Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

CHAPTER 40

Epidemiology and Infection Prevention and Control

JEAN O. KIM, MD
KEITH H. ST. JOHN, MT(ASCP), MS, CIC
SUSAN E. COFFIN, MD, MPH

BASIC PRINCIPLES

Patient safety has become a critical issue to consumers, providers, and payers of health care. Hospitals and health care systems have become acutely aware of the importance of protecting the patient in the hospital, outpatient, long-term care facilities, and home care settings from harm, as well as health care workers (HCWs) potentially exposed to infectious agents during the process of administering patient care. Infection prevention and control is now recognized as a major component of most patient safety programs.

All hospitals are required to have within their structure an infection prevention and control department or team that surveys the hospital for health care–associated infections (HAI). The HAI that are frequently monitored include those related to procedures performed (i.e., surgical site infections) and placement of medical devices (e.g., catheter-related bloodstream infections [CRBSI]). The infection prevention and control team applies epidemiologic analysis to data gathered through surveillance activities to monitor the rates and trends of specific infections and organisms. These data can be used in several ways. First, longitudinal analysis of infection rates can be used to evaluate interventions designed to reduce the risk of infection or identify outbreaks. In addition, these data permit a hospital to compare itself to other hospitals using data submitted to various benchmarking groups, including the National Healthcare Safety Network (formerly entitled the National Nosocomial Infection Surveillance System) at the Centers for Disease Control and Prevention (CDC).

HAI are a serious problem for patients and society because of the morbidity, mortality, and cost associated with HAI. For example, investigators have demonstrated that CRBSI have an attributable mortality of 10% to 35%, can prolong hospitalization by 7 days and have increased hospital costs up to $36,000 per episode. New technologies are being studied in attempts to decrease the risks of acquiring these types of infections. Some of these approaches have included impregnation of catheters with antiseptics or antibiotics, use of maximal sterile barrier during placement of catheters, and use of novel skin disinfectants (i.e., chlorhexidine gluconate/70% isopropyl alcohol). A deeper discussion of these devices is beyond the scope of this text, but one should be aware of the emerging understanding of the role of new technology to reduce the risk of HAI.

DISEASE TRANSMISSION

One important aspect of infection prevention and control activities is the prevention of transmission of microorganisms between patients and between HCWs and patients. Essential to understanding principles of infection prevention and control is an appreciation for the pathogenesis of infection and mode of transmission. Table 40–1 categorizes the practices of isolation into the different modes of transmission: contact, droplet, and airborne.

Table 40-1 Disease Transmission and Precautions

Mode of Transmission	Isolation Precaution
Standard: Applicable to all body fluids, secretions, and excretions except sweat. All patients should be considered as possibly infectious for blood-borne pathogens, such as human immunodeficiency virus (HIV).	Hand hygiene (hand washing or use of alcohol-based product) between patients and after removal of other protective gear. Gloves to be worn when touching blood, body fluids, or contaminated items. Masks and/or eye protection if generation of spray or splash of contaminated fluids possible. Gowns (nonsterile) to prevent soiling of clothing and protect skin during procedures creating splash or spray.
Contact: Direct (host-to-host) or indirect (with intermediary contaminated object) contact between infectious agent and host is required for transmission.	Private room, if available; if not, cohort patients. Gloves and gowns. Hand hygiene following glove and gown removal.
Droplet: Infection is spread by propulsion of larger droplets directly onto mucosal surfaces (conjunctivae, mouth, nose) over short distance.	Private room, if available; if not, cohort patients or place minimum 3 feet away from other patients. Masks within 3 feet of patient.
Airborne: Infection may be spread by aerosolization of small ($\leq$5 μm) droplets that may be suspended for prolonged periods in the air.	Private room in hospital. Negative air-pressure ventilation with 6 to 12 air changes per hour. Masks (for TB, N-95 respirator masks).

Disease-specific isolation precautions are based on the most common mode of transmission for a specific pathogen and should be applied during hospitalization. In addition, these precautions can be applied to syndromes of presentation while awaiting the results of diagnostic testing. For example, many hospitals begin airborne precautions when a patient is admitted with fever and a vesicular rash until the results of varicella testing are available.

