# ASSESSMENT OF STRATGIES FOR TERMINAL ROOM DISINFECTION

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# LECTURE OBJECTIVES

- Review the role of the environment in transmission of nosocomial pathogens
- Review the activity of germicides (low-level disinfectants) for surface disinfection on key hospital pathogens
- Describe best practices for terminal environmental cleaning and disinfection
- Discuss options for evaluating environmental cleaning and disinfection
- Review “no touch” methods for room decontamination

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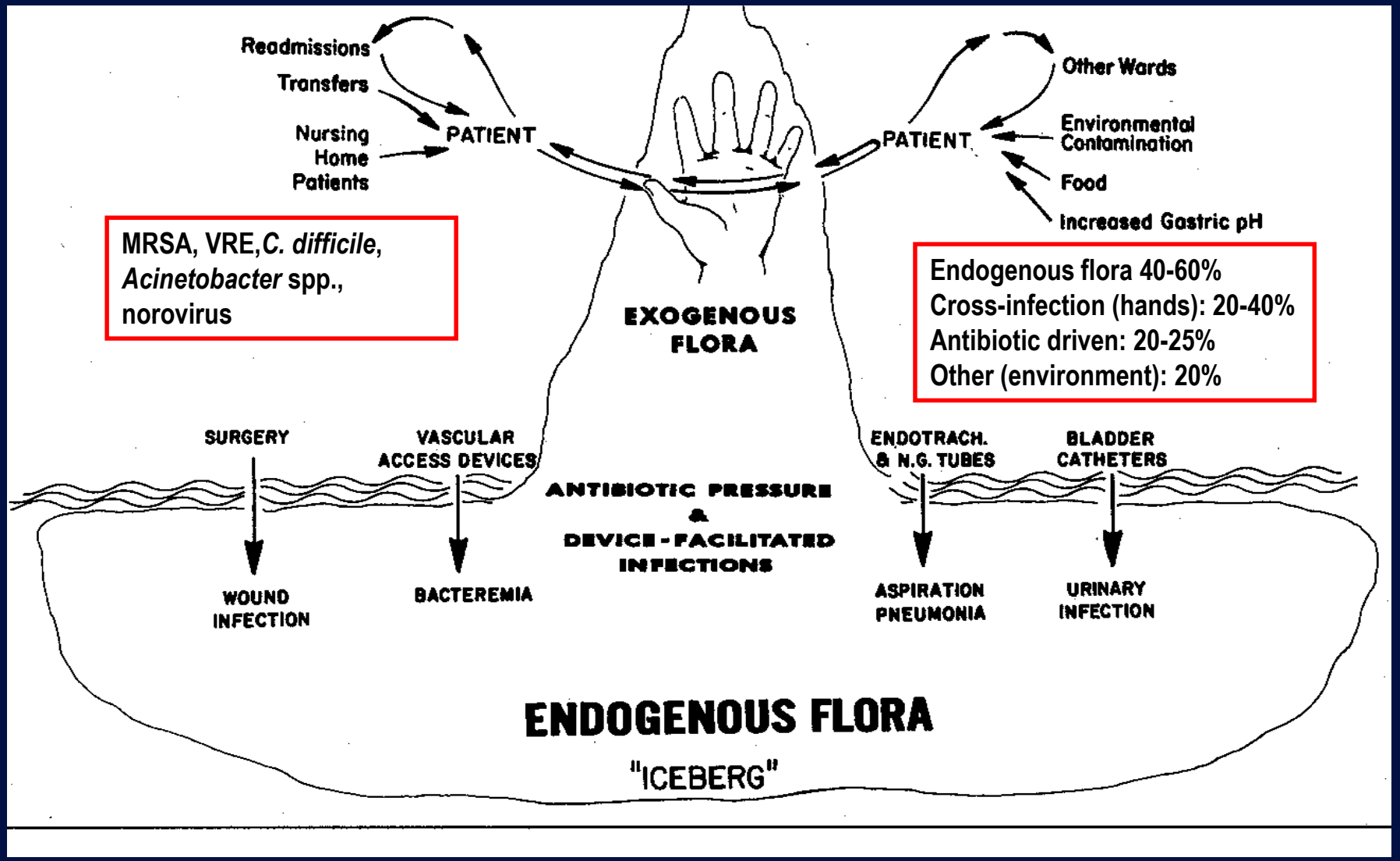
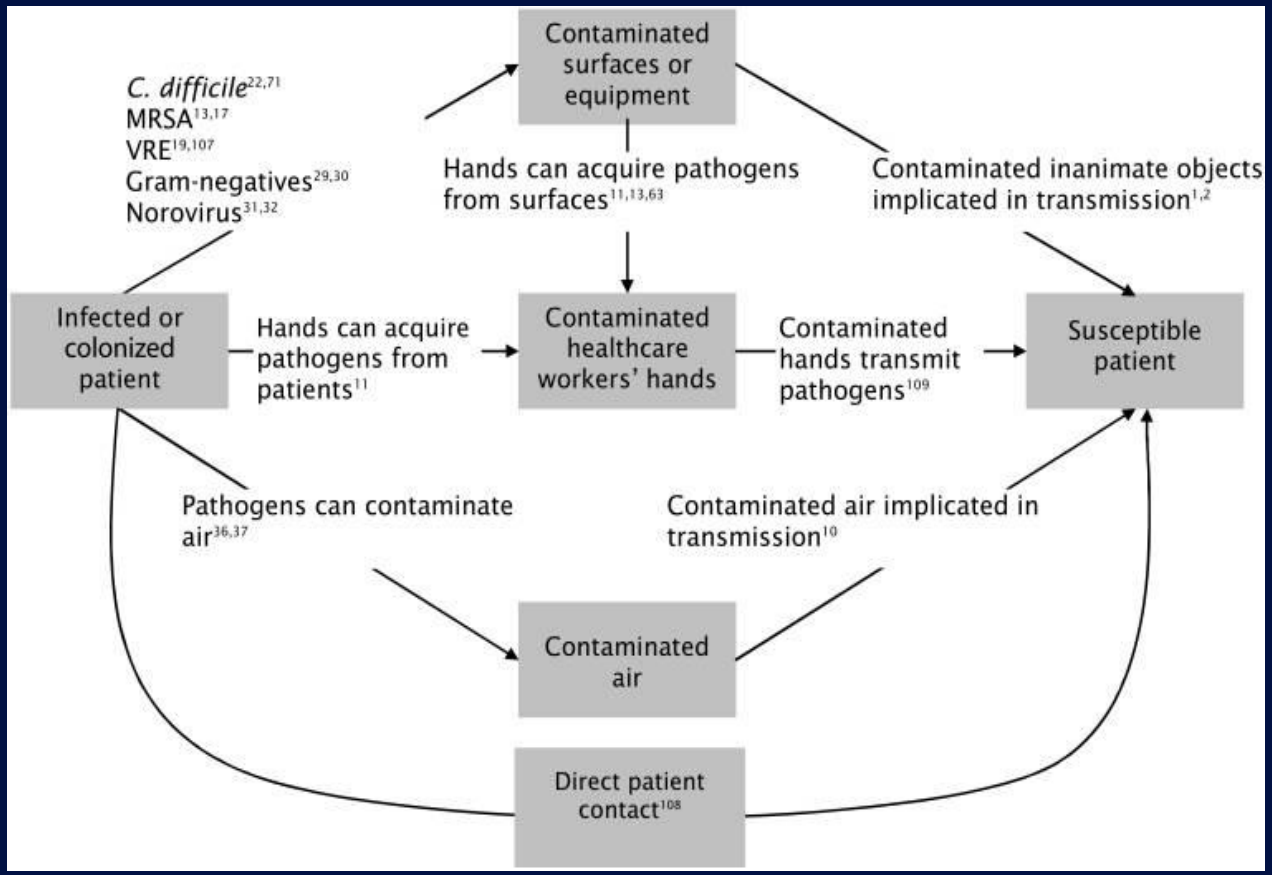
- Disclosures (speaker, consultant): Clorox

