MULTIPLE DRUG RESISTANT ORGANISMS (MDRO): A CHALLENGE TO THE ENVIRONMENT

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DISCLOSURES

- Relevant financial disclosures
  - Clorox (consultation within past 3 years)
  - ASP (speaker)
  - Grants: CDC, NIH, CMS
- Thanks for slides
  - William A. Rutala, PhD, MPH
  - Deverick Anderson, MD, MPH

LECTURE OBJECTIVES

- Review the CDC Guideline for Disinfection and Sterilization: Focus on environmental surfaces
- Review the activity of germicides (low-level disinfectants) for surface disinfection on key hospital pathogens
- Describe best practices for environmental cleaning and disinfection
- Discuss options for evaluating environmental cleaning and disinfection
- Review “no touch” methods for room decontamination

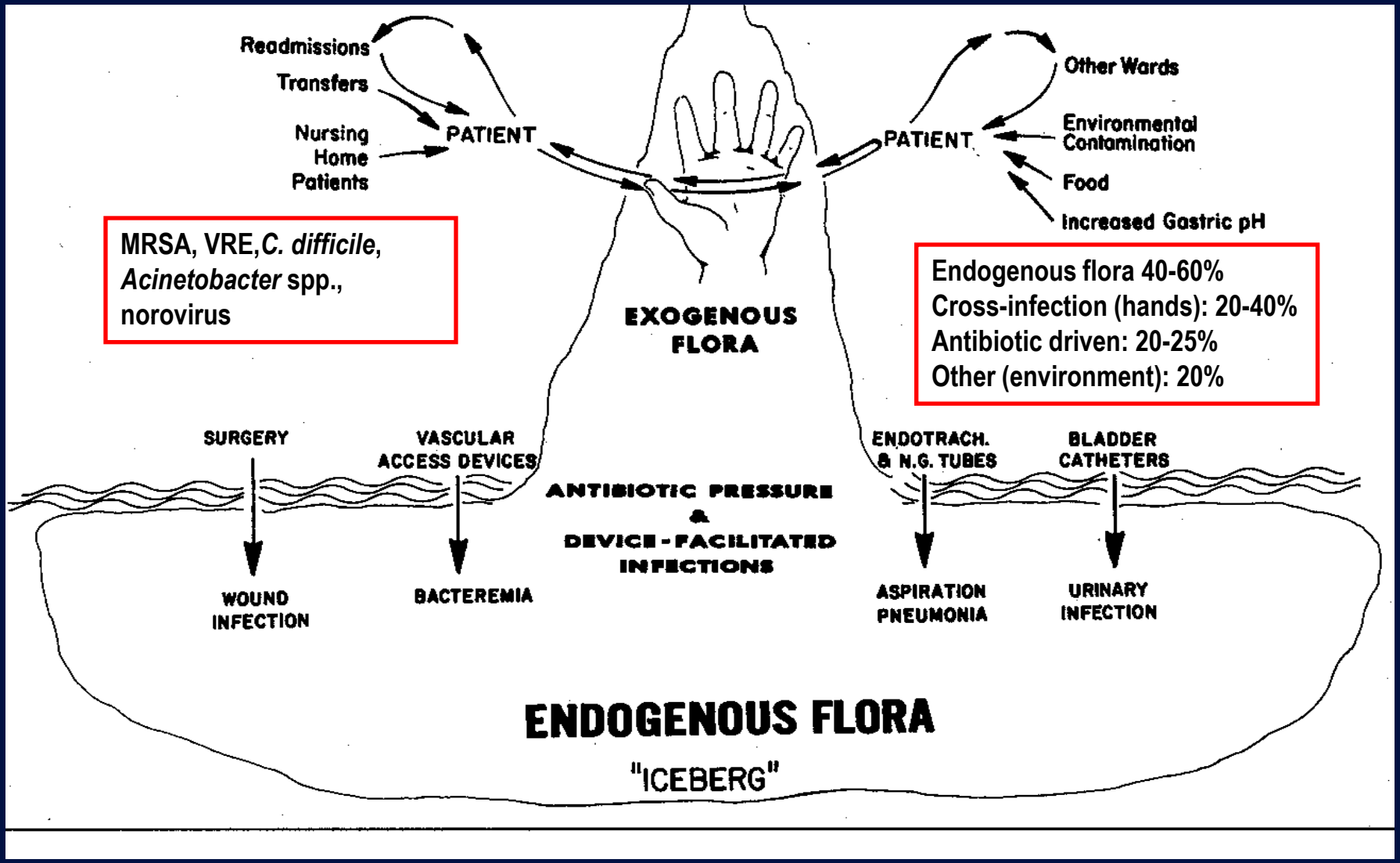
Decreasing Order of Resistance of Microorganisms to Disinfectants/Sterilants

