# Infection prevention: General principles

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## INTRODUCTION

Infection prevention and control (hereafter "infection prevention") is grounded in quality improvement activities and is critical for patient safety [1,2]. Infection prevention programs use protocols and interventions to decrease the risk of health care-associated infection (HAI). HAIs are the most common complication seen in hospitalized patients and increase morbidity, mortality, costs, and length of stay, even after adjustment for underlying illness [3].

The field of infection prevention emerged from the results of the Study of the Efficacy of Nosocomial Infection Control (SENIC) [4]. The SENIC study demonstrated that four components were essential to an effective infection prevention and control program. These included (i) surveillance with feedback of infection rates to hospital staff, (ii) enforcement of preventative practices, (iii) a supervising infection preventionist to collect and analyze surveillance data, and (iv) the involvement of a physician or microbiologist with specialized training in infection prevention and control. Programs with these elements reduced rates of the four most common HAIs by 32 percent [4,5]. Subsequently, regulatory mandates led to the establishment of formal infection prevention programs, typically supervised by physicians and/or trained nurses and overseen by hospital committees. Increasing hospital regulations, scrutiny from accreditation groups, public reporting of infection-related outcomes, and impact on hospital reimbursement have solidified infection prevention programs as a key component of health care in all settings.

The terminology surrounding infection prevention has evolved over time. Initially, infection control teams sought to monitor "nosocomial" infections (ie, infections acquired in the hospital). More recently, the focus has shifted from monitoring to preventing HAIs (infections acquired in

healthcare facilities). Similarly, as health care delivery has shifted from the hospital to various inpatient and outpatient venues, the term "health care epidemiology" has emerged to encompass infection prevention activities in the multiple areas where health care is delivered [3]. Additionally, the focus for infection prevention programs has evolved due to rising rates of antimicrobial resistance, aging populations, and increased use of immunosuppressive therapies.

In general, infection prevention programs focus on two broad goals to increase patient safety: reducing the risk of acquisition or transmission of infection following exposure to health care settings (particularly from multidrug-resistant organisms) and reducing the risk of device- and procedure-related infections. In addition, these programs are increasingly charged with protecting healthcare personnel, visitors, and others and meeting accreditation and regulatory standards [6].

This topic will review the general principles of infection control. Isolation precautions for preventing transmission of infection and issues related to infection control for COVID-19 are reviewed separately. (See "Infection prevention: Precautions for preventing transmission of infection" and "COVID-19: Infection prevention for persons with SARS-CoV-2 infection".)

## GENERAL PRINCIPLES

The scope of a health care institution's infection prevention and control/health care epidemiology program should be driven by the size and complexity of the institution's patient population; the population's risk for health care-associated infection (HAI); and local, state, and national regulatory and accreditation requirements [7]. In most hospitals, members of the infection prevention team participate in regulatory, patient safety, and quality improvement initiatives, led by a health care epidemiologist who must have formal support from hospital administration [8]. The typical infection prevention team has numerous oversight functions and responsibilities:

- Surveillance and feedback of data on health care-associated infections, including:
  - Device and procedure-related infections
  - Infections caused by multidrug-resistant organisms
  - Epidemiologically important infections (eg, *Staphylococcus aureus* bacteremia, *Clostridioides* [formerly *Clostridium*] *difficile* infection)
- Outbreak investigation – Infection prevention teams need to be familiar with the likely sources of outbreaks, how they are affected by hospital design and construction, and how

they may best be investigated and remediated [9]. Outbreak sources in hospitals commonly consist of inanimate surface and device contamination, health care workers, other patients and hospital water sources.

For example, waterborne outbreaks have occurred in health care settings with new reservoirs, including electronic faucets *(Pseudomonas aeruginosa* and *Legionella* spp), decorative water wall fountains *(Legionella* spp), and heater-cooler devices used in cardiac surgery *(Mycobacterium chimaera*) [10,11].