# HAZARDS IN THE HOSPITAL




Weinstein RA. Am J Med 1991;91(suppl 3B):179S

# TRANSMISSION MECHANISMS INVOLVING THE SURFACE ENVIRONMENT




Otter JA, et al. Infect Control Hosp Epidemiol 2011;32:687-699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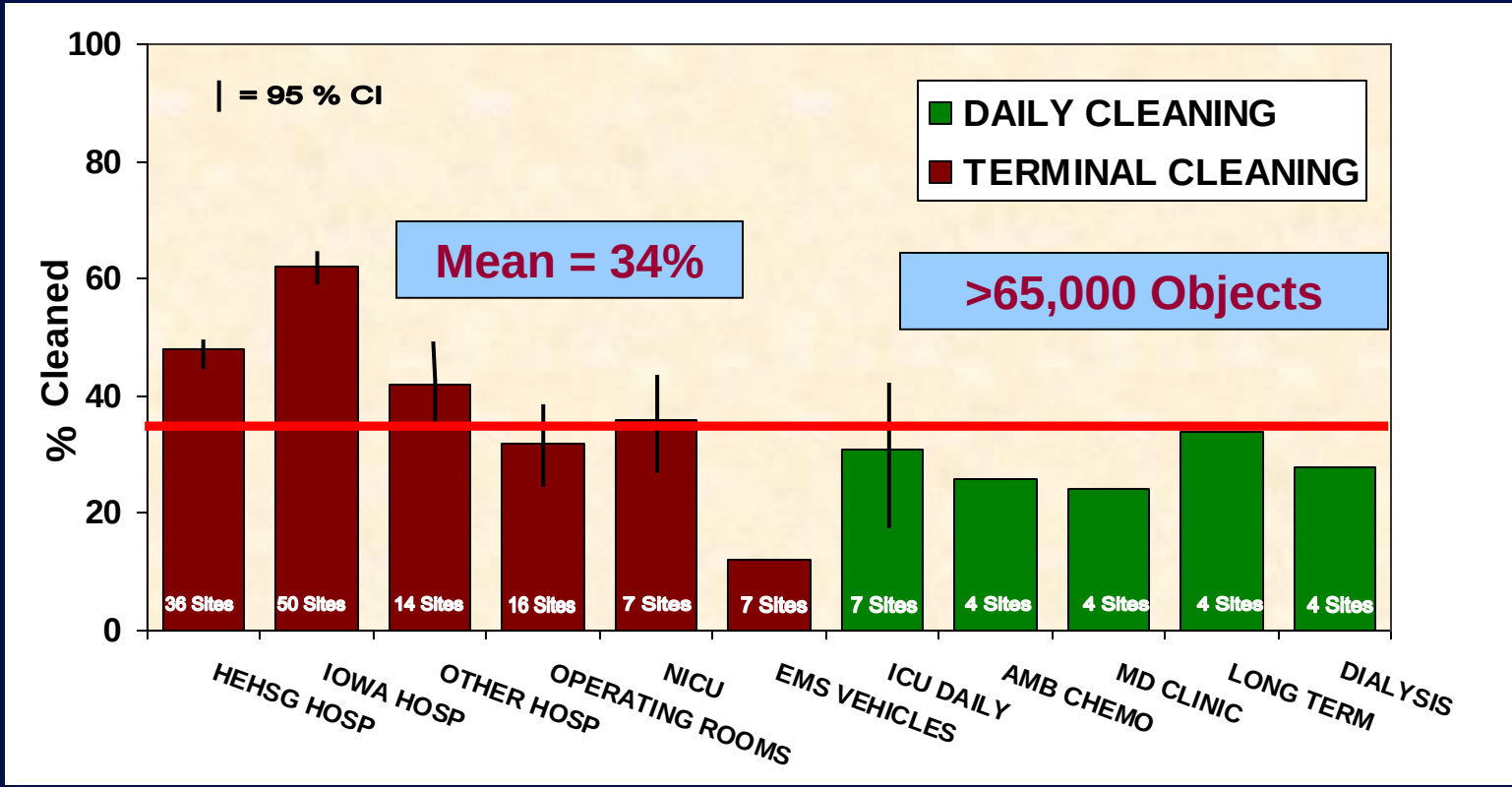
"The patient in the next bed is highly infectious. Thank God for these curtains."

