# Disinfection and Sterilization: Current Issues and New Technologies

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# Disclosure

This presentation reflects the techniques, approaches and opinions of the individual presenter. This Advanced Sterilization Products ("ASP") sponsored presentation is not intended to be used as a training guide. Before using any medical device, review all relevant package inserts with particular attention to the indications, contraindications, warnings and precautions, and steps for use of the device(s).

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# Disinfection and Sterilization: Current Issues and New Technologies

- Current Issues and New Technologies
  - Sterilization of critical items
  - High-level disinfection for semi-critical items
  - Low-level disinfection of non-critical items

# 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**
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# Disinfection and Sterilization: Current Issues and New Technologies

- Current Issues and New Technologies
  - Sterilization of critical items
    - Low-temperature sterilization technology
    - Biological indicators
  - High-level disinfection for semi-critical items
  - Low-level disinfection of non-critical items

# Low Temperature Sterilization Technology


# Newer Trends in Sterilization of Patient Equipment

- Alternatives to ETO-CFC

  ETO-$CO_2$, ETO-HCFC, 100% ETO

- New Low Temperature Sterilization Technology

  Hydrogen Peroxide Gas Plasma-most common

  Vaporized hydrogen peroxide-limited clinical use

  Ozone and hydrogen peroxide-not FDA cleared

  Nitrogen dioxide-not FDA cleared

# Rapid Readout BIs for Steam Now Require a 1-3h Readout Compared to 24-48h

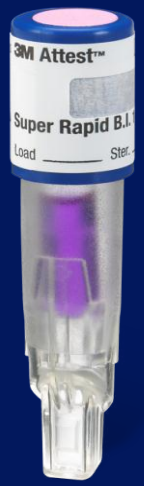
Vol. 17 No. 7 INFECTION CONTROL AND HOSPITAL EPIDEMIOLOGY 423

## COMPARISON OF A RAPID READOUT BIOLOGICAL INDICATOR FOR STEAM STERILIZATION WITH FOUR CONVENTIONAL BIOLOGICAL INDICATORS AND FIVE CHEMICAL INDICATORS

William A. Rutala, PhD, MPH; Suzanne M. Jones, MPH; David J. Weber, MD, MPH

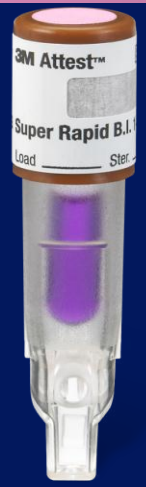
# Attest™ Super Rapid Readout Biological Indicators

## Commercially available in early 2013




1491 BI (blue cap)

- Monitors 270°F and 275°F gravity –displacement steam sterilization cycles
- 30 minute result (from 1 hour)




1492V BI (brown cap)

- Monitors 270°F and 275°F dynamic-air-removal (pre-vacuum) steam sterilization cycles
- 1 hour result (from 3 hours)

# Super Rapid Readout Biological Indicators and Challenge Packs

Rapid Attest technology has been optimized to produce a readout in 30-6-minutes. This technology will be commercialized in early 2013.

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# Disinfection and Sterilization: Current Issues and New Technologies

- Current Issues and New Technologies
  - Sterilization of critical items
  - High-level disinfection for semi-critical items
    - New high-level disinfectants
    - Reprocessing  endoscopes-manual and automated
  - Low-level disinfection of non-critical items

# 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

# 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

# Reprocessing Semicritical Items

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

# Reprocessing Semicritical Items

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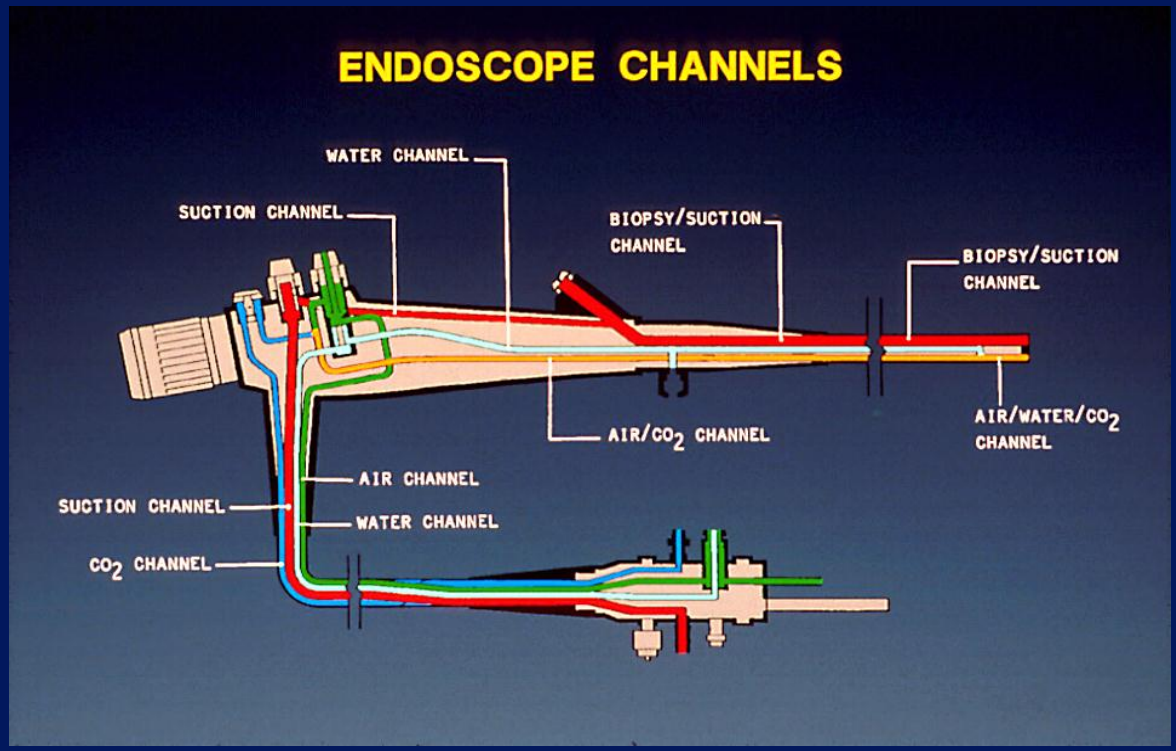
# FEATURES OF ENDOSCOPES THAT PREDISPOSE TO DISINFECTION FAILURES

- Require low temperature disinfection
- Long narrow lumens
- Right angle turns
- Blind lumens
- May be heavily contaminated with pathogens
- Use of AERs has led to a new set of problems



# Endoscope Reprocessing Methods

## Ofstead , Wetzler, Snyder, Horton, Gastro Nursing 2010; 33:204

Cori L. Ofstead, MSPH
Harry P. Wetzler, MD, MSPH
Alycea K. Snyder, BA
Rebecca A. Horton, DPT

