Current Issues in Disinfection and Sterilization

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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 but high numbers of bacterial spores.

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

Cleaning

• Mechanical cleaning machines-automated equipment may increase productivity, improve cleaning effectiveness, and decrease worker exposure
  • Ultrasonic cleaner
  • Washer sterilizer
  • Dishwasher
  • Washer disinfector
  • Manual

Bioburden on Surgical Devices

• Bioburden on instruments used in surgery (Nyström, 1981)
  • 52% contaminated with <10^3
  • 82% contaminated with <10^2
  • 91% contaminated with <10^1

• Bioburden on surgical instruments (Rutala, 1997)
  • 72% contained <10^1
  • 88% contained <10^2

Washer/Disinfector


• Five Chambers
  • Pre-wash: water/lactic acid 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>2.6x10⁶</td>
<td>Complete</td>
<td>0/8</td>
</tr>
<tr>
<td>Routine</td>
<td>VRE</td>
<td>2.6x10⁶</td>
<td>Complete</td>
<td>0/8</td>
</tr>
<tr>
<td>Routine</td>
<td>P. aeruginosa</td>
<td>2.1x10⁹</td>
<td>Complete</td>
<td>0/8</td>
</tr>
<tr>
<td>Routine</td>
<td>M. terrae</td>
<td>1.4x10⁹</td>
<td>7.8</td>
<td>2/8</td>
</tr>
<tr>
<td>Routine</td>
<td>GS spores</td>
<td>5.2x10⁶</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>8.3x10⁵</td>
<td>5.5</td>
<td>8/10</td>
</tr>
</tbody>
</table>

### Washer/Disinfector
Removal/inactivation of Inoculum (Non-Exposed) on Instruments

<table>
<thead>
<tr>
<th>WD Conditions</th>
<th>Organism</th>
<th>Inoculum</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Routine</td>
<td>MRSA</td>
<td>2.6x10⁶</td>
<td>Complete</td>
<td>0/8</td>
</tr>
<tr>
<td>Routine</td>
<td>VRE</td>
<td>2.9x10⁶</td>
<td>Complete</td>
<td>0/6</td>
</tr>
<tr>
<td>Routine</td>
<td>P. aeruginosa</td>
<td>2.1x10⁹</td>
<td>Complete</td>
<td>0/8</td>
</tr>
<tr>
<td>Routine</td>
<td>M. terrae</td>
<td>1.2x10⁹</td>
<td>7.6</td>
<td>6/8</td>
</tr>
<tr>
<td>Routine</td>
<td>GS spores</td>
<td>8.1x10⁵</td>
<td>-1</td>
<td>12/12</td>
</tr>
<tr>
<td>No Enz/Det</td>
<td>VRE</td>
<td>2.4x10⁵</td>
<td>Complete</td>
<td>0/10</td>
</tr>
<tr>
<td>No Enz/Det</td>
<td>GS spores</td>
<td>8.7x10⁵</td>
<td>1.6</td>
<td>10/10</td>
</tr>
</tbody>
</table>

### Recommendations
Monitoring of Sterilizers

- Monitor each load with physical and chemical (internal and external) indicators. If the internal indicator is visible, an external indicator is not needed.
- Use biological indicators to monitor effectiveness of sterilizers at least weekly with spores intended for the type of sterilizer (Class 6 simulating indicators not a substitute).
- Use biological indicators for every load containing implantable items and quarantine items, whenever possible, until the biological indicator is negative.

### Types of Sterilization Monitoring Devices

#### Chemical Indicators
- Internal chemical indicators
  - Class 3 (integrating indicator) — may be used as internal monitor; suppose to mimic the behavior of a biological indicator (BI)
  - Class 6 (not integrating indicator) — suppose to emulate or mimic the behavior of a biological indicator; are cycle-specific (need a sterilizing indicator designed to validate a 6 min/270°F cycle) and a different indicator to validate a 3 min/270°F. No professional organization (e.g., AOBN, AAMI) has recommended the use of Class 6 sterilizing indicator as a substitute for biological indicators and there are no data that demonstrate that it mimics a BI at suboptimal sterilization times.
- Class 2 (flow chemical indicator) — routine testing of vacuum; within a test pack daily in an empty sterilizer
- Class 3 (single port indicator; temperature, ETO, etc.) — may be used as external monitor
- Class 4 (multiport indicator) — may be used as internal monitor
Current Issues in Disinfection and Sterilization

