In the name of God

Nosocomial infection and infection control

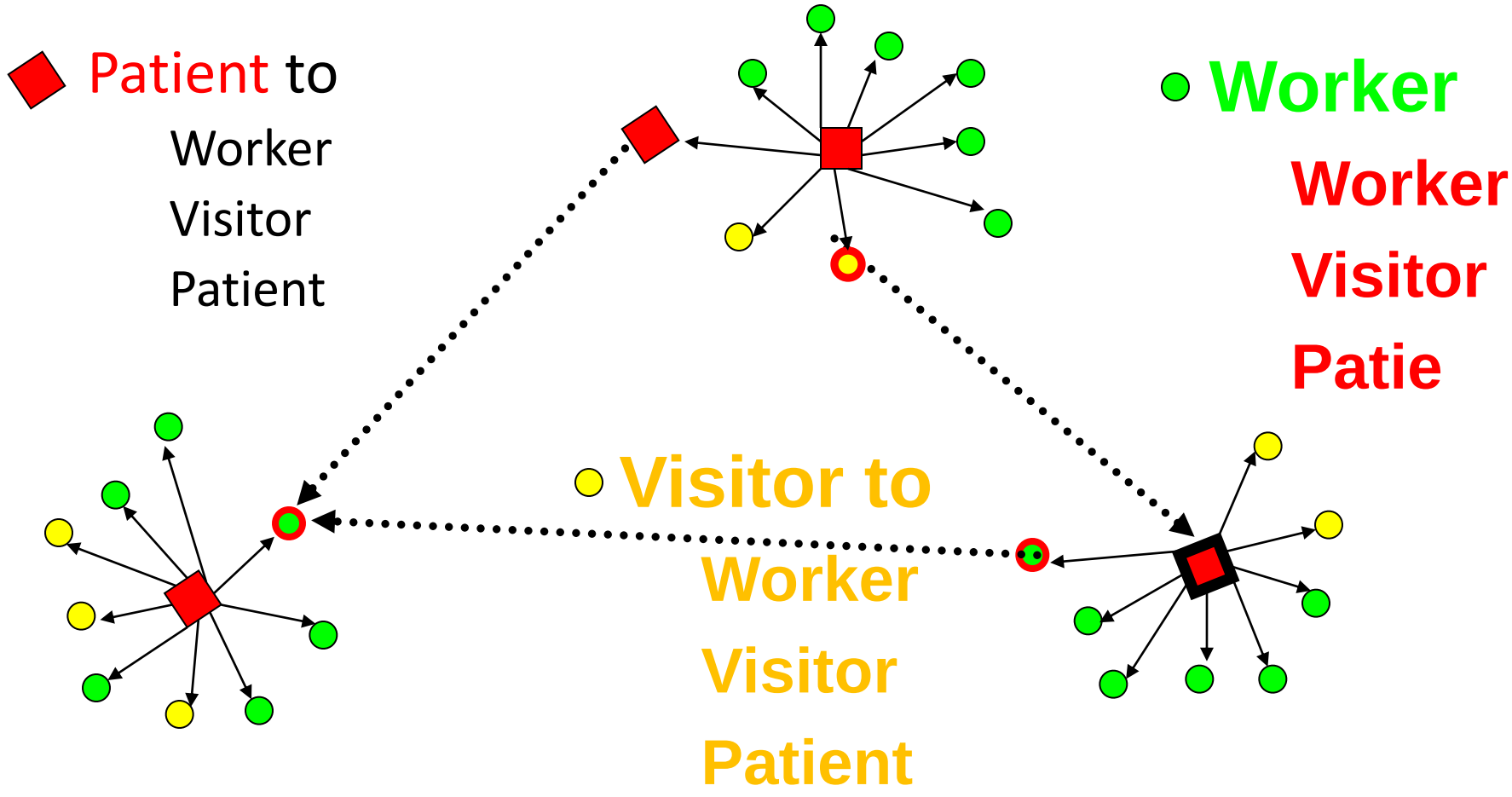
Dr.h.mazaherpour

Assistant professor of infectious disease

Arak university of medical science

- **Infection Control—**The process by which health care facilities develop and implement specific policies and procedures to prevent the spread of infections among health care staff and patients

