The Role of the Environment in Infection Control

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“De contagione”

- Published in 1546 by Hieronymus Fracastorius
- Postulated that the cause of infectious disease was from invisible living seeds
- Described 3 modes of disease spread
  - Direct contact with infected persons
  - Indirect contact with fomites
  - Airborne transmission

Handwashing in the mid-1800’s

- Oliver Wendell Holmes & Ignaz Philipp Semmelweis recommendations of handwashing prior to patient contact received a cold reception
- Surgeon’s hands, rarely washed were placed directly into patient’s wounds & onlookers encouraged to “take a feel”

Early Instrument Disinfection

- Surgical instruments were crudely wiped & placed back into their velvet carriers often after being sharpened on the sole of the surgeon’s boot

Florence Nightingale

- Crimean War - Florence and her compatriots began by thoroughly cleaning the hospital and equipment and reorganizing patient care
- Identified a link between overcrowding and the hospital’s defective sewers and lack of ventilation.
- Began increasing the distance between beds

Environmental Surfaces

- William W. Keen (1837 – 1932) in the late 1800’s was one of the first American surgeons to consider the environment
  - All carpets and unnecessary furniture should be removed from a patient’s room
  - Walls and ceilings were cleaned the day before the operation
  - Woodwork, floors and remaining furniture were scrubbed with carbolic solution
Today?

- Maintaining the environment of care undeniably plays a role in containing the spread of infection including:
  - Providing a clean care environment
  - Providing clean medical equipment
  - Providing clean air

Outbreaks - MRSA

- Sept 2000, Pennsylvania DOH: College & High school aged football players
- Sept 2002, California DOH: College football team
- Jan 2003, Indiana DOH: High school wrestling team
- Feb 2003, Colorado DOH: Cluster of MRSA infections among members of a Colorado fencing club

Outbreaks – E. coli OH157:H7

- Fall 2000, Pennsylvania DOH: School visits to local dairy farm
- Oct 2004, North Carolina DOH: School Children visit Crossroads Farm Petting Zoo at State Fair

Evidence for airborne transmission of Norwalk-like virus (NLV) in a hotel restaurant; PJ Marks; Epidemiol. Infect. 2000, 124: 481-487

- Hotel restaurant with 126 patrons
- Patron (●) vomited at table
- 52 of 83 survey responders ill – 63% overall attack rate
- Attack rates higher at closer tables
- Consistent with airborne transmission of NLV

Disease Burden

Transmission

True or False: Infectious diseases are transmitted in the same way.

FALSE: There are 5 main routes of transmission.
- Contact
- Droplet
- Airborne
- Vehicle
- Vector
How Microorganisms are Acquired

- Direct
- Indirect
- Vectorborne
- Vehicle

SARS
Norwalk
Influenza
Measles
Mumps
Rubella
Colds

MRSA
VRE
Norwalk
Chicken Pox
Pink Eye
Athlete's Foot
Plantar Warts

- West Nile Virus
- Malaria

Process for Choosing a Disinfectant

- Sterilization
- High Level Disinfection
- Intermediate Level Disinfection
- Low Level Disinfection
- Sanitizing

Critical Devices

Semi-Critical Devices

Non-Critical Devices

Environmental Surfaces

On the Same Page
Terminology, Definitions, Common Words
Criteria for Sanitizing

- A process that reduces microorganisms on surfaces to a safe level
  - **Food Contact Surfaces**: reduction of surrogate bacterial strains by more than 5-log\(_{10}\) in the presence of 5% bovine serum
  - **Non-Food Contact Surfaces**: reduction of surrogate bacterial strains by more than 3-log\(_{10}\)
- Vegetative Bacteria such as E. coli, Staphylococcus, Pseudomonas and other common food borne bacteria can be used

Criteria for Low Level Disinfection

- **Bactericidal**: effective against Vegetative bacteria: > 6 Log\(_{10}\) reduction
  - Staphylococcus aureus, Pseudomonas aeruginosa, Salmonella cholerasuis
- General **Virucide**: effective against the Sabin strain of Polio virus Type 1 (Hydrophilic virus), criterion is > 3 Log\(_{10}\) reduction
- **Virucidal**: effective against targeted viruses (enveloped or non-enveloped), criterion is > 3 Log\(_{10}\) reduction
- **Fungicidal**: effective against Trichophyton mentagrophytes

Criteria for Intermediate Level Disinfection

- Bactericidal: criterion is > 6 Log\(_{10}\) reduction
- **General Virucide**: criterion is > 3 Log\(_{10}\) reduction against Polio
- **Virucidal**: criterion is > 3 Log\(_{10}\) reduction against specific viruses
- **Fungicidal**: effective against *Trichophyton mentagrophytes*, criterion is > 5 Log\(_{10}\)
- **Tuberculocidal**: effective against *Mycobacteria terrae*, criterion is > 4 Log\(_{10}\)

Criteria for High Level Disinfection & Sterilization

- **Fungicidal**: effective against *Trichophyton mentagrophytes*, criterion is > 5 Log\(_{10}\)
- **Tuberculocidal**: effective against *Mycobacteria terrae*, criterion is > 6 Log\(_{10}\)
- **Sporicidal**: effective against *Bacillus subtilis* & *Clostridium sporogenes*, criterion is > 6 Log\(_{10}\)

Cleaning, Disinfection & Cross Contamination

To Clean or Not to Clean......