# Thoroughness of Environmental Cleaning




Carling P, et al. SHEA 2010

# ROOM CONTAMINATION FOLLOWING TERMINAL CLEANING

| Pathogen | % Contaminated (rooms) | Reference |
|---|---|---|
| MRSA | 46% of rooms (N=41) | Blythe D, et al. JHI 1998;38:67-70 |
| MRSA | 74% of sampled sites (N=10) | French GL, et al. JHI 2004;57:31-7 |
| MRSA | 24% of rooms (N=37) | Goodman ER, et al. ICHE 2008;29:593-8 |
| VRE | 22% of rooms (N=37) | Goodman ER, et al. ICHE 2008;29:593-8 |
| VRE | 16% of sampled sites (N=10) | Byers K. ICHE 1998;19:261-4 |
| VRE | 71% of rooms (N=17) | Eckstein BC, et al. BMC ID;2007;7:61 |
| *C. difficile* | 100% of rooms (N=9) | Eckstein BC, et al. BMC ID;2007;7:61 |

# RELATIVE RISK OF PATHOGEN ACQUISITION IF PRIOR ROOM OCCUPANT INFECTED


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

Adapted from Otter JA, et al. Am J Infect Control 2013.

# TRANSFER OF MDR-PATHOGENS TO HCP GLOVES OR GOWNS RELATED TO ENVIRONMENTAL CONTAMINATION

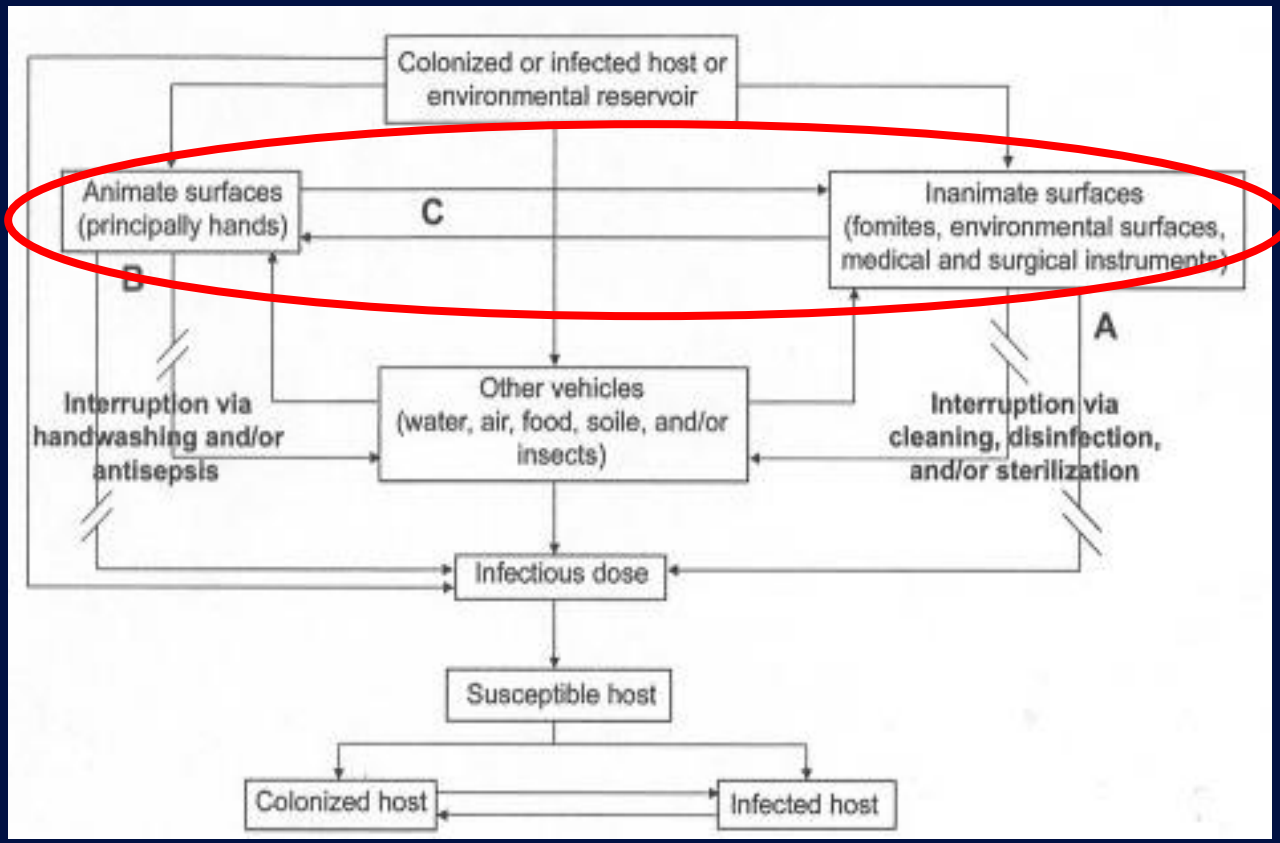
- Design: Prospective cohort in 6 ICUs
- Results
  - Frequency of contamination HCP gloves or gowns: MDR-*Acinetobacter* 32.9%, MDR-*P. aeruginosa* 17.4%, VRE 13.9%, MRSA 13.8%
  - PFGE determined that 91% of HCP isolates were related to an environmental or patient isolate

Table 4. Variables found to be independently predictive of healthcare worker contamination with multidrug-resistant bacteria

| Independent Variable | Odds Ratio (95% Confidence Interval)[a] | $p^a$ |
|---|---|---|
| Positive multidrug-resistant bacteria environmental culture | 4.15 (2.66–6.47) | <.001 |
| Duration in room >5 mins | 1.99 (1.15–3.43) | .014 |
| Performing physical examination | 1.74 (1.10–2.77) | .019 |
| Contact with ventilator | 1.78 (1.12–2.82) | .014 |

