Advanced technologies in environmental disinfection: how useful for MDRO control?

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Objectives

- Describe the role of hospital environment in infection prevention
- Discuss inclusion of enhanced decontamination in infection prevention bundles
- Describe challenges in current practice for environmental decontamination
- Discuss novel technologies for terminal cleaning and potential usefulness in today's healthcare environment

Colonization Versus Disease and Transmission

Pathogens:

- Leave original host
- Survive in transit
- Be delivered to a susceptible host — **Transmission**
- Reach a susceptible part of the host
- Escape host defenses — **Colonization**
- Multiply and cause tissue damage — **Disease**

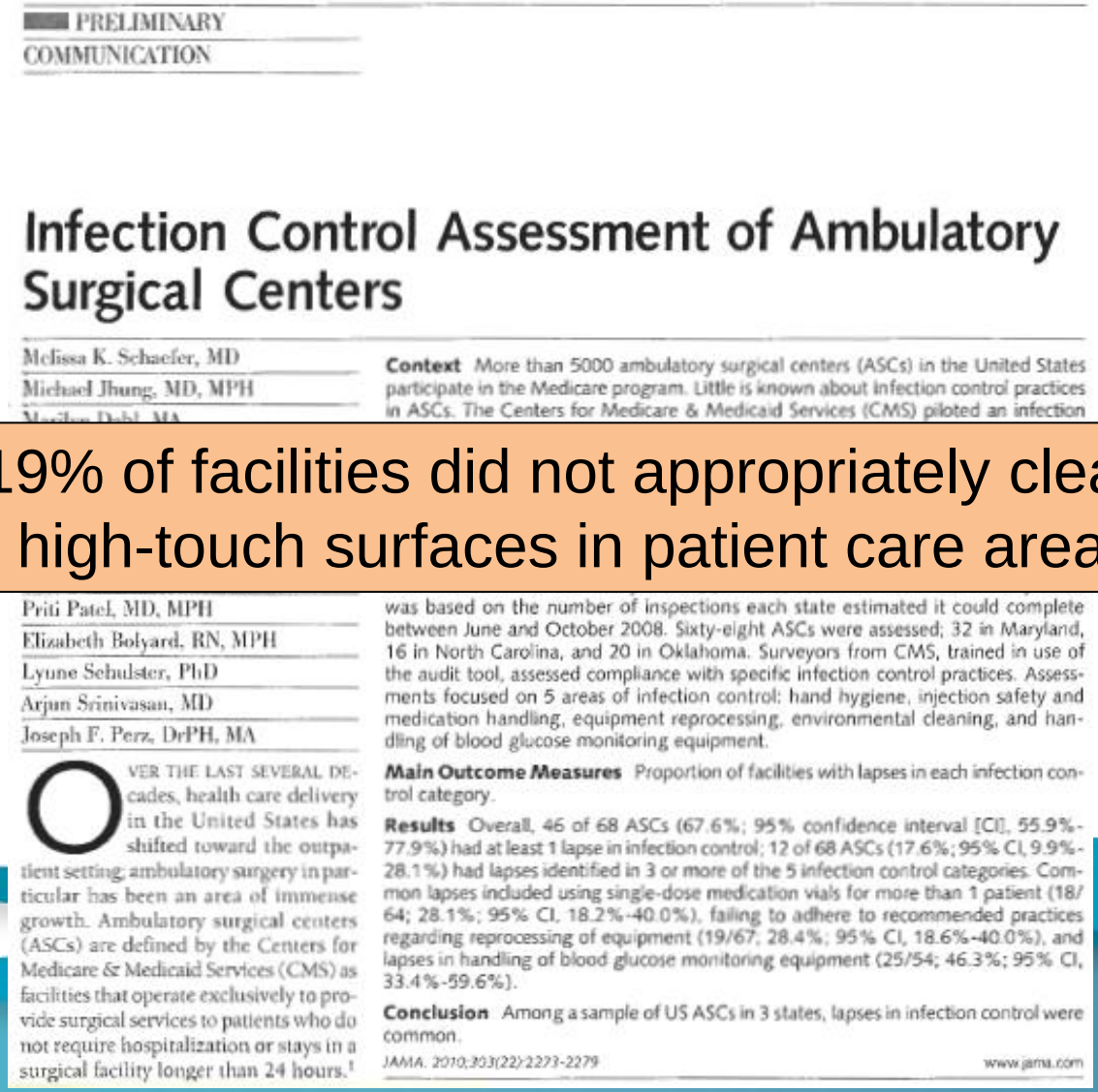
Potential Importance of Environmental Surfaces in Transmission of Nosocomial Pathogens

- Organisms may survive for long periods of time on nonporous surfaces
- Healthcare workers (HCWs) frequently do not wash hands after contact with patients and/or surfaces without direct patient contact
- Room cleaning is frequently sub optimal

The Case for Environmental Hygiene

- Previously contaminated rooms increase transmission risk
- Many patient rooms not well cleaned
- Cleaning process can be improved in most organizations
- Improved cleaning decreases environmental contamination
- Improved cleaning decreases acquisition of pathogens

Schaefer MK, et al. JAMA. 2010;303(22):2273-2279.



PRELIMINARY COMMUNICATION

Infection Control Assessment of Ambulatory Surgical Centers

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Context More than 5000 ambulatory surgical centers (ASCs) in the United States participate in the Medicare program. Little is known about infection control practices in ASCs. The Centers for Medicare & Medicaid Services (CMS) piloted an infection control assessment tool.

Objective To assess infection control practices in ASCs.

Design, Setting, and Participants Cross-sectional assessment of ASCs in 3 states. Selection was based on the number of inspections each state estimated it could complete between June and October 2008. Sixty-eight ASCs were assessed; 32 in Maryland, 16 in North Carolina, and 20 in Oklahoma. Surveyors from CMS, trained in use of the audit tool, assessed compliance with specific infection control practices. Assessments focused on 5 areas of infection control: hand hygiene, injection safety and medication handling, equipment reprocessing, environmental cleaning, and handling of blood glucose monitoring equipment.

Main Outcome Measures Proportion of facilities with lapses in each infection control category.

Results Overall, 46 of 68 ASCs (67.6%; 95% confidence interval [CI], 55.9%-77.9%) had at least 1 lapse in infection control; 12 of 68 ASCs (17.6%; 95% CI, 9.9%-28.1%) had lapses identified in 3 or more of the 5 infection control categories. Common lapses included using single-dose medication vials for more than 1 patient (18/64; 28.1%; 95% CI, 18.2%-40.0%), failing to adhere to recommended practices regarding reprocessing of equipment (19/67; 28.4%; 95% CI, 18.6%-40.0%), and lapses in handling of blood glucose monitoring equipment (25/54; 46.3%; 95% CI, 33.4%-59.6%).

Conclusion Among a sample of US ASCs in 3 states, lapses in infection control were common.