University of Arizona....
The Inanimate Environment Can Facilitate Transmission


Did you know?
• Cleaning reduces or eliminates the reservoirs of potential pathogenic organisms
• Proper cleaning methods & the mechanical action of cleaning alone will physically remove 99 to 99.9% of organisms on a surface.
• Cleaning alone will make most surfaces safe for staff, students or patients.

Mechanism of Soil Removal

• Attached soil strongly adsorbed onto a substrate is difficult to remove by mechanical action alone

Mechanism of Soil Removal

• Surfactant adsorption at various interfaces weakens the soil attachment and facilitates its removal.

Mechanism of Soil Removal

• Soil is surrounded, lifted, suspended and dispersed. Adsorbed surfactant molecules retard the process of re-deposition.

Cleaning Strategy

• Minimize contamination of cleaning solutions & cleaning tools
• Bucket solutions become contaminated almost immediately during cleaning & continued use of the solution transfers increasing numbers of microorganisms to each subsequent surface to be cleaned
• Cleaning solutions should be replaced frequently.
Verification of Cleaning

Average Cleaning score:
Semi-quantitative assessment of cleaning based on UV marker removal: 0 indicates complete cleaning, 3 indicates no cleaning.

100% (3+)
~75% (2+)
~25% (1+)
0% (0)

“UV water soluble mark”

Environmental Reservoirs

- Association between reservoirs and outbreaks
- Protocols should include careful cleaning of wet surfaces and equipment to prevent the build up of Biofilms
- Examples:
  - Faucet aerators, Shower Heads
  - Sinks, Drains
  - Flower Vase Water
  - Ice Machines
  - Hydrotherapy Tubs

Surfaces & Food-borne Infection

<table>
<thead>
<tr>
<th>Salmonella enteritidis</th>
<th>Salmonella cholerae</th>
<th>Escherichia coli</th>
<th>Salmonella typhimurium</th>
<th>Shigella sonnei</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment*</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cutting Board</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand-Mouth</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface-Mouth</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Surface-Hand-Mouth</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ward Dust</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Reported incidents of environmental surfaces implicated in transmission of food-borne infection (Bloomfield et al. 1997)

Infection Hazards from Surfaces

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Risk of Transfer</th>
<th>Disinfection Need</th>
<th>Disinfection Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservoirs (taps, U-tubes)</td>
<td>High</td>
<td>Relatively Low</td>
<td>Relatively little</td>
</tr>
<tr>
<td>Disseminators (wet/dry)</td>
<td>High</td>
<td>Constant</td>
<td>Always</td>
</tr>
<tr>
<td>Hand Contact Surfaces</td>
<td>Sometimes</td>
<td>Constant</td>
<td>Always</td>
</tr>
<tr>
<td>Food Contact Surfaces</td>
<td>Sometimes</td>
<td>Constant</td>
<td>Always</td>
</tr>
<tr>
<td>Floors, Walls</td>
<td>Low</td>
<td>Occasional</td>
<td>Relative little</td>
</tr>
</tbody>
</table>

Infection hazards associated with environmental surfaces (Bloomfield et al. 1997)

Biofilms

- Gram Positive bacteria (VRE, MRSA, Streptococcus spp.) can survive for months on surfaces
- No obvious difference in survival between multiresistant and susceptible strains of Staphylococcus aureus or Enterococcus spp.
- S. aureus found to persist longer at lower humidities

Fomites & Infection Transmission
Fomites & Infection Transmission

- Gram Negative species such as *Acinetobacter* spp., *E. coli*, *Klebsiella* spp., and *Pseudomonas aeruginosa* can survive on inanimate objects for months.
- Gram Negative species persist for longer periods than Gram Positive.
- Humid conditions increase survival times.

Transmission to Hands

- 100% success rate with *E. coli*, *Salmonella* spp. and *S. aureus*.
- 90% with *Candida albicans*.
- 61% with Rhinovirus.
- 22% – 33% with HAV.
- 16% with Rotavirus.
- Contaminated hands can be the source of recontaminating the surface.
- Compliance rates with HCWs in HH is ~50%.

Computer Keyboards May Harbor Harmful Bacteria

- Harmful bacteria can survive for prolonged periods on keyboards & keyboard covers (VRE & MRSA: 24 hrs, PSAE: 1hr).
- More contact with contaminated keyboard increase likelihood of transmitting bacteria to hands (MRSA: 42% - 92%, VRE: 22% to 50%, PSAE: 9% to 18%).
- Hand Hygiene important helps cut down on transmission.
- Cleaning & Disinfection of keyboards & keyboard covers helps decrease contamination.

Porous vs Non-Porous Surfaces

- Transfer rates from hard, nonporous surfaces is more efficient than from porous surfaces.
- Porous surfaces (ie sponge) offers many deep recesses in which organisms reside and become less accessible to the human hand.
- Hard smooth surfaces do not offer crevices hence higher transmission.

