Overview

- Hand Hygiene
- Standard and Isolation Precautions
- Discussion of Disinfection, Sterilization & Environmental cleaning
Goal of Infection Prevention

- Prevent Infections
- Prevent transmission

Preventing Transmission

Reason 1990
Preventing Transmission

Transmission of MDR bacteria

Patient with MDR bacteria

Ignaz Philipp Semmelweis (1818-1865)
Puerperal Fever “Childbed Fever”

- Postpartum Endometritis
  - Group A streptococci
  - Polymicrobial
- Currently Known Risk Factors
  - PROM and prolonged duration of labor
    - number of vaginal exams
    - internal monitoring
  - Maternal soft tissue damage
    - mid forceps delivery
    - C-section

Post-Partum Mortality

- Two wards, each had 3500 deliveries/year
  - Physicians and medical student
    - 600-800 mothers died/year
  - Midwives
    - 60 mothers died/year
Initial Interventions

- No change in mortality with:
  - Maternal delivery position
  - Decreasing the number of medical students
  - Eliminating foreign born medical students

Intervention Trial

Rub hands in chlorinated lime solution until slippery and cadaver smell gone before every vaginal exam
Why Did So Few Listen?

- “The Cause, Concept and Prophylaxis of Childbed Fever” published in 1861 - 14 years after his discovery
- 9 years before Pasteur discovered bacteria cause putrefaction
- 20 years before Lister and aseptic surgery
How NOT to do hand hygiene

Types of Hand Hygiene

- Handwashing - soap and water

- Alcoholic Hand Antiseptics (rubs)
  - 60-70% alcohol
    - Foams / rinse / gels
  - Emollients
    - glycerol, silicone oils, refattening agents
Handwashing Versus Alcohol Rub

- To achieve 100% compliance, handwashing with soap estimated to consume 16 hours of nursing time/day shift
- Alcohol hand disinfection from a bedside dispenser required only 3 hours

Alcohol as a Hand Antiseptic

- excellent against bacteria and fungi
  - good against mycobacteria
  - excellent against enveloped viruses
    - HIV, respiratory viruses
- Soap/water for C. difficile or Norovirus
Handwashing Works!

- Reduces organisms 10,000 fold
  - from $10^7$ CFU to $10^3$ CFU
- Reduces
  - overall healthcare associated infection rates
  - incidence of certain organisms and certain infections
  - mortality

After touching patient with MRSA

before using alcohol gel

After alcohol gel

Doebbeling 1988, AIM
Larson 1988, ICHE
Hand Ecology

- Resident flora
  - live in the upper hair follicles and dead epithelium
  - coagulase-negative Staphylococci and micrococi

- Transient flora
  - cannot multiply on skin
  - easily removed by mechanical means
  - Pseudomonas and other Gram-negative rods

- Somewhere in between…
  - S. aureus and beta-hemolytic streptococci

Purpose of Hand Hygiene

- Prevent cross transmission of microorganisms
  - from patient-to-patient
  - from body site to body site within the patient
When to Wash Your Hands?

- Hands soiled - soap and water (>15 sec)
- Hands appear clean - use alcohol hand rub
- Decontaminate hands prior to:
  - Direct patient contact (and after contact)
  - Before inserting central IV or urinary catheter
  - Moving from a contaminated site to a clean site
  - Putting on gloves (and after)

Hand Hygiene Compliance by Profession

- Nurses and students
  - Better than
- Physicians
- Technicians/therapists

Compliance varies by individual
More than by profession
What can we do to improve hand hygiene in our hospitals?

Be a Hand Hygiene Role Model

- Hypothesis: New hospital with better sink to patient ratios would improve hand hygiene compliance
- Poor compliance if senior member of medical team did not wash hands (OR=0.4, 95%CI 0.2 to 0.6)

Lankford et al. EID, 2003
Alcohol Rubs and Healthcare-Associated Infections

- Best study of hand hygiene Geneva hospital
- Alcohol hand rubs (in conjunction with hospital-wide campaign to increase compliance)
- Improved compliance (48% to 66%)
- Decreased
  - MRSA incidence (2.16 to 0.93 episodes per 10,000 patient days)
  - Overall nosocomial infections (17% to 10%)

Pittet, Lancet, 2000

Infection Rates with Improved Hand Hygiene

Pittet, Lancet 2000
C. difficile and hand hygiene

- Alcohol doesn’t kill spores
- Recommend soap and water if hospital having a problem with C. difficile

New approaches to improving hand hygiene

Dubberke et al ICHE 2008
Automated monitoring of Hand hygiene with RFID

Why RFID often doesn’t work?

