplets containing microorganisms that remain suspended in the air for long periods of time) or dust particles containing the infectious agent. Microorganisms carried in this manner can be dispersed widely by air currents and may become inhaled by a susceptible host within the same room or over a longer distance from the source patient, depending on environmental factors. Therefore, special air handling and ventilation are required to prevent airborne transmission. Microorganisms transmitted by airborne transmission include Mycobacterium tuberculosis and the rubeola and varicella viruses.

4. **Common vehicle transmission** applies to microorganisms transmitted by contaminated items such as food, water, medications, devices and equipment.

5. **Vector-borne transmission** occurs when vectors such as mosquitoes, flies, rats and other vermin transmit microorganisms; this route of transmission is of less significance in hospitals in the United States than in other regions of the world.

Isolation precautions are designed to prevent transmission of microorganisms by these routes in hospitals. Because agent and host factors are more difficult to control, interruption of transfer of microorganisms is directed primarily at transmission. The recommendations presented in this guideline are based on this concept.
Placing a patient on isolation precautions, however, often presents certain disadvantages to the hospital, patients, personnel and visitors. Isolation precautions may require specialized equipment and environmental modifications that add to the cost of hospitalization. They also may make frequent visits by nurses, physicians and other personnel inconvenient, and they may make it more difficult for personnel to give the prompt and frequent care that sometimes is required. The use of a multipatient room for one patient uses valuable space that otherwise might accommodate several patients. Moreover, forced solitude deprives the patient of normal social relationships and may be psychologically harmful, especially to children. These disadvantages, however, must be weighed against the hospital’s mission to prevent the spread of serious and epidemiologically important microorganisms in the hospital [19].

**Fundamentals of isolation precautions**

A variety of infection-control measures are used for decreasing the risk of transmission of microorganisms in hospitals. These measures make up the fundamentals of isolation precautions.

**Hand washing**

Hand washing is frequently the single most important measure to reduce the risks of transmitting microorganisms from one person to another or from one site to another on the same patient. Washing hands for at least 15-30 seconds as promptly and thoroughly as possible between patient contacts and after contact with blood, body fluids, secretions, excretions and equipment or articles contaminated by them is perhaps the primary component of infection control and isolation precautions.

**CDC hand hygiene fact sheet**

- Improved adherence to hand hygiene (i.e., hand washing or use of alcohol-based hand rubs) has been shown to terminate outbreaks in health care facilities, to reduce transmission of antimicrobial resistant organisms (i.e., methicillin-resistant staphylococcus aureus) and reduce overall infection rates.

- CDC is releasing guidelines to improve adherence to hand hygiene in health care settings. In addition to traditional hand washing with soap and water, CDC is recommending the use of alcohol-based hand rubs by health care personnel for patient care because they address some of the obstacles that health care professionals face when taking care of patients.

- Hand washing with soap and water remains a sensible strategy for hand hygiene in non-health care settings and is recommended by CDC and other experts.

- Health care workers whose hands are visibly soiled should wash with soap and water.

- The use of gloves does not eliminate the need for hand hygiene. Likewise, the use of hand hygiene does not eliminate the need for gloves. Gloves reduce hand contamination by 70 percent to 80 percent, prevent cross-contamination and protect patients and health care personnel from infection. Hand rubs should be used before and after each patient just as gloves should be changed before and after each patient.

- When using an alcohol-based hand rub, apply product to the palm of one hand and rub hands together, covering all surfaces of hands and fingers, until the hands are dry. Note that the volume needed to reduce the number of bacteria on hands varies by product.

- Alcohol-based hand rubs significantly reduce the number of microorganisms on skin, are fast acting and cause less skin irritation.

- Health care personnel should avoid wearing artificial nails and keep natural nails less than one-quarter of an inch long if they care for patients at high risk of acquiring infections (i.e., patients in intensive care units or in transplant units). Special care should be taken when evaluating hand hygiene products for potential use in health care facilities, administrators or product selection committees should consider the relative efficacy of antiseptic agents against various pathogens and the acceptability of hand hygiene products by personnel.

- Characteristics of a product that can affect acceptance and therefore usage include its smell, consistency, color and the effect of dryness on hands.

- As part of these recommendations, CDC is asking health care facilities to develop and implement a system for measuring improvements in adherence to these hand hygiene recommendations. Some of the suggested performance indicators include: periodic monitoring of hand hygiene adherence and providing feedback to personnel regarding their performance, monitoring the volume of alcohol-based hand rub used in every 1,000 patient-days, monitoring adherence to policies dealing with wearing artificial nails, and focused assessment of the adequacy of health care personnel hand hygiene when outbreaks of infection occur.

- Allergic contact dermatitis due to alcohol hand rubs is very uncommon. However, with increasing use of such products by health care personnel, it is likely that true allergic reactions to such products will occasionally be encountered.

- Alcohol-based hand rubs take less time to use than traditional hand washing. In an eight-hour shift, an estimated one hour of an ICU nurse’s time will be saved by using an alcohol-based hand rub.

These guidelines should not be construed to legalize product claims that are not allowed by the FDA’s over-the-counter drug review. The recommendations are not intended to apply to consumer use of the products discussed [21].

**Gloves**

In addition to hand washing, gloves play an important role in reducing the risks of transmission of microorganisms. Gloves are worn for three important reasons in hospitals:

- First, gloves are worn to provide a protective barrier and to prevent gross contamination of the hands when touching blood, body fluids, secretions, excretions, mucous membranes and nonintact skin. Use of gloves in specified circumstances to reduce the risk of exposures to blood-borne pathogens is mandated by the OSHA blood-borne pathogens final rule.

- Second, gloves are worn to reduce the likelihood that microorganisms present on the hands of personnel will be transmitted to patients during invasive or other patient-care procedures that involve touching a patient’s mucous membranes and nonintact skin.

- Third, gloves are worn to reduce the likelihood that hands of personnel contaminated with microorganisms from a patient or an object can transmit these microorganisms to another patient. In this situation, gloves must be changed between patient contacts, and hands should be washed after gloves are removed.

Wearing gloves does not replace the need for hand washing, because gloves may have small, apparent defects or may be torn during use, and hands can become contaminated during removal of gloves. Failure to change gloves between patient contacts is an infection control hazard [19].

**Patient placement**

Appropriate patient placement is a significant component of isolation precautions. A private room is important to prevent direct – or indirect – contact transmission when the source patient has poor hygienic habits, contaminates the environment or cannot be expected to assist in maintaining infection control precautions to limit transmission of microorganisms (i.e., infants, children and patients with altered mental status). When possible, a patient with highly transmissible or epidemiologically important microorganisms is placed in a private room with hand-washing and toilet facilities to reduce opportunities for transmission of microorganisms.

When a private room is not available, an infected patient is placed with an appropriate roommate. Patients infected by the same microorganism usually can share a room, provided they are not infected with other potentially transmissible microorganisms, and the likelihood of reinfection with the same organism is minimal. Such sharing of rooms, also referred to as cohorting patients, is useful especially during outbreaks or when there is a shortage of private rooms. When a private room is not available and cohorting is not achievable or recommended, it is very important to consider the epidemiology and mode of transmission of the infecting pathogen and the patient population being served in determining patient placement. Under these circumstances, consultation with infection control professionals is advised before patient placement. Moreover, when an infected patient shares a room with a noninfected patient, it also is important that
patients, personnel, and visitors take precautions to prevent the spread of infection and that roommates are selected carefully.

Guidelines for construction, equipment, air handling and ventilation for isolation rooms are discussed in detail in other publications. A private room with appropriate air handling and ventilation is particularly important for reducing the risk of transmission of microorganisms from a source patient to susceptible patients and other persons in hospitals when the microorganism is spread by airborne transmission. Some hospitals use an isolation room with an anteroom as an extra measure of precaution to prevent airborne transmission. Ventilation recommendations for isolation rooms housing patients with pulmonary tuberculosis are delineated in other CDC guidelines.

**Transport of infected patients**

Limiting the movement and transport of patients infected with virulent or epidemiologically important microorganisms and ensuring that such patients leave their rooms only for essential purposes reduces opportunities for transmission of microorganisms in hospitals. When patient transport is necessary, it is important that:

- Appropriate barriers (i.e., masks, impervious coverings) are worn or used by the patient to reduce the opportunity for transmission of microorganisms to other patients, personnel and visitors and to reduce contamination of the environment.
- Personnel in the area to which the patient is to be taken are notified of the impending arrival of the patient and of the precautions to be used to reduce the risk of transmission of infectious microorganisms.
- Patients are informed of ways by which they can assist in preventing the transmission of their infectious microorganisms to others.

**Masks, respiratory protection, eye protection and face shields**

Various types of masks, goggles and face shields are worn alone or in combination to provide barrier protection. A mask that covers both the nose and the mouth and goggles or a face shield are worn by hospital personnel during procedures and patient-care activities that are likely to generate splashes or sprays of blood, body fluids, secretions or excretions. These help to provide protection of the mucous membranes of the eyes, nose and mouth from contact transmission of pathogens. Use of masks, eye protection and face shields in specified circumstances to reduce the risk of exposures to blood-borne pathogens is mandated by the OSHA blood-borne pathogens final rule. A surgical mask generally is worn by hospital personnel to provide protection against spread of infectious large-particle droplets that are transmitted by close contact and generally travel only short distances (up to three feet) from infected patients who are coughing or sneezing [19].

Respiratory protection currently requires the use of a respirator with N95 or higher filtration to prevent inhalation of infectious particles. Respiratory protection is broadly regulated by OSHA under the general industry standard for respiratory protection that requires all U.S. employers to implement a program to protect employees from inhalation of toxic materials. OSHA program components include medical clearance to wear a respirator; provision and use of appropriate respirators, including fit-tested NIOSH-certified N95 and higher particulate filtering respirators; education on respirator use; and periodic re-evaluation of the respiratory protection program.

When selecting particulate respirators, models with good fit characteristics (i.e., those expected to provide protection factors of 10 or more to 95 percent of wearers) are preferred and could relieve the need for fit testing. Issues pertaining to respiratory protection remain the subject of ongoing debate. A user-seal check, formerly called a “fit check,” should be performed by the wearer of a respirator each time a respirator is donned to minimize air leakage around the face piece. The optimal frequency of fit-testing has not been determined [19].

**Gowns and protective apparel**

Various types of gowns and protective apparel are worn to provide barrier protection and to reduce opportunities for transmission of microorganisms in hospitals. Gowns are worn to prevent contamination of clothing and to protect the skin of personnel from blood and body fluid exposures. Gowns specially treated to make them impermeable to liquids, and leg coverings, boots or shoe covers provide greater protection to the skin when splashes or large quantities of infective material are present or anticipated. The wearing of gowns and protective apparel under specified circumstances to reduce the risk of exposures to blood-borne pathogens is mandated by the OSHA blood-borne pathogens final rule.

Gowns also are worn by personnel during the care of patients infected with epidemiologically important microorganisms to reduce the opportunity for transmission of pathogens from patients or items in their environment to other patients or environments; when gowns are worn for this purpose, they are removed before leaving the patient’s environment, and hands are washed.

**Patient-care equipment and articles**

Many factors determine whether special handling and disposal of used patient-care equipment and articles are prudent or required, including the likelihood of contamination with infective material; the ability to cut, stick or otherwise cause injury (needles, scalpels and other sharp instruments, often called sharps); the severity of the associated disease; and the environmental stability of the pathogens involved. Some used articles are enclosed in containers or bags to prevent inadvertent exposures to patients, personnel and visitors and to prevent contamination of the environment. Used sharps are placed in puncture-resistant containers; other articles are placed in a bag. One bag is adequate if the bag is sturdy and the article can be placed in the bag without contaminating the outside of the bag; otherwise, two bags are used.

Contaminated, reusable critical medical devices or patient-care equipment (i.e., equipment that enters normally sterile tissue or through which blood flows) or semicritical medical devices or patient-care equipment (i.e., equipment that touches mucous membranes) are sterilized or disinfected (reprocessed) after use to reduce the risk of transmission of microorganisms to other patients. The type of reprocessing is determined by the article and its intended use, the manufacturers’ recommendations, hospital policy and any applicable guidelines and regulations [19].

Noncritical equipment (i.e., equipment that touches intact skin) contaminated with blood, body fluids, secretions or excretions is cleaned and disinfected after use, according to hospital policy. Contaminated disposable (single-use) patient-care equipment is handled and transported in a manner that reduces the risk of transmission of microorganisms and decreases environmental contamination in the hospital. The equipment is disposed of according to hospital policy and applicable regulations.

**Linens and laundry**

Although soiled linen may be contaminated with pathogenic microorganisms, the risk of disease transmission is negligible if it is handled, transported and laundered in a manner that avoids transfer of microorganisms to patients, personnel and environments. Rather than rigid rules and regulations, hygienic and common sense storage and processing of clean and soiled linen are recommended. The methods for handling, transporting and laundering of soiled linen are determined by hospital policy and any applicable regulations.

