# Safer Healthcare Environments for Infection Prevention

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# DISCLOSURES

**2018**

- **Consultations**
  - ASP (Advanced Sterilization Products), PDI
- **Honoraria**
  - PDI, ASP
- **Scientific Advisory Board**
  - Kinnos
- **Grants**
  - CDC, CMS

disinfectionandsterilization.org

## Safer Healthcare Environments for Infection Prevention

- Reprocessing reusable medical/surgical instruments
- Environmental Surface Disinfection
  - Ideal Disinfectant
- Water

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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**

# 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
  - Contact: sterile tissue
  - Transmission: direct contact
  - Control measure: sterilization
  - Surgical instruments
    - Enormous margin of safety, rare outbreaks
    - ~85% of surgical instruments <100 microbes
    - Washer/disinfector removes or inactivates 10-100 million
    - Sterilization kills 1 trillion spores

# Sterilization of “Critical Objects”

Steam sterilization

Hydrogen peroxide gas plasma

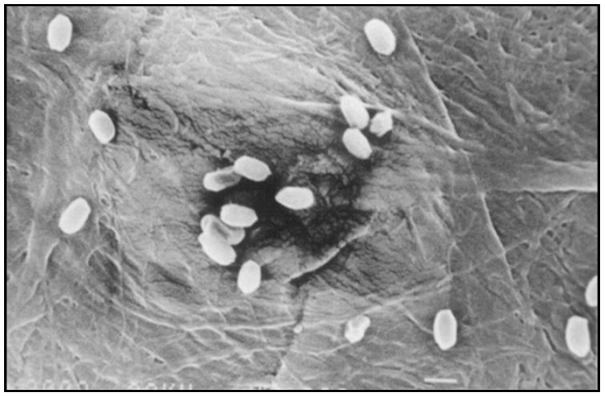
Ethylene oxide

Ozone and hydrogen peroxide

Vaporized hydrogen peroxide

# Biological Indicators

- **Select BIs that contain spores of *B. atrophaeus* or *Geobacillus stearothermophilus***
  - **Rationale: BIs are the only sterilization process monitoring device that provides a direct measure of the lethality of the process**



*Bacillus atrophaeus*

# 30m or 24m Biological Indicator for HP Sterilizers



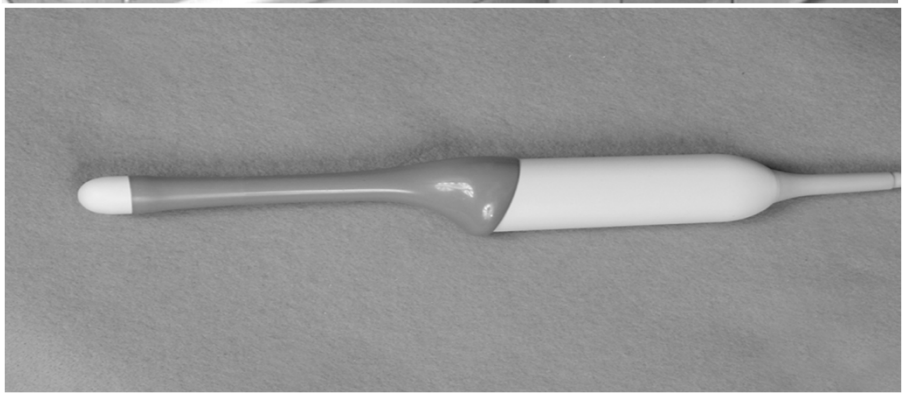
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# Semicritical Medical Devices

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

# Reprocessing Reusable Medical/Surgical Devices

- Shift from HLD to sterilization dependent on technology
- Most infections associated with endoscopes
- Perfuse channeled scopes
- Reprocessing laryngoscopes
- Endocavitary probes
- Ultrasound probe reprocessing

# GI Endoscopes: Shift from Disinfection to Sterilization

**Rutala, Weber. JAMA 2014. 312:1405-1406**

EDITORIAL

Editorials represent the opinions of the authors and *JAMA* and not those of the American Medical Association.

## 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.[1] 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.[1]

In this issue of *JAMA*, Epstein and colleagues[2] 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-

Related article page 1447

First, endoscopes are semicritical devices, which contact mucous membranes or nonintact skin, and require at least high-level disinfection.[3,4] 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.[3] 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.[3,5] However, until now,

# Evidence-Based Recommendation for Sterilization of Endoscopes

**(FDA Panel Recommendation for Duodenoscopes, May 2015; more peer-reviewed publications (>150) for the need for shifting from disinfection to sterilization than any other recommendation of AAMI, CDC [HICPAC], SHEA, APIC, SGNA, ASGE)**

>130 plus endoscope-related outbreaks

GI endoscope contamination rates of 20-40% after HLD

Scope commonly have disruptive/irregular surfaces

>50,000 patient exposures involving HLD

# Where are we?

# Potential Future Methods to Prevent Endoscope-Related Outbreaks

**Rutala, Weber. Am J Infect Control. 2016;44:e1-e6; Rutala, Weber ICHE. 2015;36:643.**

- Optimize current low temperature sterilization methods or new LTST proving SAL $10^{-6}$ achieved (2 LTS technologies, FDA-cleared)
- Disposable sterile GI endoscopes/bronchoscopes (4 manufacturers)
- Steam sterilization for GI endoscopes (1 bronchoscope manufacturer)
- Use of non-endoscope methods to diagnosis or treat disease (e.g., capsule endoscopy, stool or blood tests to detect GI cancer, stool DNA test)
- Improved GI endoscope design (to reduce or eliminate reprocessing challenges-based on 50y of experience unlikely to resolve problem; closed channel duodenoscopes increased risk)

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# Infections/Outbreaks Associated with Semicritical Medical Devices

**Rutala, Weber, AJIC, In preparation**

| Medical Device | No. Outbreaks/Infections | No. Outbreaks/Infections with Bloodborne Pathogens |
|---|---|---|
| Vaginal Probes | 0 | 0 |
| Ear-Nose-Throat Endoscopes | 0 | 0 |
| Cystoscopes | 5 | 0 |
| Hysteroscopes | 0 | 0 |
| Laryngoscopes | 1 | 0 |
| Ureteroscopes | 1 | 0 |
| Prostate Probes | 3 | 0 |
| TEE-Transesophageal echocardiogram | 3 | 0 |
| GI Endoscopes/Bronchoscopes | ~130 | 4 (HBV-1 GI; HCV-3 GI; HIV-0) |

# Infections/Outbreaks Associated with Semicritical Medical Devices

**Rutala, Weber, AJIC, In preparation**

- HBV and HCV transmission during endoscopy and use of semicritical medical devices can occur, but it is rare
- Four reports of HCV and HBV transmission related to breaches involved in GI endoscope reprocessing
- No articles related to possible transmission of HIV via medical device
- Greatest evidence of transmission associated with GI endoscopes/bronchoscopes(~130 outbreaks) likely due to microbial load and complexity.
- Other semicritical medical devices are rarely associated with infections related to inadequate reprocessing

# High-Level Disinfection of "Semicritical Objects"

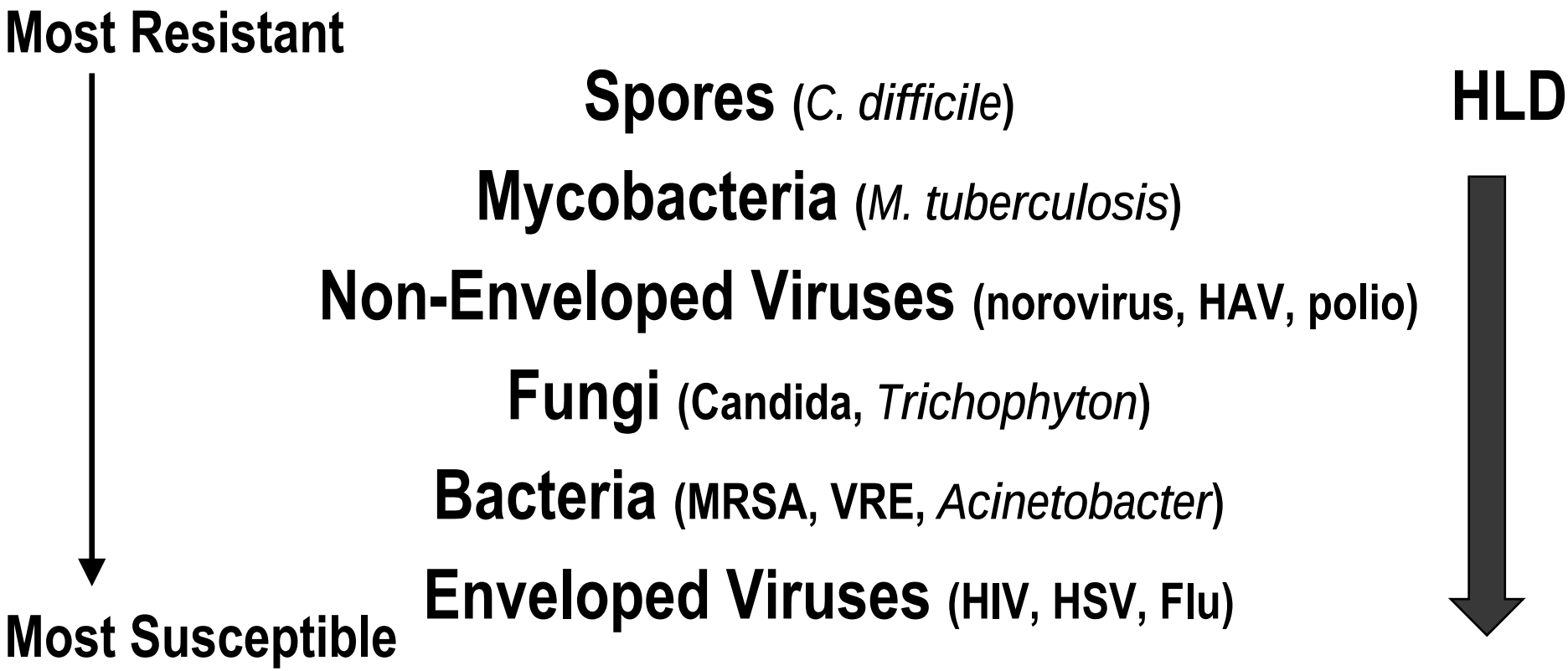
Exposure Time ≥ 8m-45m (US), 20°C

| Germicide | Concentration |
|---|---|
| Glutaraldehyde | ≥ 2.0% |
| Ortho-phthalaldehyde | 0.55% |
| Hydrogen peroxide* | 7.5% |
| Hydrogen peroxide and peracetic acid* | 1.0%/0.08% |
| Hydrogen peroxide and peracetic acid* | 7.5%/0.23% |
| Hypochlorite (free chlorine)* | 650-675 ppm |
| Accelerated hydrogen peroxide | 2.0% |
| Peracetic acid | 0.2% |
| Glut and isopropanol | 3.4%/26% |
| Glut and phenol/phenate** | 1.21%/1.93% |

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

# Microbiological Disinfectant Hierarchy

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



# Reason for Endoscope-Related Outbreaks

Rutala WA, Weber DJ. Infect Control Hosp Epidemiol 2015;36:643-648

- Margin of safety with endoscope reprocessing minimal or non-existent
- Microbial load
  - GI endoscopes contain $10^{7-10}$
  - Cleaning results in 2-6 $\log_{10}$ reduction
  - High-level disinfection results in 4-6 $\log_{10}$ reduction
  - Results in a total 6-12 $\log_{10}$ reduction of microbes
  - Level of contamination after processing: $4\log_{10}$ (maximum contamination, minimal cleaning/HLD)
- Complexity of endoscope and endoscope reprocessing
- Biofilms-could contribute to failure of endoscope reprocessing

# Microbial Surveillance of GI Endoscopes

**Saliou et al. Endoscopy. 2016**

| Characteristics of Sample | Action Level (TCU>100/scope) or EIP |
|---|---|
| Gastroscope | 26.6% |
| Colonoscope | 33.7% |
| Duodenoscope | 34.7% |
| Echo-endoscope | 31.9% |
| AER | 27.2% |
| Manual | 39.3% |
| Age of endoscope <2 years | 18.9% |
| Age of endoscope >2 years | 38.8% |

