Back to the Basics of Disinfection

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DISCLOSURES

• Consultation (2017)
  ■ PDI
  ■ ASP

• Honoraria (2017)
  ■ PDI
  ■ Kennall

• Grants to UNC or UNC Hospitals (2017)
  ■ CDC, CMS
Back to the Basics of Disinfection

- Overview of disinfection
- Low-level disinfection
  - Role of environment in disease transmission
  - Products and practices for surface disinfection
    - New issues
      - Inactivation of emerging pathogens (e.g., CRE, C. auris)
  - Technologies for terminal room decontamination (not including technologies with limited data)
- High-level disinfection
  - Reprocessing channeled scopes
  - Shift from HLD to sterilization
  - HPV
Sources of Healthcare-Associated Pathogens

- Endogenous flora (SSI, UTI, CLABSI): 40-60%
- Exogenous: 20-40% (e.g., cross-infection via contaminated hands [staff, visitors])
- Other (environment): 20%
  - Medical devices
  - Contact with environmental surfaces (direct and indirect contact)
EH Spaulding believed that how an object will be disinfected depended on the object’s intended use (developed 1968).

CRITICAL-medical/surgical devices which enter normally sterile tissue or the vascular system or through which blood flows should be sterile.

SEMICRITICAL-medical devices 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-medical devices that touch only intact skin require low-level disinfection.
Critical Medical/Surgical Devices
Rutala et al. ICHE 2014;35:883; Rutala et al. ICHE 2014;35:1068; Rutala et al. AJIC 2016;44:e47

- Critical
  - Transmission: direct contact
  - Control measure: sterilization
  - Surgical instruments
    - Enormous margin of safety, rare outbreaks (2 in 60 years)
    - ~85% of surgical instruments <100 microbes
    - Washer/disinfector removes or inactivates 10-100 million
    - Sterilization kills 1 trillion spores
Noncritical Medical Devices
Rutala et al. AJIC 2016;44:e1; Rutala, Weber. Env Issues NI, Farber 1987

- Contact: intact skin (noncritical medical devices, surfaces)
- Transmission: secondary transmission by contaminating hands/gloves via contact with the environment and transfer to patient
- Control measures: hand hygiene and low-level disinfection
- Noncritical devices (stethoscopes, blood pressure cuffs, wound vacuum), rare outbreaks
Semicritical Medical Devices
Rutala et al. AJIC 2016;44:e47

• Semicritical
  • Transmission: direct contact
  • Control measure: high-level disinfection
  • Endoscopes top ECRI list of 10 technology hazards, >130 outbreaks (GI, bronchoscopes)
    • 0 margin of safety
      • Microbial load, $10^7$-$10^{10}$
      • Complexity
      • Biofilm
  • Other semicritical devices, rare outbreaks
    • ENT scopes, endocavitary probes (prostate, vaginal, TEE), laryngoscopes, cystoscopes
    • Reduced microbial load, less complex
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
Environmental Contamination Leads to HAIs

- Evidence environment contributes
- Role-MRSA, VRE, C. difficile
- Surfaces are contaminated~25%
- EIP survive days, weeks, months
- Contact with surfaces results in hand contamination; contaminated hands transmit EIP to patients
- Disinfection reduces contamination
- Disinfection (daily) reduces HAIs
- Rooms not adequately cleaned
Admission to Room Previously Occupied by Patient C/I with Epidemiologically Important Pathogen

- Results in the newly admitted patient having an increased risk of acquiring that pathogen by 39-353%
- For example, increased risk for *C. difficile* is 235% (11.0% vs 4.6%)
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>Gender</td>
<td>1.00 (0.89-1.10)</td>
<td>.71</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 (0.44-2.78)</td>
<td>.83</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>.23</td>
</tr>
<tr>
<td>Fluoroquinolones</td>
<td>1.17 (0.72-1.91)</td>
<td>.53</td>
</tr>
<tr>
<td>Clindamycin</td>
<td>0.45 (0.14-1.42)</td>
<td>.17</td>
</tr>
<tr>
<td>Third- or fourth-generation cephalosporins</td>
<td>1.17 (0.76-1.79)</td>
<td>.48</td>
</tr>
<tr>
<td>Carbenems</td>
<td>1.05 (0.63-1.75)</td>
<td>.84</td>
</tr>
<tr>
<td>Piperacillin-tazobactam</td>
<td>1.31 (0.82-2.10)</td>
<td>.27</td>
</tr>
<tr>
<td>Other penicillin</td>
<td>0.47 (0.23-0.98)</td>
<td>.04</td>
</tr>
<tr>
<td>Metronidazole</td>
<td>1.31 (0.83-2.07)</td>
<td>.24</td>
</tr>
<tr>
<td>Vancomycin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oral</td>
<td>1.38 (0.32-5.89)</td>
<td>.67</td>
</tr>
<tr>
<td>Intravenous</td>
<td>1.55 (0.88-2.73)</td>
<td>.13</td>
</tr>
<tr>
<td>Aminoglycosides</td>
<td>1.27 (0.78-2.06)</td>
<td>.35</td>
</tr>
<tr>
<td>Multiple (2-3 antibiotic classes)</td>
<td>1.28 (0.75-2.21)</td>
<td>.37</td>
</tr>
</tbody>
</table>

**NOTE:** APACHE, Acute Physiology and Chronic Health Evaluation; CI, confidence interval; HR, hazard ratio.
ACQUISITION OF MRSA ON HANDS AFTER CONTACT WITH ENVIRONMENTAL SITES
ACQUISITION OF MRSA ON HANDS/GLOVES AFTER CONTACT WITH CONTAMINATED EQUIPMENT
TRANSFER OF MRSA FROM PATIENT OR ENVIRONMENT TO IV DEVICE AND TRANSMISSION OF PATHOGEN
ACQUISITION OF \textit{C. difficile} ON PATIENT HANDS AFTER CONTACT WITH ENVIRONMENTAL SITES AND THEN INOCULATION OF MOUTH
Back to the Basics of Disinfection

