HEALTHCARE-ASSOCIATED INFECTIONS
IN THE US: IMPACT

- 1.7 million infections per year
- 98,987 deaths due to HAI
  - Pneumonia 35,967
  - Bloodstream 30,665
  - Urinary tract 13,088
  - Surgical site infection 8,205
  - Other 11,062
- 6th leading cause of death (after heart disease, cancer, stroke, chronic lower respiratory diseases, and accidents)\(^1\)

\(^1\) National Center for Health Statistics, 2004
Sources of Healthcare-Associated Pathogens

- Endogenous flora (SSI, UTI, CLABSI): 40-60%
- Exogenous: 20-40% (e.g., cross-infection via contaminated hands [staff, visitors])
- Other (environment): 20%
  - Medical devices/inanimate objects
  - Contact with environmental surfaces (direct and indirect)
Associated With Nosocomial Infections

- Germicides: *Pseudomonas*
- Electronic thermometers: *C. difficile*, VRE
- Glass thermometers: *Salmonella*
- Bandages: *Zygomycetes*
- Air-fluidized beds: *Enterococcus*
- Mattresses: *Pseudomonas, Acinetobacter*
- Plaster: *Pseudomonas, Bacillus*
- Urine measuring devices: *Serratia*
- Animals: *Malassezia, Microsporum*
- Laundry: *Salmonella*
RESERVOIRS OF NOSOCOMIAL PATHOGENS
Rutala, Weber. Env Issues NI, Farber 1987

Not Associated With Nosocomial Infections

• ECG electrodes: *S. aureus*, GNRS
• Carpets
• Stethoscopes: *S. aureus*
• Flowers: GNR

INANIMATE ENVIRONMENT

Goals of lecture

• Surface: Review the contribution of non-critical surface contamination to disease transmission
• Endoscopes, water, air: Epidemiology and prevention of transmission
TRANSMISSION

• Person to person
• Environment to person
  ■ Airborne: Aspergillus
• Person to environment to person
  ■ Enterococcus (VRE)
• Person to fomite (e.g., bronchoscope) to person
  ■ Indirect contact: Tuberculosis (MDR-TB)

THE ROLE OF THE ENVIRONMENT IN DISEASE TRANSMISSION

• Over the past decade there has been a growing appreciation that environmental contamination makes a contribution to HAI with MRSA, VRE, Acinetobacter, norovirus and C. difficile
• Surface disinfection practices are currently not effective in eliminating environmental contamination
• Inadequate terminal cleaning of rooms occupied by patients with MDR pathogens places the next patients in these rooms at increased risk of acquiring these organisms
TRANSMISSION MECHANISMS INVOLVING THE SURFACE ENVIRONMENT

Environmental Contamination Leads to HAIs

- Evidence environment contributes
- Role-MRSA, VRE, C. difficile
- Surfaces are contaminated—~25%
- EIP survive days, weeks, months
- Contact with surfaces results in hand contamination
- Disinfection reduces contamination
- Disinfection (daily) reduces HAIs
- Rooms not adequately cleaned

Admission to Room Previously Occupied by Patient C/I with Epidemiologically Important Pathogen

- Results in the newly admitted patient having an increased risk of acquiring that pathogen by 39-353%
- For example, increased risk for C. difficile is 235% (11.0% vs 4.6%)
INANIMATE ENVIRONMENT

Goals of lecture

• Surface: Review the contribution of non-critical surface contamination to disease transmission
• Endoscopes, water, air: Epidemiology and prevention of transmission
• Widely used diagnostic and therapeutic procedure
• Endoscope contamination during use (GI $10^9$ in/$10^5$ out)
• Semicritical items require high-level disinfection minimally
• Inappropriate cleaning and disinfection has lead to cross-transmission
• In the inanimate environment, although the incidence remains low, endoscopes represent the greatest risk of disease transmission
Endoscope Reprocessing:
Current Status of Cleaning and Disinfection