# Visual Inspection of GI Endoscopes and Bronchoscopes

**GI Endoscopes, Ofstead et al. Am J Infect Control. 2017. 45:e26-e33**

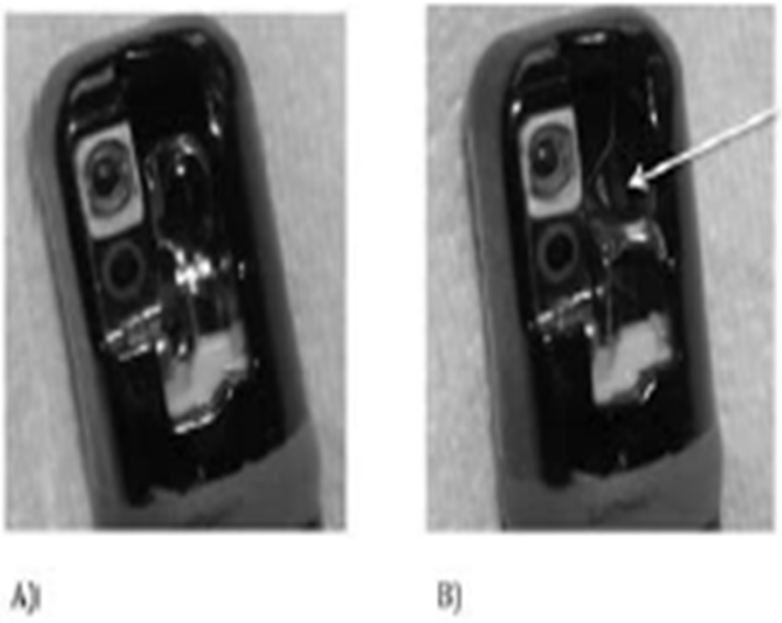
- **All endoscopes (n=20) had visible irregularities (e.g., scratches)**
- **Researchers observed fluid (95%), discoloration, and debris in channels**
- **60% scopes with microbial contamination**

**Bronchoscopes, Ofstead et al. Chest. 2018**

- **Visible irregularities were observed in 100% (e.g., retained fluid, scratches, damaged insertion tubes)**
- **Microbial contamination in 58%**
- **Reprocessing practices deficient at 2 of 3 sites**

# Duodenoscope Lever Position

**Alfa et al. AJIC 2018;46:73-75**



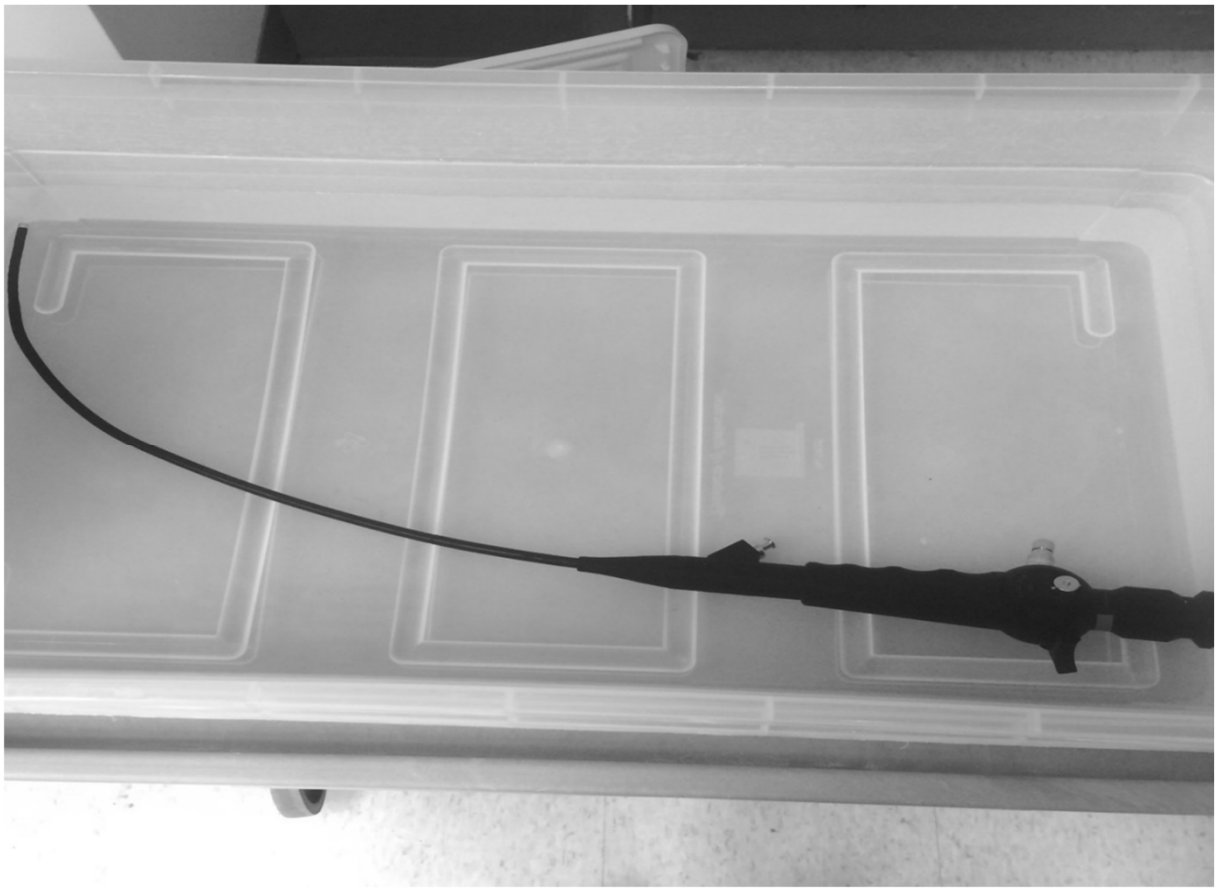

- Bacteria will survive if the elevator lever was improperly positioned (in horizontal position instead of 45º) in AER
- *E. faecalis* (7 log inoculum, 2-6 log recovered) and *E. coli* (0-3 log) survived disinfection of sealed and unsealed elevator wire channel duodenoscopes in 2 different AERs
- Ensure proper lever position when placed in AERs with PA

# Reprocessing Reusable Medical/Surgical Devices

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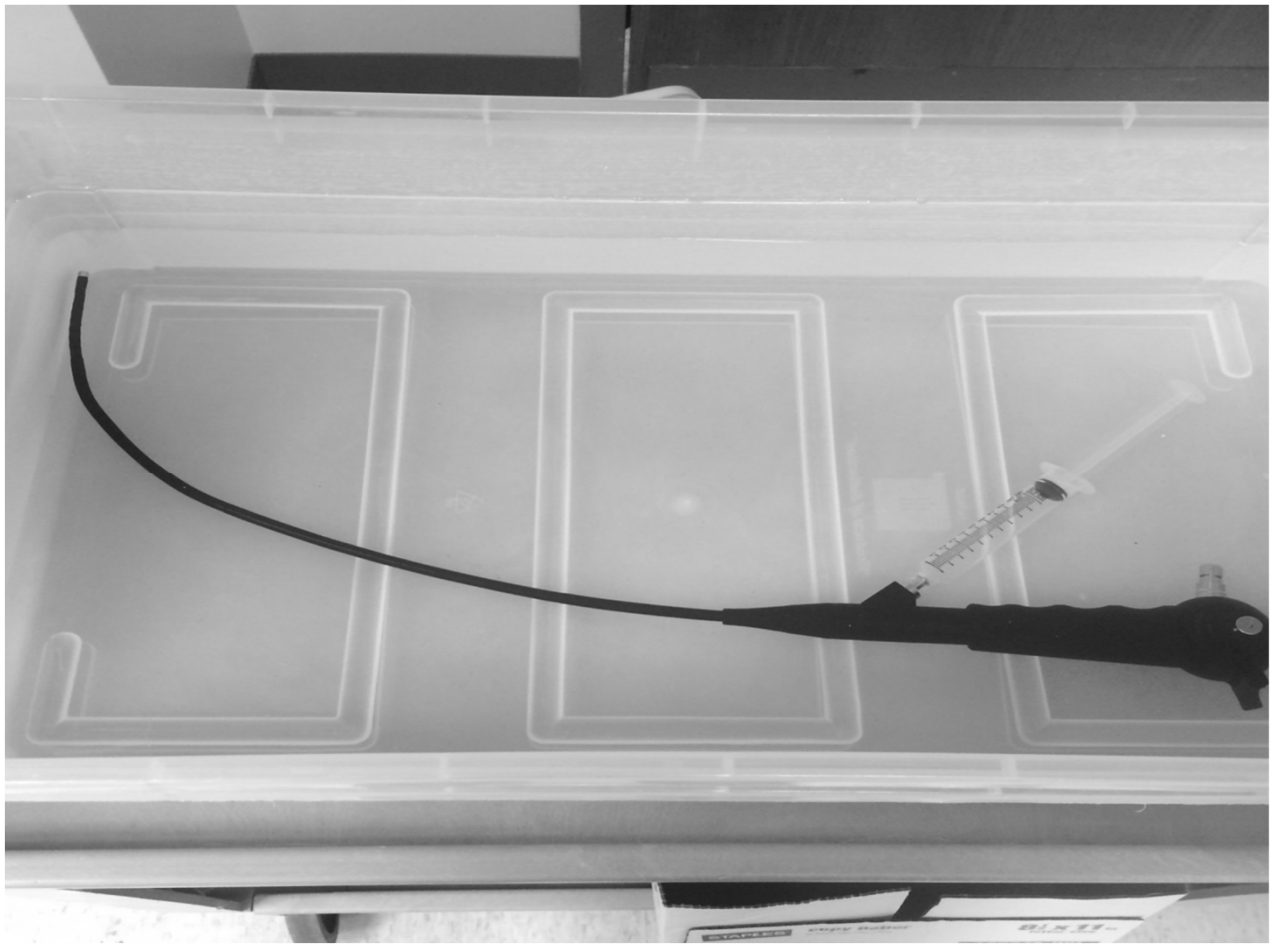
# Reprocessing Channeled Endoscopes

## Cystoscope- “completely immerse” in HLD (J Urology 2008.180:588)



# Reprocessing Channeled Endoscopes

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



# Reprocessing Channeled Endoscopes

## Rutala, Gergen, Bringhurst, Weber. ICHE. 2016;37:228-231

| Exposure Method | CRE (*K. pneumoniae*) Inoculum before HLD (glutaraldehyde) | CRE (K. pneumoniae) Contamination after HLD |
|---|---|---|
| Passive HLD (immersed, not perfused) | $3.2x10^8$<br>$1.9x10^9$<br>$4.1x10^8$ | $3.1x10^8$<br>$4.6x10^8$<br>$1.0x10^8$ |
| Active HLD (perfused HLD into channel with syringe) | $3.0x10^8$<br>$9.2x10^8$<br>$8.4x10^8$ | 0<br>0<br>0 |

- 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

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# Disposable vs Reusable Laryngoscopes



- Many hospitals transitioning to disposable laryngoscopes
- Saves time
- Virtually eliminates risk of cross contamination
- Reduces likelihood on non-performing equipment
- Possibly cost-effective when considering reprocessing costs


RUSCH
Mac: 2/s
RUSCH


RUSCH
RUSCH
Mac. 2

# Reprocessing of Rigid Laryngoscopes

JHI 2008, 68:101; ICHE 2007, 28:504; AJIC 2007, 35: 536; AJIC 2013,41:S60

- Limited guidelines for reprocessing laryngoscope's blades and handles
- For years, many hospitals consider blade as semicritical (HLD) and handle as noncritical (LLD)
- Blades linked to HAIs; handles not directly linked to HAIs but contamination with microbes/blood/OPIM suggest its potential and blade and handle function together
- Ideally, clean then HLD/sterilize blades and handles (UNCH-blades and handles sterilized).

