Re-Engineering Today's Hospitals to Prevent Infections Tomorrow

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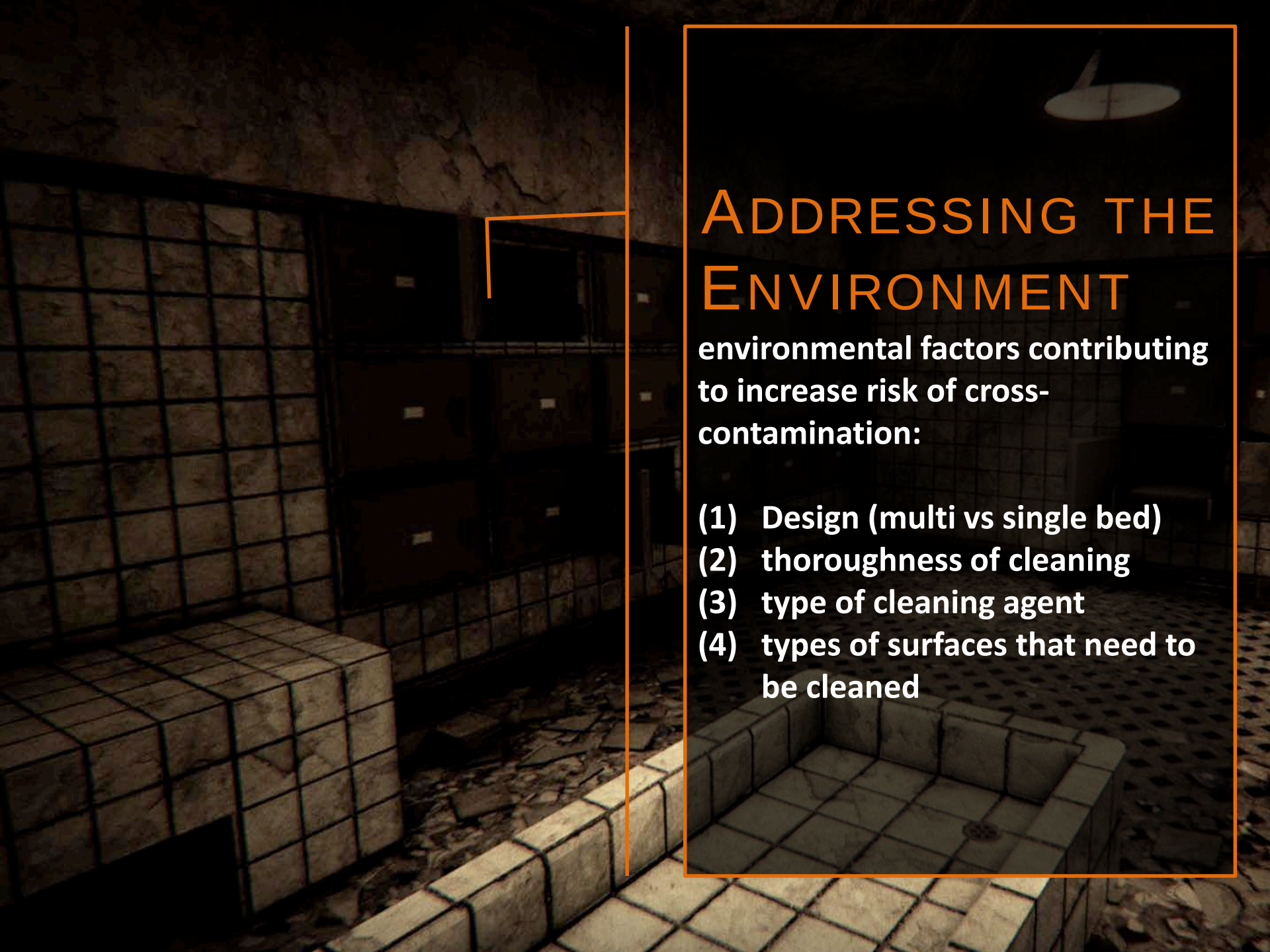
DISCLOSURE

Research: Biomerieux, Teck Resources Limited

Objectives

1. Discuss principles of engineering for infection reduction
2. Describe the Genome BMT Pilot Project
3. Review the results from the pilot project and the next steps and existing gaps in our knowledge on self-disinfecting surfaces