- Bodies block RFID
- Fields difficult to orient

Pineles et al. AJIC 2013
Automated monitoring of hand hygiene

- Many companies
- Many unsupported claims...e.g. “100% reduction in infections”
- Technology, so far, inadequate to monitor hand hygiene accurately (RFID, Alcohol detection, WiFi, infrared etc...)

<table>
<thead>
<tr>
<th>Monitoring system</th>
<th>HCP tracking method</th>
</tr>
</thead>
<tbody>
<tr>
<td>nGage™</td>
<td>Badge</td>
</tr>
<tr>
<td>HyGreen</td>
<td>Badge</td>
</tr>
<tr>
<td>BIOVIGIL</td>
<td>Badge</td>
</tr>
<tr>
<td>Versus SafeHaven™</td>
<td>Badge</td>
</tr>
<tr>
<td>UltraClenz Patient Safeguard System™</td>
<td>Badge</td>
</tr>
<tr>
<td>Hyginex</td>
<td>Wristband</td>
</tr>
<tr>
<td>MedSense</td>
<td>Badge</td>
</tr>
<tr>
<td>HandGiene HHMS™</td>
<td>Badge or wristband</td>
</tr>
<tr>
<td>IntelligentM</td>
<td>Wristband</td>
</tr>
</tbody>
</table>

Pineles et al. AJIC in press

How to do hand hygiene
Handwashing is the single most important means of preventing the spread of infection.

Centers for Disease Control and Prevention
Isolation Precautions: two tiers

Standard Precautions

Transmission-Based Precautions

Standard Precautions – All Patients All The Time

- Gloves for contact with
  - blood or
  - any contaminated body fluid (wounds, diarrhea etc.)

- Gowns & goggles for splashes
Control & Prevention based on Modes of Transmission of Infectious Agents

- **Contact**
  - Direct (body-to-body)
  - Indirect (e.g., fomites/environment, HCWs’ hands)
- **Large Droplet** (>5 μm; travel 3-6 feet)
- **Small Droplet** (droplet nuclei ≤5 μm; remain airborne)

**Contact Precautions**

- VRE, MRSA, multiple antibiotic resistant gram negative rods, *Clostridium difficile* *
  - most common form of isolation
- **private room**
  - cohort same organisms
- gloves & gowns for any contact with patient or environment

*wash hands with soap and water for *C. difficile*
How often do we use Contact Precautions?

- 20 ICUs (BUGG)—Active surveillance for MRSA ~10%; MRSA or VRE~18%
- All VAs—clinical cultures <2% + MRSA, active surveillance 14-16% + MRSA
- Prevalence one hospital: 11% ward, 22.4% ICU
- Over 11 US hospitals: 11% ward, 25% ICU

Jain et al NEJM 2011; Day et al JHI 2011; Harris et al JAMA 2013; Dhar et al ICHE 2014

Effect of gloves and gowns on hand hygiene

- Recent studies argue better HH on exit
  1. BUGG Study: Entry 56% vs. 50%
     Exit 78% vs. 63%
  2. Multicenter study: Entry 43% vs. 30%
     Exit 63% vs. 47%
  3. 11 center US Study:
     (thanks M. Edmond)

Harris et al JAMA 2013; Morgan et al ICHE 2013; Dhar et al ICHE 2014
The most appropriate hospital room placement for a patient with seasonal influenza is:

1. No special precautions once anti-viral therapy initiated
2. Private room; surgical mask for patient contact (3-6 feet of patient)
3. Private room; surgical mask and gown to enter room
4. Private room with negative pressure
5. Private room, negative pressure and 100% exhaust

**Respiratory Protection**

- N95 Respirator
- Surgical Mask
Droplet precautions

- **rationale**
  - infectious particles are airborne, but large and fall out of the air within 3 feet of the patient

- **examples**
  - *influenza*, RSV, pertussis, meningococcus

- **consist of**
  - wear surgical masks for contact with in 6 feet
  - private room or cohort

