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immunocompromise, including that due to diabetes mellitus, liver disease, or splenectomy; involvement of extremities with underlying venous and/or lymphatic compromise; and prior mastectomy on the side of an involved upper extremity. When prophylactic antibiotics are administered, they are usually given for 3–5 days.

Rabies and Tetanus Prophylaxis Rabies prophylaxis, consisting of both passive administration of rabies immune globulin (with as much of the dose as possible infiltrated into and around the wound) and active immunization with rabies vaccine, should be given in consultation with local and regional public-health authorities for some animal bites and scratches as well as for certain nonbite exposures (Chap. 214). Rabies is endemic in a variety of animals, including dogs and cats, in many areas of the world. In the United States, although the majority (90%) of rabid animals reported each year are wild (including raccoons, skunks, foxes, and bats), most rabies prophylaxis is given because of close contact with domestic animals. More cats than dogs are reported rabid each year. Many local health authorities require the reporting of all animal bites. A tetanus booster immunization should be given if the patient has undergone primary immunization but has not received a booster dose in the past 5 years. Patients who have not previously completed primary immunization should be immunized and should also receive tetanus immune globulin. Elevation of the site of injury is an important adjunct to antimicrobial therapy. Immunization of the infected area, especially the hand, also is beneficial.

Hepatitis B Prophylaxis Hepatitis B virus can be transmitted, albeit rarely, by exposure of nonintact skin to blood-free saliva. The mainstay of postexposure prophylaxis is active immunization with hepatitis B vaccine, but, in certain circumstances, hepatitis B immune globulin is recommended in addition to vaccine for added protection (Chap. 350).

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FURTHER READING Abrahamian FM, Goldstein EJC: Microbiology of animal bite wound infections. Clin Microbiol Rev 24:231, 2011. Brook I: Management of human and animal bite wounds: An overview. Adv Skin Wound Care 18:197, 2005. Bystritsky R, Chambers H: Cellulitis and soft tissue infections. Ann Intern Med 168:ITC17, 2018. Ellis R, Ellis C: Dog and cat bites. Am Fam Phys 90:239, 2014. Fallouji MA: Traumatic love bites. Br J Surg 77:100, 1990. Fleisher GR: The management of bite wounds. N Engl J Med 340:138, 1999. Kullberg BJ et al: Purpura fulminans and

symmetrical peripheral gangrene caused by *Capnocytophaga canimorsus* (formerly DF-2) septicemia—a complication of dog bite. *Medicine (Baltimore)* 70:287, 1991. Lohiya GS et al: Human bites: Bloodborne pathogen risk and postexposure follow-up algorithm. *J Natl Med Assoc* 105:92, 2013. Martino R et al: Bacteremia caused by *Capnocytophaga* species in patients with neutropenia and cancer: Results of a multicenter study. *Clin Infect Dis* 33:e20, 2001. Morgan M, Palmer J: Dog bites. *BMJ* 334:413, 2007. Oehler RL et al: Bite-related and septic syndromes caused by cats and dogs. *Lancet Infect Dis* 9:439, 2009. Stevens DL et al: Practice guidelines for the diagnosis and management of skin and soft tissue infections. 2014 update by the Infectious Diseases Society of America. *Clin Infect Dis* 59:e10, 2014. Weber DJ et al: Infections resulting from animal bites. *Infect Dis Clin North Am* 5:663, 1991. World Health Organization, Regional Office for South-East Asia: Guidelines for the management of snakebites, 2nd ed, 2016. Available at <https://iris.who.int/handle/10665/249547>. Accessed February 13, 2024.

Section 3 Clinical Syndromes: Health Care–Associated Infections Mini Kamboj, Tara N. Palmore

Infections Acquired in

Health Care Facilities Health care–associated infections affect at least 3% of hospitalized patients at any given time. Through concerted efforts, national rates of some nosocomial infections were declining before the onset of the COVID-19 pandemic, but infection control challenges related to the pandemic reversed years of progress. The past few years have also seen a rise in incidence of multidrug-resistant infections, which are challenging to treat and contain. However, newer tools combined with evidence-based methods of infection prevention and control are robust and can succeed. This chapter reviews the epidemiology, prevention, and control of health care–associated infections and recent challenges faced by health care epidemiologists.

ORGANIZATION, RESPONSIBILITIES, AND OVERSIGHT OF INFECTION PREVENTION AND CONTROL PROGRAMS

Infection prevention and control programs are composed of infection preventionists supervised by an experienced team lead. These typically include a doctoral-level (MD/DO/PhD) health care epidemiologist who may report to the chief medical officer or chief quality officer. The number of staff required in an infection prevention and control program depends on the size and complexity of the health care facility and its patients. Infection prevention and control programs are responsible for a broad range of activities, including surveillance and reporting of nosocomial infections; preventing and thwarting transmission of nosocomial pathogens through use of isolation and education; reducing device-associated infections through evidence-based interventions; collaborating with occupational health to manage infectious exposures; preparing for and managing emerging infectious diseases; and investigating and controlling outbreaks. The team collects and analyzes infection data and reports those data to institutional stakeholders, such as the multidisciplinary Infection Control Committee. Infection preventionists usually perform the mandatory reporting of select nosocomial infection data to the National Healthcare Safety Network that is managed by the Centers for Disease Control and Prevention (CDC). Such reporting is required by the U.S. Centers for Medicare and Medicaid Services and affects facilities' reimbursement for the care they have provided, i.e., nonpayment for care related to preventable nosocomial infections.

SURVEILLANCE Surveillance to detect and prevent health care–associated infections focuses on outcomes, processes, and other related measures that directly or indirectly influence the risk of contracting them. Examples of outcomes include surgical site infections and hospital-onset *Clostridioides difficile* infections. Key process measures include compliance with

evidence-based practices that reduce the risk of infection, such as hand hygiene, central line insertion care, and maintenance practices for indwelling devices. Finally, health care personnel influenza immunization rates are an example of a related measure that is tracked at a local, regional, and national level to gauge efforts toward reducing the risk of nosocomial influenza in acute and long-term care settings. Detecting health care-associated infections using a case-finding strategy is a labor- and resource-intensive process. Most U.S. hospitals rely on laboratory-based surveillance as the fundamental data collection methodology, supplemented with clinical reviews by infection preventionists.

