Selection and Use of Disinfectants

Lecture Goals
- Rational approach to disinfection
- Disinfectants used in healthcare
- Disinfection practices (e.g., endoscope, emerging pathogens)

Disinfection

Objective
To prevent infection by reducing microbial contamination on inanimate objects to a level unlikely to be hazardous

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 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 but high numbers of bacterial spores. NONCRITICAL - objects that touch only intact skin require low level disinfection.

Efficacy of Disinfection/Sterilization

Influencing Factors
- Cleaning of the object
- Organic load present
- Type and level of microbial contamination
- Concentration of and exposure time to disinfectant/sterilant
- Nature of the object
- Temperature and relative humidity

Decreasing Order of Resistance of Microorganisms to Disinfectants/Sterilants
- Spores
- Mycobacteria
- Non-Envelope Viruses
- Fungi
- Bacteria
- Envelope Viruses
Processing “Critical” Patient Care Objects

Classification: Critical objects enter normally sterile tissue or vascular system, or through which blood flows.
Object: Sterility.
Level germicidal action: Kill all microorganisms, including bacterial spores.
Examples: Surgical instruments and devices; cardiac catheters; implants; hemodialyzers; etc.
Method: Steam, gas (e.g., ETO), hydrogen peroxide gas plasma, or chemical sterilization.

Chemical Sterilization of “Critical Objects”

- Glutaraldehyde (≥ 2.0%)
- Hydrogen peroxide-HP (7.5%)
- Peracetic acid-PA (0.2%)
- HP (1.0%) and PA (0.08%)
- HP (7.5%) and PA (0.23%)
- Glut (0.95%) and Phenol/phenate (1.64%)

Exposure time per manufacturers’ recommendations

Critical Objects

- Surgical instruments
- Cardiac catheters
- Implants
- Hemodialyzers

Processing “Semicritical” Patient Care Objects

Classification: Semicritical objects come in contact with mucous membranes or skin that is not intact.
Object: Free of all microorganisms except high numbers of bacterial spores.
Level germicidal action: Kills all microorganisms except high numbers of bacterial spores.
Examples: Respiratory therapy and anesthesia equipment, GI endoscopes, endocavitary probes, etc.
Method: High-level disinfection

High-Level Disinfection of “Semicritical Objects”

<table>
<thead>
<tr>
<th>Germicide</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glutaraldehyde</td>
<td>≥ 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%/0.09%</td>
</tr>
<tr>
<td>Hydrogen peroxide and peracetic acid*</td>
<td>7.35%/0.23%</td>
</tr>
<tr>
<td>Hypochlorite</td>
<td>650-675 ppm</td>
</tr>
<tr>
<td>Glut and phenol/phenate**</td>
<td>1.21%/1.33%</td>
</tr>
</tbody>
</table>

*May cause cosmetic and functional damage; **efficacy not verified
Semicritical Items

- Endoscopes
- Respiratory therapy equipment
- Anesthesia equipment
- Endocavitary probes
- Tonometers
- Diaphragm fitting rings

Processing “Noncritical” Patient Care Objects

<table>
<thead>
<tr>
<th>Classification:</th>
<th>Noncritical objects will not come in contact with mucous membranes or skin that is not intact.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object:</td>
<td>Can be expected to be contaminated with some microorganisms.</td>
</tr>
<tr>
<td>Level germicidal action:</td>
<td>Kill vegetative bacteria, fungi and lipid viruses.</td>
</tr>
<tr>
<td>Examples:</td>
<td>Bedpans; crutches; bed rails; EKG leads; bedside tables; walls, floors and furniture.</td>
</tr>
<tr>
<td>Method:</td>
<td>Low-level disinfection</td>
</tr>
</tbody>
</table>

Low-Level Disinfection (HLD) for “Noncritical” Objects

<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>
</tbody>
</table>

UD=Manufacturer’s recommended use dilution

Endoscopes/AERS
GI ENDOSCOPE AND BRONCHOSCOPES

- Widely used diagnostic and therapeutic procedure
- Endoscope contamination during use (GI 10⁹ in/10⁵ 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 risk of disease transmission