JAMA. 2010;303(22):2273-2279 www.jama.com

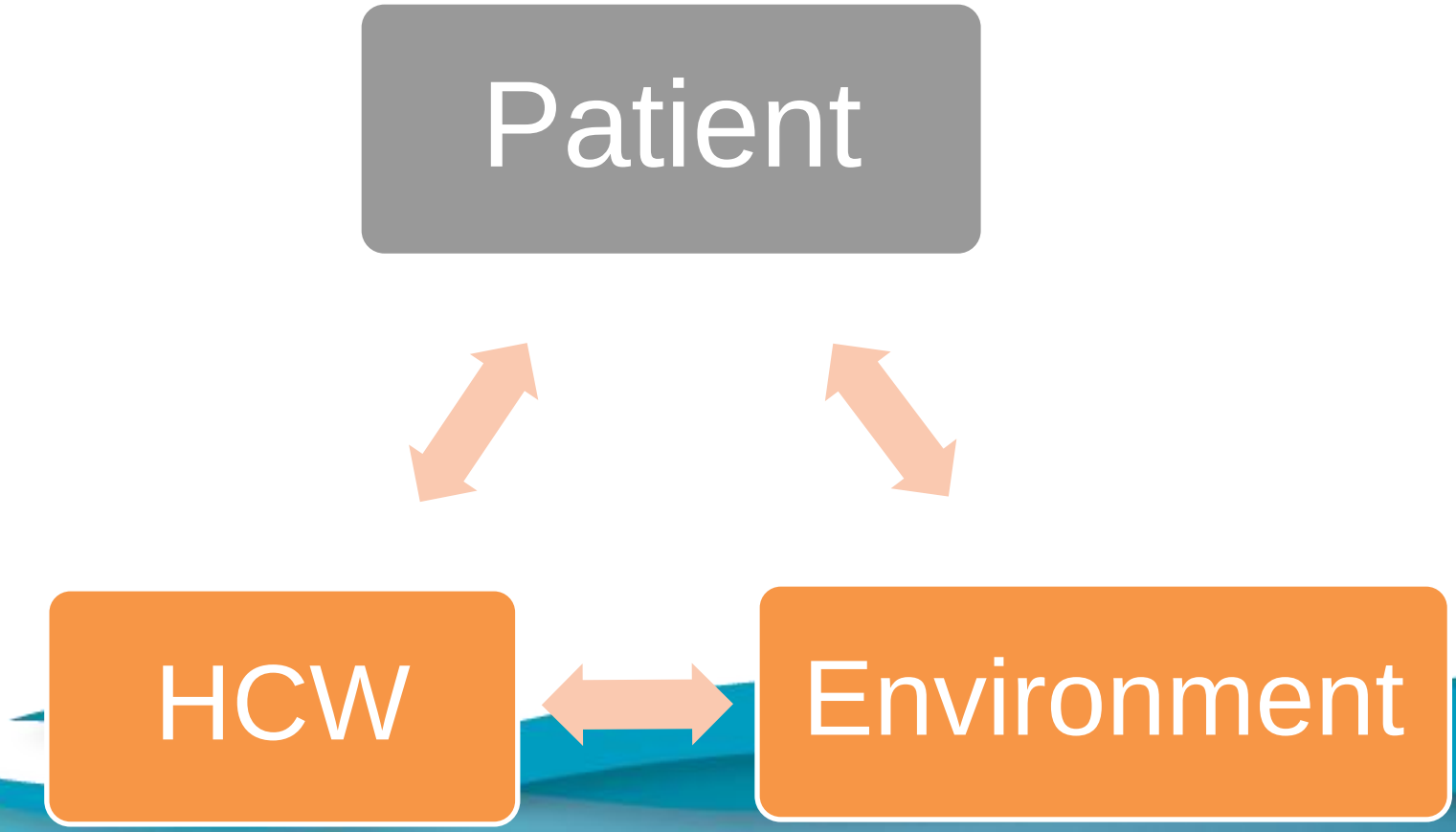
OVER THE LAST SEVERAL DECADES, health care delivery in the United States has shifted toward the outpatient setting; ambulatory surgery in particular has been an area of immense growth. Ambulatory surgical centers (ASCs) are defined by the Centers for Medicare & Medicaid Services (CMS) as facilities that operate exclusively to provide surgical services to patients who do not require hospitalization or stays in a surgical facility longer than 24 hours.[1]

19% of facilities did not appropriately clean high-touch surfaces in patient care areas

The Inanimate Environment Can Facilitate Transmission

Hayden M, et al. Poster presented at the 41st Interscience Conference on Antimicrobial Agents and Chemotherapy December 16-19, Chicago, IL. Available at: http://www.cdc.gov/handhygiene/download/hand_hygiene_supplement_minus_notes.pdf

Contaminated Environments: Key Elements



“I just touched the bed rail…”

100-1,000 bacteria transferred by:

- Pulling patients up in bed
- Taking a blood pressure or pulse
- Touching a patient’s hand
- Rolling patients over in bed
- Touching patient’s gown or bed sheets
- Touching equipment like bedside rails, over-bed tables, IV pumps

53% of HCWs Hand Imprint Cultures + After Occupied Room vs 24% of Clean Empty Rooms

Acquisition of Nosocomial Pathogens on Hands After Contact With Environmental Surfaces Near Hospitalized Patients

Anita Bhalla, MD; Nicole J. Pultz, BS; Delores M. Gries, MD; Amy J. Ray, MD; Elizabeth C. Eckstein, RN; David C. Aron, MD; Curtis J. Donskey, MD

