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20 Infection Prevention and Control in the Tropics

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KEY FEATURES

- Unique challenges of infection control in the tropics include:
  - Tropical climate and changes in microbial diversity
  - High rates of antimicrobial-resistant pathogens
  - Environmental contamination and difficult vector control
  - Lack of resources and trained personnel
  - Lack of laboratory facilities
  - Limited accessibility to safe water
  - Inappropriate use of invasive devices
  - Overcrowding and understaffing
  - Newly emerging infectious pathogens
  - Distinctive cultural beliefs and practices
- Standard infection control precautions: hand hygiene, patient isolation, aseptic technique, use of personal protective barriers, appropriate sterilization and disinfection of reused equipment, and safe injection practices, form the cornerstone of hospital infection control.
- Attention to hand hygiene is the most important component of basic infection control.
- Effective, low-cost practical solutions addressing behavior modification to improve adherence to infection control practices, coupled with surveillance, and providing essential resources can decrease the rate of health care–associated infections in developing countries.
- Establishing an effective infection control program requires an infection control committee and strong institutional commitment.
- Innovative, inexpensive solutions to accommodate natural ventilation or mixed-mode ventilation need to be incorporated in hospital design.
- Attention to public health measures in the tropics to control communicable disease outbreaks in the community will reduce the burden of infections encountered in the health care setting.

INTRODUCTION

Infection control policies and procedures are designed to prevent patients, as well as health care workers and visitors, from acquiring infections. The complexities of infection control in hospitals have challenged medical systems and are constantly evolving with advances in medical technology and the care of increasingly vulnerable patients. Environmental and climate conditions create infection control challenges unique to the tropics. Tropical climates are warm and humid, with environmental pollution (urbanization, industrial wastes, and air pollution) leading to higher vector densities and communicable disease outbreaks. Furthermore, the tropics roughly coincide with low-development-index countries, adding resource constraints. The term *nosocomial infection* has referred to hospital-acquired infections among patients presenting 72 hours after hospitalization. We prefer the term *health care–associated infections* (HAIs) because many infections associated with delivering health care occur in outpatient settings, and hospital-acquired infections can present sooner than 72 hours after admission.

BASICS OF INFECTION CONTROL

The goal of infection control is to prevent and control HAIs within hospital or clinical practice settings. This is achieved through surveilling HAI rates, implementing infection risk assessment and control, detecting and managing outbreaks, controlling antimicrobial use and stewardship, implementing policies and procedures for managing specific infections, and liaising with other hospital departments or committees to implement safety standards (e.g., sterile services, laundry, food services, and hospital design and construction).[1] Infection control teams are also responsible for educating all staff and affecting behavioral change.

An "infection control committee" should be established to oversee compliance, efficacy, and adequacy of infection control measures and to develop institution-specific guidelines. These committees are composed of representatives from the medical and surgical services, occupational health, microbiology, infectious diseases, and nursing. Strong administrative support and adequate resources are essential, as is commitment to safety and strengthening systems to convert knowledge into action. These widespread measures are important, as infection can spread at any point during the course of the patient's interaction with the health care system (Box 20.1).

INFECTION CONTROL PRACTICES TO DECREASE THE RISK OF INFECTION TRANSMISSION

Standard Infection Control Practices

Standard infection control precautions ("Standard Precautions") apply to all patients, regardless of their reason for admission or infection status (Table 20.1).[2] The most important element of Standard Precautions is hand hygiene, which can be handwashing with soap and water or alcohol-based gels or foams that do not use water. Guidelines published by the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force provide specific recommendations.[3] Alcohol-based hand rubs can be used where there is limited access to water. They have better acceptability, less skin irritation, and quicker application compared with soap and water, resulting in improved compliance. Commercially prepared products are available, but a low-cost gel can be prepared by hospital pharmacies using 20 mL of glycerin, propylene glycol, or sorbitol mixed with 980 mL of >70% isopropanol. Gels combining chlorhexidine and alcohol may be more effective than alcohol alone because of chlorhexidine's prolonged bactericidal effect, but are expensive. They should be limited to situations when a high degree of hand antisepsis is necessary, such as before surgical procedures and placing invasive devices.