Morgan DJ, et al. Crit Care Med 2012;40:1045-1051

# 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.

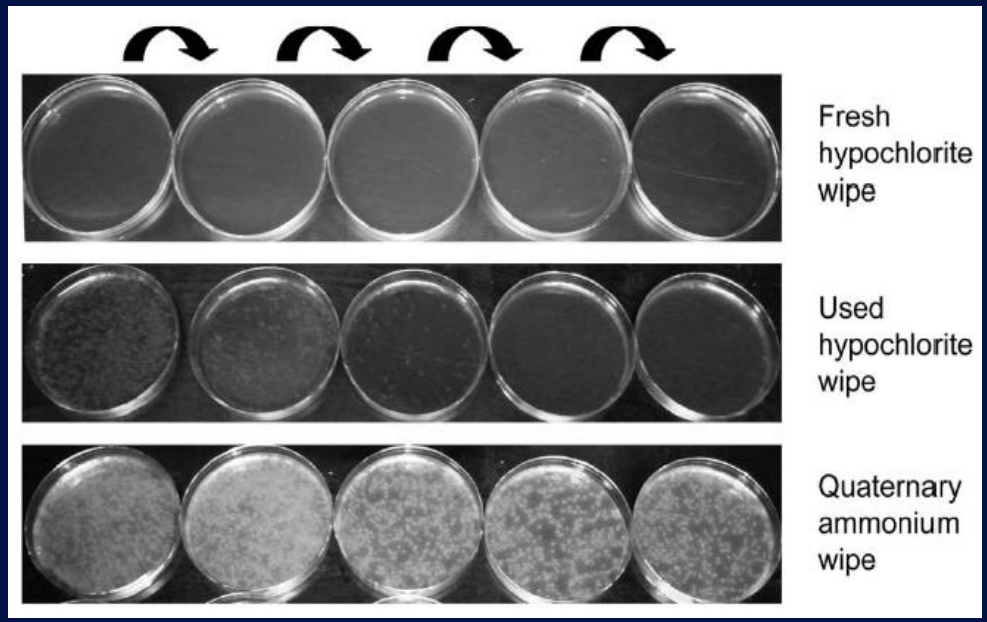
# Effective Surface Decontamination

Product and Practice = Perfection

# TRANSFER OF *C. DIFFICILE* SPORES BY NONSPORICIDAL WIPES AND IMPROPERLY USED HYPOCHLORITE WIPES

- Study design: *In vitro* study that assessed efficacy of different wipes in killing of *C. difficile* spores (5-$\log_{10}$)
  - Fresh hypochlorite wipes
  - Used hypochlorite wipes
  - Quaternary ammonium wipes
- Results (4$^{th}$ transfer)
  - Quat had no efficacy (3-$\log_{10}$ spores)
  - Fresh hypochlorite worked
  - Used hypochlorite transferred spores in lower concentration (0.4-$\log_{10}$ spores)

**Practice + Product = Perfection**




Cadnum JL, et al. ICHE 2013;34:441-2

# Surface Disinfection

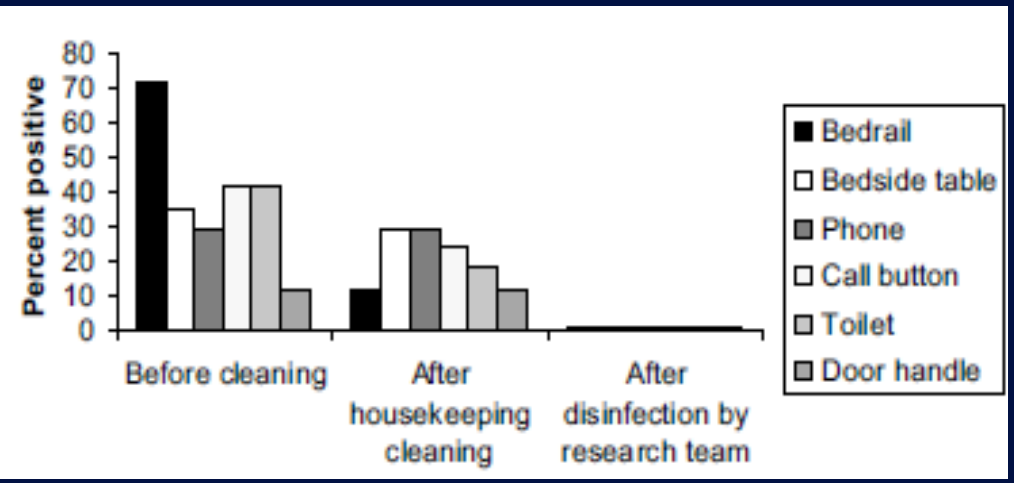
## Effectiveness of Different Methods For *C. difficile*

| Product | Wipe and/or spray method | | | | | |
|---|---|---|---|---|---|---|
| | Saturated cloth[a] | Spray (10 s) and wipe | Spray, wipe, spray (1 min), wipe | Disposable pop-up wipes | Spray, wipe, spray, air dry | Spray and air dry |
| Ecolab QC-53, detergent | | | | | | |
| Reduction | 3.38 (1.61–5.16) | 3.28 (2.18–4.38) | 4.02 (3.68–4.35) | NT | 2.90 (1.34–4.45) | <2.00 (1.78–2.21) |
| Drying time, min:s | 2:09 | 4:18 | 3:34 | NT | 24:26 | 28:11 |
| Ecolab A456-II | | | | | | |
| Reduction | 3.14 (2.01–4.27) | 2.98 (1.92–4.04) | 4.18 (3.46–4.90) | NT | 2.90 (1.52–4.27) | <2.00 (1.78–2.21) |
| Drying time, min:s | 2:26 | 6:18 | 4:44 | NT | 24:00 | 30:14 |
| 1 : 10 Bleach | | | | | | |
| Reduction | 3.90 (2.87–4.92) | 4.48 (4.26–4.69) | 4.48 (4.26–4.69) | NT | 4.48 (4.26–4.69) | 3.44 (1.65–5.22) |
| Drying time, min:s | 1:45 | 5:18 | 5:21 | NT | 51:08 | 39:40 |
| Kimtech One-Step Germicidal Wipe | | | | | | |
| Reduction | NT | NT | NT | 4.18 (4.18–4.18) | NT | NT |
| Drying time, min:s | NT | NT | NT | 4:06 | NT | NT |
| Clorox Germicidal Wipe | | | | | | |
| Reduction | NT | NT | NT | 3.98 (3.23–4.72) | NT | NT |
| Drying time, min:s | NT | NT | NT | 1:47 | NT | NT |
| Clorox #9255–41–1 and 3 | | | | | | |
| Reduction | NT | 6.14 (6.14–6.14) | NT | NT | NT | 5.96 (5.22–6.70) |
| Drying time, min:s | NT | 2:49 | NT | NT | NT | 40:14 |