Widespread adoption of automated surveillance systems to collect, analyze, and combine infection and antimicrobial prescription data from diverse sources within electronic records has improved surveillance efficiency and scalability. Challenges with reliability, interfacility standardization, and the need for considerable human input to refine and ensure comprehensive data flow and adjudication of infection definitions continue to leave considerable room for improvement in electronic surveillance. Leveraging natural language processing models for health care-associated infection surveillance should further enhance existing systems. Surveillance data interpretation can be complex as hospitals apply health care-associated infection metrics for diverse purposes, including monitoring disease trends, detecting outbreaks, driving quality improvement, and meeting mandated reporting requirements to state and federal agencies, and as a vital part of value-based care measures. Because of its role as the nation's mandatory reporting mechanism for health care-associated infections, the CDC's National Healthcare Safety Network benchmarks and tracks health care-associated infections and provides the measures and analytical tools that allow comparison across facilities. Infection rates are expressed as standardized infection ratios, calculated by dividing the number of observed infections by the number of predicted infections.

EPIDEMIOLOGIC BASIS AND GENERAL MEASURES FOR PREVENTION AND CONTROL

Patients in health care facilities are vulnerable to transmission of pathogens from other patients, visitors, staff, or the inanimate health care environment. Health care personnel may convey multidrug-resistant organisms between patients and the environment on their hands or on shared patient care equipment (e.g., stethoscopes or portable imaging machines). Spread can also occur from contaminated plumbing, person to person via a respiratory route (e.g., influenza or group A *Streptococcus* from health care personnel), or via contamination of food, water, or medications. Infections that arise within the first 48–72 h after admission are generally considered community acquired or, if the patient was transferred from another facility, attributed to the transferring institution. Those occurring henceforth are considered health care associated, or nosocomial. Patient factors that increase vulnerability to nosocomial infection include presence of an invasive device, immune deficiency (congenital or acquired), renal insufficiency, diabetes, and other major comorbidities. When patients' own microbiota have been altered by exposure to antibiotics or other medications, they become more susceptible to colonization with multidrug-resistant organisms. Colonized patients serve as unintentional reservoirs for transmission of resistant organisms to other patients or to the hospital environment, including shared equipment. Patients can develop nosocomial infections from these transmitted pathogens (cross-transmission) or from their own microbiota. Hand hygiene and environmental cleaning are essential interventions to interrupt transmission. Hand hygiene can be performed either with soap and water or alcohol-based hand gel, with special requirements for care of patients who have diarrhea (see "Health Care-Associated Diarrhea," below). Environmental cleaning and disinfection are focused on frequently touched surfaces, such as doorknobs, bed rails, and objects in the bathroom, and are similarly adjusted for

disinfectant-resistant pathogens when necessary. ■ ■COLONIZATION Nosocomial bacteria or yeast that are transmitted to a patient may be unintentionally ingested, leading to colonization with the organism, a carrier state. Patients whose microbiota have been altered by antibiotics are more susceptible to colonization with nosocomial organisms. Colonization pressure, the proportion of patients in a ward who are colonized, is a risk factor for spread of resistant organisms. Patients who are immunocompromised or whose immune barriers have been breached by surgery or invasive devices, are at increased risk of infection from the nosocomial organisms with which they are colonized.

■ ■OUTBREAK INVESTIGATION AND RESPONSE Transmission in a health care facility may be detected via careful surveillance or by notification from a clinician or laboratory. Investigation typically involves molecular typing of bacterial or fungal (less commonly viral) isolates to ascertain whether they are, in fact, closely related and represent an outbreak. The gold standard for these comparisons is whole genome sequencing, which has high resolution for determining clonality and, in the case of bacteria, conveys valuable information about plasmid-carried resistance genes.

Once transmission has been established, outbreak investigation involves a series of steps including drafting a case definition, finding cases, reviewing medical records, performing descriptive epidemiology, and developing a hypothesis regarding the source of the outbreak. Control measures are implemented while surveillance (including environmental cultures in some cases) is conducted. Communicating with patients, staff, facility leaders, and public health is integral to the outbreak response. NOSOCOMIAL AND DEVICE-RELATED INFECTIONS Invasive procedures and indwelling devices deliver supportive care and can save lives, but they provide potential portals of entry for pathogens. Infections in patients who undergo surgery or have indwelling devices are important targets for prevention in health care facilities. Postsurgical infections occur more frequently when surgery is performed in the setting of emergencies, tissue damage from trauma or radiation, uncontrolled infection elsewhere in the body, malnutrition, chemotherapy, and other conditions that impair wound healing. CHAPTER 147 Routine perioperative checklists enumerate activities that reduce the risk of surgical site infections (Table 147-1). After years of decline due to prevention efforts, rates of device-related and other nosocomial infections rose during the COVID-19 pandemic. These infections are a substantial cause of morbidity and mortality for hospitalized patients and are often due to antimicrobial-resistant infections. Infections Acquired in Health Care Facilities ■ ■CATHETER-ASSOCIATED URINARY

TRACT INFECTIONS Catheter-associated urinary tract infections occur more frequently in patients with critical illness, older age, and female sex. Sterile and atraumatic insertion of catheters and preservation of a closed drainage system help prevent contamination. Infections are preventable largely by concerted efforts to avoid the placement of indwelling urinary catheters and by reevaluating daily the duration of their use. The presence of asymptomatic bacteriuria, or bacteria without symptoms of urinary tract infection, often leads to improper antimicrobial treatment in patients with indwelling urinary catheters. Apart from pregnant patients, most others need not undergo urine culture or treatment for asymptomatic bacteriuria. Diagnostic stewardship efforts include guidelines to reduce collection of urinalysis and culture from patients in whom these studies are not indicated to avoid subsequent inappropriate treatment of asymptomatic bacteriuria. In the elderly, this often occurs in the setting of nonspecific symptoms, such as confusion, that are not related to asymptomatic bacteriuria. Improper treatment of asymptomatic

bacteriuria is often followed by improper testing for “clearance” of bacteriuria, which results in a vicious cycle of escalating antimicrobial use and resistance. ■ ■HEALTH CARE-ASSOCIATED PNEUMONIA Hospital-acquired pneumonia is often due to aspiration of oral or gastric contents or, less commonly, hematogenous transmission from a remote source. Because of changes in patients’ microbiota in medical facilities, bacterial causes of nosocomial pneumonia are frequently antimicrobial resistant. The most likely pathogens involved in nosocomial pneumonia and its treatment are discussed in Chaps. 131 and 147. Ventilator-associated pneumonia is a subset of nosocomial pneumonia that occurs in up to 10% of ventilated patients. Mechanical ventilation can be complicated by a variety of infectious and noninfectious problems that are encompassed under the term ventilator-associated