Alcohol-based hand rubs should be combined with feedback and awareness messages and other basic infection control practices.

Transmission-Based Precautions for Prevention of Infection

Table 20.2 provides a summary of different modes of transmission of infectious organisms, all of which necessitate specific transmission-based precautions.

SURVEILLANCE FOR HEALTH CARE–ASSOCIATED INFECTIONS

Surveillance of resistant organisms and device- and procedure-related infections is a marker of effective infection control and provides an early alert for outbreaks. Using standardized definitions, rates of targeted HAIs can be calculated and compared across institutions, as well as before and after interventions. Although passive surveillance (based on clinical samples) is less costly and labor intensive, it can miss a reservoir of asymptomatic, colonized patients.

Active surveillance involves screening asymptomatic patients for resistant organisms and can lead to rapid isolation of colonized patients. However, the patient populations that should be targeted for screening and the optimal screening method remain unresolved. Cost is another major limiting factor. Hospitals should assess what is feasible in their setting. To overcome surveillance shortcomings, the World Health Organization (WHO) has developed a low-cost, computer-based antimicrobial resistance (AMR) surveillance program (WHONET) that can monitor resistance trends and generate locally applicable guidelines on antimicrobial use.[4] An additional impediment to surveying resistant organisms is the lack of reliable culture and susceptibility data, as standardization and quality assurance of microbiology laboratories is not enforced in most developing countries.

BOX 20.1 Basic Infection Control Measures for Health Facilities

- Surveillance, either hospital-wide or targeted
- Hand hygiene
- Outbreak investigations
- Cleaning, disinfection, and sterilization of equipment and disposal of infectious waste
- Hospital employee health, specifically after exposure to either blood-borne or respiratory pathogens
- Review of antibiotic utilization, its relationship to local antibiotic resistance patterns, and antibiotic stewardship programs
- Prevention of infections due to surgical procedures and invasive devices (e.g., central venous catheters, urinary catheters, and ventilators)
- Development of infection control policies and procedures
- Transmission-risk based patient isolation
- Oversight on the use of new products that directly or indirectly relate to the risk of health care–associated infections

Burden of Health Care–Associated Infections in Developing Countries

HAIs are a serious problem in high-income countries; 1.7 million cases and an estimated 100,000 deaths per annum are reported in the United States.[5] In a meta-analysis from low-income countries, HAIs were found to be greater than in the United States or Europe[6]; gram-negative bacilli were the most common nosocomial pathogens. High rates of gram-negative HAIs have been documented in neonatal nurseries in low-income countries with rates threefold to twentyfold higher than in developed regions.[7,8] HAIs are responsible for increased morbidity and mortality, are a waste of precious resources, and subvert patient expectations of quality medical care. This increases negativity toward the health care system, especially because patients bear the costs of HAIs in many developing countries. Reducing the risk of HAIs in developing countries is a priority of the WHO.[9]

TABLE 20.1 Components of Standard Infection Control Precautions

Component	Recommendation
Hand hygiene	Employ after touching blood, body fluids, secretions, contaminated items; immediately after removing gloves; between patient contacts
Personal protective equipment (PPE)	
Gloves	For touching blood, body fluids, secretions, contaminated items; for touching mucous membranes and non-intact skin
Gowns	During procedures and patient care activities when contact with clothing/exposed skin with blood/body fluids, secretions is anticipated
Mask, eye protection	During procedures and patient care activities when contact with clothing/exposed skin with blood/body fluids, secretions is anticipated
Soiled patient care equipment	Handle in a manner that prevents transfer of microorganisms to others and to the environment; wear gloves if visibly contaminated; perform hand hygiene
Environmental control	Develop procedures for routine care, cleaning, and disinfection of environmental surfaces, especially frequently touched surfaces in patient care areas
Textiles and laundry	Handle in a manner that prevents transfer of microorganisms to others and to the environment Bag linen at point of disposal into a receptacle, and place soiled linen in leak-proof bags
Needles and other sharps	Do not recap, bend, break, or hand-manipulate used needles; if recapping is required, use a one-handed scoop technique only; use safety features when available; place used sharps in puncture-resistant container
Patient placement	Prioritize for single-patient room if patient is at increased risk of transmission of infection, is likely to contaminate the environment, does not maintain appropriate hygiene, is at increased risk of acquiring infection or developing an adverse outcome after infection
Respiratory hygiene/ cough etiquette	Instruct symptomatic persons to cover mouth/nose when sneezing/coughing; use tissues and dispose in no-touch receptacle; hand hygiene after soiling hands with respiratory secretions; wear surgical mask if tolerated or maintain spatial separation >3 feet if possible