Hospital sinks, drains, showers, wash basins, and tap water have been the reservoir of infections caused by nontuberculous mycobacterial species, fungi, and multidrug-resistant gram-negative pathogens [10,11]. Molecular typing has been increasingly applied to hospital outbreak investigation, including the use of pulsed-field gel electrophoresis followed by random amplification of polymorphic DNA and whole-genome and shotgun metagenomic sequencing [10,12,13].

- Education of health care providers and patients
- Performance improvement to prevent or reduce HAIs
- Reporting of HAIs
- Occupational infection prevention for health care providers

The Society for Healthcare Epidemiology of America recommends the following core competencies for a successful health care epidemiologist [14]:

- Training in:
  - Clinical infectious disease/pathogen transmission
  - Microbiologic and laboratory diagnostic techniques
  - Knowledge of quality improvement science
  - Public health and emergency preparedness
- Skills in:
  - Leadership
  - Data management
  - Program implementation, assessment, and advocacy
  - Outcomes assessment

The infection prevention team develops, implements, and monitors the success of the following infection prevention protocols and interventions to achieve the goals of the program and of the hospital:

- Surveillance data analysis and feedback.
- Hand hygiene.
- Health care provider education.
- Cleaning/disinfecting medical equipment.
- Cleaning/disinfecting the health care environment.
- Environmental infection control (including air handling, water supply, and construction-related issues).
- Isolation precautions and the use of personal protective equipment (PPE). Educating staff on the use of appropriate PPE is an integral part of infection prevention within hospitals. (See "Infection prevention: Precautions for preventing transmission of infection".)

These interventions may be described as "horizontal", in which an intervention may prevent infection from many organisms (eg, surveillance, hand hygiene, and cleaning/disinfection), or "vertical", in which an intervention may prevent infection from a specific organism (eg, isolation precautions) [15].

General principles related to surveillance and feedback, regulations that impact infection prevention programs, and environmental cleaning/disinfection will be discussed below. Issues related to use of surveillance for control of specific pathogens such as methicillin-resistant *S. aureus* and vancomycin-resistance enterococci are discussed separately. (See "Methicillin-resistant Staphylococcus aureus (MRSA) in adults: Prevention and control", section on 'Role of active surveillance' and "Vancomycin-resistant enterococci: Epidemiology, prevention, and control", section on 'Surveillance cultures'.)

## SURVEILLANCE AND FEEDBACK

Surveillance for health care-associated infections is an essential component of infection prevention [16]. Effective surveillance involves counting cases and calculating rates of infections [17-19]. Surveillance data are useful for identifying necessary interventions and also for assessing the efficacy of interventions to improve infection rates [20-22]. Surveillance data should be reported to hospital leadership, personnel involved in patient care, and to monitoring agencies such as state health departments or statewide or national surveillance programs according to local requirements [16,23-26].

In the United States, most programs perform surveillance using standardized definitions and methods developed by the Centers for Disease Prevention and Control's (CDC's) National Healthcare Safety Network (NHSN) [27-29]. In Europe, some countries use NHSN's definitions, while others use European definitions from the European CDC (ECDC) and Hospitals in Europe

Link for Infection Control through surveillance (HELICS/IPSE) project. In general, there is excellent concordance between United States and European definitions of pneumonia and primary bloodstream infection, and rates of infection between countries can be compared at least for some health care-associated infections (HAIs) [30,31].

Surveillance data may be used for both intrahospital comparison (ie, comparing the rate of infection in a particular hospital to a benchmark for similar hospitals) as well as interhospital comparison (ie, comparing infection rates between hospitals). In addition, comparing surveillance data between hospitals is subject to bias; risk adjustment for clinical factors is required but may not be sufficient [32-39]. (See 'Regulatory organization and public reporting' below.)

Risk assessment is the cornerstone of designing an organization-specific surveillance program and involves identifying the most important populations and infections to follow so that resources can be focused on the most worthwhile prevention activities [7].