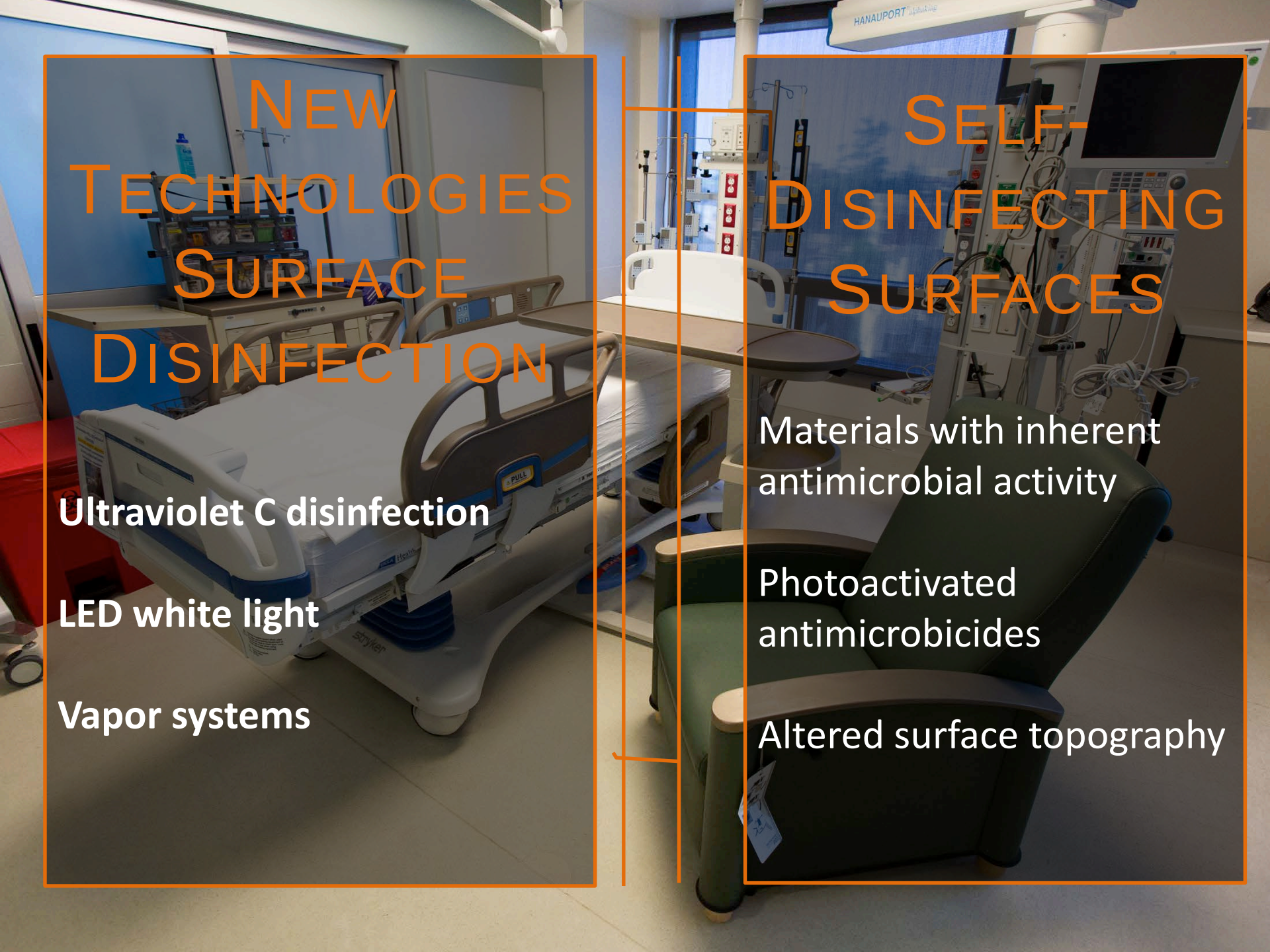

Microbes transfer between Patients,
Healthcare Workers, and Environment



Addressing the Environment

environmental factors contributing to increase risk of cross-contamination:

(1) Design (multi vs single bed)
(2) thoroughness of cleaning
(3) type of cleaning agent
(4) types of surfaces that need to be cleaned



New Technologies Surface Disinfection

Ultraviolet C disinfection

LED white light

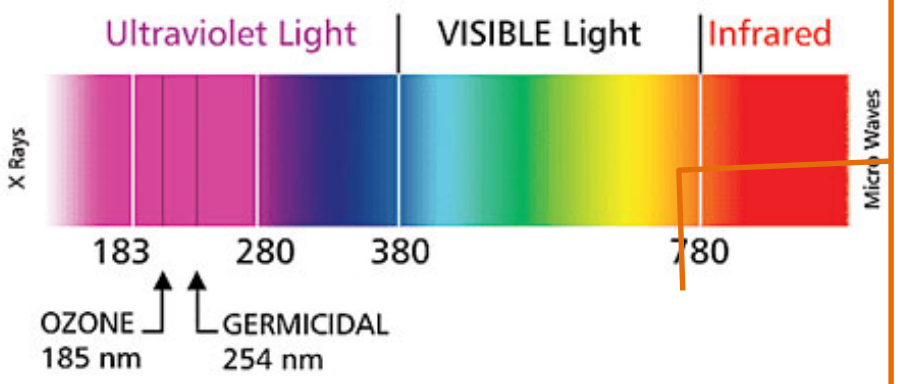
Vapor systems

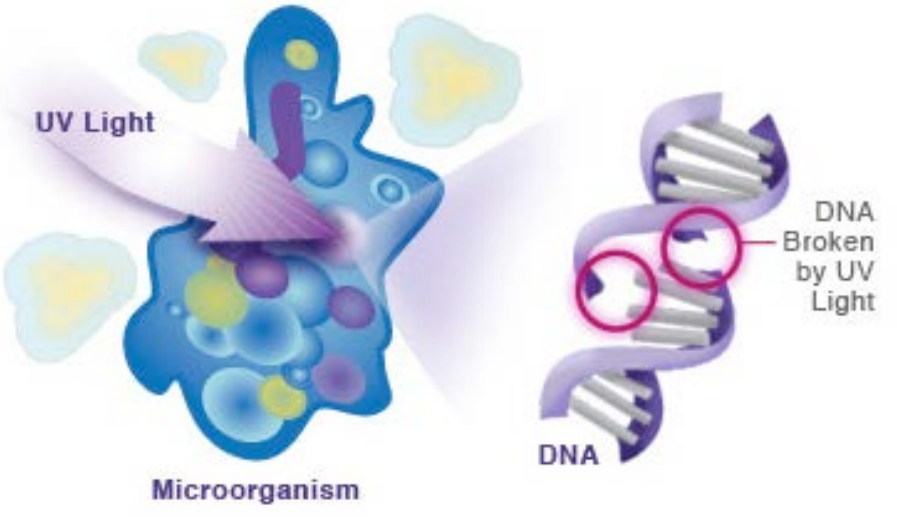
Self-Disinfecting Surfaces

Materials with inherent antimicrobial activity

Photoactivated antimicrobicides

Altered surface topography





UV Surface Disinfection

used in laboratories for years

new literature demonstrates value as an adjunct to cleaning

reduces CD spores, MRSA, VRE in hospital rooms

evaluation must include ability to integrate technology into workflow

Common Questions

IS IT SAFE?

Yes, sensors and barriers prevent accidental human exposure
UVC does not penetrate glass

DOES IT WORK?