TABLE 147-1 Evidence-Based Bundled Measures to Reduce the Risk of Select Device- and Procedure-Related Infections
Prevention of Surgical Site Infections
 Treat active infections prior to surgery
 Administer prophylactic antibiotics within 1 h before surgery and discontinue immediately after surgery
 Wear surgical attire that covers hair, mouth, and nose
 Perform hand hygiene with an antiseptic agent
 Perform antisepsis of the surgical site with chlorhexidine/alcohol solutions whenever possible
 If hair must be removed, clip rather than shave (to avoid skin microtrauma)
 Implement operating room asepsis, minimizing movement into and out of

the room
 Maintain operating room air at positive pressure, with moderate humidity

(20–60%) and at least 20 air changes per hour
Prevention of Ventilator-Associated Pneumonia
 Attempt to avoid intubation using high-flow nasal oxygen or noninvasive

positive-pressure ventilation
 Elevate head of bed to 30–45 degrees to reduce risk from gastric contents
 Brush teeth daily
 Use aseptic care of all respiratory care equipment
 Avoid use of tap water for rinsing any respiratory care equipment
 Follow strategies to promote earlier extubation: • Minimize sedation • Provide early exercise and mobilization • Provide early enteral feeding • Assess readiness for extubation on a daily basis
PART 5 Infectious Diseases
Prevention of Catheter-Associated Urinary Tract Infection
 Place indwelling catheters only when strictly necessary, e.g., to relieve obstruction, and not for convenience
 Use aseptic equipment and technique for catheter insertion and urinary tract instrumentation
 Minimize urinary tract instrumentation
 Minimize manipulation of or entry into urinary catheter systems, and avoid catheter irrigation
 Reevaluate daily the need for continued use of an indwelling urinary catheter in each patient
 Use alternative methods to avoid indwelling catheters, e.g., bladder scans, condom catheters, intermittent catheterization
Prevention of Catheter-Associated Central Line Infections
 Optimize nurse-to-patient ratio
 Consider alternatives to central line (e.g., peripheral IV, midline catheter)
Catheter insertion • Use a checklist to ensure adherence to insertion bundle • Use hand hygiene • Use maximum sterile barrier precautions and aseptic technique • Use chlorhexidine-alcohol antisepsis to prepare the site • Use ultrasound guidance • Use an all-inclusive catheter insertion kit • The subclavian vein is least prone and the femoral vein most prone to infection in the intensive care unit (ICU) setting
Catheter maintenance • Administer daily chlorhexidine gluconate baths to ICU patients with central lines • Scrub the hub with alcohol • Cleanse the catheter site with chlorhexidine-based antiseptic with every dressing change, at a minimum every 7 days (earlier if site is soiled or dressing disrupted) • Use disinfectant caps • Apply chlorhexidine-impregnated dressings • Reevaluate daily the need for continued use of each central line in each patient

events. Ventilator-associated pneumonia can prolong the duration of ventilation and intensive care unit (ICU) stay or even prove fatal. Like other device-related infections, ventilator-associated pneumonia is preventable by limiting use of the invasive device (Table 147-1). ■ ■

CATHETER-ASSOCIATED BLOODSTREAM INFECTIONS

Central venous catheters represent another major target for infection prevention. Although they are often necessary for patient care, central lines are foreign objects that lie in direct contact with the bloodstream. Without meticulous care, each health care personnel interaction with the catheter serves as a potential contamination event. Catheter-associated bloodstream infections triple a patient's risk of in-hospital death. Similar to other device-related infections, the rate of catheter-related bloodstream infections had declined in the years leading up to 2020, when infection control gains were lost with the onset of the pandemic. Preventing catheter-associated bloodstream infections begins with aseptic insertion technique using a bundle, or checklist, of evidence-based steps (Table 147-1). Catheter maintenance practices are important for ongoing prevention of infection and include meticulous, aseptic technique in handling the catheter. Daily full-body cleansing with 2% chlorhexidine gluconate is effective for preventing bloodstream infections, particularly central line infections, in the ICU and are standard of care. Although studies outside the ICU show mixed results, some hospitals utilize the baths for all patients with central lines because of the treatment's low side effect profile and the potential impact of the intervention.

TRANSMISSION-BASED PRECAUTIONS

Standard precautions are the basic set of practices that health care personnel should follow to minimize exposure to potentially infectious material and prevent pathogen transmission while caring for all patients in all health care settings. The key elements of standard precautions are applied based on the situational risk and include hand hygiene; respiratory etiquette; personal protective equipment use depending on the potential for exposure to blood, body fluid, or infectious material; and safe injection practices. Additional pathogen-specific prevention measures are called transmission-based precautions. When patients harbor a suspected or confirmed communicable disease, transmission-based precautions are used to prevent spread in the health care setting. The fundamental modes of pathogen transmission inform the recommended prevention methods categorized by the World Health Organization (WHO) and CDC into contact, droplet, and airborne precautions. Contact precautions utilize hand hygiene and barrier methods (gown and gloves) to prevent the spread of ubiquitous pathogens in a colonized or infected person's immediate environment, for example, *C. difficile* and multidrug-resistant organisms. Institutions differ in use of contact precautions for ubiquitous resistant organisms such as methicillin-resistant *Staphylococcus aureus*. Droplet precautions are implemented when a patient has respiratory symptoms or a confirmed respiratory infection with a pathogen that is transmitted from person to person. Protective equipment includes a gown, gloves, eye protection, and a mask or respirator, given recent evidence that respiratory viruses are spread by both droplets (respiratory particles ≥ 100 microns in size) and aerosols (sprays of particles <100 microns). The principal mode of respiratory pathogen spread is by inhalation of respiratory particles emitted by an infected person during sneezing, coughing, talking, and breathing. Host factors such as infection stage, symptoms, immune status, and environmental conditions, including ventilation and humidity, influence pathogen transmissibility. Respiratory droplets remain suspended in the air only briefly and travel short distances. Airborne transmission occurs via tiny particles 100 that can travel larger distances and remain suspended in the air for an extended duration. Measles, tuberculosis, varicella, and COVID-19 are infectious agents that pose a major risk of airborne transmission. Airborne precautions require respirators and placement of the infected individual in a negative-pressure airborne isolation room with a minimum air flow

rate of 12 air changes per hour with direct exhaust outside the building or recirculation through a high-efficiency particulate air (HEPA) filter and respirator use. Some conditions may merit combinations of these precautions (e.g., patients with varicella and SARS-CoV-2 are placed in contact and air borne precautions).