Many hospitals perform surveillance for the following infections:

- Surgical site infections
- Catheter-associated urinary tract infections
- Central line–associated bloodstream infections
- Pneumonia, particularly ventilator-associated pneumonia
- *C. difficile* infections
- Infections caused by multidrug-resistant organisms

Surveillance for all types of infection may not be possible in all settings; at a minimum, surveillance should be targeted to the following categories:

- Patients or care units at high risk for infection (for example, patients in intensive care units)
- Particular infections that are highly preventable and/or associated with substantial morbidity
- Emerging infections

**Components of surveillance** — Components of effective surveillance include the following [40,41]:

- Standardized definitions
- Routine review of microbiologic and clinical records
- Review of discharge diagnoses

- Review of records of patients who are readmitted after surgical procedures or patients who undergo reoperation
- Review of autopsy, radiologic, and pathologic reports
- Review of known or suspected infections among clinical personnel

**Data collection and automation** — Traditional manual surveillance methods are labor intensive, lack standardization, and are limited by inter-observer variability [42,43]. Electronic surveillance systems are becoming integral to routine infection control activities and have the potential to improve infection control outcomes in surveillance, prevention, and connections with public health [44].

Semi-automated and fully automated electronic surveillance systems are now widely used:

- Semi-automated electronic surveillance systems are used by many infection prevention programs. These systems filter data from laboratory, pharmacy, and admission/discharge/transfer records and have been found to successfully perform surveillance for various types of HAIs, including surgical site infections (SSIs) and CLABSIs [45]. Such systems also have the potential to identify outbreaks that may be missed by routine detection methods [46]. They do, however, require substantial user input, have limitations with regard to interfacility comparison, and do not replace the need for chart review [41,43,46].

- Fully automated electronic surveillance systems function autonomously via a complex series of algorithms to identify cases of nosocomial infection; such systems generally do not require user input or chart review but may still include some manual steps [47-49]. The systems mine the electronic health record to collect data on clinical signs and symptoms, medical procedure details (eg, duration of surgery), and medical device exposure data (eg, duration of catheterization) [47]. Some systems require adjustment of algorithms for specific populations (such as those in an intensive care unit) [50]. Implementation of automated surveillance systems in practice is complicated by practical challenges regarding the availability of high-quality data, electronic health record standardization, specialized information technology (IT) and infection control personnel, and costs [43]. As hospitals adopt medical record systems that meet uniform standards and regulatory requirements, the costs associated with building interfaces to collect and analyze clinical data, and the ability to compare rates between facilities and regions, are likely to improve [43,47].

Validation of surveillance data is necessary to ensure scientific credibility and identify methodological problems [51]. Automated surveillance data should also undergo clinical and

technical validation in all contexts, including validation of the source data, algorithms, denominator data, and an assessment of the ability to provide reliable benchmark data [43]. The results of validation studies are important for informing interventions to improve surveillance data quality, especially if validation studies reveal that the quality of surveillance data is suboptimal [52,53].

**Education and training** — Education and training of health care personnel are critical functions to prevent HAIs and core functions of infection prevention and control programs. Focused training for various disciplines has been effective in durably reducing HAIs [54]. Routine in-service training should be directed toward health care personnel of all disciplines, including physicians, nurses, medical and nursing students, as well as other staff with direct or indirect contact with patients or equipment. Training should be tailored to the appropriate educational level, learning styles, and work duties of the employees [7]. The training should incorporate hand hygiene and all tasks for which personnel are responsible and incorporate assessment of well-defined competencies for each task [55].

Basic infection prevention education and training should include numerous topics including but not limited to:

- Hand hygiene
- Aseptic technique
- Injection safety practices
- Equipment reprocessing
- Single-use devices
- Single- and multi-dose medication vials
- Personal protective equipment
- Standard- and transmission-based precautions
- Cleaning and disinfection

**Regulatory organization and public reporting** — Regulatory burden has increased significantly for infection prevention programs over the past decade. Governments may directly regulate patient safety with mandatory reporting legislation. Alternatively, governments may require healthcare facilities to report to professional regulatory bodies or to create and enforce their own policies [56].

- **Regulatory entities in the United States** – The main regulatory organizations for infection prevention programs in the United States include federal agencies and accreditation organizations. Additional regulations and reporting requirements vary by state. The provides information on infection prevention–related regulations [57].