PRECAUTIONS

Infection control precautions should be used for every patient encounter. HCW should always employ standard precautions, regardless of the setting in which care is being delivered. For patients with known or suspected infection with pathogens of epidemiologic significance, expanded transmission-based precautions should also be employed. The importance of this approach to patient care was clearly evident in the outbreak of severe acute respiratory syndrome (SARS) in 2003 caused by a new coronavirus, during which implementation of isolation precautions alone attributed to the cessation of spread in the most severely affected countries in Asia and Canada. Table 40–2 summarizes the modes of transmission of specific infectious diseases.

Standard Precautions

This category, previously referred to as *Universal Precautions,* applies to all patients, regardless of diagnosis, and describes the appropriate handling of all human body substances, including blood, secretions, excretions (except sweat), nonintact skin, and mucous membranes. The precautions presume that all patients may have certain body substances containing blood-borne pathogens such as human immunodeficiency virus (HIV), hepatitis B virus, or hepatitis C virus that have not yet been identified. Implementation of these precautions includes the following:

- Hand hygiene, which includes hand washing after visible contamination with blood or other body fluids, or use of alcohol-based hand rubs. This is to be done before donning and after removing gloves, after contact with the patient or the patient's environment, and after touching other body substances or contaminated items.
- Gloves should be used when touching or potentially touching blood, body substances as listed above, or nonintact skin/mucous membranes. Gloves should be changed between procedures on the same patient and between seeing patients. Use of gloves does not replace hand hygiene as an important infection prevention intervention.
- Masks, eye protection, and face shields should be used when potential splashing or spray of body substances is present. The intent of this equipment is to protect the membranes of the eyes, nose, and mouth during patient care activities.
- Gowns—nonsterile and fluid-resistant—should be used when potential soiling of clothing due to either direct contact or splashing or spray of body substances is present. Gowns should be changed between seeing patients.
- Linen previously used should be handled such that minimum exposure to contamination and mucous membranes occurs.

Table 40-2 Disease Transmission and Precautions

Mode of Transmission/ Isolation Precautions	Clinical Example
Standard	All patient care
Airborne	Tuberculosis
	Varicella-zoster
	Measles
	Smallpox
Droplet	Adenovirus
	Haemophilus influenzae type b
	Influenza
	Meningococcal disease
	Mumps
	Mycoplasma pneumoniae
	Parvovirus B19
	Pertussis
	Rubella
	Streptococcus pyogenes pharyngitis or pneumonia (untreated)
Contact	Abscess (cutaneous, draining) or cellulitis
	Clostridium difficile colitis
	Enteroviruses
	Hepatitis A
	Herpes simplex virus (mucocutaneous)
	Herpes zoster (unless immunocompromised*)
	Lice (pediculosis)
	Parainfluenza
	Respiratory syncytial virus
	Rotavirus
	Scabies
	Shigellosis
	Viral hemorrhagic fevers
	Multidrug-resistant bacteria:
	Methicillin-resistant *Staphylococcus aureus* (MRSA)
	Vancomycin-resistant enterococci (VRE)
	Glycopeptide-intermediate/resistant *S. aureus* (GISA)
	Extended-spectrum β-lactamase (ESBL)-producing gram-negative bacilli

*Immunocompromised hosts with herpes zoster infection and immunocompetent hosts with disseminated disease are able to shed from the respiratory tract and require contact plus airborne isolation for the duration of illness, as for varicella-zoster virus.

Airborne Precautions

This category of infections involves organisms with very small particle size, 5 μm or less, that allows transmission via small droplets. These droplets may be carried through the air to other hosts for inhalation and new infection. Methods used to limit spread of these pathogens involves placement of the patient in a room with negative air pressure as well as protective equipment for HCWs including special masks such as N95 respirator masks that are designed to filter out these particles.

Droplet Precautions

Pathogens in this category are usually spread via larger droplets expelled by the infected person from the respiratory tract. Because the droplets are larger in size, transmission requires closer proximity between the infected and exposed individuals for transmission to occur. Thus, precautions are focused on protecting the HCW and other patients by incorporating protective equipment including a mask when one is within 3 feet of the patient as recommended by the CDC.

Contact Precautions

This is the most common mode of infection transmission within the hospital setting. The pathogens in this category include viruses and bacteria that may or may not produce symptoms, in that many of the bacteria produce asymptomatic colonization that alone poses a risk for future HAI. The most important aspect of this mode of transmission is following the appropriate sequence of applying and removing protective equipment, which includes nonsterile gowns and gloves. In order to interrupt transmission from patient to patient, one must change gowns and gloves between seeing patients and employ adequate hand hygiene, as well as use additional personal protective equipment.

