Best Practices in Disinfection and Sterilization

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DISCLOSURES

• Consultation and Honoraria
  ▪ ASP (Advanced Sterilization Products), Clorox

• Honoraria
  ▪ 3M

• Grants
  ▪ CDC, CMS
Learning Objective

• Discuss a rational approach to disinfection and sterilization
• Identify best practices for low level disinfection, high level disinfection and sterilization
• Describe at least two unresolved issues/controversies related to disinfection and sterilization

Best Practices in Disinfection and Sterilization

• Best Practices
  ■ Sterilization of critical items
    ◆ Biological indicators, cleaning indicators, washer disinfectors
  ■ High-level disinfection for semi-critical items
    ◆ Endoscope reprocessing issues, laryngoscopes
  ■ Low-level disinfection of non-critical items
    ◆ New low-level disinfectants, curtain decontamination, selecting a disinfectant
  ■ D/S and Emerging Pathogens
    ◆ MERS-CoV, Enterovirus D68, Ebola
# Best Practices in Disinfection and Sterilization

- **Best Practices**
  - Sterilization of critical items
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    - MERS-CoV, Enterovirus D68, Ebola

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# DISINFECTION AND STERILIZATION

- EH Spaulding believed that how an object will be disinfected depended on the object's intended use
  - **CRITICAL** - objects which enter normally sterile tissue or the vascular system or through which blood flows should be sterile
  - **SEMICRITICAL** - objects that touch mucous membranes or skin that is not intact require a disinfection process (high-level disinfection[HLD]) that kills all microorganisms except for high numbers of bacterial spores
  - **NONCRITICAL** - objects that touch only intact skin require low-level disinfection
Sterilization of “Critical Objects”

Steam sterilization
Hydrogen peroxide gas plasma
Ethylene oxide
Ozone
Vaporized hydrogen peroxide
Steam formaldehyde
Cleaning

- Items must be cleaned using water with detergents or enzymatic cleaners before processing.
- Cleaning reduces the bioburden and removes foreign material (organic residue and inorganic salts) that interferes with the sterilization process.
- Cleaning and decontamination should be done as soon as possible after the items have been used as soiled materials become dried onto the instruments.
Washer/Disinfector

• Five Chambers
  - Pre-wash: water/ enzymatic is circulated over the load for 1 min
  - Wash: detergent wash solution (150°F) is sprayed over load for 4 min
  - Ultrasonic cleaning: basket is lowered into ultrasonic cleaning tank with detergent for 4 min
  - Thermal and lubricant rinse: hot water (180°F) is sprayed over load for 1 min; instrument milk lubricant is added to the water and is sprayed over the load
  - Drying: blower starts for 4 min and temperature in drying chamber 180°F
Washer/Disinfector
Removal/Inactivation of Inoculum (Exposed) on Instruments

<table>
<thead>
<tr>
<th>WD Conditions</th>
<th>Organism</th>
<th>Inoculum</th>
<th>Log Reduction</th>
<th>Positives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine</td>
<td>MRSA</td>
<td>2.6x10⁷</td>
<td>Complete</td>
<td>0/8</td>
</tr>
<tr>
<td>Routine</td>
<td>VRE</td>
<td>2.6x10⁷</td>
<td>Complete</td>
<td>0/8</td>
</tr>
<tr>
<td>Routine</td>
<td>P aeruginosa</td>
<td>2.1x10⁷</td>
<td>Complete</td>
<td>0/8</td>
</tr>
<tr>
<td>Routine</td>
<td>M terrae</td>
<td>1.4x10⁸</td>
<td>7.8</td>
<td>2/8</td>
</tr>
<tr>
<td>Routine</td>
<td>GS spores</td>
<td>5.3x10⁵</td>
<td>4.8</td>
<td>11/14</td>
</tr>
<tr>
<td>No Enz/Det</td>
<td>VRE</td>
<td>2.5x10⁷</td>
<td>Complete</td>
<td>0/10</td>
</tr>
<tr>
<td>No Enz/Det</td>
<td>GS spores</td>
<td>8.3x10⁶</td>
<td>5.5</td>
<td>8/10</td>
</tr>
</tbody>
</table>

Washer/disinfectors are very effective (>7 log₁₀ reduction) in removing/inactivating microorganisms from instruments
Cleaning Indicators for Washer Disinfector

- Monitor the automated washer and instrument cleaning chemistry functionality; AAMI recommends weekly (preferably daily)
- Washer indicators have been used in Europe and Canada and some US hospitals
- Indicator includes proteins, lipids, and polysaccharides to mimic common challenging test soils
- Washer indicators are chemical indicators imprinted with a dried test soil formula and a dye

Rapid Readout BIs for Steam Now Require a 1-3h Readout Compared to 24-48h
Attest™ Super Rapid Readout Biological Indicators
Commercially available