**Dishes, glasses, cups and eating utensils**

No special precautions are needed for dishes, glasses, cups or eating utensils. Either disposable or reusable dishes and utensils can be used for patients on isolation precautions. The combination of hot water and detergents used in hospital dishwashers is sufficient to decontaminate dishes, glasses, cups and eating utensils.

**Routine and terminal cleaning**

The room, or cubicle, and bedside equipment of patients on transmission-based precautions are cleaned using the same procedures used for patients on standard precautions, unless the infecting microorganism(s) and the amount of environmental contamination indicate special cleaning. In addition to thorough cleaning, adequate disinfection of bedside equipment and environmental surfaces (e.g., bed rails, bedside tables, carts, commodes, doorknobs, faucet handles) is indicated for certain pathogens, especially enterococci, which can survive in the inanimate environment for prolonged periods of time. Patients admitted to hospital rooms
that previously were occupied by patients infected or colonized with such pathogens are at increased risk of infection from contaminated environmental surfaces and bedside equipment if they have not been cleaned and disinfected adequately. The methods, thoroughness and frequency of cleaning and the products used are determined by hospital policy [19].

**HICPAC isolation precautions**

There are two tiers of HICPAC (Healthcare Infection Control Practices Advisory Committee) isolation precautions. The first, and most important, tier includes precautions designed for the care of all patients in hospitals, regardless of their diagnosis or presumed infection status. Implementation of these standard precautions is the primary strategy for successful nosocomial infection control. In the second tier are precautions designed only for the care of specified patients. These additional transmission-based precautions are for patients known or suspected to be infected by epidemiologically important pathogens spread by airborne or droplet transmission or by contact with dry skin or contaminated surfaces.

**Standard precautions**

Standard precautions synthesize the major features of universal precautions (blood and body fluid precautions, designed to reduce the risk of transmission of blood-borne pathogens) and BSI (designed to reduce the risk of transmission of pathogens from moist body substances) and applies them to all patients receiving care in hospitals, regardless of their diagnosis or presumed infection status. Standard precautions apply to:

- Blood.
- Nonintact skin.
- Mucous membranes.

Standard precautions are designed to reduce the risk of transmission of microorganisms from both recognized and unrecognized sources of infection in hospitals.

**Transmission-based precautions**

Transmission-based precautions are designed for patients documented or suspected to be infected with highly transmissible or epidemiologically important pathogens for which additional precautions beyond standard precautions are needed to interrupt transmission in hospitals. There are three types of transmission-based precautions: airborne precautions, droplet precautions and contact precautions. They may be combined for diseases that have multiple routes of transmission. When used either singularly or in combination, they are to be used in addition to standard precautions.

- **Airborne precautions** are designed to reduce the risk of airborne transmission of infectious agents. Airborne transmission occurs by dissemination of either airborne droplet nuclei (small-particle residue \(\leq 5 \text{ um}

\) or smaller in size) of evaporated droplets that may remain suspended in the air for long periods of time) or dust particles containing the infectious agent. Microorganisms carried in this manner can be dispersed widely by air currents and may become inhaled by or deposited on a susceptible host within the same room or over a longer distance from the source patient, depending on environmental factors. Therefore, special air handling and ventilation are required to prevent airborne transmission. Airborne precautions apply to patients known or suspected to be infected with epidemiologically important pathogens that can be transmitted by the airborne route.

- **Droplet precautions** are designed to reduce the risk of droplet transmission of infectious agents. Droplet transmission involves contact of the conjunctivae or the mucous membranes of the nose or mouth of a susceptible person with large-particle droplets (larger than 5 \(\text{ um}\) in size) containing microorganisms generated from a person who has a clinical disease or who is a carrier of the microorganism. Droplets are generated from the source person primarily during coughing, sneezing or talking and during the performance of certain procedures such as suctioning and bronchoscopy. Transmission via large-particle droplets requires close contact between source and recipient persons, because droplets do not remain suspended in the air and generally travel only short distances, usually three feet or less, through the air. Because droplets do not remain suspended in the air, special air handling and ventilation are not required to prevent droplet transmission. Droplet precautions apply to any patient known or suspected to be infected with epidemiologically important pathogens that can be transmitted by infectious droplets [19].

- **Contact precautions** are designed to reduce the risk of transmission of epidemiologically important microorganisms by direct or indirect contact. Direct-contact transmission involves skin-to-skin contact and physical transfer of microorganisms to a susceptible host from an infected or colonized person, such as occurs when personnel turn patients, bathe the patients or perform other patient-care activities that require physical contact. Direct-contact transmission also can occur between two patients (i.e., by hand contact), with one serving as the source of infectious microorganisms and the other as a susceptible host. Indirect-contact transmission involves contact of a susceptible host with a contaminated intermediate object, usually inanimate, in the patient’s environment. Contact precautions apply to specified patients known or suspected to be infected or colonized (where there is a presence of the microorganism in or on patient but without clinical signs and symptoms of infection) with epidemiologically important microorganisms that can be transmitted by direct or indirect contact.

**Empiric use of airborne, droplet, or contact precautions**

In many instances, the risk of nosocomial transmission of infection may be highest before a definitive diagnosis can be made and before precautions based on that diagnosis can be implemented. The routine use of standard precautions for all patients should reduce greatly this risk for conditions other than those requiring airborne, droplet, or contact precautions. While it is not possible to prospectively identify all patients needing these enhanced precautions, certain clinical syndromes and conditions carry a sufficiently high risk to warrant the empiric addition of enhanced precautions while a more definitive diagnosis is pursued.

The organisms listed under the column potential pathogens are not intended to represent the complete or even most likely diagnoses, but rather possible etiologic agents that require additional precautions beyond standard precautions until they can be ruled out. Infection control professionals are encouraged to modify or adapt this table according to local conditions. To ensure that appropriate empiric precautions are implemented always, hospitals must have systems in place to evaluate patients routinely according to these criteria as part of their predmission and admission care [19].

**Immunocompromised patients**

Immunocompromised patients vary in their susceptibility to nosocomial infections, depending on the severity and duration of immunosuppression. They generally are at increased risk for bacterial, fungal, parasitic and viral infections from both endogenous and exogenous sources. The use of standard precautions for all patients and transmission-based precautions for specified patients, as recommended in this guideline, should reduce the acquisition by these patients of institutionally acquired bacteria from other patients and environments. Refer to the “Guideline for Prevention of Nosocomial Pneumonia” for the HICPAC recommendations for immunocompromised patients.

**Recommendations**

- **Category IA.** Strongly recommended for all hospitals and strongly supported by well-designed experimental or epidemiologic studies.
- **Category IB.** Strongly recommended for all hospitals and reviewed as effective by experts in the field and a consensus of HICPAC based on strong rationale and suggestive evidence, even though definitive scientific studies have not been done.
- **Category IC.** Required for implementation, as mandated by federal and/or state regulation or standard.
- **Category II.** Suggested for implementation in many hospitals. Recommendations may be supported by suggestive clinical or epidemiologic studies, a strong theoretical rationale, or definitive studies applicable to some, but not all, hospitals.
No recommendation; unresolved issue. Practices for which insufficient evidence or consensus regarding efficacy exists.

The recommendations are limited to the topic of isolation precautions. Therefore, they must be supplemented by hospital policies and procedures for other aspects of infection and environmental control, occupational health, administrative and legal issues, and other issues beyond the scope of this guideline.

**Administrative controls**

- Education: Develop a system to ensure that hospital patients, personnel and visitors are educated about use of precautions and their responsibility for adherence to them. Category IB
- Adherence to precautions: Periodically evaluate adherence to precautions, and use findings to direct improvements. Category IB

**Standard precautions**

Use standard precautions, or the equivalent, for the care of all patients. Category IB:

- **Hand washing**: Wash hands after touching blood, body fluids, secretions, excretions and contaminated items, regardless of whether gloves are worn. Wash hands immediately after gloves are removed, between patient contacts, and when otherwise indicated to avoid transfer of microorganisms to other patients or environments. It may be necessary to wash hands between tasks and procedures on the same patient to prevent cross-contamination of different body sites. Category IA.
  - Use a plain (nonantimicrobial) soap for routine hand-washing. Category IB (3).
  - Use an antimicrobial agent or a waterless antiseptic agent for specific circumstances (e.g., control of outbreaks or hyperendemic infections), as defined by the infection control program. Category IB (See contact precautions for additional recommendations on using antimicrobial and antiseptic agents.)
- **Gloves**: Wear gloves (clean, nonsterile gloves are adequate) when touching blood, body fluids, secretions, excretions and contaminated items. Put on clean gloves just before touching mucous membranes and nonintact skin. Change gloves between tasks and procedures on the same patient after contact with material that may contain a high concentration of microorganisms. Remove gloves promptly after use, before touching noncontaminated items and environmental surfaces, and before going to another patient, and wash hands immediately to avoid transfer of microorganisms to other patients or environments. Category IB.
- **Mask, eye protection, face shield**: Wear a mask and eye protection or a face shield to protect mucous membranes of the eyes, nose and mouth during procedures and patient-care activities that are likely to generate splashes or sprays of blood, body fluids, secretions and excretions. Category IB.
- **Gown**: Wear a gown (a clean, nonsterile gown is adequate) to protect skin and to prevent soiling of clothing during procedures and patient-care activities that are likely to generate splashes or sprays of blood, body fluids, secretions or excretions. Select a gown that is appropriate for the activity and amount of fluid likely to be encountered. Remove a soiled gown as promptly as possible and wash hands to avoid transfer of microorganisms to other patients or environments. Category IB.

- **Patient-care equipment**: Handle used patient-care equipment soiled with blood, body fluids, secretions and excretions in a manner that prevents skin and mucous membrane exposures, contamination of clothing and transfer of microorganisms to other patients and environments. Ensure that reusable equipment is not used for the care of another patient until it has been cleaned and reprocessed appropriately. Ensure that single-use items are discarded properly. Category IB.
- **Environmental control**: Ensure that the hospital has adequate procedures for the routine care, cleaning and disinfection of environmental surfaces, beds, bed rails, bedside equipment and other frequently touched surfaces and ensure that these procedures are being followed. Category IB.
- **Linen**: Handle, transport andprocess used linen soiled with blood, body fluids, secretions, and excretions in a manner that prevents skin and mucous membrane exposures and contamination of clothing, and that avoids transfer of microorganisms to other patients and environments. Category IB.
- **Occupational health and blood-borne pathogens**: Take care to prevent injuries when using needles, scalpels and other sharp instruments or devices; when handling sharp instruments after procedures; when cleaning used instruments; and when disposing of used needles. Never recap used needles or otherwise manipulate them using both hands or use any other technique that involves directing the point of a needle toward any part of the body. Rather, use either a one-handed “scoop” technique or a mechanical device designed for holding the needle sheath. Do not remove used needles from disposable syringes by hand, and do not bend, break, or otherwise manipulate used needles by hand. Place used disposable syringes and needles, scalpel blades and other sharp items in appropriate puncture-resistant containers located as close as practical to the area in which the items were used, and place reusable syringes and needles in a puncture-resistant container for transport to the reprocessing area. Category IB.
- **Use mouthpieces, resuscitation bags, or other ventilation devices** as an alternative to mouth-to-mouth resuscitation methods in areas where the need for resuscitation is predictable. Category IB.
- **Patient placement**: Place a patient who contaminates the environment or who does not (or cannot be expected to) assist in maintaining appropriate hygiene or environmental control in a private room. If a private room is not available, consult with infection control professionals regarding patient placement or other alternatives. Category IB [19]

**Airborne precautions**

In addition to standard precautions, use airborne precautions, or the equivalent, for patients known or suspected to be infected with microorganisms transmitted by airborne droplet nuclei (small-particle residue [5 um or smaller in size] of evaporated droplets containing microorganisms that remain suspended in the air and that can be dispersed widely by air currents within a room or over a long distance). Category IB.

- **Patient placement**: Place the patient in a private room that has:
  - Monitored negative air pressure in relation to the surrounding area.
  - Six to 12 air changes per hour.
  - Appropriate discharge of air outdoors or monitored high-efficiency filtration of room air before the air is circulated to other areas in the hospital. Keep the room door closed and the patient in the room.
  - When a private room is not available, place the patient in a room with a patient who has active infection with the same microorganism, unless otherwise recommended, but with no other infection. When a private room is not available and cohorting is not desirable, consultation with infection control professionals is advised before patient placement. Category IB.
- **Respiratory protection**: Wear respiratory protection when entering the room of a patient with known or suspected infectious pulmonary tuberculosis. Susceptible persons should not enter the room of patients known or suspected to have measles or (rubeola) or varicella (chickenpox) if other immune caregivers are available. If susceptible persons must enter the room of a patient known or suspected to have measles (rubeola) or varicella, they should wear respiratory protection. Persons immune to measles (rubeola) or varicella need not wear respiratory protection. Category IB.
- **Patient transport**: Limit the movement and transport of the patient from the room to essential purposes only. If transport or movement is necessary, minimize patient dispersal of droplet nuclei by placing a surgical mask on the patient, if possible. Category IB.
- **Additional precautions**: Consult the CDC “Guidelines for Preventing the Transmission of Tuberculosis in Health-Care Transmission of Facilities” for additional prevention strategies.