Adapted from Siegel JD, Rhinehart E, Jackson M, et al. Healthcare Infection Control Practices Advisory Committee 2007 guideline for isolation precautions: Preventing transmission of infectious agents in healthcare settings, February 2017. http://www.cdc.gov/ncidod/dhqp/gl_isolation.html (accessed June 4, 2017).

TABLE 20.2 Modes of Transmission in Health Care Settings

Mode	Features
Contact transmission	Most common route. Divided into two subgroups:
Direct contact	Organisms are transferred from one infected person to another without a contaminated intermediate, e.g., body fluid of patient directly enters health care worker's body through mucous membrane or cut in skin.
Indirect contact	Transfer of organism through a contaminated intermediate object or person. Important intermediates include hands of health care workers, patient care devices and instruments, and clothing.
Droplet transmission	Respiratory droplets (>5 μm) carry organisms directly from the respiratory tract of the patient over short distances (usually ≤3 feet), necessitating facial protection such as with masks: e.g., *Bordetella pertussis, Mycoplasma pneumoniae,* respiratory syncytial virus, and influenza virus.
Airborne transmission	Transmission of droplet nuclei (≤5 μm) or small particles containing infectious agents that remain infective over time and distance, e.g., *Mycobacterium tuberculosis,* measles virus, varicella-zoster virus. These necessitate use of special air handling and ventilation systems.

Risk Factors for Health Care–Associated Infections in Developing Countries

Universal risk factors for HAIs include severity of underlying disease and factors associated with poor patient outcomes, such as malnutrition, length of hospital stay, inter-hospital transfers, use of invasive medical devices (intravascular devices, urinary catheters, intubation, and mechanical ventilation), surgery, and prolonged and/or broad-spectrum antimicrobial therapy. In developing countries there are multiple additional contributors (Table 20.3). These include lack of surveillance to control infections and outbreaks, inappropriate antibiotic use, non-adherence to infection control practices, inadequate sterilization of medical equipment, reuse of single-use devices, and reservoirs of infection in places such as contaminated food and water in the hospital. Staff training, adequately sterilizing equipment, and improving compliance with hand hygiene are easier to address than are overcrowding and understaffing.

TABLE 20.3 Factors Underlying Health Care–Associated Infections in Developing Countries

Programmatic factors	Lack of resources (financial, programmatic, institutional) Low priority of infection control Lack of integration of infection control practices in routine medical care Over-the-counter availability and indiscriminate use of antibiotics Lack of infection surveillance systems Lack of microbiologic laboratory facilities for reliable identification of infecting pathogens and antimicrobial susceptibility
Health care staff factors	Lack of infection control training Poor compliance with standard infection control practices, especially handwashing Carriage of organisms (hands, clothing, linen) Understaffing Inadequate sterilization and disinfection of equipment Use of devices (ventilators, central lines, urinary catheters) without aseptic precautions
Facility-related factors	Inadequate vector control (pests, rodents, arthropods) Overcrowding Lack of ventilation, climate control, and isolation areas Lack of sinks and running water, soap, alcohol rubs, gloves, and other supplies Reservoirs of community infections in hospitals Re-use of single-use invasive devices (syringes, catheters, tubings) because of supply shortages Inadequate facilities for sterilization and disinfection
Host factors	Severity of underlying disease Length of hospital stay High burden of infectious diseases in the patient population
Pathogen factors	High prevalence of multidrug-resistant organisms