Yes, both in laboratory and clinical setting

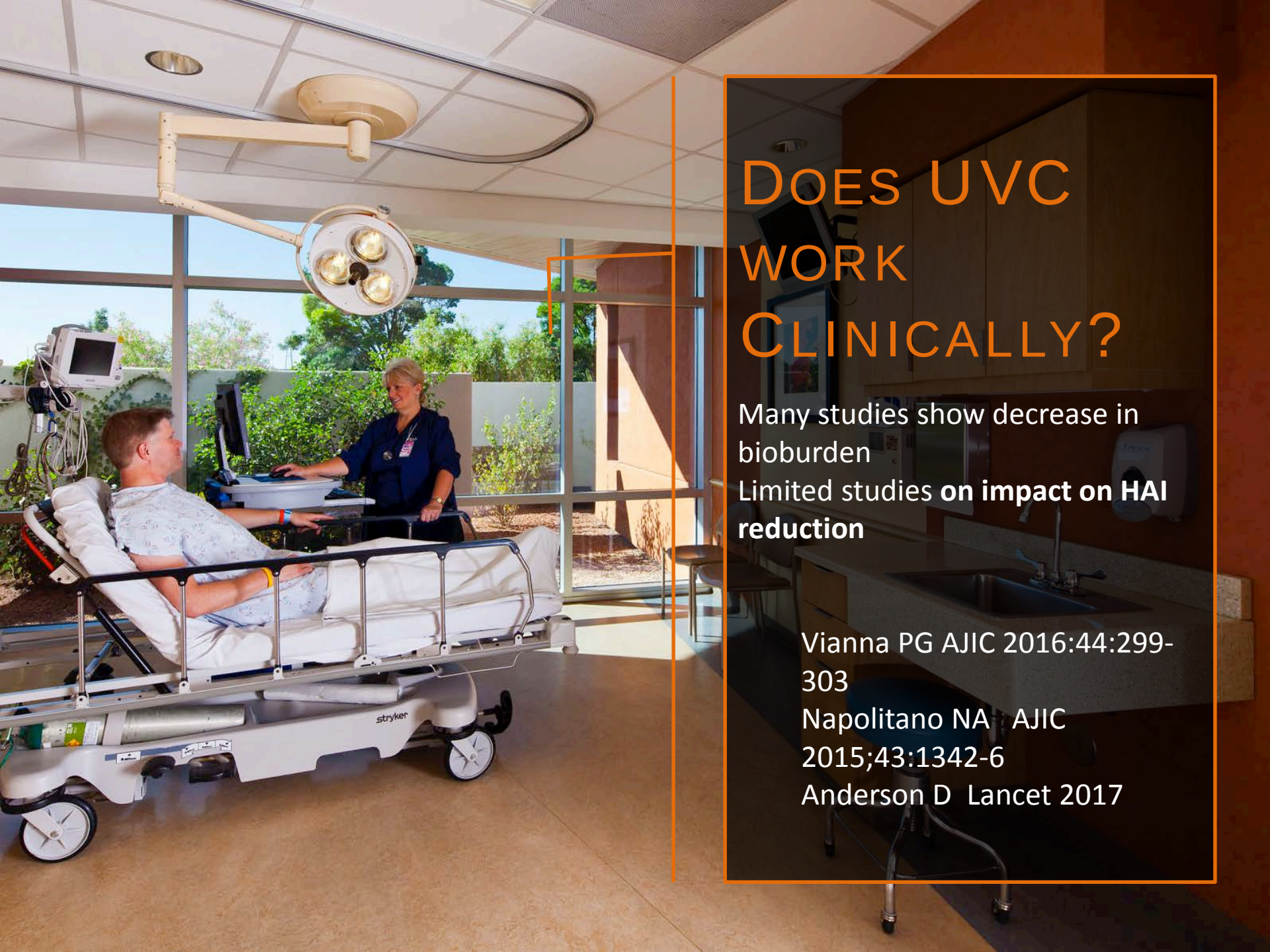
Types of UVC Technology Available

Continuous UVC

Low pressure mercury 254 nm
Cycle time:5 to >60 min
One study suggests more effective than pulsed xenon
Purchase prices vary significantly

Pulsed Xenon

Pulsed light from 200 to 320 nm
Cycle time 5-7 min
Purchase prices also vary



Does UVC work Clinically?