- Guidelines
  - Multi-Society Guideline, 12 professional organizations, 2011
  - Centers for Disease Control and Prevention, 2008
  - Society of Gastroenterology Nurses and Associates, 2010
  - Food and Drug Administration, 2009
  - Endoscope Reprocessing, Health Canada, 2010
  - Association for Professional in Infection Control and Epidemiology, 2000

ENDOSCOPE INFECTIONS

- Infections traced to deficient practices
  - Inadequate cleaning (clean all channels)
  - Inappropriate/ineffective disinfection (time exposure, perfuse channels, test concentration)
  - Failure to follow recommended disinfection practices (drying, contaminated water bottles, irrigating solutions)
  - Flaws in design/manufacture of endoscopes or AERs
TRANSMISSION OF INFECTION

- Gastrointestinal endoscopy
  - >150 infections transmitted
  - *Salmonella* sp. and *P. aeruginosa*
  - Clinical spectrum ranged from colonization to death (~4%)

- Bronchoscopy
  - ~100 infections transmitted
  - *M. tuberculosis*, atypical *Mycobacteria*, *P. aeruginosa*

- Endemic transmission may go unrecognized (e.g., inadequate surveillance, low frequency, asymptomatic infections)

ENDOSCOPE REPROCESSING

- PRECLEAN- point-of-use (bedside) remove debris by wiping exterior and aspiration of detergent through air/water and biopsy channels; leak testing
- CLEAN- mechanically cleaned with water and enzymatic cleaner
- HLD/STERILIZE- immerse scope and perfuse HLD/sterilant through all channels for exposure time (>2% glut at 20m at 20°C). If AER used, review model-specific reprocessing protocols from both the endoscope and AER manufacturer
- RINSE- scope and channels rinsed with sterile water, filtered water, or tap water. Flush channels with alcohol and dry
- DRY- use forced air to dry insertion tube and channels
- STORE- hang in vertical position to facilitate drying; stored in a manner to protect from contamination

High-Level Disinfection of “Semicritical Objects”

<table>
<thead>
<tr>
<th>Germicide</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glutaraldehyde</td>
<td>&gt; 2.0%</td>
</tr>
<tr>
<td>Ortho-phthalaldehyde</td>
<td>0.55%</td>
</tr>
<tr>
<td>Hydrogen peroxide*</td>
<td>7.5%</td>
</tr>
<tr>
<td>Hydrogen peroxide and peracetic acid*</td>
<td>1.0%/0.08%</td>
</tr>
<tr>
<td>Hydrogen peroxide and peracetic acid*</td>
<td>7.5%/0.23%</td>
</tr>
<tr>
<td>Hypochlorite (free chlorine)*</td>
<td>650-675 ppm</td>
</tr>
<tr>
<td>Accelerated hydrogen peroxide</td>
<td>2.0%</td>
</tr>
<tr>
<td>Peracetic acid</td>
<td>0.2%</td>
</tr>
<tr>
<td>Glut and isopropanol</td>
<td>3.4%/26%</td>
</tr>
<tr>
<td>Glut and phenol/phenate**</td>
<td>1.21%/1.93%</td>
</tr>
</tbody>
</table>

*May cause cosmetic and functional damage; **efficacy not verified
ENDOSCOPE SAFETY

- Ensure protocols equivalent to guidelines from professional organizations (APIC, SGNA, ASGE)
- Are the staff who reprocess the endoscope specifically trained in that job?
- Are the staff competency tested at least annually?
- Conduct IC rounds to ensure compliance with policy

INANIMATE ENVIRONMENT

Goals of lecture
- Surface: Review the contribution of non-critical surface contamination to disease transmission
- Endoscopes, water, air: Epidemiology and prevention of transmission
Water and Healthcare
Multiple Uses

Water-Related Pathogens and Their Disease Transmission Pathways
Exner et al. AJIC 33:S26-40; 2005