SPECIAL PROBLEMS OF THE TROPICS

Crossover of Community Infections into Hospitals

Several recent outbreaks in the tropics have mandated development of infection control strategies specific to transmission dynamics of infectious agents (see Table 20.2). Fig. 20.1 shows communicable disease outbreaks during the 2013 to 2017 period notified to the WHO in tropical countries.[10] Nosocomial transmission of community-acquired infection (CAI) outbreaks occurred for Ebola virus disease (EVD) in the 2014 West African outbreak,[11] Middle East respiratory syndrome coronavirus (MERS-CoV), H7N9 and H5N6 influenza, and dengue virus. Guidelines to manage viral hemorrhagic fevers (VHFs), EVD, and MERS-CoV infections in health care facilities are available.

Outbreaks of cholera, measles, non-typhoidal *Salmonella*, and other fecal–oral-transmitted organisms have been reported.[12] Drivers of infections include overcrowding, improper patient isolation, the presence of visitors and outsiders, contaminated food products brought into the hospital, and infected hospital food-handlers.[13]

Hospitals with inadequate vector control can amplify vector-borne illnesses such as malaria, dengue, leishmaniasis, and filariasis because of infected patients in an overcrowded environment.[14]

Viral Hemorrhagic Fevers

VHFs such as Lassa, Ebola, Marburg, and Crimean-Congo hemorrhagic fever present unique challenges for infection control measures. Nosocomial transmission can occur directly from the patient, when transferring the dead body, through contact with infectious fluids, contaminated equipment, or needle stick injuries. Standard precautions combined with strict contact precautions and single-room isolation, especially for acutely bleeding patients or in those with profuse diarrhea or vomiting, are recommended until discharge to prevent nosocomial transmission.[15] Patients can be cohorted in a designated area; failing that, they can be housed in a portion of a larger ward, in an uncrowded corner of a large hall, in rooms designated for airborne isolation, or in private rooms. In the Ebola virus outbreak of 2014, treatment centers were created for assessing, observing, and treating patients suspected of having Ebola. Health care workers should be specifically trained in caring for these patients and other personnel restricted. Personal protective equipment (PPE) should include a scrub suit, gloves, and waterproof boots (if the floor is soiled), over which a disposable gown, plastic apron, thick gloves, fluid-resistant particulate respirator (FFP2- or EN-certified equivalent or U.S. NIOSH-certified N95), and protective goggles or face shield should be worn. If this level of protection is not available, alternatives are old shirts for scrubs,