# Contamination of Laryngoscope Handles

**J Hosp Infect 2010;74:123**

- **55/64 (86%) of the handles deemed "ready for patient use" positive for HA pathogens (*S. aureus*, enterococci, *Klebsiella*, *Acinetobacter*)**

  **Anesth Analg 2009;109:479**

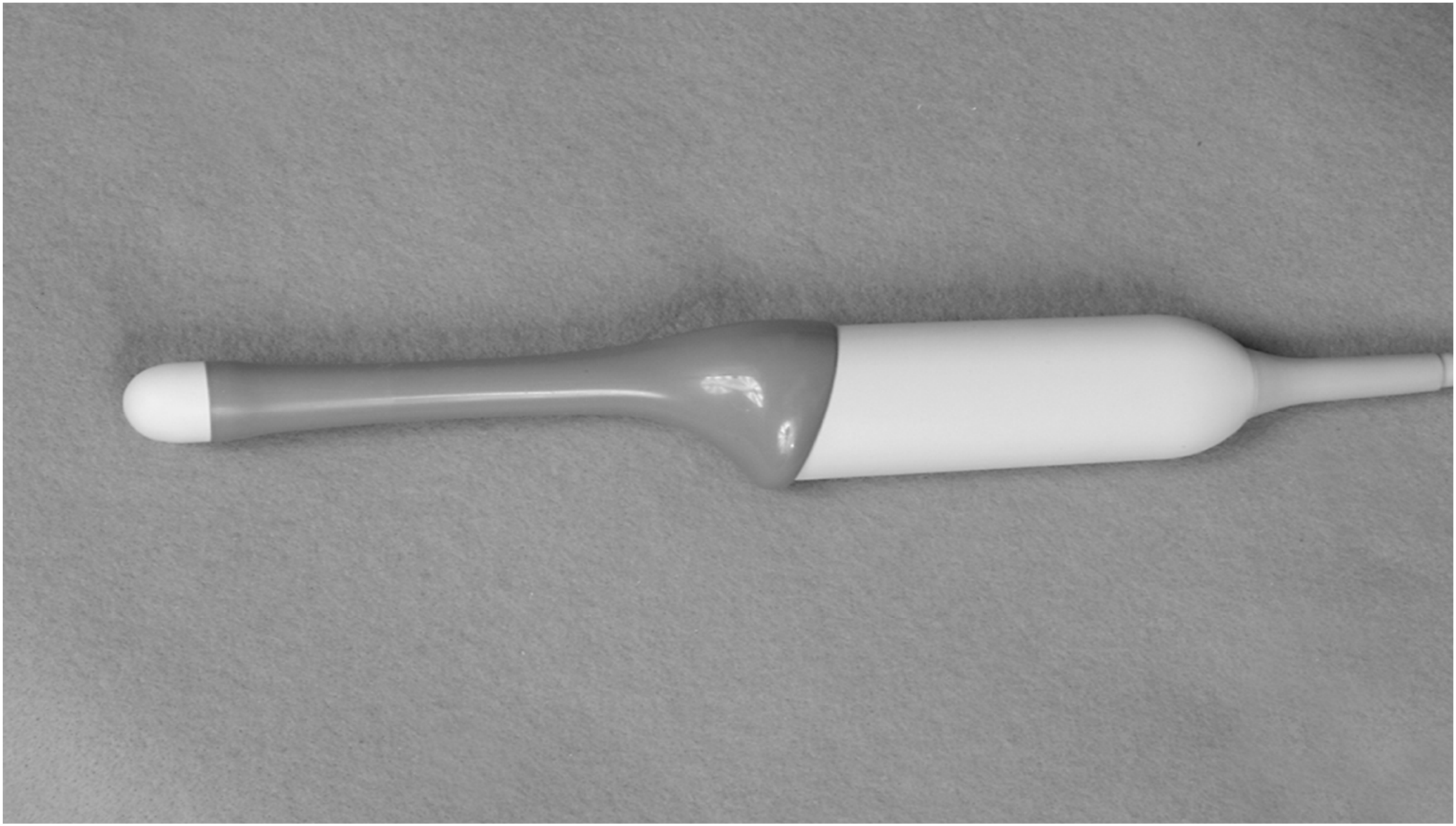
- **30/40 (75%) samples from handles positive (CONS, *Bacillus*, *Streptococcus*, *S. aureus*, *Enterococcus*) after cleaning**

**AANA J 1997;65:241**

- **26/65 (40%) of the handles and 13/65 (20%) of the blades were positive for occult blood. These blades and handles were identified as ready for patient use.**

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# Endocavitary Probes

**Rutala, Weber, HIPAC. www.cdc.gov 2008; Rutala, Weber. AJIC 2016.44:e53-e62**

- Probes-Transesophageal echocardiography probes, vaginal/rectal probes used in sonographic scanning
- Probes with contact with mucous membranes are semicritical
- Guideline recommends that a new condom/probe cover should be used to cover the probe for each patient and since covers may fail (1-80%), HLD (semicritical probes) should be performed

# Endocavitary Probe Covers

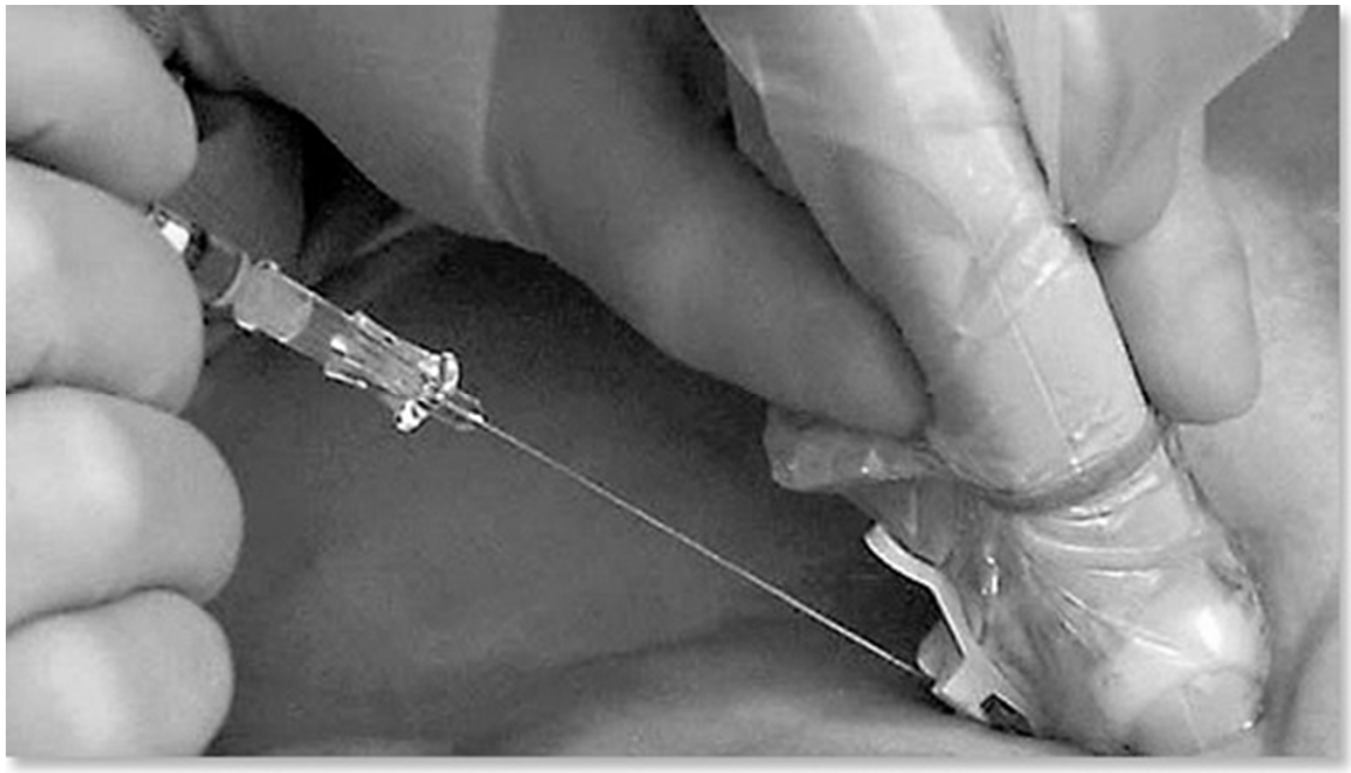
**Rutala, Weber. AJIC 2013. 41:S60-S66; Rutala, Weber. AJIC 2016.44:e53-e62**

- Sterile transvaginal probe covers had a very high rate pf perforations before use (0%, 25%, 65% perforations from three suppliers)
- A very high rate of perforations in used endovaginal probe covers was found after oocyte retrieval use (75% and 81% from two suppliers) but other investigators found a lower rate of perforations after use of condoms (0.9-2.0%)
- Condoms superior to probe covers for ultrasound probe (1.7% condom, 8.3% leakage for probe covers)

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**Do ultrasound transducers used for placing peripheral or central venous access devices require HLD/sterilization?**



## Do ultrasound transducers used for placing peripheral or central venous access devices require HLD/sterilization?

A publication has interpreted CDC and AIUM recommendations differently than most hospitals (AJIC 2018:46:913-920): ultrasound guided CVC insertion (critical-sterilize or HLD with sterile sheath and sterile gel); scan across unhealthy skin (semicritical-HLD and use with clean sheath and clean gel)

# Transducer Disinfection for Insertion of Peripheral and Central Catheters

**Association of Vascular Access Guideline. June 2018; AIUM 2017**

- "All transducers/probes used for peripheral VAD insertion will undergo, at a minimum, low-level disinfection…." Clean (step 1) the probe prior to disinfection (step 2).
- "During assessment, consider using a single-use condom or commercially manufactured transducer sheath (excluded: transparent dressing, gloves) during all use where there is the possibility of contact with blood/body fluids or non-intact skin"
- "Perform ALL ultrasound guided vascular access device insertions (PIV, Midline, PICC, CVC, arterial line) with the use of a sterile sheath and single-use sterile gel".
  - After the procedure, the used sheath should be inspected for tears and the transducer inspected for potential compromise
  - Once inspected, the probe should be cleaned and then disinfected.

# Transducer Disinfection for Insertion of Peripheral and Central Catheters

**Association of Vascular Access (AVA) Guideline. June 2018; AIUM 2017**

- All clinicians  involved in ultrasound guidance should undergo comprehensive training on disinfection of the US transducers
- The AVA recommendations are similar to guidelines from the American Institute for Ultrasound in Medicine (AIUM): that is, internal probes-HLD; “interventional percutaneous procedure probes that are used for percutaneous needle or catheter placement…should be cleaned using LLD and be used in conjunction with a single-use sterile probe cover”, if probe cover compromised HLD the probe.

# Transducer Disinfection for Insertion of Peripheral and Central Catheters

**Comments**

- Blood contamination of probe is infrequent
- Sheath plus cleaning plus LLD should eliminate HBV, HCV, HIV
- Likelihood of transmission, even if probe still contaminated, very remote – would require contaminating virus gaining entry via contact with the actual injection site
- Transmission of HIV, HBV, HCV via a probe using on external body surface never demonstrated
- Only semicritical medical device to transmit HBV or HCV is GI endoscope (HIV not transmitted)
- If all devices that could contact non-intact skin or be blood contaminated require HLD prior to reuse that would include linen/mattresses (Burn Center), stethoscopes, BP cuffs, xray cassettes, etc

# DISINFECTION AND STERILIZATION

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  - Ideal Disinfectant
- Water

# Environmental Contamination Leads to HAIs

**Weber, Kanamori, Rutala. Curr Op Infect Dis .2016.29:424-431**



- Evidence environment contributes
- Role-MRSA, VRE, *C. difficile*
- Surfaces are contaminated-~25%
- EIP survive days, weeks, months
- Contact with surfaces results in hand contamination
- 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 previous patient's pathogen by 39-353%
- For example, increased risk for *C. difficile* is 235% (11.0% vs 4.6%)
- Exposure to contaminated rooms confers a 5-6 fold increase in odds of infection, hospitals must adopt proven methods for reducing environmental contamination (Cohen et al. ICHE. 2018;39:541-546)

# Acquisition of EIP on Hands of Healthcare Providers after Contact with Contaminated Environmental Sites and Transfer to Other Patients





# Acquisition of EIP on Hands of Patient after Contact with Contaminated Environmental Sites and Transfers EIP to Eyes/Nose/Mouth



# Environmental Contamination Leads to HAIs

- By contaminating hands/gloves via contact with the environment and transfer to patient, or patient self inoculation
- Surface should be hygienically clean (not sterile)-free of pathogens in sufficient numbers to prevent human disease
- Two environmental surface concerns
  - Discharge/terminal-new patient in room
  - Daily room decontamination