The National Quality Forum (NQF) endorses 25 measures related to patient safety, several of which are related to infection prevention [58]. Measures endorsed by NQF often translate into reporting requirements for hospitals, which they are required to report as a condition of participation in Centers for Medicare and Medicaid Services (CMS). Hospitals that perform well on these measures receive additional incentive payments. Data are posted for public reporting allowing the public to compare various quality metrics, including patient experiences, process measures, and infection data [59].

The Occupational Safety and Health Administration (OSHA) provides standards and directives to improve infection prevention for health care providers [60]. In general, these focus on prevention of infections from bloodborne pathogens following exposure to blood or body fluids and personal protective equipment for health care providers.

The Joint Commission places particular emphasis on infection prevention when providing accreditation to health care organizations [61]. Infection prevention programs in acute care hospitals must develop policies and procedures to meet specific goals related to:

- Infection prevention team staffing and institutional support
- Hand hygiene policies and practices
- Prevention of infections caused by multidrug-resistant organisms, including regular assessment (via surveillance) and education for health care providers
- Prevention of central line–associated bloodstream infection
- Prevention of surgical site infections
- Prevention of catheter-associated urinary tract infections

- **Regulatory entities outside the United States** – Similar regulatory agencies oversee infection prevention regulations throughout the world. For example, the European Commission and other agencies, in particular the European Academies Science Advisory Council and the ECDC, play a role in integrated surveillance in Europe [62]. ECDC established HAI-Net, a network of national and regional networks collecting surveillance data across Europe [63].

  In Canada, mandatory reporting of HAIs is a provincial, not a federal, responsibility [64]. Eight of 13 Canadian jurisdictions have instituted mandatory reporting legislation [56].

  In Australia, The National Safety and Quality Health Service (NSQHS) Standards include the Preventing and Controlling Infections Standard, which aims to improve infection prevention and control measures to help prevent infections and the spread of antimicrobial resistance [65]. Australia does not, however, have a national HAI surveillance program [66].

## CLEANING, DISINFECTION, AND STERILIZATION

Ensuring the cleanliness of medical equipment and patient care areas are important horizontal measures for prevention and reduction of health care-associated infection [1,2]. In general, the oversight and monitoring of these practices are the joint responsibilities of the infection prevention program and the environmental services department. Personnel from specialized areas (such as operating rooms) also share in these responsibilities at their locations.

Terms used in the following discussion include cleaning, disinfection, and sterilization ( table 1):

- Cleaning refers to removal of organic material on soiled surfaces; it is generally accomplished with water, mechanical action, and detergents or enzymatic products [2,67].
- Disinfection refers to the elimination of many or most microorganisms. Chemical disinfectants can kill most vegetative bacteria, some fungi, and some viruses.
- Sterilization refers to complete elimination of all forms of microbial life. Sterilization can be accomplished by either physical or chemical processes; techniques include steam under pressure, dry heat, low temperature sterilization processes (ethylene oxide gas, plasma sterilization), and liquid chemicals [68,69].

**Health care environment: Cleaning and disinfection** — Environmental cleaning and disinfection reduce organisms transmissible via contact with environmental surfaces; these include methicillin-resistant *S. aureus* (MRSA), vancomycin-resistant enterococci (VRE), and *C. difficile* [70-73].

Environmental cleaning refers to removal of organic material on soiled surfaces of patient care areas; it is generally accomplished with water, mechanical action, and detergents or enzymatic products [2,67].

Environmental cleaning is typically followed by disinfection, which eliminates microorganisms [74]. Disinfection in health care settings should be performed with Environmental Protection Agency (EPA)-registered chemicals such as those summarized in the table ( table 1) [68,69,75,76]. Data comparing disinfection products are limited [77,78].

For certain situations, specific disinfection protocols are warranted. As an example, disinfection with standard quaternary ammonium-based chemicals does not eliminate bacterial spores (eg, *C. difficile*) or nonenveloped viruses (eg, norovirus). For disinfection of patient care areas with known or suspected of contamination with these pathogens, use of a sporicidal agent (such as

bleach) is warranted [79-84]. (See "Clostridioides difficile infection: Prevention and control", section on 'Environmental cleaning and disinfection'.)