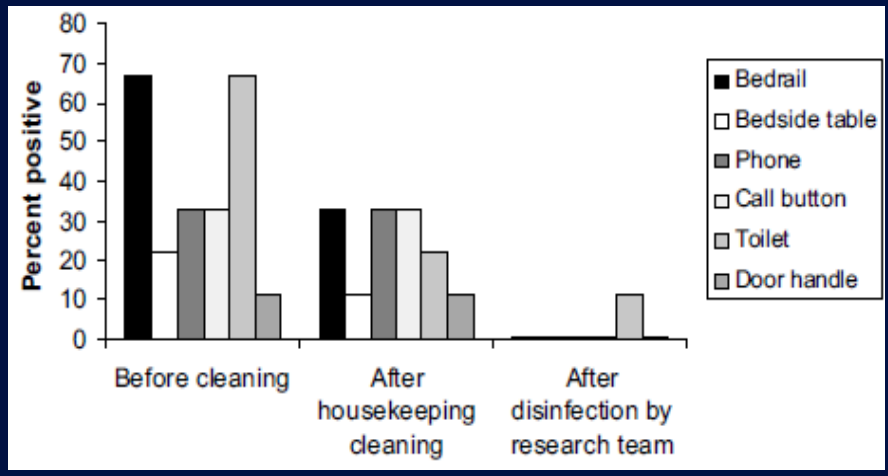
# IMPROVING ROOM CLEANING: PRACTICE NOT PRODUCT

- Room surfaces occupied by VRE colonized or CDI infected patients cultured for VRE (17 rooms) or *C. difficile* (9 rooms) before and after terminal cleaning
- 10% bleach used for terminal cleaning by housekeeping for CDI patients
- 10% bleach used by research staff for all terminal cleaning

**VRE**




***C. difficile***




Eckstein BC, et al. BMC Infect Dis 2007;7:61

# 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.

# Decreasing Order of Resistance of Microorganisms to Disinfectants/Sterilants

**Most Resistant**

**Most Susceptible**

Prions
Bacterial spores (*C. difficile*)
Protozoal oocysts
Helminth eggs
Mycobacteria
Small, non-enveloped viruses (norovirus)
Protozoal cysts
Fungal spores
Gram-negative bacilli (*Acinetobacter*)
Vegetative fungi and algae
Large, non-enveloped viruses
Gram-positive bacteria (MRSA, VRE)
Enveloped viruses

# 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 | 0.5% |

UD=Manufacturer's recommended use dilution

# METHODS TO IMPROVE DISINFECTION OF ENVIRONMENTAL SURFACES

Follow “best” practices for room cleaning and disinfection

- Follow CDC guideline for choosing disinfectant and “best” practices
- Improve training/education of environmental service workers
- Use of checklists to ensure all room surfaces are cleaned/disinfected
- Assure nursing and EVS agreed what items disinfected by nursing vs EVS
- Use of method (fluorescent dye, ATP) to ensure proper cleaning

# DAILY CLEANING/DISINFECTING PRACTICES

- Disinfect (damp wipe) all horizontal, vertical and contact surfaces with a cotton cloth saturated (or microfiber) with a disinfectant-detergent solution (examples of surfaces to be cleaned)
  - Bed rails, overbed table, infusion pumps, IV poles/Hanging IV poles, nurse call box, monitor cables, telephone, countertops
  - Soap dispenser, paper towel dispenser, cabinet fronts including handles, visitor chair, door handles inside and outside, sharps container, TV remote, bed call remote, bathroom-toilet seat, shower fixtures, flush handle
- Use EPA-registered disinfectant-detergent (if prepared on-site, document correct concentration)
- Cleaned surface should appear visibly wet and should be allowed to air dry at least one minute

Hota et al. J Hosp Infect 2009;71:123

# TERMINAL CLEANING/DISINFECTING PRACTICES

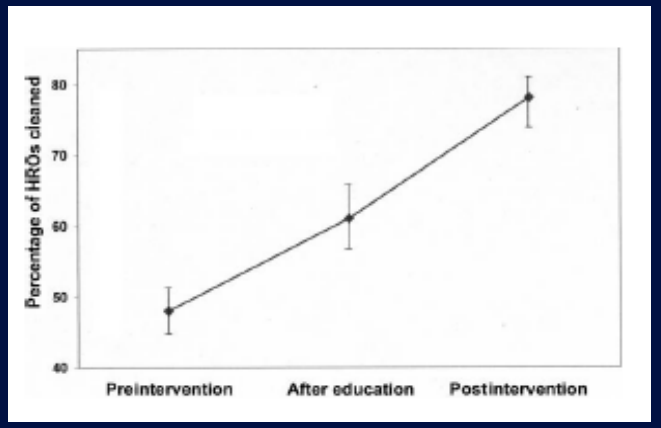
- "Terminal" or discharge  cleaning of non-isolation rooms consists of the same procedures as daily cleaning plus disinfection of bed mattresses and inaccessible items
- Trash can cleaned weekly and when visible soiled
- Do not wash walls, strip and wax floors, or discard wrapped disposable supplies left in drawers

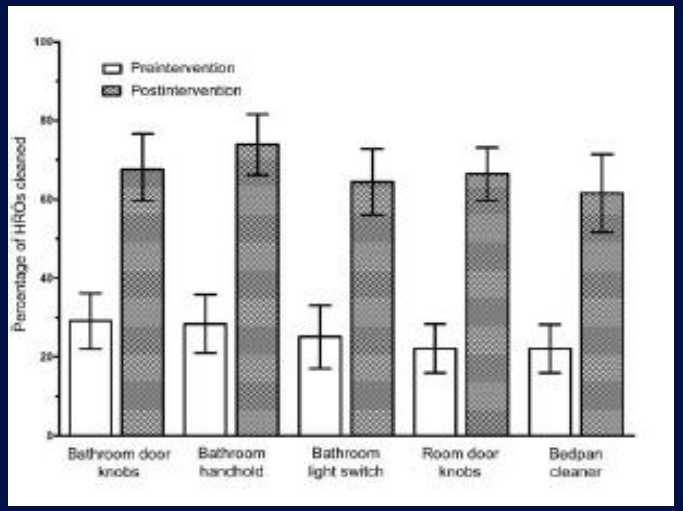
Hota et al. J Hosp Infect 2009;71:123

# 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

Carling PC, et al. ICHE 2008;29:1035-41



# CDC Recommendations

Acute Care Hospitals should implement a:

Level I Program:

Basic interventions to optimize disinfection cleaning policies, procedures and ES staff education and Practice. When completed move to Level II Program

Level II Program:

All elements of Level I + Objective monitoring

**Options for Evaluating Environmental Cleaning**

October 2010

National Center for Emerging and Zoonotic Infectious Diseases

Division of Healthcare Quality Promotion

CDC

# METHODS OF ASSESSING ENVIRONMENTAL CLEANING

- Visual (direct observation)
  - Not a reliable indicator of surface cleanliness
- Culture, <2.5 CFUL/$cm^2$ (aerobic plate counts or specific pathogen cultures)
  - Costly and results delayed
- ATP bioluminescence
  - Measures organic debris
  - No validated cut-offs (<250-500 RLU)
- Fluorescent system
  - Easy to use; use demonstrated to improve cleaning and reduce HAI

# USE OF A FLUORESCENT DYE TO ASSESS CLEANING EFFECTIVENESS

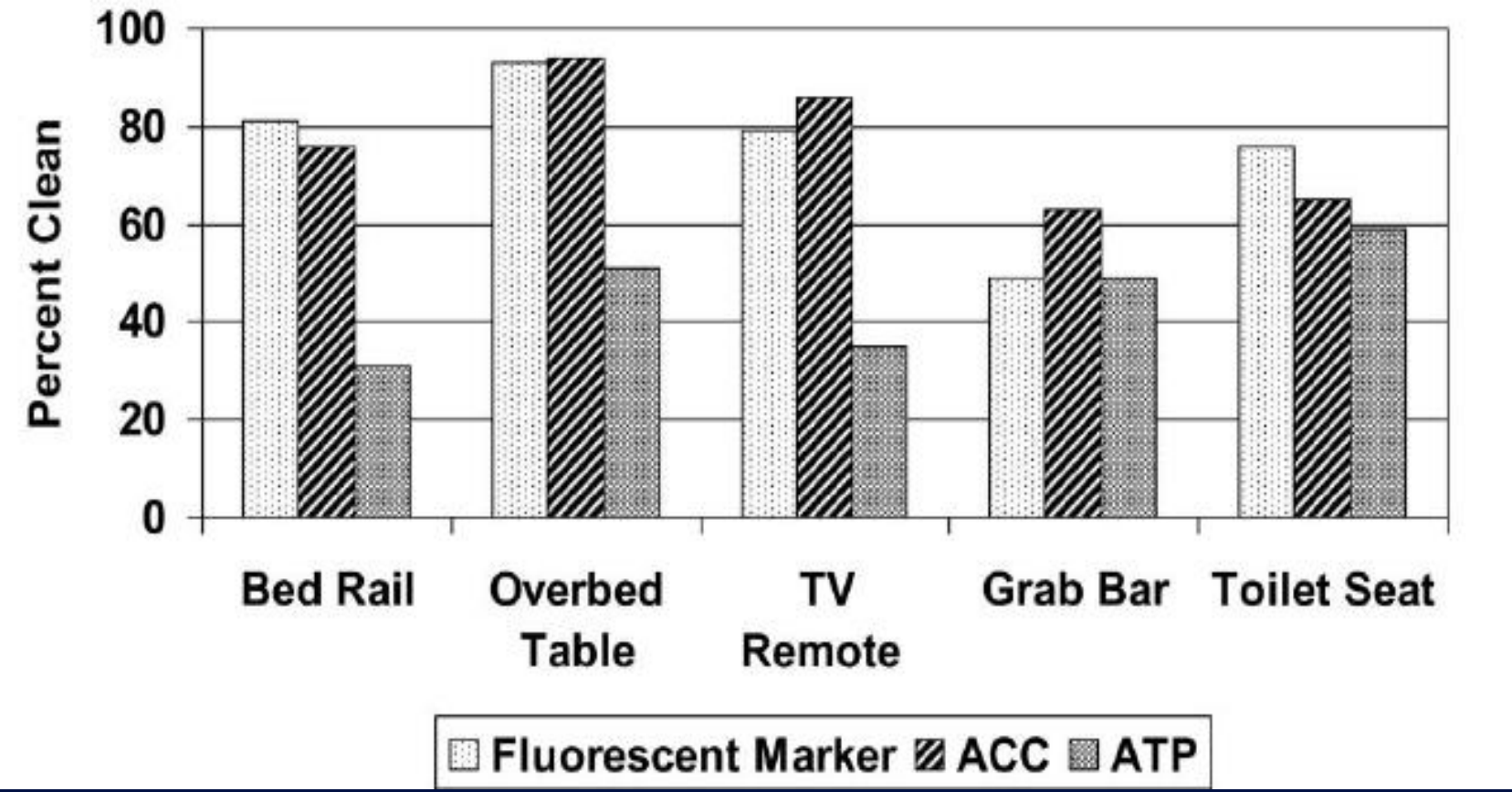
- Dye should be randomly be placed on multiple surfaces
- Feed back to environmental surfaces work is key

# 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.**

# COMPARISON OF DIFFERENT METHODS OF ASSESSING TERMINAL ROOM CLEANING PRACTICES




ACC, aerobic colony count; ATP, adenosine triphosphase  Boyce JM, et al. ICHE 2011;32:1187

# EVALUATING ENVIRONMENTAL SURFACE CLEANING

| Method | Ease of Use | Identifies Pathogens | Accuracy | Useful for Teaching | Use in Programmatic Monitoring |
|---|---|---|---|---|---|
| Direct observation | Low | No | Variable | Yes | Difficult |
| Culture swab | High | Yes | High | No | No |
| Agar culture system | Moderate | Possible | Moderate | No | Possible* |
| Fluorescent system | High | No | High | Yes | Yes |
| ATP Bioluminescence | High | No | Variable | Yes | Possible* |

