

**HEALTHCARE ASSOCIATED
INFECTIONS
BACTERIA**

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Reference

- **"Guidelines for Environmental Infection Control in Health-Care Facilities 2003"**
 - **Centers for Disease Control and Prevention
Healthcare Infection Control Practices Advisory
Committee (HICPAC)**
 - **U.S. Department of Health and Human Services
Centers for Disease Control and Prevention (CDC)
Atlanta, GA 30333**

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Areas to Inspect

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Environmental Vehicles Implicated in Hospital Infections

- **Improperly functioning HVAC systems**
- **Air filters**
- **Backflow of contaminated air**
- **False ceilings**
- **Hospital vacuum cleaners**
- **Elevators**
- **Fiberglass duct insulation**

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Contributions of HVAC Systems

- **Decreased performance**
- **Filter inefficiencies**
- **Improper installation**
- **Poor maintenance**
- **Temperature/humidity control**

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Suspect Systems

- **Personal Hygiene Practices**
- **HVAC Systems**
- **Water Supply Systems**
- **Air Concentrations in Critical Care Areas**
- **“Wet” Equipment**
 - **Ventilators, Catheters, Medical Devices**
 - **Hemodialysis, Hydrotherapy, Ice Machines**
- **Surface Cleaning and Disinfection**
 - **Routine and Terminal**

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Chain of Infection

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Chain of Infection

- Adequate number of pathogenic organisms (dose)
- Pathogenic organisms of sufficient virulence
- A susceptible host
- An appropriate mode of transmission of the organism from source to host
- The correct portal of entry into the host
 - Inhalation, Contact, Aspiration, Ingestion

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Assessing Infectious Agents in The Environment

- **Fomite: an object that may be contaminated with infectious organisms and serve [as a pathway] in their transmission**
- **The organism can survive after inoculation onto a fomite.**
- **The organism can be cultured from the in-use fomite.**
- **The organism can proliferate in-on the fomite.**
- **Studies have shown an association between exposure to the fomite and infection.**
- **A subset of patients exposed to those fomites show an association between exposure and infection.**
- **Decontamination of the fomite results in the elimination of infection transmission.**

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Operating Rooms

- **Microbial level in OR air is directly proportional to the number of people moving in the room**
 - **Minimize personnel traffic during operations**
- **Laser plumes and surgical smoke**
 - **Staphylococcus**
 - **Corynebacterium spp.**
 - **Neisseria spp.**

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Contact with Environmental Surfaces

- **Patients and health-care workers contribute significantly to the contamination of surfaces**
 - **Vancomycin-resistant Enterococcus faecium [VRE]**
 - **Clostridium difficile**

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Gram-negative HAI Bacteria

- **Acinetobacter**
- **Burkholderia**
- **Enterococci**
- **Escherichia [E. coli]**
- **Klebsiella**
- **Legionellae**
- **Pseudomonas**
- **Shigella**

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Gram-negative Bacteria

Infections

- Surgical sites
- Post-surgical

Reservoirs

- Soil
- Water
- Surfaces
 - Dry & moist

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Gram-negative Bacteria

- Rarely associated with airborne transmission
 - Require moist environments for persistence and growth.
- **Acinetobacter spp.**
 - Can withstand the inactivating effects of drying
- Strict adherence to hand hygiene helps prevent the spread of both **Acinetobacter spp.** and **Enterobacter spp.**

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Gram-negative Bacteria

- **Contact with Water and Aqueous Solutions**
 - Legionellae
 - Pseudomonas aeruginosa
 - Nontuberculous mycobacteria (NTM)
 - Acinetobacter spp.
 - Enterobacter spp
- **Inhalation of aerosols generated from showers and faucets**

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Pseudomonas (aeruginosa)

Infections

- Surgical sites
- Post-surgical
- Medical devices
- Ventilators
- Catheters

Reservoirs

- Skin
- Soil
- Water
- Surfaces
 - Moist
- Hypoxic atmospheres

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Gram-negative Bacteria [Water & Moist Environments]

- **Enterobacter spp.**
 - Humidifier water
 - Intravenous fluids
 - Unsterilized cotton swabs
 - Ventilators
 - Rubber piping on a suctioning machine
 - Blood gas analyzers
- **Bloodstream infections, pneumonia, and urinary tract infections**
- **Especially ICU's**

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Enterobacter

Infections

- **Pneumonia**
 - 5% of infections
- **Surgical sites**
 - 10% of infections

Reservoirs

- **GI tract**
- **Skin**
- **Dust**

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Gram-negative Bacteria [Water & Moist Environments]

- **Burkholderia cepacia**
 - Distilled water
 - Contaminated solutions and disinfectants
 - Dialysis machines
 - Nebulizers
 - Water baths
 - Ventilator temperature probes
 - Mouthwash (Intrinsically-contaminated)

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Burkholderia (cepacia)

Infections

- Chronic lung diseases

Reservoirs

- Skin
- Soil, dust
- Water

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Gram-negative Bacteria [Water & Moist Environments]

- **Acinetobacter spp.**
 - Medical equipment that collects moisture
 - Mechanical ventilators, cool mist humidifiers, vaporizers, and mist tents
 - Room humidifiers
 - Especially ICU's
- Average infection rates are higher from July through October