Most Resistant

Most Susceptible

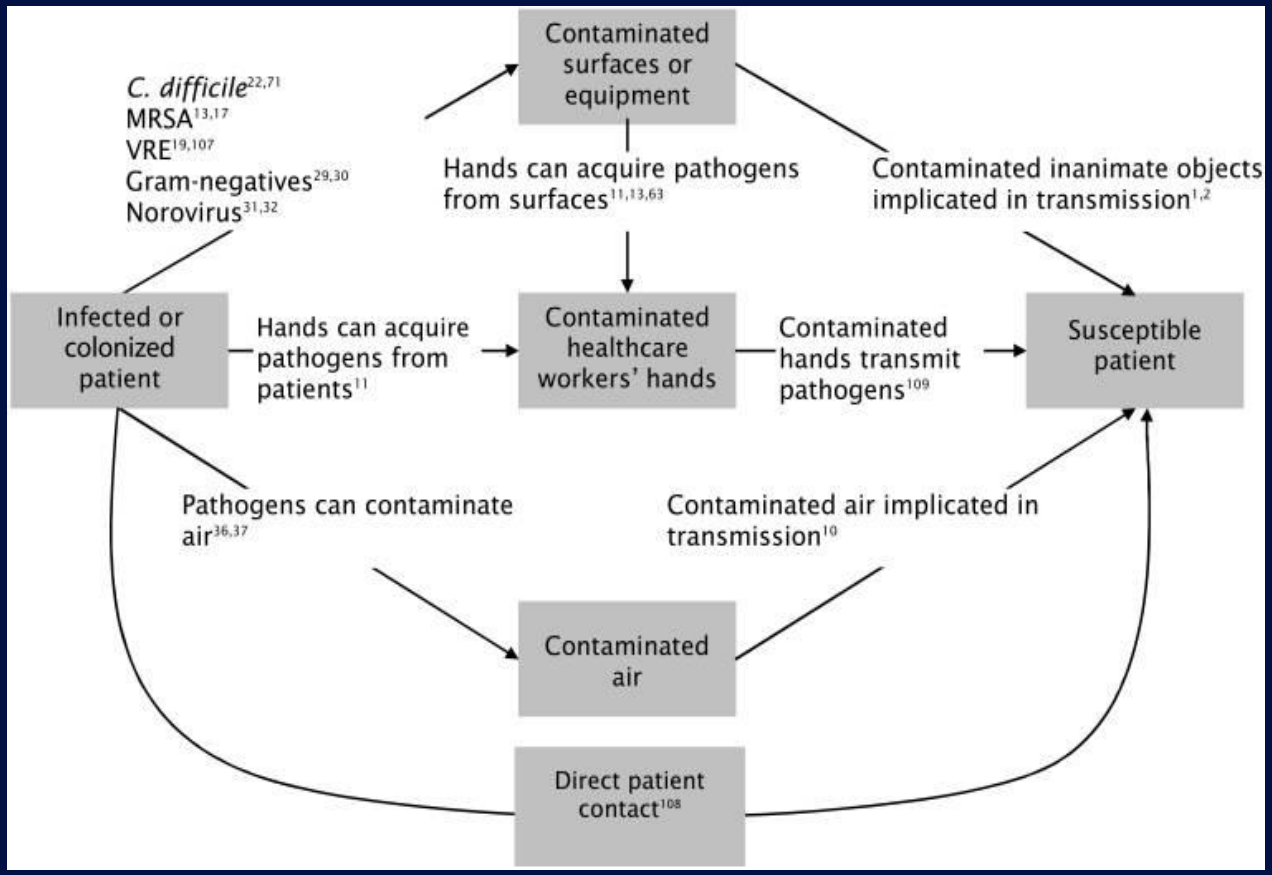
Prions
Bacterial spores (*C. difficile*)
Protozoal oocysts
Helminth eggs
Mycobacteria
Small, non-enveloped viruses (norovirus)
Protozoal cysts
Fungal spores
Gram-negative bacilli (*Acinetobacter*)
Vegetative fungi and algae
Large, non-enveloped viruses
Gram-positive bacteria (MRSA, VRE)
Enveloped viruses

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

EVIDENCE TO SUPPORT THE CONTRIBUTION OF THE ENVIRONMENT TO HAIs

- Microbial persistence in the environment
  - ***In vitro* studies and environmental samples**
  - **MRSA, VRE, *Acinetobacter*, *C. difficile,* norovirus**
- Frequent environmental contamination
  - **MRSA, VRE, *Acinetobacter*, *C. difficile,* norovirus**
- HCP hand contamination
  - **MRSA, VRE, *Acinetobacter*, *C. difficile***
- Relationship between level of environmental contamination and hand contamination
  - ***C. difficile***

EVIDENCE TO SUPPORT THE CONTRIBUTION OF THE ENVIRONMENT TO HAIs

- Person-to-person transmission
  - **Molecular link**
  - **MRSA, VRE, *Acinetobacter*, *C. difficile*, norovirus**
- Housing in a room previously occupied by a patient with the pathogen of interest is a risk factor for disease
  - **MRSA, VRE, *Acinetobacter*, *C. difficile***
- Improved surface cleaning/disinfection reduces disease incidence
  - **MRSA, VRE, *C. difficile***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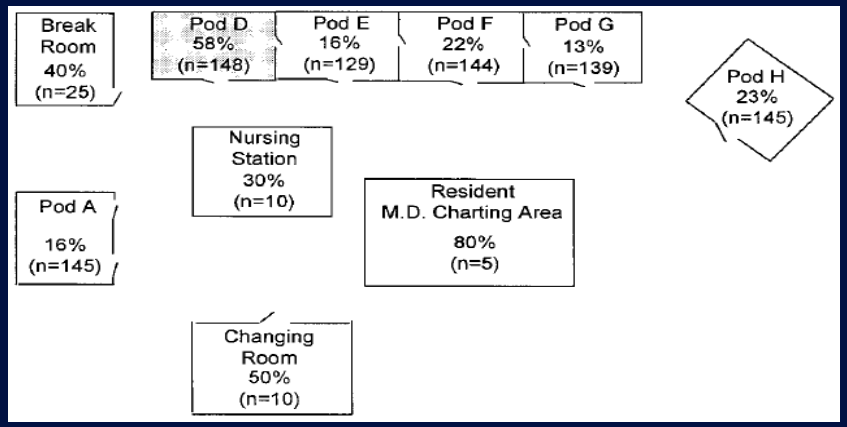
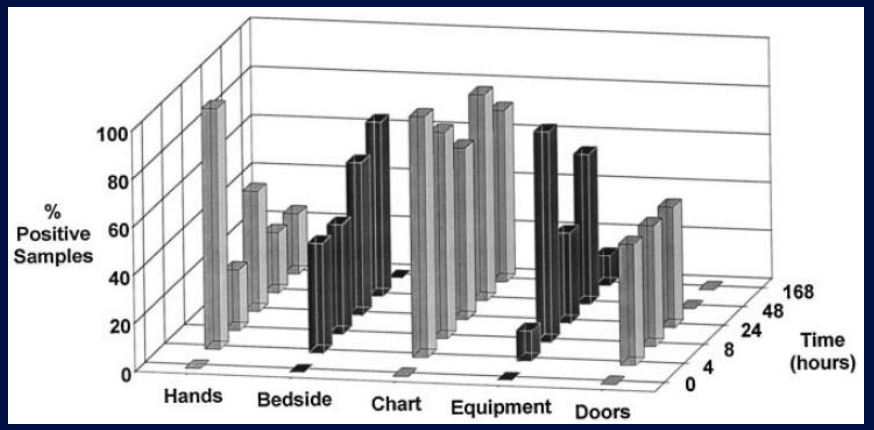
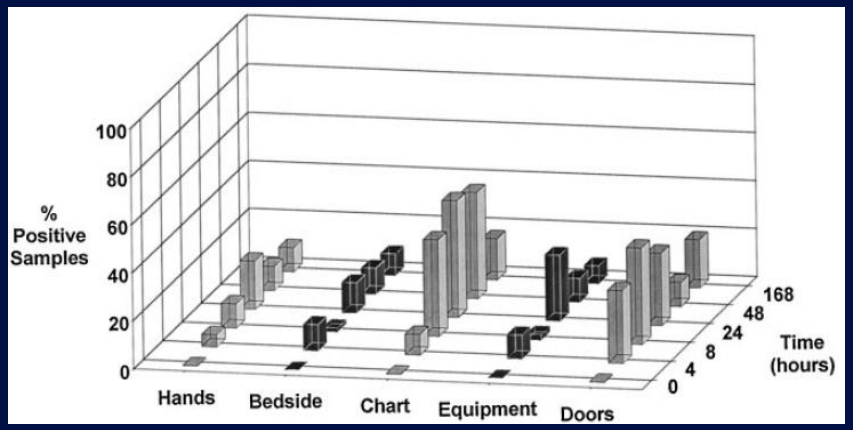
"The patient in the next bed is highly infectious. Thank God for these curtains."