* Measures cleanliness at that moment but NOT the process of cleaning

Carling P. A J Infect Control 2013;41:S20-25

# RATIONALE FOR DEVELOPING NEW TECHNOLOGIES TO AID IN ROOM DISINFECTION

- Current limitations of disinfectants for room surfaces (innovation = improved hydrogen peroxide)
  - Quats: Slow speed (many have 10 min label claim), allergies/asthma?
  - Hypochlorites: Irritant (bothers some HCP)
  - Alcohols: Flammability
- Failures of current terminal clean/disinfection: inadequate practice NOT product (innovation = "no touch" methods of room disinfection)
  - High frequency of inadequate cleaning resulting in risk of HAI to subsequent patients
- High frequency of contamination of room surfaces (innovation = "self-disinfecting" surfaces)
  - Inability to use UV or hydrogen peroxide systems for daily room disinfection

# TECHNOLOGIES TO IMPROVE DISINFECTION OF ENVIRONMENTAL SURFACES

- New surface disinfectants
  - **Improved hydrogen peroxide**
  - **Electrochemically activated saline solution**
- "No touch" terminal disinfection
  - **UV light devices: UV-C or pulsed xenon**
  - **Hydrogen peroxide systems: Vapor or aerosol**
  - **Portable devices: UV, steam**
- "Self disinfecting" surfaces
  - **Heavy metal surface coatings: Silver, copper**
  - **Sharklet pattern**
  - **Germicide impregnated surfaces: Triclosan**

# IMPROVED HYDROGEN PEROXIDE 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 1min

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 | A456-II 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 |

FCS, fetal calf serum; HP, hydrogen peroxide

Rutala WA, Gergen M, Weber DJ. ICHE 2012;33:1159

# Decontamination of Curtains with Activated HP (1.4%)

Rutala, Gergen, Weber. Am J Infect Control. 2014;42:426-428

| CP for: | Before Disinfection CFU/5 Rodacs (#Path) | After Disinfection CFU/5 Rodacs (#Path) | % Reduction |
|---|---|---|---|
| MRSA | 330 (10 MRSA) | 21*(0 MRSA) | 93.6% |
| MRSA | 186 (24 VRE) | 4* (0 VRE) | 97.9% |
| MRSA | 108 (10 VRE) | 2* (0 VRE) | 98.2% |
| VRE | 75 (4 VRE) | 0 (0 VRE) | 100% |
| VRE | 68 (2 MRSA) | 2* (0 MRSA) | 97.1% |
| VRE | 98 (40 VRE) | 1* (0 VRE) | 99.0% |
| MRSA | 618 (341 MRSA) | 1* (0 MRSA) | 99.8% |
| MRSA | 55 (1 VRE) | 0 (0 MRSA) | 100% |
| MRSA, VRE | 320 (0 MRSA, 0 VRE) | 1* (0 MRSA, 0 VRE) | 99.7% |
| MRSA | 288 (0 MRSA) | 1* (0 MRSA) | 99.7% |
| Mean | 2146/10=215 (432/10=44) | 33*/10=3 (0) | 98.5% |

* All isolates after disinfection were *Bacillus sp;* now treat CP patient curtains at discharge

# PROPERTIES OF AN IDEAL DISINFECTANT

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

- **Broad spectrum**-wide antimicrobial spectrum
- **Fast acting**-should produce a rapid kill
- **Remains Wet**-meet listed kill/contact times with a single application
- **Not affected by environmental factors**-active in the presence of organic matter
- **Nontoxic**-not irritating to user
- **Surface compatibility**-should not corrode instruments and metallic surfaces
- **Persistence**-should have sustained antimicrobial activity
- **Easy to use**
- Acceptable odor
- Economical-cost should not be prohibitively high
- Soluble (in water) and stable (in concentrate and use dilution)
- Cleaner (good cleaning properties) and nonflammable

# Key Considerations for Selecting the Ideal Disinfectant for Your Facility

| 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 offer 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).

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

# Novel Methods of Room Disinfection

# SELECTED STUDIES OF UV AND HPV TO REDUCE HAIs

| Author, Yr | Design | Setting | Modality | Pathogen | Outcome* |
|---|---|---|---|---|---|
| Anderson, 2015 | RCT | 9 hospitals | UV-C | MRSA+VRE+CDI | 51.3 to 33.9 (p=0.036) |
| Pegues, 2015 | Before-After | Academic hosp | UV-C | CDI | 30.3 to 22.9 (p=0.03) |
| Nagaraja, 2015 | Before-After | Academic hosp | UV-PX | CDI | 10.6 to 8.3 (p=0.06) |
| Miller, 2015 | Before-After | Urban hosp | UV-PX | CDI | 23.3 to 8.3 (p=0.02) |
| Hass, 2014 | Before-After | Academic hosp | UV-PX | CDI | 7.9 to 6.5 (p=0.02) |
| Hass, 2014 | Before-After | Academic hosp | UV-PX | MRSA | 4.5 to 3.3 (p=0.007) |
| Hass, 2014 | Before-After | Academic hosp | UV-PX | MRSA+VRE,+ CDI+MDRO | 26.7 to 21.4 (p<0.001) |
| Passaretti, 2013 | Prospective cohort | Academic hosp | HPV | MDRO (all) | 124 to 62 (p<0.01) |
| Manian, 2013 | Before-After | Community hosp | HPV | CDI | 8.8 to 5.5 (p<0.0001) |
| Levin, 2013 | Before-After | Community hosp | UV-PX | CDI | 9.46 to 4.45 (p=0.01) |

Per 10,000 patient-days; Anderson and Pugues measured HH and EVS compliance

Weber and Rutala AJIC (in press)

# "NO TOUCH" ROOM DECONTAMINATION: ADVANTAGES AND DISADVANTAGES OF UV DEVICES AND HP SYSTEMS

## Advantages

- Reliable biocidal activity against a wide range of pathogens (UV, HP)
- Surfaces and equipment decontaminated (UV, HP)
- Demonstrated effectiveness to reduce HAIs in before-after studies (UV, HP) and randomized clinical trial (UV)
- Residual free and does not give rise to health and safety concerns (UV, HP)