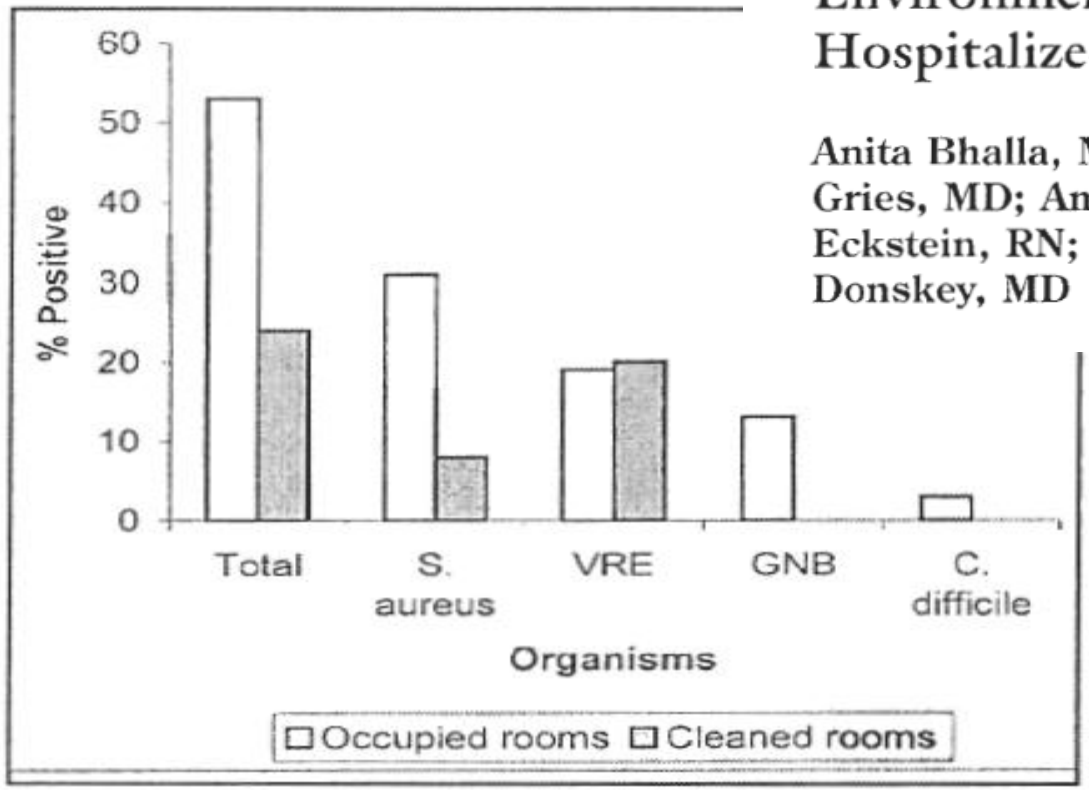
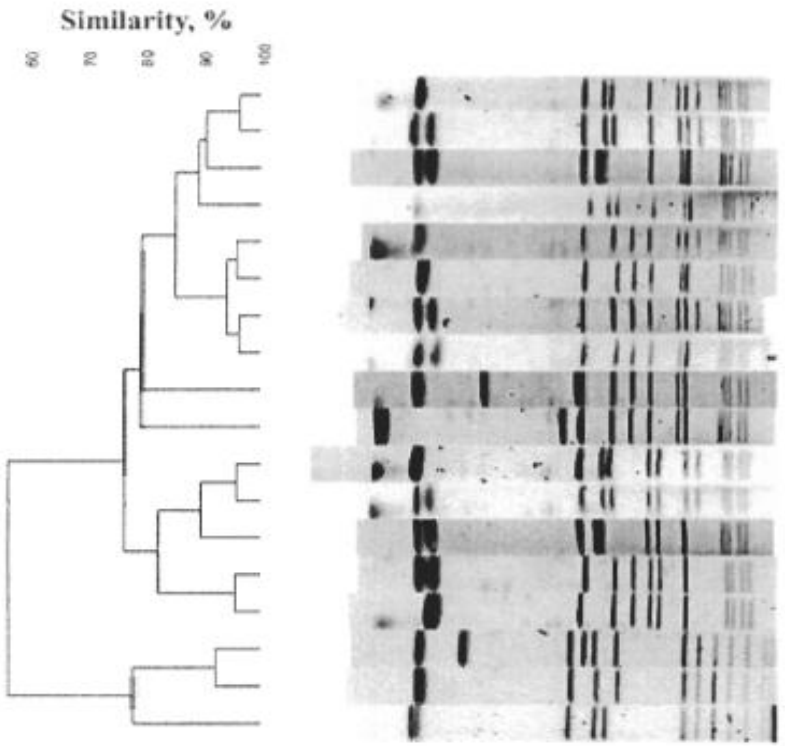


FIGURE. Percentage of hand imprint cultures yielding pathogens after contact with environmental surfaces near patients in occupied patient rooms or in rooms that had been cleaned after patient discharge. VRE = vancomycin-resistant *Enterococcus*; GNB = gram-negative bacillus.

Bhalla A, et al. *Infect Control Hosp Epidemiol.* 2004;25(2):164-167.

35.7% of MRSA Strains From ICU Patients Indistinguishable From Immediate Environment

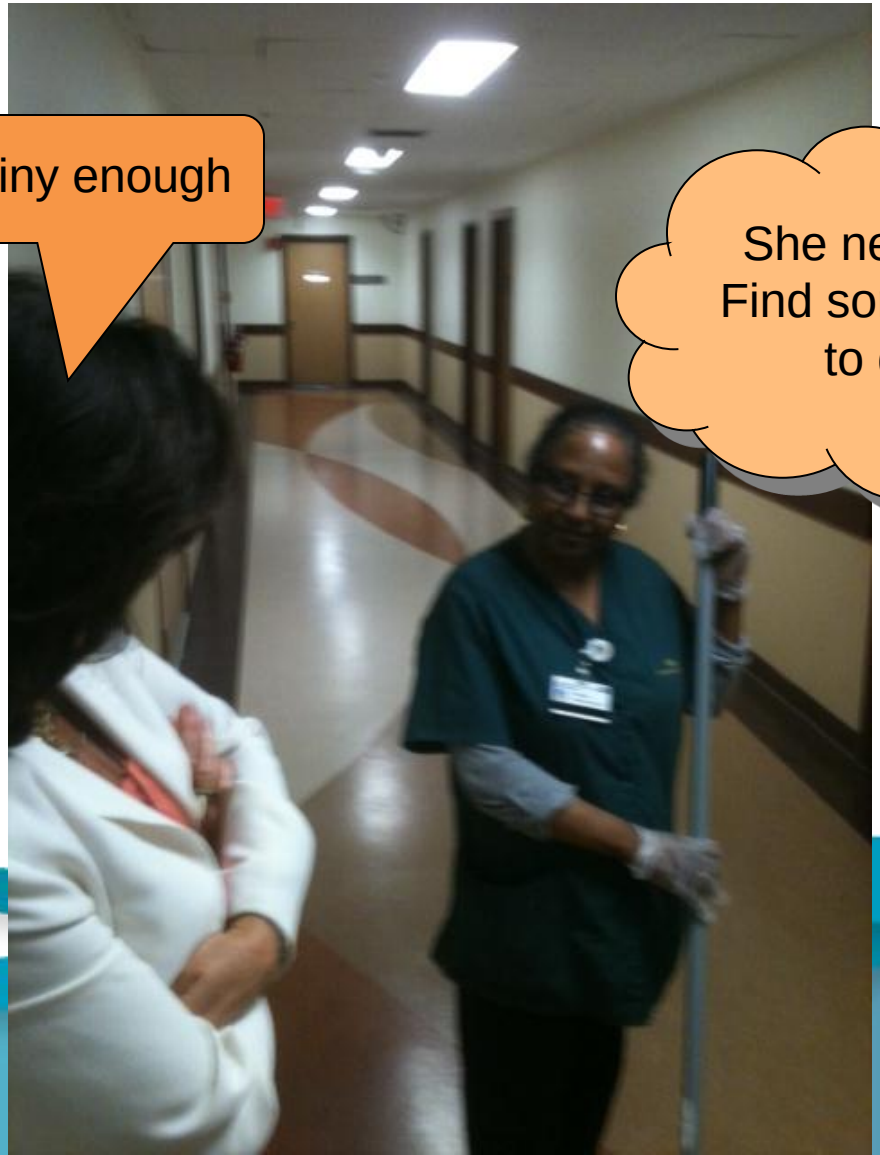


Designated PFGE Profile	Number of environmental screenings detected	Number of patients colonized with strain
I	11	7
J	14	6
L	1	2
U	0	1
N	5	4
M	2	0
O	11	17
P	11	8
Y	2	0
X	1	0
F	1	0
H	1	0
Z	0	1
D	7	5
E	8	0
W	1	0
B	4	6
T	1	1

FIGURE 1. Pulsed-field gel electrophoresis (PFGE) profiles of methicillin-resistant *Staphylococcus aureus* isolated from the environment, the number of environmental screenings during which each of the different PFGE profiles was identified, and the correlation with PFGE profiles of strains colonizing patients.

Hardy KJ, et al. *Infect Control Hosp Epidemiol*. 2006;27(2):127-132.