EMERGING INFECTIOUS DISEASES ■ ■ EPIDEMICS, EMERGING INFECTIOUS DISEASES, AND AGENTS OF BIOTERRORISM

Preparedness for newly evolved and reemerging human pathogens is critical to infection prevention and control activities. The 21st century has witnessed the emergence of several infectious threats and two major pandemics: 2009 H1N1 swine influenza and 2019 SARS-CoV-2, with their vast worldwide impact and, in the case of SARS-CoV-2, millions of deaths. The changing of global ecosystems from deforestation, climate change, and extensive urbanization with a rising world population has increased the proximity between humans and wildlife. The confluence of these factors can generate conditions that favor mutational viral evolution and, ultimately, cross-species spillover of otherwise geographically confined zoonotic illnesses, as was seen with the outbreaks of Ebola in 2014, Zika in 2016, SARS-CoV-2, and the 2022–2023 international monkeypox (mpox) epidemic. Another emerging challenge relates to socio-behavioral perceptions and beliefs linked to vaccines; the perpetuation of misinformation through social media around childhood and adult immunizations has amplified vaccine hesitancy, threatening the maintenance of safe vaccination rates and herd immunity. The most urgent threat is from highly contagious illnesses such as measles, mumps, polio, and varicella. The current global rise in measles cases has disproportionately affected unvaccinated or partially vaccinated individuals. Therefore, addressing vaccine access, misinformation, and declining immunization rates is critical to avert outbreaks of vaccine-preventable illnesses with a high public health impact. Finally, health care personnel awareness of intentional human threats from potential agents of bioterrorism such as *Bacillus anthracis* and variola virus is essential. Natural smallpox is no longer a hazard; routine vaccination against smallpox ended in the United States in 1971. However, there is a possibility of laboratory-maintained variola outside of the WHO-approved repositories. In the event of an accidental or intentional release, vaccination is the primary strategy to stop smallpox spread. Two currently licensed vaccines for smallpox prevention are the replication-competent vaccinia virus vaccine, ACAM2000, and the live, nonreplicating modified vaccinia Ankara vaccine. Both vaccines are also recommended for prevention of mpox in high-risk groups. *B. anthracis* is a category A pathogen with a high case fatality rate and potential for mass casualty if aerosolized. After the U.S. inhalational anthrax cases in 2001 from mailed letters containing anthrax spores that resulted in five deaths, protocols for a mass disaster related to *B. anthracis* exposure have been a biodefense preparedness priority.

■ ■ VIRAL RESPIRATORY INFECTIONS WITH PANDEMIC POTENTIAL

Safety protocols for patients and health care personnel from new and reemerging contagious respiratory illnesses including novel influenza A viruses, Middle East respiratory syndrome coronavirus (MERS-CoV), and other novel coronaviruses are vital. Adopting an integrated all-hazard screening approach to identify and implement infection control measures, initiate diagnostic testing, and safely deliver care is critical. Lessons from the COVID-19 pandemic underscore the importance of maintaining par levels of personal protective equipment, testing supplies, and essential therapeutics. Regular training of frontline health care personnel on appropriate donning and doffing of personal protective equipment ensures readiness to handle patients with contagious illnesses safely. Testing for novel pathogens may only be available through public health laboratories; however, developing the capability for laboratory-developed tests and existing infrastructures to rapidly adopt testing protocols ensures timely diagnosis,

contact investigations, and postexposure management, which is critical for effective containment. Health care facilities should leverage a structured information-sharing approach through hospital incident command system activation. From a public health standpoint, robust surveillance mechanisms, clear and concise guidelines for clinicians and the public, and alignment among federal agencies, state and local public health, and commercial laboratories are critical to ensure testing capacity and vaccine and therapeutics access.

■ ■ **HIGHLY PATHOGENIC AVIAN INFLUENZA** Among the potential pandemic pathogens, avian influenza A (H5 and H7 strains) has an exceptionally high impact due to its constant viral evolution and potential for adaptation to transmit effectively in humans. The most immediate pandemic threat is posed by highly pathogenic H5N1 avian influenza, with ~900 known human infections worldwide since 2003 and a case fatality rate of ~50%. Sustained person-to-person transmission of this group of viruses has not occurred thus far. H5N1 began circulating in North American wild birds and poultry in late 2021, with subsequent detections in mammals, including U.S. dairy cattle herds and barn cats, in multiple U.S. states and numerous cases of animal-to-human transmission. The recommended prevention measures against novel influenza in hospitals are similar to those against other high-consequence pathogens, including contact and airborne precautions and eye protection. Close contacts should receive antiviral prophylaxis with oseltamivir. Regarding diagnostics, influenza targets on commercial multiplex reverse transcriptase polymerase chain reaction (PCR) panels are insufficient for strain identification and additional, dedicated testing in public health laboratories from nasopharyngeal swabs, washes, and conjunctival swabs is required to establish the diagnosis in the appropriate clinical and epidemiologic context. CHAPTER 147 ■