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  - Discharge/terminal-prevent infection to new patient in room
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# “No Touch” Approaches To Room Decontamination

**(UV/VHP~20 microbicidal studies, 12 HAI reduction studies; will not discuss technology with limited data)**

**Weber, Kanamori, Rutala. Curr Op Infect Dis 2016;29:424-431; Weber, Rutala et al. AJIC; 2016:44: e77-e84; Anderson et al. Lancet 2017;389:805-14; Anderson et al. Lancet Infect Dis 2018;June 2018.**







# Enhanced Disinfection Leading to Reduction of Microbial Contamination and a Decrease in Patient Col/Infection

**Anderson et al. Lancet 2017;289:805; Rutala et al. ICHE 2018;38:1118-1121**

| | Standard Method | | Enhanced method | |
|---|---|---|---|---|
| | Quat | Quat/UV | Bleach | Bleach/UV |
| EIP (mean CFU per room)[a] | 60.8 | 3.4 | 11.7 | 6.3 |
| Reduction (%) | | 94 | 81 | 90 |
| Colonization/Infection (rate)[a] | 2.3 | 1.5 | 1.9 | 2.2 |
| Reduction (%) | | 35 | 17 | 4 |

**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.**

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  - Discharge/terminal-new patient in room
  - Daily room decontamination (referred to “trash and dash”)

# Evidence That All Touchable Room Surfaces Are Equally Contaminated

**Huslage K, Rutala W, Gergen M, Sickbert-Bennett E, Weber D. ICHE 2013;34:211-2**

TABLE 1. Precleaning and Postcleaning Bacterial Load Measurements for High-, Medium-, and Low-Touch Surfaces

| Surface (no. of samples) | Mean CFUs/RODAC (95% CI) | |
|---|---|---|
| | Precleaning | Postcleaning |
| High ($n$ = 40) | 71.9 (46.5–97.3) | 9.6 (3.8–15.4) |
| Medium ($n$ = 42) | 44.2 (28.1–60.2) | 9.3 (1.2–17.5) |
| Low ($n$ = 37) | 56.7 (34.2–79.2) | 5.7 (2.01–9.4) |

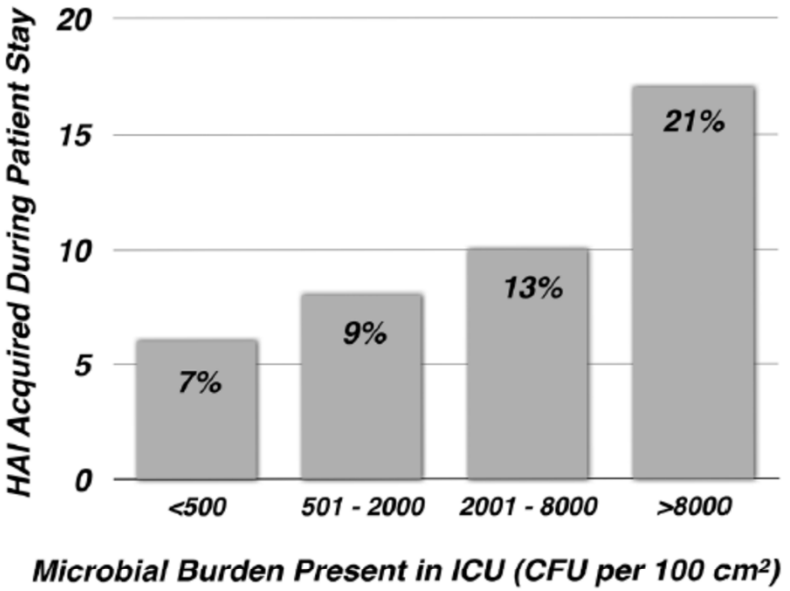
NOTE. CFU, colony-forming unit; CI, confidence interval.

# Relationship Between Microbial Burden and HAIs

**Rutala WA et al. ICHE 2018;38:1118-1121; Salgado CD, et al. ICHE 2013;34:479-86**

Table 2. Relationship between microbial reduction of epidemiologically-important pathogens (EIP) and colonization/infection in a patient subsequently admitted to a room of a patient colonized/infected with an EIP by decontamination method.

| | Standard Method | | Enhanced method | |
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IGURE 2. Quartile distribution of healthcare-acquired infections HAIs) stratified by microbial burden measured in the intensive care nit (ICU) room during the patient's stay. There was a significant ssociation between burden and HAI risk ($P = .038$), with 89% of HAIs occurring among patients cared for in a room with a burden of more than 500 colony-forming units (CFUs)/100 cm².

# To reduce microbial contamination

Continuous Room Decontamination Technology

# Continuous Room Decontamination Technologies for Disinfection of the Healthcare Environment

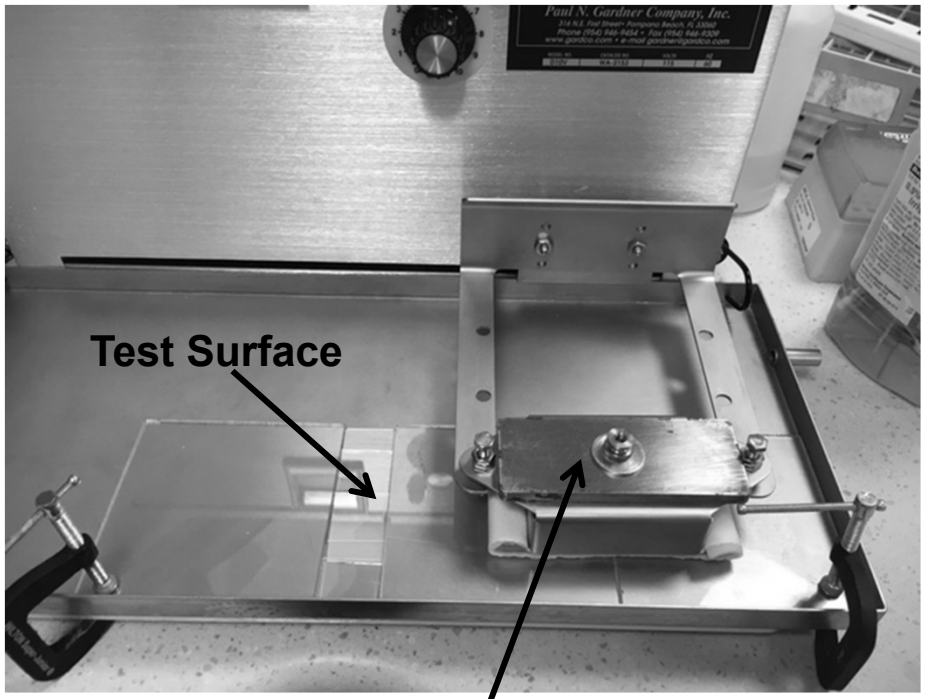
- Visible light disinfection through LEDs
- Low concentration hydrogen peroxide
- Self-disinfecting surfaces
- Persistent (or continuously active) disinfectant that provides continuous disinfection action

# Evaluation of a Persistent Surface Disinfectant

## "EPA Protocol for Residual Self-Sanitizing Activity of Dried Chemical Residuals on Hard, Non-Porous Surfaces"

## Abrasion Tester





# Efficacy of a Persistent Surface Disinfectant

## Rutala WA, Gergen M, Sickbert-Bennett E, Anderson D, Weber D. ID Week 2018

**4-5 $log_{10}$ reduction in 5min over 24hr for most pathogens; ~99% reduction with *Klebsiella* and CRE *Enterobacter*.**

| Test Pathogen | Mean $Log_{10}$ Reduction , 95% CI n=4 |
|---|---|
| *S.aureus** | 4.4 (3.9, 5.0) |
| *S.aureus* (formica) | 4.1 (3.8, 4.4) |
| *S.aureus* (stainless steel) | 5.5 (5.2, 5.9) |
| VRE | ≥4.5 |
| *E.coli* | 4.8 (4.6, 5.0) |
| *Enterobacter sp.* | 4.1 (3.5, 4.6) |
| *Candida auris* | ≥5.0 |
| *K pneumoniae* | 1.5 (1.4, 1.6) |
| CRE *E.coli* | 3.0 (2.6, 3.4) |
| CRE *Enterobacter* | 2.0 (1.6, 2.4) |
| CRE *K pneumoniae* | 2.1 (1.8, 2.4) |

***Test surface glass unless otherwise specified**

# Effective Surface Decontamination

Product and Practice = Perfection

# LOW-LEVEL DISINFECTION FOR NONCRITICAL EQUIPMENT AND SURFACES

**Rutala, Weber. Infect Control Hosp Epidemiol. 2014;35:855-865**

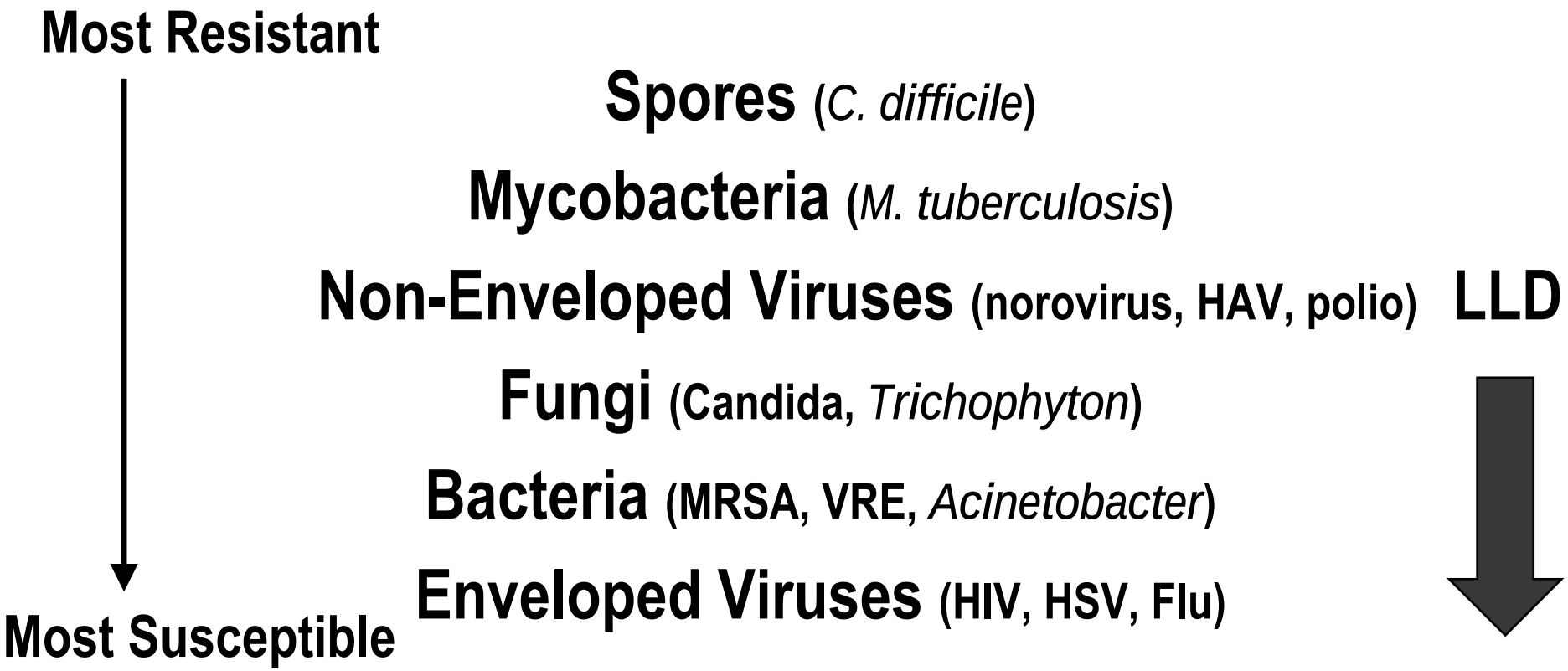
Exposure time ≥ 1 min

| Germicide | Use Concentration |
|---|---|
| Ethyl or isopropyl alcohol | 70-90% |
| Chlorine | 100ppm (1:500 dilution) |
| Phenolic | UD |
| Iodophor | UD |
| Quaternary ammonium (QUAT) | UD |
| QUAT with alcohol | RTU |
| Improved hydrogen peroxide (HP) | 0.5%, 1.4% |
| Peracetic acid with HP (*C. difficile*) | UD |

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)