## Endoscope Reprocessing Methods

*A Prospective Study on the Impact of Human Factors and Automation*

**ABSTRACT**

The main cause of endoscopy-associated infections is failure to adhere to reprocessing guidelines. More information about factors impacting compliance is needed to support the development of effective interventions. The purpose of this multisite, observational study was to evaluate reprocessing practices, employee perceptions, and occupational health issues. Data were collected utilizing interviews, surveys, and direct observation. Written reprocessing policies and procedures were in place at all five sites, and employees affirmed the importance of most recommended steps. Nevertheless, observers documented guideline adherence, with only 1.4% of endoscopes reprocessed using manual cleaning methods with automated high-level disinfection versus 75.4% of those reprocessed using an automated endoscope cleaner and reprocessor. The majority reported health problems (i.e., pain, decreased flexibility, numbness, or tingling). Physical discomfort was associated with time spent reprocessing ($p = .041$). Discomfort diminished after installation of automated endoscope cleaners and reprocessors ($p = .001$). Enhanced training and accountability, combined with increased automation, may ensure guideline adherence and patient safety while improving employee satisfaction and health.

# Endoscope Reprocessing Methods

## Ofstead , Wetzler, Snyder, Horton, Gastro Nursing 2010; 33:204

Performed all 12 steps for 1.4% (1/69) endoscopes using manual and 75.4% (86/114) endoscopes using AER

TABLE 3. Documented Completion of Steps During Manual Cleaning With High-Level Disinfection Reprocessing

| Observed Activity | Steps Completed (%) (n = 69) |
|---|---|
| Leak test performed in clear water | 77 |
| Disassemble endoscope completely | 100 |
| Brush all endoscope channels and components | 43 |
| Immerse endoscope completely in detergent | 99 |
| Immerse components completely in detergent | 99 |
| Flush endoscope with detergent | 99 |
| Rinse endoscope with water | 96 |
| Purge endoscope with air | 84 |
| Load and complete automated cycle for high-level disinfection | 100 |
| Flush endoscope with alcohol | 86 |
| Use forced air to dry endoscope | 45 |
| Wipe down external surfaces before hanging to dry | 90 |

# Effectiveness of Endoscope Reprocessing

## Infect Control Hosp Epidemiol 2013;34:309

- Practice of reprocessing endoscopes and effectiveness evaluated in 37 services (Brazil)
  - Contamination of at least 1 scope identified in 34 (92%) of 37 services
  - Bacteria, fungi and/or mycobacteria isolated from 84.6% (33/39) of the colonoscopes (110-32,000CFU/ml) and from 80.6% (50/62) of the gastroscopes (100-33,000CFU/ml)
  - Not all services followed guidelines; patients were exposed to diverse pathogens

# Automated Endoscope Reprocessors (AER)

- Manual cleaning of endoscopes is prone to error. AERs can enhance efficiency and reliability of HLD by replacing some manual reprocessing steps
- 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 (until now-EvoTech) BMC Infect Dis 2010;10:200
- Problems: incompatible AER (side-viewing duodenoscope); biofilm buildup; contaminated AER; inadequate channel connectors; used wrong set-up or connector MMWR 1999;48:557
- Must ensure exposure of internal surfaces with HLD/sterilant

# Automated Endoscope Reprocessors with Cleaning Claim


- **Product Definition:**
  - Integrated double-bay AER
  - Eliminates manual cleaning
  - Uses New High-Level Disinfectant (HLD) with IP protection
  - Single-shot HLD
  - Automated testing of endoscope channels and minimum effective concentration of HLD
  - Incorporates additional features (LAN, LCD display)
  - Eliminates soil and microbes equivalent to optimal manual cleaning. BMC ID 2010; 10:200

# MULTISOCIETY GUIDELINE ON REPROCESSING GI ENDOSCOPES, 2011

## Petersen et al. ICHE. 2011;32:527

INFECTION CONTROL AND HOSPITAL EPIDEMIOLOGY JUNE 2011, VOL. 32, NO. 6

ASGE-SHEA GUIDELINE

### Multisociety Guideline on Reprocessing Flexible GI Endoscopes: 2011

Bret T. Petersen, MD, FASGE; Jennifer Chennat, MD; Jonathan Cohen, MD, FASGE; Peter B. Cotton, MD, FASGE; David A. Greenwald, MD, FASGE; Thomas E. Kowalski, MD; Mary L. Krinsky, DO; Walter G. Park, MD; Irving M. Pike, MD, FASGE; Joseph Romagnuolo, MD, FASGE; for the ASGE Quality Assurance in Endoscopy Committee; and William A. Rutala, PhD, MPH; for the Society for Healthcare Epidemiology of America

The beneficial role of GI endoscopy for the prevention, diagnosis, and treatment of many digestive diseases and cancer is well established. Like many sophisticated medical devices, the endoscope is a complex, reusable instrument that requires reprocessing before being used on subsequent patients. The most commonly used methods for reprocessing endoscopes result in high-level disinfection. To date, all published occurrences of pathogen transmission related to GI endoscopy have been associated with failure to follow established cleaning and disinfection/sterilization guidelines or use of defective equipment. Despite the strong published data regarding the safety of endoscope reprocessing, concern over the potential spread gaps in infection prevention practices.[10] Given the ongoing occurrences of endoscopy-associated infections attributed to lapses in infection prevention, an update of the multisociety guideline is warranted.

This document provides an update of the previous guideline, with additional discussion of new or evolving reprocessing issues and updated literature citations, where appropriate. Specific additions or changes include review of expanded details related to critical reprocessing steps (including cleaning and drying), reprocessing issues for various endoscope attachments such as flushing catheters, discussion of risks related to selected periprocedural practices including

# ENDOSCOPE REPROCESSING

## Multi-Society Guideline on Endoscope Reprocessing, 2011

- PRECLEAN-point-of-use (bedside) remove debris by wiping exterior and aspiration of detergent through air/water and biopsy channels
- CLEAN-mechanically cleaned with water and enzymatic cleaner
- HLD/STERILIZE-immerse scope and perfuse HLD/sterilant through all channels for exposure time (>2% glut at 20m at 20$^{o}$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

# Disinfection and Sterilization: Current Issues and New Technologies

- Current Issues and New Technologies
  - Sterilization of critical items
  - High-level disinfection for semi-critical items
  - Low-level disinfection of non-critical items
    - New low-level disinfectants (improved hydrogen peroxide)
    - Surface disinfection
    - Transmission via environmental surfaces
    - Inactivation of *C. difficile*

# DISINFECTION AND STERILIZATION

Rutala, Weber, HICPAC. 2008. www.cdc.gov

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# LOW-LEVEL DISINFECTION FOR NONCRITICAL EQUIPMENT AND SURFACES

Exposure time ≥ 1 min

| Germicide | Use Concentration |
|---|---|
| Ethyl or isopropyl alcohol | 70-90% |
| Chlorine | 100ppm (1:500 dilution) |
| Phenolic | UD |
| Iodophor | UD |
| Quaternary ammonium | UD |
| Improved hydrogen peroxide (HP) | 0.5%, 1.4% |