■ ■ **MPOX** Previously a geographically constrained virus endemic to West Africa mpox Clade II virus caused a global outbreak in 2022. On its heels, in central Africa, cases of Clade I, endemic to that region, soared. The virus is zoonotic, and spreads from person to person through close contact of mucosal surfaces or nonintact skin with open lesions or via contaminated inanimate objects such as bed linens. The role of respiratory transmission without close physical contact is less well established. Despite initial concerns, health care-associated transmission of mpox in nonendemic countries is rare, with multiple reported occupational transmissions after direct inoculation from needlestick injuries. Post exposure prophylaxis with the JYNNEOS or ACAM2000 vaccine series is recommended for high-risk exposures. Infections Acquired in Health Care Facilities ■ ■ **VIRAL HEMORRHAGIC FEVER PREPAREDNESS** During the 2014–2015 West African Ebola epidemic, symptomatic returning travelers presented to U.S. hospitals, resulting in occupational Ebola infections in two nurses at one facility. These and other events led to formation of a national network of Regional Emerging Special Pathogen Treatment Centers at large hospitals that have built specially engineered containment wards and trained staff to care for patients with suspected or confirmed Ebola, Marburg, or other viral hemorrhagic fever diseases. A series of additional hospitals are prepared to receive and provide temporary care for such patients prior to transferring them to these treatment centers. Finally, all medical facilities and emergency services should have plans for managing patients with highly contagious diseases who may present unexpectedly. **HEALTH CARE-ASSOCIATED DIARRHEA** ■ ■ **CLOSTRIDIUM DIFFICILE INFECTION** Diarrhea that begins in health care facilities or is attributable to recent care in a health care facility is considered health care associated.

C. difficile infection (Chap. 139) is not only the most frequent cause but also the most frequent hospital-acquired infection in the United States. C. difficile colitis has symptoms that can range in

severity from mild diarrhea to life-threatening toxic megacolon. Receipt of antibiotics is the most common cause of *C. difficile* infection, making antimicrobial

stewardship the first-line measure for its prevention. Restricting use of antibiotics that are highly associated with subsequent *C. difficile* infection, such as quinolones and clindamycin, has been shown to reduce the incidence of the disease. Longitudinal genomic surveillance shows that patients who enter the hospital already colonized with *C. difficile* are by far the most likely to develop the infection during their hospital stay.

Patients who have suspected or confirmed *C. difficile* infection are placed in contact isolation to contain spores that infected patients shed in high numbers and that heavily contaminate their skin and environment. These spores are hardy, survive for a prolonged time in the health care environment, and can be transmitted on hands of health care personnel, on surfaces, or on shared patient care equipment. Because alcohol-based hand gel and standard hospital cleaners do not kill *C. difficile* spores, handwashing with soap and water is preferred to mechanically remove them, and sporicidal disinfectants such as bleach are used to clean the rooms of infected patients. ■

■ **NOROVIRUS** Norovirus is another important cause of health care-associated diarrhea that can be transmitted among patients and staff and cause outbreak in facilities. A nonenveloped virus that is poorly inactivated by alcohol-based hand gel and standard hospital cleaners, norovirus is also addressed with handwashing with soap and water and bleach cleaning. Another potential cause of health care-associated diarrhea is a foodborne outbreak, which can start with symptomatic food handlers or point-source food contamination that originates outside the facility. **TUBERCULOSIS**

Tuberculosis (Chap. 183) requires special infection prevention and occupational health measures. Early identification, isolation, and testing of patients who may have active tuberculosis are critical steps in tuberculosis control in health care facilities. Patients with suspected or confirmed tuberculosis should be managed with airborne precautions (see “Transmission-Based Precautions”). Health care personnel managing patients with infectious tuberculosis use fit-tested particulate respirators, known in the United States and Canada as N95 respirators because they filter 95% of airborne particles, or powered air-purifying respirators that draw air through a HEPA filter into a hood. **PART 5 Infectious Diseases** Health care personnel should undergo preemployment screening for tuberculosis, preferably with an interferon- γ release assay rather than a tuberculin skin test due to its higher positive predictive value. Staff with positive tests should be evaluated further with symptom screening and chest imaging to assess for active or latent tuberculosis. Staff who have latent tuberculosis should be encouraged to undergo treatment to reduce the risk of reactivation and transmission to patients. In hospitals with high caseloads and local prevalence of tuberculosis, follow-up testing may be performed routinely among staff in certain disciplines. In most facilities, follow-up testing is event driven, such as following exposure to a patient with active tuberculosis. **FUNGAL INFECTIONS** ■ ■ **MOLD INFECTIONS** Some

immunocompromised hospitalized patients are highly susceptible to nosocomial mold infections, which are usually acquired through inhalation. Patients who will experience prolonged neutropenia during treatment of leukemia and stem cell transplant recipients require protective isolation rooms that are specially engineered with positive pressure, HEPA-filtered airflow and sealed seams to repel mold spores, which, at 2–4 microns in size, are ubiquitous in dust and air currents. Vulnerable patients should wear masks when leaving their rooms to go to areas of the hospital that lack such measures. Exposure to hospital construction is a well-described risk factor for invasive fungal infections among immunosuppressed patients; thus, all construction sites within the hospital must

employ negative airflow, HEPA filtration, sealed walls, and sticky doormats to minimize leakage of particles containing mold spores into patient care areas.

■ ■ **CANDIDA INFECTIONS** Candida infections represent the vast majority of health care-associated fungal infections. Many of these arise from endogenous sources in patients who are immunosuppressed, have undergone surgery, or have invasive devices in place. Although *Candida albicans* represent a majority of Candida infections, antifungal prophylaxis may select out non-*albicans* species such as *Candida glabrata*. *Candida auris* Some Candida infections are attributed to exogenous transmission. *Candida auris* was first isolated in Japan in 2009 and subsequently emerged as a global nosocomial pathogen. Since the first U.S. case was identified in 2015, the incidence has increased steadily, with a sharp acceleration during the COVID-19 pandemic. *C. auris* has become an increasing cause of candidiasis in hospitals and in long-term care facilities where patients are mechanically ventilated. A multidrug-resistant species that is adapted to the health care environment, *C. auris* survives for extended periods on surfaces, and rapid recontamination from colonized persons makes sustained disinfection challenging. Shared medical equipment such as glucometers, ultrasound machines, blood pressure cuffs, and axillary temperature probes are potential sources of transmission between patients, and thorough disinfection after each use is vital to prevent the spread of *C. auris*. Hand hygiene and contact precautions should be followed strictly when caring for a colonized or infected patient. The organism is resistant to some hospital disinfectant cleaners and requires use of select disinfectants. *C. auris* is of substantial public health concern, such that efforts to contain its spread require collaboration among infection control, public health, and laboratory experts on a facility, local, and regional basis. Patients transferred from long-term care facilities are often screened for *C. auris* by PCR or culture and isolated pending the results of screening (Fig. 147-1).