# Microbiological Disinfectant Hierarchy

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



# EFFECTIVENESS OF DISINFECTANTS AGAINST MRSA AND VRE

**Rutala WA, et al.** *Infect Control Hosp Epidemiol* **2000;21:33-38**

TABLE 2
DISINFECTANT ACTIVITY AGAINST ANTIBIOTIC-SUSCEPTIBLE AND ANTIBIOTIC-RESISTANT BACTERIA

| | $Log_{10}$ Reductions | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | VSE | | VRE | | MSSA | | MRSA | |
| Product | 0.5 min | 5 min | 0.5 min | 5 min | 0.5 min | 5 min | 0.5 min | 5 min |
| Vesphene IIse | >4.3 | >4.3 | >4.8 | >4.8 | >5.1 | >5.1 | >4.6 | >4.6 |
| Clorox | >5.4 | >5.4 | >4.9 | >4.9 | >5.0 | >5.0 | >4.6 | >4.6 |
| Lysol Disinfectant | >4.3 | >4.3 | >4.8 | >4.8 | >5.1 | >5.1 | >4.6 | >4.6 |
| Lysol Antibacterial | >5.5 | >5.5 | >5.5 | >5.5 | >5.1 | >5.1 | >4.6 | >4.6 |
| Vinegar | 0.1 | 5.3 | 1.0 | 3.7 | +1.1 | +0.9 | +0.6 | 2.3 |

Abbreviations: MRSA, methicillin-resistant *Staphylococcus aureus;* MSSA, methicillin-susceptible *S aureus;* VRE, vancomycin-resistant *Enterococcus;* VSE, vancomycin-susceptible *Enterococcus.*
Data represent mean of two trials (n=2). Values preceded by ">" represent the limit of detection of the assay. Assays were conducted at a temperature of 20°C and a relative humidity of 45%. Results were calculated as the log of Nd/No, where Nd is the titer of bacteria surviving after exposure and No is the titer of the control.

# PROPERTIES OF AN IDEAL SURFACE DISINFECTANT

**Rutala WA, Weber DJ. Infect Control Hosp Epidemiol 2014;35:855-865**

- 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

**Rutala, Weber. Infect Control Hosp Epidemiol. 2014;35:855-865**

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

**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)**
**Rutala, Weber. Am J Infect Control 2013;41:S36-S41**

## 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

**Rutala, Weber. Am J Infect Control 2013;41:S36-S41**

## 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

# Improved Hydrogen Peroxide

Rutala, Weber. Am J Infect Control 2013;41:S36-S41

## 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

**Rutala, Weber. Am J Infect Control 2013;41:S36-S41**

## 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

Rutala, Weber. Am J Infect Control 2013;41:S36-S41

## 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

# Quat/Alcohol vs Quat

**Rutala et al. Antimicrob Agents Chemother 2006. 50:1419-1424**

- 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 ~0.7 $\log_{10}$ reduction against adenovirus with 1m exposure time
- Quat/Alcohol demonstrates a ~4 $\log_{10}$ reduction against adenovirus with 1m exposure time
- Chlorine (~5000ppm) demonstrates a ~5 $\log_{10}$ reduction against adenovirus with 1m exposure time
- Quat/Alcohol has improved virucidal activity compared to Quat and accelerated hydrogen peroxide

# Surface Disinfection:
## Treatment Time (Wipes/Sprays) versus Contact Time (Liquids)
### Rutala, Weber. ICHE 2018;39

INFECTION CONTROL & HOSPITAL EPIDEMIOLOGY MARCH 2018, VOL. 39, NO. 3

COMMENTARY

## Surface Disinfection: Treatment Time (Wipes and Sprays) Versus Contact Time (Liquids)

William A. Rutala, PhD, MPH;[1] David J. Weber, MD, MPH[1,2]

(See the article by Rutala W, Weber DJ, Selection of the ideal disinfectant. *Infect Control Hosp Epidemiol* 2014;35:855–865.)

In 2014, we published a paper on the "Selection of the Ideal Disinfectants."[1] Disinfectant selection (ie, disinfectant product) is 1 of 2 essential components for effective disinfection. The other component, the practice, is the thorough application of the disinfectant such that the disinfectant contacts all contaminated surfaces. This practice should include proper training of hospital staff, especially environmental services and nursing staff, and adherence to the manufacturer's label instructions. The combi-

The EPA position is this: "By law, all applicable label instructions on EPA-registered products must be followed. If the user selects exposure conditions that differ from those on the EPA-registered product label, the user assumes liability from any injuries resulting from off-label use and is potentially subject to enforcement action under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)."[1,3] According to this position, contact or kill times for the organisms listed on the label must be followed. Currently, EPA-registered disinfectants are available with contact times of 1–4 minutes against most

**The term "wetness" is controversial. Based on EPA test for wipes/sprays, treatment time is the kill time and includes a wet time via wiping as well as the undisturbed time. Duration of wet time is not relevant.**

# Risk Assessment Worksheet

## Justifies to TJC/CMS Off-Label Use for Surface Disinfection

## www.disinfectionandsterilization.org

**Risk-Assessment Worksheet**

Issue: Off-label use for undisturbed time after environmental disinfection

Assessment Date: March 5, 2018

Scoring: Low = 1 Moderate = 3 High = 5

Team Members:

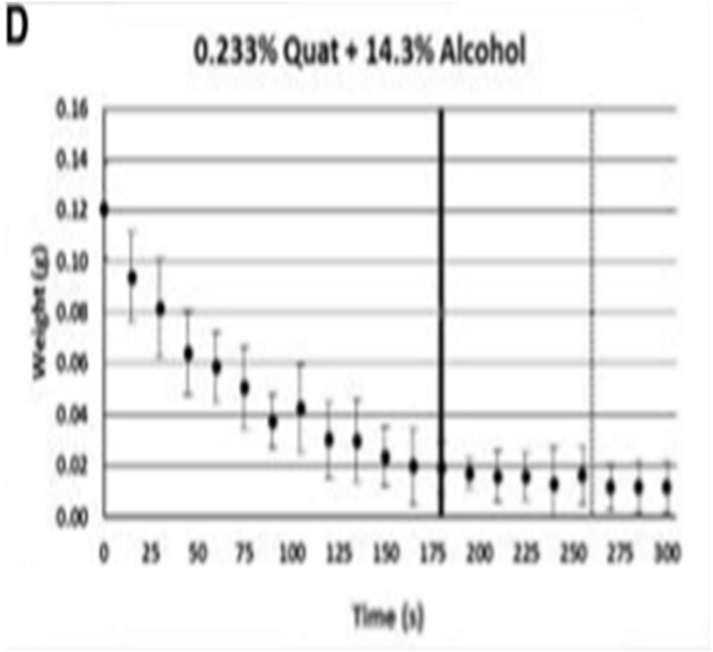
Meeting Actions: Team members evaluated the evidence and determined that off-label use of undisturbed time was sufficient to disinfect noncritical environmental surfaces and noncritical patient care equipment in a healthcare environment.

| Suggested Questions | Benefit | Risk |
|---|---|---|
| What is the truth about disinfectant contact time? | Most manufacturers suggest the user maintain wetness for the duration of the contact time. The method used to assess efficacy of disinfectant wipes by the EPA is the Disinfectant Towelette Test. The procedure involves using one towelette to wipe ten carriers/slides. The area of the towelette used for wiping is folded and rotated so as to expose a new surface of the towelette for each carrier. To generate test cultures, carriers are inoculated using pathogens *Staphylococcus aureus, Pseudomonas aeruginosa, and Salmonella enteric.* The test procedure involves wiping the slide back and forth for a total of six passes across the inocula for ±5 seconds of | There is no risk to utilizing a treatment time instead of a wet time for the given contact time of a disinfectant.<br>Score = 1 |

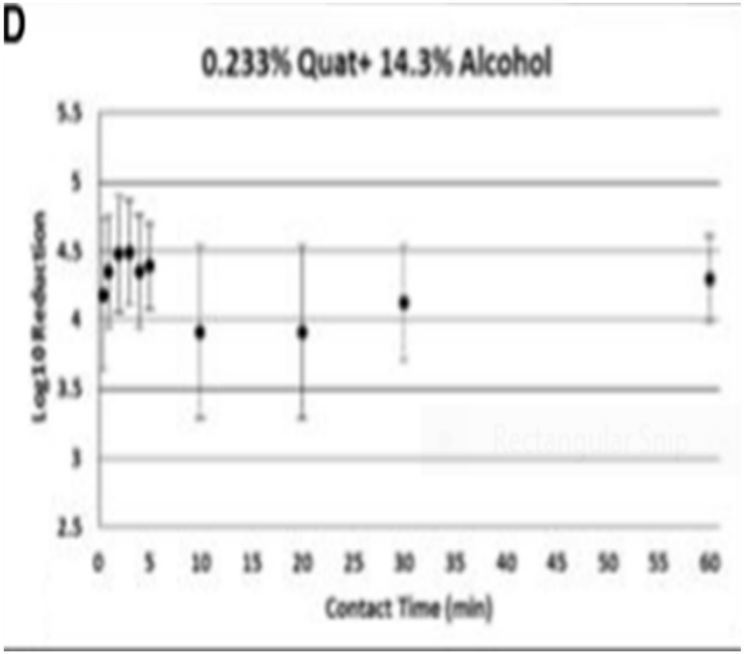
# Bactericidal (*S. aureus*) Efficacy of EPA-Registered Towelettes

**West, Teska, Oliver, AJIC, 2018**

- Drying time curve based on surface wetness; bold-contact time (180s); dashed-dry (~260s)




- Wet time Is not crucial for complete disinfection (wet or dry ~4.5 $\log_{10}$ reduction); 30s for $\log_{10}$ reduction