**Droplet precautions**

In addition to standard precautions, use
Patient transport: Place the patient in a private room. When a private room is not available, place the patient in a room with a patient who has active infection with the same microorganism but with no other infection (cohorting). When a private room is not available and cohorting is not achievable, maintain spatial separation of at least three feet between the infected patient and other patients and visitors. Special air handling and ventilation are not necessary, and the door may remain open. Category IB.

Mask: In addition to standard precautions, wear a mask when working within three feet of the patient. (Logistically, some hospitals may want to implement the wearing of a mask to enter the room.) Category IB.

Patient transport: Limit the movement and transport of the patient from the room to essential purposes only. If transport or movement is necessary, minimize patient dispersal of droplets by masking the patient, if possible. Category IB.

Contact precautions
In addition to standard precautions, use contact precautions, or the equivalent, for specified patients known or suspected to be infected or colonized with epidemiologically important microorganisms that can be transmitted by direct contact with the patient (hand- or skin-to-skin contact that occurs when performing patient-care activities that require touching the patient’s dry skin) or indirect contact (touching) with environmental surfaces or patient-care items in the patient’s environment. Category IB.

Patient placement: Place the patient in a private room. When a private room is not available, place the patient in a room with a patient who has active infection with the same microorganism but with no other infection (cohorting). When a private room is not available and cohorting is not achievable, consider the epidemiology of the microorganism and the patient population when determining patient placement. Consultation with infection control professionals is advised before patient placement. Category IB.

Gloves and hand washing: In addition to wearing gloves as outlined under standard precautions, wear gloves (clean, nonsterile gloves are adequate) when entering the room. During the course of providing care for a patient, change gloves after having contact with infective material that may contain high concentrations of microorganisms (fecal material and wound drainage).

Remove gloves before leaving the patient’s environment and wash hands immediately with an antimicrobial agent or a waterless antiseptic agent. After glove removal and hand washing, ensure that hands do not touch potentially contaminated environmental surfaces or items in the patient’s room to avoid transfer of microorganisms to other patients or environments. Category IB.

Gown: In addition to wearing a gown as outlined under standard precautions, wear a gown (a clean, nonsterile gown is adequate) when entering the room if you anticipate that your clothing will have substantial contact with the patient, environmental surfaces or items in the patient’s room, or if the patient is incontinent or has diarrhea, an ileostomy, a colostomy or wound drainage not contained by a dressing. Remove the gown before leaving the patient’s environment. After gown removal, ensure that clothing does not contact potentially contaminated environmental surfaces to avoid transfer of microorganisms to other patients or environments. Category IB.

Patient transport: Limit the movement and transport of the patient from the room to essential purposes only. If the patient is transported out of the room, ensure that precautions are maintained to minimize the risk of transmission of microorganisms to other patients and contamination of environmental surfaces or equipment. Category IB.

Patient-care equipment: When possible, dedicate the use of noncritical patient care equipment to a single patient (or cohort of patients infected or colonized with the pathogen requiring precautions) to avoid sharing between patients. If use of common equipment or items is unavoidable, then adequately clean and disinfect them before use for another patient. Category IB [19].

As these guidelines demonstrate, much of the efforts to prevent the spread of drug-resistant microorganisms is done by containing the organism. Your actions must include:

- Washing hands with an antibacterial soap for a full 30 seconds before and after patient contact.
- Following isolation guidelines based on the mode of transmission of the organism.
- Having dedicated equipment in the isolation area.
- Changing gloves when moving from dirty to clean areas.
- Reporting patients with signs of infection to the infection control practitioner promptly.
- Using extra care if you have an open wound.
- Using an appropriate wound cover.
- Using adequate personal protective equipment (PPE).
- Using correct cleaners/ disinfecting agents and procedures.
- Segregating contaminated materials, i.e., transporting soiled linens in a closed container and separating equipment contaminated by different organisms.
- Limiting the movement and transport of patients with drug-resistant infection or colonization.

According to a number of studies, health care workers’ actions that play a part in the development of drug-resistant organisms are not only negligence in washing hands for at least 30 seconds before and after patient contact, but also not maintaining appropriate isolation, mishandling contaminated material, not using appropriate cleaning or disinfecting procedures, and not restricting duty when infectious.

The Guideline for Infection Control in Health Care Personnel strongly recommends appropriate work restrictions for nurses to prevent transmission of infection to and from personnel. Some of these restrictions involve known communicable diseases, like mumps, measles or tuberculosis, but many infections requiring work restrictions are not as obvious: Actively draining skin lesions, acute diarrhea, conjunctivitis, herpes simplex (on hands or orofacial), pediculosis and scabies all require work restrictions. Work restrictions are critical in areas where “at risk” patients are found [19].

Anyone can be colonized with drug-resistant microorganisms. Environmental cultures have shown VRE and MRSA on linens as well as hard surfaces such as bed rails, bedside stands and medical devices. Use techniques that avoid contamination when collecting wound cultures:

- Rinse wound with saline to expose wound bed.
- Do not culture wound exudates/drainage.
- Swab edges and base of the wound.
- Use culture tube swab; do not substitute cotton swab.

Postoperative wound infections may be the result of contamination of the surgical wound during the procedure, or migration of an infection from another infection site. It could also be a reactivation of an infection that occurred previously. For example, a common site of hospital-acquired infection is the urinary tract, secondary to a procedure or catheterization. Infection can occur when a microorganism moves to a location where it is not normally found.

Some people are more susceptible to infection. These same people are often patients in a clinic or hospital. At-risk populations include:

- The elderly.
- Individuals with suppressed immune systems.
- Individuals with orthopaedic implant surgery.
- Individuals with other infection sites.
- The morbidly obese.
- Those using IV, catheter, feeding tube or other invasive lines or tubes.

Others include those with a history of:

- Long-term and/or frequent use of antibiotics.
- Multiple hospitalizations.
- Long-term inpatient care.

Therefore, in hospitals and non-hospital health care environments such as nursing homes, drug-resistant microorganisms also require contact isolation, the transmission-based strategy of isolation recommended by the CDC [26].
A CDC fact sheet for multidrug-resistant organisms in non-hospital health care settings

What are “non-hospital health care settings”? They refer to residential settings (i.e., long-term care and skilled nursing homes), home care, hemodialysis centers and physicians' offices.

What are multidrug-resistant organisms? They are bacteria and other microorganisms that have developed resistance to antimicrobial drugs. Common examples of these organisms include:
- MRSA – methicillin/resistant Staphylococcus aureus.
- VRE – vancomycin-resistant enterococci.
- ESBLs – extended-spectrum beta-lactamases (which are resistant to cephalosporins and monobactams).
- PRSP – penicillin-resistant Streptococcus pneumonia.

Which multidrug-resistant organisms are most commonly seen in non-hospital settings? MRSA and VRE are the most commonly encountered multidrug-resistant organisms in patients residing in non-hospital health care facilities, such as nursing homes and other long-term care facilities. PRSP are more common in patients seeking care in outpatient settings, such as physicians’ offices and clinics, especially in pediatric settings.

What is the difference between colonization and infection? Colonization means that the organism is present and is not causing illness. Infection means that the organism is present and is causing illness.

What conditions increase the risk of acquiring these organisms? There are several risk factors for both colonization and infection:
- Severity of illness.
- Previous exposure to antimicrobial agents.
- Underlying diseases or conditions, particularly:
  - Chronic renal disease.
  - Insulin-dependent diabetes mellitus.
  - Peripheral vascular disease.
  - Dermatitis or skin lesions.
- Invasive procedures, such as:
  - Dialysis.
  - Presence of invasive devices such as urinary catheterization.
- Repeated contact with the health care system.
- Previous colonization of by a multidrug-resistant organism.
- Advanced age.

Should patients colonized or infected with these organisms be admitted to non-hospital health care facilities? Non-hospital health care facilities can safely care for and manage these patients by following appropriate infection control practices. In addition, non-hospital health care facilities should be aware that persons with MRSA, VRE and other infections may be protected by the Americans with Disabilities Act or other applicable state or local laws or regulations.

What can be done to prevent or control transmission of these pathogens in my facility? CDC’s recommendations for preventing transmission of MRSA/VRE in hospitals consist of standard precautions, which should be used for all patient care. In addition, CDC recommends contact precautions when the facility (based on national or local regulations) deems the multidrug-resistant microorganism to be of special clinical and epidemiologic significance. The components of contact precautions may be adapted for use in non-hospital health care facilities, especially if the patient has draining wounds or difficulty controlling body fluids.

In addition to standard and contact precautions, the following procedures also may be considered for non-hospital health care facilities:
- **Patient placement**: Place the patient in a private room, if possible. When a private room is not available, place the patient in a room with a patient who is colonized or infected with the same organism, but does not have any other infection (cohorting). Another option is to place an infected patient with a patient who does not have risk factors for infection.
- **Patient placement in dialysis facilities**: Dialyze the patient at a station with as few adjacent stations as possible (i.e., at the end or corner of the unit).
- **Group activities**: It is extremely important to maintain the patient’s ability to socialize and have access to rehabilitation opportunities. Infected or colonized patients should be permitted to participate in group meals and activities if draining wounds are covered, bodily fluids are contained, and the patients observe good hygienic practices.

The following are recommended for prevention of VRE/MRSA in hospitals and may be adapted for use in non-hospital health care facilities:
- Obtain stool cultures or rectal swab cultures of roommates of patients newly found to be infected or colonized with VRE and nasal swabs for MRSA.
- Adopt a policy for deciding when patients can be removed from isolation, i.e., VRE-negative results on at least three consecutive occasions, one or more weeks apart.
- Consult health departments regarding discharge requirements for patients with MRSA or VRE.

Are there any recommendations for pre-admission screening in non-hospital settings? CDC does not have recommendations for pre-admission screening. However, the following options may be considered:
- Do not perform screening.
- Screen high-risk patients on admission. (Some evidence from a multicenter study suggests that screening before transfer leads to increased isolation and decreased transmission of VRE).

How should clusters or outbreaks of infections be handled? Consult with state or local health departments or an experienced infection control professional for reporting requirements and management of MRSA or VRE outbreaks.

If a patient in a facility is colonized or infected with MRSA or VRE, what do their visitors/family members need to know? In general, healthy people are at low risk of getting infected with MRSA or VRE. Therefore, casual contact – kissing, hugging, and touching – is acceptable. Visitors should wash their hands before leaving an infected person's room. Also, disposable gloves should be worn if contact with body fluids is expected. (If excessive contact with body fluids is expected, gowns should also be worn.) It is also acceptable for infants and children to have casual contact with these patients.

What precautions should family caregivers take for infected persons in their homes? Outside of health care settings, there is little risk of transmitting organisms to persons at risk of disease from MRSA/VRE, and healthy people are at low risk of getting infected. In the home, the following precautions should be followed:
- Caregivers should wash their hands with soap and water after physical contact with the infected or colonized person and before leaving the home.
- Towels used for drying hands after contact should be used only once.
- Disposable gloves should be worn if contact with body fluids is expected, and hands should be washed after removing the gloves.
- Linens should be changed and washed if they are soiled and on a routine basis.
- The patient’s environment should be cleaned routinely and when soiled with body fluids.
- Notify doctors and other health care personnel who provide care for the patient that the patient is colonized/infected with a multidrug-resistant organism [22].

Drug resistant microorganisms of particular concern

The following section highlights a number of the most dangerous drug-resistant bacteria:
- Methicillin-resistant Staphylococcus aureus (MRSA).
- Penicillin-resistant Pneumococcus (PRSP).
- Multiresistant pseudomonas aeruginosa.
- Multidrug-resistant Mycobacterium tuberculosis (TB).
- Vancomaycin-resistant Enterococcus (VRE).
- Other germs that have grown resistant to formerly reliable antibiotics include: Neisseria gonorrhoea, the cause of the sexually transmitted disease gonorrhea; and food poisons, including Salmonella, Escherichia coli (E. coli) and other Enterobacteriaceae.
Methicillin-resistant Staphylococcus aureus (MRSA)
The bacterium Staphylococcus aureus, which is the biggest cause of infections in patients in U.S. hospitals, can infect burns and skin and surgical wounds. Since 1996, at least four patients have been infected with a strain that was partially resistant to normal doses of the powerful, last-resort antibiotic vancomycin. Some strains of S. aureus have already shown resistance to all antibiotics other than vancomycin, raising the fear that an invincible strain is near at hand.