- **Nosocomial Infection—**An infection contracted by a patient or staff member while in a hospital or health care facility (and not present or incubating on admission)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- Cross transmission in the hospital environment has been linked to contamination of hospital surfaces, contaminated medical devices and other fomites, and contamination of healthcare worker hands and clothing.
- Bacterial pathogens of epidemiologic significance typically inhabit specific niches on or in the human body, or in the hospital environment, that can serve as reservoirs for transmission. Patients' skin, intestinal, and respiratory microbiota are distorted within a few days in the hospital, and their flora in turn colonize their inanimate environment within the hospital

- Patients who are colonized with resistant bacteria serve as accidental reservoirs for spread to other patients.
- Most nosocomial pathogens are thought to be transmitted from person to person on the hands of health care personnel, from contaminated surfaces in the hospital environment, or from contaminated patient care equipment

Why Infection Control?

- Hospital acquired infections are a common problem prevalence about 9%

- Hospital acquired infections contribute to AMR
  - Overuse of antimicrobials (development)
  - Poor infection control practices (spread)

Development of AMR

- Poor or absent IC practices, especially in intensive care units, results in cross-transmission of antibiotic-resistant bacteria.

- Resistant bacteria prompts even greater antibiotic use by physicians.

- Perception of knowledge by physicians of poor sterilization, disinfection, or patient care practices prompts increased antibiotic use (e.g., broad spectrum and prolonged surgical prophylaxis in an effort to prevent infections).

Epidemiology of Nosocomial Infections

- Most common sites for nosocomial infections
  - Surgical incisions
  - Urinary tract (i.e., catheter-related)
  - Lower respiratory tract
  - Bloodstream (i.e., catheter-related)

Common microorganisms

- Aerobic gram-positive cocci (*Staphylococcus aureas* [MRSA], enterococci [vancomycin-resistant]),
- Aerobic gram-negative bacilli (*Escherichia coli*, *P. aeruginosa*, *Enterobacter* spp., and *Klebsiella pneumoniae*)

Root Causes of Nosocomial Infections

- Lack of training in basic IC
- Lack of an IC infrastructure and poor IC practices (procedures)
- Inadequate facilities and techniques for hand hygiene
- Lack of isolation precautions and procedures

- Use of advanced and complex treatments without adequate training and supporting infrastructure, including:
  - Invasive devices and procedures
  - Complex surgical procedure
  - Intravenous catheters, fluids, and medications
  - Urinary catheters
  - Mechanical ventilators
- Inadequate sterilization and disinfection practices and inadequate cleaning of hospital

Infection Control Committee

Membership—

- ☐ Doctors
  - ☐ General physician
  - ☐ Infectious disease specialist
  - ☐ Surgeon
  - ☐ Clinical microbiologist
- ☐ Infection control nurse
- ☐ Representatives from other relevant departments
  - ☐ Laboratory
  - ☐ Pharmacy and central supply
  - ☐ Administration

Goal:

- To prevent the spread of infections within the health care facility

Functions:

- Addressing food handling, laundry handling, cleaning procedures, visitation policies, and direct patient care practices
- Obtaining and managing critical bacteriological data and information, including surveillance data

Functions

- Recognizing and investigating outbreaks of infections in the hospital and community
- Intervening directly to prevent infections
- Educating and training health care workers, patients, and nonmedical caregivers

Methods of Environmental Cleaning and Disinfection

- Environmental cleaning and disinfection focus on surfaces that are repeatedly soiled, such as bathrooms and surfaces that are “high touch.” Even floors should be considered as potential sources of transmission to patients. Hydrogen peroxide and bleach solutions have activity against these pathogens, in addition to standard viruses and vegetative bacteria, and may be preferable for routine environmental cleaning and disinfection.

- **Water Management** As with other health care–associated infections, waterborne infections can cause significant morbidity and mortality, and some are preventable. Pathogens such as *Legionella* and nontuberculous mycobacteria can colonize the central pipes or outlets of potable water distribution systems in hospitals, and other gram-negative bacteria reside in biofilms near the points of use

- Although most municipal water may be adequately chlorinated, free chlorine, the component of total chlorine that has antimicrobial activity
- Supplemental disinfection systems add chlorine (in the form of sodium hypochlorite, or bleach), monochloramine, chlorine dioxide, ozone, or copper-silver ions to the water supply.

