Establishing a Culture of Safety: Eliminating Environmental Infection Risks with Effective Prevention Measures

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List of Sources

- Patient Care Equipment
- Environmental surfaces
- Medications
- Food and Enteral Feedings
- Air Handling Systems
- Water and Sewerage
- Construction sites
- Unique environmental sources

Modes of Transmission

- **Modes of Transmission:**
  - Direct contact with blood and bodily fluids (HIV, HBV)
  - Indirect contact with contaminated items and patient care equipment and the environment (MRSA, VRE, C.difficile)
  - Droplet nuclei (Influenza, Pertussis, Bacterial Meningitis, SARS)
  - Airborne route (TB, Chickenpox, Measles)
  - Vector (West Nile Virus, Malaria, Ebola Virus)
Surface Contamination (in hospitals) with MRSA, VRE, and C. Difficile

Pathogens survival on surfaces

<table>
<thead>
<tr>
<th>Organism</th>
<th>Survival period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clostridium difficile</td>
<td>35-700 days</td>
</tr>
<tr>
<td>Methicillin-resistant Staphylococcus aureus (MRSA)</td>
<td>16-300 days</td>
</tr>
<tr>
<td>Vancomycin-resistant enterococcus (VRE)</td>
<td>58-200 days</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>&lt;150-480 days</td>
</tr>
<tr>
<td>Acinetobacter</td>
<td>150-300 days</td>
</tr>
<tr>
<td>Klebsiella</td>
<td>&gt;300 days</td>
</tr>
<tr>
<td>Salmonella typhimurium</td>
<td>10 days-4.2 years</td>
</tr>
<tr>
<td>Mycobacterium tuberculosis</td>
<td>120 days</td>
</tr>
<tr>
<td>C. Difficile</td>
<td>120 days</td>
</tr>
<tr>
<td>Most viruses from the respiratory tract (e.g., coronavirus, influenza, SARS, rhino virus)</td>
<td>Few days</td>
</tr>
<tr>
<td>Viruses from the gastrointestinal tract (e.g., astrovirus, parvovirus or rotavirus)</td>
<td>60-90 days</td>
</tr>
<tr>
<td>Most bacteria viruses (e.g., HAV or HIV)</td>
<td>&gt;7 days</td>
</tr>
<tr>
<td>Surgical and respiratory (e.g., rhino virus)</td>
<td>&gt;7 days</td>
</tr>
</tbody>
</table>

Patients as Source of Room Contamination

Prior room occupancy increases risk

<table>
<thead>
<tr>
<th>Study</th>
<th>Healthcare associated pathogens</th>
<th>Likelihood of patient acquiring HAI based on prior room occupancy (comparing a previously “positive” room with a previously “negative” room)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mohan et al. 2007*</td>
<td>VRE – cultured within room</td>
<td>2.4x</td>
</tr>
<tr>
<td>Huyng 2009F</td>
<td>VRE – prior room occupant</td>
<td>1.6x</td>
</tr>
<tr>
<td>Davies 2008B</td>
<td>MRSA – prior room occupant</td>
<td>1.3x</td>
</tr>
<tr>
<td>Davies 2008B</td>
<td>VRE – cultured within room</td>
<td>2.9x</td>
</tr>
<tr>
<td>Davies 2008B</td>
<td>VRE – prior room occupant</td>
<td>2.7x</td>
</tr>
<tr>
<td>Davies 2008B</td>
<td>VRE – prior room occupant in previous two weeks</td>
<td>2.0x</td>
</tr>
<tr>
<td>Dougherty 2008A</td>
<td>C. difficile – prior room occupant</td>
<td>2.6x</td>
</tr>
<tr>
<td>Roel 2002P</td>
<td>A. baumannii – prior room occupant</td>
<td>3.8x</td>
</tr>
<tr>
<td>Egertshag 2008</td>
<td>P. aeruginosa – prior room occupant</td>
<td>2.2x</td>
</tr>
</tbody>
</table>