THE HEALTH CARE BUILT ENVIRONMENT Patients, staff, and visitors continually shed microorganisms into the built environment of a health care facility (surfaces and plumbing). Organisms are also introduced via the external environment, including potable water. Patients who are immunologically vulnerable may acquire pathogens from the built environment. Health care facilities must reduce their risk through adherence to current guidelines and through surveillance for such infections.

■ ■ **ENVIRONMENTAL CLEANING** Floors and frequently touched surfaces in health care facilities should be cleaned often with disinfectant cleaners in order to reduce the burden of communicable bacteria, viruses, and fungi. Patient care equipment (e.g., stethoscopes, portable x-ray cartridges) should be disinfected between patients to avoid becoming point sources for transmission of multidrug-resistant pathogens. Sporidicidal cleaners and ultraviolet C light are often used as adjunctive methods for inactivating *C. difficile* spores and other tenacious pathogens. Clinical trial data suggest that standard cleaning plus adjunctive ultraviolet C may reduce nosocomial transmission of pathogens over cleaning alone.

■ **WATER SAFETY** Waterborne infections arising from wastewater (drains and toilets) as well as potable water (sinks, showers, and fountains) pose a potential risk to vulnerable patients in health care facilities. Because many of these infections are preventable, hospitals are required to have a water management plan to anticipate and reduce risk to patients. Tap water is not sterile, and contamination of potable hospital water and plumbing occurs most frequently when waterborne organisms (e.g., *Legionella pneumophila*, nontuberculous mycobacteria, and many others) colonize the biofilm within the pipes or cooling towers of a health care facility. Low disinfectant levels, warm temperature ranges, and stagnation of water promote organism growth, which can lead to transmission to patients via aerosols or droplets. Immunosuppressed patients are the most susceptible to waterborne infections; pneumonia in this patient population should be thoroughly

investigated to include testing for waterborne infection.

Facilities work together to protect patients. The Problem Many patients transfer back and forth for treatment within different regional facilities. If patients are colonized or infected with multidrug-resistant or other infectious pathogens (such as *C. difficile* and *C. auris*), those organisms are introduced to the different facilities. After introduction, other patients can acquire organisms, silently spreading them throughout the region's healthcare network. A collaborative approach and timely communication between public health agencies and healthcare facilities are essential to prevent and mitigate the regional spread of contagious pathogens. Facilities convey infection control data promptly to public health

FIGURE 147-1 Regional spread and control of antimicrobial resistance. (Modified from <https://archive.cdc.gov/#/details?url=https://www.cdc.gov/vitalsigns/stop-spread/infographic.html>.) In the case of nosocomial Legionnaires disease, detection of a single case should prompt a thorough investigation. In facilities with no history of an outbreak, routine hospital water testing for *L. pneumophila* is not strictly necessary if robust clinical surveillance is in place. Institutions that have had nosocomial cases should conduct regular water testing for the organism as part of their water management plan. Wastewater drains in health care facility sinks, tubs, and showers, as well as toilets, serve as silent reservoirs for multidrug-resistant gram-negative organisms and can cause protracted outbreaks. These bacteria reach patients via transmission in droplets or aerosols of contaminated water from splashback, plumbing fixtures, or toilet flushing. Maneuvers to reduce risk include installing lids on toilets and angling sink faucets so water does not land directly on the drain. Contamination of medications and medical devices can also lead to nosocomial outbreaks. In the past decade, outbreaks of nontuberculous mycobacterial infections among cardiac surgery patients have been linked to operative heater-cooler units that aerosolized the organisms from contaminated water tanks.

ANTIBIOTIC-RESISTANT BACTERIA Implementing measures to stop the spread of multidrug-resistant organisms is a key priority for public health agencies and health care epidemiologists. Globally, 1.27 million deaths were attributed to antibiotic-resistant infections in 2019, with the highest rates in sub-Saharan Africa. According to recent estimates, infections due to methicillin-resistant *S. aureus* (MRSA) and extended-spectrum β -lactamase

Facilities must alert receiving locations about infection control issues prior to transferring patients. Public health authorities implement collective actions to reduce interfacility transmission.

CHAPTER 147 Facilities convey infection control data promptly to public health.

Infections Acquired in Health Care Facilities (ESBL) Infections are the most common multidrug-resistant organism infections in U.S. hospitals. While improved infection prevention measures have led to a substantial reduction in MRSA, vancomycin-resistant *Enterococcus* (VRE), carbapenem-resistant *Acinetobacter*, and multidrug-resistant *Pseudomonas* infections, the prevalence of carbapenem-resistant *Enterobacterales* and ESBL-producing *Enterobacterales* has not declined. Infections due to multidrug-resistant organisms, which frequently colonize the human gastrointestinal and respiratory tracts, are associated with higher morbidity and mortality and other adverse clinical consequences such as extended hospital stays, transmission risk, and added health care costs. Without meticulous environmental disinfection, many of these organisms can establish enduring reservoirs in the hospital environment, effectively transmitting between patients and posing the risk of horizontal gene transfer among co-colonizing strains. Coordination of care during interfacility transfer of known patients with MDRO colonization is paramount to ensure timely implementation

of infection prevention and control measures (Fig. 147-1). Regardless of pathogen, frequent health care–related exposure, extended hospital stays, residence in long-term care facilities, multiple comorbid conditions, short- or long-term indwelling devices, and anti biotic exposure are among the key risk factors for multidrug-resistant organism acquisition. Additionally, community determinants can contribute substantially to spread of certain organisms. For example, people who use drugs, prison inmates, and those without stable housing conditions are at a greater risk of MRSA infections.

■ ■ **METHICILLIN-RESISTANT STAPHYLOCOCCUS AUREUS** Among hospitalized patients, up to a third of MRSA-colonized individuals develop MRSA infection, and the risk in the pediatric ICU can be as high as 47%. MRSA is the most common health care–associated infection in neonatal ICUs. Transmission within facilities occurs through indirect contact with contaminated environments and sometimes from contaminated or colonized health care personnel. Screening, contact precautions, and education can reduce MRSA transmission, but most U.S. hospitals selectively deploy MRSA screening only in high-risk settings, including ICUs; dialysis, burn, and transplant units; and post-acute care facilities. Screening is also the fundamental approach to combat MRSA outbreaks.