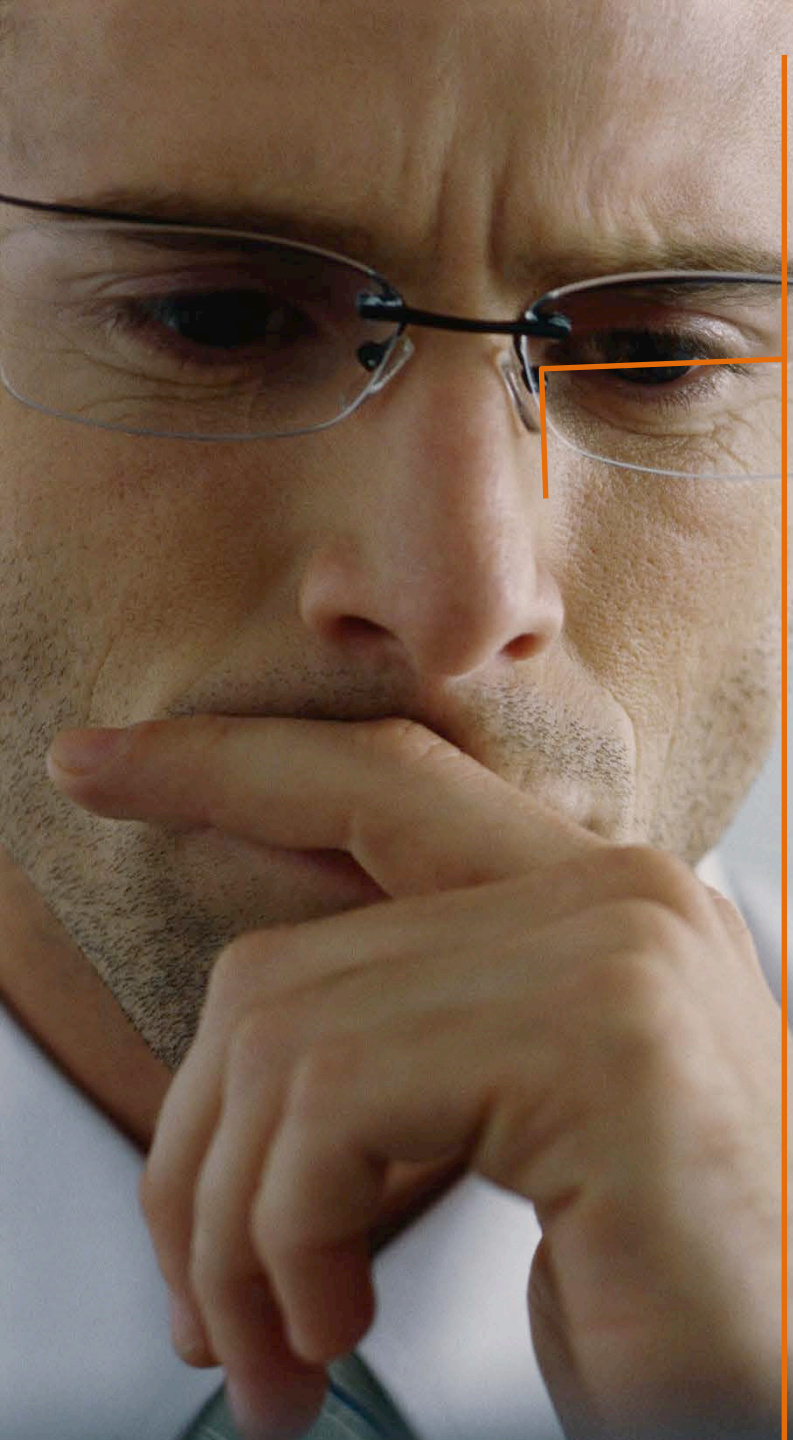
Many studies show decrease in bioburden

Limited studies **on impact on HAI reduction**

Vianna PG AJIC 2016:44:299-303

Napolitano NA AJIC 2015;43:1342-6

Anderson D Lancet 2017



Purchase Considerations

Canadian facilities work at 100% capacity. No ability to extend “down time” for rooms

Most UVC machines are microbiologically effective

Functionality, integration into workflow , operator considerations become the primary determinants for purchase
Cycle time may become paramount

Consider how your facilities operates when selecting UVC machines

Permanent UVC Installation in Bathrooms

J Cooper, G Astrakianskis, K Bartlet, E Bryce

The Problem: Common shared hallway bathrooms with limited sink access

The background: Toilets generate aerosols of bacteria and viruses that follow air currents for long distances or land on surfaces.

The question: Is permanently installed UVC light effective in decreasing microorganisms in the air and on surfaces

The Study Design

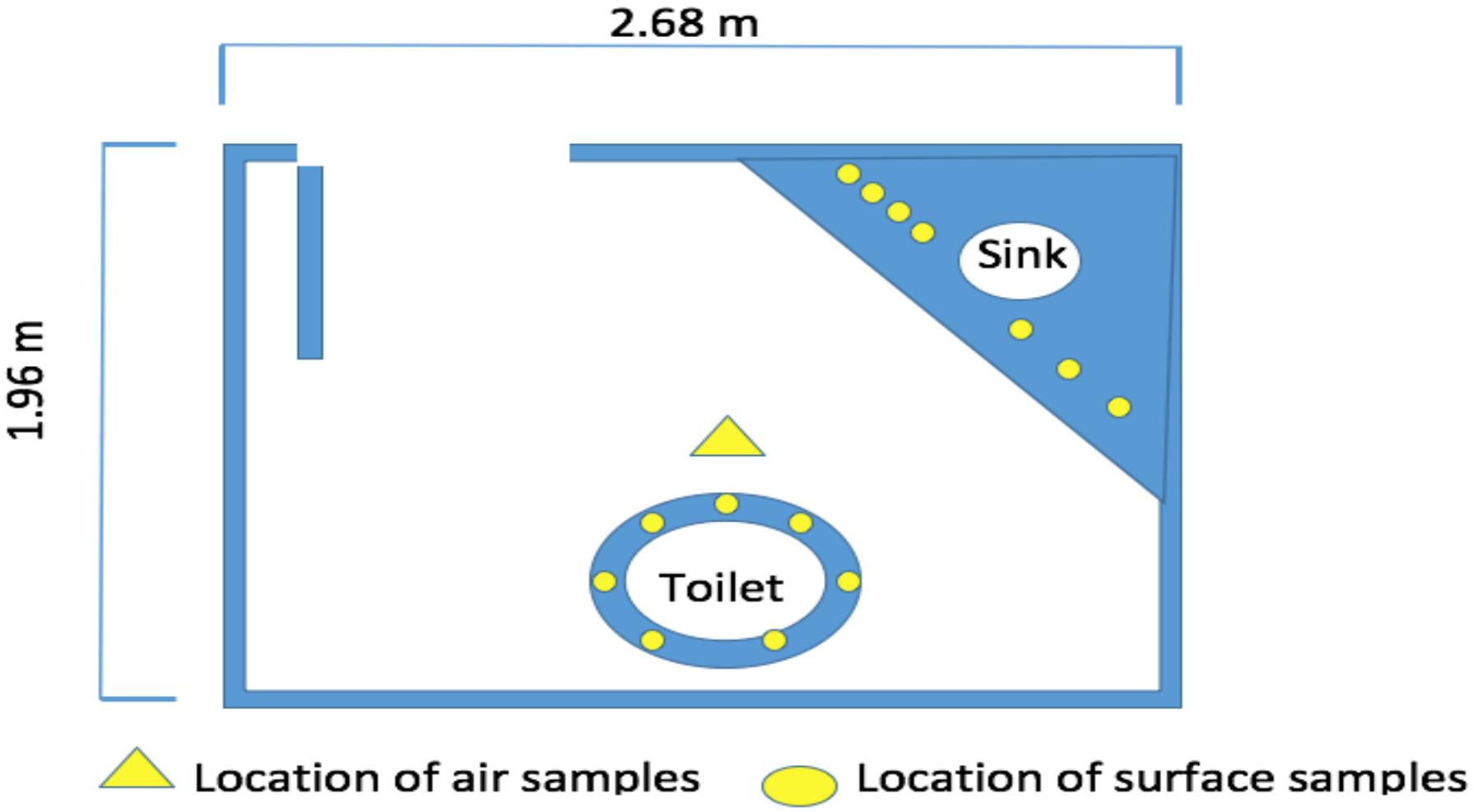
J Cooper, G Astrakianskis, K Bartlet, E Bryce