**Route of infection**
- **Ingestion (Drinking)**
  - **Gastrointestinal**
    - Bacteria: Campylobacter spp., E. coli, Salmonella spp., Shigella spp., Vibrio cholerae, Yersinia spp.
    - Viruses: Adenovirus, Astrovirus, Enterovirus, Hepatitis A virus, Norovirus, Rotavirus, Sapovirus
    - Protozoa and helminths: Cryptosporidium parvum, Dracunculus medinensis, Entamoeba histolytica, Giardia intestinalis, Toxoplasma gondii
  - Legionella pneumophila, Mycobacteria (non-tuberculous) N. fowleri, Diverse viral infections, Many other agents in high-exposure situations
- **Inhalation and aspiration (Aerosol)**
  - **Respiratory**
    - Acanthamoeba spp., Aeromonas spp., Burkholderia pseudomallei, Mycobacteria (non-tuberculous), Leptospira spp., Pseudomonas aeruginosa, Schistosoma mansoni*
- **Contact (Bathing)**
  - **Skin (especially if abraded), mucous membranes, wounds, eyes**

* Primarily from contact with highly contaminated surface waters.
WATER RESERVOIRS

- Potable water
- Sinks
- Faucet aerators
- Showers
- Tub immersion
- Toilets

- Dialysis water
- Ice and ice machines
- Water baths
- Flowers
- Eye wash stations

---

**TABLE**
**WATER AS A RESERVOIR OF NONOCOMIAL PATHOGENS**

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Associated Pathogen(s)</th>
<th>Transmission</th>
<th>Importance</th>
<th>Prevention and Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potable water</td>
<td>Pseudomonas, Mycobacteria, Legionella, Pseudomonas</td>
<td>Contact</td>
<td>Moderate</td>
<td>Follow public health guidelines</td>
</tr>
<tr>
<td>Sinks</td>
<td>Contact, droplet</td>
<td>Low</td>
<td></td>
<td>Use separate sinks for handwashing and disposal of contaminated fluids</td>
</tr>
<tr>
<td>Faucet aerators</td>
<td>Pseudomonas, Legionella</td>
<td>Contact, droplet, Inhalation</td>
<td>Low</td>
<td>No precautions necessary at present Prohibit use in immunocompromised patients</td>
</tr>
<tr>
<td>Showers</td>
<td>Legionella</td>
<td>Ingestion, contact</td>
<td>Moderate</td>
<td>Periodic cleaning; use automatic dispenser (ie, avoid open chest storage compartments in patient areas)</td>
</tr>
<tr>
<td>Ice and ice machines</td>
<td>Legionella, Enterobacter, Pseudomonas, Salmonella, Cryptosporidia</td>
<td>Contact</td>
<td>Low</td>
<td>Have available sterile water for eye flush or weekly (or monthly) flush eyewash stations</td>
</tr>
<tr>
<td>Eyewash stations</td>
<td>Pseudomonas, Legionella, Ameba</td>
<td>Contact</td>
<td>Low</td>
<td>Clean water systems</td>
</tr>
<tr>
<td>Dental-unit water systems</td>
<td>Pseudomonas, Legionella, Sphingomonas, Acinetobacter</td>
<td>Contact</td>
<td>Low</td>
<td>Clean water systems</td>
</tr>
<tr>
<td>Dialysis water</td>
<td>Gram-negative bacilli</td>
<td>Contact</td>
<td>Moderate</td>
<td>Follow guidelines: dialysate &lt;=2,000 organisms/mL; water &lt;=200 organisms/mL</td>
</tr>
</tbody>
</table>
Healthcare Outbreaks Associated with Water Reservoir

Clinical Infectious Diseases
INVITED ARTICLE
HEALTHCARE EPIDEMIOLOGY: Robert A. Weinstein, Section Editor

Healthcare Outbreaks Associated With a Water Reservoir and Infection Prevention Strategies

Helen Kanamori,1,2 David J. Weber,1,3 and William A. Rutala2
1Division of Infectious Disease, University of North Carolina School of Medicine, and 2Hospital Epidemiology, University of North Carolina Health Care, Chapel Hill