Moist Patient Care Equipment

- Urinary drainage systems
  - urine is a culture medium for microorganisms and provides a medium to transfer antibiotic resistance
- Urinals, bedpans, commodes
  - sources for multiple drug resistant organisms (CRE, VRE) and Clostridium difficile
- Respiratory therapy equipment
  - suction devices – great source for water loving organisms, such as Pseudomonas, Serratia, Enterobacter, Klebsiella, Acinetobacter
  - sterile water bottles – only good for 24 hrs after opened
  - sterile saline – only good for 24 hrs after opened
- Enteral feed equipment
  - bags and tubing, irrigating bottles and syringes

IV Equipment and Patient Items

- Intravenous therapy equipment
  - can become contaminated with gram negative bacilli and candida
- IV sites
  - Staphylococcus and candida most common pathogens
- Rectal Electronic thermometers
  - C. Difficile, VRE, gram negative bacilli, such as E.Coli
- Stethoscopes, blood pressure apparatus
  - MRSA, Staph aureus, Coag neg staph, gram negatives
- Beds, poles, stretchers, chairs, privacy curtains
  - MRSA, VRE, Staphylococcus, gram negatives

Other Patient Care Equipment

- EKG machine and leads
  - Telemetry units
  - Dynamap
  - Defibrillator
  - Crutches and walkers
  - Lifts and scales
  - IV and other pumps
  - Pulse oximeters
  - Venoflow machine
  - Storage bins
  - Ultrasound Gel
  - CDC Alert April 20, 2012 – Pseudomonas and Klebsiella contamination of ultrasound gel
Hemodynamic monitoring equipment

- Hemodynamic monitoring equipment has been associated with over 24 outbreaks of HA bacteremia
- The use of disposable monitoring equipment and improved disinfection procedures have reduced this risk
- IV Stopcocks can become contaminated

Hand Contamination of Anesthesia Providers Is an Important Risk Factor for Intraoperative Bacterial Transmission


Outbreak Investigation – at a large teaching institution 1989

- 36 cases of Pseudomonas Fluorescens
  - All in cardiac surgical patients
  - All were bacteremias – several patients died
  - Cultures from ICU arterial port stopcocks were positive with the organisms
  - Cultures from OR stopcocks were positive
  - Source – manometer used to calibrate the transducer in the OR
    - Why? To save money – anesthesia stopped using a 4 foot piece of sterile tubing between the stopcock and the unsterile manometer – direct contact with the manometer pushed fluid into the coil of the manometer and the organisms grew in the dark wet environment

Spencer, M et al. APIC Oral Presentation 1989
Contaminated hands have the potential to leave biofilm on stopcocks and other devices.
Environmental Surfaces
- Source for numerous types of microorganisms; hospitals should be clean – free of dirt, dust, lint
- Floor
- Bathrooms
- Bed, side rails, bedside table, chairs
- Shelving and Bins
- Privacy Curtains
- Trash Barrels
- Intake and exhaust grills
- Carts, wheels, stands


MRSA contamination in precaution rooms – Classic Study
- 70% of rooms had environmental contamination when the patient was colonized or infected
- 42% of nurses’ gloves cultured were contaminated after touching environmental surfaces WITHOUT touching the patient!


Blood contamination – and HBV
- Estimated to be four million infectious doses of HBV in a drop of blood
- Can survive on environmental surfaces for long periods of time, even in dried blood

Blood contamination and HBV. Estimated to be four million infectious doses of HBV in a drop of blood. Can survive on environmental surfaces for long periods of time, even in dried blood.
Environmental Sources

- Mops, buckets, sponges, cloths – anything with stagnant water can proliferate large numbers of microorganisms
- Organisms multiply every 20 minutes
- Periodic changing of the water and exchange of cleaning cloths is of utmost importance to prevent spreading infectious agents
- No brooms or sponges allowed in healthcare setting

Carpets in Hospitals

- Carpets
  - Can have increased microorganisms than floor coverings
  - Can be sources for Aspergillus, molds and fungus
  - Difficult to clean if wet or moist

Mattresses

- Cracked mattresses
  - outbreak in a burn unit with Pseudomonas and Acinetobacter
  - Cracked gel pads can attract organisms in OR

Aspergillosis due to carpet contamination.