Additionally, hospital water is a source of infection transmission [10,12,85]. For example, specific disinfection strategies decrease the risk of transmission from water-containing heater-cooler units; however, full disinfection of faucets and plumbing in patient rooms is typically not feasible [11].

The efficacy of disinfection is affected by several factors [68,86]:

- Physical cleaning prior to disinfection and level of residual organic contamination
- Configuration of surfaces to be cleaned (eg, disinfection of crevices, hinges, and lumens may be more difficult than smooth surfaces)
- Type and level of microbial contamination
- Concentration, temperature and pH of disinfectant
- Exposure time to disinfectant

Barriers to effective disinfection include [87,88]:

- Confusion between nursing and environmental services staff over the allocation of cleaning responsibilities
- Insufficient training
- Inadequate time to complete cleaning
- Inappropriate dilution of disinfectant solutions [89]
- Difficulty ensuring disinfection of mobile equipment
- Contamination of reusable cleaning supplies and disinfectant solutions with pathogenic bacteria [89]
- Inability to fully disinfect highly contaminated areas (eg, sinks, plumbing, and water reservoirs) [10]

To overcome these difficulties, infection prevention programs should develop specific policies in collaboration with environmental services teams. In addition, hospitals should implement ongoing training of staff with responsibility for cleaning and disinfection. Consistent results may be achieved by formation of a dedicated cleaning team and implementation of a standardized cleaning process [90]. Visual inspection of cleaning and disinfection is not adequate; infection prevention programs must obtain objective data from cleaning and disinfection processes and provide feedback to environmental services with these data [87,91-93].

Systematic execution of such comprehensive infection prevention interventions can reduce the incidence of infections in the health care environment. In a randomized, multicenter trial in 11

Australian hospitals, a multimodal intervention focused on optimization of routine cleaning techniques with staff training and feedback reduced the incidence of VRE infections from 0.35 to 0.22 per 10,000 occupied bed-days (relative risk 0.63, 95% CI 0.41-0.97) [94]. Changes in the incidences of *S. aureus* and *C. difficile* infections were not statistically significant. This is consistent with the understanding that the epidemiology of *C. difficile* infection is more complicated than simple acquisition from the environment. A separate randomized, multicenter trial in 16 United States acute care hospitals concluded that optimized disinfection strategies led to lower rates of *C. difficile* detection on environmental surfaces but did not impact the rate of hospital-acquired *C. difficile* infections [95].

No accepted standards exist to establish the cleanliness of a health care environment [88,96,97]. Tools to assess room cleanliness include direct observation, fluorescent markers, and adenosine triphosphate (ATP) bioluminescence. To train cleaning teams, invisible fluorescent markers are applied to surfaces before cleaning; after cleaning, a special light is used to illuminate the surfaces and identify any markers that were missed by the cleaning team [98]. ATP bioluminescence may be used to evaluate for the presence of residual organic material after cleaning, although benchmark standards have not been established [90,99,100]. Cultures are not typically used for routine monitoring of disinfection.

**Adjunctive environmental cleaning methods** — Technological advances have led to environmental cleaning methods that augment traditional manual cleaning. These new technologies do not replace the need for manual cleaning.

Examples include ultraviolet (UV) radiation and hydrogen peroxide vapor/aerosol. The major advantage of both UV radiation and hydrogen peroxide systems are their ability to consistently decontaminate hospital room surfaces. Both systems are residue-free. However, both UV radiation and HP may only be used for terminal disinfection and neither can physically clean a room [101].

**UV radiation** — Ultraviolet (UV) radiation may be a useful adjunctive tool for disinfection, particularly against multidrug-resistant organisms [90,102-109]. In one cluster-randomized crossover study including 21,395 patients (in the intention-to-treat analysis) admitted to rooms from which a patient on contact precautions was discharged, the addition of UV light to disinfection with quaternary ammonium reduced the cumulative incidence of infection or colonization with pathogenic organisms (MRSA, VRE, multidrug-resistant *Acinetobacter*, and *C. difficile*) by 30 percent (relative risk 0.70, 95% CI 0.50-0.98; p = 0.036) [102]. No substantial individual decrease in *C. difficile* infection was observed with the addition of UV light to bleach disinfection (versus bleach alone) for the next patient in the room. However, use of the UV radiation in these targeted rooms did lead to an 11 percent decrease in *C. difficile* incidence and

a 44 percent decrease in VRE incidence for the hospital-wide population [110]. (See "Clostridioides difficile infection: Prevention and control", section on 'Environmental cleaning and disinfection'.)