It’s Not Just About Shiny Floors



Review Terminal Room Cleaning Practice Expectations

CDC Environmental Checklist for Monitoring Terminal Cleaning[1]

Date:	
Unit:	
Room Number:	
Initials of ES staff (optional):[2]	

Evaluate the following priority sites for each patient room:

High-touch Room Surfaces[3]	Cleaned	Not Cleaned	Not Present in Room
Bed rails / controls			
Tray table			
IV pole (grab area)			
Call box / button			
Telephone			
Bedside table handle			
Chair			
Room sink			
Room light switch			
Room inner door knob			
Bathroom inner door knob / plate			
Bathroom light switch			
Bathroom handrails by toilet			
Bathroom sink			
Toilet seat			
Toilet flush handle			
Toilet bedpan cleaner			

Evaluate the following additional sites if these equipment are present in the room:

High-touch Room Surfaces[3]	Cleaned	Not Cleaned	Not Present in Room
IV pump control			
Multi-module monitor controls			
Multi-module monitor touch screen			
Multi-module monitor cables			
Ventilator control panel			

Mark the monitoring method used:

☐ Direct observation ☐ Fluorescent gel
☐ Swab cultures ☐ ATP system ☐ Agar slide cultures

[1]Selection of detergents and disinfectants should be according to institutional policies and procedures
[2]Hospitals may choose to include identifiers of individual environmental services staff for feedback purposes.
[3]Sites most frequently contaminated and touched by patients and/or healthcare workers

National Center for Emerging and Zoonotic Infectious Diseases
Division of Healthcare Quality Promotion

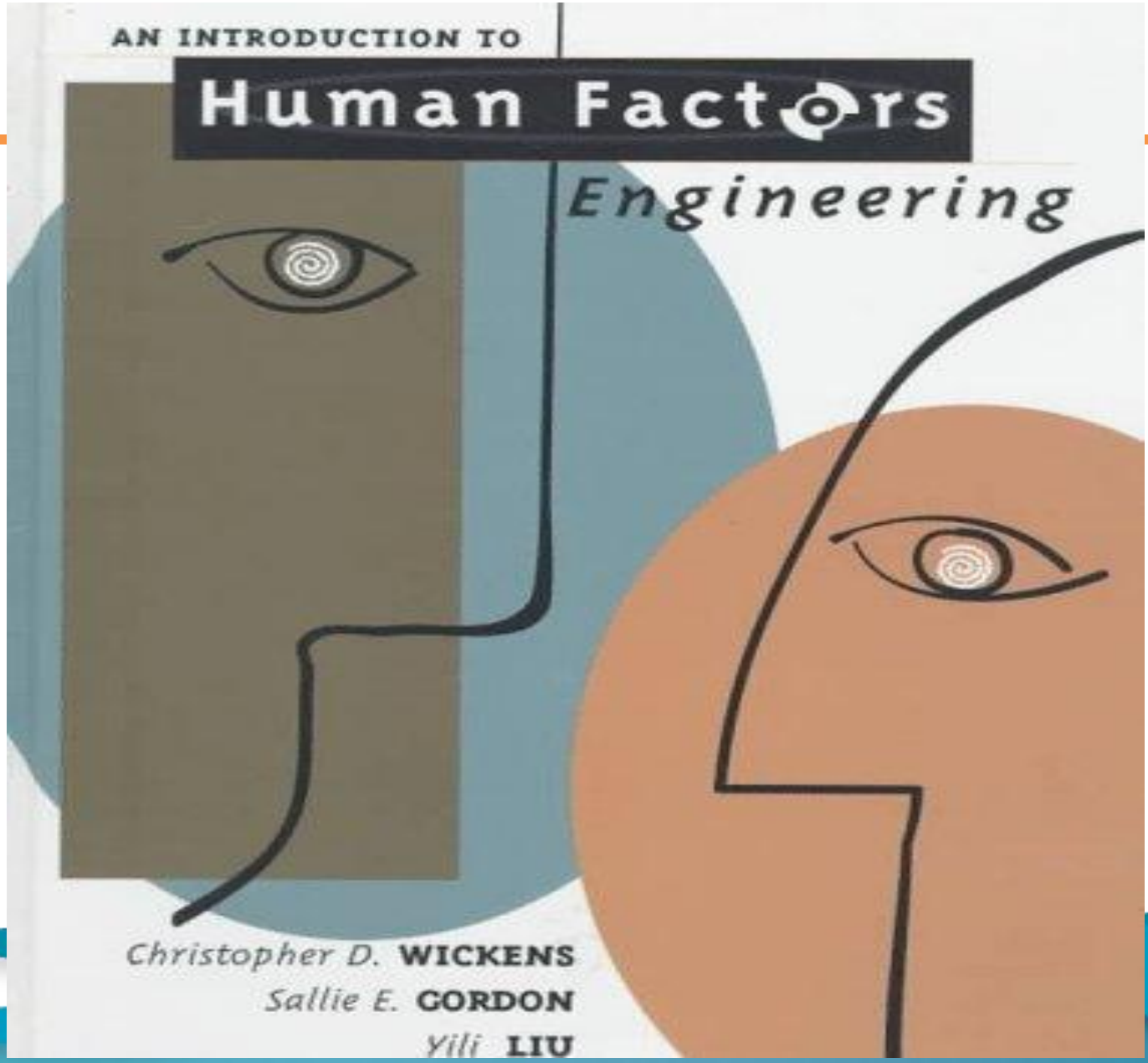
CDC

http://www.cdc.gov/HAI/recoveryact/stateResources/toolkits.html

Other Considerations

- Increased risk of prior room occupant transmission is 73%[1]
- Potential for transmission despite enhanced cleaning procedures
- Novel terminal cleaning and disinfection methods hold promise[2]
- Effectiveness depends on a team approach

1. Carling PC, Bartley D. *Am J Infect Control.* 2010;38(5 Suppl 1):S41-S50.
2. Falagas ME, et al. *J Hosp Infect*. 2011. doi:10.1016/j.jhin.2010.12.006.

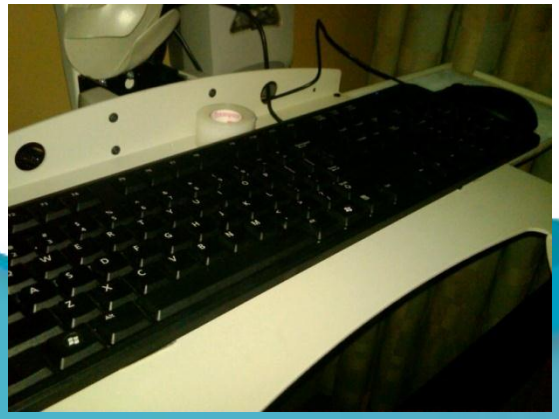

AN INTRODUCTION TO
Human Factors
Engineering
Christopher D. WICKENS
Sallie E. GORDON
Yili LIU

The Hospital Bed: Friend or Foe

- A great asset for the patient, complete with fall alarms, nurse call buttons and the TV remote![1]
- Highly contaminated space
- Lots of nooks and crannies!

1. Boyce 2007 JOHI

No Man's Land - Another Benefit



Who is responsible to clean these often missed items?