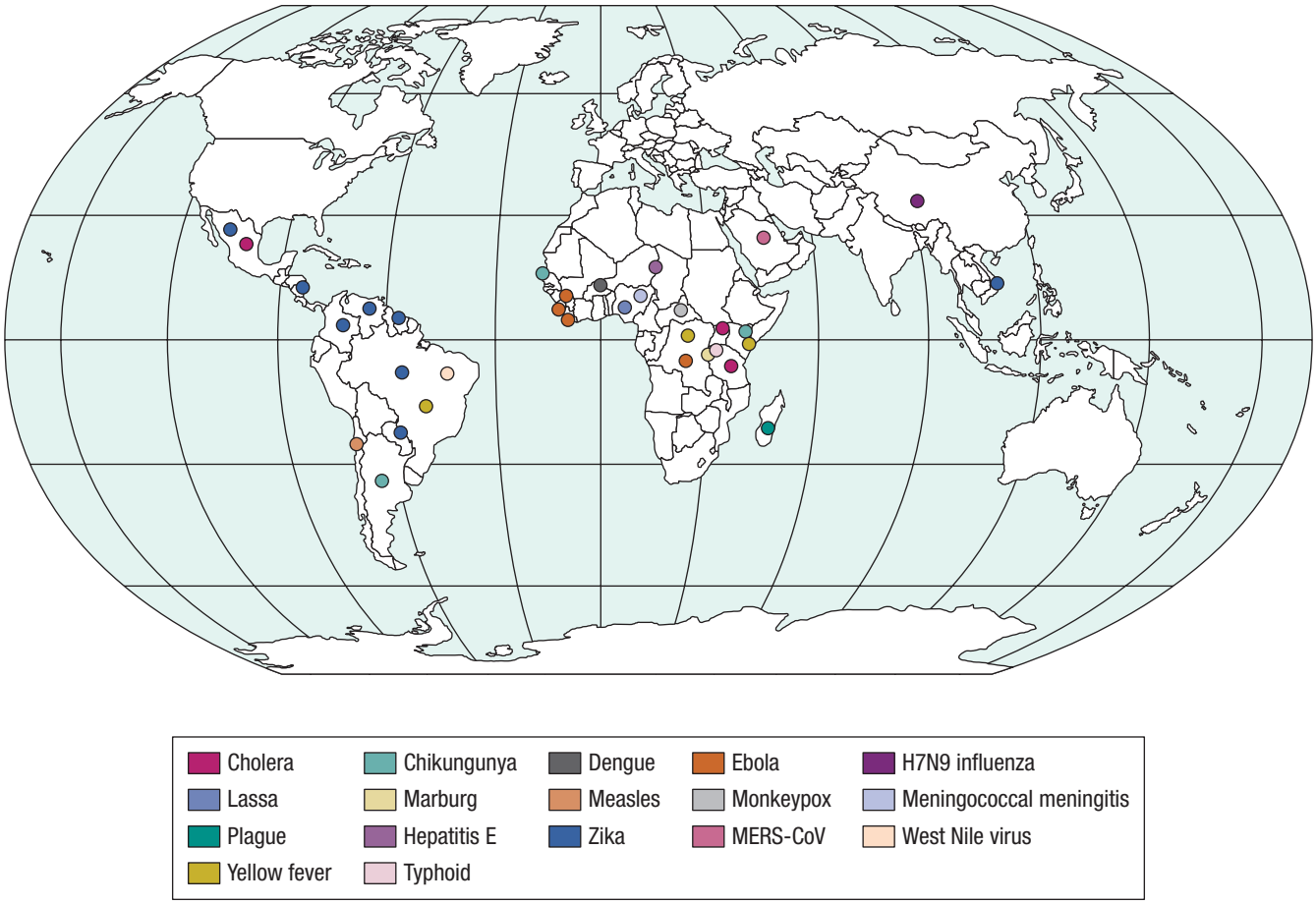

Fig. 20.1 Infectious disease outbreaks in tropical countries reported from 2013 to 2017. (Extracted from World Health Organization [WHO]. *Global alert and response. Disease outbreak by year.* Geneva: WHO. http://www.who.int/csr/don/archive/year/en/. Accessed June 4, 2017).

washable cotton gowns for disposable gowns, plastic bags for boots, plastic sheets or plastic cloth for aprons, commercially available eyeglasses for eye protection, and plastic bottles modified for sharps disposal. In regions prone to VHF outbreaks, a VHF coordinator should be appointed to oversee preparations and response and to coordinate activity and mobilize communities for rapid control.[16]

Viral Respiratory Infections

Respiratory viral illnesses with significant morbidity and a high transmission potential such as MERS-CoV and influenza need transmission-based precautions. The Centers for Disease Control and Prevention (CDC) and WHO advise standard contact and airborne precautions for these patients.[17–20] Contact precautions should exceed 24 hours in duration after symptom resolution. Health care worker vaccination against influenza virus may only provide minimal protection against novel influenza strains and therefore may not be feasible to sustain in areas with limited resources.

Vaccine-Preventable Diseases

If there is low vaccination coverage, health care workers and facilities are at risk of becoming transmission hubs for vaccine preventable diseases (VPDs). Measles and varicella nosocomial transmission can be prevented by ensuring health care worker immunity, vaccinating the non-immune, prompt diagnosis, and early institution of airborne isolation precautions.[21]

Emerging Infections

Emerging infections such as Zika, Chikungunya, West Nile virus, and plague (see Fig. 20.1) require vector control measures and transmission-based precautions in addition to standard precautions.