POSTEXPOSURE PROPHYLAXIS

Chemoprophylaxis is the administration of an antimicrobial agent for the purpose of preventing infection following exposure to an infectious agent, that is, postexposure prophylaxis (PEP). This is sometimes referred to as *secondary prophylaxis*. This may be indicated if the host is at particularly high risk of developing severe infection or complications of infection due to immunocompromise, or if the infectious agent is particularly virulent and highly transmissible. Table 40–3 lists common scenarios when PEP should be considered.

For many highly transmissible infections, mandatory reporting to the public health department should be carried out, because they have far-reaching public health considerations that may warrant widespread prophylaxis beyond the immediate family of the index case. Agents other than antibiotics that may be given in a postexposure situation include immune globulin preparations, such as high-titer hepatitis B immune globulin (HBIG) following exposure of a nonimmune patient or HCW.

Table 40-3 Postexposure Prophylaxis Regimens

Disease	Definition of Exposure/Indication for Prophylaxis	Agent
Meningococcal disease Spread through large droplets	Close contacts: Household contacts Childcare/nursery school contact within 7 days Direct contact with index patient's secretions: kissing, sharing toothbrush or eating utensils Mouth-to-mouth resuscitation or endotracheal intubation without protection Sleeping/eating frequently in same place as index patient Do not use oral or nasopharyngeal cultures to guide therapy Not indicated for casual contact, such as schoolmate or daycare contacts if older than nursery school age Report to and consult with local public health department for specific contacts	Rifampin 10 mg/kg (max 600 mg) PO every 12 hours for 2 days if older than 1 month of age Rifampin 5 mg/kg PO every 12 hours for 2 days if 1 month of age or younger Ceftriaxone 250 mg IM for 1 dose if older than 12 years; 125 mg IM for 1 dose if 12 years or younger Ciprofloxacin 500 mg PO for 1 dose if 18 years old or older (This antibiotic has not yet been approved by the Food and Drug Administration for use in patients younger than 18 years for this indication)
Tuberculosis (TB) Spread by inhalation of small droplets (droplet nuclei), may be over long distances	Close contact with potentially contagious case of TB within 3 months All household contacts younger than 4 years old exposed to adult with TB disease Consult with public health department/TB control for specific guidelines	Isoniazid (INH) 10 to 15 mg/kg/day PO daily (max 300 mg) If exposed to INH-resistant TB, consider adding rifampin 10 to 20 mg/kg/day PO daily (max 660 mg). Place initial tuberculin skin test (TST) and repeat at 12 weeks; if positive, continue therapy for 9 months; if negative, discontinue therapy.
Pertussis Spread by droplets inhaled over short distances	All household contacts or other close contacts (e.g., childcare, regardless of immunization status) If chemoprophylaxis is not administered, contact should be monitored for respiratory symptoms for 20 days following exposure	Erythromycin (estolate) 40 to 50 mg/kg/day PO in 4 divided doses for 14 days (maximum 2 g/day) 19 mg/kg (maximum 500 mg) on day 1; then 5 mg/kg per day on days 2-5 (maximum 250 mg/day) if 6 months or older Tdap vaccine booster if 11-18 years
Hepatitis A	Spread by fecal contamination and oral ingestion	If ≤2 weeks from exposure, hepatitis A immune globulin (0.02 mL/kg IM); if 1 year of age or older, also give hepatitis A vaccine.
Hepatitis B Blood-borne pathogen present in blood or body fluids	Needlestick or other contaminated sharp exposure Splash to mucous membranes Contact with nonintact skin	If exposed person has known protection (positive HBsAb), none indicated If exposed person has negative titer, HBIG 0.06 mL/kg IM for 1 dose, and begin HBV vaccine or reinitiate vaccine. If exposed person has had vaccine but negative titer, may give HBIG for 2 doses. Evaluation should include HBsAg, HBsAb, and liver enzymes at baseline, 3, and 6 months.
Hepatitis C Blood-borne pathogen present in blood or body fluids	Needlestick or other contaminated sharp exposure Splash to mucous membranes Contact with nonintact skin	No prophylaxis available Evaluation should include hepatitis C virus Ab, liver enzymes at baseline, 3, and 6 months.
Influenza Spread through large droplets	Exposure to respiratory secretions	May give amantadine 100 mg PO twice daily, rimantadine 100 mg PO twice daily, or oseltamivir 75 mg PO twice daily for 5 days Influenza vaccine should be administered simultaneously, if not previously given.
Varicella-zoster (chickenpox) Spread through small droplets (airborne) or contact with skin lesions	Exposure to household member (living in the same house), face-to-face indoor play (usually more than 1 hour), hospitalization within same 2- to 4-bed room for chickenpox or close contact with person with zoster (infectious lesions), or neonate with maternal chickenpox Host must be susceptible (i.e., negative history of chickenpox and titers)	Varicella vaccine may be given up to 5 days postexposure to hosts without immunocompromise. If indicated, VariZIG may be given.* Susceptible, exposed health care workers should be furloughed from days 10 to 21 following exposure (VariZIG recipients should be furloughed until day 28).