Another systematic review and meta-analysis including 13 studies evaluating UV systems concluded that UV light no-touch disinfection technology was most effective at preventing *C. difficile* and VRE [111]. Other than the randomized controlled trial described above, all the studies included in the analysis were quasi-experimental, single-center studies.

**Hydrogen Peroxide** — Hydrogen peroxide (HP) disinfection methods include the use of both vaporized and aerosolized HP. Vaporized HP produces the best log reduction in colony-forming units, achieving essentially complete eradication of experimentally placed bacteria in a test space. Aerosolized HP can produce >5 log reductions in colony-forming units of bacteria, although a wide range (1 to >5) has been reported and there may be unequal dispersion of the aerosols through a space [112].

**Medical equipment: Disinfection and sterilization** — The type of cleaning, disinfection, and sterilization required depends on the type of medical equipment. Types of medical equipment include the following ( table 1) [2]:

- Noncritical equipment – Medical equipment that comes into contact with intact skin but not mucous membranes (eg, stethoscopes, blood pressure cuffs, patient care area surfaces)
- Semi-critical equipment – Medical equipment that comes into contact with nonintact skin or mucous membranes (eg, thermometers, endoscopes)
- Critical medical equipment – Medical equipment that comes into contact with sterile tissue or the vascular system (eg, implants, catheters, surgical instruments)

Noncritical medical equipment should be cleaned using a disinfectant that kills most bacteria and some viruses and fungi; cleaning these items with an alcohol wipe between uses is often sufficient [69,75,113,114]. Mobile communication devices such as pagers and cell phones may also become contaminated with bacteria, but effective decontamination of these devices is difficult; hand hygiene immediately prior to patient-contact can remediate the risk to a substantial extent [115,116].

Semi-critical medical equipment should be free from all vegetative microorganisms, but small numbers of bacterial spores are permissible since nonintact skin and mucous membranes are

generally resistant to infection by spores [2]. Semi-critical medical equipment should be cleaned as summarized in the table ( table 1).

Critical medical equipment must be sterile because any microbial contamination could transmit disease. These items should be purchased as sterile or be sterilized between uses [2]. Critical medical equipment should be cleaned as summarized in the table ( table 1). Disinfection of endoscopes and bronchoscopes is discussed further separately. (See "Preventing infection transmitted by gastrointestinal endoscopy" and "Flexible bronchoscopy in adults: Overview", section on 'Cleaning the bronchoscope'.)

Critical medical equipment used for care of patients with known or suspected disease due to prions (infectious agents composed of protein) requires specific procedures for sterilization. Agents that do **not** inactivate prions include alcohol, ethylene oxide, formaldehyde, glutaraldehyde, hydrogen peroxide, iodine, ionizing radiation, phenolics, quaternary ammonium compounds, steam sterilization (121°C), or urea (concentration 6 to 8 mol/L) [117]. Issues related to sterilization of prion-contaminated medical equipment are discussed further separately. (See "Creutzfeldt-Jakob disease", section on 'Iatrogenic CJD'.)

## SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Infection control".)

## SUMMARY

- Infection prevention programs use protocols and interventions to decrease the risk of infection associated with exposure to health care settings. (See 'Introduction' above.)
- The cornerstone of successful infection control is effective surveillance, which involves counting cases and calculating rates of infections, with subsequent data reporting to hospital leadership and personnel involved in patient care. (See 'General principles' above and 'Surveillance and feedback' above.)
- Cleaning and disinfection of medical equipment and patient care areas are important measures for prevention of transmission of pathogens that may cause infection. (See 'Cleaning, disinfection, and sterilization' above.)