<table>
<thead>
<tr>
<th>1491 BI (blue cap)</th>
<th>1492V BI (brown cap)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Monitors 270°F and 275°F gravity-displacement steam sterilization cycles</td>
<td>• Monitors 270°F and 275°F dynamic-air-removal (pre-vacuum) steam sterilization cycles</td>
</tr>
<tr>
<td>• 30 minute result (from 1 hour)</td>
<td>• 1 hour result (from 3 hours)</td>
</tr>
</tbody>
</table>

Immediate-Use Steam Sterilization
AAMI, AORN, APIC, IAHCSMM

• “Flash” originally defined as sterilization of an unwrapped medical instrument subjected to an abbreviated exposure time and then used after cycle completion without storage (contrast to “terminal sterilization”)
• “Flash sterilization” antiquated term
• IUSS has the same critical reprocessing steps (cleaning, decontaminating and transporting sterilized items)
Immediate-Use Steam Sterilization
AAMI, AORN, APIC, IAHCSMM

• “Immediate use” is broadly defined as the shortest possible time between a sterilized items removal from the sterilizer and its aseptic transfer to the sterile field.

• Because of the potential for serious infections, implanted surgical devices should not be sterilized by immediate-use method unless a documented emergency situation when no option is available.

Best Practices in Disinfection and Sterilization

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  - NONCRITICAL - objects that touch only intact skin require low-level disinfection

Reprocessing Semicritical Items

- New Developments in Reprocessing
  - Endoscopes
  - Laryngoscopes
  - Infrared coagulation device
  - Nasopharyngoscopes
  - Endocavitary probe
  - Prostate biopsy probes
  - Tonometers
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

ENDOSCOPES

- Widely used diagnostic and therapeutic procedure (11-22 million GI procedures annually in the US)
- GI endoscope contamination during use ($10^9$ 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 very low, endoscopes represent a significant risk of disease transmission
Transmission of Infection by Endoscopy

<table>
<thead>
<tr>
<th>Scope</th>
<th>Outbreaks</th>
<th>Micro (primary)</th>
<th>Pts Contaminated</th>
<th>Pts Infected</th>
<th>Cause (primary)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper GI</td>
<td>19</td>
<td>Pa, H. pylori, Salmonella</td>
<td>169</td>
<td>56</td>
<td>Cleaning/Disinfection (C/D)</td>
</tr>
<tr>
<td>Sigmoid/Colonoscopy</td>
<td>5</td>
<td>Salmonella, HCV</td>
<td>14</td>
<td>6</td>
<td>Cleaning/Disinfection</td>
</tr>
<tr>
<td>ERCP</td>
<td>23</td>
<td>Pa</td>
<td>152</td>
<td>89</td>
<td>C/D, water bottle, AER</td>
</tr>
<tr>
<td>Bronchoscopy</td>
<td>51</td>
<td>Pa, Mtb, Mycobacteria</td>
<td>778</td>
<td>98</td>
<td>C/D, AER, water</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>98</strong></td>
<td></td>
<td><strong>1113</strong></td>
<td><strong>249</strong></td>
<td></td>
</tr>
</tbody>
</table>

Based on outbreak data, if eliminated deficiencies associated with cleaning, disinfection, AER, contaminated water and drying would eliminate about 85% of the outbreaks.
FEATURES OF ENDOSCOPES THAT PREDISPOSE TO DISINFECTION FAILURES

- Require low temperature disinfection
- Long narrow lumens
- Right angle turns
- Blind lumens
- May be heavily contaminated with pathogens (9-10 logs inside)
- Cleaning (4-6 log₁₀ reduction) and HLD (4-6 log₁₀ reduction) essential for patient safe instrument

MULTISOCIETY GUIDELINE ON REPROCESSING GI ENDOSCOPES, 2011
Petersen et al. ICHE. 2011;32:527
ENDOSCOPE REPROCESSING
Multi-Society Guideline on Endoscope Reprocessing, 2011

- 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
Performed all 12 steps with only 1.4% of endoscopes using manual versus 75.4% of those processed using AER

<table>
<thead>
<tr>
<th>Observed Activity</th>
<th>Steps Completed (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leak test performed in clear water</td>
<td>77</td>
</tr>
<tr>
<td>Disassemble endoscope completely</td>
<td>100</td>
</tr>
<tr>
<td>Brush all endoscope channels and components</td>
<td>43</td>
</tr>
<tr>
<td>Immense endoscope completely in detergent</td>
<td>99</td>
</tr>
<tr>
<td>Immense components completely in detergent</td>
<td>99</td>
</tr>
<tr>
<td>Flush endoscope with detergent</td>
<td>92</td>
</tr>
<tr>
<td>Rinse endoscope with water</td>
<td>98</td>
</tr>
<tr>
<td>Purge endoscope with air</td>
<td>84</td>
</tr>
<tr>
<td>Load and complete automated cycle for high-level disinfection</td>
<td>100</td>
</tr>
<tr>
<td>Flush endoscope with alcohol</td>
<td>86</td>
</tr>
<tr>
<td>Use forced air to dry endoscope</td>
<td>45</td>
</tr>
<tr>
<td>Wipe down external surfaces before hanging to dry</td>
<td>90</td>
</tr>
</tbody>
</table>