Hospital Fabrics & Plastic

- Common Hospital fabrics:
  - 100% cotton clothing
  - 100% cotton terry towels
  - 60% cotton/40% polyester blend scrub attire & lab coats
  - 100% polyester privacy drapes
  - 100% polypropylene plastic splash aprons.
- *Enterococci* spp. survived at least 11 days on all fabrics but longest on polyester & polypropylene plastic.
- *Staphylococci* spp. survived at least one day on all fabrics but longest on polyester & polypropylene.
- Enterococci lived longer than Staphylococci on fabric.
Cross-Sectional Study

- 102 active visitation dogs in Ontario, 2004
  - 0.75-15 yrs of age
- 80% carried at least one potentially zoonotic pathogen

*Lefebvre et al J Hosp Inf 2006*

C. difficile: 58%
- Including ribotype 027/NAP1
Salmonella: 3%
ESBL E. coli: 4%
Giardia: 7%
Toxocara canis: 2%
Pasteurella canis/multicida: 22%/7%

Disinfectants: Desired Traits & Limiting Factors

- Group A streptococci: 0%
- MRSA: 0%
- VRE: 0%
- Ringworm: 0%
- Cryptosporidium spp: 0%

Effects of Germicides on Microorganisms

- HCWs take for granted the action of disinfectants without fully understanding mechanism of action
- Differences in the action of antimicrobial ingredients
- Differences depending on concentration of chemical used

Basic Facts

- Disinfectants are the backbone of Infection Control
- >8000 Products registered in the U.S. & Canada
- 50% of which are used for Healthcare Infection Control
- There are 300 different active chemistries
  - 14 are in 95% of the disinfectant products
  - 6 are the most common
Factors Affecting Disinfectants

• Prior cleaning of a surface or device
  – Cleaning MUST precede disinfection & sterilization procedures
  – Cleaning residues can interfere with the activity of some disinfectants
  – Chemical sterilants can be relied on to produce sterility only if adequate cleaning occurs
• Organic load on the surface or device
  – Soil can provide a protection barrier for microbes
  – Soil can neutralize many of the disinfectant chemistries

Factors Affecting Disinfectants

• Type & level of microbial load on the surface or device
  – Mechanism of action differs for each chemistry (surface actives, cell components)
• Water Quality
  – Many chemistries can be neutralized when diluted with hard water
• Concentration of the chemical
  – Improper dilution can lead to a false sense of security

Factors Affecting Disinfectants

• Exposure time of the surface or device to the chemical
  – Contact time must be adhered to in order to achieve desired level of disinfection
  – Surface or device must remain wet
• Physical configuration of the object (crevices, hinges etc)
  – Difficult to remove debris or ensure disinfectant comes in contact with all areas of a surface or device
• Temperature
  – Effectiveness is enhanced or hindered by various temperature levels
  – Higher temperatures can accelerate the evaporation of volatiles which can reduce the concentration & effectiveness
• pH
  – Some products need to be activated prior to use
  – Changes to pH can decrease (neutralize) some chemistries
• Storage & Shelf-life
  – Must consider how products are stored (too cold or hot)
  – Efficacy of product decreases once diluted

Factors Affecting Disinfectants

• Disinfection should be considered a two step process (clean, then disinfect)
• Disinfection is a result of allowing the appropriate contact (dwell) time on each surface
  – 10 minute contact time MEANS surface must stay wet for 10 minutes!

FACTS

• Hands play a major role in the transmission of pathogenic microorganisms to susceptible hosts
• Hands acquire known or potential pathogens by contact with objects and animate and inanimate surfaces
• Strict adherence to HH is more likely to prevent the spread of infections than procedures exceeding routine cleaning of the environment
Hand Hygiene

- Recognized as the best way of stopping the spread of organisms in this setting
- Soap and water
  - No indication for antimicrobial soap
  - 10-15 seconds of lathering
- Alcohol
  - more research into concentration required to kill all viruses

Adherence - Hand Hygiene

- Many studies conducted on HH report that HCWs practice appropriate HH only 25 – 50% of the time
- Female HCWs wash 33% more frequently then males, but when males did wash, they washed more effectively
- It is sobering to realize that despite the research, despite the product innovation & technology – it all comes down to us & whether or not we choose best practice & wash our hands

Conclusions

- Controlling Infectious Disease is everybody’s business
- Environmental Services department plays an important role in closing the gap in Infection Control
- Engage all personnel from every department

Disinfectant Selection

Remember:
- Match Product with Protocol
  - Surfaces vs Instruments
- Cleaning = 1st step
- Disinfection = 2nd step
- Contact Time is MANDITORY!

Handwashing

- Challenge staff to make a difference in the lives of patients, our families & ourselves by setting the standard, that model for HH against which everyone else is compared

Stay Healthy–Wash Your Hands
What YOU need to know

• “Coughs and Sneezes Spread Diseases”
• “If It’s Moist and It’s not Yours, Don’t Touch It”