- **Air Handling** Hospital ventilation is a critical feature of the building infrastructure that must be engineered to meet a range of infection-control requirements in different areas of the hospital
- Notable issues include negative pressure isolation rooms for patients who have suspected or confirmed airborne infections; positive pressure protective environment rooms for patients who are undergoing treatment for leukemia or stem cell transplantation; and laminar flow in operating rooms.

- Therefore, hospitalized patients who have suspected or known airborne infection should be housed in airborne isolation rooms—private rooms that have monitored negative airflow with respect to the anteroom or hallway, and 6 to 12 air changes per hour, with the exhausted air filtered through a high-efficiency particulate air (HEPA) filter or released to the outside

TRANSMISSION-BASED INFECTION-CONTROL PRECAUTIONS

- **Colonization** Colonization refers to the peaceable presence of bacteria or fungi on or in a person, including organisms that are part of the normal human microbiota. Colonized patients can serve as silent reservoirs for transmission.
- **Organisms Transmitted by Contact** Most epidemiologically important bacteria, including MDROs and many viruses, are spread directly by means of person-to-person contact, or indirectly via contact with contaminated patient care equipment or surfaces.

TABLE 298.2 Sites for Microbial Surveillance to Detect Colonization With Select Multidrug-Resistant Organisms

RESISTANT ORGANISM	HIGHEST-YIELD SITES
Methicillin-resistant *Staphylococcus aureus*	Anterior nares[187]
Vancomycin-resistant *Enterococcus faecium/faecalis*	Rectal/perirectal[188]
Multidrug-resistant *Acinetobacter baumannii*	Groin and throat[189,190]
Multidrug-resistant Enterobacteriaceae	Rectal/perirectal[189]
Candida auris	Groin and axillae[28]

- Contact precautions with use of barriers such as gowns and gloves are intended to interrupt transmission of MDROs and other pathogens, although their effectiveness can be undermined by contaminated equipment such as stethoscopes or portable radiography film cartridges that are not properly disinfected.
- **Organisms Transmitted by Droplet** Pathogens that infect or colonize the upper respiratory tract, such as respiratory viruses, staphylococci, *Bordetella pertussis,* and group A streptococci, can spread via droplet routes.

- These pathogens are shed from the upper respiratory tract in droplets that are typically greater than 5 µM in size and fall within 1 to 2 meters of the patient
- Pathogens within those droplets can spread to health care personnel when they land on mucous membranes or may be transmitted indirectly via hands or fomites. Thus a face mask and gloves are components of droplet isolation.

- **Organisms Transmitted by the Airborne Route** Infections known to spread via the airborne route include tuberculosis, varicella, and measles. Pathogens that are shed in droplet nuclei, which are viable particles 2 to 5 µM in size, can remain airborne for prolonged periods, traveling in air currents.
- Health care personnel wear fitted particulate respirators, referred to as N95 respirators because they filter 95% of airborne particles, or powered air-purifying respirators that draw air into a hood through a HEPA filter and provide better protection

- Aerosol-producing procedures, such as endotracheal intubation, bronchoscopy, sputum induction merit use of respirators to protect health care personnel from the temporarily airborne particles.

DEVICE-RELATED INFECTIONS

- **Ventilator-associated pneumonia (VAP)** is a largely preventable complication of mechanical ventilation in the ICU.
- In patients who are already intubated, national consensus guidelines recommend minimizing sedation, conducting spontaneous awakening trials, and assessing patients' readiness for extubation daily in an effort to reduce the duration of mechanical ventilation. In addition, patients should have the head of the bed elevated to 30 to 45 degrees to reduce reflux of gastric contents and should undergo regular subglottic secretion suctioning to avoid pooling of secretions above the endotracheal tube cuff

- **Central Venous Catheter–Associated Infections** Their use is associated with complications, including bloodstream infections introduced by contamination of the foreign material that is penetrating the skin and residing in a large vein. Patients who develop catheter-associated bloodstream infections have increased length of stay and approximately triple the risk of in-hospital death.

- Prevention of catheter-associated bloodstream infections:
- nursing observation of insertion procedures
- hand hygiene
- maximum sterile barrier precautions for the operator and for the patient
- chlorhexidine-alcohol antiseptic skin preparation.