Among the preventative practices assessed in ICUs, universal gowns and gloves and decolonization have reduced MRSA acquisition and infections. Universal decolonization is more effective than screening and contact precautions, with or without concurrent targeted decolonization with chlorhexidine bathing and 5-day nasal application of mupirocin. The advantages of decolonizing MRSA carriers extend beyond the hospital stay, and post-hospital discharge measures can reduce the short-term risk of MRSA infections in carriers by 30%. Still, this approach may not achieve sustained benefits over longer time periods. Preventing postoperative and device-related MRSA infections is an essential surgical quality and safety goal for health care settings. A meta-analysis of 39 studies evaluated nasal decolonization and glycopeptide antibacterial prophylaxis before cardiac and orthopedic surgery, demonstrating a reduced risk of *S. aureus* infections with universal nasal decolonization and all gram-positive surgical site infections with a combined approach of decolonization and targeted antibacterial prophylaxis. Similarly, universal decolonization methods may be effective in non-ICU settings where there is high utilization of invasive devices to lower the risk of associated infections, including MRSA.

PART 5 Infectious Diseases ■ ■ VANCOMYCIN-RESISTANT ENTEROCOCCUS (VRE) Soon after VRE emerged in the U.S. in 1987, identifying carriers by screening for gastrointestinal carriage to institute contact precautions proved to be an influential early approach. This commonly applied method successfully controlled the regional spread of this pathogen while its prevalence in health care settings was still low. Initial animal studies and clinical observations established the critical role of antibiotic exposure to vancomycin, third-generation cephalosporins, and anti-anaerobic agents as risk drivers of VRE acquisition and overgrowth. Subsequently, microbiome analysis elucidated that a higher VRE colonization burden often precedes mucosal translocation in susceptible hosts, also influencing the number of bacteria shed in the environment that can facilitate person-to-person spread. Immunocompromised patients with hematologic malignancy, as well as stem cell and liver transplant recipients, are especially vulnerable to VRE colonization and infection. Over the years, VRE has become ubiquitous in many U.S. health care settings. Active surveillance and contact precautions offer minimal benefit in hyperendemic settings. However, the judicious use of antibiotics through robust stewardship measures and bundles incorporating chlorhexidine baths remain effective in reducing the impact of VRE by rendering colonized patients less infectious and decreasing the risk of

invasive infection. ■ ■ **MULTIDRUG-RESISTANT GRAM-NEGATIVE BACTERIA** Multidrug-resistant gram-negative bacteria are increasingly common in health care settings. Chromosomally encoded resistance mechanisms and plasmid-carried resistance genes make them particularly challenging therapeutic targets. Multidrug resistance is defined as nonsusceptibility to at least one agent from three distinct antibacterial drug classes. Difficult-to-treat resistance is defined as resistance to all first-line antibacterial agents. Extensively drug-resistant organisms exhibit nonsusceptibility to two or fewer antimicrobials in all categories. Finally, pan-drug resistance is defined by the noneffectiveness of all antimicrobial agents. The rising incidence of drug-resistant gram-negative bacteria has been noted across all types of health care settings,

carrying decreased survival compared with susceptible infections from the same species. Carbapenem-resistant Enterobacteriales and *Acinetobacter baumannii*, multidrug-resistant *Pseudomonas aeruginosa*, and ESBL-producing *Escherichia coli* and *Klebsiella pneumoniae* are among the top threats. Extended hospital stays, long-term care facility exposure, antimicrobials, medical devices, mechanical ventilation, and impaired immunity are frequent risk factors for acquisition of multidrug-resistant gram-negative bacteria. Outbreaks mainly occur in long-term care facilities, and hospital-based clusters tend to occur in intensive care, hematology/oncology, and liver transplant units. Inadequate disinfection of endoscopes due to their complex design has made them vulnerable to sterilization lapses, resulting in numerous outbreaks of multidrug-resistant gram-negative bacteria. Aggressive control measures are among the cornerstones of prevention. Given an association between antimicrobial overuse and the emergence of multidrug-resistant gram-negative organisms, antimicrobial stewardship is a pivotal component in the strategies to prevent their emergence and spread. Targeted screening and contact precautions for rapid identification and isolation of gastrointestinal carriers have proven essential for outbreak management. Universal gown and glove use failed to reduce acquisition. Local epidemiology and international travel to hyperendemic areas, especially for medical care, are other important risk factors to consider when deciding on targeted screening practices. Finally, there are no proven decolonization strategies for multidrug-resistant gram-negative bacteria. ■ ■ **DIAGNOSTIC**

STEWARDSHIP Diagnostic advances, including molecular technologies and high-throughput automated systems, have vastly enhanced clinical laboratory efficiencies and reduced the time to actionable information. However, rapid, convenient, and unrestricted testing can become problematic when used excessively for medically unnecessary investigations. From a health care-associated infection standpoint, inappropriate testing for *C. difficile* infection and excessive pursuit of urine cultures are pervasive problems in the current health care environment. Estimates show that as much as 40–60% of testing in hospitalized patients may not be medically indicated. Consequently, overtesting for these two common health care-associated infections leads to antibiotic overuse, patient distress, **TABLE 147-2 Diagnostic Stewardship Examples**

KEY FOCUS AREAS

Urine culture

- Educate clinicians on asymptomatic bacteriuria and appropriate indications to suspect urinary tract infection.
- Require documentation of patient symptoms at the time of urine culture order placement.
- Implement alerts to discourage testing when patient is asymptomatic, with exceptions (pregnancy, urologic procedures, etc.).
- Consider algorithms that incorporate pyuria threshold

(>10 white blood cells per high-power field) to proceed to culture in nonneutropenic patients.

- Educate clinicians on appropriate methods for urine collection, storage, and transport for voided and catheterized urine. Avoid collection from the bag or a catheter that has been in place for an

extended time. Clostridioides difficile testing • Set clinical criteria for testing: three or more unformed stools in 24 h in the absence of alternate etiology for the diarrhea. • Implement alerts that discourage an ordering clinician from testing when a patient is on laxatives. • Empower laboratory to reject specimens based on Bristol stool scale. • Apply auto-cancellation of test if sample is not received within 24 h or repeated within 7 days after a negative test or 14 days after a positive test. • Educate clinicians on the lack of utility of a test of cure. • Implement a two-step algorithm for testing including a toxin detection method.