ENDOSCOPE REPROCESSING: CHALLENGES
NDM-Producing E. coli Associated ERCP
Epstein et al. JAMA 2014;312:1447-1455

NDM-producing E. coli recovered from elevator channel
ENDOSCOPE REPROCESSING: CHALLENGES

Complex [elevator channel]-$10^9$ bacteria

Surgical instruments-$<10^2$ bacteria

NDM-Producing *E. coli* Associated ERCP

Epstein et al. JAMA 2014;312:1447-1455

- March-July 2013, 9 patients with cultures for New Delhi Metallo-β-Lactamase producing *E. coli* associated with ERCP
- History of undergoing ERCP strongly associated with cases
- NDM-producing *E. coli* recovered from elevator channel
- No lapses in endoscope reprocessing identified
- Hospital changed from automated HLD to ETO sterilization
- Due to either failure of personnel to complete required process every time or intrinsic problems with these scopes (not altered reprocessing)
ENDOSCOPE REPROCESSING: CHALLENGES
NDM-Producing \( E. \) coli Associated ERCP
Epstein et al. JAMA 2014;312:1447-1455

• Recommendations
  - Education/adherence monitoring
    - Certification/competency testing of reprocessing staff
  - Enforcement of best practices-preventive maintenance schedule
  - Improved definition of the scope of the issue and contributing factors
  - Development of innovative approaches to improve and assess the process
    - Systematic assessment of the ability of AERs/technicians to clean/disinfect scopes
    - Disinfection evaluation testing that relates to risk of pathogen transmission
  - Perform periodic microbiologic surveillance of duodenoscopes (e.g., weekly, monthly) to assess whether bacteria have survived the reprocessing procedure.

GI Endoscopes: Shift from Disinfection to Sterilization
Rutala, Weber. JAMA 312:1405-1406

Gastrointestinal Endoscopes
A Need to Shift From Disinfection to Sterilization?
William A. Rutala, PhD, MPH; David J. Weber, MD, MPH

More than 10 million gastrointestinal endoscopic procedures are performed annually in the United States for diagnostic purposes, therapeutic interventions, or both. Because gastrointestinal endoscopes contact mucosal surfaces, use of a contaminated endoscope may lead to patient-to-patient transmission of potential pathogens with a subsequent risk of infection.

In this issue of JAMA, Epstein and colleagues report findings from their investigation of a cluster of New Delhi metallo-\( \beta \)-lactamase (NDM)-producing \( E. \) coli associated with gastrointestinal endoscopy that occurred from March 2013 to July 2013 in a single hospital in northeastern Illinois. During the 5-month period, 9 pa...
GI Endoscopes:
Shift from Disinfection to Sterilization
Rutala, Weber. JAMA 312:1405-1406

• Endoscopes undergo high-level disinfection
• More HAIs linked to endoscopes than any other medical device
• Data demonstrate all steps in reprocessing rarely performed
• Endemic transmission may go unrecognized due to inadequate surveillance of outpatient procedures
• Margin of safety is minimal (0-2 log_{10} margin of safety)
• What should be done: new endoscope reprocessing technologies need to be developed that reliably result in sterilization of GE endoscopes via an FDA-cleared sterilization process

Margin of Safety
HLD of Colonoscopes vs Sterilization of Surgical Devices
Reprocessing of Rigid Laryngoscopes

- Limited guidelines for reprocessing laryngoscope’s blades and handles
- Many hospitals consider blade as semicritical (HLD) and handle as noncritical (LLD)
- Blades linked to HAIs; handles not directly linked to HAIs but contamination with blood/OPIM suggest its potential and blade and handle function together
- Ideally, clean then HLD/sterilize blades and handles (UNCHC-blades wrapped in a tray-HPGP; handle wrapped in tray [without batteries]-steam); the blades and handles placed together in a Ziploc bag. Blades and handles checked for function prior to packaging.

Contamination of Laryngoscope Handles

J Hosp Infect 2010;74:123
- 55/64 (86%) of the handles deemed “ready for patient use” positive for S. aureus, enterococci, Klebsiella, Acinetobacter

Anesth Analg 2009;109:479
- 30/40 (75%) samples from handles positive (CONS, Bacillus, Streptococcus, S. aureus, Enterococcus) after cleaning

AANA J 1997;65:241
- 26/65 (40%) of the handles and 13/65 (20%) of the blades were positive for occult blood. These blades and handles were identified as ready for patient use.
Laryngoscopes Blades
The Joint Commission, FAQ, October 24, 2011

• How should we process and store laryngoscope blades?
  ■ Processed via sterilization or HLD
  ■ Packaged in some way
  ■ Stored in a way that prevents recontamination.
    Examples of compliant storage include, but are not limited to, a peel pack post steam sterilization (long-term) or wrapping in a sterile towel (short term)
  ■ Should not place unwrapped blades in an anesthesia drawer