- Infections related to infection-prevention breaches during catheter insertion typically manifest within 5 days of insertion.
- **Catheter-Associated Urinary Tract Infections** Catheter-associated urinary tract infections are among the most common health care–associated infections
- Risk factors for catheter-associated urinary tract infections were established long ago and include duration of catheterization, female sex, critical illness, and older age

- Daily reevaluation of indications for urinary catheters identifies unnecessary catheter use and significantly reduces catheter use, duration of catheter use, and the rate of catheter-associated urinary tract infections. Use of alternatives to indwelling catheters, such as condom catheters and intermittent straight catheterization, also reduces risk of urinary tract infection. Other strategies that prevent catheter-associated urinary tract infections include education, sterile and atraumatic insertion, and maintenance of a sterile, closed drainage system.

DEFINITION OF TERMS

- ***Sterilization*** is defined as the complete elimination or destruction of all forms of microbial life and is accomplished in health care facilities through either physical or chemical processes.
- ***Disinfection*** describes a process that eliminates many or all pathogenic microorganisms on inanimate objects, with the exception of bacterial spores.
- ***Cleaning***, on the other hand, is the removal of visible soil and microbial contaminants from objects and surfaces, and it normally is accomplished by manual or mechanical means using water with detergents or enzymatic products.

- **Critical Items**
- high risk of infection if such an item is contaminated with any microorganism
- It is critical that objects that enter sterile tissue or the vascular system be sterile because any microbial contamination could result in disease transmission.
- This category includes surgical instruments, cardiac and urinary catheters, implants, arthroscopes, laparoscopes, and ultrasound probes used in sterile body cavities.

- Most of the items in this category should be purchased as sterile or be sterilized with steam sterilization if possible. If heat sensitive, the object may be treated with ETO, hydrogen peroxide gas plasma, vaporized hydrogen peroxide vapor, hydrogen peroxide vapor plus ozone, or liquid chemical sterilants if other methods are unsuitable.
- **Semicritical Items** Semicritical items are those that come in contact with intact mucous membranes or nonintact skin.

- Respiratory therapy and anesthesia equipment, some endoscopes, laryngoscope blades and handles, esophageal manometry probes, endocavitary probes, nasopharyngoscopes, prostate biopsy probes, infrared coagulation devices, anorectal manometry catheters, cystoscopes are included in this category.
- These medical devices should be free of all microorganisms, although small numbers of bacterial spores may be present.

- Semicritical items minimally require high-level disinfection with chemical disinfectants. Glutaraldehyde, hydrogen peroxide, OPA, peracetic acid, hypochorite (via superoxidized water) and peracetic acid with hydrogen peroxide are cleared by the Food and Drug Administration (FDA) and are dependable high-level disinfectants, provided that the factors influencing germicidal procedures are met

- **Noncritical Items** Noncritical items are those that come in contact with intact skin but not mucous membranes.
- Examples of noncritical items are bedpans, blood pressure cuffs, bed rails, bedside tables, patient furniture, toys, portable equipment (e.g., wheelchairs, infusion pumps, pulse oximeters, medication carts), and floors. However, these items (e.g., bedside tables, bed rails) could potentially contribute to secondary transmission by contaminating hands of health care providers or by contact with medical equipment that will subsequently come in contact with patients.

TABLE 299.1 Methods for Disinfection and Sterilization of Patient Care Items and Environmental Surfaces