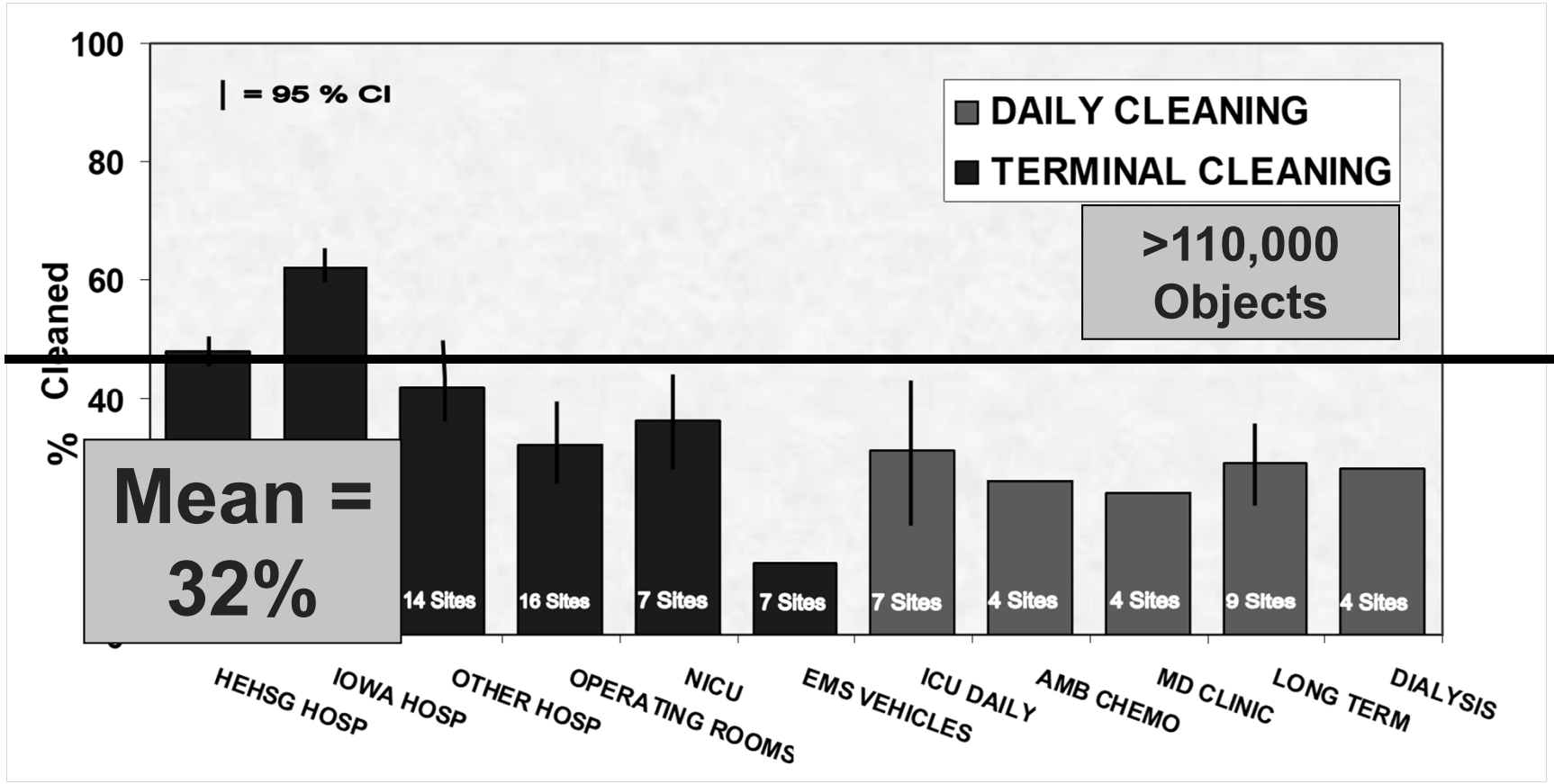


# Effective Surface Decontamination

Product and Practice = Perfection

# Thoroughness of Environmental Cleaning

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



# MONITORING THE EFFECTIVENESS OF CLEANING

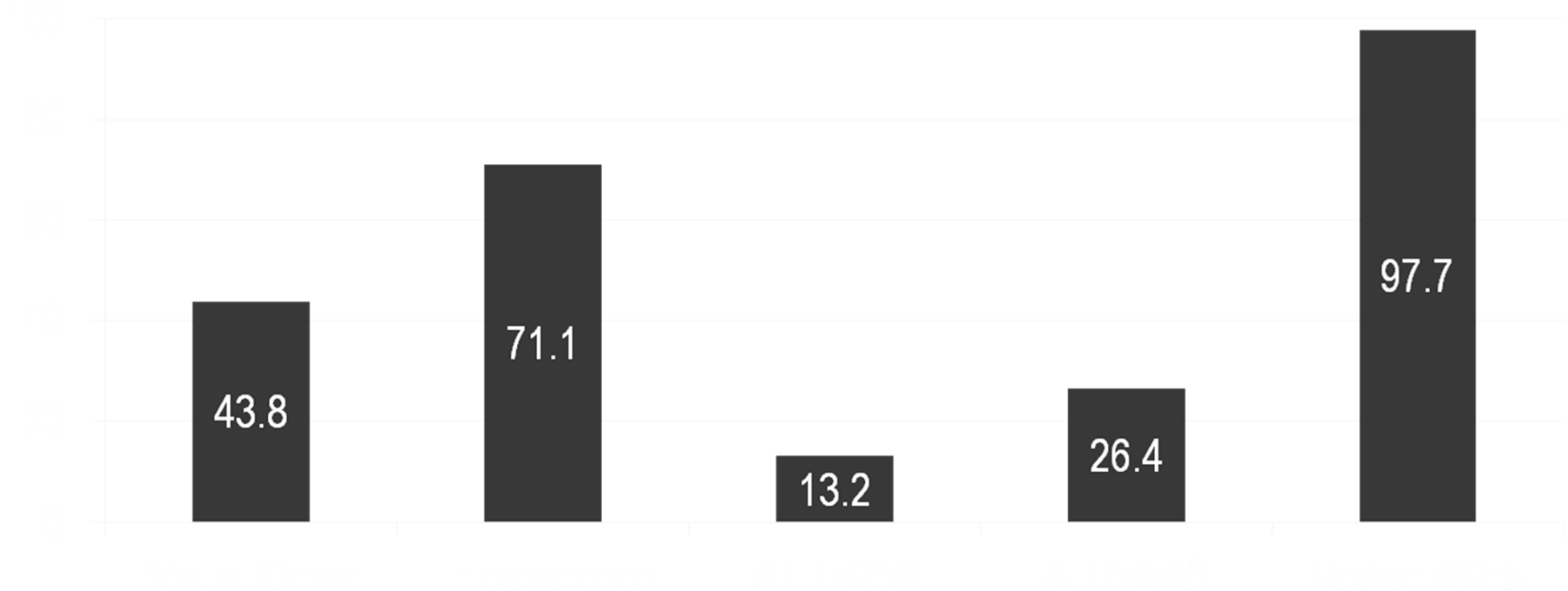
**Cooper et al. AJIC 2007;35:338**

- 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/$cm^2$-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)

# Percentage of Surfaces Clean by Different Measurement Methods

Rutala, Kanamori, Gergen, Sickbert-Bennett, Huslage, Weber. APIC 2017.

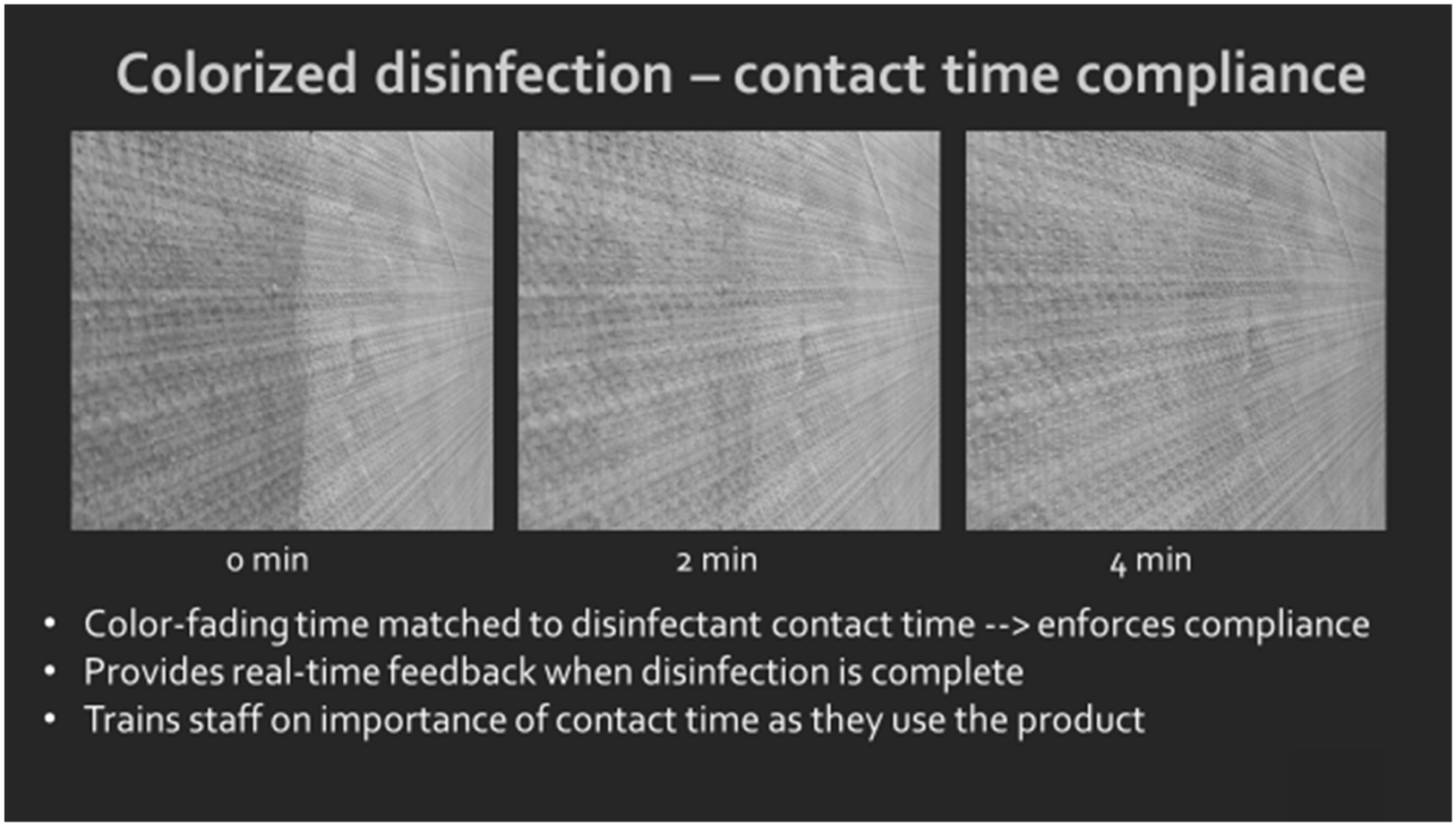
**Fluorescent marker is a useful tool in determining how thoroughly a surface is wiped and mimics the microbiological data better than ATP**



# Colorized Disinfectant



# Future May Have Methods to Ensure Thoroughness Such as Colorized Disinfectant



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

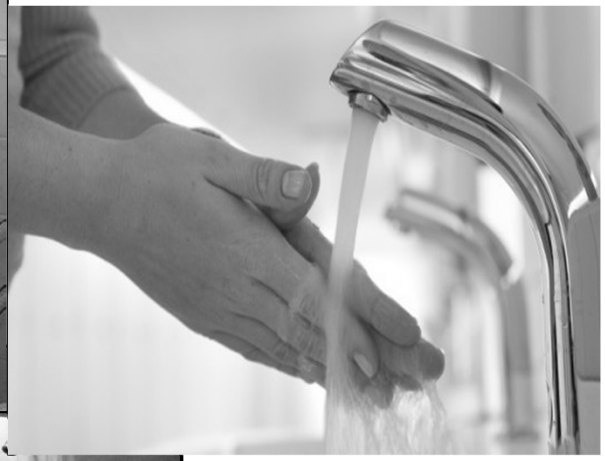
**“High touch” objects only recently defined (no significant differences in microbial contamination of different surfaces) and “high risk” objects not epidemiologically defined.**

## Safer Healthcare Environments for Infection Prevention

- Reprocessing reusable medical/surgical instruments
- Environmental Surface Disinfection
  - Ideal Disinfectant
- Water