UD=Manufacturer's recommended use dilution

# IMPROVED HYDROGEN PEROXIDE (HP) SURFACE DISINFECTANT

- Advantages
  - 30 sec -1 min bactericidal and virucidal claim (fastest non-bleach contact time)
  - 5 min mycobactericidal claim
  - Safe for workers (lowest EPA toxicity category, IV)
  - Benign for the environment; noncorrosive; surface compatible
  - One step cleaner-disinfectant
  - No harsh chemical odor
  - EPA registered (0.5% RTU, 1.4% RTU, wet wipe)
- Disadvantages
  - More expensive than QUAT

# BACTERICIDAL ACTIVITY OF DISINFECTANTS ($log_{10}$ reduction) WITH A CONTACT TIME OF 1m WITH/WITHOUT FCS. Rutala et al. ICHE. In press

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

| Organism | Oxivir-0.5% | 0.5% HP | Clorox HC HP Cleaner-Dis 1.4% | 1.4% HP | 3.0% HP | QUAT |
|---|---|---|---|---|---|---|
| MRSA | >6.6 | <4.0 | >6.5 | <4.0 | <4.0 | 5.5 |
| VRE | >6.3 | <3.6 | >6.1 | <3.6 | <3.6 | 4.6 |
| MDR-*Ab* | >6.8 | <4.3 | >6.7 | <4.3 | <4.3 | >6.8 |
| MRSA, FCS | >6.7 | NT | >6.7 | NT | <4.2 | <4.2 |
| VRE, FCS | >6.3 | NT | >6.3 | NT | <3.8 | <3.8 |
| MDR-*Ab*, FCS | >6.6 | NT | >6.6 | NT | <4.1 | >6.6 |

# Wipes

## Cotton, Disposable, Microfiber

**Wipe should have sufficient wetness to achieve the disinfectant contact time.**
**Discontinue use of a disposable wipe if it no longer leaves the surface visibly wet for ≥ 1m**

# Low Level disinfectants
## Non-critical surfaces and Objects

- Quaternary ammonium
- Chlorine
- Improved hydrogen peroxide
- Phenolic

# Surface Disinfection

- Wipe all “touchable” or “hand contact” surfaces with sufficient wetness to achieve the disinfectant contact time (≥ 1 minute).
- Daily disinfection of surfaces (vs cleaned when soiled) with disinfectant 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

# SURFACE DISINFECTION

## Effectiveness of Different Methods, Rutala et al. 2012

| Technique (with cotton) | MRSA $Log_{10}$ Reduction (QUAT) |
|---|---|
| Saturated cloth | 4.41 |
| Spray (10s) and wipe | 4.41 |
| Spray, wipe, spray (1m), wipe | 4.41 |
| Spray | 4.41 |
| Spray, wipe, spray (until dry) | 4.41 |
| Disposable wipe with QUAT | 4.55 |
| Control: detergent | 2.88 |

# Daily Disinfection of High-Touch Surfaces

## Kundrapu et al. ICHE 2012;33:1039

**Daily disinfection of high-touch surfaces** (vs cleaned when soiled) with sporicidal disinfectant 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**