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  ■ D/S and Emerging Pathogens
    ◆ MERS-CoV, HPV, C. difficile, Prions, Enterovirus 68, Ebola
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### ENVIRONMENTAL CONTAMINATION LEADS TO HAIs

- There is increasing evidence to support the contribution of the environment to disease transmission
- This supports comprehensive disinfecting regimens (goal is not sterilization) to reduce the risk of acquiring a pathogen from the healthcare environment/equipment

### KEY PATHOGENS WHERE ENVIRONMENTAL SURFACES PLAY A ROLE IN TRANSMISSION

- MRSA
- VRE
- *Acinetobacter* spp.
- *Clostridium difficile*
- Norovirus
- Rotavirus
- SARS
ENVIRONMENTAL CONTAMINATION
ENDEMIC AND EPIDEMIC MRSA

ENVIRONMENTAL SURVIVAL OF KEY PATHOGENS ON HOSPITAL SURFACES

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Survival Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. aureus (including MRSA)</td>
<td>7 days to &gt;12 months</td>
</tr>
<tr>
<td>Enterococcus spp. (including VRE)</td>
<td>5 days to &gt;46 months</td>
</tr>
<tr>
<td>Acinetobacter spp.</td>
<td>3 days to 11 months</td>
</tr>
<tr>
<td>Clostridium difficile (spores)</td>
<td>&gt;5 months</td>
</tr>
<tr>
<td>Norovirus (and feline calicivirus)</td>
<td>8 hours to &gt;2 weeks</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>6 hours to 16 months</td>
</tr>
<tr>
<td>Klebsiella spp.</td>
<td>2 hours to &gt;30 months</td>
</tr>
</tbody>
</table>

FREQUENCY OF ACQUISITION OF MRSA ON GLOVED HANDS AFTER CONTACT WITH SKIN AND ENVIRONMENTAL SITES

No significant difference on contamination rates of gloved hands after contact with skin or environmental surfaces (40% vs 45%; p=0.59)


Thoroughness of Environmental Cleaning


Mean = 32%
EVALUATION OF HOSPITAL ROOM ASSIGNMENT AND ACQUISITION OF CDI

- Study design: Retrospective cohort analysis, 2005-2006
- Setting: Medical ICU at a tertiary care hospital
- Methods: All patients evaluated for diagnosis of CDI 48 hours after ICU admission and within 30 days after ICU discharge
- Results (acquisition of CDI)
  - Admission to room previously occupied by CDI = 11.0%
  - Admission to room not previously occupied by CDI = 4.6% (p=0.002)

Shaughnessy MK, et al. ICHE 2011;32:201-206

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>HR (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior room occupant with CDI</td>
<td>2.35 (1.21-4.54)</td>
<td>.01</td>
</tr>
<tr>
<td>Older age</td>
<td>1.00 (1.00-1.01)</td>
<td>.06</td>
</tr>
<tr>
<td>Higher APACHE III score</td>
<td>1.00 (1.00-1.01)</td>
<td>.06</td>
</tr>
<tr>
<td>Proton pump inhibitor use</td>
<td>1.11 (0.64-2.78)</td>
<td>.85</td>
</tr>
<tr>
<td>Antibiotic exposure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norfloxacin</td>
<td>0.38 (0.05-2.72)</td>
<td>.33</td>
</tr>
<tr>
<td>Levofloxacin</td>
<td>1.08 (0.67-1.73)</td>
<td>.75</td>
</tr>
<tr>
<td>Ciprofloxacin</td>
<td>0.49 (0.15-1.67)</td>
<td>.33</td>
</tr>
<tr>
<td>Fluoroquinolones</td>
<td>1.17 (0.72-1.91)</td>
<td>.33</td>
</tr>
<tr>
<td>Ceftriaxime</td>
<td>0.45 (0.14-1.42)</td>
<td>.17</td>
</tr>
<tr>
<td>Third- or fourth-generation cephalosporin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vancomycin</td>
<td>1.17 (0.76-1.79)</td>
<td>.48</td>
</tr>
<tr>
<td>Carbapenems</td>
<td>1.05 (0.63-1.75)</td>
<td>.84</td>
</tr>
<tr>
<td>Piperacillin-tazobactam</td>
<td>1.11 (0.82-2.51)</td>
<td>.27</td>
</tr>
<tr>
<td>Other penicillin</td>
<td>0.47 (0.23-0.98)</td>
<td>.24</td>
</tr>
<tr>
<td>Meropenem</td>
<td>1.51 (0.83-2.87)</td>
<td>.13</td>
</tr>
<tr>
<td>Aminoglycosides</td>
<td>1.27 (0.78-2.06)</td>
<td>.35</td>
</tr>
<tr>
<td>Multiple (≥2) antibiotic classes</td>
<td>1.28 (0.75-2.23)</td>
<td>.37</td>
</tr>
</tbody>
</table>

NOTE. APACHE, Acute Physiology and Chronic Health Evaluation; CI, confidence interval; HR, hazard ratio.