DISPERSAL OF CAULIFLOWER DNA AFTER DEPOSITION ON TELEPHONE HANDLE, POD D

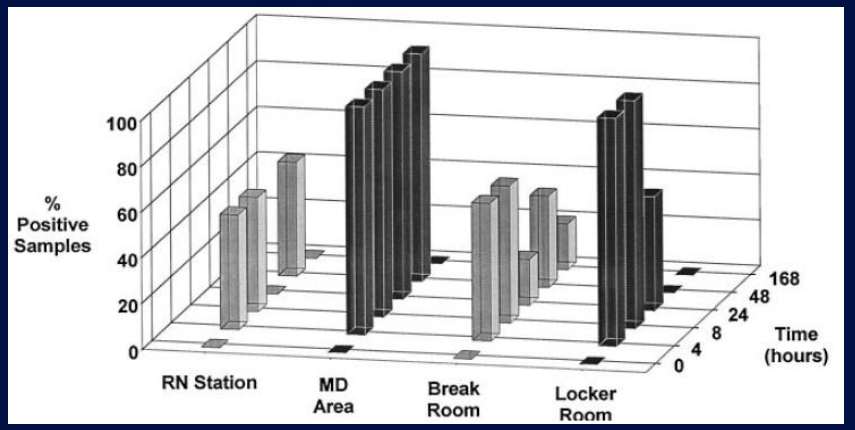


Pod D





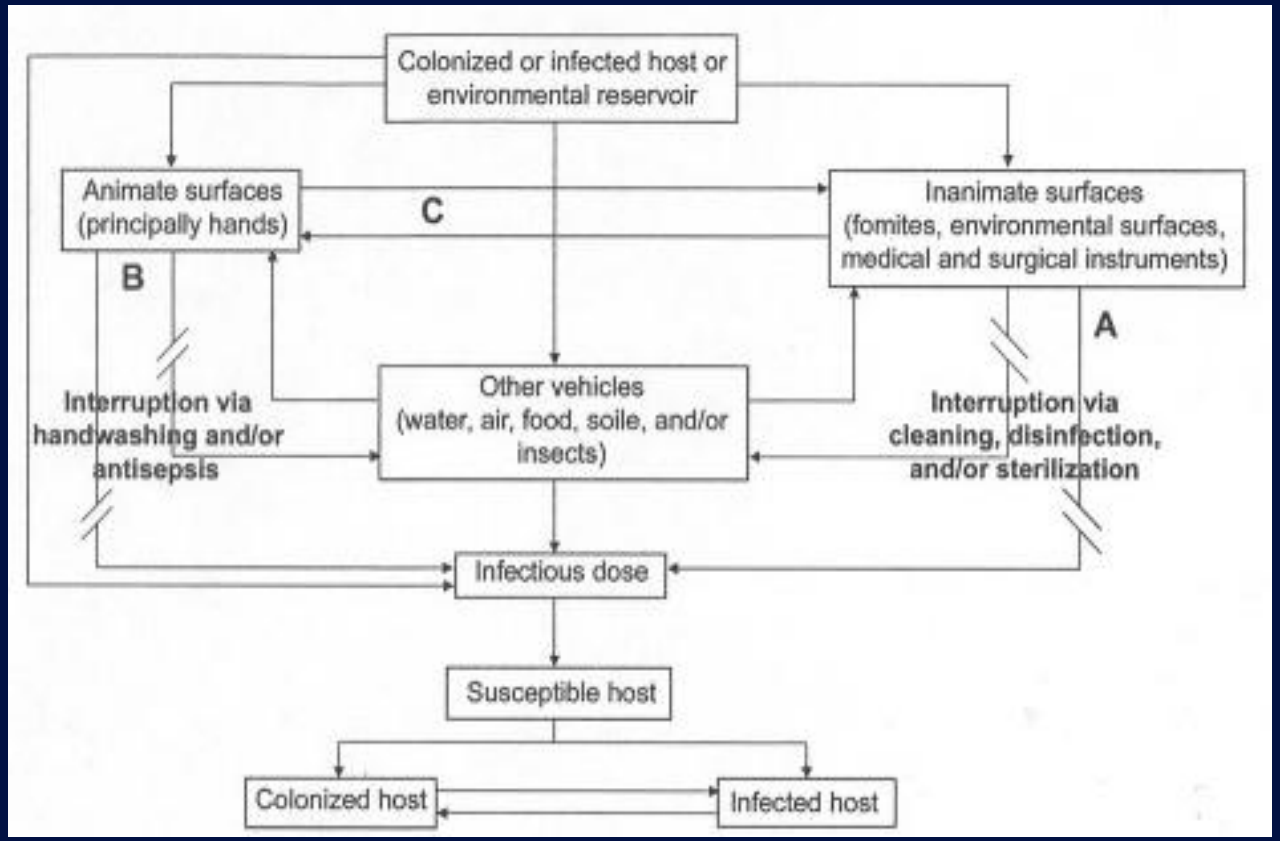
Pods A, E, F, G, H



Non-Patient Areas

Oelberg DG, et al. Pediatr 2000;105:311-15

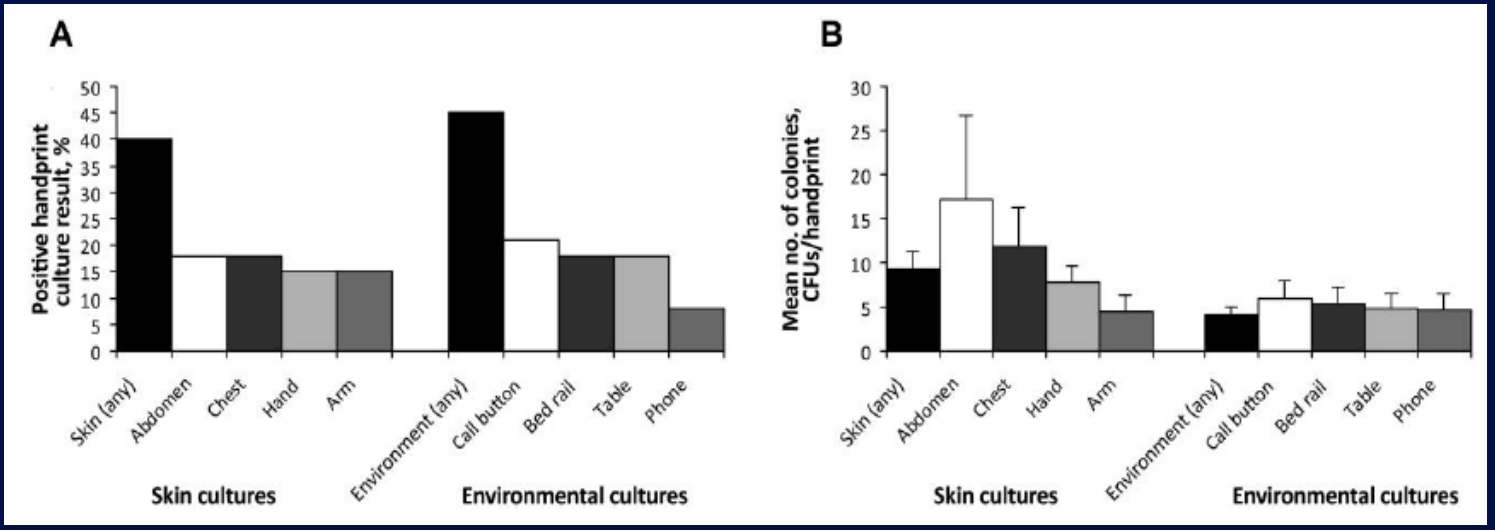
TRANSMISSION MECHANISMS INVOLVING THE SURFACE ENVIRONMENT



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

ROLE OF CONTAMINATED ENVIRONMENT IN CONTAMINATION OF HCP HANDS

- Design: Convenience sample of 40 patients with MRSA
- Methods: Gloved hands sampled
- Results: Hand contamination equally likely after contact with commonly examined skin sites vs commonly touched environmental surfaces (40% vs 45%)



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

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

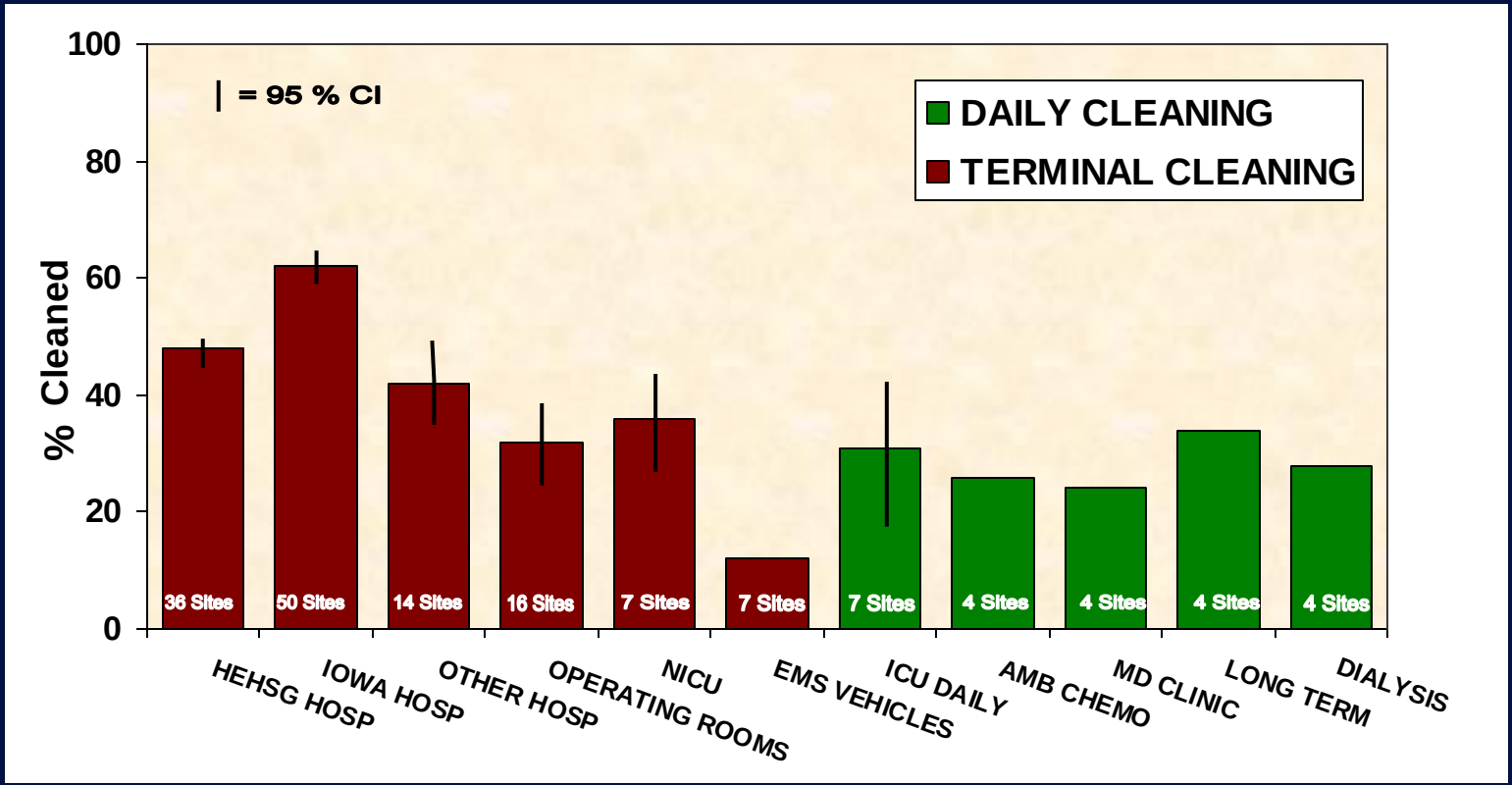
- Design: Prospective cohort in 6 ICUs
- Results
  - Frequency of contamination HCP gloves or gowns: MDR-*Acinetobacter* 32.9%, MDR-*P. aeruginosa* 17.4%, VRE 13.9%, MRSA 13.8%
  - PFGE determined that 91% of HCP isolates were related to an environmental or patient isolate

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

THROUGHNESS OF ROOM CLEANING



Carling P. 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 (In press)

LEVEL OF CONTAMINATION OF "HIGH, MEDIUM, AND LOW" TOUCH SURFACES

- Study: Microbial assessment of contamination of "high", "medium", and "low" touch surfaces
- Results
  - **No significant differences in microbial contamination of different surfaces**
  - **Terminal cleaning significantly reduced microbial contamination of all surfaces**

Surface (number of samples)	Prior to Cleaning: Mean CFU/Rodac (95% CI)	After Cleaning: Mean CFU/Rodac (95% CI)
High Touch (N=40)	71.9 (46.5, 97.3)	9.6 (3.8, 15.4)
Medium Touch (N=42)	44.2 (28,1, 60.2)	9.3 (1.2, 17.5)
Low Touch (N=37)	56.7 (34.2, 79.2)	5.7 (2.0, 9.4)