TRANSMISSION OF INFECTION

- Gastrointestinal endoscopy
  - >300 infections transmitted
  - 70% agents Salmonella sp. and P. aeruginosa
  - Clinical spectrum ranged from colonization to death (~4%)
- Bronchoscopy
  - 90 infections transmitted
  - M. tuberculosis, atypical Mycobacteria, P. aeruginosa

Nosocomial Infections via GI Endoscopes

- Infections traced to deficient practices
- Inadequate cleaning (clean all channels)
- Inappropriate/ineffective disinfection (time exposure, perfuse channels, test concentration, ineffective disinfectant, inappropriate disinfectant)
- Failure to follow recommended disinfection practices (tapwater rinse)
- Flaws is design of endoscopes or AERs

Endoscope Reprocessing: Current Status of Cleaning and Disinfection

- Guidelines
  - Society of Gastroenterology Nurses and Associates, 2000
  - European Society of Gastrointestinal Endoscopy, 2000
  - British Society of Gastroenterology Endoscopy, 1996
  - Gastroenterological Society of Australia, 1999
  - Gastroenterological Nurses Society of Australia, 1999
  - American Society for Gastrointestinal Endoscopy, 2003
  - Association for Professional in Infection Control and Epidemiology, 2000
  - Centers for Disease Control and Prevention, 2007 (in press)

Endoscope Reprocessing, Worldwide

- Worldwide, endoscopy reprocessing varies greatly
  - India, of 133 endoscopy centers, only 1/3 performed even a minimum disinfection (2% glut for 2 min)
  - Brazil, “a high standard … occur only exceptionally”
  - Western Europe, >30% did not adequately disinfect
  - Japan, found “exceedingly poor” disinfection protocols
  - US, 25% of endoscopes revealed >100,000 bacteria

ENDOSCOPE DISINFECTION

- CLEAN-mechanically cleaned with water and enzymatic cleaner
- HLD/STERILIZE-immersce scope and perfuse HLD/sterilant through all channels for exposure time
- RINSE-scope and channels rinsed with sterile water, filtered water, or tap water followed by alcohol
- DRY-use forced air to dry insertion tube and channels
- STORE-prevent recontamination
### Bacterial Bioburden Associated with Endoscopes

<table>
<thead>
<tr>
<th></th>
<th>Gastroscope, log_{10} CFU</th>
<th>Colonoscope, log_{10} CFU</th>
</tr>
</thead>
<tbody>
<tr>
<td>After procedure</td>
<td>6.7</td>
<td>8.5</td>
</tr>
<tr>
<td></td>
<td>6.8</td>
<td>9.8</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>4.8</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>5.1</td>
<td></td>
</tr>
</tbody>
</table>

### Viral Bioburden from Endoscopes Used with AIDS Patients

<table>
<thead>
<tr>
<th></th>
<th>Dirty</th>
<th>Cleaned</th>
<th>Disinfected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastroscopes</td>
<td>7/20</td>
<td>0/20</td>
<td>0/20</td>
</tr>
<tr>
<td>HIV (PCR)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HBsAg</td>
<td>1/20</td>
<td>0/20</td>
<td>0/7</td>
</tr>
<tr>
<td>Bronchoscopes</td>
<td>7/7</td>
<td>0/7</td>
<td>0/7</td>
</tr>
<tr>
<td>HIV (cDNA)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HBsAg</td>
<td>1/10</td>
<td>0/10</td>
<td>0/10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### ENDOSCOPE DISINFECTION

- **CLEAN**: mechanically cleaned with water and enzymatic detergent
- **HLD/STERILIZE**: immerse scope and perfuse HLD/sterilant through all channels for exposure time
- **RINSE**: scope and channels rinsed with sterile water, filtered water, or tap water followed by alcohol
- **DRY**: use forced air to dry insertion tube and channels
- **STORE**: prevent recontamination

### High-Level Disinfection

#### Semicritical Equipment (eg, endoscopes)

- **Inactivate**
  - Bacteria
  - Viruses
  - Fungi and yeast
  - Mycobacteria
  - Some bacterial spores

### 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 (12 m)</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>7.35%/0.23%</td>
</tr>
<tr>
<td>Hypochlorite (chlorine-generated on-site)*</td>
<td>650-675 ppm</td>
</tr>
<tr>
<td>Glut and phenolphthalein**</td>
<td>1.21%/1.93%</td>
</tr>
</tbody>
</table>