Shared hallway washrooms of similar design and size with or without either UVC (with 5 minute run time)

150 litre air samples were collected 5 minutes and 30 seconds after patient use and cultured

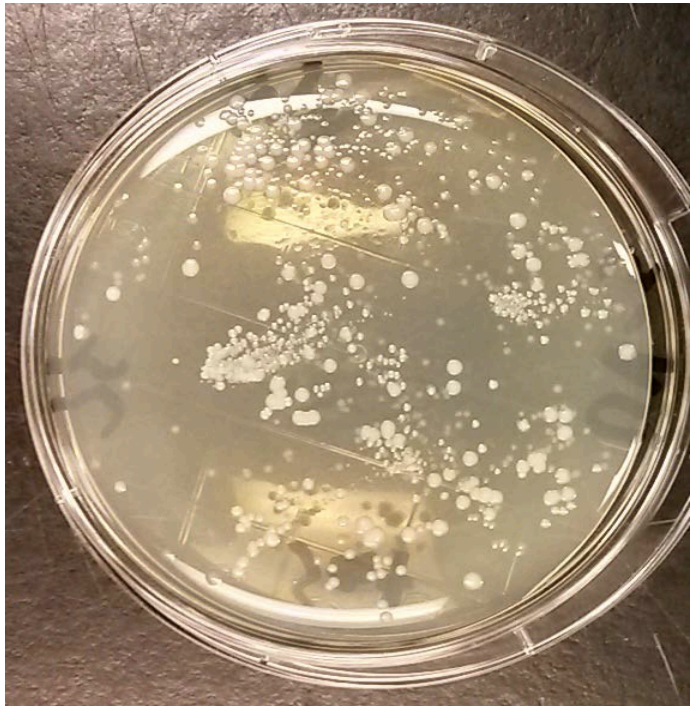
Surface samples from toilet and counter cultured

Washroom Layout and Sampling Locations

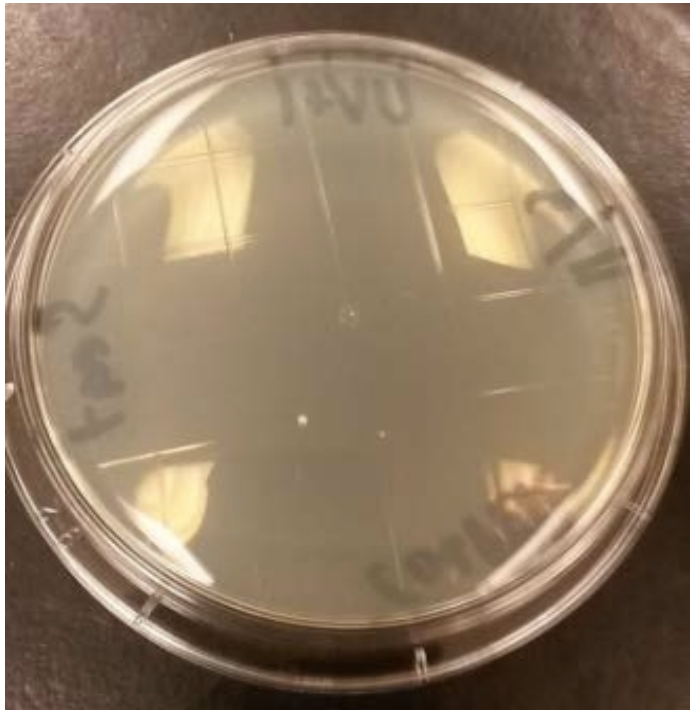


Sample	Geometric Mean Concentration	Geometric Standard Deviation	% Reduction in Mean Concentration
Seat Bacteria[1] UV+ve	7.7	5.5	97*
Seat Bacteria[1] UV-ve	224	7.5	
Counter Bacteria[1] UV+ve	1.6	2.2	95*
Counter Bacteria[1] UV-ve	31	3.1	
Anaerobic Bioaerosol[2] UV+ve	45	2.4	47.7**
Anaerobic Bioaerosol[2] UV-ve	86	2.8	
Aerobic Bioaerosol[2] UV+ve	153.2	1.7	35.2**
Aerobic Bioaerosol[2] UV-ve	236.5	1.4	

Counter Contact Plate
UV-ve



Counter Contact Plate
UV+ve



Study Conclusions

J Cooper, G Astrakianskis, K Bartlet, E Bryce

Automated, permanent UVC lights can decrease exposure to potential pathogens

Again, careful consideration of where these devices are placed – AND WHY – is required.