Hospital water may serve as a reservoir of healthcare-associated pathogens, and contaminated water can lead to outbreaks and severe infections. The clinical features of waterborne outbreaks and infections as well as prevention strategies and control measures are reviewed. The common waterborne pathogens were bacteria, including Legionella and other gram-negative bacteria, and neutrophilic mycobacteria, although fungi and viruses were occasionally described. These pathogens caused a variety of infections, including bacteremia and invasive and disseminated diseases, particularly among immunocompromised hosts and critically ill adults as well as neonates. Waterborne outbreaks occurred in healthcare settings with emergence of new reported reservoirs, including electronic faucets (Pseudomonas aeruginosa and Legionella), decorative water wall fountains (Legionella), and heater-cooler devices used in cardiac surgery (Mycobacterium chimaera). Advanced molecular techniques are useful for achieving a better understanding of reservoirs and transmission pathways of waterborne pathogens. Developing prevention strategies based on water reservoirs provides a practical approach for healthcare personnel.

Keywords: waterborne outbreaks; healthcare-associated infections; water; outbreaks.

Table 2. Summary of Key Issues and Infection Prevention Strategies Against Waterborne Outbreaks by Major Water Reservoir in Healthcare Settings

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Key Issues</th>
<th>Infection Prevention Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potable water, tap water, and hospital water systems</td>
<td>Potable water is not sterile, and pathogens waterborne organisms may grow in potable water at acceptable levels of coliform bacteria &lt;1.0 cfu per 100 mL. Healthcare-associated outbreaks have been linked to potable water. Sanitary devices are often mixed with potable water, which may lead to transmission of the environment and subsequent healthcare-associated infections. Common pathogens include nonhuman gram-negative bacilli (e.g., Pseudomonas aeruginosa, Legionella, N. M. F., and other species).</td>
<td>Follow public health guidelines. Hot water temperature at the outlet is at the highest temperature allowable, preferably &gt;60°C. Water disinfection, point of use or nurse stations, and do not drink tap water. Maintain standards for potable water with &lt;1.0 cfu per 100 mL. Follow standard precautions with sterile water, filtered water, or tap water followed by alcohol rinse. Some experts have recommended periodic monitoring of water distribution systems. Legionella eradication can be technically difficult, temporary, and expensive. Use potential methods of eradication include filtration, ultraviolet, ionization, heat treatment (450°C), hypochlorination, and chlorination (20 ppm at 0.04 ppm, respectively).</td>
</tr>
<tr>
<td>Sink(s)</td>
<td>Colonization of sinks with gram-negative bacilli has been reported. Some studies demonstrate a transmission link between a colonized sink and infected patients. Some studies also detect that multi-drug-resistant gram-negative bacilli may colonize the sink. Transmission is likely by direct contact with contaminated water from a sink, for a long time (&gt;100 d). Transmission can be prevented by filling water droplet from sink. Transmission can be prevented by the use of sink covers. Colonization of healthcare personnel, followed by transmission colonization of hands. Common pathogens include gram-negative bacilli (e.g., Pseudomonas, Acinetobacter, Stenotrophomonas, and LegiOnella).</td>
<td>Use separate sink for handwashing and disposal of contaminated fluids. Decontamination of sinks in sink area or sink area of exposure to spreading of gram-negative bacteria via sinks is suspected.</td>
</tr>
<tr>
<td>Faucet sensiters</td>
<td>Hand washing may serve as a platform for accumulation of waterborne pathogens. Potential pathogens include Pseudomonas, Stenotrophomonas, and LegiOnella.</td>
<td>Routine screening and disinfection or permanent removal of all sinks are not warranted at present. No procedure is necessary at present.</td>
</tr>
<tr>
<td>Shower(s)</td>
<td>Same outbreak is linked to contaminated shower heads or inoculation of aerosols. Potential pathogens include Legionella, Pseudomonas, N. M. F., and other species.</td>
<td>Prohibit use of showers in neutropenic patients. Control Legionella colonization of potable water.</td>
</tr>
<tr>
<td>Ice and ice machines</td>
<td>Ice can contain microorganisms on ice, ingesting ice drinks, or use of contaminated ice for cooling medical procedures and patients’ skin. Large outbreaks occurred when ice machines have become contaminated and ice used for cooling drinking water. Common pathogens include Pseudomonas, Enterobacter, and other species.</td>
<td>Do not handle ice for hand. Do not store pharmaceuticals or medical solutions in ice or for consumption. Use automatic dispenser rather than open chest storage compartments in patient areas. Clean and disinfect ice storage chest regularly.</td>
</tr>
</tbody>
</table>
## Healthcare Outbreaks Associated with Water Reservoir