Consider Enhanced Monitoring Techniques

Method	Ease of use	Identifies pathogens	Useful for individual teaching	Directly evaluates cleaning	Published use in programatic improvement
Covert practice observation	Low	No	Yes	Yes	1 hospital
Swab cultures	High	Yes	Not studied	Potentially	1 hospital
Agar slide cultures	Good	Limited	Not studies	Potentially	1 hospital
Fluorescent gel	High	No	Yes	Yes	49 hospitals
ATP system	High	No	Yes	Potentially	2 hospitals

Carling P, Bartley J. *Am J Infect Control*. 2010;38:S41-S50.

New Technologies

Overview of Area Decontamination Technologies (cont)

Technology	Advantages	Disadvantages
Gaseous chlorine dioxide[1]	• Active against many pathogens, including spores • More effective than manual cleaning/disinfection	• Room must be empty and sealed • Potentially toxic by-products • Affected by UV light and humidity • Can discolor some materials • No data on use in clinical setting • Explosive at >10%
Gaseous hydroxyl radicals[2]	• Can be used whilst room is occupied • Silent and odorless	• Limited data on effectiveness against nosocomial infections
Air filtration technologies[3]	• Can be used whilst room is occupied • Proven effectiveness at reducing environmental contamination rates	• Noisy • Requires regular cleaning and filter changes

1. Hubbard H, et al. *Environ Sci Technol*. 2009;43(5):1329-1335.
2. Wong V, et al. *J Hosp Infect*. 2011;78:194-199.
3. Qian H, Li Y. *Indoor Air*. 2010;20(4):284-297.

Overview of Area Decontamination Technologies

Technology	Advantages	Disadvantages
Gaseous hydrogen peroxide[1]	• Active against many pathogens, including spores • More effective than manual cleaning/disinfection • No toxic by-products • Published evidence of use in clinical settings to reduce environmental contamination and infection rates	• Room must be empty and sealed
UV disinfection[2]	• Active against many pathogens • Relatively simple and easy to use • No toxic residues	• Limited data to date
Ozone[3]	• Active against many pathogens • More effective than manual cleaning/disinfection	• Room must be empty and sealed • Affected by humidity • No data on use in clinical setting

1. **Shapey S, et al. *J Hosp Infect*. 2008;70:136-141.**
2. **Stibich M, et al. *Infect Control Hosp Epidemiol*. 2011;32(3):286-288.**
3. **Moat J, et al. *Can J Microbiol*. 2009;55(8):928-933.**

The Basics

- Hydrogen Peroxide (H202) is delivered into the environment by vapor or mist. [1]
- Effective in eradicating environmental pathogens in hospitals. [2-4]
- Used to eliminate persistent contamination during outbreaks of infection. [5, 6]

1. http://www.shea-online.org/Portals/0/SHEA-APIC-AHE_EPA_fogging_letter_FINAL_%2801281%29.pdf
2.Cummins M, et al. J Hosp Infect 2007; 67:182 – 188.
3. Johnston MD, et al. J Microbiol Methods 2005; 60:403 – 411.
4. French GL, et al. J Hosp Infect 2004; 57:31 – 37.
5. Bates CJ, et al. J Hosp Infect 2005; 61:364 – 366.
6. Jeanes A, et al. MRSA. J Hosp Infect 2005; 61:85 – 86.

HP Systems vs. Manual Cleaning

- Evenly disperses disinfectant over all exposed surfaces in a room.
- Compared to manual cleaning, it does not rely on the operator to ensure adequate distribution.[1]
  - 50% of high touch surfaces are routinely cleaned [2]
- HP systems do not replace the need for manual cleaning!
- It can supplement it!

1 Otter, et al. Infect Control Hosp Epidemiol 2009; 30:574-577
2. Carling, etal. *Clin InfectDis* 2006;42:385–388.

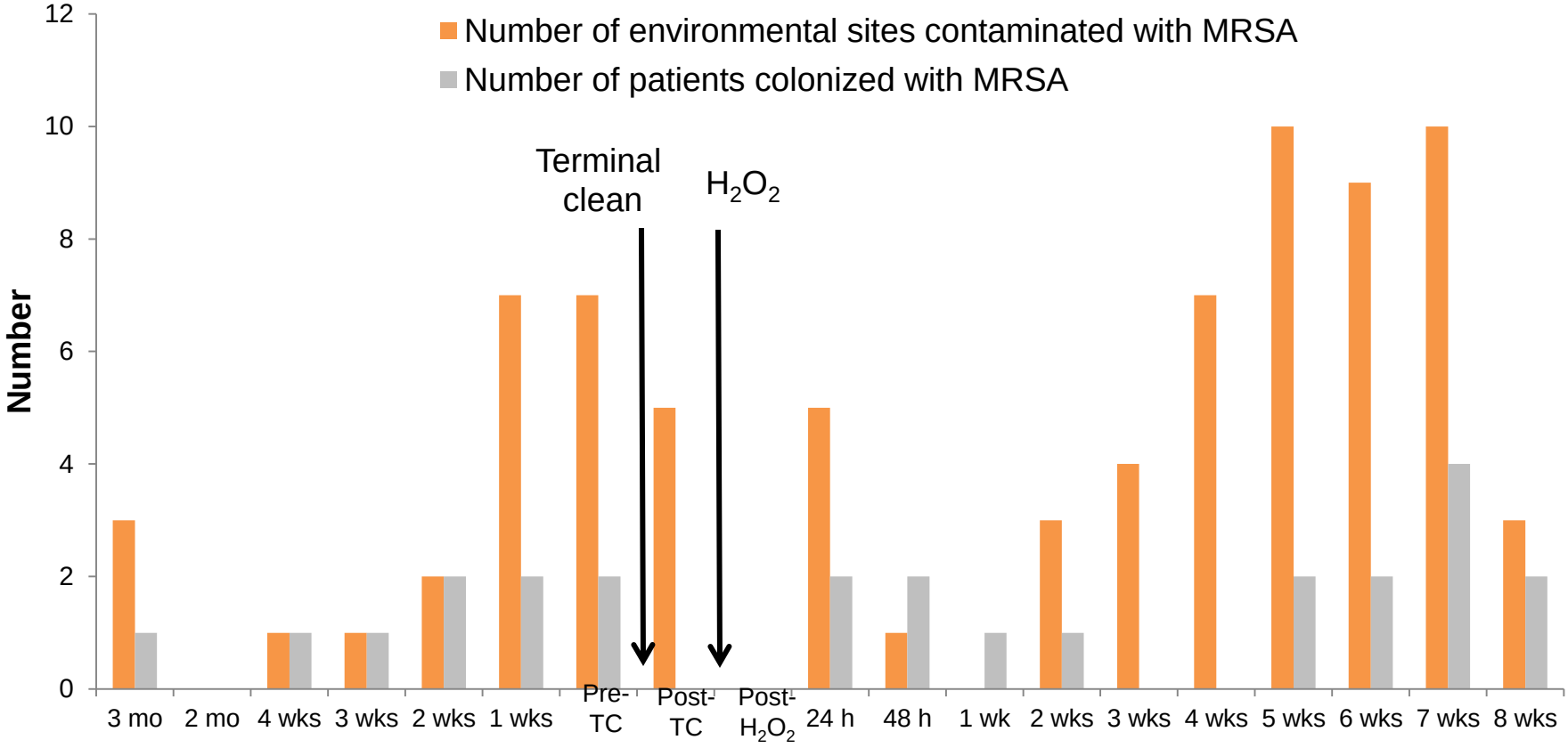
Gaseous Hydrogen Peroxide Impact on MRSA in Patient Isolation Rooms/bathrooms