Huslage K, Rutala WA, Gergen M, Sickbert-Bennett E, Weber DJ. ICHE 2013;34:211-2

LOW-LEVEL DISINFECTION FOR NONCRITICAL EQUIPMENT AND SURFACES

Germicide	Exposure time ≥ 1 min 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%, 1.4%

UD=Manufacturer's recommended use dilution

* Limited or no activity against *C. difficile* **(Rutala W, Weber D, et al ICHE 2006)**

DISINFECTION OF NONCRITICAL PATIENT-CARE DEVICES

- Process noncritical patient-care devices using a disinfectant and concentration of germicide as recommended in the Guideline {IB}
- Disinfect noncritical medical devices (e.g., blood pressure cuff) with an EPA-registered hospital disinfectant using the label's safety precautions and use directions. Most EPA-registered hospital disinfectants have a label contact time of 10 minutes but multiple scientific studies have demonstrated the efficacy of hospital disinfectants against pathogens with a contact time of at least 1 minute {IB}
- Ensure that, at a minimum noncritical patient-care devices are disinfected when visibly soiled and on a regular basis (e.g., once daily or weekly) {II}
- If dedicated, disposable devices are not available, disinfect noncritical patient-care equipment after using is on a patient, who is on contact precautions before using this equipment on another patient {IB}

Rutala WA, Weber DJ. HICPAC Guideline.

CLEANING AND DISINFECTION OF ENVIRONMENTAL SURFACES IN HEALTHCARE FACILITIES - I

- Clean housekeeping surfaces (e.g., floors, tabletops) on a regular basis, when spills occur, and when these surfaces are visibly soiled {II}
- Disinfect (or clean) environmental surfaces on a regular basis (e.g., 3x per week) and when surfaces are visibly soiled {II}
- Follow manufacturers' instructions for proper use of disinfecting (or detergent) products – such as recommended use-dilution, material compatibility, storage, shelf-life, and safe use and disposal {II}
- Clean walls, blinds, and window curtains in patient-care areas when these surfaces are visibly contaminated or soiled {II}
- Prepare disinfecting (or detergent) solutions as needed and replace with fresh solution frequently (e.g., replace floor mopping solution every 3 patient rooms, change no less often than at 60-minute intervals) {IB}

CLEANING AND DISINFECTION OF ENVIRONMENTAL SURFACES IN HEALTHCARE FACILITIES - II

- Decontaminate mop heads and cleaning cloths regularly to prevent contamination (e.g., launder and dry at least daily) {II}
- Use a one-step process and EPA-registered hospital disinfectant designed for housekeeping purposes in patient care areas where 1) uncertainty exists about the nature of the soil on the surfaces (e.g., blood versus routine dust or dirt); or 2) uncertainty exists about the presence of multidrug resistant organisms on such surfaces {II}
- Detergent and water are adequate for cleaning surfaces in non-patient areas (e.g., administrative offices) {II}
- Do NOT use high-level disinfectants/liquid chemical sterilants for disinfection of non-critical surfaces {IB}

CLEANING AND DISINFECTION OF ENVIRONMENTAL SURFACES IN HEALTHCARE FACILITIES - III

- Wet-dust horizontal surfaces regularly (e.g., daily, 3x per week) using clean cloths moistened with an EPA-registered hospital disinfectant (or detergent). Prepare the disinfectant (or detergent) as recommended by the manufacturer {II}
- Disinfect noncritical surfaces with an EPA-registered hospital disinfectant according to the label's safety precautions and use directions. Most EPA-registered hospital disinfectants have a label contact time of 10 minutes but multiple scientific studies have demonstrated the efficacy of hospital disinfectants against pathogens with a contact time of at least 1 minute {IB}
- Do not use disinfectants to clean infant bassinets and incubators while these items are occupied. If disinfectants (e.g., phenolics) are used for the terminal cleaning of infant bassinets and incubators, thoroughly rinse the surfaces of these items with water and dry them before use {IB}

CLEANING AND DISINFECTION OF ENVIRONMENTAL SURFACES IN HEALTHCARE FACILITIES - IV

- Promptly clean and decontaminate spills of blood and other potentially infectious materials. Discard blood-contaminated items in compliance with local regulations {IB}
- For site decontamination of spills of blood or other potentially infectious materials implement the following: Use protective gloves and other PPE (e.g., forceps to pick up sharps) appropriate for this task. Disinfect contaminated areas with an EPA-registered tuberculocidal agent, a registered germicide on the EPA Lists D and E (claim against HIV or HBV), or a freshly diluted hypochlorite solution (e.g., 1:100 dilution of 5.25-6.15% sodium hypochlorite for small spills, <10mL; for large spills, >10 mL or a culture spill in the laboratory, use a 1:10 dilution for the first application of hypochlorite solution BEFORE cleaning to reduce the risk of infection during the cleaning process if a sharp injury occurs). Follow with a terminal disinfection, using 1:100 dilution of sodium hypochlorite {IB}

CLEANING AND DISINFECTION OF ENVIRONMENTAL SURFACES IN HEALTHCARE FACILITIES - V

- If a spill contains large amounts of blood or body fluids, clean the visible matter with disposable absorbent material, and discard the contaminated materials in appropriate, labeled container {II}
- Use protective gloves and other PPE appropriate to the task {II}
- In units with high rates of endemic *C. difficile* infection or in outbreak setting, use dilute solutions of 5.25-6.15% sodium hypochlorite (e.g., 1:10 dilution of household bleach) for routine environmental disinfection (II}
  - Or use an EPA-registered agent with activity against *C. difficile*
- If chlorine solution is not prepared fresh daily, it can be stored at room temperature for up to 30 days in capped, opaque plastic bottle with a 50% reduction in chlorine concentration after 30 days of storage {IB}
- An EPA-registered sodium hypochlorite product is preferred but is such products are not available, generic versions (household bleach) can be used (II}

BEST PRACTICES FOR ROOM DISINFECTION USING STANDARD GERMICIDES

- Follow the CDC Guideline for Disinfection and Sterilization with regard to choosing an appropriate germicide and best practices for environmental disinfection
- Appropriately train environmental service workers on proper use of PPE and clean/disinfection of the environment
- Have environmental service workers use checklists to ensure all room surfaces are cleaned/disinfected
- Assure that nursing and environmental service have agreed what items (e.g., sensitive equipment) is to be clean/disinfected by nursing and what items (e.g., environmental surfaces) are to be cleaned/disinfected by environmental service workers
- Use a method (e.g., fluorescent dye) to ensure proper cleaning