- Overview of disinfection
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# LOW-LEVEL DISINFECTION FOR NONCRITICAL EQUIPMENT AND SURFACES

Exposure time > 1 min

<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 (QUAT)</td>
<td>UD</td>
</tr>
<tr>
<td>QUAT with alcohol</td>
<td>RTU</td>
</tr>
<tr>
<td>Improved hydrogen peroxide (HP)</td>
<td>0.5%, 1.4%</td>
</tr>
<tr>
<td>Peracetic acid with HP (C. difficile)</td>
<td>UD</td>
</tr>
</tbody>
</table>

UD=Manufacturer’s recommended use dilution; others in development/testing-electrolyzed water; polymeric guanidine; cold-air atmospheric pressure plasma (Boyce Antimicrob Res IC 2016. 5:10)
Inappropriate over-dilution of disinfectant solutions by housekeepers or by malfunctioning automated dilutions systems may result in applying disinfectants using inappropriate solutions

- Audit of 33 automated dispensing stations that mix concentrated disinfectant with water to yield desired in-use QUAT conc of 800 ppm
  - QUAT solutions dispensed were tested with test strips, ~50% of stations delivered solutions with 200-400ppm
- Several flaws in dispensing system
PROPERTIES OF AN IDEAL SURFACE DISINFECTANT


- Broad spectrum
- Fast acting
- Remains wet
- Not affected by environmental factors
- Nontoxic
- Surface compatibility
- Persistence

- Easy to use
- Acceptable odor
- Economical
- Solubility
- Stability
- Cleaner
- Nonflammable
### Key Considerations for Selecting the Ideal Disinfectant for Your Facility


<table>
<thead>
<tr>
<th>Consideration</th>
<th>Question 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</td>
<td>How quickly does the product kill the prevalent healthcare pathogens. Ideally,</td>
<td></td>
</tr>
<tr>
<td>Times</td>
<td>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,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>works in organic matter, one-step (cleans/disinfects)</td>
<td></td>
</tr>
<tr>
<td>Other factors</td>
<td>Supplier offers comprehensive training/education, 24-7 customer support, overall</td>
<td></td>
</tr>
<tr>
<td></td>
<td>cost acceptable (product capabilities, cost per compliant use, help standardize</td>
<td></td>
</tr>
<tr>
<td></td>
<td>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).
Quaternary ammonium compounds
(e.g., didecyl dimethyl ammonium bromide, dioctyl dimethyl ammonium bromide)

Advantages
- Bactericidal, fungicidal, virucidal against enveloped viruses (e.g., HIV)
- Good cleaning agents
- EPA registered
- Surface compatible
- Persistent antimicrobial activity when undisturbed
- Inexpensive (in dilutable form)
- Not flammable

Disadvantages
- Not sporicidal
- In general, not tuberculocidal and virucidal against non-enveloped viruses
- High water hardness and cotton/gauze can make less microbicidal
- A few reports documented asthma as result of exposure to benzalkonium chloride
- Affected by organic matter
- Multiple outbreaks ascribed to contaminated benzalkonium chloride
Alcohol

Advantages

- Bactericidal, tuberculocidal, fungicidal, virucidal
- Fast acting
- Non-corrosive
- Non-staining
- Used to disinfect small surfaces such as rubber stoppers on medication vials
- No toxic residue

Disadvantages

- Not sporicidal
- Affected by organic matter
- Slow acting against non-enveloped viruses (e.g., norovirus)
- No detergent or cleaning properties
- Not EPA registered
- Damage some instruments (e.g., harden rubber, deteriorate glue)
- Flammable (large amounts require special storage)
- Evaporates rapidly making contact time compliance difficult
- Not recommended for use on large surfaces
- Outbreaks ascribed to contaminated alcohol
Quat/Alcohol vs Quat

- Adenovirus is a hardy virus that is relatively resistant to disinfectants
- Quat about $<0.5 \log_{10}$ reduction against adenovirus with 1m exposure time
- Accelerated hydrogen peroxide (0.5%) demonstrates $\sim0.7 \log_{10}$ reduction against adenovirus with 1m exposure time
- Quat/Alcohol demonstrates a $\sim4 \log_{10}$ reduction against adenovirus with 1m exposure time
- Chlorine ($\sim5000$ppm) demonstrates a $\sim5 \log_{10}$ reduction against adenovirus with 1m exposure time
- Quat/Alcohol has improved virucidal activity compared to Quat and accelerated hydrogen peroxide
Improved Hydrogen Peroxide

Advantages

- Bactericidal, tuberculocidal, fungicidal, virucidal
- Fast efficacy
- Easy compliance with wet-contact times
- Safe for workers (lowest EPA toxicity category, IV)
- Benign for the environment
- Surface compatible
- Non-staining
- EPA registered
- Not flammable

Disadvantages

- More expensive than most other disinfecting actives
- Not sporicidal at low concentrations
## Sodium Hypochlorite


### Advantages

- Bactericidal, tuberculocidal, fungicidal, virucidal
- Sporicidal
- Fast acting
- Inexpensive (in dilutable form)
- Not flammable
- Unaffected by water hardness
- Reduces biofilms on surfaces
- Relatively stable (e.g., 50% reduction in chlorine concentration in 30 days)
- Used as the disinfectant in water treatment
- EPA registered

### Disadvantages

- Reaction hazard with acids and ammonias
- Leaves salt residue
- Corrosive to metals (some ready-to-use products may be formulated with corrosion inhibitors)
- Unstable active (some ready-to-use products may be formulated with stabilizers to achieve longer shelf life)
- Affected by organic matter
- Discolors/stains fabrics
- Potential hazard is production of trihalomethane
- Odor (some ready-to-use products may be formulated with odor inhibitors). Irritating at high concentrations.
Phenolics

Advantages
- Bactericidal, tuberculocidal, fungicidal, virucidal
- Inexpensive (in dilutable form)
- Non-staining
- Not flammable
- EPA registered

Disadvantages
- Not sporicidal
- Absorbed by porous materials and irritate tissue
- Depigmentation of skin caused by certain phenolics
- Hyperbilirubinemia in infants when phenolic not prepared as recommended
Decreasing Order of Resistance of Microorganisms to Disinfectants/Sterilants