Aspergillosis due to carpet contamination.


Terminal cleaning fails to eliminate bacteria from the surface of the hospital mattress. A randomized trial to evaluate a launderable bed protection system for hospital beds. Antimicrobial Resistance and Infection Control 2012, 1:17.
Operating Room Equipment

- Buttons and equipment to touch and clean
- Many surfaces can become contaminated
- Wheels on carts moving dust
- Equipment interfering with air flow to exhaust vents
- Too many staff and visitors entering ORs
- Tape on equipment can attract organisms – must remove it

Carts, Tables, Wheels

- Many of the carts and stands in the hospital are caked with dirt, dust, blood, rust, etc.
- Cultures from wheels grew numerous organisms.
- Source for infection? Unlikely – however, serve as a source for organisms entering patient care areas and operating rooms and tracking organisms throughout

Computer screen and keyboards


Computer Screens And Keyboards

- Many pathogens including those that cause diarrhea, skin infections, colds and other respiratory infections can survive on surfaces for varying lengths of time.
- Conjunctivitis can be easily spread through person-to-person contact such as eye secretions, sneezing and coughing.
- During one outbreak on a college campus, about 10 percent of the student body, or nearly 500 students, contracted conjunctivitis.
- Computer keyboards were considered a source for the outbreak.

"New England Journal of Medicine June 19, 2003;348:2577-2578"

Computer Keyboards and Contaminated Faucets

- Computer keyboards and faucet handles in medical intensive care units are potential reservoirs of pathogens.
- 144 environmental samples from 10 computer keyboards in 8 patient rooms, 1 nurses’ station and 1 doctors’ station, as well as from 8 pairs of faucet handles in the hospital’s medical ICU.
- Samples were collected over eight collection periods in a 2-month period.

Keyboards and Faucets

- Results:
  - In occupied rooms, 26% of keyboards and 15% of faucets were contaminated.
  - In unoccupied rooms, the rates were 17% and 0%, respectively.
  - 33 environmental isolates
    - methicillin-resistant Staphylococcus aureus (MRSA) was the most frequently occurring pathogen, followed by Enterococcus, Enterobacter and other gram-negative rods.
  - 14 patient isolates
    - MRSA was again the most frequently occurring pathogen, followed by Enterobacter and other gram-negative rods.

"AJIC 2000, vol. 28, No 6, pp. 465-470"
Reprocessing and Sterilization of Orthopedic Instruments

- Cleaning tissue and blood from the instruments in the OR
- Sorting used instruments for decontamination processing
- Cleaning procedures for the inside lumens of instruments
- Sterilization process
- CMS and TJC focusing on SPD and instrument reprocessing due to outbreaks

CDC Investigation Uncovers Dirty Surgical Instruments at Houston Hospital: Human tissue and bone found stuck in shavers and cannulas. Outpatient Surgery, April 4, 2012

Laryngoscope blades and handles

Laryngoscopes handles - contaminated with blood, fluid and blades.
Blade and handle should be high level disinfected
Three papers on contamination of handles

Contamination of Laryngoscope Handles

- 192 specimens from 64 laryngoscope handles deemed 'ready for patient use' in the anaesthetic rooms of 32 operating rooms were semi-quantitatively assessed for bacterial contamination
- One or more species of bacteria were isolated from 55 (86%) of the handles, and included organisms such as enterococci, methicillin-susceptible Staphylococcus aureus, Klebsiella and acinetobacter

Instrument Reprocessing

- Check biological indicator logs and assure they are being done correctly
- Check location of manufacturers recommendations for cleaning and sterilization – make sure they are following them
- Check how they handle instrument rep trays
- Check for double peel pack wrapping
- Check for immediate use steam sterilization practices (“flashing”)

Microorganisms which have contaminated antiseptics and disinfectants

- Benzalkonium chloride – Enterobacter, Pseudomonas and Serratia
- Chlorhexidine – Flavobacterium, Pseudomc and Serratia
- Hexachlorophene – Pseudomonas, E.Coli
- Povidine-iodine – Pseudomonas cepacia
- Phenolic – Alcaligenes and Pseudomonas
- Quaternary Ammonium – Pseudomonas and Serratia