Staphylococci reside on the skin and mucous membranes, including the linings of the respiratory, intestinal and genitourinary tracts. Intact skin is adequate to prevent infection by staphylococci, but any break in skin integrity may lead to staphylococcal infection. Staphylococcus aureus becomes pathogenic in surgical wounds. Infection may result from inadequate skin preparation or contamination of the surgical site by bacteria on hands or adjacent skin. Overuse or misuse of antibiotics, particularly methicillin, to treat wound cultures that grow Staphylococcus aureus have contributed to the development of MRSA [28].

Infections that people acquire while receiving care at a health care institution are referred to as health care-associated infections (HAIs). MRSA is the most common multidrug-resistant organism. In 1972, MRSA was responsible for only 2 percent of all Staphylococcus aureus HAIs that were reported to the CDC. Today, MRSA is responsible for 60 percent of the Staphylococcus aureus infections. The death rate from MRSA is estimated at greater than 2.5 times higher than Staphylococcus aureus infections that respond to methicillin.

According to a recent study by the Association for Professionals in Infection Control (APIC), the MRSA rate is 46.3 per 1,000 inpatients in the U.S., which includes infection or colonization. This is 8-11 times higher than previous estimates. This study also revealed that there are 2 million hospital-acquired infections in the U.S. annually, and that the average length of a hospital stay is extended due to a patient contracting an antibiotic resistant infection [17].

What is Staphylococcus aureus?
Staphylococcus aureus, often referred to simply as “staph,” are bacteria commonly carried on the skin or in the nose of healthy people. Approximately 25 percent to 30 percent of the population is colonized (when bacteria are present, but not causing an infection) in the nose with staph bacteria. Sometimes, staph can cause an infection. Staph bacteria are one of the most common causes of skin infections in the United States. Most of these skin infections are minor (such as pimples and boils) and can be treated without antibiotics (also known as antimicrobials or antibacterials). However, staph bacteria also can cause serious infections (such as surgical wound infections, bloodstream infections and pneumonia).

What is MRSA (methicillin-resistant Staphylococcus aureus)?
Some staph bacteria are resistant to antibiotics. MRSA is a type of staph that is resistant to antibiotics called beta-lactams. Beta-lactam antibiotics include methicillin and other more common antibiotics such as oxacillin, penicillin and amoxicillin. While 25 percent to 30 percent of the population is colonized with staph, approximately 1 percent is colonized with MRSA.

Who gets staph or MRSA infections?
Staph infections, including MRSA, occur most frequently among persons in hospitals and health care facilities (such as nursing homes and dialysis centers) who have weakened immune systems. These health care-associated staph infections include surgical wound infections, urinary tract infections, bloodstream infections and pneumonia.

What is community-associated MRSA (CA-MRSA)?
Staph and MRSA can also cause illness in persons outside of hospitals and health care facilities. MRSA infections that are acquired by persons who have not been recently (within the past year) hospitalized or had a medical procedure (such as dialysis, surgery, catheters) are known as CA-MRSA infections. Staph or MRSA infections in the community are usually manifested as skin infections, such as pimples and boils, and occur in otherwise healthy people.

Are certain people at increased risk for community-associated staph or MRSA infections?
CDC has investigated clusters of CA-MRSA skin infections among athletes, military recruits, children, Pacific Islanders, Alaskan Natives, Native Americans, men who have sex with men and prisoners.

Factors that have been associated with the spread of MRSA skin infections include close skin-to-skin contact, openings in the skin such as cuts or abrasions, contaminated items and surfaces, crowded living conditions and poor hygiene [18].

What are the clinical features of CA-MRSA?
CA-MRSA most often presents as skin or soft tissue infection such as a boil or abscess. Patients frequently recall a “spider bite.” The involved site is red, swollen and painful and may have pus or other drainage. Staph infections also can cause more serious infections, such as blood stream infections or pneumonia, leading to symptoms of shortness of breath, fever and chills.

What are the criteria for distinguishing community-associated MRSA (CA-MRSA) from health care-associated MRSA (HA-MRSA)?
Persons with MRSA infections that meet all of the following criteria likely have CA-MRSA infections:
- Diagnosis of MRSA was made in the outpatient setting or by a culture positive for MRSA within 48 hours after admission to the hospital.
- No medical history of MRSA infection or colonization.
- No medical history in the past year of:
  - Hospitalization.
  - Admission to a nursing home, skilled nursing facility or hospice.
  - Dialysis.
  - Surgery.
- No permanent indwelling catheters or medical devices that pass through the skin into the body.

What is the main way that staph or MRSA is transmitted in the community?
The main mode of transmission of staph and/or MRSA is via hands, which may become contaminated by contact with:
- Colonized or infected individuals.
- Colonized or infected body sites of other persons.
- Devices, items or environmental surfaces contaminated with body fluids containing staph or MRSA.

Other factors contributing to transmission include skin-to-skin contact, crowded conditions and poor hygiene.

How is a MRSA infection diagnosed?
In general, a culture should be obtained from the infection site and sent to the microbiology laboratory. If S. aureus is isolated, the organism should be tested as follows to determine which antibiotics will be effective for treating the infection:
- Skin infection: Obtain either a small biopsy of skin or drainage from the infected site.
- Culture of a skin lesion is especially useful in recurrent or persistent cases of skin infection, in cases of antibiotic failure and in cases that present with advanced or aggressive infections.
- Pneumonia: Obtain a sputum culture (expectorated purulent sputum, respiratory lavage, or bronchoscopy).
- Bloodstream infection: Obtain blood cultures using aseptic techniques.
- Urinary infection: Obtain urine cultures using aseptic techniques.

How are CA-MRSA infections treated?
Staph skin infections, such as boils or abscesses, may be treated by incision and drainage, depending on severity. Antibiotic treatment, if indicated, should be guided by the susceptibility profile of the organism.

How do CA-MRSA and HA-MRSA strains differ?
Recently recognized outbreaks of MRSA in community settings have been associated with strains that have some unique microbiologic and genetic properties compared with the traditional hospital-based MRSA strains, suggesting some biologic properties (e.g., virulence factors) may allow the community strains to spread more easily or cause more skin disease. Additional studies are under way to characterize and
Pneumococcal infections are a leading cause of morbidity and mortality in the United States. S. pneumonia causes more than 500,000 cases of pneumonia, 55,000 cases of bacteremia, and 6,000 cases of meningitis annually, which result in 40,000 deaths. The death rate from pneumococcal bacteremia approaches 30 percent, despite the use of appropriate antimicrobial therapy. Reports of refractory illness due to resistant pneumococci demonstrate the clinical relevance of these strains. Identifying risk factors in the development of PRSP infections is important for both the prevention and treatment of these infections [27].

Streptococcus pneumonia, or pneumococcus, is a bacteria that causes many different kinds of infections in people, ranging from ear infections and sinus infections to pneumonia, meningitis and sepsis. Up to 30 percent of the strains of the bacterium are at least partially resistant to antibiotics in the penicillin family, Although the names (and bacterial genuses) are similar, S. pneumonia is quite different from group A streptococcus (the bacteria that causes strep throat and rheumatic fever). S. pneumonia infections are on the average much more serious – pneumococcus is the most common cause of bacterial meningitis in the United States, and about 8 percent of children with pneumococcal meningitis die of the infection, while one out of four surviving children or more have neurological damage including hearing loss after “getting over” the infection. Pneumococci are the most common cause of ear infections and sinus infections, as well as the most common bacteria found in the blood of children under 2 years old with fevers, many of whom have no obvious site of infection. Many people have pneumococci in their noses and throats but have no symptoms. The bacteria is transmitted from one person to another, usually by droplets.

Like viral upper respiratory infections, pneumococcal infections are more common in winter. Infection can begin as little as one to three days after exposure. Studies of ear fluid cultures suggest that anywhere from 20 to 40 percent of ear infections are caused by pneumococcus. The signs of pneumococcal meningitis and sepsis can be the same as those of meningococcal meningitis. Often, however, pneumococcal infection can appear first as a high fever with a very high white-blood-cell count (where almost all of the white cells are neutrophils or bacteria-fighting cells) and no obvious site of infection.

There are also some people who are more susceptible to pneumococcal infections than others. One particular group of people who are more likely to be infected are those whose spleens have been damaged or removed – whether because of injury or because of disease. People with sickle-cell anemia are at special risk, because repeated sickle-cell crises and the resulting damage to red blood cells results in destruction of spleen tissue. Most doctors assume that if you have sickle-cell disease, your spleen will not be working any more by, at the latest, your 20s, and so we vaccinate sickle-cell patients against bacteria such as pneumococcus and meningococcus, which healthy people’s spleens help their bodies kill. Other people who are more susceptible to pneumococcus than the average person are those with immune system problems (including AIDS, but also people who do not produce enough of certain kinds of white cells or who lack other important components of their immune systems, or those with some kinds of chronic illness that weakens their immune systems).

Multiresistant pseudomonas aeruginosa

Pseudomonas aeruginosa is noted for its environmental versatility, ability to cause disease in particularly susceptible individuals and its resistance to antibiotics. The pathogens are widespread in nature, inhabiting soil, water, plants and animals, including humans. Pseudomonas aeruginosa has become an important cause of infection, especially in patients with compromised host defense mechanisms. It is the most common pathogen isolated from patients who have been hospitalized longer than one week, and is a frequent cause of nosocomial infections such as pneumonia, urinary tract infections (UTIs) and bacteremia. Pseudomonal infections are complicated and can be life-threatening.

The bacterium is capable of utilizing a wide range of organic compounds as food sources, thus giving it an exceptional ability to colonize ecological niches where nutrients are limited. P aeruginosa can produce a number of toxic proteins that not only cause extensive tissue damage, but also interfere with the human immune system’s defense mechanisms. These proteins range from potent toxins that enter and kill host cells at or near the site of colonization to degradative enzymes that permanently disrupt the cell membranes and connective tissues in various organs.

Cancer and burn patients also commonly suffer serious infections by this organism, as do certain other individuals with immune system deficiencies. Unlike many environmental bacteria, P. aeruginosa has a remarkable capacity to cause disease in susceptible hosts. It has the ability to adapt to and thrive in many ecological niches, from water and soil to plant and animal tissues. The most serious complication of cystic fibrosis is respiratory tract infection by Pseudomonas aeruginosa.

P aeruginosa is an opportunistic pathogen. It rarely causes disease in healthy persons. In most cases of infection, the integrity of a physical barrier to infection (e.g., skin, mucous membrane) is lost or an underlying immune deficiency (e.g., neutropenia, immunosuppression) is present. Pseudomonas is both invasive and toxigenic. The three stages are:

1. Bacterial attachment and colonization.
2. Local infection.

The importance of colonization and adherence is most evident when studied in the context of respiratory tract infection in patients with cystic fibrosis and in those that complicate mechanical ventilation. Production of extracellular proteases adds to the organism’s virulence by assisting in bacterial adherence and invasion.

According to U.S. Centers for Disease Control and Prevention (CDC) data collected from 1990-1996, P aeruginosa was the second-most common cause of nosocomial pneumonia (17 percent of isolates), the third-most common cause of UTI (11 percent), the fourth-most common cause of surgical site infections (8 percent), the seventh-most common isolated pathogen from the bloodstream (3 percent), and the fifth-most common isolate overall (9 percent) obtained from all sites. Internationally, P aeruginosa is common in patients with diabetes who are immunocompromised.

All infections caused by P aeruginosa are treatable and potentially curable. Acute fulminant infections, such as bacteremic pneumonia, sepsis, burn wound infections and meningitis, however, are associated with extremely high mortality. Vertebral osteomyelitis resulting from a pseudomonal infection mainly occurs in elderly patients and often involves the lumbar sacral spine. Young people who use IV drugs may also be affected. Involvement of the GI tract most commonly occurs in infants and patients with hematologic malignancies and neutropenia that has resulted from chemotherapy. The incidence of
pseudomonal pneumonia in patients with cystic fibrosis has shown a shift towards patients who are older than 26 years [30].

The clinical evaluation of the pneumococcal infections depends on the age and health condition of the patient, site and severity of the infection and the adequacy of the treatment. Penicillin was uniformly effective against pneumococcus until three decades ago, when the first reports of clinical resistance were published. Since then, there has been a rapid increase in the level and rates of resistance to penicillin, which parallels other beta-lactams and antimicrobials.

Pneumonia is the second-most common nosocomial infection in the United States and is associated with substantial morbidity and mortality. Most patients who have nosocomial pneumonia are infants, young children and persons older than 65; persons who have severe underlying disease, immunosuppression, depressed sensorium and/or cardiopulmonary disease; and persons who have had thoracoabdominal surgery.