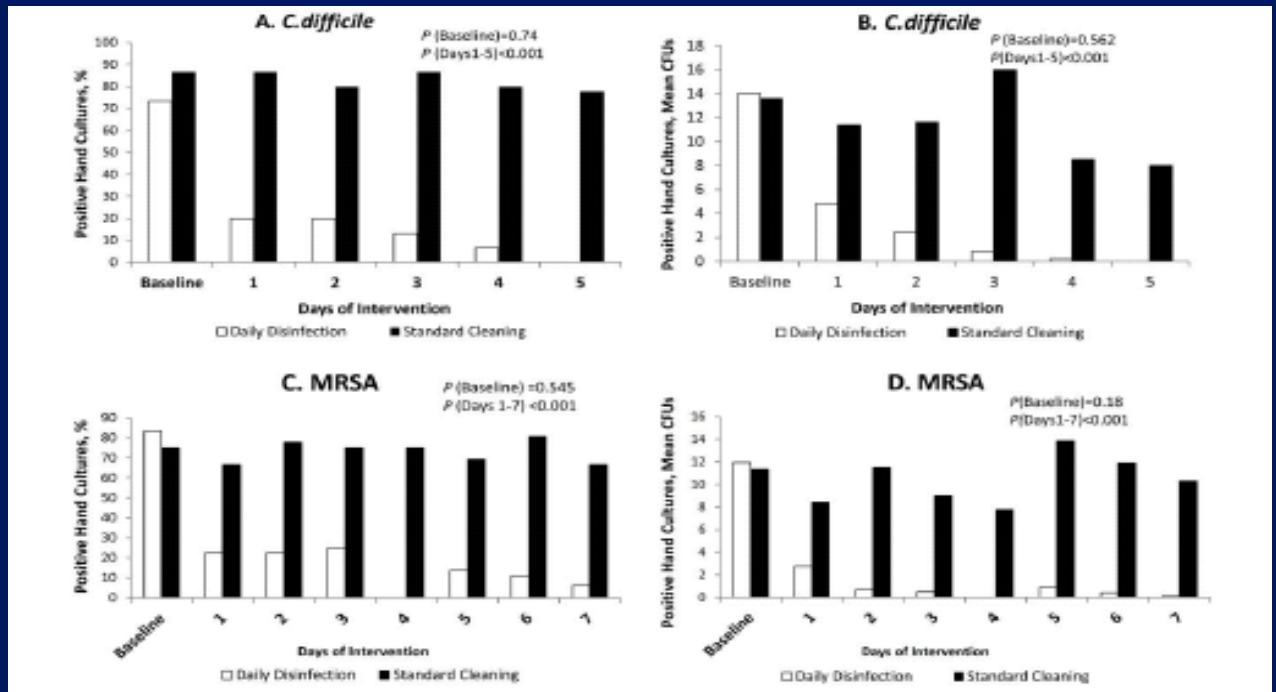


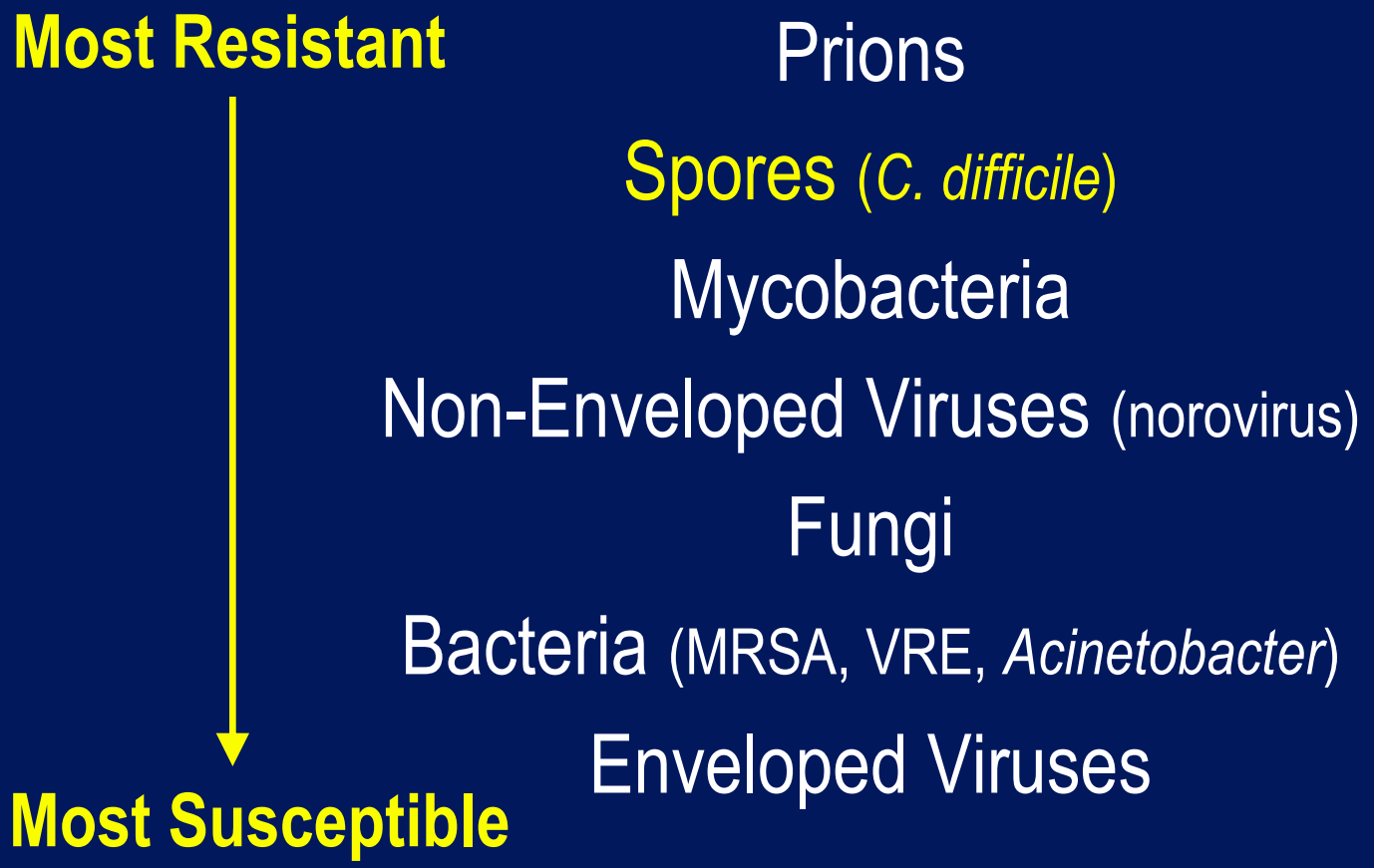

FIGURE 1. Effect of daily disinfection of high-touch environmental surfaces on acquisition of *Clostridium difficile* and methicillin-resistant *Staphylococcus aureus* (MRSA) on gloved hands of investigators after contact with the surfaces. *A*, Percentage of positive *C. difficile* cultures; *B*, mean number of *C. difficile* colony-forming units acquired; *C*, percentage of positive MRSA cultures; *D*, mean number of MRSA colony-forming units acquired.

# Wipes

## Cotton, Disposable, Microfiber

# Blood Pressure Cuff
## Non-Critical Patient Care Item


# DECREASING ORDER OF RESISTANCE OF MICROORGANISMS TO DISINFECTANTS/STERILANTS



# DISINFECTANTS AND ANTISEPSIS

## *C. difficile* spores at 10 and 20 min, Rutala et al, 2006

- ~4 $\log_{10}$ reduction (3 *C. difficile* strains including BI-9)
  - Bleach, 1:10, ~6,000 ppm chlorine (but not 1:50)
  - Chlorine, ~19,100 ppm chlorine
  - Chlorine, ~25,000 ppm chlorine
  - 0.35% peracetic acid
  - 2.4% glutaraldehyde
  - OPA, 0.55% OPA
  - 2.65% glutaraldehyde
  - 3.4% glutaraldehyde and 26% alcohol

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    - Inactivation of *C. difficile*
    - Transmission via environmental surfaces

# KEY PATHOGENS WHERE ENVIRONMENTIAL SURFACES PLAY A ROLE IN TRANSMISSION

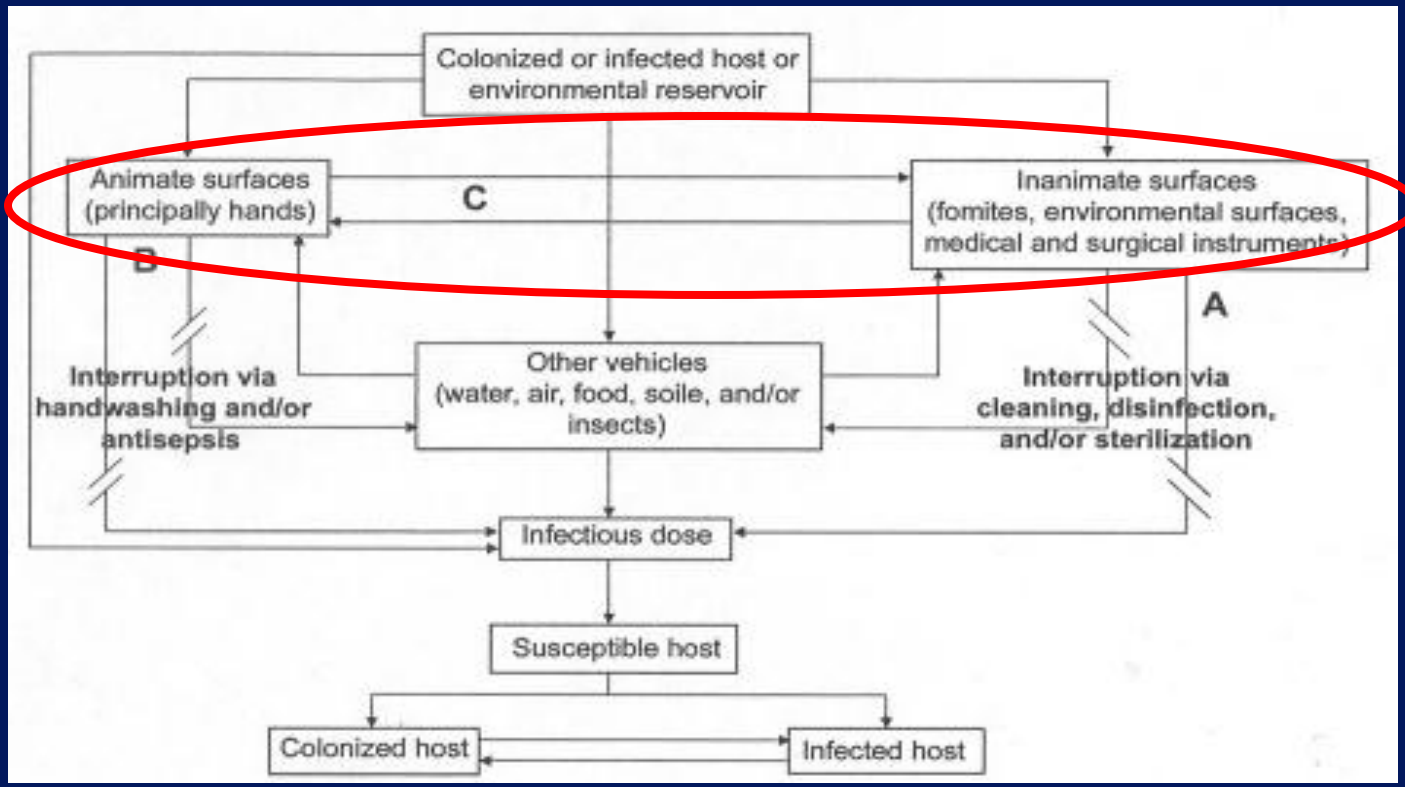
- MRSA
- VRE
- *Acinetobacter* spp.
- *Clostridium difficile*
- Norovirus
- Rotavirus
- SARS