Most Resistant

- Prions
- Spores (C. difficile)
- Mycobacteria
- Non-Enveloped Viruses (norovirus, adeno)
- Fungi
- Bacteria (MRSA, VRE, Acinetobacter)

Most Susceptible

- Enveloped Viruses
Norovirus:
Microbiology and Epidemiology

- Classified as a calicivirus: RNA virus, non-enveloped
- Prevalence
  - Causes an estimated 23 million infections per year in the US
  - Results in 50,000 hospitalizations per year (310 fatalities)
  - Accounts for >90% of nonbacterial and ~50% of all-cause epidemic gastroenteritis
- Infectious dose: 10-100 viruses (ID$_{50}$ = 18 viruses)
- Fecal-oral transmission (shedding for up to 2-3 weeks)
  - Direct contact and via fomites/surfaces; food and water
- Droplet transmission? (via ingestion of airborne droplets of virus-containing particles)
- May cause chronic infection in transplant recipients
Why Chlorine for Norovirus?

• Chlorine is the most robust disinfectant against a wide range of pathogens including norovirus, rotavirus, adenovirus and C. difficile

• Types of isolation at UNC Hospitals: Contact Enteric and Contact. Contact we use Quat, Quat/Alc and Contact Enteric (C. difficile, norovirus) we use chlorine

• Use of two products simplifies training of healthcare providers regarding isolation signs and EVS training regarding the two disinfectants

• Additionally, when confronted with a norovirus outbreak (and possibly a closed unit), we recommend the most effective and proven control measures to terminate the outbreak
  ■ Hand hygiene with soap and water
  ■ Chlorine disinfection of surfaces
Accelerated Hydrogen Peroxide and QUAT Less Effective at 10m than Sodium Hypochlorite at 1m
Accelerated Hydrogen Peroxide and QUAT Less Effective at 10m than Sodium Hypochlorite at 1m

### Table 1
Summary of the most effective concentrations and contact times of commonly used disinfectants against MNV-1 and FCV, with and without soil load

<table>
<thead>
<tr>
<th>Disinfectant</th>
<th>MNV-1 Without soil load</th>
<th>MNV-1 With soil load</th>
<th>FCV Without soil load</th>
<th>FCV With soil load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concentration (ppm)/contact time (min)</td>
<td>Wet and dry load mean(^{1}) log(_{10}) reduction</td>
<td>Concentration (ppm)/contact time (min)</td>
<td>Wet and dry load mean(^{1}) log(_{10}) reduction</td>
</tr>
<tr>
<td>Sodium hypochlorite</td>
<td>2700/1</td>
<td>6.8</td>
<td>5400/1</td>
<td>5.7</td>
</tr>
<tr>
<td></td>
<td>1350/5</td>
<td>6.0</td>
<td>1350/5</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>675/10</td>
<td>6.4</td>
<td>1350/10</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td>35,000/10</td>
<td>6.5</td>
<td>1750/5</td>
<td>5.7</td>
</tr>
<tr>
<td>AHP</td>
<td>5000/10</td>
<td>2.6</td>
<td>5000/10</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>2800/10</td>
<td>2.0</td>
<td>2800/10</td>
<td>3.6</td>
</tr>
<tr>
<td>RTU AHP</td>
<td>2000/5</td>
<td>6.9</td>
<td>2000/10</td>
<td>2.4</td>
</tr>
<tr>
<td>QUAT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
</tr>
<tr>
<td>QUAT-alcohol (70% ethanol)</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
</tr>
</tbody>
</table>

\(^{1}\)Mean values from experimental trials performed in triplicate.

A QUAT-alcohol containing 2000 ppm QUAT and 70% ethanol was effective in inactivating MNV after 5 minutes
Surface Disinfection:
Treatment Time (Wipes/Sprays) versus Contact Time (Liquids)

Dilutable liquid disinfectant-contact time is “wet” time
Wipes/Sprays-treatment time is undisturbed time ("wet" time is not relevant)
Surface Disinfection:

Treatment Time (Wipes/Sprays) versus Contact Time (Liquids)

Rutala, Weber. Submitted for publication

- Registration test for liquid disinfectants is the AOAC Use-Dilution Method (UDM).
- SS cylinders are inoculated with the test organism (S. aureus, S. choleraesuis, P. aeruginosa) and then dried. After drying, the cylinder is transferred to a disinfectant tube and immersed in the disinfectant for the contact time (e.g., 5 minutes).
- Thus, for liquid disinfectants tested by the UDM, the contact time should be the “wet” time (not undisturbed time).
Surface Disinfection:
Treatment Time (Wipes/Sprays) versus Contact Time (Liquids)

- Registration test for wipe is EPA Disinfectant Towelette Test
- Treatment time is equal to combination of physical removal and inactivation caused by the disinfectant regardless of the surface appearance (i.e. wet or dry)
- Thus, if disinfectant wipe has a registration time of 1 minute, then the surface should be allowed to remain undisturbed for the registration time of 1 minute (i.e. wet time is not relevant)
• *Candida auris* is a globally emerging pathogen that is often resistant to multiple antifungal agents

• In several reports, *C. auris* has been recovered from the hospital environment

• CDC has recommended daily and post-discharge disinfection of surfaces in rooms of patients with *C. auris* infection.