RELATIVE RISK OF PATHOGEN ACQUISITION IF PRIOR ROOM OCCUPANT INFECTED~120%

* Prior room occupant infected; ^Any room occupant in prior 2 weeks infected. Otter, Yezli, French. ICHE. 2012;32:687-699
Environmental Disinfection Interventions

Donskey CJ. Am J Infect Control 2013;41:S12

- Cleaning product substitutions
- Improvements in the effectiveness of cleaning and disinfection practices
  - Education
  - Audit and feedback
  - Addition of housekeeping personnel or specialized cleaning staff
- Automated technologies
- Conclusion: Improvements in environmental disinfection may prevent transmission of pathogens and reduce HAIs
LOW-LEVEL DISINFECTION FOR NONCRITICAL EQUIPMENT AND SURFACES

<table>
<thead>
<tr>
<th>Germicide</th>
<th>Use Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethyl or isopropyl alcohol</td>
<td>70-90%</td>
</tr>
<tr>
<td>Chlorine</td>
<td>100ppm (1:500 dilution)</td>
</tr>
<tr>
<td>Phenolic</td>
<td>UD</td>
</tr>
<tr>
<td>Iodophor</td>
<td>UD</td>
</tr>
<tr>
<td>Quaternary ammonium</td>
<td>UD</td>
</tr>
<tr>
<td>Improved hydrogen peroxide (HP)</td>
<td>0.5%, 1.4%</td>
</tr>
</tbody>
</table>

UD=Manufacturer's recommended use dilution

REVIEW THE “BEST” PRACTICES FOR CLEANING AND DISINFECTING

Cleaning and disinfecting is one-step with disinfectant-detergent (EPA claim in presence of soil). No pre-cleaning necessary unless spill or gross contamination.
BACTERICIDAL ACTIVITY OF DISINFECTANTS (log_{10} reduction) WITH A CONTACT TIME OF 1m WITH/WITHOUT FCS.
Rutala et al. ICHE. 2012;33:1159

<table>
<thead>
<tr>
<th>Organism</th>
<th>IHP-0.5%</th>
<th>0.5% HP</th>
<th>IHP Cleaner-Dis 1.4%</th>
<th>1.4% HP</th>
<th>3.0% HP</th>
<th>QUAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRSA</td>
<td>&gt;6.6</td>
<td>&lt;4.0</td>
<td>&gt;6.5</td>
<td>&lt;4.0</td>
<td>&lt;4.0</td>
<td>5.5</td>
</tr>
<tr>
<td>VRE</td>
<td>&gt;6.3</td>
<td>&lt;3.6</td>
<td>&gt;6.1</td>
<td>&lt;3.6</td>
<td>&lt;3.6</td>
<td>4.6</td>
</tr>
<tr>
<td>MDR-Ab</td>
<td>&gt;6.8</td>
<td>&lt;4.3</td>
<td>&gt;6.7</td>
<td>&lt;4.3</td>
<td>&lt;4.3</td>
<td>&gt;6.8</td>
</tr>
<tr>
<td>MRSA, FCS</td>
<td>&gt;6.7</td>
<td>NT</td>
<td>&gt;6.7</td>
<td>NT</td>
<td>&lt;4.2</td>
<td>&lt;4.2</td>
</tr>
<tr>
<td>VRE, FCS</td>
<td>&gt;6.3</td>
<td>NT</td>
<td>&gt;6.3</td>
<td>NT</td>
<td>&lt;3.8</td>
<td>&lt;3.8</td>
</tr>
<tr>
<td>MDR-Ab, FCS</td>
<td>&gt;6.6</td>
<td>NT</td>
<td>&gt;6.6</td>
<td>NT</td>
<td>&lt;4.1</td>
<td>&gt;6.6</td>
</tr>
</tbody>
</table>

Improved hydrogen peroxide is significantly superior to standard HP at same concentration and superior or similar to the QUAT tested.

PROPERTIES OF AN IDEAL DISINFECTANT

• Broad spectrum-wide antimicrobial spectrum
• Fast acting-should produce a rapid kill
• Remains Wet-meet listed kill/contact times with a single application
• Not affected by environmental factors-active in the presence of organic matter
• Nontoxic-not irritating to user
• Surface compatibility-should not corrode instruments and metallic surfaces
• Persistence-should have sustained antimicrobial activity
• Easy to use
• Acceptable odor
• Economical-cost should not be prohibitively high
• Soluble (in water) and stable (in concentrate and use dilution)
• Cleaner (good cleaning properties) and nonflammable
## Key Considerations for Selecting the Ideal Disinfectant for Your Facility