# ENVIRONMENTAL CONTAMINATION LEADS TO HAIs

**Weber, Rutala, Miller et al. AJIC 2010;38:S25**

- Microbial persistence in the environment
- Frequent environmental contamination
- HCW hand contamination with the environment
- Prior room occupant with MRSA, VRE, CDI is a significant risk for acquisition of these pathogens.

# TRANSMISSION MECHANISMS INVOLVING THE SURFACE ENVIRONMENT




Rutala WA, Weber DJ. In:"SHEA Practical Healthcare Epidemiology" (Lautenbach E, Woeltje KF, Malani PN, eds), 3rd ed, 2010.

# ENVIRONMENTAL SURVIVAL OF KEY PATHOGENS ON HOSPITAL SURFACES

| Pathogen | Survival Time |
|---|---|
| *S. aureus* (including MRSA) | 7 days to >12 months |
| *Enterococcus* spp. (including VRE) | 5 days to >46 months |
| *Acinetobacter* spp. | 3 days to 11 months |
| *Clostridium difficile* (spores) | >5 months |
| Norovirus (and feline calicivirus) | 8 hours to >2 weeks |
| *Pseudomonas aeruginosa* | 6 hours to 16 months |
| *Klebsiella* spp. | 2 hours to >30 months |

**Adapted from Hota B, et al. Clin Infect Dis 2004;39:1182-9 and Kramer A, et al. BMC Infectious Diseases 2006;6:130**

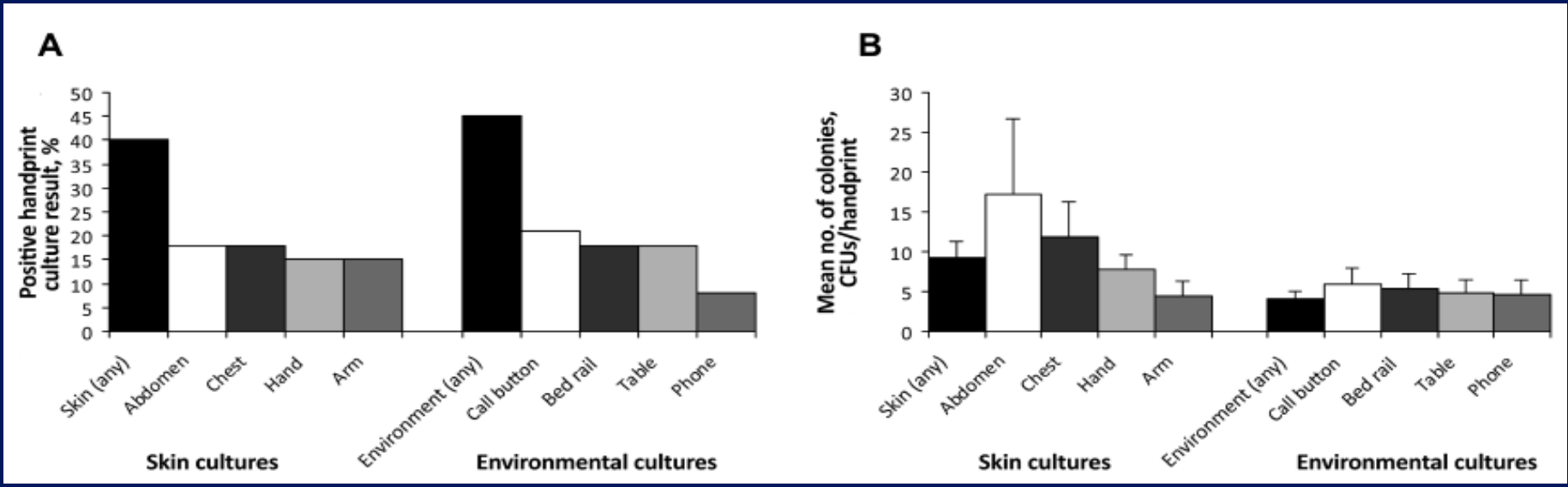
# ENVIRONMENTAL CONTAMINATION ENDEMIC AND EPIDEMIC MRSA

| | Outbreak | Endemic | | | | Site estimated mean§ |
|---|---|---|---|---|---|---|
| | Rampling et al[27]* | Boyce et al[48]* | Sexton et al[51]† | Lemmen et al[50]*‡ | French et al[64]* | |
| Floor | 9% | 50–55% | 44–60% | 24% | .. | 34·5% |
| Bed linen | .. | 38–54% | 44% | 34% | .. | 41% |
| Patient gown | .. | 40–53% | .. | 34% | .. | 40·5% |
| Overbed table | .. | 18–42% | 64–67% | 24% | .. | 40% |
| Blood pressure cuff | 13% | 25–33% | .. | .. | .. | 21% |
| Bed or siderails | 5% | 1–30% | 44–60% | 21% | 43% | 27% |
| Bathroom door handle | .. | 8–24% | .. | 12%¶ | .. | 14% |
| Infusion pump button | 13% | 7–18% | .. | 30% | .. | 19% |
| Room door handle | 11% | 4–8% | .. | 23% | 59% | 21·5%‖ |
| Furniture | 11% | .. | 44–59% | 19% | .. | 27% |
| Flat surfaces | 7% | .. | 32–38% | .. | .. | 21·5% |
| Sink taps or basin fitting | .. | .. | .. | 14% | 33% | 23·5% |
| Average quoted** | 11% | 27% | 49% | 25% | 74% | 37% |