*Indications for VariZIG after significant exposure are the following: hosts who are immunocompromised without history of chickenpox; susceptible pregnant women, newborns with maternal chickenpox within 5 days before delivery or 48 hours after; hospitalized premature infant with negative maternal history for chickenpox if infant 28 weeks' gestation or more, or infant who is less than 28 weeks' gestation or weighs 1000 g or less, regardless of maternal history.

Blood-borne Pathogen Exposure

Of all potential infectious exposures, none is more anxiety-provoking than that following exposure to potential blood-borne pathogens. In this grouping are the viruses hepatitis B, hepatitis C, and HIV. Recommendations for management of hepatitis B virus and hepatitis C virus exposure are listed in Table 40–3.

Needlestick injuries are the most frequent mechanism by which HCWs are exposed to blood-borne pathogens. The overall risk for transmission of HIV following a contaminated hollow-bore needlestick in an HCW is 0.3%, compared to that following a transfusion with HIV-infected blood, which is 95%. In determining postexposure management, one must first assess the degree of risk for HIV infection. Risk can be classified by nature of the exposure and status of the source, that is, the patient whose blood was drawn. The highest risk of exposure occurs when the "sharp," or needle, is large-bore and hollow, visibly contaminated with blood, and has punctured deeply the skin of the HCW, or when the blood volume is large, that is, major splash. There is considerably less risk with solid needles, superficial injuries, or small volumes of blood, (i.e., few drops). When determining the status of risk from the source patient, one should ascertain the HIV status (i.e., positive, negative, or unknown), and if positive, the viral load, for example, less than 1500 RNA copies/mL, and classification of symptoms (e.g., asymptomatic versus acquired immunodeficiency syndrome).

Principles for Postexposure Prophylaxis

- For greatest benefit, PEP should be started as soon as possible, ideally within 2 hours after the exposure.
- If the risk from exposure is high and the source patient is known to have HIV infection, PEP with antiviral therapy, combination of two or three drugs, is recommended. If exposure risk is lower and/or the source patient's status is unknown, PEP may be considered, with the plan to determine the HIV status and potentially discontinue therapy with further information.
- The recommended duration of PEP is a total of 4 weeks, if the source patient is either HIV positive or no further information can be ascertained. If the source is found to be HIV negative, PEP may be discontinued.
- The exposed person should have baseline serologic testing for HIV and hepatitis C virus at the initial consultation along with assessment of HB vaccine status, and reevaluation should occur at 72 hours, whenever PEP is initiated. This ensures compliance and aids to clarify any additional information/counseling required to allay the fears and anxiety that may occur surrounding this exposure event.
- The inciting agent, that is, needle of contaminated sharp, should not be tested for HIV.
- Follow-up serologic testing (HIV antibody) should be performed at 6 weeks, 12 weeks, and 6 months. Additional testing at 12 months should be performed if there has been coexposure to hepatitis C virus.

Formal guidelines for the use of postexposure prophylaxis following occupational exposure to HIV have been developed and are continually revised by the CDC. These guidelines should be consulted for the most current recommendations (www.cdc.gov).

CASE SCENARIOS

The following are frequently encountered clinical scenarios that illustrate the relevance of infection prevention and control practices to clinical pediatric medicine.