<table>
<thead>
<tr>
<th>Consideration</th>
<th>Questions to Ask</th>
<th>Score (1-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kill Claims</td>
<td>Does the product kill the most prevalent healthcare pathogens</td>
<td></td>
</tr>
<tr>
<td>Kill Times and Wet-Contact Times</td>
<td>How quickly does the product kill the prevalent healthcare pathogens. Ideally, contact time greater than or equal to the kill claim.</td>
<td></td>
</tr>
<tr>
<td>Safety</td>
<td>Does the product have an acceptable toxicity rating, flammability rating</td>
<td></td>
</tr>
<tr>
<td>Ease-of-Use</td>
<td>Odor acceptable, shelf-life, in convenient forms (wipes, spray), water soluble, works in organic matter, one-step (cleans/disinfects)</td>
<td></td>
</tr>
<tr>
<td>Other factors</td>
<td>Supplier offer comprehensive training/education, 24/7 customer support, overall cost acceptable (product capabilities, cost per compliant use, help standardize disinfectants in facility)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Consider the 5 components shown, give each product a score (1 is worst and 10 is best) in each of the 5 categories, and select the product with the highest score as the optimal choice (maximum score is 50).

---

**ALL “TOUCHABLE” (HAND CONTACT) SURFACES SHOULD BE WIPED WITH DISINFECTANT**

“High touch” objects only recently defined (no significant differences in microbial contamination of different surfaces) and “high risk” objects not epidemiologically defined.
### Table. Rates of Cleaning for 14 Types of High-Risk Objects

<table>
<thead>
<tr>
<th>Object</th>
<th>Percentage cleaned</th>
<th>95% CI</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sink</td>
<td>82 ± 12</td>
<td>57-97</td>
<td>77-88</td>
</tr>
<tr>
<td>Toilet seat</td>
<td>76 ± 18</td>
<td>40-98</td>
<td>68-84</td>
</tr>
<tr>
<td>Tray table</td>
<td>77 ± 15</td>
<td>53-100</td>
<td>71-84</td>
</tr>
<tr>
<td>Bedside table</td>
<td>64 ± 22</td>
<td>23-100</td>
<td>54-73</td>
</tr>
<tr>
<td>Toilet handle</td>
<td>60 ± 22</td>
<td>23-89</td>
<td>50-69</td>
</tr>
<tr>
<td>Side rail</td>
<td>60 ± 21</td>
<td>25-96</td>
<td>51-69</td>
</tr>
<tr>
<td>Call box</td>
<td>50 ± 19</td>
<td>9-90</td>
<td>42-58</td>
</tr>
<tr>
<td>Telephone</td>
<td>49 ± 16</td>
<td>18-86</td>
<td>42-56</td>
</tr>
<tr>
<td>Chair</td>
<td>48 ± 28</td>
<td>11-100</td>
<td>35-61</td>
</tr>
<tr>
<td>Toilet door knobs</td>
<td>28 ± 22</td>
<td>0-82</td>
<td>18-37</td>
</tr>
<tr>
<td>Toilet hand hold</td>
<td>28 ± 23</td>
<td>0-90</td>
<td>18-38</td>
</tr>
<tr>
<td>Bedpan cleaner</td>
<td>25 ± 18</td>
<td>0-79</td>
<td>17-33</td>
</tr>
<tr>
<td>Room door knobs</td>
<td>23 ± 19</td>
<td>2-73</td>
<td>15-31</td>
</tr>
<tr>
<td>Bathroom light switch</td>
<td>20 ± 21</td>
<td>0-81</td>
<td>11-30</td>
</tr>
</tbody>
</table>

**Note.** CI, confidence interval.

---

### FREQUENCY (mean) OF HCP CONTACT FOR SURFACES IN AN ICU (N=28) AND WARD (N=24)

#### ICU

#### WARD

### Microbial Burden on Room Surfaces as a Function of Frequency of Touching


<table>
<thead>
<tr>
<th>Surface</th>
<th>Prior to Cleaning Mean CFU/RODAC (95% CI)</th>
<th>Post Cleaning (mean) Mean CFU/RODAC (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>71.9 (46.5-97.3)</td>
<td>9.6</td>
</tr>
<tr>
<td>Medium</td>
<td>44.2 (28.1-60.2)</td>
<td>9.3</td>
</tr>
<tr>
<td>Low</td>
<td>56.7 (34.2-79.2)</td>
<td>5.7</td>
</tr>
</tbody>
</table>

- The level of microbial contamination of room surfaces is similar regardless of how often they are touched both before and after cleaning.
- Therefore, all surfaces that are touched must be cleaned and disinfected.
Blood Pressure Cuff
Non-Critical Patient Care Item

Surface Disinfection
Noncritical Patient Care

• Disinfecting Noncritical Patient-Care Items
  ■ Process noncritical patient-care equipment with a EPA-registered disinfectant at the proper use dilution and a contact time of at least 1 min. *Category IB*
  ■ Ensure that the frequency for disinfecting noncritical patient-care surfaces be done minimally when visibly soiled and on a regular basis (such as after each patient use or once daily or once weekly). *Category IB*
Surface Disinfection
Environmental Surfaces

• Disinfecting Environmental Surfaces in HCF
  ■ Disinfect (or clean) housekeeping surfaces (e.g., floors, tabletops) on a regular basis (e.g., daily, three times per week), when spills occur, and when these surfaces are visibly soiled. *Category IB*
  ■ Use disinfectant for housekeeping purposes where: uncertainty exists as to the nature of the soil on the surfaces (blood vs dirt); or where uncertainty exists regarding the presence of multi-drug resistant organisms on such surfaces. *Category II*
“The patient in the next bed is highly infectious. Thank God for these curtains.”