- The approach to medical equipment disinfection and sterilization required depends on the equipment type. Types of medical equipment and the approach to disinfection and sterilization are summarized in the table ( table 1). (See 'Medical equipment: Disinfection and sterilization' above.)

- Environmental cleaning refers to removal of organic material on soiled surfaces of patient care areas; it is typically followed by disinfection, which eliminates microorganisms. Disinfection in health care settings is usually performed with Environmental Protection Agency (EPA)-registered chemicals such as those summarized in the table ( table 1). Special disinfectants are required to eliminate *Clostridioides difficile* and nonenveloped viruses such as norovirus. (See 'Health care environment: Cleaning and disinfection' above.)

- Hospitals should implement ongoing training and retraining of staff with responsibility for cleaning and disinfection, together with monitoring and feedback. Consistent results may be achieved by formation of a dedicated cleaning team and implementation of a standardized cleaning process. (See 'Health care environment: Cleaning and disinfection' above.)



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**GRAPHICS**

## Approach to disinfection and sterilization of medical devices

| Device classification | Devices (examples) | Spaulding process classification/time | Processes | EPA product classification |
|---|---|---|---|---|
| **Noncritical** (touches intact skin, not mucous membranes) | Stethoscopes, bedpans, blood pressure cuffs, patient furniture | Low-level disinfection: Kills most bacteria, some viruses and fungi. Cannot reliably kill resistant microorganisms (eg, tubercle bacilli, bacterial spores).<br>**Time:** 10 minutes or less | Chemical disinfectants; ethyl or isopropyl alcohol, sodium hypochlorite, hydrogen peroxide, quaternary ammonium germicidal detergent. | Hospital disinfectant without label claim for tuberculocidal activity |
| **Semi-critical** (touches intact mucous membranes [except dental]) | Flexible endoscopes, laryngoscopes, endotracheal tubes, cervical diaphragms | High-level disinfection: Destroys all microorganisms except high numbers of bacterial spores.<br>**Time:** 20 minutes or more | Wet pasteurization or chemical disinfectants.* Heat sterilization preferred for between patient processing of heat stable instruments. Follow by rinsing with sterile water. | Sterilant/disinfectant |
| | Thermometers, hydrotherapy tanks | Intermediate-level disinfection: Inactivates tubercle bacilli, vegetative bacteria, most viruses and fungi. Does not necessarily kill bacterial spores.<br>**Time:** 10 minutes or | Chemical disinfectants; sodium hypochlorite ethyl or isopropyl alcohol, phenolic and iodophor solutions. | Hospital disinfectant with label claim for tuberculocidal activity |

| | | | | |
|---|---|---|---|---|
| | | less | | |
| **Critical** (enters sterile tissue or vascular system) | Implants, scalpels, needles, cardiac and urinary catheters | Sterilization.<br>**Time:** prolonged contact (hours) | Purchase as sterile. Sterilize by steam under pressure. If heat labile, use ethylene oxide gas or chemical sterilants.¶ | Sterilant/disinfectant |

EPA: Environmental Protection Agency.

* 2% glutaraldehyde-based products, 6% stabilized hydrogen peroxide, chlorine, peracetic acid.

¶ 2% glutaraldehyde-based products, 6% stabilized hydrogen peroxide, peracetic acid.

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## Contributor Disclosures

**Deverick J Anderson, MD, MPH** Other Financial Interest: Major Sports LLC [Infection control education]. All of the relevant financial relationships listed have been mitigated. **N Deborah Friedman, MPH, MBBS, FRACP, MD** No relevant financial relationship(s) with ineligible companies to disclose. **Daniel J Sexton, MD** Equity Ownership/Stock Options: Magnolia Medical Technologies [Medical diagnostics – Ended August 2022]. Consultant/Advisory Boards: Magnolia Medical Technologies [Medical diagnostics – Ended August 2022]. All of the relevant financial relationships listed have been mitigated. **Keri K Hall, MD, MS** No relevant financial relationship(s) with ineligible companies to disclose.

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Conflict of interest policy

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