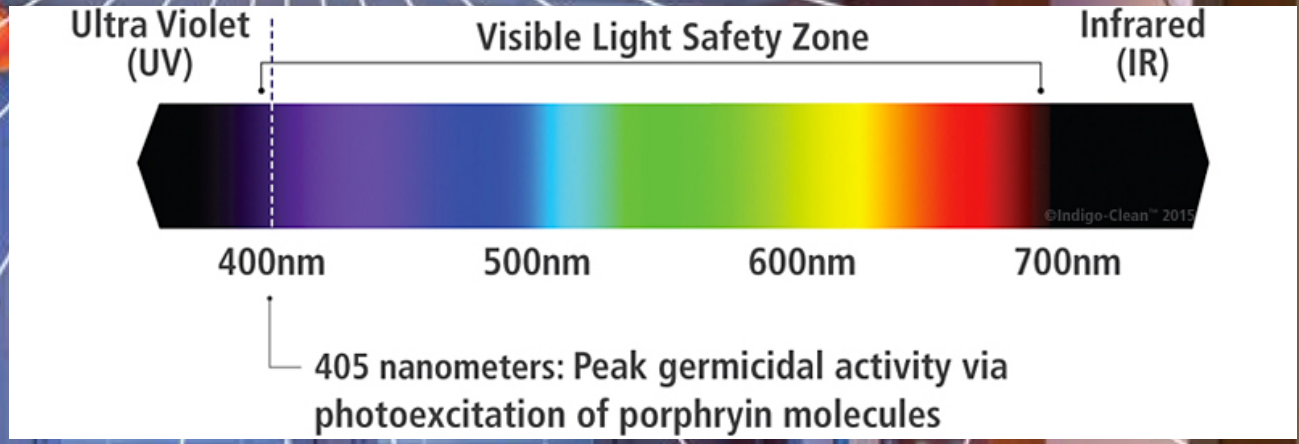
UVC for Mobile Equipment

Li, Wong, Rose, Wickham, Bryce Am J Infect Control 2016

Hand-held equipment can be fomites for microbe transmission

Aluvis machine is effective at disinfecting hand-held devices, but requires some human factors optimization

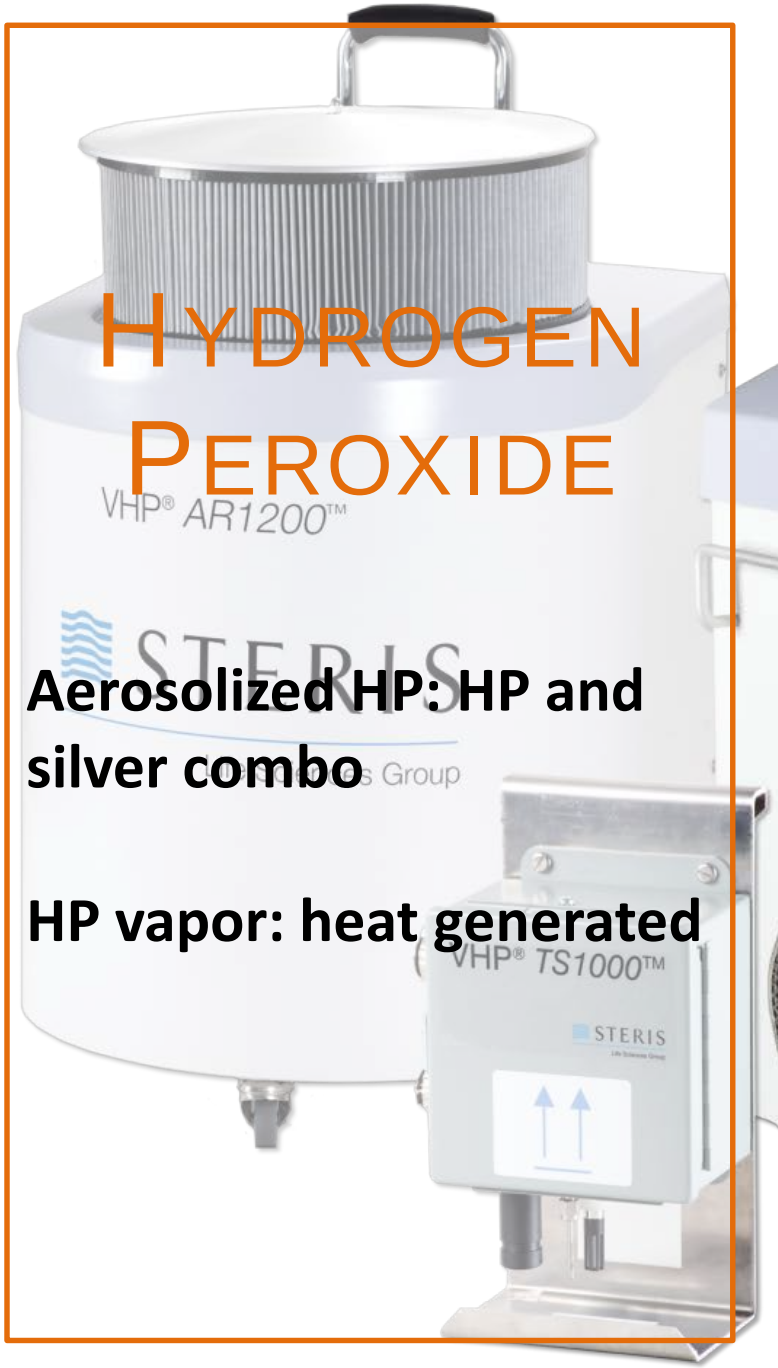
Ambient LED and White Light



Hydrogen Peroxide

Aerosolized HP: HP and silver combo

HP vapor: heat generated



Pros / Cons

Less easy to use compared to UV-C
requires generator
requires aeration unit door and vents need to be sealed