# Water and Healthcare
## Multiple Uses

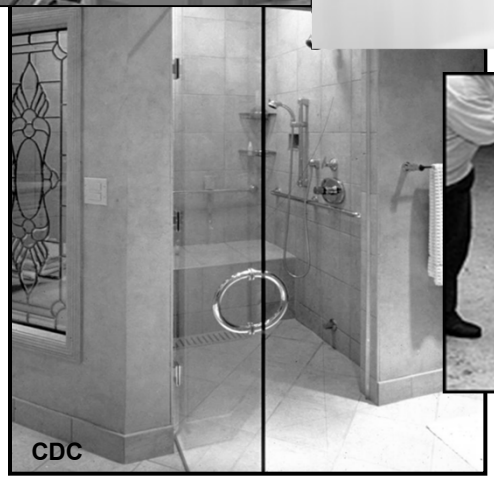














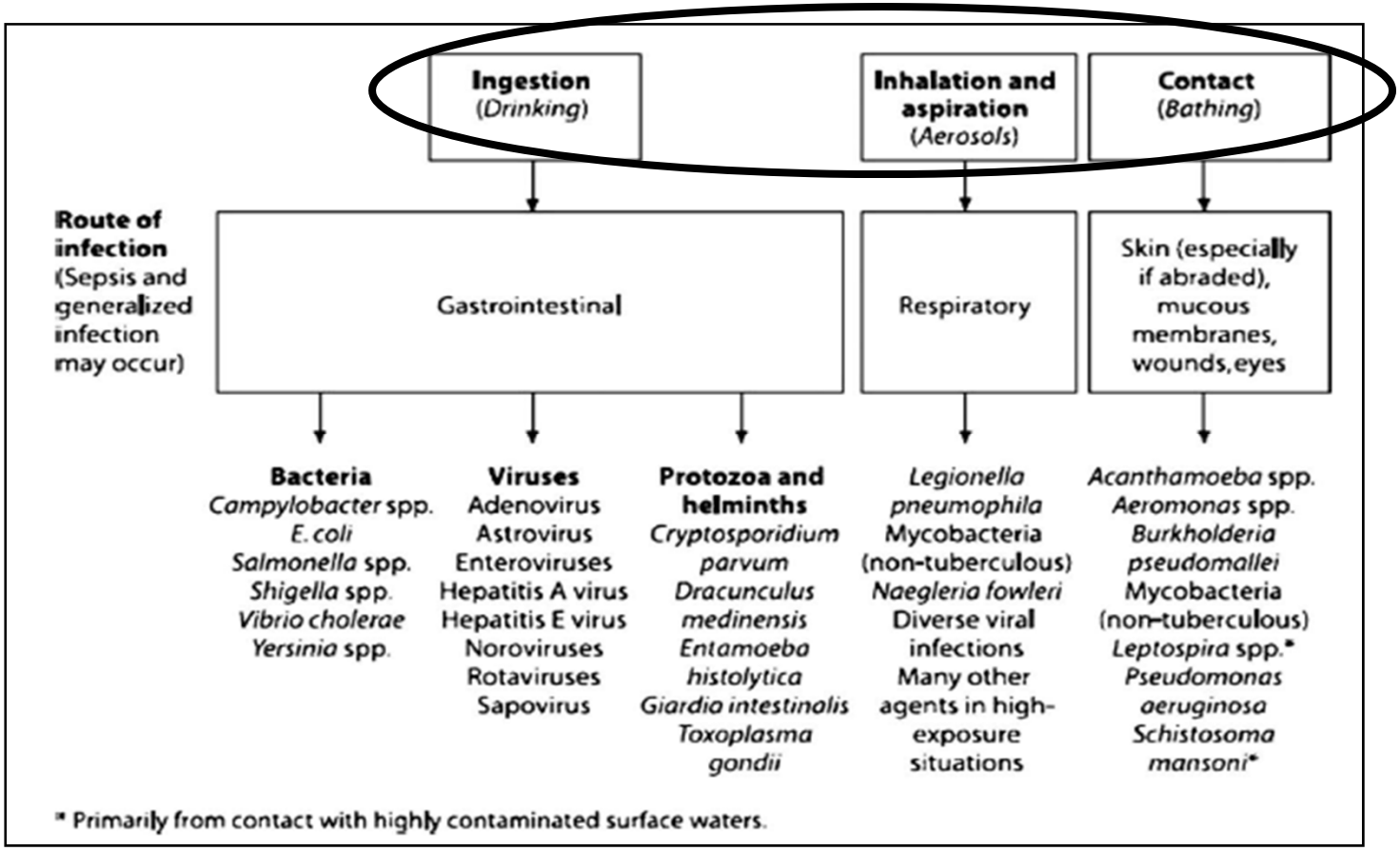






# Water-Related Pathogens and Their Disease Transmission Pathways

**Exner et al. AJIC 33:S26-40; 2005**



# Healthcare Outbreaks Associated with Water Reservoir

**Kanamori, Weber, Rutala. Clin Infect Dis 2016;62:1423**

*Clinical Infectious Diseases*

INVITED ARTICLE

HEALTHCARE EPIDEMIOLOGY: Robert A. Weinstein, Section Editor

## Healthcare Outbreaks Associated With a Water Reservoir and Infection Prevention Strategies

**Hajime Kanamori,[1,2] David J. Weber,[1,2] and William A. Rutala[1,2]**

[1]Division of Infectious Diseases, University of North Carolina School of Medicine, and [2]Hospital Epidemiology, University of North Carolina Health Care, Chapel Hill

Hospital water may serve as a reservoir of healthcare-associated pathogens, and contaminated water can lead to outbreaks and severe infections. The clinical features of waterborne outbreaks and infections as well as prevention strategies and control measures are reviewed. The common waterborne pathogens were bacteria, including *Legionella* and other gram-negative bacteria, and nontuberculous mycobacteria, although fungi and viruses were occasionally described. These pathogens caused a variety of infections, including bacteremia and invasive and disseminated diseases, particularly among immunocompromised hosts and critically ill adults as well as neonates. Waterborne outbreaks occurred in healthcare settings with emergence of new reported reservoirs, including electronic faucets (*Pseudomonas aeruginosa* and *Legionella*), decorative water wall fountains (*Legionella*), and heater-cooler devices used in cardiac surgery (*Mycobacterium chimaera*). Advanced molecular techniques are useful for achieving a better understanding of reservoirs and transmission pathways of waterborne pathogens. Developing prevention strategies based on water reservoirs provides a practical approach for healthcare personnel.

**Keywords.** waterborne outbreaks; healthcare-associated infections; water; outbreaks.

# Healthcare Outbreaks Associated with Water Reservoir

## Kanamori, Weber, Rutala. Clin Infect Dis 2016;62:1423

**Table 2. Summary of Key Issues and Infection Prevention Strategies Against Waterborne Outbreaks by Major Water Reservoir in Healthcare Settings**

| Reservoir | Key Issues | Infection Prevention Strategies |
|---|---|---|
| Potable water, tap water, and hospital water systems | Potable water is not sterile, and pathogenic waterborne organisms may exist in potable water at acceptable levels of coliform bacteria (<1 coliform bacterium/100 mL).<br>Healthcare-associated outbreaks have been linked to contaminated potable water.<br>Semicritical devices are often rinsed with potable water, which may lead to contamination of the equipment and subsequent healthcare-associated infections.<br>Common pathogens include nonenteric gram-negative bacilli (eg, *Pseudomonas aeruginosa*), *Legionella*, NTM. | Follow public health guidelines.<br>Hot water temperature at the outlet at the highest temperature allowable, preferably >51°C.<br>Water disruptions: post signs and do not drink tap water.<br>Maintain standards for potable water (<1 coliform bacterium/100 mL).<br>Rinse semicritical equipment with sterile water, filtered water, or tap water followed by alcohol rinse.<br>Some experts have recommended periodic monitoring of water samples for growth of *Legionella*.<br>*Legionella* eradication can be technically difficult, temporary, and expensive.<br>Potential methods of eradication include filtration, ultraviolet, ozonization, heat inactivation (>60°C), hyperchlorination, and copper-silver ionization (>0.4 ppm and >0.04 ppm, respectively). |
| Sinks | Colonization of sinks with gram-negative bacilli has been reported.<br>Some studies demonstrate a transmission link between a colonized sink and infected patients.<br>Some studies describe that multidrug-resistant gram-negative bacilli are associated with contaminated sinks.<br>Gram-negative bacilli can survive wet environments, including sinks, for a long time (>250 d)<br>Transmission can be caused by splashing of water droplet from contaminated sinks to hands of healthcare personnel, followed by transient colonization of hands.<br>Common pathogens include gram-negative bacilli (eg, *Pseudomonas*, *Acinetobacter*, *Serratia*). | Use separate sinks for handwashing and disposal of contaminated fluids.<br>Decontaminate or eliminate sinks as a reservoir if epidemic spread of gram-negative bacteria via sinks is suspected. |
| Faucet aerators | Faucet aerators may serve as a platform for accumulation of waterborne pathogens.<br>Potential pathogens include *Pseudomonas*, *Stenotrophomonas*, and *Legionella*. | Routine screening and disinfection or permanent removal of all aerators are not warranted at present.<br>No precautions necessary at present.<br>For *Legionella* outbreaks, clean and disinfect faucet aerators in high-risk patient areas periodically, or consider removing them in the case of additional infections. |
| Showers | Some outbreaks are linked to contaminated shower heads or inhalation of aerosols.<br>Potential pathogens include *Legionella*, *Pseudomonas*, NTM, group A *Streptococcus*, and *Aspergillus*. | Prohibit use of showers in neutropenic patients.<br>Control *Legionella* colonization of potable water. |
| Ice and ice machines | Patients can acquire pathogens by sucking on ice, ingesting iced drinks, or use of contaminated ices for cooling medical procedure and patients' skin.<br>Large outbreaks occurred when ice machines have become contaminated and ice used for cooling drinking water.<br>Common pathogens include *Pseudomonas*, *Enterobacter*, | Do not handle ice by hand.<br>Do not store pharmaceuticals or medical solutions on ice for consumption.<br>Use automatic dispenser rather than open chest storage compartments in patient areas.<br>Clean and disinfect ice-storage chests regularly. |

# Healthcare Outbreaks Associated with Water Reservoir

## Kanamori, Weber, Rutala. Clin Infect Dis 2016;62:1423

| | | |
|---|---|---|
| Eyewash stations | Stationary and portable eyewash stations may not be used for months or years.<br>The water source may stand in the incoming pipes at room temperature for a long period.<br>Pathogens, including *Pseudomonas*, *Legionella*, amoebae, and fungi, could be transmitted. | Use sterile water for eye flush or regularly (eg, monthly) flush eyewash stations. |
| Dental-unit water systems | Potable water usually supplies dental units.<br>Water delivered to dental devices (eg, dental handpieces and air/water syringes) as well as dental unit water lines may be contaminated.<br>Immunocompromised patients may be at risk for infection.<br>Pathogens, including *Sphingomonas*, *Pseudomonas*, *Acinetobacter*, *Legionella*, and NTM, have been recovered from water supplies in dental units. | Clean dental water systems.<br>Flush with water and disinfectant solution, or use of clean-water systems that put sterile water into the dental unit.<br>Flush dental instruments with water and air for 20–30 sec from any dental device connected to the dental water system that enters the patient's mouth (eg, handpieces).<br>Ensure that water in dental unit meets standards (<500 CFU/mL). |
| Dialysis water | Excessive levels of gram-negative bacilli in the dialysate were responsible for pyrogenic reactions in patients or bacteremia, which was caused by bacteria or endotoxin entry into the blood from the contaminated dialysate. | Follow AAMI standards for quality assurance performance of dialysis devices.<br>Disinfect water distribution system on a regular basis.<br>Perform microbiological testing and endotoxin testing for water in dialysis settings regularly.<br>Maintain dialysis water (input) <200 CFU/mL and dialysate (output) <200 CFU/mL per CMS. |
| Water and ice baths | Contaminated water baths were used to thaw or warm blood products (fresh plasma, cryoprecipitate) or peritoneal dialysate bottles, followed by contamination of the infusates occurred during preparation.<br>Contaminated ice baths were used to cool syringes or bottles of saline in measuring cardiac output.<br>Potential pathogens include *Pseudomonas*, *Acinetobacter*, *Burkholderia*, *Staphylococcus*, and *Ewingella*. | Consider routine cleaning, disinfection, and changing of water in water baths.<br>Add germicide to water bath or use plastic overwrap of blood products and keep the surfaces dry.<br>Use sterile water in ice baths (or at room temperature) used for thermodilution catheters. |