Surface Disinfection

Effectiveness of Different Methods

Practice NOT Product

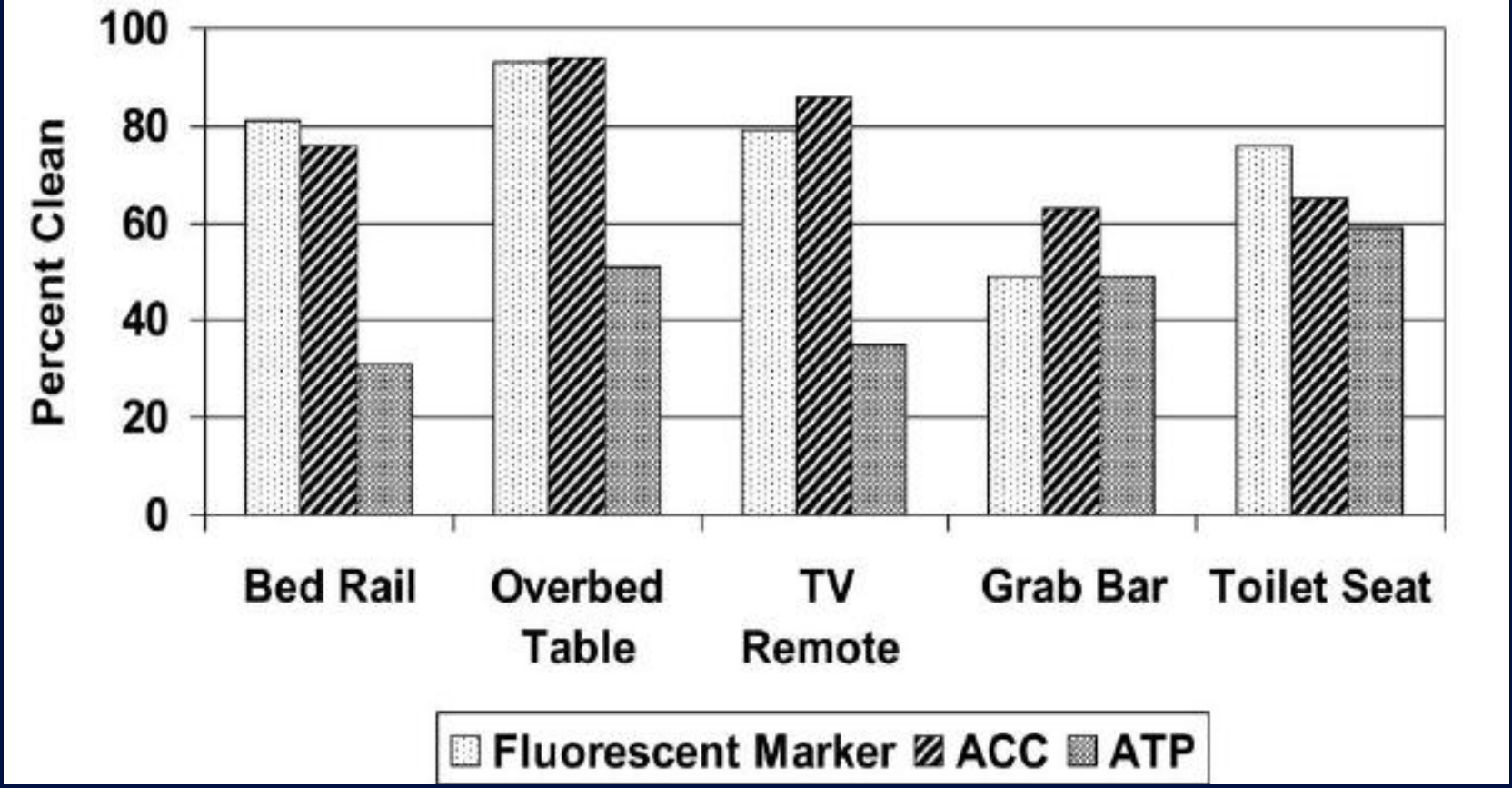
Technique (with cotton)	MRSA Log_{10} Reduction (QUAT)
Saturated cloth	4.41
Spray (10s) and wipe	4.41
Spray, wipe, spray (1m), wipe	4.41
Spray	4.41
Spray, wipe, spray (until dry)	4.41
Disposable wipe with QUAT	4.55
Control: detergent	2.88

Rutala WA, Gergen MF, Weber DJ. ICHE 2012;33:1255-1258

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

COMPARISON OF DIFFERENT METHODS OF ASSESSING TERMINAL ROOM CLEANING PRACTICES

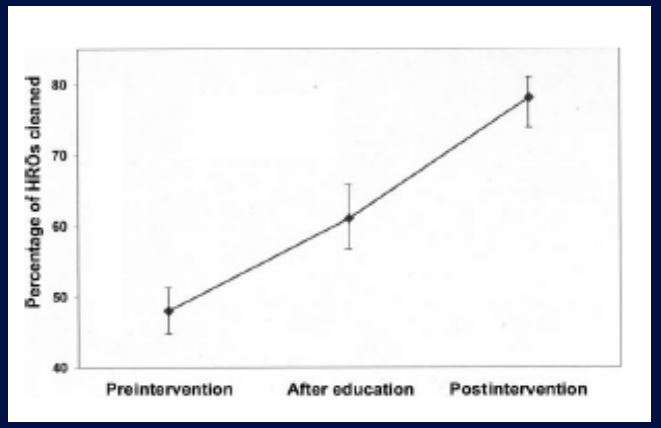


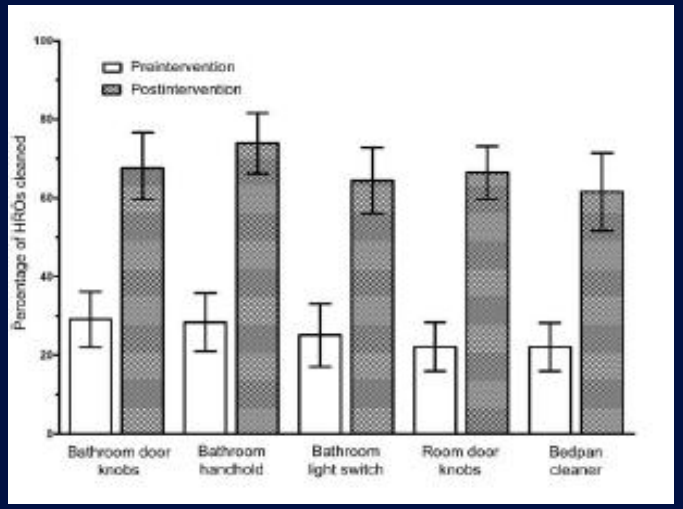
ACC, aerobic colony count; ATP, adenosine triphosphase Boyce JM, et al. ICHE 2011;32:1187