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

### Unacceptable Disinfectants for HLD

- Benzalkonium chloride
- Iodophor
- Hexachlorophene
- Alcohol
- Chlorhexidine gluconate
- Cetrimide
- Quaternary ammonium compounds
- Glutaraldehyde (0.13%) with phenol
ENDOSCOPE REPROCESSING

- Inappropriate disinfectants
  - Benzalkonium chloride (Greene WH. Gastroenterol 1974;67:912)
  - 70% alcohol (Elson CO. Gastroenterol 1975;69:507)
  - QUAT (Tuffnell PG. Canad J Publ Health 1976;67:141)
  - Hexachlorophene (Dean AG. Lancet 1977;2:134)
  - Hexachlorophene (Beecham HJ. JAMA 1979;1013)
  - 70% alcohol (Parker HW. Gasoro Endos 1979;25:102)
  - Povidone-iodine (Low DE. Arch Intern Med 1980;1076)
  - Cetrimonium bromide. (Schliessler KH. Lancet 1980;2:1246)

- 3% hexachlorophene. (Schousboe M. NZ Med J 1980;92:275)
- 0.5% CHG in alcohol, 0.015% CHG and 0.15% cetrimide; 87 s exposure to 2% glut. (Hawkey PM. J Hosp Inf 1981;2:373)
- 1% Savlon (cetramide and CHG). (O’Connor BH. Lancet 1982;2:864)
- 0.0075% iodophor. (Dwyer DM. Gastroint Endosc 1987;33:84)
- 0.13% glut with phenol. (Classen DC. Am J Med 1988;84:580)
- 70% ethanol for 3 min. (Langenberg W. J Inf Dis 1990;161:507)

High-Level Disinfection of “Semicritical Objects”

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</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>7.5%</td>
</tr>
<tr>
<td>Hydrogen peroxide and peracetic acid</td>
<td>1.0%/0.06%</td>
</tr>
<tr>
<td>Hydrogen peroxide and peracetic acid</td>
<td>7.5%/0.23%</td>
</tr>
<tr>
<td>Chlorine (sodium hypochlorite)*</td>
<td>1000 ppm (1.50 dil)</td>
</tr>
<tr>
<td>Glut and phenolphenate**</td>
<td>1.12%/1.93%</td>
</tr>
</tbody>
</table>

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

ENDOSCOPE DISINFECTION

- CLEAN-mechanically cleaned with water and enzymatic detergent
- HLD/STERILIZE-immersse scope and perfuse HLD/sterilant through all channels for 12-20 min (US)
- RINSE-scope and channels rinsed with sterile water or tap water followed by alcohol
- DRY-use forced air to dry insertion tube and channels
- STORE-prevent recontamination

[Graph showing Glutaraldehyde concentration over time]
Minimum Effective Concentration
Chemical Sterilant

- Dilution of chemical sterilant occurs during use
- Test strips are available for monitoring MEC
- Test strips for glutaraldehyde monitor 1.5%
- Test strip not used to extend the use-life beyond the expiration date (date test strips when opened)
- Testing frequency based on how frequently the solutions are used (used daily, test at least daily)
- Record results

Semicritical Items

- Endoscopes
- Respiratory therapy equipment
- Anesthesia equipment
- Endocavitary probes
- Tonometers
- Diaphragm fitting rings

New FDA-Cleared Sterilants/HLDs

- “Old”
  - > 2% Glut, 7.5% HP, 1.0% HP and 0.01% PA
- New
  - 1.50% Glut and 1.50% phosphoric acid (HLD-20 m at 25°C)
  - 0.50% ortho-phthalaldehyde (OPA) (HLD-12 m, 5 min at 25°C)
  - 7.35% HP and 0.23% PA (HLD-15 m at 20°C)
  - 2.5% Glut (HLD-5 m at 35°C)
  - 8.3% HP and 7.0% PA (HLD-6 m at 20°C)
  - 3.4% Glut and 26% isopropanol (HLD-10 m at 20°C)
  - 650-675 hypochlorite (HLD-10 m at 25°C, generated on-site)
- Ensure antimicrobial activity and material compatibility

Glutaraldehyde

- Advantages
  - Numerous use studies published
  - Relatively inexpensive
  - Excellent materials compatibility
- Disadvantages
  - Respiratory irritation from vapor
  - Pungent and irritating odor
  - Relatively slow mycobactericidal activity
  - Coagulate blood and fix tissues to surfaces
  - Allergic contact dermatitis
OPA Research

- Alfa and Sitter, 1994. OPA eliminated all microorganisms from 100 different endoscopes used in a clinical setting.
- Gregory et al, 1999. OPA achieved a 6 log reduction of M. bovis in 5.5 min compared to 32 min for glutaraldehyde.
- Walsh et al, 1999. OPA effective against glutaraldehyde-resistant M. chelonae strains.