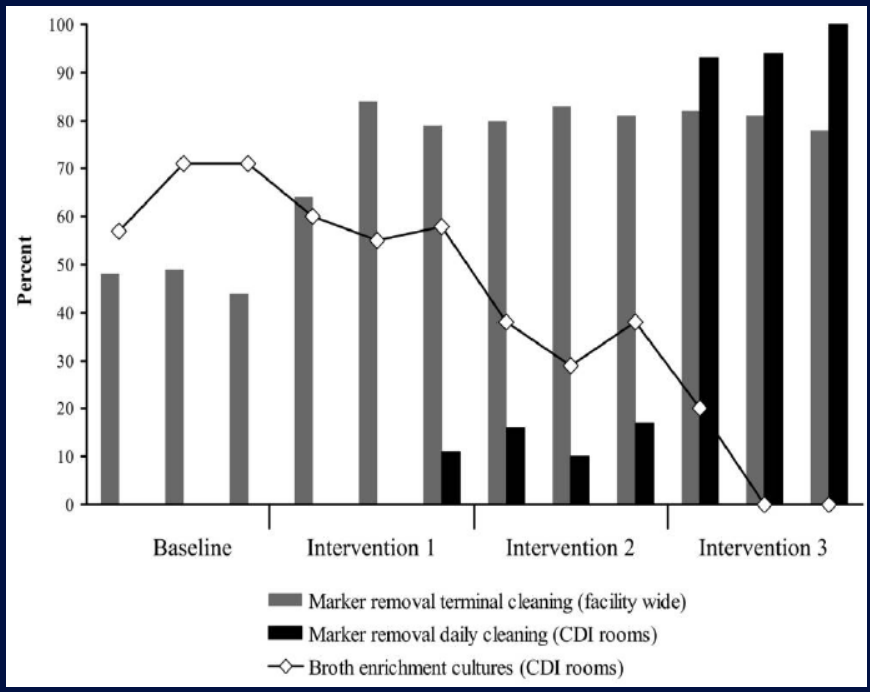
## Differences and disadvantages

- Can only be done for terminal disinfection (UV, HP)
- All patients and staff must be removed from room (UV, HP)
- Time: ~UV=15 min (vegetative bacteria), ~45 min (C. diff); HP=1.5-2.5 hr
- UV required direct or indirect line of sights unlike HP
- HP requires the HVAC system be sealed off unlike UV
- Substantial capital equipment costs (UV, HP)
- Does not remove dust and stains which are important to patients/visitors (UV, HP)

Rutala WA, Weber DJ. (unpublished)

# VALUE OF SEQUENTIAL INTERVENTIONS TO IMPROVE DISINFECTION OF *C. difficile* ROOMS

- Design: Prospective intervention
- Interventions
  - 1. Fluorescent markers used to provide monitoring and feedback on cleaning
  - 2. UV irradiation used for terminal disinfection of CDI rooms
  - 3. Enhanced disinfection of CDI rooms including dedicated daily disinfection team
- Results
  - Cleaning improvement: 47%→87%
  - Reduction CDI positive cultures: 67% (baseline)→57% (1) →35% (2)→7% (3)




Sitzlar B, et al. ICHE 2013;34:459-465

# CONCLUSIONS

- Determining the role of environmental contamination in the transmission of healthcare-associated pathogens is very difficult (difficult to separate roles played by direct person-to-person transmission versus person-to-environment-to-person transmission)
- Contaminated environment likely important for MRSA, VRE, norovirus, *Acinetobacter*, and *C. difficile*
- Eliminating the environment as a source for transmission of HIA pathogens: contact precautions, adherence to proper room cleaning and disinfection protocols (or use of UV or VHP), compliance with proper hand hygiene (soap & water for norovirus and *C. difficile*)
- Additional research required before widespread adoption of "no touch" disinfections methods and/or use of self disinfecting surfaces (key outcome should be reduction of HAIs)

# REFERENCES

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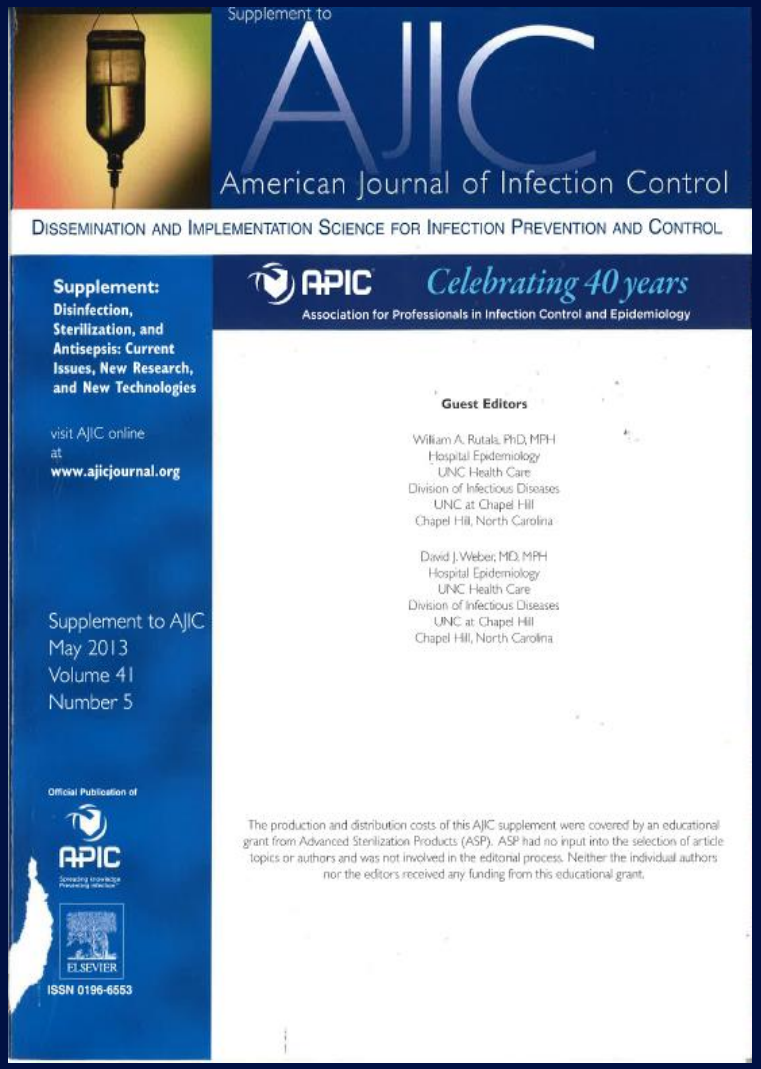

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