	Total before cleaning	Matched before cleaning	Matched after cleaning	Matched before H_2O_2[a]	Matched after H_2O_2[a]
No. of rooms sampled	24[b]	10[c]	10[c]	6[d]	6[d]
No. of swabs	359	124	124	85	85
Swabs yielding MRSA, n (%)	264 (73.5)	111 (89.5)	82 (66.1)	61 (71.8)	1 (1.2)
From direct plating	185 (70.1)	87 (78.4)	61 (74.4)	44 (72.1)	0
++Growth	75 (40.5)	37 (42.5)	26 (42.6)	24 (54.5)	-
+Growth	110 (59.5)	50 (57.5)	35 (57.4)	20 (45.5)	-
From enrichment only	79 (29.9)	24 (21.6)	21 (25.6)	17 (27.9)	1 (100.0)

"Matched" denotes rooms in which adjacent sites were sampled before and after intervention.
[a]Hydrogen peroxide vapor decontamination.
[b]Eighteen single isolation rooms, two 4-bed days, 4 bathrooms.
[c]Eight single isolation rooms, two 4-bed days.
[d]Four single isolation rooms, 2 bathrooms.

French GL, et al. *J Hosp Infect.* 2004;57(1):31-37.

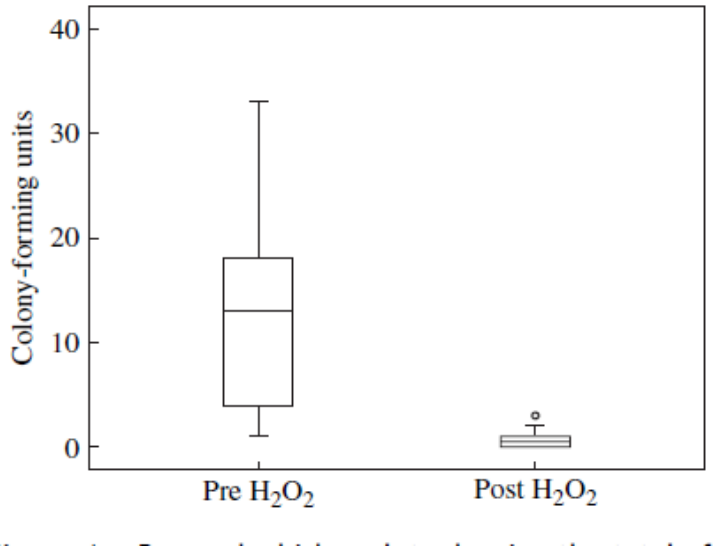
Gaseous Hydrogen Peroxide Impact on MRSA in an Open-plan ICU



MRSA, multidrug-resistant *Staphylococcus aureus*; ICU, intensive care unit; TC, terminal clean.
Hardy KJ, et al. *J Hosp Infect.* 2007;66(4):360-368.

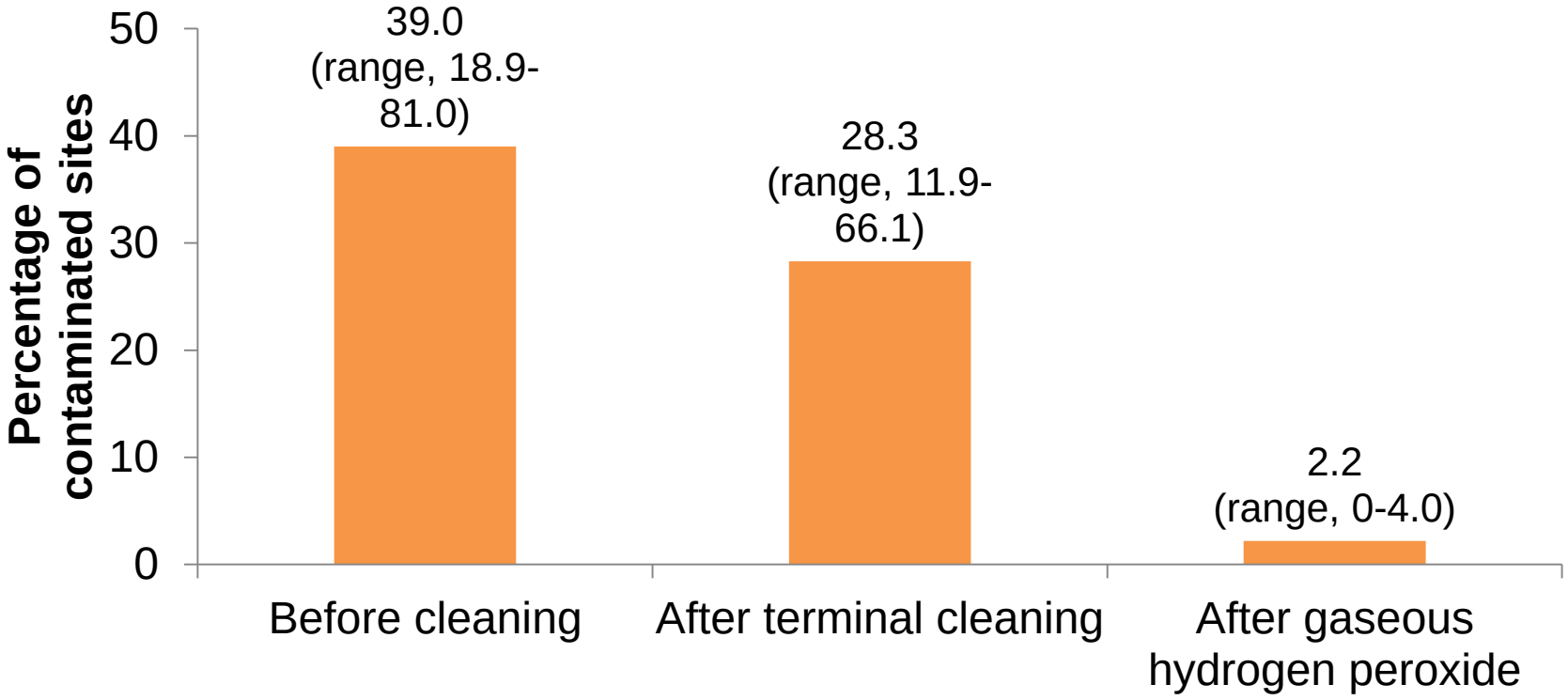
Hydrogen Peroxide against C.difficile in an Elderly Unit

- After a single cycle of hydrogen peroxide
- decontamination, only 3% (7/203) of samples were positive ($P < 0.001$),
- with a mean of 0.4 cfu per 10 samples (w94% reduction). [1]
- The hydrogen peroxide system significantly reduced the extent of environmental contamination with *C. difficile* in these elderly care rooms.[1]



1. Shapey et al. Journal of Hospital Infection (2008) 70, 136e141

Systematic Review of Peroxide-based Systems in the Hospital Environment



Falagas ME, et al. *J Hosp Infect*. 2011. doi:10.1016/j.jhin.2010.12.006.