# Healthcare Outbreaks Associated with Water Reservoir

## Kanamori, Weber, Rutala. Clin Infect Dis 2016;62:1423

| Reservoir | Key Issues | Infection Prevention Strategies |
|---|---|---|
| Bathing, tub immersion, and hydrotherapy | Tub immersion used in hospitals for physical hydrotherapy and for cleaning of burn wounds can cause cross-transmission, transmission from environmental reservoirs, or autotransmission.<br>Skin infections such as folliculitis and cellulitis occurred related to water immersion.<br>Water contamination of central venous catheters during bathing was related to bloodstream infection.<br>Potential pathogens include *Pseudomonas*, *Enterobacter*, *Citrobacter*, *Acinetobacter*, *Legionella*, *Alcaligenes*, and NTM. | Adhere strictly to proper disinfection of tub between patients.<br>Drain and clean tanks and tubs after use of each patient, and disinfect surfaces and components according to the manufacturer's instructions.<br>Add disinfectant to the water: 15 ppm in small hydrotherapy tanks and 2–5 ppm in whirlpools per CDC.<br>Disinfect after using tub liners.<br>Cover catheter sites with transparent occlusive dressing. |
| Toilets | Transmission can be caused by aerosolization of fecal bacteria via flushing or surface contamination by fecal bacteria.<br>Transmission could happen in healthcare facilities caring for mentally or neurologically impaired patients, or children.<br>Potential pathogens include enteric bacteria, *Pseudomonas*, *Clostridium difficile*, and norovirus. | Facilitate good handwashing practices.<br>Maintain clean surfaces with disinfectants.<br>Clean bowl with a scouring powder and a brush.<br>No reason to pour disinfectant into bowl.<br>Separate toilet bowl from clean hospital surfaces. |
| Flowers and vases | Flower vases and potted plants are heavily colonized with potential pathogens, including *Acinetobacter*, *Klebsiella*, *Enterobacter*, *Pseudomonas*, *Serratia*, *Burkholderia cepacia*, *Aeromonas hydrophila*, and *Flavobacterium*.<br>No healthcare-associated outbreaks directly linked to flower vases or potted plants have been reported. | Prohibit fresh flowers and potted plants in the rooms of immunocompromised and ICU patients.<br>Or add antimicrobial agent to vase water and disinfect vases after use. |
| Electronic faucets | Electronic faucets were likely to be contaminated by several waterborne pathogens than handle-operated faucets.<br>Issues associated with electronic faucets include a longer distance between the valve and the tap, resulting in a longer column of stagnant, warm water, which favors production of biofilms; reduced water flow; reduced flushing effect (growth favored); valves and pipes made of plastic (enhances adhesion of *P. aeruginosa*). | Electronic faucets need to be designed so that they do not promote the growth of microorganisms.<br>No guideline (but some authors have recommended) to remove electronic faucets from high-risk patient care areas [eg, BMTU].<br>Some have recommended periodic monitoring of water samples for growth of *Legionella*. |
| Decorative water wall fountains | *Legionella* pneumonia cases associated with decorative water fountain were reported.<br>There is an unacceptable risk in hospitals serving immunocompromised patients (even with standard maintenance and sanitizing methods). | Avoid installation, especially in healthcare facilities serving immunocompromised patients or in areas caring for high-risk patients.<br>Perform maintenance regularly and monitor water safety strictly unless removed. |
| Heater-cooler units | Healthcare-associated *Mycobacterium chimaera* outbreak due to heater-cooler units during cardiac surgeries as a water source has been recently reported.<br>Airborne transmission from contaminated heater-cooler unit water tanks. | Ensure that heater-cooler units are safe and properly maintained according to the manufacturer's instructions.<br>Enhance vigilance for NTM infections in patients after cardiac surgeries using heater-cooler devices.<br>If NTM infections are suspected, review microbiology database (NTM-positive cultures) and medical records of surgical procedures within several years after cardiac surgeries. |
| Miscellaneous | Potential reservoirs include distilled water or containers (outbreaks with *Enterobacter cloacae* and *B. cepacia*), wash basins (*Salmonella urbana* infection, *Trichosporon asahii* infection, *Legionella* pneumonia), intraaortic balloon pump (*B. cepacia* bacteremia), humidifier water in ventilator systems (*Acremonium kiliense* postoperative endophthalmitis), water cooler (gastrointestinal illness), holy water (*Acinetobacter baumannii* infection), deionized water (*Exophiala jeanselmei* fungemia), water-damaged plaster (mucormycosis), water birth (*Legionella* pneumonia), water-saving device (*P. aeruginosa* infection), rinse water during endoscope reprocessing (gram-negative bacteria). | Consider control measures based on risk assessment by each reservoir when available. |

# Water Wall Fountains and Electronic Faucets





# Water Walls Linked to Legionnaires'

- Palmore et al. ICHE 2009;30:764
  - 2 immunocompromised patients exposed to decorative fountain in radiation oncology; isolates from patients and fountain identical; disinfection with ozone, filter and weekly cleaning
- Houpt et al. ICHE 2012;33:185
  - Lab-confirmed Legionnaires disease was dx in 8 patients; 6 had exposure to decorative fountain (near main entrance to hospital); high counts of *Legionella pneumophila* 1 despite disinfection and maintenance

# Water Walls and Decorative Water Fountains

Present unacceptable risk in hospitals serving immunocompromised patients (even with standard maintenance and sanitizing methods)

# Electronic Faucets
## A Possible Source of Nosocomial Infection?



# Electronic Faucets

- Conserve water
- Conserve energy
- Hygienic
- Hands free
- Barrier free

# Electronic (E) vs Handle-Operated (HO) Faucets

- 100% E vs 30% HO *Legionella* (no cases). Halabi et al. JHI 2001:49:117
- Significant difference HPC levels between brand A (32%) and B (8%) E compared to HO (11%). Hargreaves et al. 2001; 22:202
- No difference in *P. aeruginosa*. Assadian et al. ICHE. 2002;23:44.
- 73% E samples did not meet German water standard vs 0% HO. Chaberny et al. ICHE 2004;25:997
- 39% of water samples from E and 1% from HO yielded *P. aeruginosa*. Merrer et al. Intensive Care Med 2005;31:1715
- 95% E grew *Legionella* compared to 45% HO (water-disruption events). Syndor et al. ICHE 2012; 33:235

# Issues Associated with Electronic Faucets

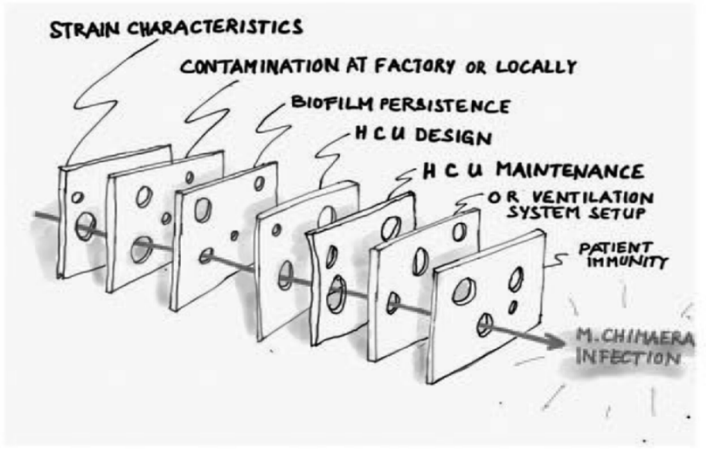
- A longer distance between the valve and the tap, resulting in a longer column of stagnant, warm water, which favors production of biofilms
- Reduced water flow; reduced flushing effect (growth favored)
- Valves and pipes made of plastic (enhances adhesion *P. aeruginosa*)

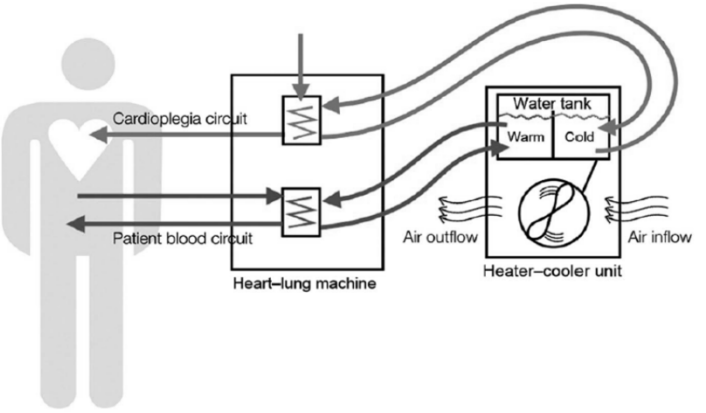
# Prevention Measures

- Electronic faucets constructed so they do not promote the growth of microorganisms
- A potential source of nosocomial pathogens but more data are needed to establish role in HAI
- No guideline (but some have recommended) to remove electronic faucets from at-risk patient care areas (BMTU)
- Some have recommended periodic monitoring of water samples for growth of *Legionella*

# WORLDWIDE OUTBREAK OF *M. chimaera* DUE TO CONTAMINATED HCUs

- Since 2003, >200 cases of *M. chimaera* prosthetic valve endocarditis and disseminated disease reported
- Outbreak linked to intrinsically contaminated heater-cooler unit (HCU) – Stockert 3T HCU (Sorin)
- Internal water channels/tanks intrinsically contaminated; transmission from device to patients via aerosols
- Error = Failure to use disposable channels/tanks; intrinsic contamination and/or inability to disinfect/sterilize internal water tanks
- Problem = Presence of biofilm
- Risk = 0.4-16 per 10,000 Pt-years



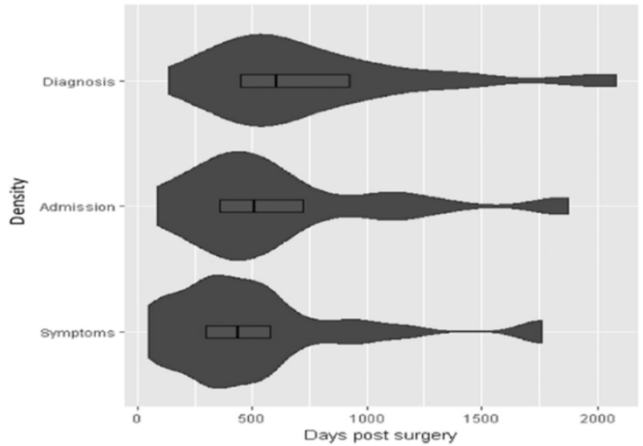




Sommerstein R,e t al. ICHE 2017;38:103;
Schreiber PW, Sax H. Curr Opin ID 2017;30:388;

# CLINICAL FEATURES AND COURSE OF *M. chimaera* HCU-ASSOCIATED INFECTIONS

- Study goal: Assess HCU associated infections, UK
- Results (30 patients):
  - 28/30 had prosthetic material; prosthetic valve endocarditis (14/30), sternal wound infection (2/30), aortic graft infection (4/30), and disseminated infection (10/30)
  - Mean presentation time = 14 mo (max 5 yrs)
  - 18/30 patients died (60%), a median of 30 mo after initial surgery and 9 mo after initiation of therapy

Scriven JE, et al. Clin Microbiol Infect 2018 (Epub)




| Clinical findings, *n* (%) | |
|---|---|
| Fever | 24 (80) |
| Malaise | 24 (80) |
| Weight loss | 18 (60) |
| Arthralgia | 6 (20) |
| Cough | 11 (37) |
| Dyspnoea | 10 (33) |
| Chest pain | 6 (20) |
| Abdominal pain | 3 (10) |
| Back pain | 2 (7) |
| Temperature >38°C | 13 (43) |
| New cardiac murmur | 9 (30) |
| Splinter haemorrhages | 0 (0) |
| Oedema | 6 (20) |
| Crepitations | 6 (20) |
| Pulse oximetry <96% | 3 (10) |
| Lymphadenopathy | 1 (3) |
| Hepatomegaly | 6 (20) |
| Splenomegaly | 8 (27) |
| Sternal wound | 4 (13.3) |
| Skin lesion | 2 (7) |
| Choroiditis | 2 (7) |

# US FDA GENERAL GUIDANCE

- Strictly adhere to the cleaning and disinfection instructions provided in the manufacturer's device labeling.
- DO NOT use tap water to rinse, fill, refill or top-off heater-cooler water tanks since this may introduce NTM organisms. Use only sterile water or water that has been passed through a filter of less than or equal to 0.22 microns.
- Direct and/or channel the heater-cooler's exhaust vent(s) away from the surgical field and toward an operating room exhaust vent to mitigate the risk of aerosolized heater-cooler tank water reaching the sterile field.
- Immediately remove from service heater-cooler devices that show discoloration or cloudiness in the fluid lines/circuits.
- Consider performing environmental, air, and water sampling and monitoring if heater-cooler contamination is suspected.
- Healthcare facilities should follow their internal procedures for notifying and culturing patients if they suspect infection associated with heater-cooler devices.

http://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/CardiovascularDevices/Heater-CoolerDevices/ucm492583.htm
https://www.tga.gov.au/alert/infections-associated-heater-cooler-devices

## Safer Healthcare Environments for Infection Prevention

# New Technologies and Future Challenges

- Reprocessing reusable medical/surgical instruments
- Hospital surfaces
- Water

# CONCLUSIONS

- **In general, sterilization, high-level disinfection and low-level disinfection technologies, practices, and products are effective**
- **Endoscopes (and semicritical items) represent an infection risk. Urgent need to understand the gaps in endoscope reprocessing. Reprocessing guidelines must be followed to prevent exposure to pathogens that may lead to infection. Endoscopes have narrow margin of safety and manufacturers should be encouraged to develop practical sterilization technology.**
- **The contaminated surface environment in hospital rooms is important in the transmission of healthcare-associated pathogens (MRSA, VRE, *C. difficile*)**
- **Effective surface disinfection (excellent products, suboptimal practices) essential to eliminate the environment as a source for transmission of HA pathogens.**
- **New methods of reducing transmission of these pathogens may include: improved room cleaning/disinfection, "no-touch" methods (e.g., UV, HP), and continuous room decontamination**
- **Water reservoirs of HA pathogens (e.g., water walls) may present unacceptable risk to high-risk patients**

# THANK YOU!
# www.disinfectionandsterilization.org