Multiple safety monitors to ensure no leakage occurs

Takes longer than UVC

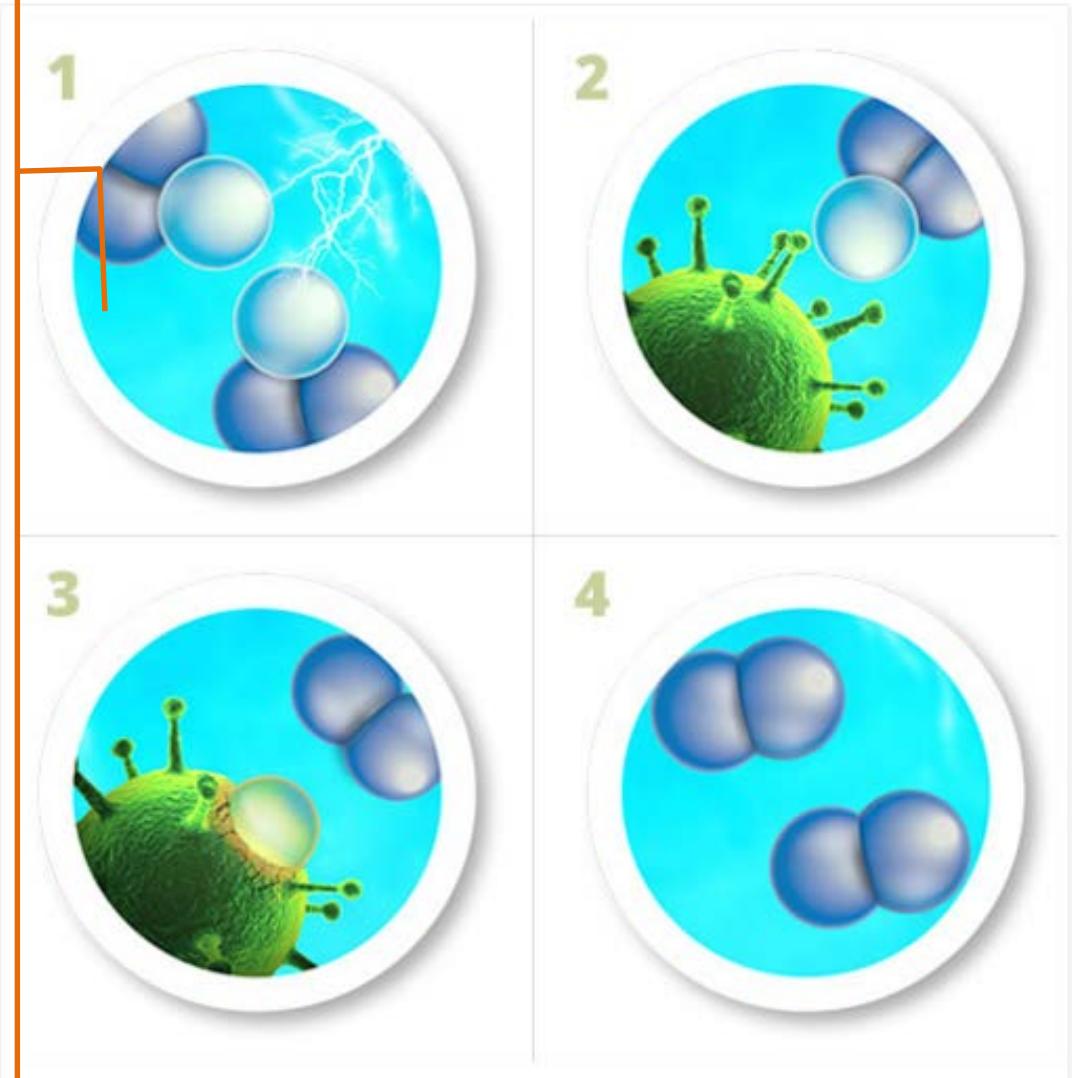
Stabilized Aqueous Ozone

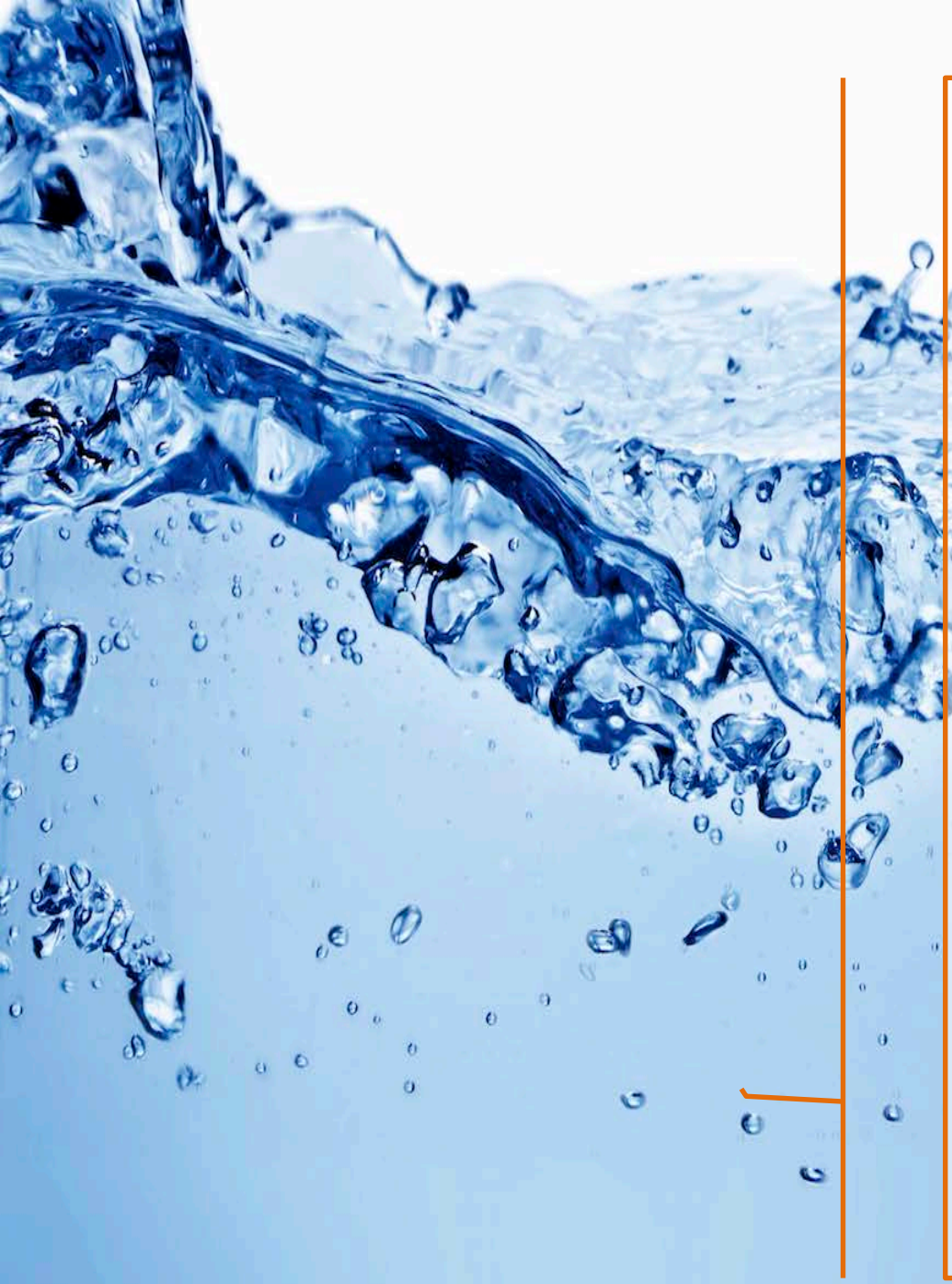
(1) Machine generates ozone and binds with H20