PROCESS	LEVEL OF MICROBIAL INACTIVATION	METHOD	EXAMPLES (WITH PROCESSING TIMES)	HEALTH CARE APPLICATION (EXAMPLES)
Sterilization[a]	Destroys all microorganisms, including bacterial spores	High temperature Low temperature Liquid immersion	Steam (approximately 40 min), dry heat (1–6 h depending on temperature) Ethylene oxide gas (approximately 15 h), hydrogen peroxide gas plasma (24–60 min, 100 NX), hydrogen peroxide and ozone (46–60 min, VP4), hydrogen peroxide vapor (28–35 min, V-Pro MAX) Chemical sterilants[b]: >2% glut (approximately 10 h at 20°C–25°C); 1.12% glut with 1.93% phenol (12 h at 25°C); 7.35% HP with 0.23% PA (3 h at 20°C); 7.5% HP (6 h at 20°C); 1.0% HP with 0.08% PA (8 h at 20°C); approximately 0.2% PA (12 min at 50°C–56°C)	Heat-tolerant critical (surgical instruments) and semicritical patient care items Heat-sensitive critical and semicritical patient care items Heat-sensitive critical and semicritical patient care items that can be immersed
High-level disinfection	Destroys all microorganisms except some bacterial spores	Heat automated Liquid immersion	Pasteurization (65°C–77°C, 30 min) Chemical sterilants or high-level disinfectants[b]: >2% glut (20–90 min at 20°C–25°C); >2% glut (5 min at 35°C–37.8°C); 0.55% OPA (12 min at 20°C); 1.12% glut with 1.93% phenol (20 min at 25°C); 7.35% HP with 0.23% PA (15 min at 20°C); 7.5% HP (30 min at 20°C); 1.0% HP with 0.08% PA (25 min at 20°C); 650–675 free chlorine (10 min at 30°C); 2.0% HP (8 min at 20°C); 3.4% glut with 20.1% isopropanol (5 min at 25°C)	Heat-sensitive semicritical items (e.g., respiratory therapy equipment) Heat-sensitive semicritical items (e.g., GI endoscopes, bronchoscopes, endocavitary probes)
Low-level disinfection	Destroys vegetative bacteria, some fungi and viruses, but not mycobacteria or spores	Liquid contact	EPA-registered hospital disinfectant with no tuberculocidal claim (e.g., chlorine-based products, phenolics, improved hydrogen peroxide, hydrogen peroxide plus peracetic acid, quaternary ammonium compounds ["quats"], quats plus alcohol—exposure times approximately 1 min) or 70–90% alcohol	Noncritical patient care item (blood pressure cuff) or surface (bedside table) with no visible blood

TABLE 299.2 Summary of Advantages and Disadvantages of Chemical Agents Used as Chemical Sterilants or as High-Level Disinfectants

STERILIZATION METHOD	ADVANTAGES	DISADVANTAGES
Peracetic acid and hydrogen peroxide	No activation required	Material compatibility concerns (lead, brass, copper, zinc), both cosmetic and functional Limited clinical experience Mucous membrane and respiratory health effects[165] Potential for eye and skin damage
Glutaraldehyde	Numerous use studies published Relatively inexpensive Excellent material compatibility	Respiratory irritation from glutaraldehyde vapor Pungent and irritating odor Relatively slow mycobactericidal activity (unless other disinfectants added, such as phenolic, alcohol) Coagulates blood and fixes tissue to surfaces Allergic contact dermatitis
Hydrogen peroxide (standard)	No activation required May enhance removal of organic matter and organisms No disposal issues No odor or irritation issues Does not coagulate blood or fix tissues to surfaces Inactivates *Cryptosporidium* at 6%–7.5% Use studies published	Material compatibility concerns (brass, zinc, copper, and nickel/silver plating), both cosmetic and functional Serious eye damage with contact
Ortho-phthalaldehyde (OPA)	Fast acting high-level disinfectant No activation required Odor not significant Excellent materials compatibility claimed Does not coagulate blood or fix tissues to surfaces claimed	Stains protein gray (e.g., skin, mucous membranes, clothing, and environmental surfaces) More expensive than glutaraldehyde Eye irritation with contact Slow sporicidal activity Anaphylactic reactions to OPA in bladder cancer patients with repeated exposure to OPA through cystoscopy

Peracetic acid	Standardized cycle (e.g., liquid chemical sterilant processing system using peracetic acid, rinsed with extensively treated potable water) Low temperature (50°C–55°C) liquid immersion sterilization Environmental friendly by-products (acetic acid, O_2, H_2O) Fully automated Single-use system eliminates need for concentration testing May enhance removal of organic material and endotoxin No adverse health effects to operators under normal operating conditions Compatible with many materials and instruments Does not coagulate blood or fix tissues to surfaces Sterilant flows through scope, facilitating salt, protein, and microbe removal Rapidly sporicidal Provides procedure standardization (constant dilution, perfusion of channel, temperatures, exposure)	Potential material incompatibility (e.g., aluminum anodized coating becomes dull) Used for immersible instruments only Biologic indicator may not be suitable for routine monitoring One scope or a small number of instruments can be processed in a cycle More expensive (endoscope repairs, operating costs, purchase costs) than high-level disinfection Serious eye and skin damage (concentrated solution) with contact Point-of-use system, no sterile storage An AER using 0.2% peracetic acid has not been cleared by FDA as sterilization process but for high-level disinfection
Improved hydrogen peroxide (2.0%); high-level disinfectant	No activation required No odor Nonstaining No special venting requirements Manual or automated applications 12-mo shelf life, 14-day reuse 8 min at 20°C high-level disinfectant claim	Material compatibility concerns owing to limited clinical experience Organic material resistance concerns owing to limited data