• No hospital disinfectants are registered for use specifically against *C. auris*, and its susceptibility to germicides is not known
Deadly, drug-resistant Candida yeast infection spreads in the US

*Candida auris* causes multidrug-resistant infections that can result in organ failure

Katerina Kon/Science Photo Library
Effectiveness of Disinfectants Against *Candida auris* and Other *Candida* Species
Cadnum et al. ICHE 2017;38:1240-1243

<table>
<thead>
<tr>
<th>Disinfectant</th>
<th>Active Components</th>
<th>Contact Time&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Sporicidal Claim&lt;sup&gt;b&lt;/sup&gt;</th>
<th><em>Candida albicans</em> Claim&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clorox Healthcare bleach germicidal cleaner</td>
<td>Sodium hypochlorite 0.65%</td>
<td>1 min</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Clorox Healthcare Fuzion cleaner disinfectant</td>
<td>Sodium hypochlorite 0.39%</td>
<td>1 min</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Clorox germicidal bleach (1:10 dilution)</td>
<td>Sodium hypochlorite 0.825% when diluted</td>
<td>1 min</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>OxyGide daily disinfectant</td>
<td>Peroxide 1200 parts per million, hydrogen peroxide &lt;1%, acetic acid</td>
<td>3 min</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Clorox Healthcare hydrogen peroxide cleaner disinfectant</td>
<td>Hydrogen peroxide 1.4%</td>
<td>1 min&lt;sup&gt;d&lt;/sup&gt;</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Oxivir Tb</td>
<td>Hydrogen peroxide 0.5%</td>
<td>10 min</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>White distilled vinegar</td>
<td>Acetic acid &gt;5% (pH 2.0)</td>
<td>3 min&lt;sup&gt;e&lt;/sup&gt;</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Purell healthcare surface disinfectant</td>
<td>Ethyl alcohol 29.4%</td>
<td>30 s</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Lysol all-purpose cleaner</td>
<td>Alkyl dimethyl benzyl ammonium chlorides</td>
<td>10 min</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Virex II 256</td>
<td>Didecyl dimethyl ammonium chlorides, n-Alkyl dimethyl benzyl ammonium chloride</td>
<td>10 min</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

<sup>a</sup>Contact time for disinfectants based on manufacturers’ recommendations for *Candida albicans* unless otherwise specified.

<sup>b</sup>Environmental Protection Agency–registered claim against *Clostridium difficile* spores.

<sup>c</sup>Environmental Protection Agency–registered claim against *Candida albicans*.

<sup>d</sup>A 1-minute exposure was used, but the claim is based on a 3-minute exposure.

<sup>e</sup>There is no established contact time for vinegar.
Effectiveness of Disinfectants Against *Candida auris* and Other *Candida* Species

Cadnum et al. ICHE 2017;38:1240-1243

In lab testing, sporicidal and IHP disinfectants were highly effective against *C. auris*, *C. glabrata* and *C. albicans*. Quats exhibited relatively poor activity against all of the *Candida* species.
Efficacy of Disinfectants and Antiseptics against *Candida auris*

Rutala, Kanamori, Gergen, Sickbert-Bennett, Weber, 2017

- \( \geq 3 \log_{10} \) reduction (C. *auris*, 1m, 5% FCS, QCT)
  - 0.20% peracetic acid
  - 2.4% glutaraldehyde
  - 0.65% hydrogen peroxide, 0.14% peroxyacetic acid
  - 0.5% Quat, 55% isopropyl alcohol
  - Disinfecting spray (58% ethanol, 0.1% QUAT)
  - 28.7% isopropyl alcohol, 27.3% ethyl alcohol, 0.61% QAC
  - 0.07% o-phenylphenol, 0.06% p-tertiary amylphenol
  - 70% isopropyl alcohol
  - \(~5,250\) ppm chlorine
  - Ethanol hand rub (70% ethanol)
  - Accelerated hydrogen peroxide, 1.4%
  - Accelerated hydrogen peroxide, 2%
Efficacy of Disinfectants and Antiseptics against *Candida auris*

Rutala, Kanamori, Gergen, Sickbert-Bennett, Weber, 2017

- $\leq 3 \log_{10}$ (most $< 2 \log_{10}$) reduction ($C. \text{ auris}$, 1m, 5% FCS, QCT)
  - 0.55% OPA
  - 3% hydrogen peroxide
  - Quat, (0.085% QACs)
  - 10% povidone-iodine
  - $\sim 1,050$ ppm chlorine
  - 2% Chlorhexidine gluconate-CHG
  - 4% CHG
  - 0.5% triclosan
  - 1% CHG, 61% ethyl alcohol
  - 1% chloroxylenol
Efficacy of Disinfectants and Antiseptics against Carbapenem-Resistant Enterobacteriaceae
Rutala, Kanamori, Gergen, Sickbert-Bennett, Weber, 2017

• $\geq 3$ log$_{10}$ reduction (CRE, 1m, 5% FCS, QCT)
  - 0.20% peracetic acid
  - 2.4% glutaraldehyde
  - 0.5% Quat, 55% isopropyl alcohol
  - 58% ethanol, 0.1% QUAT
  - 28.7% isopropyl alcohol, 27.3% ethyl alcohol, 0.61% QAC
  - 0.07% o-phenylphenol, 0.06% p-tertiary amylphenol
  - ~5,250 ppm chlorine
  - 70% isopropyl alcohol
  - Ethanol hand rub (70% ethanol)
  - 0.65% hydrogen peroxide, 0.15% peroxyacetic acid
  - Accelerated hydrogen peroxide, 1.4% and 2.0%
  - Quat, (0.085% QACs; not K. pneumoniae)
Germicidal Activity of UV-C Against *C. auris* and *C. albicans*

UNC Hospitals, 2017

Very good inactivation of *Candida auris* by UV. Used Tru-D bacteria cycle (17-19 minute cycle, 12,000µWs/cm²).
ALL "TOUCHABLE" (HAND CONTACT) SURFACES SHOULD BE WIPEP WITH DISINFECTANT

“High touch” objects only recently defined (no significant differences in microbial contamination of different surfaces) and “high risk” objects not epidemiologically defined. Cleaning and disinfecting is one-step with disinfectant-detergent. No pre-cleaning necessary unless spill or gross contamination.
Effective disinfection of contaminated surfaces is essential to prevent transmission of epidemiologically-important pathogens.

Efforts to improve disinfection focuses on touched surfaces.

Although floors contaminated, limited attention because not frequently touched.

Floors are a potential source of transmission because often contacted by objects that are then touched by hands (e.g., shoes, socks).