Dancer SJ et al. Lancet ID 2008;8(2):101-13

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

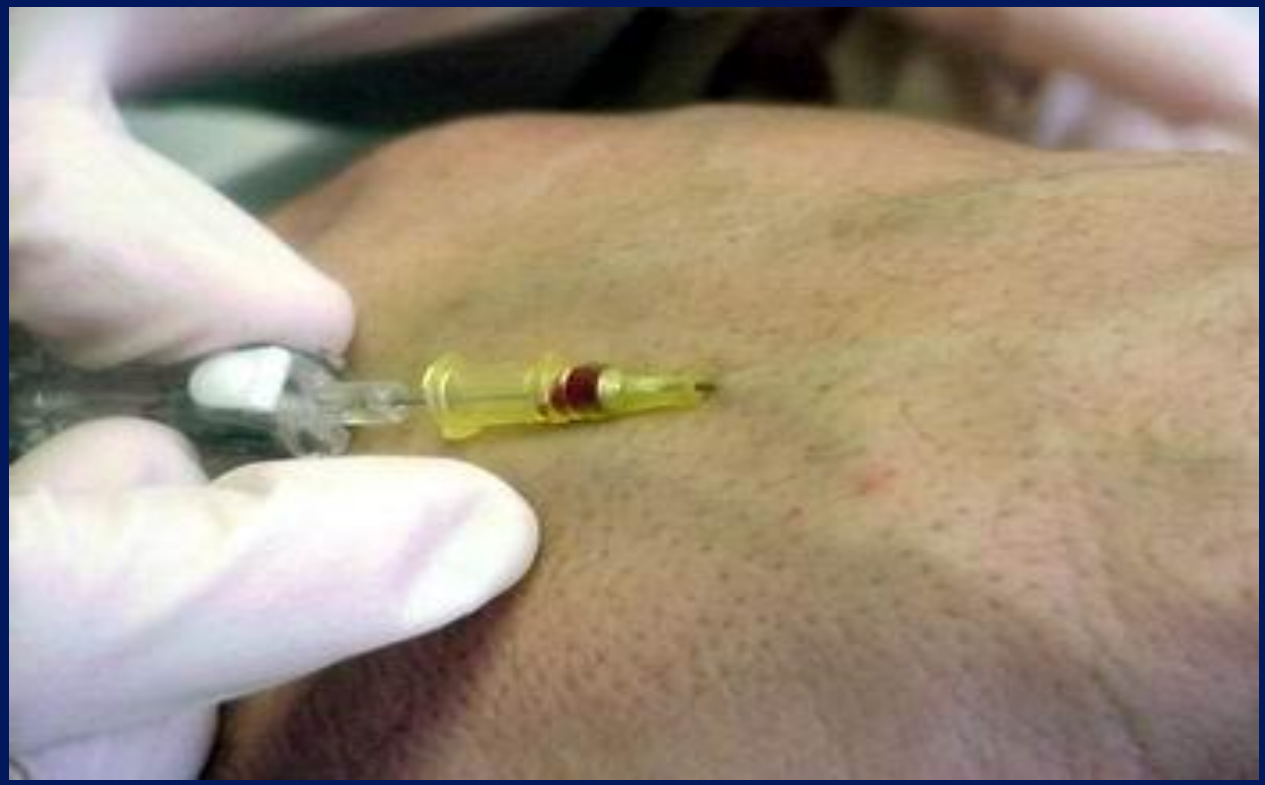
**No significant difference on contamination rates of gloved hands after contact with skin or environmental surfaces (40% vs 45%; p=0.59)**