Although patients receiving mechanically assisted ventilation do not represent a major proportion of patients who have nosocomial pneumonia, they are at highest risk for acquiring the infection. Most bacterial nosocomial pneumonias occur by aspiration of bacteria colonizing the oropharynx or upper gastrointestinal tract of the patient. Because intubation and mechanical ventilation alter first-line patient defenses, they greatly increase the risk for nosocomial bacterial pneumonia.

Pneumonias caused by Legionella sp., Aspergillus sp. and influenza virus are often caused by inhalation of contaminated aerosols. RSV infection usually occurs after viral inoculation of the conjunctivae or nasal mucosa by contaminated hands. Traditional preventive measures for nosocomial pneumonia include decreasing aspiration by the patient, preventing cross-contamination or colonization via hands of personnel, appropriate disinfection or sterilization of respiratory-therapy devices, use of available vaccines to protect against particular infections and education of hospital staff and patients. New measures being investigated involve reducing oropharyngeal and gastric colonization by pathogenic microorganisms [20].

Risk factors and control measures for pneumonia

Several large studies have examined the potential risk factors for nosocomially acquired bacterial pneumonia. Although specific risk factors have differed between study populations, they can be grouped into the following general categories:

- Host factors (e.g., extremes of age and severe underlying conditions, including immunosuppression).
- Factors that enhance colonization of the oropharynx and/or stomach by microorganisms (e.g., administration of antimicrobials, admission to an ICU, underlying chronic lung disease, or coma).
- Conditions favoring aspiration or reflux (e.g., endotracheal intubation, insertion of nasogastric tube or supine position).
- Conditions requiring prolonged use of mechanical ventilatory support with potential exposure to contaminated respiratory equipment and contact with contaminated or colonized hands of health care workers; and factors that impede adequate pulmonary toilet (i.e., undergoing surgical procedures that involve the head, neck, thorax or upper abdomen or being immobilized as a result of trauma or illness).

Oropharyngeal, tracheal and gastric colonization

In many studies, the administration of antacids and H-2 blockers for prevention of stress bleeding in critically ill, postoperative, and/or mechanically ventilated patients has been associated with gastric bacterial overgrowth. Sucralfate, a cytoprotective agent that has little effect on gastric pH and may have bactericidal properties of its own, has been suggested as a potential substitute for antacids and H-2 blockers. In most randomized trials, ICU patients receiving mechanically assisted ventilation who were treated either with only antacids or with antacids and H-2 blockers had increased gastric pH, high bacterial counts in the gastric fluid and increased risk for pneumonia in comparison with patients treated with sucralfate.

Selective decontamination of the digestive tract (SDD) is another strategy designed to prevent bacterial colonization and lower respiratory tract infection in mechanically ventilated patients. SDD is aimed at preventing oropharyngeal and gastric colonization with aerobic gram-negative bacilli and Candida sp. without altering the anaerobic flora. Various SDD regimens use a combination of locally administered nonabsorbable antibiotic agents, such as polymyxin and an aminoglycoside (either tobramycin, gentamicin, or, rarely, neomycin) or a quinolone (either norfloxacin or ciprofloxacin) coupled with either amphotericin B or nystatin. The local antimicrobial preparation is applied as a paste to the oropharynx and administered either orally or via the nasogastric tube four times a day. In addition, in many studies, a systemic (intravenous) antimicrobial (e.g., cefotaxime or trimethoprim) is administered to the patient.

Currently available data do not justify the routine use of SDD for prevention of nosocomial pneumonia in ICU patients. SDD may be ultimately useful for specific subsets of ICU patients, such as patients with trauma or severe immunosuppression (i.e., bone-marrow-transplant recipients) [20].

Aspiration of oropharyngeal and gastric flora

Clinically important aspiration usually occurs in patients who:

- Have a depressed level of consciousness.
- Have dysphagia resulting from neurological or esophageal disorders.
- Have an endotracheal (nasotracheal or orotracheal), tracheostomal, or enteral (nasogastric or orogastric) tube in place.
- Are receiving enteral feeding.

Placement of an enteral tube may increase nasopharyngeal colonization, cause reflux of gastric contents or allow bacterial migration via the tube from the stomach to the upper airway. When enteral feedings are administered, gross contamination of the enteral solution during preparation and elevated gastric pH may lead to gastric colonization with gram-negative bacilli. In addition, gastric reflux and aspiration might occur because of increased intragastric volume and pressure.

Although prevention of pneumonia in such patients may be difficult, methods that make regurgitation less likely (e.g., placing the patient in a semirecumbent position, i.e., by elevating the head of the bed, and withholding enteral feeding if the residual volume in the stomach is large or if bowel sounds are not heard upon auscultation of the abdomen) may be beneficial. Conversely, equivocal results have been obtained by:

- Administering enteral nutrition intermittently in small boluses rather than continuously.
- Using flexible, small-bore enteral tubes.
- Placing the enteral tube below the stomach (e.g., in the jejunum).

Mechanically assisted ventilation and endotracheal intubation

Patients receiving continuous, mechanically assisted ventilation have 6-21 times the risk for acquiring nosocomial pneumonia compared with patients not receiving ventilatory support. One study indicated that the risk for developing ventilator-associated pneumonia increased by 1 percent per day. This increased risk was attributed partially to carriage of oropharyngeal organisms upon passage of the endotracheal tube into the trachea during intubation, as well as to depressed host defenses secondary to the patient’s severe underlying illness. In addition, bacteria can aggregate on the surface of the tube over time and form a glycocalyx (i.e., a biofilm) that protects the bacteria from the action of antimicrobial agents or host defenses. Some researchers believe that these bacterial aggregates can become dislodged by ventilation flow, tube manipulation or suctioning and subsequently embolize into the lower respiratory tract and cause focal pneumonia. Removing tracheal secretions by gentle suctioning and using aseptic techniques to reduce cross-contamination to patients from contaminated respiratory therapy equipment or contaminated or colonized hands of health care workers have been used traditionally to help prevent pneumonia in patients receiving mechanically assisted ventilation.

The risk for pneumonia also is increased by the direct access of bacteria to the lower respiratory tract, which often occurs because of leakage around the endotracheal cuff, thus enabling pooled secretions above the cuff to
enter the trachea. In one study, the occurrence of nosocomial pneumonia was delayed and decreased in intubated patients whose endotracheal tubes had a separate dorsal lumen that allowed drainage (i.e., by suctioning) of secretions in the space above the endotracheal tube cuff and below the glottis. However, additional studies are needed to determine the cost-benefit ratio of using this device.

Cross-colonization via hands of health care workers
Pathogens that cause nosocomial pneumonia (e.g., gram-negative bacilli and S. aureus) are ubiquitous in hospitals, especially in intensive- or critical-care areas. Transmission of these microorganisms to patients frequently occurs via an attending health care worker’s hands that have become contaminated or transiently colonized with the microorganisms. Procedures such as tracheal suctioning and manipulation of the ventilator circuit or endotracheal tubes increase the opportunity for cross-contamination. The risk for cross-contamination can be reduced by using aseptic techniques and sterile or disinfected equipment when appropriate and by eliminating pathogens from the hands of health care workers. In theory, adequate hand washing is an effective way of removing transient bacteria from the hands; however, personnel compliance with hand-washing recommendations has been generally poor. For this reason, the routine use of gloves has been advocated to help prevent cross-contamination. The routine use of gloves, in addition to the use of gowns, was associated with a decrease in the incidence of nosocomial RSV infections and other infections acquired in ICUs. However, nosocomial pathogens can colonize gloves, and outbreaks have been traced to workers who did not change gloves after having contact with one patient and before providing care to another. In addition, gloved hands can be contaminated through leaks in the gloves.

Contamination of devices used on the respiratory tract
Devices used on the respiratory tract for respiratory therapy (e.g., nebulizers), diagnostic examination (i.e., bronchoscopes and spirometers) and administration of anesthesia are potential reservoirs and vehicles for infectious microorganisms. Routes of transmission might be from device to patient, from one patient to another or from one body site to the lower respiratory tract of the same patient via hand or device. Contaminated reservoirs of aerosol-producing devices (i.e., nebulizers) can allow the growth of hydrophilic bacteria that subsequently can be aerosolized during use of the device. Gram-negative bacilli (e.g., Pseudomonas sp., Xanthomonas sp., Flavobacterium sp., Legionella sp. and nontuberculous mycobacteria) can multiply to substantial concentrations in nebulizer fluid and increase the risk for pneumonia in patients using such devices.

Proper cleaning and sterilization or disinfection of reusable equipment are important components of a program to reduce infections associated with respiratory therapy and anesthesia equipment. Many devices or parts of devices used on the respiratory tract have been categorized as semicritical in the Spaulding classification system for appropriate sterilization or disinfection of medical devices because they come into direct or indirect contact with mucous membranes but do not ordinarily penetrate body surfaces; the associated risk for infection in patients after the use of such devices is less than that associated with devices that penetrate normally sterile tissues. Thus, if sterilization of these devices by steam autoclave or ethylene oxide is not possible or cost-effective, they can be subjected to high-level disinfection by pasteurization at 75 C for 30 minutes or by use of liquid chemical disinfectants approved by the Environmental Protection Agency (EPA) as sterilants/disinfectants and approved for use on medical instruments by the Food and Drug Administration [20].

If a respiratory device needs rinsing to remove a residual liquid chemical sterilant/disinfec tant after chemical disinfection, sterile water is preferred because tap or locally prepared distilled water might contain microorganisms that can cause pneumonia. In some hospitals, a tap-water rinse followed by air-drying with or without an alcohol rinse (i.e., to hasten drying) is used. In theory, if complete drying is achieved after a tap-water rinse, the risk for nosocomial pneumonia associated with the use of the device is probably low. Air-drying reduces the level of microbial contamination of the hands of health care workers after washing, and air-drying also reduces contamination of gastrointestinal endoscopes. However, many semicritical items used on the respiratory tract (e.g., corrugated tubing, jet or ultrasonic nebulizers, and bronchoscopes) are difficult to dry, and the degree of dryness of a device is difficult to assess. Data are insufficient regarding the safety of routinely using tap water for rinsing (followed by drying) reusable semicritical respiratory devices after their disinfection or between their uses on the same patient.

Mechanical ventilators, breathing circuits, humidifiers, heat-moisture exchangers, and in-line nebulizers

Mechanical ventilators. The internal machinery of mechanical ventilators used for respiratory therapy is not considered an important source of bacterial contamination of inhaled gas. Thus, routine sterilization or high-level disinfection of the internal machinery is considered unnecessary.

Breathing circuits, humidifiers and heat-moisture exchangers. In the United States, most hospitals use ventilators with either bubble-through or wick humidifiers that produce either insignificant or no aerosols for humidification. Thus, these devices probably do not pose an important risk for pneumonia in patients. Sterile water, however, is still usually used to fill these humidifiers because tap or distilled water might contain microorganisms, such as Legionella sp., that are more heat-resistant than other bacteria.

The potential risk for pneumonia in patients using mechanical ventilators that have heated bubble-through humidifiers stems primarily from the condensate that forms in the inspiratory-phase tubing of the ventilator circuit as a result of the difference in the temperatures of the inspiratory-phase gas and ambient air; condensate formation increases if the tubing is unheated. The tubing and condensate can rapidly become contaminated, usually with bacteria that originate in the patient’s oropharynx. In one study, 33 percent of inspiratory circuits were colonized with bacteria via this route within two hours, and 80 percent within 24 hours, after initiation of mechanical ventilation. Spillage of the contaminated condensate into the patient’s tracheobronchial tree, as can occur during procedures in which the tubing is moved (i.e., for suctioning, adjusting the ventilator setting or feeding or caring for the patient), may increase the risk for pneumonia in the patient. Thus, in many hospitals, health care workers are trained to prevent such spillage and to drain the fluid periodically. Microorganisms contaminating ventilator-circuit condensate can be transmitted to other patients via the hands of health care workers handling the fluid, especially if the worker neglects washing hands after handling the condensate.

Condensate formation can be eliminated by using a heat-moisture exchanger (HME) or a hygroscopic condenser humidifier (i.e., an “artificial nose”). An HME recycles heat and moisture exhaled by the patient and eliminates the need for a humidifier. In the absence of a humidifier, no condensate forms in the inspiratory-phase tubing of the ventilator circuit. Thus, bacterial colonization of the tubing is prevented, and the need to change the tubing on a periodic basis is obviated. Some models of HMEs are equipped with bacterial filters, but the advantage of using such filters is unknown. HMEs can increase the dead space (i.e., the area of the lung in which air is not exchanged) and resistance to breathing, might leak around the endotracheal tube, and might result in drying of sputum and blockage of the tracheobronchial tree. Although recently developed HMEs that have humidifiers increase airway humidity without increasing colonization of bacteria, additional studies are needed to determine whether the incidence of pneumonia is decreased.