- Disinfection and sterilization principles
- Current issues
  - Critical cleaning with weaker disinfectants, Class B chemical indicator
  - Semicritical items (e.g., endoscopes and C. difficile spores, new AE's)
  - Noncritical-surface disinfection
    - Norovirus and C. difficile spores
    - Birdseye
    - Computer-mediated antimicrobial activity, touchscreen cleaning
    - Germination-MRSA inoculation by disinfectants, techniques
    - Green products

C. difficile spores

Disinfectants and Antiseptics
C. difficile spores at 10 and 20 min, Ratke et al. 2009

- 4 log₁₀ reduction (3 C. difficile strains including BI-8)
  - Clorox, 1:10; 6,000 ppm chlorine (but not 1:50, 1,000 ppm)
  - Clorox Clean-up, 1,310 ppm chlorine
  - Tex., 25,000 ppm chlorine
  - Steris 20 sterile, 0.35% peracetic acid
  - Cidex, 2.4% glutaraldehyde
  - Cidex-OPA, 0.5% OPA
  - Wavicide, 2.63% glutaraldehyde
  - Aldehyde, 3.4% glutaraldehyde and 20% alcohol

High-Level Disinfection
C. difficile spores

- 2% glutaraldehyde is effective against C. difficile at 20 minutes
- 0.55% ortho-phthalaldehyde is effective against C. difficile at 10 minutes
- Steris 20 is effective against C. difficile at 10 and 20 minutes

Semicritical Equipment

- Reprocessing semicritical items has been shown to have a narrow margin of safety
- Generally, the narrow margin of safety attributed to high microbial load and complex instruments with lumens
- Any deviation from the recommended reprocessing protocol can lead to the survival of microorganisms and an increased risk of infection
- Problems encountered with reprocessing semicritical equipment often related to improper cleaning

Errors in designing and reprocessing semicritical items continue and place patients at risk of infection
Automatic Endoscope Reprocessors (AERs)

- Manual cleaning of endoscopes is prone to error.
- AER Advantages: automate and standardize reprocessing steps, reduce personnel exposure to chemicals, filtered tap water
- AER Disadvantages: failure of AERs linked to outbreaks, does not eliminate precleaning, does not monitor HLD concentration
- Problems: incompatible AER (side-viewing duodenoscope), biofilm buildup, contaminated AER, inadequate channel connectors; used wrong set-up or connector
- Must ensure exposure of internal surfaces with HLD/distillant

Automatic Endoscope Reprocessors

- EvoTech integrates cleaning (FDA-cleared claim) and disinfection. Automated cleaning compares to manual cleaning. All residual data for cleaning of the internal channel as well as external insertion tube surfaces were below the limit of <8 Sigma.
- Reliance requires a minimal number of connections to the endoscope channels and uses a control boot housing apparatus the creates pressure differentials to ensure continuous fluid flow through all channels that are accessible through the endoscope's control handle channel port. Data demonstrates that the soil and microbial removal offered by Reliance washing phase was equivalent to that achieved by optimal manual cleaning. All, Olson, DeGagne. AJIC 2005;34:551.

Infrared Coagulation (IRC)

- IRC is a widely used method for treating hemorrhoids. The procedure involves applying infrared light to compress and seal hemorrhoid veins.
- The manufacturer sells a sterile disposable sheath and states removing and soaking lightguides between procedures is no longer required.
- The manufacturer also states that the lightguide is damaged by immersion in a disinfectant (as the lightguide is not sealed at the end and disinfectant gets between the quartz glass and the covering)

Infrared Coagulation (IRC)