INFECTION CONTROL AND HOSPITAL EPIDEMIOLOGY OCTOBER 2010, VOL. 31, NO. 10

ORIGINAL ARTICLE

Room Decontamination with UV Radiation

William A. Rutala, PhD, MPH; Maria F. Gergen, MT (ASCP); David J. Weber, MD, MPH

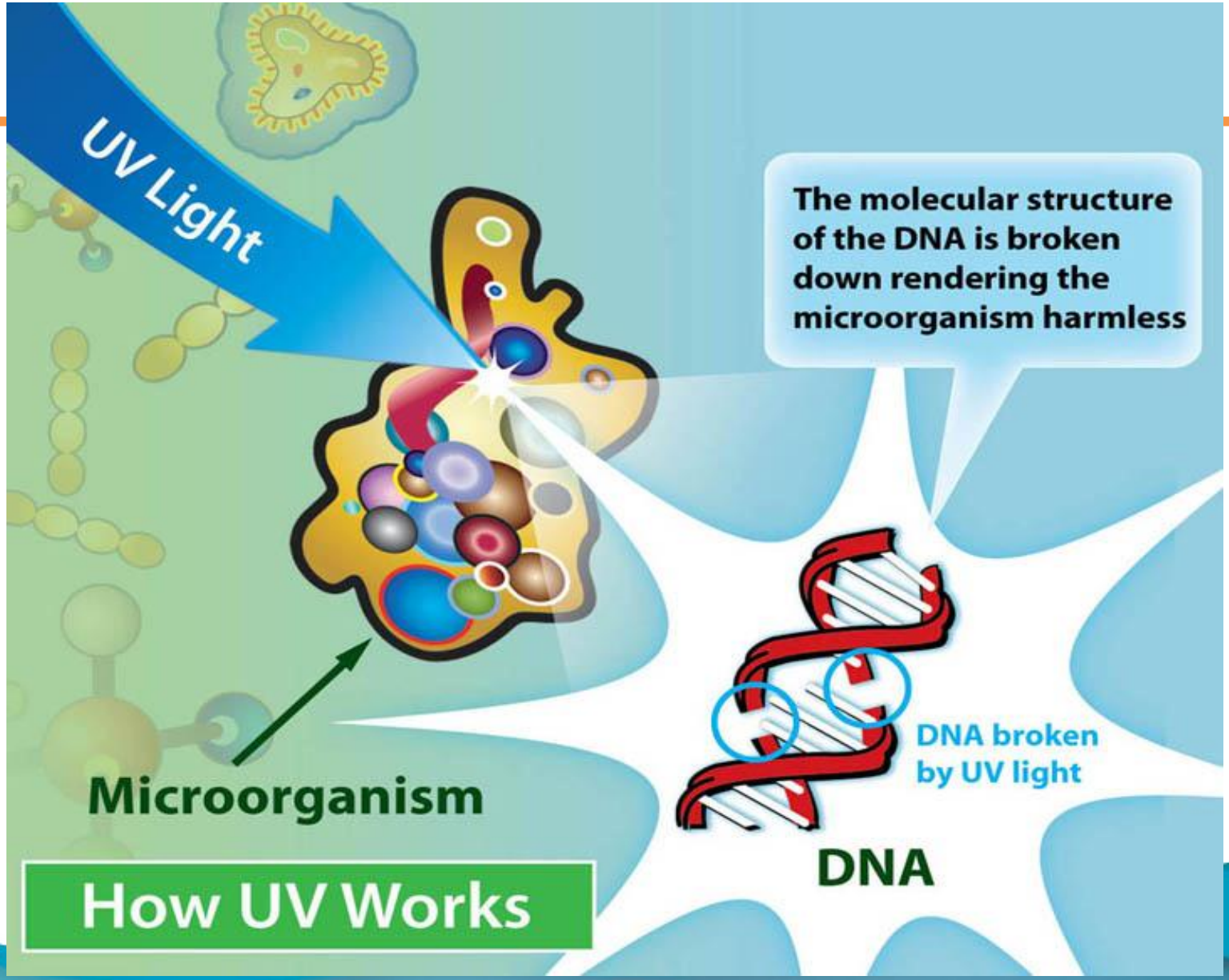
OBJECTIVE. To determine the effectiveness of a UV-C–emitting device to eliminate clinically important nosocomial pathogens in a contaminated hospital room.

METHODS. This study was carried out in a standard but empty hospital room (phase 1) and in a room previously occupied by a patient with methicillin-resistant *Staphylococcus aureus* (MRSA) or vancomycin-resistant *Enterococcus* (VRE) infection (phase 2) in an acute care tertiary hospital in North Carolina from January 21 through September 21, 2009. During phase 1, 8 × 8 cm Formica sheets contaminated with approximately 10^4–10^5 organisms of MRSA, VRE, multidrug-resistant (MDR) *Acinetobacter baumannii*, or *Clostridium difficile* spores were placed in a hospital room, both in direct line of sight of the UV-C device and behind objects. After timed exposure, the presence of the microbes was assessed. During phase 2, specific sites in rooms that had housed patients with MRSA or VRE infection were sampled before and after UV-C irradiation. After timed exposure, the presence of MRSA and VRE and total colony counts were assessed.

RESULTS. In our test room, the effectiveness of UV-C radiation in reducing the counts of vegetative bacteria on surfaces was more than 99.9% within 15 minutes, and the reduction in *C. difficile* spores was 99.8% within 50 minutes. In rooms occupied by patients with MRSA, UV-C irradiation of approximately 15 minutes duration resulted in a decrease in total CFUs per plate (mean, 384 CFUs vs 19 CFUs; $P < .001$), in the number of samples positive for MRSA (81 [20.3%] of 400 plates vs 2 [0.5%] of 400 plates; $P < .001$), and in MRSA counts per MRSA-positive plate (mean, 37 CFUs vs 2 CFUs; $P < .001$).

CONCLUSIONS. This UV-C device was effective in eliminating vegetative bacteria on contaminated surfaces both in the line of sight and behind objects within approximately 15 minutes and in eliminating *C. difficile* spores within 50 minutes.