Airborne precautions

- **rationale**
  - infectious particles are airborne due to small

- **examples**
  - tuberculosis, varicella, measles, smallpox

- **consists of**
  - Negative pressure room
  - wearing approved respiratory protection to enter patient room
Isolation Categories are Based on Modes of Transmission

<table>
<thead>
<tr>
<th>Isolation Category</th>
<th>Hand Hygiene</th>
<th>Private Room</th>
<th>Gloves</th>
<th>Gown</th>
<th>Mask</th>
<th>Eye Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>Yes</td>
<td>PRN</td>
<td>PRN</td>
<td>PRN</td>
<td>PRN</td>
<td>PRN</td>
</tr>
<tr>
<td>Droplet</td>
<td>Yes</td>
<td>Yes*</td>
<td>PRN</td>
<td>PRN</td>
<td>W/in 3 ft</td>
<td>PRN</td>
</tr>
<tr>
<td>Contact</td>
<td>Yes</td>
<td>Yes*</td>
<td>Yes</td>
<td>Yes</td>
<td>PRN</td>
<td>PRN</td>
</tr>
<tr>
<td>Airborne</td>
<td>Yes</td>
<td>All</td>
<td>PRN</td>
<td>PRN</td>
<td>N95</td>
<td>PRN</td>
</tr>
</tbody>
</table>

* When possible: cohort if not possible. Avoid rooming with immunosuppressed or high risk patients. All = Airborne Infection Isolation: negative pressure with no air recirculation (unless HEPA-filtered); 6-12 ACH.

Do Contact Precautions work?
Gowns and gloves are frequently contaminated

<table>
<thead>
<tr>
<th>Organism</th>
<th>Glove or Gown Contamination</th>
<th>Gown Contamination</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRE</td>
<td>11%</td>
<td>5%</td>
</tr>
<tr>
<td>MRSA</td>
<td>16%</td>
<td>5%</td>
</tr>
<tr>
<td>KPC</td>
<td>14%</td>
<td>3%</td>
</tr>
<tr>
<td>MDR <em>P. aeruginosa</em></td>
<td>14%</td>
<td>3%</td>
</tr>
<tr>
<td>MDR A. <em>baumannii</em></td>
<td>33%</td>
<td>13%</td>
</tr>
</tbody>
</table>

Snyder et al ICHE 2008; Morgan et al ICHE 2010/CCM 2012; Rock et al ICHE 2014

Reviews of Contact Precautions

• Cooper et al.
  – 4 studies with aggressive IC including CP were effective
  – 2 studies with endemic MRSA failed to show effect

• Marshall et al.
  – “unable to claim that our [MRSA isolation] practices are fully evidence-based and we question whether current guidelines can or should be followed”

Are there harms from Contact Precautions?

Patient Outcomes?

- ~30% fewer visits
- Possible delays in admit/discharge
- Adverse events
  - Mixed results
- Psychological effects
  - More depression in patients with MRSA/VRE
  - CP likely does not increase depression
- Patient satisfaction
  - Worse perception of care and satisfaction
A few words on Disinfection Sterilization & Cleaning

Bacteria live on surfaces

<table>
<thead>
<tr>
<th>Type of Bacteria</th>
<th>Duration of persistence (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acinetobacter</td>
<td>3 days - 5 months</td>
</tr>
<tr>
<td>C. difficile</td>
<td>5 months (spores)</td>
</tr>
<tr>
<td>Enterococcus</td>
<td>5 days – 4 months</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>7 days – 7 months</td>
</tr>
</tbody>
</table>

(yeast and viruses as well)

Kramer et al BMC ID 2006
Therefore….  