TABLE 147-3 Health Care Personnel Immunizations VACCINE VACCINE TYPE ELIGIBILITY
RECOMMENDATIONS COVID-19 Non-live All HCP Per latest CDC recommendations Influenza Non-live All HCP Once annually Hepatitis B Non-live HCP without serologic evidence of immunity or past infection MMR Live HCP without serologic evidence of immunity or past infection Varicella Live HCP without serologic evidence of immunity, clinician-verified history, or serologic evidence of past infection Tetanus-diphtheria-pertussis (Tdap) Non-live HCP without immunization in past 10 years Pregnant HCP Meningococcal Non-live Laboratory workers with potential exposure Men ACWY (booster every 5 years) and MenB (booster at 1 year and every 2–3 years thereafter) Abbreviations: CDC, Centers for Disease Control and Prevention; HCP, healthcare personnel; MMR, measles, mumps, rubella.

spurious inflation of publicly reported infection rates, and excess health care costs. Clinicians should use interventions implemented through the computerized clinical decision support systems. Lab measures such as reflex or multistep testing algorithms can address the potential harms of overtesting. Interventions based on the electronic health record yield better results than human interventions. Key strategies to reduce inappropriate testing are included in Table 147-2.

OCCUPATIONAL HEALTH ■ ■ VACCINATION OF HEALTH CARE PERSONNEL Health care personnel are at higher risk for acquiring certain vaccine-preventable illnesses and for transmitting infection to patients. The goals of vaccination are to provide personal safety, reduce the risk of occupational acquisition or transmission to preserve the workforce during periods of high community transmission, and protect vulnerable patients. Pathogens that pose a substantial risk of occupational transmission for which licensed vaccines are available include respiratory viruses such as influenza, COVID-19, measles and mumps, varicella, pertussis, hepatitis B, and meningococcus. Vaccine eligibility is assessed at the time of employment, and the schedules for recommended immunizations are shown in Table 147-3. Additional risk-based vaccines may be recommended (e.g., Ebola, vaccine, hepatitis A). Highly contagious illnesses such as measles and varicella have caused outbreaks in health care settings, disproportionately affecting underimmunized or unimmunized patients and health care personnel. Even with vaccines that have only moderate effectiveness against infection, higher vaccination uptake is associated with a lower risk of respiratory illness among personnel and a lower risk of nosocomial acquisition of these infections, especially in vulnerable patients. Numerous medical professional societies endorse mandatory health care personnel influenza immunization, and many facilities require it. Health care personnel who provide direct care to patients should be tested for hepatitis B surface antibody 1–2 months after the last dose of the series and reimmunized if antibody levels are <10 mIU/mL. Nonresponders after repeat series are considered susceptible to hepatitis B and should be treated as such in the event of a bloodborne pathogen exposure. ■ ■ **BLOODBORNE PATHOGEN EXPOSURE** Since 1991, the U.S. Occupational Safety and Health Administration has promulgated a standard to regulate exposure to bloodborne TABLE 147-4 Estimated Risk of Bloodborne Pathogen Transmission from Percutaneous Injury PATHOGEN RISK Hepatitis B 6–30% Hepatitis C 1–3% HIV 0.3% aHighest for hepatitis B e antigen positive. bIf on effective treatment and with an

undetectable viral load, the risk is negligible.

Two-dose series (Heplisav-B) or three-dose series (Engerix-B, PreHevbrio, or Recombivax HB) Two doses at a 4-week interval Two doses at a 4-week interval Single dose (booster every 10 years) With every pregnancy pathogens. Advancements in engineering and workplace controls, such as needleless catheter systems, have made the use of medical devices safer, prevented sharps-related injuries, and reduced bloodborne pathogen transmission events. Despite this, exposure to potentially infectious agents in blood and other bodily fluids through contact with skin, eyes, and other mucous membranes remains a significant problem during health care delivery. HIV and hepatitis B and C acquisition after blood exposure are the most common concerning risks; semen, vaginal and rectal fluid, and breast milk can also pose a transmission risk. The risk of bloodborne pathogen transmission after contact with feces, urine, gastric and respiratory secretions, saliva, and sweat that is not contaminated with blood is exceedingly low. Significant exposures involve percutaneous injury or skin puncture with a much lower risk from contamination of nonintact skin and mucous membranes. CHAPTER 147 Among the three pathogens, hepatitis B transmits most effectively, with the estimated risks after percutaneous injury from needlesticks or other sharps shown in Table 147-4. Infections Acquired in Health Care Facilities When managing personnel with a bloodborne pathogen exposure, a thorough history and risk evaluation and baseline serologic testing should be conducted. For significant potential hepatitis B exposures in nonimmune persons, hepatitis B immune globulin should ideally be given within 24 h and can effectively prevent transmission when administered up to 7 days from exposure. HIV postexposure prophylaxis must be started within 72 after possible exposure, and likely has diminishing efficacy the longer initiation is delayed. Serial testing for HIV, hepatitis B, and hepatitis C should be performed 6 weeks and

3 months after exposure, followed by testing for hepatitis C and HIV at 6 months if the exposed person is found to be immune to hepatitis B or received immune globulin. With widespread vaccination, transmission of hepatitis B from health care personnel to patients is rare. Cases have occurred in the setting of occult hepatitis B with high-grade viremia and invasive procedures. Guidelines set out recommendations for management of clinicians infected with HIV, hepatitis B, and hepatitis C to minimize risks to patients. Unsafe medical device and medication management can spread infection between patients. Outbreaks and transmission events arise from improper disinfection of blood glucose monitors between patient uses, infection control breaches during dialysis, single-dose medication reuse, improper practices with multidose vials, and drug diversion. Such occurrences are entirely preventable with adherence to basic hygiene and patient safety practices. ■ ■ FURTHER READING Harris AD et al: Acquisition of antibiotic-resistant gram-negative bacteria in the benefits of universal glove and gown (BUGG) cluster randomized trial. Clin Infect Dis 72:431, 2021. Huang SS et al: Decolonization to reduce postdischarge infection risk among MRSA carriers. N Engl J Med 380:638, 2019. Lyman M et al: Worsening spread of Candida auris in the United States, 2019 to 2021. Ann Intern Med 176:489, 2023.

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