Scenario One:

You are on-call on a general inpatient ward at night, when one of the nursing staff notifies you that a patient who had been admitted 2 days earlier with a fever has now developed a rash. Upon your examination, you find that this 5-year-old child has broken out with chickenpox. He has been in the playroom as well as in a multibed room, because he was not toxic appearing and otherwise had no other problems. The staff asks you what needs to be done now.

Response:

As you recall, varicella virus is spread by the airborne and contact route. Thus this patient, the index case, should be placed in a negative-air pressure room, and airborne and contact precautions should also be instituted for a minimum of 5 days after onset of rash and until all lesions are crusted. He was likely contagious for the past 2 days and therefore could have infected other susceptible patients on the ward. Two things should be considered at this juncture:

1. Patients who are susceptible may be given either varicella vaccine or varicella zoster immune globulin (VariZIG) if available to abort or attenuate a varicella infection.
2. Exposed patients who remain in the hospital may become contagious, because the incubation period from time of exposure to development of rash is

typically 10 to 21 days, and one is most contagious in the 1 to 2 days before onset of rash. Therefore the next appropriate step is to identify those patients who may have been in contact with the index case and determine by history whether or not they have had chickenpox and/or received the varicella vaccine. Close contact may be defined as being in the same room for 1 hour or more; however, this may be difficult to discern, and in these situations, it is wise to be more inclusive in determining possible exposures.

Once exposed patients have been identified, history of either past varicella infection or varicella vaccine should be obtained. If the patients have had varicella infection or vaccine in the past, they should have adequate protection from this exposure, and no further precautions are necessary for these children. However, if there has been no history of either, then the patient's immune status must be assessed, because those who are immunocompromised (i.e., primary immunodeficiency, cancer, acquired immunodeficiency, or on chemotherapeutics for other diseases) may be candidates for receiving varicella-zoster immune globulin, a high-titer preparation of antivaricella antibodies, pooled from human donors. If exposed, susceptible children require hospitalization beyond the time of exposure; they should be placed in airborne isolation from days 10 to 21 after exposure (until day 28 after exposure if immune globulin has been given). Susceptible children who have been exposed to varicella-zoster virus but are not immunocompromised might be candidates for the varicella vaccine. The vaccine should be administered within 72 hours for maximal effect. If the current exposure does not cause disease, the vaccine may prevent against future disease. As with VariZIG recipients, these children should also be placed in airborne isolation during the incubation period, although this period would be 8 to 21 days, because vaccine does not extend the incubation period as does VariZIG. There is presently no role in varicella-zoster exposure for antiviral therapy for the prevention of disease.

Scenario Two:

As the admitting resident on the general pediatric service, you are seeing as an inpatient a 6-year-old female who recently emigrated from Africa and has had an increasingly productive cough. The charge nurse asks you if any special isolation precautions are necessary.

Response:

The primary considerations here include the differential diagnosis for productive cough in a patient with history of international travel. If the patient has a focal infiltrate on chest radiograph, the differential diagnoses include primarily bacterial causes of pneumonia, including typical bacteria (e.g., *Pneumococcus*, *Staphylococcus aureus, Streptococcus pyogenes*, nontypeable or types other than type b *Haemophilus influenzae*, and gram-negative bacilli. These infections do not typically require special isolation precautions, except *S. pyogenes* pharyngitis or pneumonia, which require droplet precautions until 24 hours after initiation of appropriate therapy. However, given this patient's history of travel, the list of possible etiologic agents must include other respiratory pathogens, mainly *Mycobacterium tuberculosis*.

In order to determine whether or not this patient poses a risk to other patients, one must understand the pathogenesis of tuberculosis (TB). TB may be classified in stages: exposure, latent infection, and disease. Exposure comprises a person being in contact with a known case of active TB. During this time, chemoprophylaxis may be given, and the tuberculin skin test (TST) placed at the initiation of therapy will likely be negative. If prophylaxis is not given, the patient may go on to develop latent infection, which typically occurs 2 to 12 weeks from exposure. The patient may be completely asymptomatic but upon TST will have a positive reaction with significant induration. The usual treatment for this stage of TB is single drug, usually isoniazid, for a period of 9 months. This course of therapy markedly reduces the future risk of progression to active disease.