Stiefel U, et al. ICHE 2011;32:185-187

# ACQUISITION OF MRSA ON HANDS AFTER CONTACT WITH ENVIRONMENTAL SITES

# TRANSFER OF MRSA FROM PATIENT OR ENVIRONMENT TO IV DEVICE AND TRANSMISSON OF PATHOGEN



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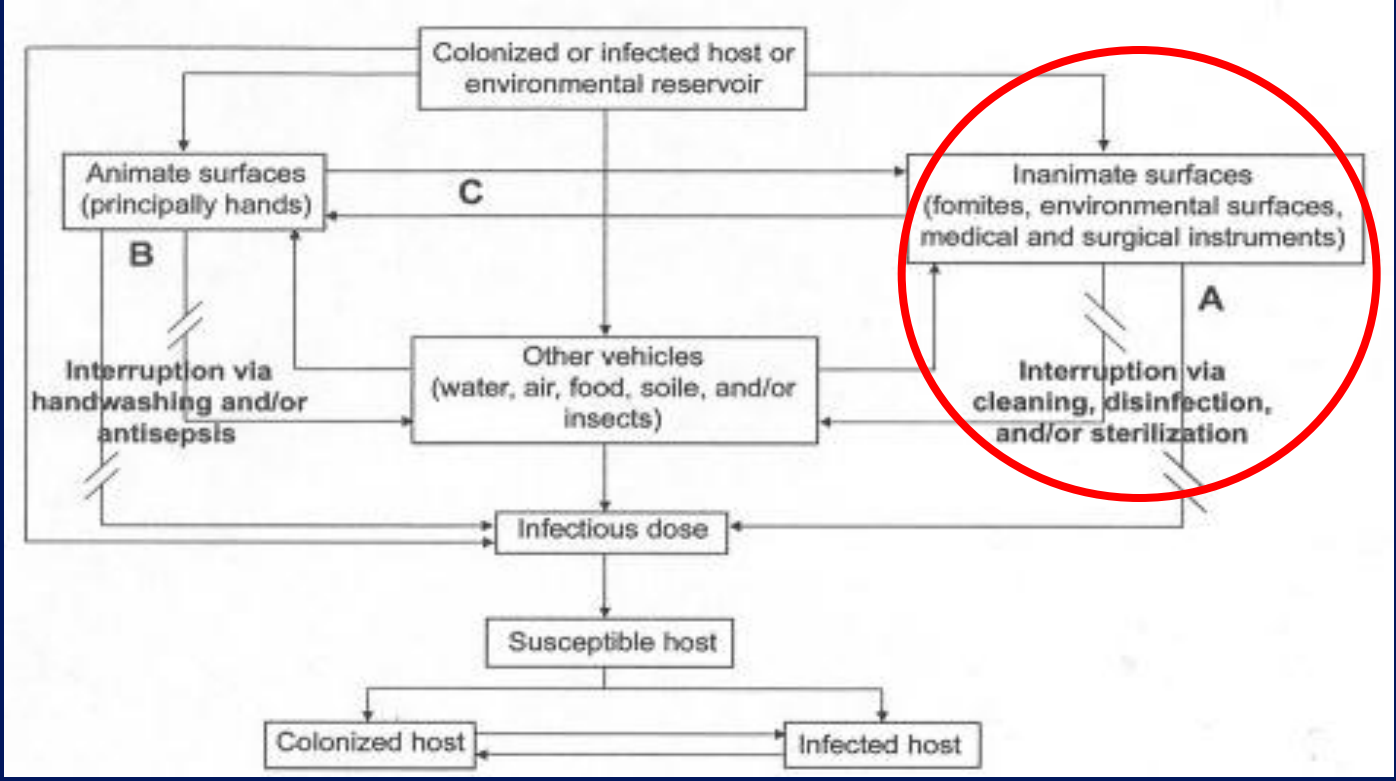
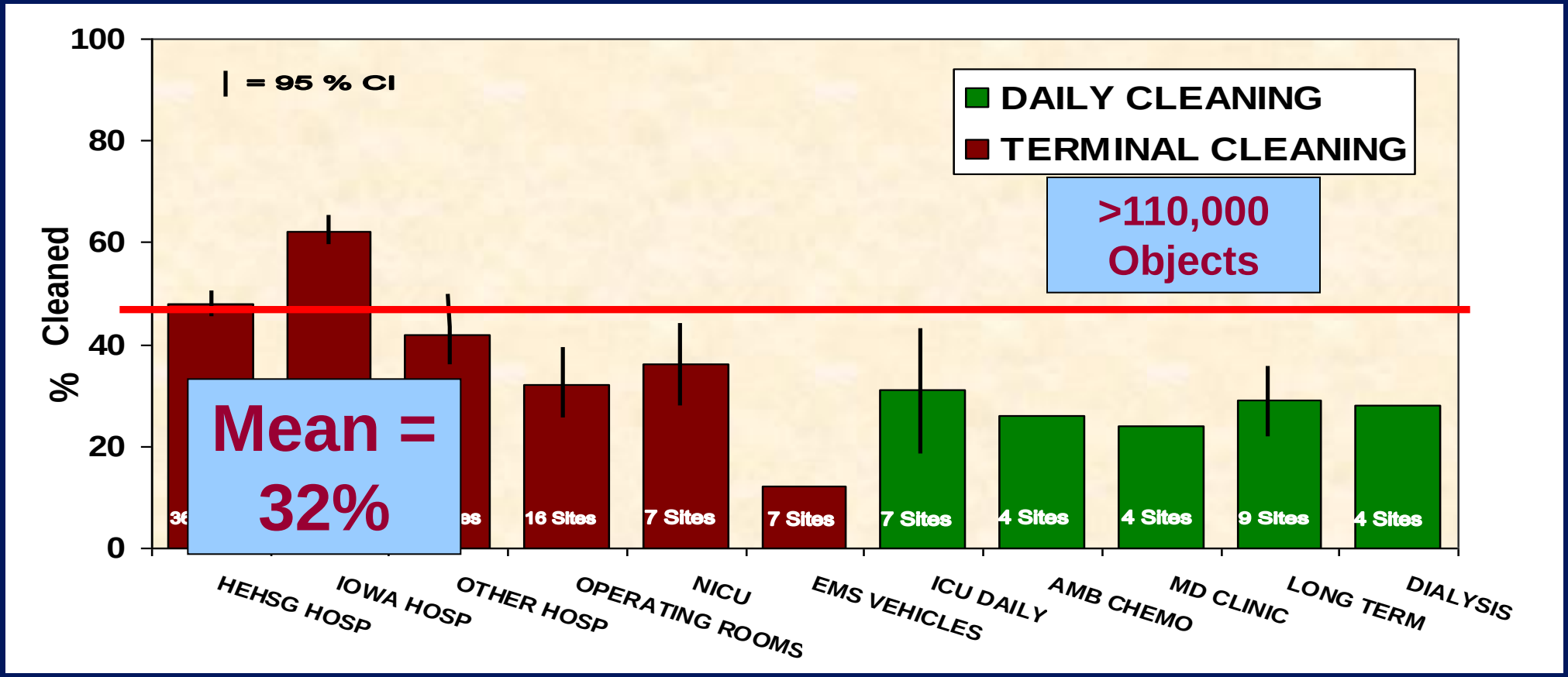



Rutala WA, Weber DJ. In:"SHEA Practical Healthcare Epidemiology" (Lautenbach E, Woeltje KF, Malani PN, eds), 3rd ed, 2010.

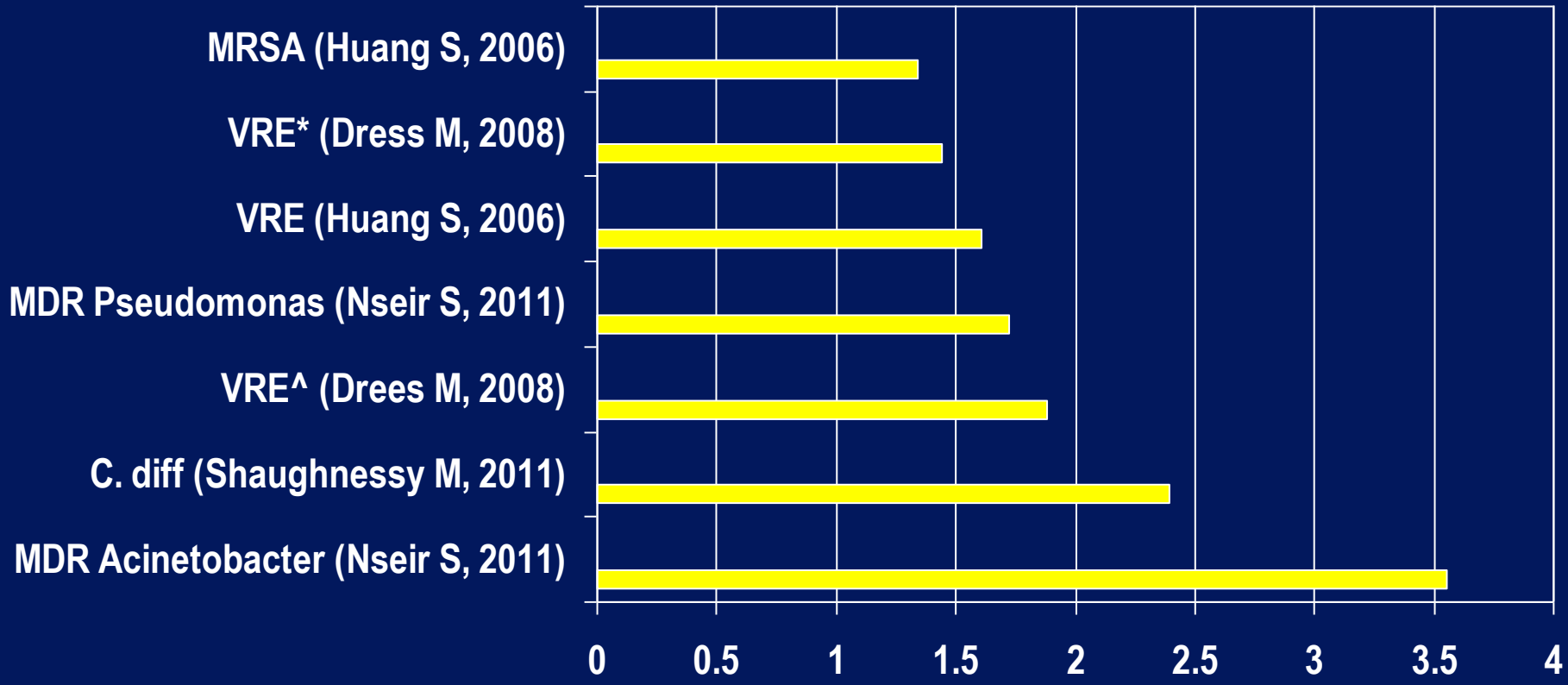
# ACQUISITION OF *C. difficile* ON PATIENT HANDS AFTER CONTACT WITH ENVIRONMENTAL SITES AND THEN INOCULATION OF MOUTH