Ortho-phthalaldehyde

**Advantages**
- Fast acting HLD
- No activation
- Excellent materials compatibility
- Not a known irritant to eyes and nasal passages
- Weak odor

**Disadvantages**
- Stains protein gray
- Cost ($30/gal) but lower reprocessing costs (soak time, devices per gal)
- Slow sporicidal activity
- Eye irritation with contact
- Exposure may result in hypersensitivity

Comparison of Glutaraldehyde and OPA

<table>
<thead>
<tr>
<th>Glutaraldehyde</th>
<th>OPA</th>
<th>Ortho-phthalaldehyde</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;2.0% Glutaraldehyde</td>
<td>0.55% Ortho-phthalaldehyde</td>
<td></td>
</tr>
<tr>
<td>HLD: 45 min at 25°C</td>
<td>HLD: 12 min at 20°C</td>
<td></td>
</tr>
<tr>
<td>Needs activator</td>
<td>No activator needed</td>
<td></td>
</tr>
<tr>
<td>14 day use life</td>
<td>14 day use life</td>
<td></td>
</tr>
<tr>
<td>2 year shelf life</td>
<td>2 year shelf life</td>
<td></td>
</tr>
<tr>
<td>ACGIH ceiling limit, 0.05ppm</td>
<td>No ACGIH or OSHA limit</td>
<td></td>
</tr>
<tr>
<td>Strong odor</td>
<td>Weak odor</td>
<td></td>
</tr>
<tr>
<td>MEC, 1.5%</td>
<td>MEC, 0.3%</td>
<td></td>
</tr>
<tr>
<td>Cost - $10/gallon</td>
<td>Cost - $30/gallon</td>
<td></td>
</tr>
</tbody>
</table>

OPA Label Claims Worldwide

1. Europe, Asia, Latin America
   5 min at 20°C
2. Canada and Australia
   10 min at 20°C
3. United States
   12 min at 20°C

Peracetic Acid/Hydrogen Peroxide

**Advantages**
- No activation required
- No odor or irritation issues
- Effective in the presence of organic matter

**Disadvantages**
- Material compatibility issues for lead, brass, copper, zinc (cosmetic and functional damage for 1.0% HP and 0.08% PA)
- Limited clinical use
Hydrogen Peroxide

**Advantages**
- No activation required
- Enhanced removal of organisms
- No disposal issues
- No odor or irritation issues
- Compatible with metals, plastics and elastomers
- Use studies published

**Disadvantages**
- Material compatibility concerns for brass, zinc, copper, and nickel/silver plating (cosmetic and functional damage)

Superoxidized Water

**Advantages**
- Highly microbiocidal - 5 log reduction of M. tuberculosis, E. coli, B. subtilis spores, MRSA, Enterococcus, Polio, HIV in 5 minutes or less
- Main product is hypochlorous acid and chlorine (activity reduced in organic matter)
- Generated at point-of-use by passing saline solution over titanium electrodes
- Strict criteria must be met - current, pH, redox potential, used within 24 hours
- Claim non-damaging and non-corrosive
- Not FDA cleared


Commercially available technologies for high-level disinfection

- **Automatic Endoscope Reprocessors (AERs)**
  - Advantages: automate and standardize reprocessing steps, reduce personnel exposure to chemicals
  - Disadvantages: failure of AERs linked to outbreaks
  - Problems: incompatible AER; biofilm buildup; contaminated AER; inadequate channel connectors
  - MMWR 1999;48:557. Used wrong set-up or connector
  - Must ensure exposure of internal surfaces with HLD/sterilant

Automated Endoscope Reprocessors (AERs)

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
Disinfection and Sterilization of Emerging Pathogens

- Hepatitis C virus
- Clostridium difficile
- Cryptosporidium
- Helicobacter pylori
- E.coli 0157:H7
- Antibiotic-resistant microbes (MDR-TB, VRE, MRSA)
- SARS Coronavirus, avian influenza, norovirus
- Bioterrorism agents (anthrax, plague, smallpox)

Standard disinfection and sterilization procedures for patient care equipment are adequate to sterilize or disinfect instruments or devices contaminated with blood and other body fluids from persons infected with emerging pathogens.