In children, active TB often presents with pneumonia associated with weight loss and night sweats. This primary TB does not pose any risk to contacts, because a single cough in this phase is not sufficient to expel significant numbers of organisms to transmit disease. The infiltrate will often be in the lower lobes and may be associated with an enlarged hilar lymph node, comprising a Ghon complex. This form of active TB disease is treated with multidrug regimens, which should include at least two drugs to which the organism is sensitive, for a course of 6 months. If this stage of TB is not treated adequately, the patient may develop reactivation of TB several years later, or if the patient is immunocompromised, he or she may progressively develop disseminated disease (i.e., miliary TB). Reactivated TB typically presents in older patients with significant productive cough, night sweats, weight loss, and on chest radiograph a cavitary lesion in the upper lobes. These cavities contain 10^4 to 10^6 organisms that are expelled in high numbers with each cough. These people are highly contagious to those around them and pose significant risk to other patients in the hospital. Miliary TB may present with pulmonary symptoms but may also present with manifestations of dissemination elsewhere, including meningitis, osteomyelitis, and arthritis. The typical chest radiograph pattern is a millet seed, or miliary pattern, which represents diffuse disease. Therapy for these presentations constitutes prolonged courses of antitubercular drugs

with periodic monitoring of sputum for acid-fast staining to determine level of contagion as represented by relative number of organisms (i.e., 1+ to 4+ acid-fast bacilli).

In our case scenario, the patient has a focal lower lobe infiltrate that does not appear cavitary in nature. It is not likely that the patient has reactivated TB, but certainly primary pulmonary TB should be on the list of possible diagnoses. It is also not likely that this patient poses any risk to other patients, because she does not have reactivation. However, she may be accompanied by other family members who may have reactivated TB. The finding of a child with TB represents a sentinel event, meaning that she was exposed to another person with active TB, because there are no nonhuman reservoirs for this disease.

In this case, the patient does not require airborne precaution because a 6-year-old patient is most likely not contagious. The focus should be on identifying contagious household or family members. Therefore, visitation should be limited to people who have had a chest radiograph that excludes contagious tuberculosis. Household members and contacts should be issued a properly fitted surgical mask when visiting until they have been demonstrated to not have contagious tuberculosis. Nonadherent household contacts should be excluded from the hospital until evaluation is complete and tuberculosis is excluded or treatment has rendered source cases noncontagious.

MAJOR POINTS

- Infection prevention and control departments perform active surveillance of specific health care–associated infections in order to improve patient care and safety.
- The basic tenets of infection prevention and control involve understanding the mode of transmission of infectious agents. These are then translated into appropriate precautions along with proper hand hygiene to prevent further spread of disease within a hospital or health care organization.
- All health care workers, including physicians, share in the responsibility of reporting specific diseases with public health ramifications to the local health agencies.
- Following significant exposure, transmission of certain infectious diseases may be halted by the administration of chemoprophylaxis, including antibiotic agents, vaccines, or immune globulin products.
- The implementation of infection prevention and control practices should be integrated into the practice of general pediatric medicine.

SUGGESTED READINGS

American Academy of Pediatrics: 2006 Red Book: Report of the Committee on Infectious Diseases, 27th ed. Elk Grove Village, IL: American Academy of Pediatrics, 2006.

Association for Professionals in Infection Control and Epidemiology: APIC Handbook of Infection Control, 3rd ed. Washington, DC: APIC, 2002.

Centers for Disease Control and Prevention: Updated U.S. Public Health Service Guidelines for the management of occupational exposures to HBV, HCV, and HIV and recommendations for post exposure prophylaxis. MMWR 2005;55 (No. RR-09):1-17.

Centers for Disease Control and Prevention: Update: Outbreak of severe acute respiratory syndrome-worldwide 2003. MMWR 2003;52:269-272.

Siegel JD: Controversies in isolation and general infection control practices in pediatrics. Semin Pediatr Infect Dis 2002; 13:48-54.

Stephenson J: CDC campaign targets antimicrobial resistance in hospitals. JAMA 2002;287:2351-2352.

Veenstra DL, Saint S, Saha S, et al: Efficacy of antiseptic-impregnated central venous catheters in preventing catheter-related bloodstream infections: A meta-analysis. JAMA 1999; 281:261-267.

Zaoutis TE, Coffin SE: Infection control and hospital epidemiology: A pediatric perspective. Infecti Dis Clin North Am 2005; 19:647-665.

Zaoutis T, Dawid S, Kim JO: Multidrug-resistant organisms in general pediatrics. Pediatr Ann 2002;31:313-320.