- CDC guideline (In press) recommends immersion for reprocessing endocavitary probes with covers because integrity of the cover is compromised (failure rate 1-80%)
- Since the lightguide cannot be immersed we investigated an alternative procedure
  - Wipe the probe for 2 minutes with 1:10 bleach
  - Wipe probe with sterile water and let air dry

Infrared Coagulation Testing

<table>
<thead>
<tr>
<th>Test Organism</th>
<th>Inoculum</th>
<th>Log₁₀ Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mycobacterium terrae</td>
<td>7.8 x 10⁶</td>
<td>6.9</td>
</tr>
</tbody>
</table>

Current Issues in Disinfection and Sterilization

- Disinfection and sterilization principles
- Current issues
  - Critical cleaning with washer disinfectant, Class II chemical indicator
  - Sensitival items (e.g., endoscopes and C. difficile spore, new AER)
  - Noncritical surface disinfection
    - Microbiota C. difficile spores
    - Microfiber
    - Computer-controlled disinfectant activity, immersion cleaning
    - Disinfect-MSRA disinfection by disinfectants, technique
    - Green products
Low-Level Disinfection for “Noncritical” Objects

<table>
<thead>
<tr>
<th></th>
<th>Use Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethyl or isopropyl alcohol</td>
<td>70-80%</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

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, prions
- Bioterrorism agents (anthrax, plague, smallpox)

C. difficile and Norovirus

Due to the relative resistance of C. difficile spores and norovirus, during clusters, surfaces should be disinfected with a product shown to be effective (e.g., chlorine 5000ppm [1:10 bleach])

Current issues in Disinfection and Sterilization

- Disinfection and sterilization principles
- Current issues
  - Critical cleaning with washer disinfectors, Class B chemical indicator
  - Semicritical items (e.g., endoscopes and C. difficile spores, raw AFPs)
  - Noncritical surface disinfection
    - Microfiber and C. difficile spores
    - Microfiber
    - Computers: sustained antimicrobial activity, touchscreen cleaning
    - Gemizinic-MRSA inactivation by disinfectants, technique
    - Grease products

Microfiber Cleaning

- Pad contains fibers (polyester and polyamide) that provide a cleaning surface 40 times greater than conventional string mops
- Proposed advantages: reduce chemical use and disposal (disinfectant solution not changed after every third room, clean microfiber per room [wastage lifetime 500-1000%]); light (~5 lbs less than string mop) and ergonomic; reduce cleaning times
- Does the microfiber provide the same or better removal of microorganisms on surfaces?

Effectiveness of Microfiber Mop

- Test conditions with an EPA-registered disinfectant: compared routine mop and bucket; microfiber mop and bucket; microfiber mop and system bucket. Twenty-four replicates per condition.
- Conducted RODAC sampling before and after floor disinfection (5 samples per room)
- New disinfectant solution for each test condition
- Dry time varied from 2 (routine mop and bucket)-8 (microfiber mop and bucket) minutes
### Effectiveness of Microfiber Mop

<table>
<thead>
<tr>
<th>Mop Type</th>
<th>Elimination (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disinfectant-regular mop</td>
<td>95%</td>
</tr>
<tr>
<td>Disinfectant-microfiber system</td>
<td>96%</td>
</tr>
<tr>
<td>Disinfectant-microfiber mop and regular mop bucket</td>
<td>88%</td>
</tr>
<tr>
<td>Detergent-regular mop</td>
<td>68%</td>
</tr>
<tr>
<td>Detergent-microfiber system</td>
<td>95%</td>
</tr>
<tr>
<td>Detergent-microfiber mop and regular mop bucket</td>
<td>78%</td>
</tr>
</tbody>
</table>

*Summary*
- The microfiber system demonstrated superior microbial removal compared to cotton string mops when used with a detergent cleaner.
- The use of a disinfectant did not improve the microbial elimination demonstrated by the microfiber system.
- Use of a disinfectant did significantly improve microbial removal when a cotton string mop was used.