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Gram-negative Bacteria [Water & Moist Environments]

- **Acinetobacter spp.**
 - Also found on dry environmental surfaces
- The survival periods of *Acinetobacter baumannii* and *Acinetobacter calcoaceticus* on dry surfaces approximated that for *S. aureus* (e.g., 26–27 days)

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Acinetobacter (baumannii)

Infections

- **Surgical site**
- **Post-surgical**
 - 80% of ICU infections
- **Ventilators**
- **Blood products**
- ***A. baumannii* can survive on skin & dry surfaces for weeks**

Reservoirs

- **Skin**
- **Soil & dust (floors)**
- **Surfaces**
 - Moist & dry
- **Potable water systems**
 - Sink traps

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Klebsiella

Infections

- **Surgical sites**
- **Post-surgical**
- **Ventilators**
- **Catheters (venous)**

Reservoirs

- **GI Tract**

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Nontuberculous Mycobacteria (NTM)

- Acid-fast bacilli (AFB) commonly found in potable water
- Many NTM are of low pathogenicity, and some measure of host impairment is necessary
- Person-to-person acquisition of NTM infection does not appear to occur
- NTM are spread via all modes of transmission associated with water
 - Ingestion, Aspiration, Inhalation, Penetration

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Nontuberculous Mycobacteria (NTM)

- **Mycobacterium chelonae, M. gordonae, M. xenopi**
 - Bronchoscopy and gastrointestinal endoscopy
- **Mycobacterium xenopi**
 - Can survive in water at 113°F (45°C)
 - Can be isolated from hot water taps
- **Mycobacterium kansasii, M. gordonae, M. fortuitum, M. chelonae**
 - Cannot tolerate high temperatures; cold water lines, taps.
- **NTM have a high resistance to chlorine**
 - Tolerate free chlorine concentrations of 0.05–0.2 mg/L (0.05–0.2 ppm) found at the tap

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Nontuberculosis *mycobacteria*

Infections

- **Medications**
- **Medical devices**
- **Environ exposures**
 - No human-to-human
- **Catheters (urinary)**
- **Post-LASIK**
- **Pulmonary infections**
- **Skin, soft tissue**
 - Post-cosmetic surgery

Reservoirs

- **Skin**
- **Soil, dust**
- **Water**
- **Damp materials**

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Gram-positive HAI Bacteria

- **Candida**
- **Chlmydia**
- **Clostridium**
- **Neisseria**
- **Staphylococcus**
- **Streptococcus**

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Air Transmission: General

- **If environmental reservoirs are disturbed.**
 - (soil, water, dust, and organic matter)
- **Droplets produced during a sneeze or cough**
 - If within 3 feet of the potential host
- **Via droplet nuclei produced after a sneeze or cough**
 - **Mycobacterium tuberculosis**
 - **Aspergillus fumigatus**
 - **spores resist desiccation, can remain airborne indefinitely in air currents**

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Air Transmission: Bacteria

- **Gram-positive cocci are important HA pathogens**
 - **Staphylococcus aureus**
 - **group A streptococci**
- **Resistant to inactivation by drying**
- **Can persist in the environment and on environmental surfaces for extended periods**
- **Transmission occurs primarily via contact and droplets**
- **Surgical site infections (SSIs) have been traced to airborne transmission**
 - **From staff in OR's, burn units, NICU's to patients**

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Air Transmission: Bacteria

- Other gram-positive bacteria: *Bacillus* spp
- Infections commonly secondary to environmental contamination
- *Bacillus cereus*
 - Maternity, pediatric, intensive care, and bronchoscopy units
- *Mycobacterium tuberculosis*
 - Human-to-human
 - Can travel long distances

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Candida (albicans)

Infections

- Post-surgical
- ICU
- Catheters (venous)

Reservoirs

- Prevented by high pH

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Clostridium (difficile)

Infections

- Spore forming
- Anaerobic
- Antibiotic-induced

Reservoirs

- GI tract
- Surfaces
 - Dry & moist

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Cornynebacteria (diphtheria)

Infections

- Prosthetic heart valves
- Shunts
- Catheters

Reservoirs

- Skin
- Nasopharynx, mucosa
- Soil, plants
- Food products
- Water

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Escherichia (coli)

Infections

- **Surgical sites**
- **Blood products**

Reservoirs

- **GI tract**
- **Skin**
- **Surfaces**

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Enterococcus (faecilis)

Infections

Reservoirs

- **GI tract**

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Staphylococcus (aureus)

Infections

- **Surgical sites**
- **Post-surgical (frequent)**
- **Catheters (venous)**
- **Blood products**
- **Human-to-human**
 - Staff hygiene (lack)
 - Pet-to-human
- **Prevention**
 - Cleaning, routine & terminal

Reservoirs

- **Skin**
 - Perspiration present
- **Nasopharynx (20%)**
- **Surfaces**
 - Dry & moist
- **Survival on surfaces**
 - 3 months on privacy curtains (polyester)
 - 1 minute @ 78 °C
 - 10 minutes @ 64 °C

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Streptococcus (pneumoniae)

Infections

Reservoirs

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