<table>
<thead>
<tr>
<th>Resource</th>
<th>Key Issues</th>
<th>Infection Prevention Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bathing, tub immersion, and hydrotherapy</td>
<td>Tub immersion used in hospitals for physical hydrotherapy and for cooling of burn wounds can cause pseudomonas, transmission from environmental reservoirs, or person-to-person transmission</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prevention: Use sterile water for eye flush or regular eye drops, use clean eye wash bottles. Use sterile water for eye flush or regular eye drops, use clean eye wash bottles. Use sterile water for eye flush or regular eye drops, use clean eye wash bottles.</td>
<td></td>
</tr>
<tr>
<td>Toilets</td>
<td>Transmission can be caused by aerosolization of fecal bacteria via flushing or surface contamination by fecal bacteria, or through direct contamination of the vagina or rectum by the inflow of contaminated water.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prevention: Use sterile water for eye flush or regular eye drops, use clean eye wash bottles. Use sterile water for eye flush or regular eye drops, use clean eye wash bottles. Use sterile water for eye flush or regular eye drops, use clean eye wash bottles.</td>
<td></td>
</tr>
<tr>
<td>Flowers and vases</td>
<td>flower vases and portable plants are heavily colonized with potential pathogens, including Acinetobacter, Klebsiella, Eikenella, Pseudomonas, and Enterococcus.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prevention: Use sterile water for eye flush or regular eye drops, use clean eye wash bottles. Use sterile water for eye flush or regular eye drops, use clean eye wash bottles. Use sterile water for eye flush or regular eye drops, use clean eye wash bottles.</td>
<td></td>
</tr>
<tr>
<td>Electronic faucets</td>
<td>Electronic faucets were found to be contaminated by several waterborne pathogens than hand-operated faucets.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prevention: Use sterile water for eye flush or regular eye drops, use clean eye wash bottles. Use sterile water for eye flush or regular eye drops, use clean eye wash bottles. Use sterile water for eye flush or regular eye drops, use clean eye wash bottles.</td>
<td></td>
</tr>
<tr>
<td>Decorative water well fountains</td>
<td>Legionella pneumonia cases associated with decorative water well fountains can be reported.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prevention: Use sterile water for eye flush or regular eye drops, use clean eye wash bottles. Use sterile water for eye flush or regular eye drops, use clean eye wash bottles. Use sterile water for eye flush or regular eye drops, use clean eye wash bottles.</td>
<td></td>
</tr>
<tr>
<td>Heat-cooler units</td>
<td>Healthcare-associated Mycobacterium chimaera outbreak due to water in heat-cooler units while waiting for discharge.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prevention: Use sterile water for eye flush or regular eye drops, use clean eye wash bottles. Use sterile water for eye flush or regular eye drops, use clean eye wash bottles. Use sterile water for eye flush or regular eye drops, use clean eye wash bottles.</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Potential reservoirs include water faucets, whirlpools, whirlpool baths, showers, and hot tubs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prevention: Use sterile water for eye flush or regular eye drops, use clean eye wash bottles. Use sterile water for eye flush or regular eye drops, use clean eye wash bottles. Use sterile water for eye flush or regular eye drops, use clean eye wash bottles.</td>
<td></td>
</tr>
</tbody>
</table>

Healthcare Outbreaks Associated with Water Reservoir

Water Wall Fountains and Electronic Faucets

Water Walls Linked to Legionnaires’