Infect Control Hosp Epidemiol 2010; 31(10):1025-1029

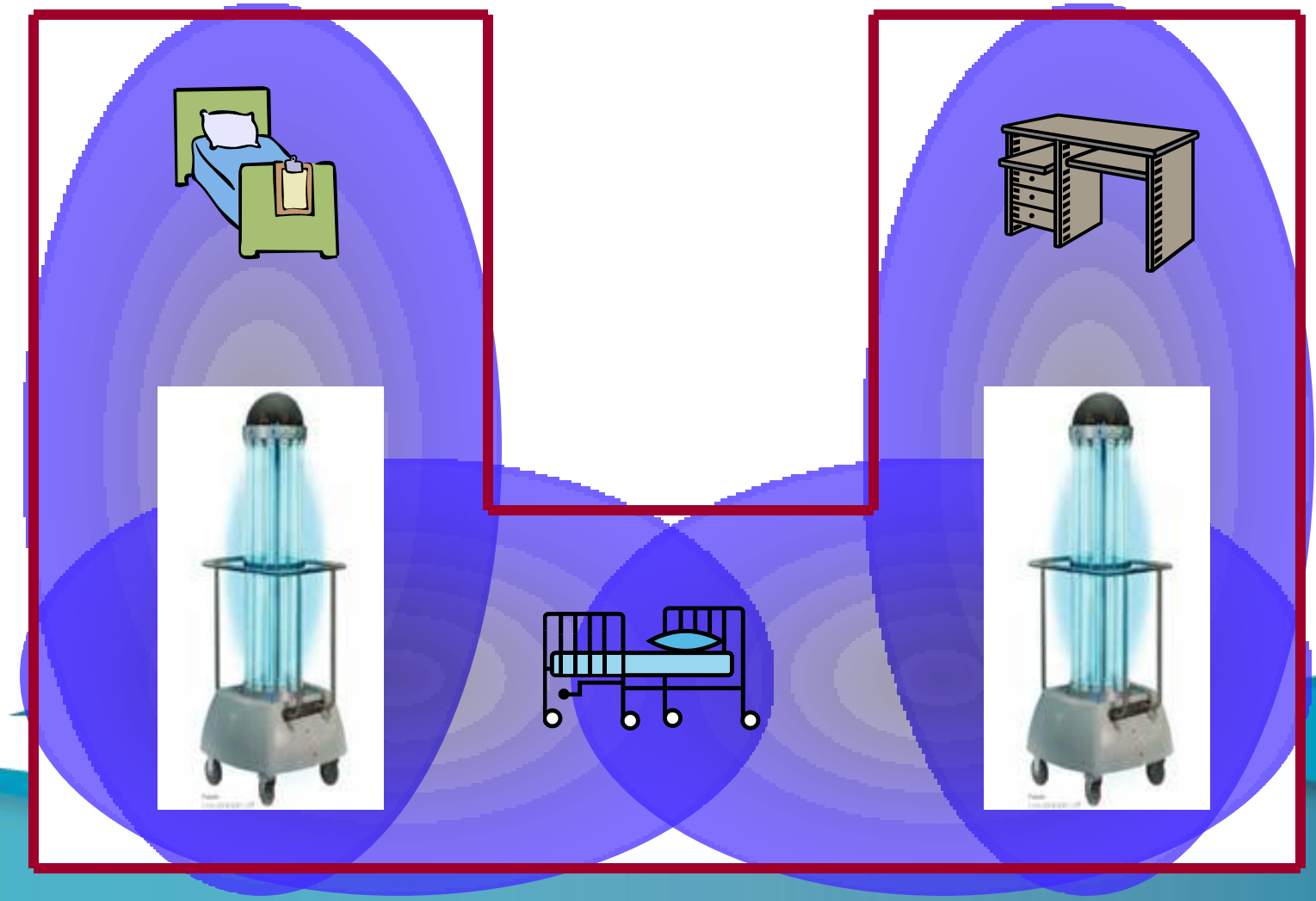

UV Light
The molecular structure of the DNA is broken down rendering the microorganism harmless
Microorganism
DNA broken by UV light
DNA
How UV Works

Operation Overview

- **Handheld remote** activates decontamination and monitors the progress.
- **Remote Sensors measure** the actual germicidal energy

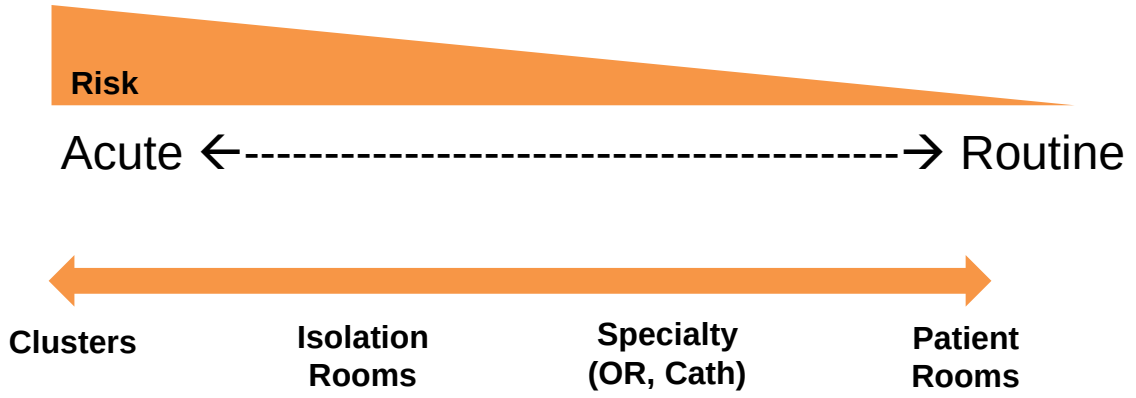
  dose received at multiple targets including shadowed areas.
- Decontamination time is **automatically calculated** based upon environmental factors including room size, configuration and surface materials.
- Areas commonly **missed by manual and chemical cleaning** are decontaminated and/or sterilized.
- Room may be **occupied immediately** after treatment.

Multiple applications, or multiple units can be used for areas with unique geometric challenges.



Inputs to Consider When Developing Disinfection Strategies

Needs



Time

How critical is time for a given use area?

Identifying Areas for Enhanced Cleaning

Clusters	• Requires shutdown of room/unit • Longest accepted time frame
Isolation rooms	• Requires enhanced procedures (gown/glove) • Less time constraint
Specific pathogens	• High level of concern • Linked to environment • Cause of clusters
OR/Cath/Endoscopy	• Down-time off-hours • Night-time terminal cleaning
“Spring Cleaning”	• Routine deep-clean in unit • Periodic deep clean in patient rooms

Successful Implementation & Creating Enhanced Bundles

- Work collaboratively with EVS
- Develop a plan
- Identify high priority areas based upon risk assessment
- Establish how and when enhanced room disinfection strategies will be used
- Successful integration of new technologies
- Monitor implementation

Clean Sweep

- Useful during outbreaks or times of high endemicity
- Patients are moved to an empty room and room disinfected. Patient then moved to that room, etc

Focused

- Terminally clean all rooms in high risk area based upon preset timeline
- Limit to specific types of rooms (isolation)

The Bottom Line; is it useful?

- Ample evidence that contamination with important MDROs such as VRE, Acientobacter and C. *difficile* pose a risk for patient to patient transmission of these pathogens
- Multiple studies have shown that environmental service workers often fail to decontaminate high risk objects
- Contact with the environment can contaminate health care worker's hands as much as contact with the patient
- New technologies can be useful especially useful during outbreaks, discharge of patients on contact precautions and in special rooms.

Rutala, *ICHE* 2011:32; 8

Major Disadvatages

- Cost
- User and resource dependent
- Time

Conclusion

- Usefulness of enhanced technologies has been demonstrated
- Links to reduction of infection has occurred primarily in outbreak settings or with hyper-endemic rates
- Cost effective studies needed to guide selection and usage.
- Robust studies needed on decrease of endemic rates of MDROS
- Need technological advances for daily cleaning

Remember that these technologies are simply one tool in a complex and multifactoral environmental contamination issue.