Small-volume (“in-line”) medication nebulizers. Small-volume medication nebulizers that are inserted in the inspiratory circuit of mechanical ventilators can produce bacterial aerosols. If such devices become contaminated by condensate in the inspiratory tubing of the breathing circuit, they can increase the patient’s risk for pneumonia because the nebulizer aerosol is directed through the endotracheal tube and bypasses many of the normal host defenses against infection.

Large-volume nebulizers. Nebulizers with large-volume (greater than 500 cc) reservoirs, including those used in intermittent positive-
pressure breathing (IPPB) machines and ultrasonic or spinning-disk room-air humidifiers, pose the greatest risk for pneumonia to patients, probably because of the large amount of aerosols they generate. These reservoirs can become contaminated by the hands of health care workers, unsterile humidification fluid or inadequate sterilization or disinfection between uses. Once introduced into the reservoir, various bacteria, including Legionella sp., can multiply to sufficiently large numbers within 24 hours to pose a risk for infection in patients who receive inhalation therapy. Sterilization or high-level disinfection of these nebulizers can eliminate vegetative bacteria from their reservoirs and make them safe for patient use. However, unlike nebulizers attached to IPPB machines, room-air humidifiers have a high cost-benefit ratio: Evidence of clinical benefits from their use in hospitals is lacking, and the potential cost of daily sterilization or disinfection and use of sterile water to fill such devices is substantial.

Hand-held small-volume medication nebulizers. Small-volume medication nebulizers used to administer bronchodilators, including nebulizers that are hand-held, can produce bacterial aerosols. Hand-held nebulizers have been associated with nosocomial pneumonia, including Legionnaires disease, resulting from either contamination with medications from multidose vials or Legionella-contaminated tap water used for rinsing and filling the reservoir.

Suction catheters, resuscitation bags, oxygen analyzers and ventilator spirometers. Tracheal suction catheters can introduce microorganisms into a patient’s lower respiratory tract. Two types of suction-catheter systems are used in U.S. hospitals: the open single-use catheter system and the closed multiseat catheter system. Studies comparing the two systems have involved low numbers of patients; the results of these studies suggest that the risk for catheter contamination or pneumonia does not differ between patients on either system. Although advantages of cost and decreased environmental contamination have been attributed to use of the closed-suction system, larger studies are needed to compare the advantages and disadvantages of both systems. Reusable resuscitation bags are particularly difficult to clean and dry between uses; microorganisms in secretions or fluid left in the bag may be aerosolized and sprayed into the lower respiratory tract of the patient on whom the bag is used; in addition, contaminating microorganisms might be transmitted from one patient to another via hands of health care workers (311-313). Oxygen analyzers and ventilator spirometers have been associated with outbreaks of gram-negative respiratory tract colonization and pneumonia resulting from patient-to-patient transmission of organisms via hands of health care workers. These devices require either sterilization or high-level disinfection between uses on different patients. Education of physicians, respiratory therapists and nursing staff regarding the associated risks and appropriate care of these devices is essential.

Anesthesia equipment. The contributory role of anesthesia equipment in outbreaks of nosocomial pneumonia was reported before hospitals implemented routine after-use cleaning and disinfection/sterilization of reusable anesthesia equipment components that could become contaminated with pathogens during use.

Anesthesia machine. The internal components of anesthesia machines, which include the gas sources and outlets, gas valves, pressure regulators, flow meters and vaporizers, are not considered an important source of bacterial contamination of inhaled gases. Thus, routine sterilization or high-level disinfection of the internal machinery is unnecessary.

Breathing system or patient circuit. The breathing system or patient circuit (including the tracheal tube or face mask, inspiratory and expiratory tubing, y-piece, CO2 absorber and its chamber, anesthesia ventilator bellows and tubing, humidifier, adjustable pressure-limiting valve and other devices and accessories), through which inhaled and exhaled gases flow to and from a patient can become contaminated with microorganisms that might originate from the patient’s oropharynx or trachea. In general, reusable components of the breathing system that directly touch the patient’s mucous membranes (e.g., face mask or tracheal tube) or become readily contaminated with the patient’s respiratory secretions (e.g., y-piece, inspiratory and expiratory tubing, and attached sensors) are cleaned and subjected to high-level disinfection or sterilization between patients. The other parts of the breathing system (e.g., CO2 absorber and its chamber), for which an appropriate and cost-effective schedule of reprocessing has not been firmly determined, are changed, cleaned and sterilized or subjected to high-level disinfection periodically in accordance with published guidelines or the manufacturer’s instructions. Using high-efficiency bacterial filters at various positions in the patient circuit (e.g., at the y-piece or on the inspiratory and expiratory sides of the patient circuit) has been advocated and shown to decrease contamination of the circuit. However, the use of bacterial filters to prevent nosocomial pulmonary infections has not been proven to be effective and requires additional analysis.

Pulmonary function testing apparatus

Internal parts of pulmonary function testing apparatus. The internal parts of pulmonary function testing apparatus usually are not considered an important source of bacterial contamination of inhaled gas. However, because of concern about possible carryover of bacterial aerosols from an infectious patient-user of the apparatus to the next patient, placement of bacterial filters (that remove exhaled bacteria) between the patient and the testing equipment has been advocated. More studies are needed to evaluate the need for and efficacy of these filters in preventing nosocomial pneumonia.

Tubing, rebreathing valves, and mouthpieces. Tubing, connectors, rebreathing valves, and mouthpieces could become contaminated with patient secretions during use of the pulmonary function testing apparatus. Thus, these items should be cleaned and subjected to high-level disinfection or sterilization between uses on different patients.

Thoracotomy abdominal surgical procedures

Certain patients are at high risk for developing postoperative pulmonary complications, including pneumonia. These persons include those who are obese, older than 70 or who have chronic obstructive pulmonary disease. Abnormal results from pulmonary function tests (especially decreased maximum expiration flow rate), a history of smoking, the presence of tracheostomy or prolonged intubation, or protein depletion that can cause respiratory-muscle weakness are also risk factors. Patients who undergo surgery of the head, neck, thorax or abdomen might have impairment of normal swallowing and respiratory clearance mechanisms as a result of instrumentation of the respiratory tract, anesthesia or increased use of narcotics and sedatives. Patients who undergo upper abdominal surgery usually have diaphragmatic dysfunction that results in decreased functional residual capacity of the lungs, closure of airways and atelectasis.

Interventions aimed at reducing the postoperative patient’s risk for pneumonia have been developed. These include deep breathing exercises, chest physiotherapy, use of incentive spirometry, IPPB and continuous positive airway pressure by face mask. Studies evaluating the relative efficacy of these modalities reported variable results and were difficult to compare because of differences in outcome variables assessed, patient populations studied and study design. Nevertheless, many studies have reported that deep breathing exercises, use of incentive spirometry and IPPB are advantageous maneuvers, especially in patients who had preoperative pulmonary dysfunction. In addition, control of pain that interferes with cough and deep breathing during the immediate postoperative period decreases the incidence of pulmonary complications after surgery. Several methods of controlling pain have been used; these include both intramuscular or intravenous (including patient-controlled) administration of analgesia and regional (i.e., epidural) analgesia.

Other prophylactic measures

Vaccination of patients. Although pneumococci are not a major cause of nosocomial pneumonia, these organisms have been identified as etiologic agents of serious nosocomial pulmonary infection and bacteremia. The following factors place patients at high risk for complications from pneumococcal infections: age 65 or older, chronic cardiovascular or pulmonary disease, diabetes mellitus, alcoholism, cirrhosis, cerebrospinal...
fluid leaks, immunosuppression, functional or anatomic asplenia, or infection with human immunodeficiency virus (HIV). Pneumococcal vaccine is effective in preventing pneumococcal disease. Because two thirds or more of patients with serious pneumococcal disease have been hospitalized at least once within the five years preceding their pneumococcal illness, offering pneumococcal vaccine in hospitals (i.e., at the time of patient discharge) should contribute substantially to preventing the disease.

**Prophylaxis with systemic antimicrobial agents.** The systemic administration of antimicrobials is commonly used to prevent nosocomial pneumonia — especially for patients who are receiving mechanical ventilation, are post-operative or are critically ill. However, the efficacy of this practice is questionable, and superinfection, which is possible as a result of any antimicrobial therapy, could occur.

**Use of “kinetic beds” or continuous lateral rotational therapy (CLRT) for immobilized patients.** Use of kinetic beds, or CLRT, is a maneuver for prevention of pulmonary and other complications resulting from prolonged immobilization or bed rest, such as in patients with acute stroke, critical illness, head injury or traction, blunt chest trauma, and/or mechanically assisted ventilation. This procedure involves the use of a bed that turns continuously and slowly (from less than or equal to 40 for CLRT to greater than or equal to 40 for kinetic therapy) along its longitudinal axis. Among the hypothesized benefits are improved drainage of secretions within the lungs and lower airways, increased tidal volume and reduction of venous thrombosis with resultant pulmonary embolization. However, the efficacy of CLRT in preventing pneumonia needs further evaluation because studies have yielded variable results. In addition, the studies either involved small numbers of patients, lacked adequate randomization, had no clear definition of pneumonia, did not distinguish between community-acquired and nosocomial pneumonia, or did not adjust for possible confounding factors (e.g., mechanical ventilation, endotracheal intubation, nasogastric intubation and enteral feeding) [4].

**Multidrug-resistant mycobacterium tuberculosis (TB)**

- Multidrug-resistant tuberculosis (MDR TB) is a form of tuberculosis that is resistant to two or more of the primary drugs used for the treatment of tuberculosis. Resistance to one or several forms of treatment occurs when the bacteria develops the ability to withstand antibiotic attack and relay that ability to their progeny. Since that entire strain of bacteria inherits this capacity to resist the effects of the various treatments, resistance can spread from one person to another. On an individual basis, however, inadequate treatment or improper use of the anti-tuberculosis medications remains an important cause of drug-resistant tuberculosis.

- In 2003, the CDC reported that 7.7 percent of tuberculosis cases in the U.S. were resistant to isoniazid, the first-line drug used to treat TB.

- The CDC also reported that 1.3 percent of tuberculosis cases in the U.S. were resistant to both isoniazid and rifampin. Rifampin is the drug most commonly used with isoniazid.

- The World Health Organization estimates that up to 50 million persons worldwide may be infected with drug resistant strains of TB. Also, 300,000 new cases of MDR-TB are diagnosed around the world each year, and 79 percent of the MDR-TB cases now show resistance to three or more drugs.

- A strain of MDR TB originally develops when a case of drug-susceptible tuberculosis is improperly or incompletely treated. This occurs when a physician does not prescribe proper treatment regimens or when a patient is unable to adhere to therapy. Inproper treatment allows individual TB bacilli that have natural resistance to a drug to multiply. Eventually the majority of bacilli in the body are resistant.

- Once a strain of MDR TB develops, it can be transmitted to others just like a normal drug-susceptible strain. Airborne transmission has been the cause of several well-publicized outbreaks of MDR TB in New York City and Florida. These outbreaks were responsible for the deaths of several patients and health care workers, a majority of whom were coinfected with HIV.

- MDR-TB has been a particular concern among HIV-infected persons. Some of the factors that have contributed to the number of cases of MDR-TB, both in general and among HIV-infected individuals, are:
  - Delayed diagnosis and delayed determination of drug susceptibility, which may take several weeks.
  - Susceptibility of immunosuppressed individuals for not only acquiring MDR-TB but also for rapid disease progression, which may result in rapid transmission of the disease to other immunosuppressed patients.
  - Inadequate respiratory isolation procedures and other environmental safety conditions, especially in confined areas such as prisons.
  - Noncompliance or intermittent compliance with anti-tuberculosis drug therapy.

- MDR-TB is more difficult to treat than drug-susceptible strains of TB. The success of treatment depends upon how quickly a case of TB is identified as drug resistant and whether an effective drug therapy is available. The second-line drugs used in cases of MDR-TB are often less effective and more likely to cause side effects.

- Tests to determine the resistance of a particular strain to various drugs usually take several weeks to complete. During the delay the patient may be treated with a drug regimen that is ineffective. Once a strain’s drug resistance is known, an effective drug regimen must be identified and begun. Some strains of MDR-TB are resistant to seven or more drugs, making the identification of effective drugs difficult. To deal with this problem, it is recommended that newly discovered cases of TB in populations at high risk for MDR-TB be treated with four drugs rather than the standard three as part of initial treatment.

- Treatment for MDR-TB involves drug therapy over many months or years. Despite the longer course of treatment, the cure rate decreases from over 90 percent for nonresistant strains of TB to 50 percent or less for MDR-TB.