### Disinfection of Computer Keyboards

**Computer Keyboards, ICHE 2006:27:372**

- Increased use of computers in patient areas has led to contamination of keyboards as reservoirs of pathogens
- Study performed to:
  - Examine the efficacy of different disinfectants on the computer keyboard
  - Determine if there were cosmetic (key lettering removed) or functional changes after 300 wipes

### Disinfection of Computer Keyboards

- All tested products were effective (>95%) in removing and/or inactivating the test pathogens (MRSA, P. aeruginosa). No functional/cosmetic damage after 300 wiper wipes.
- Disinfectants included: 3 quaternary ammonium compounds, 70% isopropanol alcohol, phenolic, chlorine (80ppm)
- At present, recommend that keyboards be disinfected daily (for 5 sec) and when visibly soiled

### Table 3: Terminal Efficacy of Disinfectants Applied to Keyboard Against Vancomycin-Resistant Envelopes Species

<table>
<thead>
<tr>
<th>Disinfectant</th>
<th>Challenge at 6 Hours</th>
<th>Challenge at 24 Hours</th>
<th>Challenge at 48 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 min</td>
<td>60 min</td>
<td>10 min</td>
</tr>
<tr>
<td>Marked</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co-Wipes</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Ocean Disinfecting Wipes</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td>Surf Clear Plus</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td>80% Isopropanol</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Note:** Efficiency was calculated as the percentage difference in the number of colony-forming units on the terminal hour, compared with the number of colony-forming units on the initial key. Challenge done for 5 sec after disinfectant exposure.

**QUATS demonstrated excellent sustained activity against VRE and antimicrobial activity was maintained over the 48 test period.**
**Touchscreen Cleaning**
- Follow the manufacturer's recommendations
- Prepare the cleaning solution according to the manufacturer's instructions (e.g., alcohol, glutaraldehyde, mild soap, phenolic)
- Wet a clean, soft cloth with the selected cleaning solution
- Remove excess liquid from the cloth and squeeze damp
- Wipe exposed surfaces (do not allow liquid to enter interior)
- Remove any soap residue by gently wiping with clean cloth
- QUATS are not recommended by some manufacturers

**Current Issues in Disinfection and Sterilization**
- Disinfection and sterilization principles
- Current issues
  - Critical cleaning with washer disinfector, Class II-chemical indicator
  - Sterilization lots (e.g., endoscopes and C. difficile spore, raw A/E5)
  - Noncritical surface disinfection
    - MRSA and C. difficile spore
    - Miscellaneous
    - Computer-sustained endometriosis activity, touchscreen cleaning
    - Gemecide-MRSA locations by disinfectant, technique
    - Green products

**MRSA**
- Frequency of environmental contamination in areas housing MRSA patients has ranged from 1 to 7% (23.1%, 50.0% from toilet seats) of surfaces cultured.
- MRSA visible in the environment for days to weeks.
- HDW can contaminate their hands or gloves by touching contaminated surfaces.
- Cleaning or disinfecting the environment can reduce transmission but cleaning regimens, as currently practiced, may not eliminate MRSA from surfaces.
- Since MRSA sensitive to all gemecides, likely due to surfaces not cleaned disinfecting.
- Need targeted methods to evaluate the thoroughness of room cleaning.

**Susceptibility of MSSA and MRSA to a Phenolic and Quaternary Product**

<table>
<thead>
<tr>
<th>Product</th>
<th>Phenolic 1:256</th>
<th>Phenolic 1:128</th>
<th>QUAT 1:56</th>
<th>QUAT 1:32</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSSA</td>
<td>2/60</td>
<td>0/60</td>
<td>5/60</td>
<td>1/60</td>
</tr>
<tr>
<td>MRSA</td>
<td>0/60</td>
<td>0/60</td>
<td>4/60</td>
<td>1/60</td>
</tr>
</tbody>
</table>

**Practice or Product**
Surface Disinfection
Effectiveness of Different Methods

<table>
<thead>
<tr>
<th>Technique (with cotton)</th>
<th>MRSA Log_{10} Reduction (QUAT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated cloth</td>
<td>4.56</td>
</tr>
<tr>
<td>Spray (10s) and wipe</td>
<td>4.56</td>
</tr>
<tr>
<td>Spray, wipe, spray (1m), wipe</td>
<td>4.56</td>
</tr>
<tr>
<td>Spray</td>
<td>4.56</td>
</tr>
<tr>
<td>Spray, wipe, spray (unti dry)</td>
<td>4.56</td>
</tr>
<tr>
<td>Control: detergent</td>
<td>2.83</td>
</tr>
</tbody>
</table>