Non-slip socks contaminated with MRSA, VRE (Mahida, J Hosp Infect. 2016;94:273)
Evaluation of Hospital Floors as a Potential Source of Pathogen Dissemination Using a Nonpathogenic Virus

Koganti et al. ICHE 2016. 37:1374

Figure 1. Illustration of high-touch surfaces sampled. Star, surfaces less than or equal to 3 feet from the center of the bed; square, surfaces more than 3 feet from the center of the bed; circle, personal items.
Recovery of Nonpathogenic Viruses from Surfaces and Patients on Days 1, 2, and 3 After Inoculation of Floor Near Bed
Koganti et al. ICHE 2016. 37:1374

<table>
<thead>
<tr>
<th>Variable</th>
<th>Day 1 (% Positive)</th>
<th>Day 2 (% Positive)</th>
<th>Day 3 (% Positive)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Hands</td>
<td>40</td>
<td>63</td>
<td>43</td>
</tr>
<tr>
<td>Patient Footwear</td>
<td>100</td>
<td>100</td>
<td>86</td>
</tr>
<tr>
<td>High-touch surface &lt;3ft</td>
<td>58</td>
<td>62</td>
<td>77</td>
</tr>
<tr>
<td>High-touch surface &gt;3ft</td>
<td>40</td>
<td>68</td>
<td>34</td>
</tr>
<tr>
<td>Personal items</td>
<td>50</td>
<td>44</td>
<td>50</td>
</tr>
<tr>
<td>Adjacent room floor</td>
<td>NA</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>Adjacent room environment</td>
<td>NA</td>
<td>40</td>
<td>11</td>
</tr>
<tr>
<td>Nursing station</td>
<td>53</td>
<td>47</td>
<td>63</td>
</tr>
<tr>
<td>Portable equipment</td>
<td>33</td>
<td>23</td>
<td>100</td>
</tr>
</tbody>
</table>

Surfaces <3ft included bedrail, call button, telephone, tray table, etc; surfaces >3ft included side table, chair, IV pole, etc; personal-cell phones, books, clothing, wheelchairs; nurses station included computer keyboard, mouse, etc
Found that a nonpathogenic virus inoculated onto floors in hospital rooms disseminated rapidly to the footwear and hands of patients and to high-touch surfaces in the room.

The virus was also frequently found on high-touch surfaces in adjacent rooms and nursing stations.

Contamination in adjacent rooms in the nursing station suggest HCP contributed to dissemination after acquiring the virus during contact with surfaces or patients.

Studies needed to determine if floors are source of transmission.
Evaluation of Hospital Floors as a Potential Source of Pathogen Dissemination

Deshpande et al. AJIC 2017. 45:336.

- 318 floors sites sampled in 159 rooms
- *C. difficile* most frequently isolated
- MRSA and VRE isolated more frequently from CDI rooms
- 41% (100) had objects (personal-clothing, phone chargers; medical-BP cuff, call button) in contact with floor
- Of 31 objects on floor, 18% MRSA, 6% VRE, 3% Cd bare/glove cultures positive
- Demonstrates potential for indirect transfer of pathogens to hands from fomites on floor

Fig 1. Recovery of *Clostridium difficile*, methicillin-resistant *Staphylococcus aureus*, and vancomycin-resistant enterococci from floors in patient rooms from 5 hospitals in northeast Ohio.
Potential Vector for Dissemination of Pathogens in an ICU

John et al. ICHE 2017;38:1247-1249

- A DNA marker inoculated onto shared portable equipment in SICU (Doppler ultrasound) and MICU (electrocardiogram) disseminated widely to surfaces in patient rooms and provider work areas and to other types of portable equipment.

- Results demonstrate the potential for contaminated portable equipment to serve as a vector for dissemination of pathogens.

William A. Rutala, Ph.D., M.P.H.\textsuperscript{1,2}, David J. Weber, M.D., M.P.H.\textsuperscript{1,2}, and the Healthcare Infection Control Practices Advisory Committee (HICPAC)\textsuperscript{3}
It appears that not only is disinfectant use important but how often is important.

Daily disinfection vs clean when soiled
Daily disinfection of high-touch surfaces (vs cleaned when soiled) with sporicidal disinfectant (PA) in rooms of patients with CDI and MRSA reduced acquisition of pathogens on hands after contact with surfaces and of hands caring for the patient.
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
Thoroughness of Environmental Cleaning

Carling et al. ECCMID, Milan, Italy, May 2011

![Graph showing thoroughness of environmental cleaning](image)

Mean = 32%

>110,000 Objects
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)
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
Percentage of Surfaces Clean by Different Measurement Methods


Fluorescent marker is a useful tool in determining how thoroughly a surface is wiped and mimics the microbiological data better than ATP.
There was no statistical correlation between ATP levels and standard aerobic plate counts.
Future Methods to Ensure Thoroughness
Future May Have Methods to Ensure Thoroughness

Solution: Highlight®

- Color-fading time can be matched to contact kill time for a disinfectant --> enforces compliance
- Prevents staining on permanent structures + reusable materials
- Provides real-time feedback when a surface is safe to touch
These interventions (effective surface disinfection, thoroughness indicators) not enough to achieve consistent and high rates of cleaning/disinfection

No Touch
(supplements but do not replace surface cleaning/disinfection)
“NO TOUCH” APPROACHES TO ROOM DECONTAMINATION

(will not discuss technology with limited data)

This technology (“no touch”-UV/HP) should be used (capital equipment budget) for terminal room disinfection (e.g., after discharge of patients on Contact Precautions).
New Technologies for Room/Surface Decontamination

Assessment Parameters


- Safe
- Microbicidal
- Reduction of HAIs
- Cost-effective
Since different UV and hydrogen peroxide systems vary substantially, infection preventionists should review the peer-reviewed literature and choose only devices with demonstrated bactericidal capability as assessed by carrier tests and/or the ability to disinfect actual patient rooms.