- Because it is difficult for some people to successfully complete their tuberculosis treatment, several innovations have been developed. One of these is the use of incentives and enablers, which may be transportation, tokens or food coupons that are given to patients each time they appear at the clinic or doctor’s office for treatment. Incentives and enablers are combined with the use of directly observed therapy (DOT). DOT is a system of treatment in which the patient is administered his or her medication by a nurse or health worker and observed taking the medication.

- FDA has approved Rifater, a medication that combines the three main drugs (isoniazid, rifampin, and pyrazinamide) used to treat tuberculosis into one pill. This reduces the number of pills a patient has to take each day and makes it impossible for the patient to take only one of the three medications, a common path to the development of MDR-TB. [14]

- In June 1998, the U.S. Food and Drug Administration approved the first new drug for pulmonary tuberculosis in 25 years. The drug, rifapentine (Priftin), has been approved for use with other drugs to fight TB. One potential advantage of rifapentine is that it can be taken less often in the final four months of treatment — once a week compared with twice a week for the standard regimen.

Stephen Weis and colleagues at the University of North Texas Health Science Center in Fort Worth reported in the April 28, 1994, New England Journal of Medicine on research they conducted in Tarrant County, Texas, that vividly illustrates how helping patients to take the full course of their medication can actually lower resistance rates for tuberculosis.

TB is an infection that has experienced spectacular ups and downs. Drugs were developed to treat it, complacency set in that it was beaten, and the disease resurfaced because patients stopped their medication too soon and infected others. Today, one in seven new TB cases is resistant to the two drugs most commonly used to treat it (isoniazid and rifampin), and 5 percent of these patients die.
In the Texas study, 407 patients from 1980 to 1986 were allowed to take their medication on their own. From 1986 until the end of 1992, 581 patients were closely followed, with nurses observing them take their pills. By the end of the study, the relapse rate – which reflects antibiotic resistance – fell from 20.9 to 5.5 percent. This trend is especially significant, the researchers note, because it occurred as risk factors for spreading TB – including AIDS, intravenous drug use and homelessness – were increasing. The conclusion: Resistance can be slowed if patients take medications correctly [29].

The relationship between TB and HIV

Tuberculosis (TB) is a disease that is spread from person to person through the air, and it is particularly dangerous for people infected with HIV. Worldwide, TB is the leading cause of death among people infected with HIV.

An estimated 10 million to 15 million Americans are infected with TB bacteria, with the potential to develop active TB disease in the future. About 10 percent of these infected individuals will develop TB at some point in their lives. However, the risk of developing TB disease is much greater for those infected with HIV and living with AIDS. Because HIV infection so severely weakens the immune system, people dually infected with HIV and TB have a 100 times greater risk of developing active TB disease and becoming infectious compared with people not infected with HIV. CDC estimates that 10 to 15 percent of all TB cases and nearly 30 percent of cases among people ages 25 to 44 are occurring in HIV-infected individuals.

This high level of risk underscores the critical need for targeted TB screening and preventive treatment programs for HIV-infected people and those at greatest risk for HIV infection. All people infected with HIV should be tested for TB, and, if infected, complete preventive therapy as soon as possible to prevent TB disease.

Two global epidemics

◊ Approximately 2 billion people (one-third of the world’s population) are infected with Mycobacterium tuberculosis, the cause of TB.
◊ TB is the cause of death for one out of every three people with AIDS worldwide.
◊ The spread of the HIV epidemic has significantly impacted the TB epidemic – one-third of the increase in TB cases over the last five years can be attributed to the HIV epidemic (Source: UNAIDS).

Every nation must face the challenge of combating multidrug-resistant (MDR) TB. People infected with HIV and living with AIDS are at greater risk for developing MDR TB, which is extremely difficult to treat and can be fatal. While the number of cases has remained stable in the United States over the past few years, people with MDR TB have now been reported from 43 states and the District of Columbia.

To prevent the continued emergence of drug-resistant strains of TB, treatment for TB must be improved in the United States and across the globe. Inconsistent or partial treatment is the main cause of TB that is resistant to available drugs (MDR-TB). The most effective strategy for ensuring completion of treatment is directly observed therapy, and its use must be expanded.

Another challenge that individuals co-infected with HIV and TB face is the possible complications that can occur when taking HIV treatment regimens along with drugs commonly used to treat TB. Physicians prescribing these drugs must carefully consider all potential interactions. TB control is an exercise in vigilance; the goal of controlling and eventually eliminating TB requires a targeted and continuous effort to address the prevention and treatment needs for those most at risk, including HIV-infected individuals. Efforts to eliminate TB are therefore essential to reducing the global toll of HIV [24].

Vancomycin-resistant enterococcus (VRE)

Enterococci, previously called group D strep, can cause everything from urinary tract to heart valve infections. Resident in the gastrointestinal tract and female genital tract, skin surfaces may easily be contaminated by enterococci due to poor hygiene. Overuse of vancomycin to treat other infections may have caused the development of VRE.

When microbes began resisting penicillin, medical researchers fought back with chemical cousins, such as methicillin and oxacillin. By 1953, the antibiotic armamentarium included chloramphenicol, neomycin, terramycin, tetracycline and cephalosporins. But today, researchers fear that we may be nearing an end to the seemingly endless flow of antimicrobial drugs.

At the center of current concern is the antibiotic vancomycin, which for many infections is literally the drug of “last resort,” says Michael Blum, M.D., medical officer in FDA’s division of anti-infective drug products. Some hospital-acquired staph infections are resistant to all antibiotics except vancomycin.

Now vancomycin resistance has turned up in another common hospital bug, enterococcus. And since bacteria swap resistance genes like teenagers swap T-shirts, it is only a matter of time, many microbiologists believe, until vancomycin-resistant staph infections appear. “Staph aureus may pick up vancomycin resistance from enterococci, which are found in the normal human gut,” says Madden. And the speed with which vancomycin resistance has spread through enterococci has prompted researchers to use the word “crisis” when discussing the possibility of vancomycin-resistant staph.

Vancomycin-resistant enterococci were first reported in England and France in 1987, and appeared in one New York City hospital in 1989. By 1991, 38 hospitals in the United States reported the bug. By 1993, 14 percent of patients with enterococcus in intensive-care units in some hospitals had vancomycin-resistant strains, a 20-fold increase from 1987. A frightening report came in 1992, when a British researcher observed a transfer of a vancomycin-resistant gene from enterococcus to Staph aureus in the laboratory. The researcher immediately destroyed the bacteria [29].

HICPAC recommendations for preventing the spread of vancomycin resistance

Since 1989, a rapid increase in the incidence of infection and colonization with vancomycin-resistant enterococci (VRE) has been reported by U.S. hospitals. This increase poses important problems, including:

◊ The lack of available antimicrobial therapy for VRE infections, because most VRE are also resistant to drugs previously used to treat such infections (i.e., aminoglycosides and ampicillin).
◊ The possibility that the vancomycin-resistant genes present in VRE can be transferred to other gram-positive microorganisms (e.g., Staphylococcus aureus).

An increased risk for VRE infection and colonization has been associated with previous vancomycin and/or multiantimicrobial therapy, severe underlying disease or immunosuppression, and intra-abdominal surgery. Because enterococci can be found in the normal gastrointestinal and female genital tracts, most enterococcal infections have been attributed to endogenous sources within the individual patient. However, recent reports of outbreaks and endemic infections caused by enterococci, including VRE, have indicated that patient-to-patient transmission of the microorganisms can occur either through direct contact or through indirect contact via the hands of personnel or contaminated patient-care equipment or environmental surfaces.

The Hospital Infection Control Practices Advisory Committee (HICPAC) offers the following recommendations for preventing and controlling the spread of vancomycin resistance, with a special focus on VRE. Preventing and controlling the spread of vancomycin resistance will require coordinated, concerted efforts from all involved hospital departments and can be achieved only if each of the following elements is addressed:

◊ Prudent vancomycin use by clinicians.
◊ Education of hospital staff regarding the problem of vancomycin resistance.
◊ Early detection and prompt reporting of vancomycin resistance in enterococci and other gram-positive microorganisms by the hospital microbiology laboratory.
◊ Immediate implementation of appropriate infection-control measures to prevent person-to-person transmission of VRE.

Vancomycin resistance in enterococci has coincided with the increasing incidence of high-level enterococcal resistance to penicillin and aminoglycosides, thus presenting a challenge for physicians who treat patients who have infections caused by these microorganisms. Treatment options are often limited to combining

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antimicrobials or experimental compounds that have unproven efficacy [23].

The epidemiology of VRE has not been clarified; however, certain patient populations are at increased risk for VRE infection or colonization. These populations include critically ill patients or those with severe underlying disease or immunosuppression (i.e., patients in ICUs or in oncology or transplant wards); persons who have had an intra-abdominal or cardiothoracic surgical procedure or an indwelling urinary or central venous catheter; and persons who have had a prolonged hospital stay or received multiantimicrobial or vancomycin therapy. Because enterococci are part of the normal flora of the gastrointestinal and female genital tracts, most infections with these microorganisms have been attributed to the patient’s endogenous flora. However, recent studies have indicated that VRE and other enterococci can be transmitted directly by patient-to-patient contact or indirectly by transient carriage on the hands of personnel or by contaminated environmental surfaces and patient-care equipment.

The potential emergence of vancomycin resistance in clinical isolates of Staphylococcus aureus and Staphylococcus epidermidis also is a public health concern. The vanA gene, which is frequently plasmid-borne and confers high-level resistance to vancomycin, can be transferred in vitro from enterococci to a variety of gram-positive microorganisms, including S. aureus. Although vancomycin resistance in clinical strains of S. epidermidis or S. aureus has not been reported, vancomycin-resistant strains of Staphylococcus haemolyticus have been isolated.

In November 1994, HICPAC ratified the following recommendations for preventing and controlling the spread of vancomycin resistance, with special focus on VRE:

- HICPAC recognizes that data are limited and additional research will be required to clarify the epidemiology of VRE and determine cost-effective control strategies, and that many U.S. hospitals have concurrent problems with other antimicrobial-resistant organisms (i.e., methicillin-resistant S. aureus, or MRSA; and beta-lactam and aminoglycoside-resistant gram-negative bacilli) that might have different epidemiologic features and require different control measures.
- Each hospital – through collaboration of its quality-improvement and infection-control programs; pharmacy and therapeutics committee; microbiology laboratory; clinical departments; and nursing, administrative and housekeeping services – should develop a comprehensive, institution-specific, strategic plan to detect, prevent and control infection and colonization with VRE. The following elements should be addressed in the plan:
  - **Prudent vancomycin use**: Vancomycin use has been reported consistently as a risk factor for infection and colonization with VRE and may increase the possibility of the emergence of vancomycin-resistant S. aureus (VRSA) and/or vancomycin-resistant S. epidermidis (VRSE). Therefore, all hospitals and other healthcare delivery services, even those at which VRE have never been detected, should:
    - Develop a comprehensive, antimicrobial-utilization plan to provide education for their medical staffs (including medical students who rotate their training in different departments of the health care facility).
    - Overseer surgical prophylaxis.
    - Develop guidelines for the proper use of vancomycin (as applicable to the institution). Guideline development should be part of the hospital’s quality-improvement program and should involve participation from the hospitals pharmacy and therapeutics committee; hospital epidemiologist; and infection-control, infectious-disease, medical and surgical staffs. The guidelines should include the following considerations:
      - **Situations in which the use of vancomycin is appropriate or acceptable**:
        - For treatment of serious infections caused by beta-lactam-resistant gram-positive microorganisms. Vancomycin may be less rapidly bactericidal than are beta-lactam agents for beta-lactam-susceptible staphylococci.
        - For treatment of infections caused by gram-positive microorganisms in patients who have serious allergies to beta-lactam antimicrobials.
        - When antibiotic-associated colitis fails to respond to metronidazole therapy or is severe and potentially life-threatening.
        - Prophylaxis, as recommended by the American Heart Association, for endocarditis following certain procedures in patients at high risk for endocarditis.
        - Prophylaxis for major surgical procedures involving implantation of prosthetic materials or devices (i.e., cardiac and vascular procedures [26] and total hip replacement) at institutions that have a high rate of infections caused by MRSA or methicillin-resistant S. epidermidis. A single dose of vancomycin administered immediately before surgery is sufficient unless the procedure lasts more than six hours, in which case the dose should be repeated. Prophylaxis should be discontinued after a maximum of two doses.
  - **Situations in which the use of vancomycin should be discouraged**:
    - Routine surgical prophylaxis other than in a patient who has a life-threatening allergy to beta-lactam antibiotics.
    - Empiric antimicrobial therapy for a febrile neutropenic patient, unless initial evidence indicates that the patient has an infection caused by gram-positive microorganisms (e.g., at an inflamed exit site of Hickman catheter) and the prevalence of infections caused by MRSA in the hospital is substantial.
    - Treatment in response to a single blood culture positive for coagulase-negative staphylococcus, if other blood cultures taken during the same time frame are negative (e.g., if contamination of the blood culture is likely). Because contamination of blood cultures with skin flora (i.e., S. epidermidis) could result in inappropriate administration of vancomycin, phlebotomists and other personnel who obtain blood cultures should be trained to minimize microbial contamination of specimens.
    - Continued empiric use for presumed infections of inpatients whose cultures are negative for beta-lactam-resistant gram-positive microorganisms.
    - Systemic or local (e.g., antibiotic lock) prophylaxis for infection or colonization of indwelling central or peripheral intravascular catheters.
    - Selective decontamination of the digestive tract.
    - Eradication of MRSA colonization.
    - Primary treatment of antibiotic-associated colitis.
    - Routine prophylaxis for very low birth-weight infants (e.g., infants who weigh less than 1,500g, or 3 pounds, 4 ounces).
    - Routine prophylaxis for patients on continuous ambulatory peritoneal dialysis or hemodialysis.
    - Treatment (chosen for dosing convenience) of infections caused by beta-lactam-sensitive gram-positive microorganisms in patients who have renal failure.
    - Use of vancomycin solution for topical application or irrigation.
  - Enhancing compliance with recommendations:
    - Although several techniques may be useful, further study is required to
determine the most effective methods for influencing the prescribing practices of physicians.