Medication Vials and Equipment

- Multi-dose vials have caused numerous outbreaks
  - heparinized solution with Serratia
  - sterile saline used for spinal anesthesia was contaminated with Pseudomonas and caused meningitis and an outbreak of Hepatitis B from a multi-dose vial.
- Jet injector for IM injections - outbreak of Hepatitis B
- Contaminated Ophthalmic solution led to keratitis.
- Insulin pens - outbreaks of Hepatitis C – being used between patients

Antimicrob. Agents Chemother Outbreaks Associated with Contaminated Antiseptics and Disinfectants. December 2007 vol. 51 no. 12 4217-4224

http://www.contaminateddrugs.com/news.htm
Hepatitis B and C Transmission Related to Multi-dose Vials of Heparin

- Hepatitis B outbreak related to multiple dose heparin
- July 17, 1996 Medication Safety Alert
- PROBLEM: Several patients in a California hemodialysis center, previously HBsAg-negative, developed hepatitis B after they received heparin administered from multiple dose vials shared with a patient with chronic infection
- Hepatitis C outbreak related to multiple dose heparin vials – Hepatology, Oct. 2002

http://www.contaminateddrugs.com/news.htm

Multidose vials and Syringes

- The American Society of Anesthesiologist’s “Recommendations for infection control for the practice of anesthesiology” support the practice of using aseptic technique, using multiuse vials appropriately, and not reusing syringes and needles
- Safe handling of vials and syringes to prevent HAI infections in patients undergoing anesthesia or sedation
- Recent outbreaks of MRSA and other pathogens from steroid injections in pain clinics where vials were shared and not cleansed properly

http://www.contaminateddrugs.com/news.htm

Multi-dose Bottles of Albuterol

- Apr. 19, 2002
  - Hospital outbreaks of lower respiratory tract colonization and infection with Burkholderia cepacia attributed to contaminated multi-dose bottles of albuterol sulfate.
  - In most cases, colonization or infection occurred in the ICU setting, often in patients receiving mechanical ventilation

Contaminated Albuterol Sulfate Solution for Inhalation April 19, 2002 - Public Health Advisory – FDA
Diagnostic Equipment

- CT Scans – contrast medium – a diagnostic tracer was contaminated with Achromobacter
- Intravascular pressure transducers were contaminated – Pseudomonas
- X-ray cassettes caused a cross-contamination outbreak of MRSA in an Intensive Care Unit

Food and Enteral Nutrition Solutions

- Food preparation areas can be reservoirs of pathogens
  - cutting boards, meat slicers, handling of raw foods (eggs, vegetables, salads) milk, cream products.
- Food temperatures and utensil cleaning is extremely important to reduce microbial growth
- Contaminated blenders, mixers, homogenizers, dish cloths, work surfaces, metal sieves, juice, milk, coffee, ice cream/yogurt dispensers and a detergent dispenser have been shown to be reservoirs for pathogens.

Kitchen Issues – Two Common Findings are Uncovered Food and Dusty Fans in Refrigerators

- Uncovered food in refrigerators
- Dusty fans in refrigerators
Outbreak Investigation in a large teaching institution

- Leuconostoc bacteremia in a Burn Unit
  - 12 cases of bacteremia
  - Cultures of powdered egg white with protein grew the organism
    - Blenders were contaminated
    - Enteral feed equipment left standing more than 4 hours supported the growth of the organism
  - Spencer, M et al  APIC Oral Presentation 1989

Air Handling Systems and Fans

- Air handling system and 95% efficiency filters
- Humidity & temperature of air
- Source and mix of outdoor air
- Air intakes – keep away from cooling towers, waste storage areas, incinerators, exhaust vents for gases
- Negative vs positive pressure, air exchanges – documentation needed
- Fans – if allowed have cleaning policy