Tuberculosis

Individuals co-infected with HIV and tuberculosis (TB) have rapidly progressive disease. Those with pulmonary disease are highly infectious via aerosolized droplet nuclei, posing challenges for infection control and a risk to health care and laboratory workers. U.S. CDC guidelines recommend rapid diagnosis and treatment, isolation in negative-pressure rooms, and special masks to prevent nosocomial transmission, which are rarely feasible in resource-poor settings. However, early diagnosis and treatment, outpatient evaluation of suspected TB patients, a separate TB ward with adequate ventilation using exhaust fans and large open windows to allow ultraviolet (UV) rays from sunlight, early collection of samples, disinfecting sputum containers, and treating the sputum with household bleach can be applied.[22] The WHO published guidelines to control TB transmission in health care settings[23];

however, there is little evidence of efficacy and cost-effectiveness in low-resource settings.

Antimicrobial Resistance

AMR is a global health crisis,[24,25] with carbapenem and colistin resistance recently emerging among gram-negatives.[26,27] The proportion of resistant organisms such as methicillin-resistant *Staphylococcus aureus*, extended-spectrum β-lactamase–producing Enterobacteriaceae, and multidrug-resistant *Pseudomonas aeruginosa* and *Acinetobacter* spp. is substantially higher in developing countries.[6] Factors that predispose to AMR infections are misuse of broad-spectrum antimicrobials (inappropriate prescription, suboptimal dosing and duration), low-potency antibiotic formulations, poor hospital hygiene, overcrowding, lack of infection control, unavailability of reliable diagnostic and susceptibility testing, and a lack of personnel trained in controlling infections.

Managing AMR requires adherence to infection control and restricted antibiotic use. Hospitals and health care facilities should initiate antibiotic stewardship programs (ASPs) that can reduce AMR and associated costs. ASPs function best with the collaboration and support of physicians, infection control teams, nurses, microbiology laboratories, pharmacy services, quality management teams, and information systems. However, if they depend on the availability of diagnostic laboratories and information systems, it may be a challenge to implement them where there are limited trained personnel and resources. Moreover, it is difficult to restrict antibiotics where third-generation cephalosporins and fluoroquinolones are freely available over-the-counter and are widely used.[28] Countries that adhere to the WHO's essential drug policies provide greater access to essential drugs for vulnerable populations with less indiscriminate prescription of antimicrobials and injections.[29]

Sepsis and HAIs in Neonates

Newborn care and neonatal sepsis are major challenges. Lack of infection prevention antepartum and intrapartum, overcrowding, poor hand hygiene, and invasive devices for ventilatory support and vascular access contribute to high rates of infections in the newborn and especially in premature infants. High antibiotic use exerts antibiotic selection pressure, and an overwhelming proportion of neonatal intensive care infections are resistant to multiple antibiotic classes.[8,30] Pan-resistant *Acinetobacter* and *Pseudomonas* are common.

Infection control in the labor ward and neonatal intensive care unit (NICU) requires hand hygiene and rational antibiotic use, along with an appropriately trained and motivated workforce.[7,8,31] Although preventive measures such as using chlorhexidine gluconate and catheter care bundles in NICUs have proven effective against neonatal HAIs,[32] resource constraints and lack of public health attention to generating inexpensive solutions hinder control efforts.

Hospital Design in the Tropics

Hospital design affects thermal comfort, availability of clean air, control of air movement, and indoor air quality. In many tropical regions, resource limitations and electric power shortages prevent using heating, ventilation, and air conditioning (HVAC) systems. Because airborne isolation of patients with TB, measles, and varicella pneumonia employ modifications in HVAC, isolating these patients is difficult without HVAC. Multi-bed hospitals can employ hybrid natural and mechanical ventilation to optimize air movement and exchanges per hour. Not many solutions are available for thermal comfort in hot and humid climates, but design features to decrease indoor temperature such as cantilevered roofs can be added to existing buildings. Cockroaches, ants, bedbugs, flies, and rodents abound in tropical regions and can carry microorganisms.[33] Their proliferation can be controlled by adequate plumbing, waste disposal, regular laundry of linen, and encasing pillows and mattresses in plastic.[34] Waste disposal can decrease rodent infestations, and screened doors and windows, as well as traps, are used in vector control. New and more cost-effective light-emitting diode (LED) insect traps are effective.