Hospital Privacy Curtains
(pre- and post-intervention study; sampled curtain, sprayed “grab area” 3x from 6-8” with 1.4% IHP and allowed 2 minute contact; sampled curtain)
Decontamination of Curtains with Activated HP (1.4%)

<table>
<thead>
<tr>
<th>CP for:</th>
<th>Before Disinfection CFU/5 Rodacs (#Path)</th>
<th>After Disinfection CFU/5 Rodacs (#Path)</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRSA</td>
<td>330 (10 MRSA)</td>
<td>21 (0 MRSA)</td>
<td>93.6%</td>
</tr>
<tr>
<td>MRSA</td>
<td>186 (24 VRE)</td>
<td>4* (0 VRE)</td>
<td>97.9%</td>
</tr>
<tr>
<td>MRSA</td>
<td>108 (10 VRE)</td>
<td>2* (0 VRE)</td>
<td>98.2%</td>
</tr>
<tr>
<td>VRE</td>
<td>75 (4 VRE)</td>
<td>0 (0 VRE)</td>
<td>100%</td>
</tr>
<tr>
<td>VRE</td>
<td>68 (2 MRSA)</td>
<td>2* (0 MRSA)</td>
<td>97.1%</td>
</tr>
<tr>
<td>VRE</td>
<td>98 (40 VRE)</td>
<td>1* (0 VRE)</td>
<td>99.0%</td>
</tr>
<tr>
<td>MRSA</td>
<td>618 (341 MRSA)</td>
<td>1* (0 MRSA)</td>
<td>99.8%</td>
</tr>
<tr>
<td>MRSA</td>
<td>55 (1 VRE)</td>
<td>0 (0 MRSA)</td>
<td>100%</td>
</tr>
<tr>
<td>MRSA, VRE</td>
<td>320 (0 MRSA, 0 VRE)</td>
<td>1* (0 MRSA, 0 VRE)</td>
<td>99.7%</td>
</tr>
<tr>
<td>MRSA</td>
<td>288 (0 MRSA)</td>
<td>1* (0 MRSA)</td>
<td>99.7%</td>
</tr>
<tr>
<td>Mean</td>
<td>2146/10=215 (432/10=44)</td>
<td>33*/10=3 (0)</td>
<td>98.5%</td>
</tr>
</tbody>
</table>

* All isolates after disinfection were Bacillus sp; now treat CP patient curtains at discharge with IHP

TERMINAL CLEANING PRACTICE

- Some hospitals change curtains after Contact Precaution patients
- At UNC Health Care, privacy curtains are changed routinely every 3 months or when visible soiled
- In all discharge rooms, frequently touched surfaces of the curtains is sprayed with approved disinfectant (e.g., improved HP)
- Vinyl shower curtains are cleaned when visibly soiled or replaced as needed
## WIPES

- Wipes-cotton, disposable, microfiber
- Wipe should have sufficient wetness to achieve the disinfectant contact time. Discontinue use of the wipe if no longer leaves the surface visible wet for ≥ 1 minute.
- When the wipe is visibly soiled, flip to a clean/unused side and continue until all sides of the wipe have been used (or get another wipe)
- Dispose of the wipe/cloth wipe appropriately
- Do not re-dip a wipe into the clean container of pre-saturated wipes

## DISPOSABLE WIPES

- Wetness-ideally, stays wet long enough to meet EPA-registered contact times (e.g., bacteria-1 minute).
- Surface Coverage-premoistened wipe keeps surface area wet for 1-2 minutes (e.g., 12”x12” wipes keep 55.5 sq ft wet for 2m; 6”x5” equipment wipe keeps 6.7 sq ft wet for 2m). Wipe size based on use from small surfaces to large surfaces like mattress covers
- Durable substrate-will not easily tear or fall apart
- Top-keep closed or wipes dry out
Thoroughness of Environmental Cleaning


Mean = 32%

>110,000 Objects

OPTIONS FOR EVALUATING ENVIRONMENTAL CLEANING

Guh, Carling. December 2010. CDC

- Joint effort of ES and IC
- Responsibilities of ES staff and other staff for cleaning surfaces clearly defined
- Education of ES staff to define expectations
- Development of measures for monitoring
- Interventions to optimize cleaning
- Report results to ICC and facility leadership
MONITORING THE EFFECTIVENESS OF CLEANING
Cooper et al. AJIC 2007;35:338

- Visual assessment—not a reliable indicator of surface cleanliness
- ATP bioluminescence—measures organic debris (each unit has own reading scale, <250-500 RLU)
- Microbiological methods—<2.5CFUs/cm²-pass; can be costly and pathogen specific
- Fluorescent marker—transparent, easily cleaned, environmentally stable marking solution that fluoresces when exposed to an ultraviolet light (applied by IP unbeknown to EVS, after EVS cleaning, markings are reassessed)