# Thoroughness of Environmental Cleaning

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



# RELATIVE RISK OF PATHOGEN ACQUISITION IF PRIOR ROOM OCCUPANT INFECTED




* Prior room occupant infected; ^Any room occupant in prior 2 weeks infected

# ENVIRONMENTAL CONTAMINATION LEADS TO HAIs
## Suboptimal Cleaning

- 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

# 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 Infection Preventionist unbeknown to EVS, after EVS cleaning, markings are reassessed)

# DAZO Solution (AKA – Goo)

# Target After Marking

# Target Enhanced

# SURFACE EVALUATION USING ATP BIOLUMINESCENCE

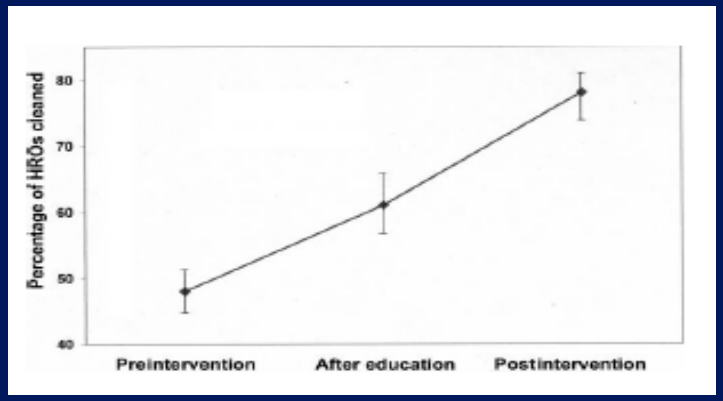
Swab surface → luciferace tagging of ATP → Hand held luminometer

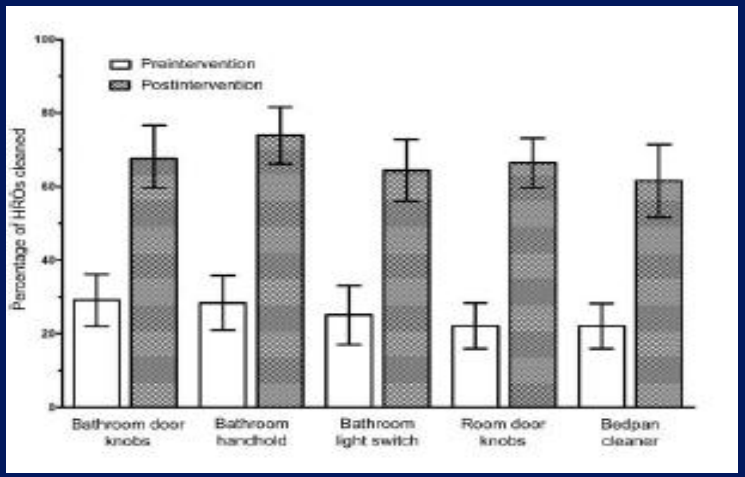

Used in the commercial food preparation industry to evaluate surface cleaning before reuse and as an educational tool for more than 30 years.

# 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

# NEW "NO TOUCH" APPROACHES TO ROOM DECONTAMINATION

## Supplement Surface Disinfection

Rutala, Weber. Infect Control Hosp Epidemiol. 2011;32:743

# ROOM DECONTAMINATION UNITS

## Rutala, Weber. ICHE. 2011;32:743

**UV and HP systems have been demonstrated to be effective against various healthcare-associated pathogens**

TABLE 1. Comparison of Room Decontamination Systems That Use UV Irradiation and Hydrogen Peroxide (HP)

| | Sterinis | Steris | Bioquell | Tru-D |
|---|---|---|---|---|
| Abbreviation | DMHP (dry mist HP) | VHP (vaporized HP) | HPV (HP vapor) | UV-C |
| Active agent | Stenusil (5% HP, <50 ppm silver cations) | Vaprox (35% HP) | 35% HP | UV-C irradiation at 254 nm |
| Application | Aerosol of active solution | Vapor, noncondensing | Vapor, condensing | UV irradiation, direct and reflected |
| Aeration (removal of active agent from enclosure) | Passive decomposition | Active catalytic conversion | Active catalytic conversion | Not necessary |
| Sporicidal efficacy | Single cycle does not inactivate *Bacillus atrophaeus* BIs; ~4-$\log_{10}$ reduction in *Clostridium difficile*[a] and incomplete inactivation in situ | Inactivation of *Geobacillus stearothermophilus* BIs | Inactivation of *G. stearothermophilus* BIs; >6-$\log_{10}$ reduction in *C. difficile*[a] in vitro and complete inactivation in situ | 1.7–4-$\log_{10}$ reduction in *C. difficile*[a] in situ |
| Evidence of clinical impact | None published | None published | Significant reduction in the incidence of *C. difficile* | None published |

NOTE. Adapted from Otter and Yezli.[18] BIs, biological indicators; VRE, vancomycin-resistant *Enterococcus*.

[a] All *C. difficile* experiments were done with *C. difficile* spores.

# Disinfection and Sterilization: Current Issues and New Technologies

- Current Issues and New Technologies
  - Sterilization of critical items
  - High-level disinfection for semi-critical items
  - Low-level disinfection of non-critical items

# Summary

- New sterilization, high-level disinfection and low-level disinfection technologies/practices/products are effective
- New technologies/practices/products integrated into guidelines/policies/practices can improve patient care
- Effective surface disinfection essential to eliminate the environment as a source for transmission of healthcare-associated pathogens.

# THANK YOU!