Low-Level Disinfection (HLD) for “Noncritical” Objects

<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>Chlorite</td>
<td>100ppm (1:500 dilution)</td>
</tr>
<tr>
<td>Phenolics</td>
<td>UD</td>
</tr>
<tr>
<td>Iodophor</td>
<td>UD</td>
</tr>
<tr>
<td>Quaternary ammonium</td>
<td>UD</td>
</tr>
</tbody>
</table>

UD=Manufacturer's recommended use dilution

"And this is for those drug-resistant microbes."
Noncritical Objects

- Bedside tables, bed rails
- Crutches
- Furniture
- Floors, walls
- Telephone, computers
- Blood pressure cuffs
- EKG leads

Low-Level Disinfection
Noncritical Surfaces or Equipment

- Bacteria (cause 90% HAIs)
- Fungi and yeast
- Some viruses (enveloped)
- Mycobacteria (alcohol, phenolic)
- No bacterial spores

Surface Disinfection
Noncritical Patient-Care-CDC, 2007

- 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. Category IB

Surface Disinfection
Environmental Surfaces-CDC, 2007

- 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 when uncertain if cleaning personnel not able to distinguish soiled areas containing blood from dirt; or determine when MDROs are likely in the environment. Category IB

Selection and Use of Disinfectants
Lecture Goals

- Rational approach to disinfection
- Disinfectants used in healthcare
- Disinfection practices (e.g., endoscope, emerging pathogens)
Hand Hygiene Agents

- Antimicrobial
  - Alcohols (ethyl, isopropanol, n-propanol)
  - Chlorhexidine gluconate (CHG)
  - Iodine and iodophors
  - Triclosan
  - Parachlorometaxylenol (PCMX)
  - Quaternary Ammonium Compounds (QAC)
- Non-Antimicrobial

Relative Efficacy of Antimicrobial Hand Hygiene Agents

<table>
<thead>
<tr>
<th>Hand Hygiene Agents</th>
<th>Gram-positive bacteria</th>
<th>Gram-negative bacteria</th>
<th>Mycobacteria</th>
<th>Fungi</th>
<th>Viruses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorhexidine Gluconate</td>
<td>+++</td>
<td>++</td>
<td>-</td>
<td>-</td>
<td>+++</td>
</tr>
<tr>
<td>Triclosan</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Quaternary Ammonium Compounds</td>
<td>+++</td>
<td>++</td>
<td>-</td>
<td>?</td>
<td>+++</td>
</tr>
<tr>
<td>Parachlorometaxylenol (PCMX)</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td>?</td>
<td>+</td>
</tr>
<tr>
<td>Alcohol</td>
<td>+++</td>
<td>+++</td>
<td>-</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>Iodophors</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>+</td>
<td>+++</td>
</tr>
</tbody>
</table>

Indications for Handwashing and Hand Antisepsis

- Hands are visibly dirty or soiled, wash with nonantimicrobial soap and water or antimicrobial soap and water. Category IA
- If hands are not visibly soiled, use an alcohol-based handrub for routinely decontaminating hands in all other clinical situations. IA. Alternatively, wash hands with antimicrobial soap and water. IB
- Liquid, bar, leaflet, or powdered forms of plain soap are acceptable when washing with a nonantimicrobial soap. II

Use nonantimicrobial/antimicrobial before eating and after using a restroom. IB
Antimicrobial towelettes may be an alternative to washing hands with nonantimicrobial soap and water. IB
No recommendation on routine use of non-alcohol-based handrubs. Unresolved issue

Thank you
References

- Rutala WA. APIC guideline for selection and use of disinfectants. Am J Infect Control 1996;24:313
- Rutala WA, Weber DJ. HICPAC. CDC guideline for disinfection and sterilization in healthcare facilities. In press