DAZO Solution (AKA – Goo)
TARGET ENHANCED

TERMINAL ROOM CLEANING: DEMONSTRATION OF IMPROVED CLEANING

- Evaluated cleaning before and after an intervention to improve cleaning
- 36 US acute care hospitals
- Assessed cleaning using a fluorescent dye
- Interventions
  - Increased education of environmental service workers
  - Feedback to environmental service workers
  - Regularly change “dotted” items to prevent targeting objects

Carling PC, et al. ICHE 2008;29:1035-41
SURFACE EVALUATION USING ATP BIOLUMINESCENCE

Swab surface → luciferase tagging of ATP → Hand held luminometer

Used in the commercial food preparation industry to evaluate surface cleaning before reuse and as an educational tool for more than 30 years.

MONITORING THE EFFECTIVENESS OF CLEANING
Cooper et al. AJIC 2007;35:338

• Visual assessment-not a reliable indicator of surface cleanliness
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• Fluorescent marker-transparent, easily cleaned, environmentally stable marking solution that fluoresces when exposed to an ultraviolet light (applied by IP unbeknown to EVS, after EVS cleaning, markings are reassessed)
METHODS TO IMPROVE DISINFECTION OF ENVIRONMENTAL SURFACES

• Follow “best” practices for room cleaning and disinfection
  ▪ Follow CDC guideline for choosing disinfectant and “best” practices
  ▪ Improve training/education of environmental service workers
  ▪ Use of checklists to ensure all room surfaces are cleaned/disinfected
  ▪ Assure nursing and EVS agreed what items disinfected by nursing vs EVS
  ▪ Use of method (fluorescent dye, ATP) to ensure proper cleaning

• “No touch” terminal disinfection
  ▪ UV light
  ▪ Hydrogen peroxide

• Self disinfecting surfaces
• New disinfection technology

NEW “NO TOUCH” APPROACHES TO ROOM DECONTAMINATION
Supplement Surface Disinfection
Best Practices in Disinfection and Sterilization

- Best Practices
  - Sterilization of critical items
    - Biological indicators, cleaning indicators, washer disinfectors
  - High-level disinfection for semi-critical items
    - Endoscope reprocessing issues, laryngoscopes
  - Low-level disinfection of non-critical items
    - New low-level disinfectants, curtain decontamination, selecting a disinfectant
  - D/S and Emerging Pathogens
    - MERS-CoV, Enterovirus D68, Ebola

Decreasing Order of Resistance of Microorganisms to Disinfectants/Sterilants

Most Resistant

- Prions
- Bacterial spores (C. difficile)
- Mycobacteria
- Small, non-enveloped viruses (HPV, polio, EV-D68)
- Fungal spores
- Gram-negative bacilli (Acinetobacter)
- Vegetative fungi and algae
- Large, non-enveloped viruses
- Gram-positive bacteria (MRSA, VRE)
- Enveloped viruses (Ebola, MERS-CoV)

Most Susceptible
New and Emerging Pathogens
MERS-CoV, Ebola, Enterovirus D68

- Will likely not have an EPA-registered disinfectant on the market to kill it
- Manufacturers may not make claims about emerging pathogens without EPA approval, which may take 18-24 months for new pathogens
- Until an EPA-approved claim is available, users may refer to the hierarchy of microbial susceptibility to select the appropriate disinfectant
- For example, use EPA-registered disinfectant suitable for non-enveloped viruses (norovirus, rotavirus, adenovirus, poliovirus) to disinfectant surfaces for Ebola

Best Practices in Disinfection and Sterilization

- Best Practices
  - Sterilization of critical items
    - Biological indicators, cleaning indicators, washer disinfectors
  - High-level disinfection for semi-critical items
    - Endoscope reprocessing issues, laryngoscopes
  - Low-level disinfection of non-critical items
    - New low-level disinfectants, curtain decontamination, selecting a disinfectant
  - D/S and Emerging Pathogens
    - MERS-CoV, Enterovirus D68, Ebola
Best Practices in Disinfection and Sterilization

- Disinfection and sterilization technologies and practices reduce risk of infection associated with medical devices and surfaces.
- Endoscope represent a nosocomial hazard. Urgent need to understand the gaps in endoscope reprocessing. Reprocessing guidelines must be followed to prevent exposure to pathogens that may lead to infection. Endoscopes have narrow margin of safety and manufacturers should be encouraged to develop practical sterilization technology.
- The contaminated surface environment in hospital rooms is important in the transmission of healthcare-associated pathogens (MRSA, VRE, C. difficile, Acinetobacter). Thoroughness of cleaning should be monitored (e.g., fluorescence).
- Emerging pathogens, such as Ebola, are susceptible to currently available disinfectants.

THANK YOU!
www.disinfectionandsterilization.org