• Palmore et al. ICHE 2009;30:764
  ■ 2 immunocompromised patients exposed to decorative fountain in radiation oncology; isolates from patients and fountain identical; disinfection with ozone, filter and weekly cleaning

• Houpt et al. ICHE 2012;33:185
  ■ Lab-confirmed Legionnaires disease was dx in 8 patients; 6 had exposure to decorative fountain (near main entrance to hospital); high counts of *Legionella pneumophila* 1 despite disinfection and maintenance
Water Walls and Decorative Water Fountains

Present unacceptable risk in hospitals serving immunocompromised patients (even with standard maintenance and sanitizing methods)

Electronic Faucets
A Possible Source of Nosocomial Infection?
Electronic Faucets

- Conserve water
- Conserve energy
- Hygienic
- Hands free
- Barrier free

Electronic (E) vs Handle-Operated (HO) Faucets

- 100% E vs 30% HO *Legionella* (no cases). Halabi et al. JHI 2001:49:117
- Significant difference HPC levels between brand A (32%) and B (8%) E compared to HO (11%). Hargreaves et al. 2001; 22:202
- No difference in *P. aeruginosa*. Assadian et al. ICHE. 2002;23:44.
- 73% E samples did not meet water std vs 0% HO
- 29% of water samples from E and 1% from HO yielded *P. aeruginosa*. Merrer et al. Intensive Care Med 2005;31:1715
- 95% E grew *Legionella* compared to 45% HO (water-disruption events). Syndor et al. ICHE; 33:235
Issues Associated with Electronic Faucets

• A longer distance between the valve and the tap, resulting in a longer column of stagnant, warm water, which favors production of biofilms
• Reduced water flow; reduced flushing effect (growth favored)
• Valves and pipes made of plastic (enhances adhesion *P. aeruginosa*)

Prevention Measures

• Electronic faucets constructed so they do not promote the growth of microorganisms
• A potential source of nosocomial pathogens
• No guideline (but some have recommended) to remove electronic faucets from at-risk patient care areas (BMTU)
• Some have recommended periodic monitoring of water samples for growth of *Legionella*
• More data are needed to establish role in HAIs
POTABLE WATER

• Drinking water is not sterile
• Outbreaks have been linked to contaminated water
• Typical pathogens
  ■ Non-enteric Gram negative bacilli (e.g., P. aeruginosa)
  ■ Non tuberculous mycobacteria
  ■ Legionella

POTABLE WATER

Control Measures
• Maintain standards for drinking water (<1 coliform per 100 mL)
• Rinse semi-critical equipment with sterile water or tapwater follow by alcohol rinse
Legionella: Epidemiology

- 10,000-40,000 cases/yr (1-5% of adult pneumonia)
- Reservoir: Ubiquitous in aquatic environments
- Associated with devices that produce potable or non-potable water aerosols (e.g., cooling towers, evaporative condensers, showers, faucets, decorative water fountains, whirlpool baths, ice machines, medication nebulizers, nasogastric feedings diluted in tapwater)
- Transmission: Inhalation of aerosols (no person-to-person transmission)

Legionella: Control Methods

- Eradication technically difficult, usually temporary, and costly
- Methods of eradication: filtration, UV, ozonization, heat inactivation (>60°C), hyperchlorination (4-6 ppm), copper-silver ionization (>0.4 and >0.04 ppm)
- No recommendation for specific disinfection of potable water at outlet
- No recommendation for routine environmental monitoring
Sink

SINKS

- Colonization of sinks with Gram negative bacilli reported by multiple investigators
- Gram negative bacilli survive wet environments for as long as 250 days
- Gram negative bacilli associated with sinks commonly demonstrate resistance to antibiotics
SINKS

• Few studies demonstrate link between bacteria colonized sink and actual patient pathogens
• Transmission could occur by transient colonization of the hands of healthcare personnel

Control Measures
• Use separate sinks for handwashing and disposal of body fluids