Ideally, one would select a device that has demonstrated bactericidal capability and the ability to reduce HAIs.
Enhanced Disinfection Leading to Reduction of Microbial Contamination and a Decrease in Patient Col/Infection
Rutala, Kanamori, Gergen et al. ID Week 2017; Andersen et al. Lancet 2017

<table>
<thead>
<tr>
<th>Standard Method</th>
<th>Enhanced method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quat</td>
<td>Quat/UV</td>
</tr>
<tr>
<td>Bleach</td>
<td>Bleach/UV</td>
</tr>
<tr>
<td>EIP (mean CFU per room)</td>
<td>60.8</td>
</tr>
<tr>
<td>Reduction (%)</td>
<td>94</td>
</tr>
<tr>
<td>Colonization/Infection (rate)</td>
<td>2.3</td>
</tr>
<tr>
<td>Reduction (%)</td>
<td>35</td>
</tr>
</tbody>
</table>

All enhanced disinfection technologies were significantly superior to Quat alone in reducing EIPs. Comparing the best strategy with the worst strategy (i.e., Quat vs Quat/UV) revealed that a reduction of 94% in EIP (60.8 vs 3.4) led to a 35% decrease in colonization/infection (2.3% vs 1.5%). Our data demonstrated that a decrease in room contamination was associated with a decrease in patient colonization/infection. First study which quantitatively described the entire pathway whereby improved disinfection decreases microbial contamination which in-turn reduced patient colonization/infection.
Back to the Basics of Disinfection

• **Overview of disinfection**

• **Low-level disinfection**
  - Role of environment in disease transmission
  - Products and practices for surface disinfection
    - New issues
      - Inactivation of emerging pathogens (e.g., CRE, C. auris)
  - Technologies for terminal room decontamination (not including technologies with limited data)

• **High-level disinfection**
  - Reprocessing channeled scopes
  - Shift from HLD to sterilization
  - HPV
Semicritical Items
Semicritical Medical Devices
Rutala et al. AJIC 2016;44:e47

• **Semicritical**
  - Transmission: direct contact
  - Control measure: high-level disinfection
  - Endoscopes top ECRI list of 10 technology hazards, >100 outbreaks (GI, bronchoscopes)
    - 0 margin of safety
    - Microbial load, $10^7-10^{10}$
    - Complexity
    - Biofilm
  - Other semicritical devices, rare outbreaks
    - ENT scopes, endocavitary probes (prostate, vaginal, TEE), laryngoscopes, cystoscopes
    - Reduced microbial load, less complex
Semicritical Items

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

Rutala WA, Weber DJ, HICPAC. www.cdc.gov

Spores (*C. difficile*)

Mycobacteria (*M. tuberculosis*)

Non-Enveloped Viruses (norovirus, HAV, polio)

Fungi (*Candida, Trichophyton*)

Bacteria (MRSA, VRE, Acinetobacter)

Enveloped Viruses (HIV, HSV, Flu)

Most Susceptible

Most Resistant

HLD
High-Level Disinfection of “Semicritical Objects”

Exposure Time > 8m-45m (US), 20°C

<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
Based on outbreak data, if eliminated deficiencies associated with cleaning, disinfection, AER, contaminated water and drying would eliminate about 85% of the outbreaks.
• In January 2015, after several outbreaks of serious infections, Senator Murray initiated an investigation to determine the extent of duodenoscope-linked infections

• Between 2012 and spring 2015, closed-channel duodenoscopes were linked to at least 25 different incidents of antibiotic-resistant infections that sickened at least 250 patients worldwide

• None of the manufacturers of the “closed-channel” duodenoscopes had sufficient data to show that duodenoscopes could be cleaned reliably between uses
## Recent Endoscopy-Related Outbreaks of MRDO Without Reprocessing Breaches

Rutala WA et al. Manuscript in preparation

<table>
<thead>
<tr>
<th>MDRO</th>
<th>Scope</th>
<th>No.</th>
<th>Recovered From Scope</th>
<th>Molecular Link</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. aeruginosa</em> (VIM-2)</td>
<td>Duodenoscope</td>
<td>22</td>
<td>Yes, under forceps elevator</td>
<td>Yes</td>
<td>Verfaillie CJ, 2015</td>
</tr>
<tr>
<td><em>E. coli</em> (AmpC)</td>
<td>Duodenoscope</td>
<td>35</td>
<td>Yes (2 scopes)</td>
<td>Yes</td>
<td>Wendorf, 2015</td>
</tr>
<tr>
<td><em>K. pneumoniae</em> (OXA)</td>
<td>Duodenoscope</td>
<td>12</td>
<td>No</td>
<td>Yes</td>
<td>Kola A, 2015</td>
</tr>
<tr>
<td><em>E. coli</em> (NDM-CRE)</td>
<td>Duodenoscope</td>
<td>39</td>
<td>Yes</td>
<td>Yes</td>
<td>Epstein L, 2015</td>
</tr>
<tr>
<td><em>K. pneumoniae</em></td>
<td>Duodenoscope</td>
<td>15</td>
<td>No</td>
<td>Yes</td>
<td>Kim S, 2016</td>
</tr>
<tr>
<td><em>K. pneumoniae</em></td>
<td>Duodenoscope</td>
<td>34</td>
<td>Yes</td>
<td>Yes</td>
<td>Marsh J, 2015</td>
</tr>
<tr>
<td><em>E. coli</em></td>
<td>Duodenoscope</td>
<td>3</td>
<td>No</td>
<td>Unknown</td>
<td>Smith Z, 2015</td>
</tr>
<tr>
<td><em>K. pneumoniae</em></td>
<td>Duodenoscope</td>
<td>13</td>
<td>Yes</td>
<td>Yes</td>
<td>Carbonne A, 2010</td>
</tr>
</tbody>
</table>
Reprocessing Failures Have Led to Patient Notifications and Bloodborne Pathogens Testing