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





TECHNOLOGIES TO IMPROVE DISINFECTION OF ENVIRONMENTAL SURFACES

- New surface disinfectants
  - **Improved hydrogen peroxide**
  - **Electrochemically activated saline solution**
- "No touch" terminal disinfection
  - **UV light: 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**

LOW-LEVEL DISINFECTION FOR NONCRITICAL EQUIPMENT AND SURFACES

Germicide	Exposure time ≥ 1 min 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%, 1.4%

UD=Manufacturer's recommended use dilution

* Limited or no activity against *C. difficile* **(Rutala W, Weber D, et al ICHE 2006)**

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

CONTAMINATION OF HOSPITAL CURTAINS

42% of privacy curtains contaminated with VRE, 22% MRSA and 4% *C. difficile*

FIGURE. Rates of recovery of healthcare-associated pathogens from 50 hospital privacy curtains by 3 culture methods. For methicillin-resistant *Staphylococcus aureus* (MRSA), broth enrichment cultures were not performed. For *Clostridium difficile*, direct plating cultures were not performed. VRE, vancomycin-resistant enterococci.

Trillis et al. 2008. ICHE 29:1074

Decontamination of Curtains with Improved HP

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* (0)	98.5%

* All isolates after disinfection were *Bacillus sp*

Rutala, Gergen, Weber. 2012

UV ROOM DECONTAMINATION: ADVANTAGES AND DISADVANTAGES

- Advantages
  - Reliable biocidal activity against a wide range of pathogens
  - Surfaces and equipment decontaminated
  - Room decontamination is rapid (~25 min) for vegetative bacteria
  - HVAC system does not need to be disabled and room does not need to be sealed
  - UV is residual free and does not give rise to health and safety concerns
  - No consumable products so operating costs are low (key cost = acquisition)
- Disadvantages
  - No studies evaluating whether use reduces HAIs
  - Can only be done for terminal disinfection (i.e., not daily cleaning)
  - All patients and staff must be removed from room
  - Substantial capital equipment costs
  - Does not remove dust and stains which are important to patients/visitors
  - Sensitive use parameters (e.g., UV dose delivered)

Rutala WA, Weber DJ. ICHE 2011;32:743-747

HP ROOM DECONTAMINATION: ADVANTAGES AND DISADVANTAGES

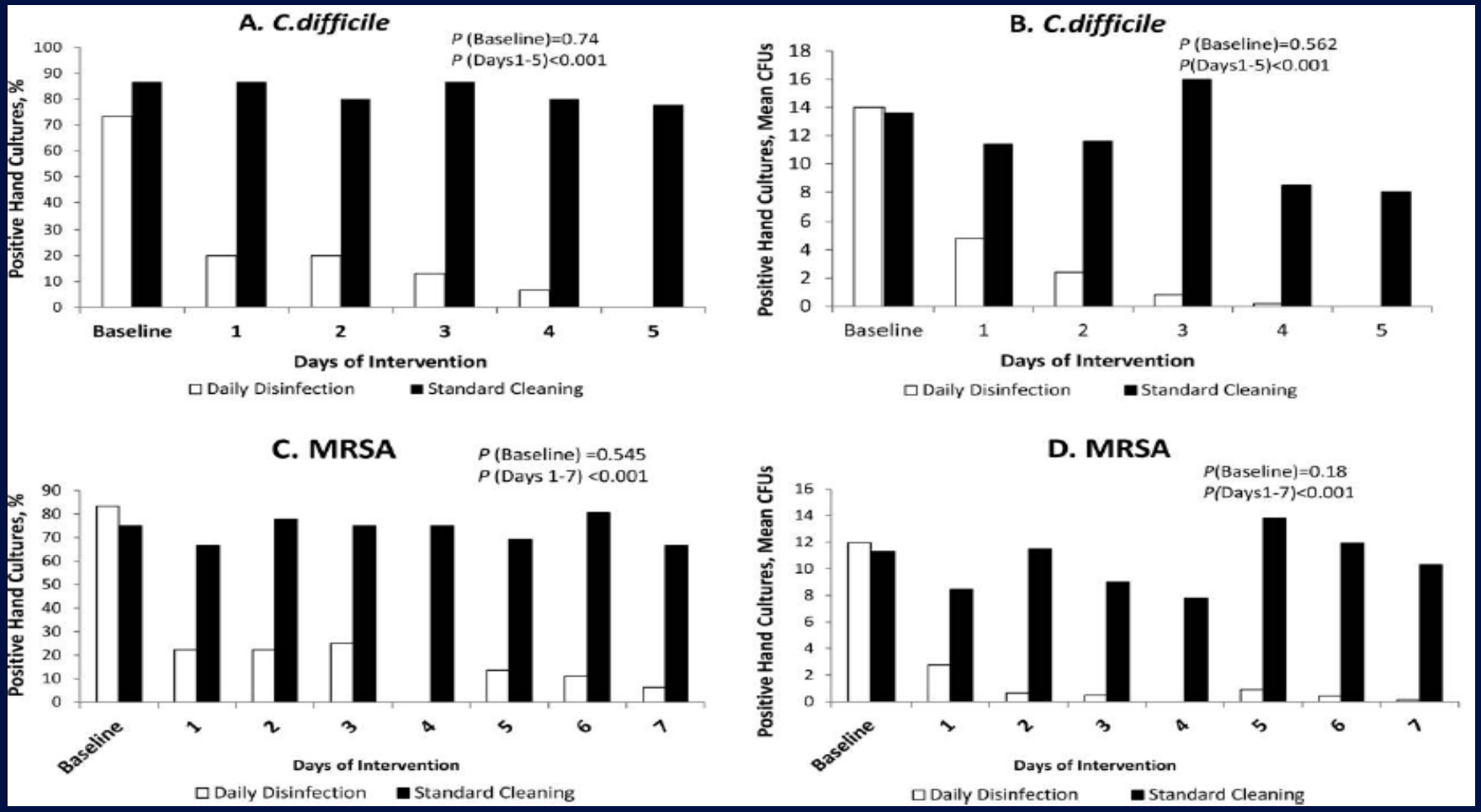
- Advantages
  - Reliable biocidal activity against a wide range of pathogens
  - Surfaces and equipment decontaminated
  - Demonstrated to decrease disease *C. difficile* incidence and MDRO acquisition
  - Residual free and does not give rise to health and safety concerns (aeration units convert HPV into oxygen and water)
  - Useful for disinfecting complex equipment and furniture
  - Does not require direct or indirect line of sight
- Disadvantages
  - Can only be done for terminal disinfection (i.e., not daily cleaning)
  - All patients and staff must be removed from room
  - Decontamination takes approximately 3-5 hours
  - HVAC system must be disabled and the room sealed with tape
  - Substantial capital equipment costs
  - Does not remove dust and stains which are important to patients/visitors
  - Sensitive use parameters (e.g., HP concentration)