SHOWERS

• Few outbreaks linked to showers
• Typical pathogens
  ■ Legionella
  ■ Group A streptococcus (single report) linked to hand held shower heads

Control Measures
• Control Legionella colonization of potable water
Faucet Aerator

FAUCET AERATORS

- Faucet aerators may serve as a platform for the replication of “water” pathogens to potentially high concentrations
- Rarely linked to patient colonization/infection
- Typical pathogens
  - *Pseudomonas*
  - *Stenotrophomonas*
FAUCET AERATORS

Control Measures
• Permanent removal of aerators or routine disinfection not warranted at present time

HYDROTHERAPY TUB
TUB IMMERSION

- Used in hospitals for physical therapy and for cleaning of burn wounds
- Skin infections have occurred related to water immersion
  - “Hot tub” folliculitis
  - Cellulitis (rare)
- Typical pathogens
  - Folliculitis: *Pseudomonas aeruginosa*
  - Cellulitis: *Citrobacter*

TUB IMMERSION

Control Measures
- Strict adherence of proper disinfection of tub between patients
- Another option would be to add a germicide to the water (e.g., chlorazine)
- Can treat patients with resistant pathogens provided contact isolation maintained and disinfection used
ICE DISPENSER

ICE AND ICE MACHINES

• Occasional source for nosocomial outbreaks
• Large outbreaks have developed when ice machines have become contaminated and ice used for cooling drinking water
• Typical pathogens
  ■ Mycobacteria
  ■ Cryptosporidium
  ■ Salmonella
  ■ Legionella
ICE AND ICE MACHINES

Control Measures

• Meaningful microbial standards for ice and ice machines do not exist
• Routine culturing of ice machines not recommended
• CDC has published a set of recommendations designed to minimize ice and ice machine-associated infections
  ■ Includes regular program of disinfection
• Avoid chest storage compartment machines whenever possible

Hemodialysis Machine
Hemodialyzer

DIALYSIS WATER

- Excessive levels of Gram-negative bacilli in the dialysate have been responsible for pyrogenic reactions in patients
- Hazard caused by bacteria or endotoxin gaining entrance into the blood from the dialysate
DIALYSIS WATER

Control Measures
• Sample dialysis water (input) monthly
  ■ Maintain water <200 bacteria/mL
• Sample dialysate (output) monthly
  ■ Maintain water <2,000 bacteria/mL
• Follow guidelines for disinfection of water distribution systems and hemodialysis machines

HOSPITAL TOILETS

• Potential hazards associated with hospital toilets
  ■ Aerosolization of fecal bacteria via flushing
  ■ Surface contamination by fecal bacteria
• Transmission risk associated with certain populations (e.g., children, mentally challenged)

Control Measures
• Maintain clean surfaces, clean bowl with a brush
• No reason to pour disinfectant into bowl
• Good handwashing practices
Flowers in a Vase

FLOWERS

- Flower vases and potted plants are heavily colonized with potential pathogens
  - Vase water colonized with $10^7 - 10^{10}$ bacteria/ml
- No outbreaks directly linked to flower vases or potted plants
- **Control Measures**
  - Prohibit fresh flowers and potted plants in the rooms of immunocompromised and ICU patients
  - Add antimicrobial agent to vase water
OTHER WATER SOURCES

- Contaminated wash basin
- Portable eye wash stations
- Dental irrigation fluid
- Pseudo-outbreaks of non-tuberculous mycobacteria
- Water containing equipment
DENTAL UNIT WATER

- Problem: Water delivered to dental handpieces and air/water syringes may become contaminated
- Contamination level = $10^2-10^6$ microorganisms/ml
- Risk for disease acquisition most likely with immunocompromised patients
- Potential control measures (between patients)
  - Flush with water
  - Flush with disinfectant solution
  - Clean water system

INANIMATE ENVIRONMENT

Goals of lecture

- Surface: Review the contribution of non-critical surface contamination to disease transmission
- Endoscopes, water, air: Epidemiology and prevention of transmission
Thank you