<table>
<thead>
<tr>
<th>Location or institution, year</th>
<th>Instrument involved</th>
<th>No. of persons exposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sacramento, CA, 2002</td>
<td>Endoscope</td>
<td>750</td>
</tr>
<tr>
<td>Toronto, ON, 2003</td>
<td>Endoscope</td>
<td>146</td>
</tr>
<tr>
<td>Seattle, WA, 2004</td>
<td>Endoscope</td>
<td>600</td>
</tr>
<tr>
<td>Sacramento, CA, 2004</td>
<td>Endoscope</td>
<td>1,331</td>
</tr>
<tr>
<td>San Francisco, CA, 2004</td>
<td>Endoscope</td>
<td>2,000</td>
</tr>
<tr>
<td>Long Island, NY, 2004</td>
<td>Endoscope</td>
<td>177</td>
</tr>
<tr>
<td>Charleston, NC, 2004</td>
<td>Endoscope</td>
<td>1,383</td>
</tr>
<tr>
<td>Toronto, ON, 2003</td>
<td>Prostate biopsy probe</td>
<td>900</td>
</tr>
<tr>
<td>Pittsburgh, PA, 2005</td>
<td>Endoscope</td>
<td>200</td>
</tr>
<tr>
<td>Leesburg, VA 2005</td>
<td>Endoscope</td>
<td>144</td>
</tr>
<tr>
<td>San Diego, CA, 2006</td>
<td>Endoscope</td>
<td>300</td>
</tr>
<tr>
<td>Augusta, ME, 2006</td>
<td>Prostate biopsy needle</td>
<td>481</td>
</tr>
<tr>
<td>Dept Veterans Affairs, 2006</td>
<td>Prostate biopsy equipment</td>
<td>2,075</td>
</tr>
<tr>
<td>San Diego, CA, 2006</td>
<td>Surgical instrument</td>
<td>82</td>
</tr>
</tbody>
</table>

**Note.** Modified from a presentation by Douglas Nelson, MD, at the 33rd Annual Conference and International Meeting of the Association for Professionals in Infection Control and Epidemiology: Tampa, Florida, 2006.
Because more outbreaks associated with endoscopes than any other reusable medical device, endoscopes top ECRI’s list of 10 health technology hazards.

If we eliminate the risk of disease transmission associated with endoscopes, will eliminate risk associated with all medical and surgical devices.
GI Endoscopes:
Shift from Disinfection to Sterilization


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-β-lactamase (NDM)-producing Escherichia 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-

First, endoscopes are semicritical devices, which contact mucous membranes or nonintact skin, and require at least high-level disinfection. High-level disinfection achieves complete elimination of all microorganisms, except for small numbers of bacterial spores. Because flexible gastrointestinal endoscopic instruments are heat labile, only high-level disinfection with chemical agents or low-temperature sterilization technologies are possible. However, no low-temperature sterilization technology is US Food and Drug Administration (FDA)-cleared for gastrointestinal endoscopes such as duodenoscopes.

Second, more health care-associated outbreaks and clusters of infection have been linked to contaminated endoscopes than to any other medical device. However, until now,
ENDOSCOPE REPROCESSING

CDC 2008: Multi-Society Guideline on Endoscope Reprocessing, 2017

- PRECLEAN-point-of-use (bedside) remove debris by wiping exterior and aspiration of detergent through air/water and biopsy channels; leak test
- CLEAN-mechanically cleaned with water and enzymatic cleaner
- HLD/STERILIZE-immersoscope 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
**TABLE 3. Documented Completion of Steps During Manual Cleaning With High-Level Disinfection Reprocessing**

<table>
<thead>
<tr>
<th>Observed Activity</th>
<th>Steps Completed (%) (n = 69)</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><strong>Brush all endoscope channels and components</strong></td>
<td>43</td>
</tr>
<tr>
<td>Immerse endoscope completely in detergent</td>
<td>99</td>
</tr>
<tr>
<td>Immerse components completely in detergent</td>
<td>99</td>
</tr>
<tr>
<td>Flush endoscope with detergent</td>
<td>99</td>
</tr>
<tr>
<td>Rinse endoscope with water</td>
<td>96</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>
### Microbial Surveillance of GI Endoscopes

Saliou et al. *Endoscopy. 2016*

<table>
<thead>
<tr>
<th>Characteristics of Sample</th>
<th>Action Level (TCU&gt;100/scope) or EIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastroscope</td>
<td>26.6%</td>
</tr>
<tr>
<td>Colonoscope</td>
<td>33.7%</td>
</tr>
<tr>
<td>Duodenumscope</td>
<td>34.7%</td>
</tr>
<tr>
<td>Echo-endoscope</td>
<td>31.9%</td>
</tr>
<tr>
<td>AER</td>
<td>27.2%</td>
</tr>
<tr>
<td>Manual</td>
<td>39.3%</td>
</tr>
<tr>
<td>Age of endoscope &lt;2 years</td>
<td>18.9%</td>
</tr>
<tr>
<td>Age of endoscope &gt;2 years</td>
<td>38.8%</td>
</tr>
</tbody>
</table>
• All endoscopes (n=20) had visible irregularities (e.g., scratches)
• Researchers observed fluid (95%), discoloration, and debris in channels
EH Spaulding believed that how an object will be disinfected depended on the object’s intended use (developed 1968).

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 but high numbers of bacterial spores.

NONCRITICAL - objects that touch only intact skin require low-level disinfection (or non-germicidal detergent).
EH Spaulding believed that how an object will be disinfected depended on the object’s intended use (modified).

CRITICAL - objects which directly or secondarily (i.e., via a mucous membrane such as duodenoscope, cystoscope, bronchoscope) 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 but high numbers of bacterial spores.