- There is a risk of inanimate surfaces remaining contaminated if not cleaned
- The higher the risk of the surface, the better it should be cleaned

Definitions

- **Clean**: remove all visible soil (dust, blood, soil, organic material)

- **Disinfect**: eliminate most pathogenic microorganisms except spores

- **Sterilize**: completely eliminate or destroy all forms of microbial life by physical or chemical processes (pressurized steam, ethylene oxide, hydrogen peroxide gas)
Selecting a Disinfectant

- Noncritical items: come in contact with intact skin but not mucous membranes
  - bedpans, blood pressure cuffs—requires low level disinfection

- Semicritical items: contacts mucous membranes or non-intact skin
  - respiratory therapy and anesthesia equipment, endoscopes—requires high level disinfection

- Critical items: enters a normally sterile tissue, the vascular system or blood will flow through it
  - urinary or IV catheters—items must be sterile

Common Disinfectants

- Chlorhexidine
  - skin preparation prior to surgery or procedures

- Alcohol
  - stethoscopes, rubber stoppers of vials

- Chlorine (bleach)/Hydrogen peroxide
  - counter tops, CPR mannequins, dialysis equipment, decontaminating blood spills

- Glutaraldehyde-like products
  - endoscopes
  - hemodialysers
Chlorine bleach: sodium hypochlorate

- Rapidly
  - bacteriocidal,
  - tuberculocidal
  - fungicidal
  - virucidal
- Broad spectrum
- Inexpensive
- Low toxicity

Uses: counter tops, dialysis equipment, decontaminating blood spills, rooms of C. difficile

- Corrosive
- Longer Contact time
- Employee complaints

Activated hydrogen peroxide

- Similar to bleach
- Some have shorter contact time (as low as 1 minute)
- Active against C. diff spores (and other organisms)
Fomites

- Stethoscopes
- BP cuffs
- Doctors ties

All become contaminated with use—MRSA, VRE, GNRs etc.

Porous vs. non-porous

- Non-porous = smooth (e.g. countertop)
- Porous = textured (cloth, money etc.)

- Non-porous (smooth) appears better at transmission
- Porous hard to clean

Fomites and transmission

- Capable of transmitting infections but no proven impact on transmission (few good studies)

Can be cleaned

- Wiping stethoscopes with alcohol or similar
- Wash clothing with washing machine

Protecting stethoscopes

- Silver impregnated diaphragm covers associated with higher colony counts!

Wood et al AJIC 2007
Room Contamination

Patients bacteria >> Foreign bacteria

Lin & Hayden CCM 2010
Reducing contamination of the inanimate environment

- **Cleaning**
  - Standard
  - Touchless
    - HPV
    - UV
- **Change the environment**
  - Coat surfaces
  - Use different surfaces

How to improve environmental cleaning

- **Improve housekeeping**
  - education, observation and supervision
- **Implement new approaches to monitoring**
- **Invest in new technology**

![Percentage of Positive Environmental Cultures for *Clostridium difficile* after Housekeeping Cleaning with Bleach](Guerrero2010)
Environmental Cleaning Checklist

Checklist tool to make sure key areas are cleaned—available from the Centers for Disease Control and Prevention

http://www.cdc.gov/HAI/toolkits/Evaluating-Environmental-Cleaning.html

Monitoring cleaning

- Direct observation
- Special Monitoring
  - Environmental cultures
  - Fluorescent Dye
  - ATP bioluminescence
Hydrogen Peroxide vapor

- New technology
- Unclear benefit
- Only used for terminal cleaning (not daily)
- Significant time requirement for room to be unoccupied
- Expensive
- Must be used in addition to normal cleaning

UV decontamination

- New technology
- Unclear benefit
- Only used for terminal cleaning (not daily)
- Significant time requirement for room to be unoccupied
- Expensive
- Must be used in addition to normal cleaning
Hydrogen peroxide vs. UV light

- Slower (~2 ½ hours)
- Kills more
- Faster (~1 hour)
- Only kills organism in line of sight

Havill et al 2012

Coating surfaces

- Lots of different materials
Changing the environment

- Copper
  - Described by Hippocrates to treat leg ulcers
  - >60% copper
  - In vitro effect
  - Less contamination of copper pens vs. stainless steel

Copper plating?
Copper high touch surfaces vs. plastic, had lower colony counts prolonged after cleaning

May reduce HAIs (biggest study involved 8 hospital beds and was not blinded)

Schmidt et al ICHE 2013; Salgado et al ICHE 2013

Treating surfaces summary

Experimental in my opinion
- Many surfaces
- Buildup of bioburden likely makes function difficult
- Lots of industry involvement

Anyone looking for a research topic to develop?
Summary

- Promote hand hygiene
  - Wash your hands
  - Be a leader and role model

- Promote compliance with isolation precautions
- Need for proper cleaning, disinfection, sterilization
- The environment could be cleaned better and likely transmits bacteria