Patient Area Cleaning/Disinfecting
PC Carling et al, SHEA 2007 and ICHE 2008;29:1

- Monitor cleaning performance using an invisible fluorescent targeting method. Rooms (14 high-touch objects) were marked and evaluated after terminal cleaning.
- Results: 1,119 rooms and 13,399 objects were evaluated in 23 hospitals. Mean proportion of objects cleaned was 46%. Following education and process improvement feedback, cleaning improved to 77%.
- Conclusion: Substantial opportunity for improving terminal cleaning/disinfecting activities.

The Green Hospital
Kesarl, Proto (Mass Gen Hosp), Fall 2007

- Hospitals are feeling the pressure to go green, both from eco-conscious donors and governmental agencies
- Some features of The Green Hospital
  - Roof garden/wildlife habitat, ads insulation, absorbs rain
  - Fewer contaminated-virality and moulds without flame retardants, formaldehyde-free insulation, green cleaning products (no hazardous fumes), triple-filtered air
  - Exposure to natural light
  - Reduced water usage-water efficient toilets and faucets
  - Greater energy efficiency-low energy fluorescent bulbs
  - More quiet number 1 complaint is noise, better insulation between rooms

Practice* NOT Product

*surfaces not wiped
**Summary**

- DIS guidelines must be followed to prevent exposure to pathogens that may lead to infection. Semiological items represent the greatest risk. Class 6 indicators not a substitute for biological indicators.
- During clusters, surfaces potentially contaminated with norovirus or C. difficile spores should be disinfected with an agent shown to have efficacy (e.g., hypochlorite, 2600 ppm)
- Washer-disinfectors are very effective in removing/inactivating microbes
- Microfiber demonstrated superior microbial removal compared to cotton-tipped swabs with a detergent
- Disinfectants (but not natural products) demonstrate excellent activity against MRSA but practices are deficient. QUATS have sustained antimicrobial activity.

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**Current Issues in Disinfection and Sterilization**

- Disinfection and sterilization principles
- Current issues
  - Critical-cleaning vs. washer disinfection, Class 6 chemical indicator
  - Semiological items (e.g., endoscopes and C. difficile spores, AFRIs)
  - Noncritical-surface disinfection
  - Norovirus and C. difficile spores
  - Microfiber
  - Computer-sustained antimicrobial activity, touchscreen cleaning
  - Green disinfection
  - Green products

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**Green** cleaners will remove microbial contaminants but will not dependably kill

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**Table 1**

<table>
<thead>
<tr>
<th>Product</th>
<th>0.5 min</th>
<th>3 min</th>
<th>5 min</th>
<th>10 min</th>
<th>15 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>NorWax</td>
<td>&gt;1.8</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
</tr>
<tr>
<td>BAC</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
</tr>
<tr>
<td>Cidex</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
</tr>
<tr>
<td>Quat</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
</tr>
</tbody>
</table>

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**Table 2**

<table>
<thead>
<tr>
<th>Product</th>
<th>0.5 min</th>
<th>3 min</th>
<th>5 min</th>
<th>10 min</th>
<th>15 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>NorWax</td>
<td>&gt;1.8</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
</tr>
<tr>
<td>Cidex</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
</tr>
<tr>
<td>Quat</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
<td>&gt;2.0</td>
</tr>
</tbody>
</table>

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**Figure**

- Disinfection and sterilization principles
- Current issues
- Critical-cleaning vs. washer disinfection, Class 6 chemical indicator
- Semiological items (e.g., endoscopes and C. difficile spores, AFRIs)
- Noncritical-surface disinfection
- Norovirus and C. difficile spores
- Microfiber
- Computer-sustained antimicrobial activity, touchscreen cleaning
- Green disinfection
- Green products

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**disinfectionandsterilization.org**
Thank you

References

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