- Key parameters of vancomycin use can be monitored through the hospital’s quality assurance/improvement process or as part of the drug-utilization review of the pharmacy and therapeutics committee and the medical staff.

- **Education programs:** Continuing education programs for hospital staff (including attending and consulting physicians, medical residents and students; pharmacy, nursing and laboratory personnel; and other direct patient-care providers) should include information concerning the epidemiology of VRE and the potential impact of this pathogen on the cost and outcome of patient care. Because detection and containment of VRE require an aggressive approach and high performance standards for hospital personnel, special awareness and educational sessions might be indicated.

- **Preventing and controlling nosocomial transmission of VRE:** Eradicating VRE from hospitals is most likely to succeed when VRE infection or colonization is confined to a few patients on a single ward. After VRE have become endemic on a ward or have spread to multiple wards or to the community, eradication becomes difficult and costly. Aggressive infection-control measures and strict compliance by hospital personnel are required to limit nosocomial spread of VRE.

Control of VRE requires a collaborative, institutionwide, multidisciplinary effort. Therefore, the hospital’s quality-assurance/improvement department should be involved at the outset to identify specific problems in hospital operations and patient-care systems and to design, implement and evaluate appropriate changes in these systems.

### Preventing and controlling VRE transmission in all hospitals

The following measures should be implemented by all hospitals, including those in which VRE have been isolated infrequently or not at all, to prevent and control transmission of VRE:

- Notify appropriate hospital staff promptly when VRE are detected (see When VRE are isolated from a clinical specimen).
- Inform clinical staff of the hospital’s policies regarding VRE-infected or colonized patients. Because the slightest delay can lead to further spread of VRE and complicate control efforts, implement the required procedures as soon as VRE are detected. Clinical staff are essential to limiting the spread of VRE in patient-care areas; thus, continuing education regarding the appropriate response to the detection of VRE is critical (see Education programs).
- Establish systems for monitoring appropriate process and outcome measures (i.e., cumulative incidence or incidence density of VRE colonization, rate of compliance with VRE isolation precautions and hand washing, interval between VRE identification in the laboratory and implementation of isolation precautions on the wards, and the percentage of previously colonized patients admitted to the ward who are identified promptly and placed on isolation precautions). Relay these data to the clinical, administrative, laboratory and support staff to reinforce ongoing education and control efforts.

- Initiate the following isolation precautions to prevent patient-to-patient transmission of VRE:
  - Place VRE-infected or colonized patients in private rooms or in the same room as other patients who have VRE.
  - Wear gloves (clean, nonsterile gloves are adequate) when entering the room of a VRE-infected or colonized patient because VRE can extensively contaminate such an environment. When caring for a patient, a change of gloves might be necessary after contact with material that could contain high concentrations of VRE (e.g., stool).
  - Wear a gown (a clean, nonsterile gown is adequate) when entering the room of a VRE-infected or colonized patient if substantial contact with the patient or with environmental surfaces in the room is anticipated; if the patient is incontinent; has had an ileostomy or colostomy; has diarrhea; or has a wound drainage not contained by a dressing.
  - Remove gloves and gown before leaving the patient’s room and immediately wash hands with an antiseptic soap or a waterless antiseptic agent. Hands can be contaminated via glove leaks or during glove removal, and bland soap does not always completely remove VRE from the hands.
  - Ensure that after glove and gown removal and hand-washing, clothing and hands do not contact environmental surfaces in the patient’s room that are potentially contaminated with VRE (i.e., a doorknob or curtain).
  - Dedicate the use of noncritical items (i.e., a stethoscope, sphygmomanometer or rectal thermometer) to a single patient or cohort of patients infected or colonized with VRE. If such devices are to be used on other patients, adequately clean and disinfect these devices first.
  - Obtain a stool culture or rectal swab from roommates of patients newly found to be infected or colonized with VRE to determine their colonization status, and apply isolation precautions as necessary. Perform additional screening of patients on the ward at the discretion of the infection-control staff.
  - Adopt a policy for deciding when patients infected or colonized with VRE can be removed from isolation precautions. The optimal requirements remain unknown. However, because VRE colonization can persist indefinitely, stringent criteria might be appropriate, such as VRE-negative results on at least three consecutive occasions (greater than or equal to one week apart) for all cultures from multiple body sites (including stool or rectal swab, perineal area, axilla or umbilicus, and wound, Foley catheter and/or colostomy sites, if present).

Because patients with VRE can remain colonized for long periods after discharge from the hospital, establish a system for highlighting the records of infected or colonized patients so they can be promptly identified and placed on isolation precautions upon readmission to the hospital. This information should be computerized so that placement of colonized patients on isolation precautions will not be delayed because the patient’s medical records are unavailable.

- Local and state health departments should be consulted when developing a plan regarding the discharge of VRE-infected or colonized patients to nursing homes, other hospitals or home-health care. This plan should be part of a larger strategy for handling patients who have resolving infections and patients colonized with antimicrobial-resistant microorganisms [23].

### Hospitals with endemic VRE or continued VRE transmission

The following measures should be taken to prevent and control transmission of VRE in hospitals that have endemic VRE or continued VRE transmission despite implementation of measures described in the preceding section (see Preventing and controlling VRE transmission in all hospitals):

- Focus control efforts initially on ICUs and other areas where the VRE transmission rate is highest. Such areas can serve as reservoirs for VRE, allowing VRE to spread to other wards when patients are well enough to be transferred.
- Where feasible, cohort the staff who provide regular, ongoing care to patients to minimize the movement/contact of health care providers between VRE-positive and VRE-negative patients.
- Hospital staff who are carriers of enterococci have been implicated rarely in the transmission of this organism. However, in conjunction with careful epidemiologic studies and upon the direction of the infection-control staff, examine personnel for chronic skin and nail problems and perform hand and rectal swab cultures of these workers. Remove from the care of VRE-negative patients those VRE-positive personnel linked epidemiologically to VRE transmission until their carrier state has been eradicated.
- Because the results of several enterococcal outbreak investigations suggest a potential role for the environment in the transmission...
of enterococci, institutions experiencing ongoing VRE transmission should verify the routine care, cleaning and disinfection of environmental surfaces (i.e., bed rails, bedside commodes, carts, charts, doorknobs and faucet handles) and that these procedures are being followed by housekeeping personnel. To verify the efficacy of hospital policies and procedures, some hospitals might elect to perform focused environmental cultures before and after cleaning rooms that house patients who have VRE. All environmental culturing should be approved and supervised by the infection-control program in collaboration with the clinical laboratory.

Consider sending representative VRE isolates to reference laboratories for strain typing by pulsed field gel electrophoresis or other suitable techniques to aid in defining reservoirs and patterns of transmission.

Detecting and reporting VRSA and VRSE

The microbiology laboratory has the primary responsibility for detecting and reporting the occurrence of VRE or VRSE in the hospital. All clinical isolates of S. aureus and S. epidermidis should be tested routinely, using standard methods, for susceptibility to vancomycin. If VRSA or VRSE is identified in a clinical specimen, confirm vancomycin resistance by repeating antimicrobial susceptibility testing using standard methods. Restreak the colony to ensure that the culture is pure. The most common causes of false-positive VRE reports are susceptibility testing on mixed cultures and misidentifying VRE, Leuconostoc, S. haemolyticus, or Pediococcus as VRE.

Immediately (i.e., while performing confirmatory testing) notify the hospital’s infection-control personnel, the patient’s primary caregiver, and patient-care personnel on the ward on which the patient is hospitalized so that the patient can be placed promptly on isolation precautions (depending on the sites of infection or colonization). Furthermore, immediately notify the state health department and CDC, and send the isolate through the state health laboratory to CDC (telephone 404-639-6413) for confirmation of vancomycin resistance [23].

12 steps to prevent antimicrobial resistance among hospitalized adults

Prevent infection

1. Step 1. Vaccinate:
   - Give influenza/pneumococcal vaccine to at-risk patients before discharge.
   - Get influenza vaccine annually.

2. Step 2. Get the catheters out:
   - Use catheters only when essential. Use the correct catheter.
   - Use proper insertion and catheter-care protocols.
   - Remove catheters when they are no longer essential.

3. Step 3. Target the pathogen:
   - Culture the patient.
   - Target empiric therapy to likely pathogens and local anti-biogram.
   - Target definitive therapy to known pathogens and antimicrobial susceptibility test results.

Diagnose and treat infection effectively

   - Consult infectious diseases experts for patients with serious infections.

5. Step 5. Practice antimicrobial control.
   - Engage in local antimicrobial control efforts.

Use antimicrobials wisely

   - Know your anti-biogram.
   - Know your patient population.

7. Step 7. Treat infection, not contamination.
   - Use proper anti-sepsis for blood and other cultures.
   - Culture the blood, not the skin or catheter hub.
   - Use proper methods to obtain and process all cultures.

8. Step 8. Treat infection, not colonization.
   - Treat pneumonia, not the tracheal aspirate.
   - Treat bacteremia, not the catheter tip or hub.
   - Treat urinary tract infection, not the indwelling catheter.

   - Treat infection, not contaminants or colonization.
   - Fever in a patient with an intravenous catheter is not a routine indication for vancomycin.

10. Step 10. Antimicrobial treatment:
    - When infection is cured.
    - When cultures are negative and infection is unlikely.
    - When infection is not diagnosed.

Prevent transmission

11. Step 11. Isolate the pathogen.
    - Use standard infection control precautions.
    - Contain infectious body fluids.

12. Step 12. Break the chain of contagion:
    - Stay home when you are sick.
    - Keep your hands clean.
    - Set an example. Source [23]
INFECTION CONTROL AND BARRIER PRECAUTIONS

Self Evaluation Exercises

Choose True or False for questions 1 through 12 and check your answers at the bottom of the page.

1. The term health care-associated infection (HAI) is used to refer to infections associated with health care delivery in any setting (e.g., hospitals, long-term care facilities, ambulatory settings, home care).

   True   False

2. Most of the factors that influence infection and the occurrence and severity of disease are related to the pathogen.

   True   False

3. Studies have shown that the nasal mucosa, conjunctivae and, less frequently, the mouth are susceptible portals of entry for respiratory viruses.

   True   False

4. Standard precautions integrate and expand the elements of universal precautions into a standard of care designed to protect health care personnel and dental health care personnel and patients from pathogens that can be spread by blood or any other body fluid, excretion, or secretion.

   True   False

5. Standard precautions are designed for patients documented or suspected to be infected with highly transmissible or epidemiologically important pathogens for which additional precautions beyond universal precautions are needed to interrupt transmission in hospitals.

   True   False

6. Much of preventing the spread of drug-resistant microorganisms is done by containing the organisms. Your actions must include washing hands with an antibacterial soap for a full 15 seconds before and after patient contact.

   True   False

7. Environmental cultures have shown VRE and MRSA on linens as well as hard surfaces such as bedrails.

   True   False

8. Most often, environmental reservoirs of pathogens during outbreaks are related to a failure to follow recommended procedures for cleaning and disinfection rather than the specific cleaning and disinfecting agents used.

   True   False

9. All fluid infusion and administration sets (e.g., IV bags, tubing and connections) are multiple-use.

   True   False

10. Wearing gloves eliminates the need for hand-washing.

    True   False

11. Studies have demonstrated that health care workers are frequently unaware of minute tears in gloves that occur during use.

    True   False

12. Because of the role of glove powder in exposure to latex protein, NIOSH recommends that if latex gloves are chosen, health care workers should be provided with reduced protein, powder-free gloves.

    True   False