Mediastinitis Outbreak Investigation

- Problem – increased infection rate in cardiac surgery – mediastinitis with Staph aureus and Coag Neg Staph
- New Operating Room – heavy lead shielded doors were installed and the room was radiofrequency free
- Laminar flow – disrupted from front door being kept open by nurses who claimed it hurt their back and back door propped opened by Anesthesia to pick up radio waves for their music – created a cross wind movement over the surgical field
- Smoke studies showed the air moved towards the heat of the overhead lights – incoming cool air pushed the smoke down over the operating room table onto the surgical field.
Outbreak of Serratia marcescens infection in a special-care baby unit (SCBU)

- Outbreak involved 36 infants and lasted for 20 weeks.
- Seven of the colonized infants developed invasive illnesses in the form of bacteremia (four cases), bacteremic meningitis (two) and clinical sepsis (one).
- Three other term infants had purulent conjunctivitis.
- There were five deaths with an overall mortality of 14%.

Outbreak of Serratia marcescens infection in a special-care baby unit (SCBU)

- S. marcescens was cultured from airflow samples from the air conditioning (AC) which was the reservoir of infection in this outbreak.
- Elimination of the source and outbreak containment were eventually achieved by specialized robotic cleaning of the entire AC duct system of the SCBU.
- Strict adherence to the infection control policies was reinforced to prevent transmission of cross-infection.

Water Sources

- Potable water can be contaminated to Pseudomonas, Legionella, and Acinetobacter
- Contaminated potable water was used to dilute alcohol skin antiseptic and caused an outbreak of bacteremia Burkholderia cepacia
- Shower heads, Drinking fountains, Eyewash stations have grown Legionella and Pseudomonas
- Dialysis water and dialysate can become contaminated
- Waterfalls and Legionella
- Water baths to thaw or warm sterile bottles and defrost frozen breast milk caused outbreaks of Pseudomonas and Acinetobacter

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Water Sources

- Faucet aerators have cultured Legionella and Pseudomonas
- Unresolved issue in hospitals

8 pairs of faucet handles in the hospital's medical ICU.
- In occupied rooms, 15% of faucets were contaminated

AJIC 2000, vol. 28, No 6, pp. 465-470

Water Sources

- Contaminated ice baths and ice in open heart surgery have caused outbreaks of Pseudomonas and Staphylococcus
- Intra-aortic balloon pump contaminated water reservoir with Pseudomonas cepacia

An outbreak of wound infections in cardiac surgery patients caused by Enterobacter cloacae resulting from cardioplegia ice.

Distilled water sitting on windowsill in hot sun incubating in NICU—used for a cooling machine

Cut Flowers

- Cut Flowers – dirty water can be steaming with Pseudomonas, Serratia and E.Coli
- Dispose the water in dirty utility room – not in patient’s room and wear gloves and sanitize hands
Construction Sites – Infection Control Risk Assessment (ICRA)
- Ceiling tiles and fireproof materials have caused aspergillus and rhizopus outbreaks
- Pigeon droppings from outside the building can transmit aspergillus
- To prevent infection, construction team must design safe traffic patterns for people and supplies
- Accomodations for immuno-compromised hosts in construction areas
- Dust, dirt, lint, stagnant water are the major problems for environmental control

Sentinel Event – Case Review
- Pediatric patient in hospital with leukemia
- Mother is an artist – volunteers to paint the ceiling tiles in his room with cartoon characters to cheer the kids while in bed
- Child developed severe case of invasive mucocutaneous Aspergillosis of nose and face
- Source – ceiling tiles painted and brought into his room by his mother

Unique Environmental Sources
- Hepatitis B linked to use of contaminated capillary-blood-sampling devices
- Contaminated silicone oil used for oil bath to promote wound healing caused an MRSA outbreak
- Acinetobacter outbreak from contaminated cell phones
- Contaminated elasticized bandage with Rhizopus caused deep tissue invasion
Hands as a Source of Microorganisms

The Role of Handwashing in Preventing Intensive Care Unit Infections, B. Simmons, et al, 1990, Infection Control Hospital Epidemiology

Bacterial Contamination of the Hands of Hospital Staff during Routine Patient Care. D. Pittet, 1999, Archives of Internal Medicine

Artificial Nails and Outbreaks

- Artificial nails worn by healthcare providers have caused several outbreaks: Klebsiella, Candida, Pseudomonas and other gram negative bacilli