Rutala WA, Weber DJ. ICHE (In press)

RATIONALE FOR DEVELOPMENT OF SELF DISINFECTING SURFACES

- Unlike improved environmental cleaning does not require a ongoing behavior change or education of personnel
- Self-sustaining once in place
- Allows continued disinfection (may eliminate the problem of recontamination), unlike no touch methods which can only be used for terminal disinfection
- Most hospital surfaces have a low bioburden of pathogens (i.e., <100 per cm^2)
- Once purchased might not have a maintenance cost

EFFECT OF DAILY CLEANING VERSUS ONLY WHEN SOILED ON CONTAMINATION OF HCP HANDS

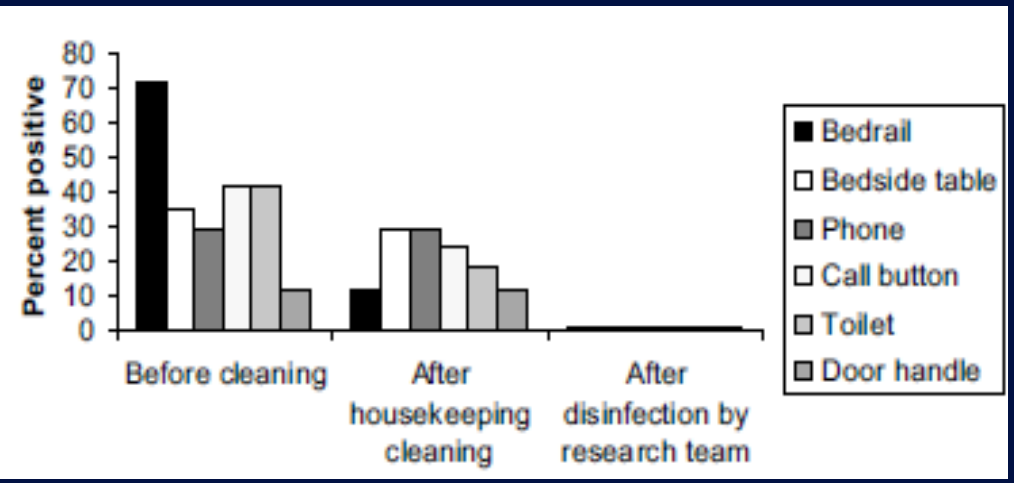


Kundrapu S, et al. ICHE 2012;33:1039-1042

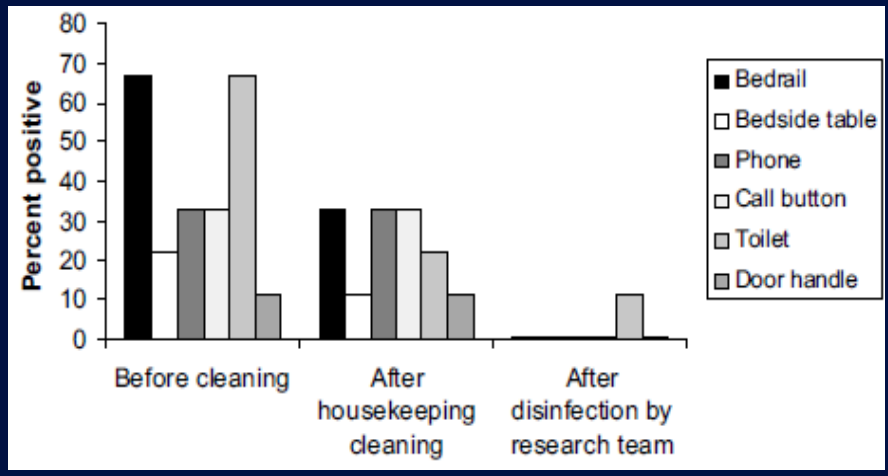
IMPROVING ROOM CLEANING: PRACTICE NOT PRODUCT

- 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



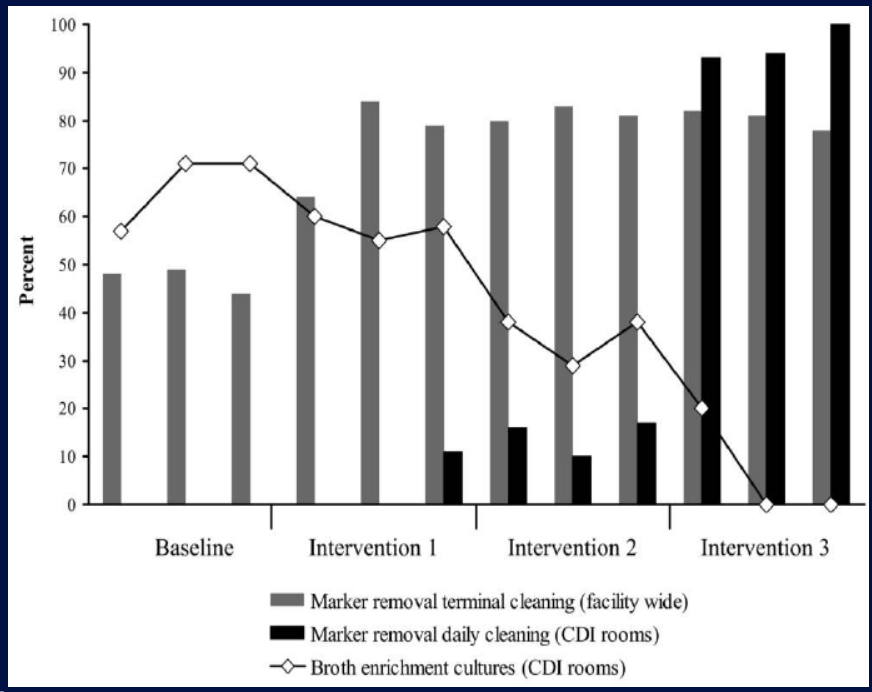
C. difficile



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

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

- The contaminated surface environment in hospital rooms is important in the transmission of healthcare-associated pathogens (MRSA, VRE, *C. difficile*, *Acinetobacter*)
- Potential methods of reducing transmission of these pathogens include: improved room cleaning/disinfection, “no-touch” methods, and ‘self-disinfecting” surfaces
- The efficacy of “no-touch” methods (HPV) to reduce HAIs (*C. difficile* incidence and MDRO acquisition) has now been demonstrated in a few studies
- Further research is warranted to further validate the reduction in HAIs
- Comparative cost effectiveness analysis of new technologies is warranted

THANK YOU!!