TABLE 299.4 Summary of Advantages and Disadvantages of Disinfectants Used as Low-Level Disinfectants

DISINFECTANT ACTIVE	ADVANTAGES	DISADVANTAGES
Alcohol	Bactericidal, tuberculocidal, fungicidal, virucidal Fast acting Noncorrosive Nonstaining Used to disinfect small surfaces such as rubber stoppers on medication vials No toxic residue	Not sporicidal Affected by organic matter Slow acting against nonenveloped viruses (e.g., norovirus) No detergent or cleaning properties Not EPA registered Damages some instruments (e.g., hardens rubber, deteriorates glue) Flammable (large amounts require special storage) Evaporates rapidly, making contact-time compliance difficult Not recommended for use on large surfaces Outbreaks ascribed to contaminated alcohol[134]
Sodium hypochlorite	Bactericidal, tuberculocidal, fungicidal, virucidal Sporicidal Fast acting Inexpensive (in dilutable form) Not flammable Unaffected by water hardness Reduces biofilms on surfaces Relatively stable (e.g., 50% reduction in chlorine concentration in 30 days)[79] Used as the disinfectant in water treatment EPA registered	Reaction hazard with acids and ammonias Leaves salt residue Corrosive to metals (some ready-to-use products may be formulated with corrosion inhibitors) Unstable active (some ready-to-use products may be formulated with stabilizers to achieve longer shelf life) Affected by organic matter Discolors or stains fabrics Potential hazard is production of trihalomethane Odor (some ready-to-use products may be formulated with odor inhibitors); irritating at high concentrations

Improved hydrogen peroxide	Bactericidal, tuberculocidal, fungicidal, virucidal Fast efficacy Easy compliance with wet-contact times Safe for workers (lowest EPA toxicity category, IV) Benign for the environment Surface compatible Nonstaining EPA registered Not flammable	More expensive than most other disinfecting actives Not sporicidal at low concentrations
Iodophors	Bactericidal, mycobactericidal, virucidal Not flammable Used for disinfecting blood culture bottles	Not sporicidal Shown to degrade silicone catheters Requires prolonged contact to kill fungi Stains surfaces Used mainly as an antiseptic rather than disinfectant
Phenolics	Bactericidal, tuberculocidal, fungicidal, virucidal Inexpensive (in dilutable form) Nonstaining Not flammable EPA registered	Not sporicidal Absorbed by porous materials and can irritate tissue Depigmentation of skin caused by certain phenolics Hyperbilirubinemia in infants when phenolic not prepared as recommended
Quaternary ammonium compounds[a] (e.g., didecyl dimethyl ammonium bromide, dioctyl dimethyl ammonium bromide)	Bactericidal, fungicidal, virucidal against enveloped viruses (e.g., HIV) Good cleaning agents EPA registered Surface compatible Persistent antimicrobial activity when undisturbed Inexpensive (in dilutable form)	Not sporicidal In general, not tuberculocidal and not virucidal against nonenveloped viruses High water hardness and cotton or gauze can make less microbicidal A few reports documented asthma as result of exposure to benzalkonium chloride Affected by organic matter Absorption by cotton, some wipes Multiple outbreaks ascribed to contaminated benzalkonium chloride[134]
Peracetic acid and hydrogen peroxide	Bactericidal, fungicidal, virucidal and sporicidal (e.g., *Clostridioides difficile* [formerly *Clostridium difficile*]) Active in the presence of organic material Environmental friendly by-products (acetic acid, O_2, H_2O) EPA registered	Lack of stability Potential for material incompatibility (e.g., brass, copper) More expensive than most other disinfecting actives Odor may be irritating Can cause mucous membrane and respiratory health effects

Thanks for your attention