Device-Associated Infections

Device-associated infections (DAIs) include central line (CL)–associated bloodstream infections, catheter-associated urinary tract infections, and ventilator-associated pneumonia. Invasive device use in developing countries has increased without prerequisite infection control measures, resulting in higher rates of DAIs than in industrialized countries. Surveillance by the International Nosocomial Infection Control Consortium (INICC) in 98 intensive care units (ICUs) in resource-limited settings in Latin America, Asia, Africa, and Europe using CDC definitions for HAIs showed that among 43,114 patients over an aggregate of 272,279 days from 2002 through 2007, the rates of DAIs were much higher compared with industrialized countries.[35] Catheter-associated bloodstream infections were 8.9 per 1000 CL-days compared with 2.4 per 1000 CL-days in comparable medical-surgical ICUs in the United States; ventilator-associated pneumonia was 19.8 versus 3.6 per 1000 ventilator-days; and catheter-associated urinary tract infections were 6.6 versus 3.4 per 1000 catheter-days. INICC-designed guidelines use positive feedback programs for hand hygiene and CL, ventilator, and urinary catheter care.[36]

Surgical Site Infections

Surgical procedures are associated with higher post-operative wound infection rates due to inadequate aseptic precautions. Although most data are anecdotal, surgical wound infections are reported to be as high as 12.5% in Vietnam and 19.6% in Kenya. Recent data also show that surgical site infection (SSI) rates are higher in warmer climates.[37] A surgical checklist developed by the WHO has reduced surgical mortality and morbidity by encouraging the use of simple measures by surgery, anesthesia, and nursing staff. Ensuring delivery of antibiotic prophylaxis in the operating room using verbal confirmation alone improved antibiotic prophylaxis compliance from 56% to 83%. Chlorhexidine–alcohol is the antiseptic of choice for pre-operative surgical-site skin cleansing, and is superior to povidone–iodine in preventing post-operative wound infections.[38] Chlorhexidine–gluconate-based scrubs are more effective than povidone–iodine-based aqueous scrubs in reducing bacterial contamination on staff hands before operations. *S. aureus*–associated post-operative wound infections can be decreased by treating nasal carriers of *S. aureus* with pre-operative mupirocin nasal ointment and chlorhexidine soap. However, application in developing countries may be limited by the need to identify *S. aureus* carriers using rapid DNA detection.

Unsafe Injections and Needle Stick Injuries

Unsafe injections and sharps injuries are instrumental in transmitting blood-borne pathogens such as hepatitis B and C and HIV.[39,40] It is estimated that 16 billion syringes are sold worldwide each year, the vast majority in developing countries; injection rates vary from 1.7 to 11.3 per person per year. Up to 75% of these may be non-sterilized.

Needle stick injuries to health care workers are another source of blood-borne pathogen infection. Needle sticks result from lack of training, improper disposal and destruction of needles, attempts to recap needles, and other unsafe practices. Trainee staff and nurses are most at risk when drawing blood.

Improving injection safety requires programmatic reform at a national level. Although expensive, the availability of needle disposal kits and disposable "auto-destruct" syringes should be increased.

Health care workers, medical and allied health students, and the public should be educated about the dangers of unsafe injections; health care workers should be trained in safe practices. Surveillance of needle stick injuries and post-exposure prophylaxis for health care workers should be part of hospital infection-control programs.

Strengthening Health Systems in the Tropics

Infection control can be achieved if strong institutional commitment exists. Despite the challenges, studies reviewing the cost-effectiveness of even minimal infection control measures are universally optimistic. These measures lower the costs incurred from HAIs due to longer hospital stays, greater disease morbidity and mortality, and antimicrobial agent use. The effectiveness of infection control measures can be used to indicate the quality of hospital care.[41] Any intervention program should comprise a holistic approach that includes basic infection control measures. The most effective solutions will be those that are indigenously developed and implemented and improved through active learning cycles and feedback. Local research is necessary to identify critical points in infection transmission and solutions to address these.

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