NONCRITICAL - objects that touch only intact skin require low-level disinfection (or non-germicidal detergent).
Other Issues
• In 2011, TJC recommended that laryngoscope blades be packaged in a way that prevent recontamination

• Examples of compliant storage include, but not limited to, a peel pouch or a closed plastic bag

• Examples of non-compliant storage would include unwrapped blades in an anesthesia drawer as well as unwrapped blades on top of or within a code cart

• Packaging not only prevents recontamination but also distinguishes a processed from non-processed semicritical item such as a specula, endoscope, etc

• The use of a tagging system that separates processed from non-processed items minimizes the use of a semicritical item that has not been reprocessed, and minimizes unnecessary patient exposures and risk of disease transmission
Reprocessing Channeled Endoscopes
Cystoscope- “completely immerse” in HLD (J Urology 2008.180:588)
## Reprocessing Channeled Endoscopes


<table>
<thead>
<tr>
<th>Exposure Method</th>
<th>CRE (K. pneumoniae) Inoculum before HLD (glutaraldehyde)</th>
<th>CRE (K. pneumoniae) Contamination after HLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive HLD (immersed, not perfused)</td>
<td>3.2x10^8 1.9x10^9 4.1x10^8</td>
<td>3.1x10^8 4.6x10^8 1.0x10^8</td>
</tr>
<tr>
<td>Active HLD (perfused HLD into channel with syringe)</td>
<td>3.0x10^8 9.2x10^8 8.4x10^8</td>
<td>0 0 0</td>
</tr>
</tbody>
</table>

- Pathogens must have exposure to HLD for inactivation
- Immerse channeled flexible scope into HLD will not inactivate channel pathogens
- Completely immerse the endoscope in HLD and ensure all channels (e.g., hysteroscopes, cystoscopes) are perfused
- Air pressure in channel stronger than fluid pressure at fluid-air interface
Reprocessing Channeled Endoscopes

Cystoscope-HLD perfused through lumen with syringe (luer locks onto port and syringe filled and emptied until no air exits in the scope nor air in barrel of syringe-syringe and lumen filled with HLD)
Summary

• High-level disinfection guidelines must be followed to prevent exposure to pathogens that may lead to infection (laryngoscopes, endocavitary probes)

• Ensure channeled scopes are perfused with HLD
Assess presence of HPV on equipment used in GYN practice
Samples from fomites (glove box, lamp on GYN chair, gel tubes, colposcope, speculum) in 2 hospitals and 4 private practices
Samples analyzed by real-time PCR
32 (18%) HPV-positive samples found
Higher risk of HPV contamination in GYN private practices
Colposcope had the highest risk of contamination
Equipment and surfaces contaminated, need strategies to prevent contamination and transmission
ENDOSCOPE/ENDOCAVITARY PROBES REPROCESSING: CHALLENGES

Susceptibility of Human Papillomavirus


• Most common STD
• In one study, FDA-cleared HLD no effect on HPV
• Finding inconsistent with other small, non-enveloped viruses such as polio, rhino, echo
• Further investigation needed: test methods unclear; glycine; organic matter; comparison virus
• Conversation with CDC: validate and use HLD consistent with FDA-cleared instructions (no alterations)
Hydrogen Peroxide Mist
(uses HP mist to achieve HLD in 7m)
Efficacy of HP Mist Against HPV
Meyers C et al.  SHEA Poster, 2015

- HLD widely used to reprocess semicritical items including endocavitary probes
- Tested OPA, hypochlorite and HP mist
- HP mist system and hypochlorite >4 log_{10} reduction, OPA achieved <1 log_{10} reduction
Effectiveness of HP Mist System in Inactivating Healthcare Pathogens on Probes

Rutala, Gergen, Sickbert-Bennett. ICHE 2016;37:613-614

- Automated, closed system that uses HP mist for HLD of ultrasound probes
- $>10^6$ pathogens inoculated onto probe at 2-3 sites
- Inactivated bacteria and good but not complete kill of mycobacteria, spores
- Alternative to high-level disinfection by high-level disinfectants

<table>
<thead>
<tr>
<th></th>
<th>Probes with vancomycin-resistant Enterococcus (VRE), No./Total</th>
<th>Probes with CR Klebsiella pneumoniae, No./Total</th>
<th>Probes with Mycobacterium terrae, No./Total (mean log$_{10}$ reduction and 95% CI)</th>
<th>Probes with Clostridium difficile spores, No./Total (mean log$_{10}$ reductions and 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>0/7</td>
<td>0/6</td>
<td>4/9 (5.19 [4.61–5.76])</td>
<td>3/6 (5.12 [4.42–5.83])</td>
</tr>
<tr>
<td>Absent</td>
<td>0/6</td>
<td>0/6</td>
<td>1/6 (4.62 [4.07–5.17])</td>
<td>1/9 (6.23 [6.02–6.43])</td>
</tr>
</tbody>
</table>

**Table 1. Proportion of Surface and Endocavitary Probes Positive After System Processing According to the Presence or Absence of an Organic Challenge**
Effectiveness of Germicides Against HPV
(Dr. Carey Allen Moody, UNC and Duke UMC)

- Germicides
  - Aldehydes
    - Glutaraldehyde
    - Ortho-phthalaldehyde
  - Others
    - Phenolics
    - Ethanol
    - CHG-4%
    - Quats

- Germicides
  - Oxidizing agents
    - 1.5% and 2.0% accelerated HP
    - 0.525% sodium hypochlorite
    - 1% HP/0.08% peracetic acid
    - 0.2% peracetic acid, 55°C
    - 1000-1300ppm peracetic acid
What if HPV is Resistant to Aldehydes?

- If unlike all other non-enveloped viruses that are susceptible to aldehydes
- Upset the Spaulding classification scheme (HLD kill all viruses)
- If only oxidizing agents kill HPV (transition to PA or HP alone or combination)
Back to the Basics of Disinfection

- Overview of disinfection
- Low-level disinfection
  - Role of environment in disease transmission
  - Products and practices for surface disinfection
    - New issues
      - Inactivation of emerging pathogens (e.g., CRE, C. auris)
  - Technologies for terminal room decontamination (not including technologies with limited data)
- High-level disinfection
  - Reprocessing channeled scopes
  - Shift from HLD to sterilization
  - HPV
Back to the Basics of Disinfection

Summary

• Implement evidence-based practices for surface and instrument disinfection

  ▪ Ensure use of safe and effective (against emerging pathogens such as C. auris and CRE) low-level disinfectants

  ▪ Ensure thoroughness of cleaning (new thoroughness technology)

  ▪ Use “no touch” room decontamination technology proven to reduce microbial contamination on surfaces and reduction of HAIs at terminal/discharge cleaning

  ▪ 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.
THANK YOU!
www.disinfectionandsterilization.org