A Prolonged Outbreak of Pseudomonas aeruginosa in NICU: Did Staff Fingernails Play a Role in Disease Transmission? Ronald L. McKinnon, MD, et al. Infection Control and Hospital Epidemiology, 2003;24:60-65


Staff Contaminated Items

Dirty stethoscope cover
Contaminated Hands Most Common Source

Hands and Gloved Hands as Sources for Spread
- Imprint of a health care worker's gloved hand after examining a patient infected with Clostridium difficile.
- The larger yellow colonies outlining the fingers are clusters of Clostridium difficile.
- The patient had showered an hour before the specimen was collected.

Most Important Control Measure
- Microorganisms multiply every 20 minutes.
- They communicate with one another and transfer resistance factors.
- Gloves can also be contaminated and transmit organisms.
To Prevent Cross Contamination and Transmission: Wear Gloves, Wash Hands Often, Use Alcohol Based Hand Rub/Foam

Hand Cultures – before and after the use of Alcohol Based Hand Sanitizer

Use Evidence Based Guidelines for Environmental Control

- CDC Guideline for Isolation Precautions in Hospitals, 2007
- CDC Guideline for Environmental Infection Control in Health-Care Facilities, 2003
- CDC Guideline for Hand Hygiene in Health-Care Settings, 2002
- CDC Guidelines for Design and Construction Of Hospital and Health-Care Facilities, 2002
Use Evidence Based Guidelines for Prevention Practices

- APIC Guidelines for Topical Antimicrobials 1998
- APIC Guidelines for Selection and Use of Disinfectants 1996
- APIC Guide to the Elimination of Clostridium difficile in Healthcare Settings
- APIC position paper: Safe injection, infusion, and medication vial practices in healthcare 2010
- APIC Guide to the Elimination of Orthopedic Surgical Site Infections 2010
- APIC Guide to the Elimination of Ventilator-Associated Pneumonia 2009
- APIC Guide to the Elimination of Infections in hemodialysis 2010
- APIC Methicillin-Resistant Staphylococcus aureus (MRSA) Transmission in Hospital Settings, 2nd Edition 2010
- CDC Guidelines for Prevention of CAUTI, 2009 Guide to the Elimination of
- CDC Guidelines for Infection Prevention Recommendations for Outpatient (Ambulatory Care) Setting 2010
- OSHA Bloodborne Pathogens Standard, 1992

Use Evidence Based Guidelines for Prevention Practices

- CDC Recommendations for Preventing the Spread of Vancomycin Resistance 1995
- CDC Guideline for Prevention of Surgical Site Infection, 1999 (currently under revision 2014)
- CDC Guidelines for Preventing the Transmission of Mycobacterium tuberculosis in Health-Care Settings, 2005
- CDC Management of Multidrug-Resistant Organisms In Healthcare Settings, 2006
- CDC Guide of infection prevention recommendations for outpatient (ambulatory care) setting 2010
- CDC Guidelines for Infection Control in Dental Health-Care Settings – 2003

Use Evidence Based Guidelines for Prevention Practices

- CDC Guideline for Infection Control in Healthcare Personnel 1998
- CDC Recommendations for Preventing Transmission of Infections Among Chronic Hemodialysis Patients
- CDC Website on Hand Hygiene in Healthcare facilities: www.cdc.gov/handhygiene
- CDC Website on Injection Safety: www.cdc.gov/injectionsafety
- CDC Website on Influenza: www.cdc.gov/flu
- CDC for the Prevention and Control of Norovirus Gastroenteritis Outbreaks in Healthcare Settings, 2011
- CDC Guidelines for the Prevention of Healthcare Associated Infections : All evidence-based recommendations for prevention of healthcare-associated infections from CDC/HICPAC can be found at the following site: http://www.cdc.gov/hicpac/peds.html
- CMS – Conditions of Participation – Infection Control and Infection Control Survey Tool
Additional Resources

- www.creativehandhygiene.com
- www.workingtowardzero.com
- www.7SBundle.com

The End
Thank You!