(2) Ozonated water comes in contact with pathogens

(3) Ozone molecule comes in contact with bacterial cell wall – oxidative burst creates holes, and pathogen dies

(4)Only normal water remains





Background

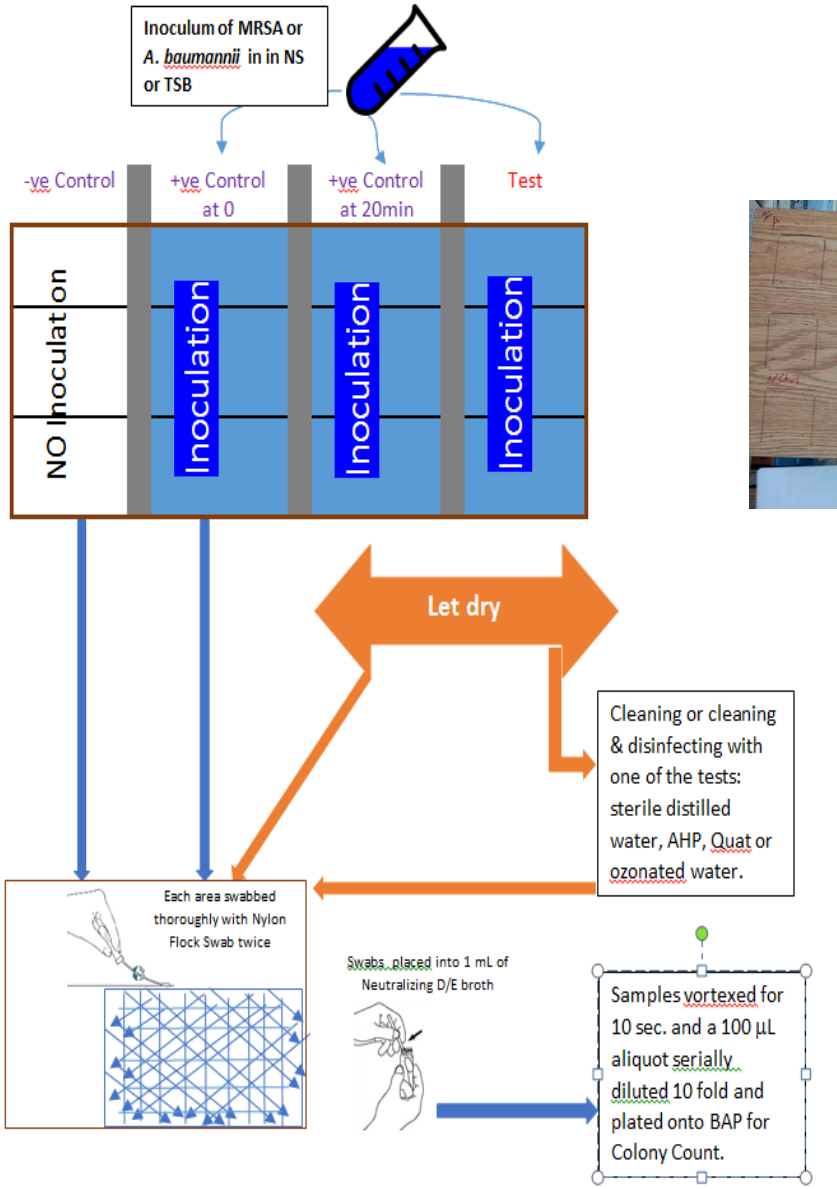
Ozonated water has been evaluated in industrial settings and in vitro

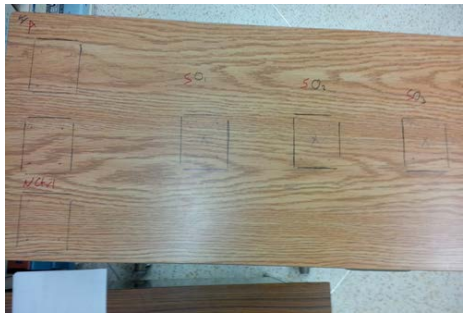
Little information on antimicrobial efficacy in clinical settings

Has potential to be cost effective and safe for staff and patients

METHODOLOGY

Fig.1 Algorithm for Overbed Tables Inoculation with MRSA or A. baumnnii then Cleaning +/- Disinfecting with the test solution.





Sample	CFU/ml	% Reduction compared to dried inoculum
Original Inoculum	5.5E+08	
Neg Ctrl t Ctrl	0	
Neg Ctrl t AHP	0	
Neg Ctrl t Oz	0	
Neg Ctrl t CC	0	
After Drying	8.20E+06	
Distilled water and microfiber	36.7	99.99955
Distilled water and cloth rag	93.3	99.99886
AHP and microfiber	0	100
AHP and cloth	100	99.99988
Ozone 1 and microfiber	107	99.9987
Ozone 1 and cloth rag	233	99.9997
Ozone 2 and microfiber	86.7	99.999
Ozone 2 and cloth rag	133	99.9998

Self-Disinfecting Surfaces

Antimicrobial Materials

Copper and other heavy metals (silver, nickel)

Use dates back to Egyptians
Mechanism: Toxic oxygen radical formation
Alloy formulations

Success in recent clinical trials

Not Known

Durability

Compatibility with cleaning agents

Resistance development

Activity over time

Copper on High Touch Surfaces

Antimicrobial copper on high-touch surfaces may decrease transmission of microorganisms

photo courtesy of R. Dixon, CHAIR Canada

Compressed Salt

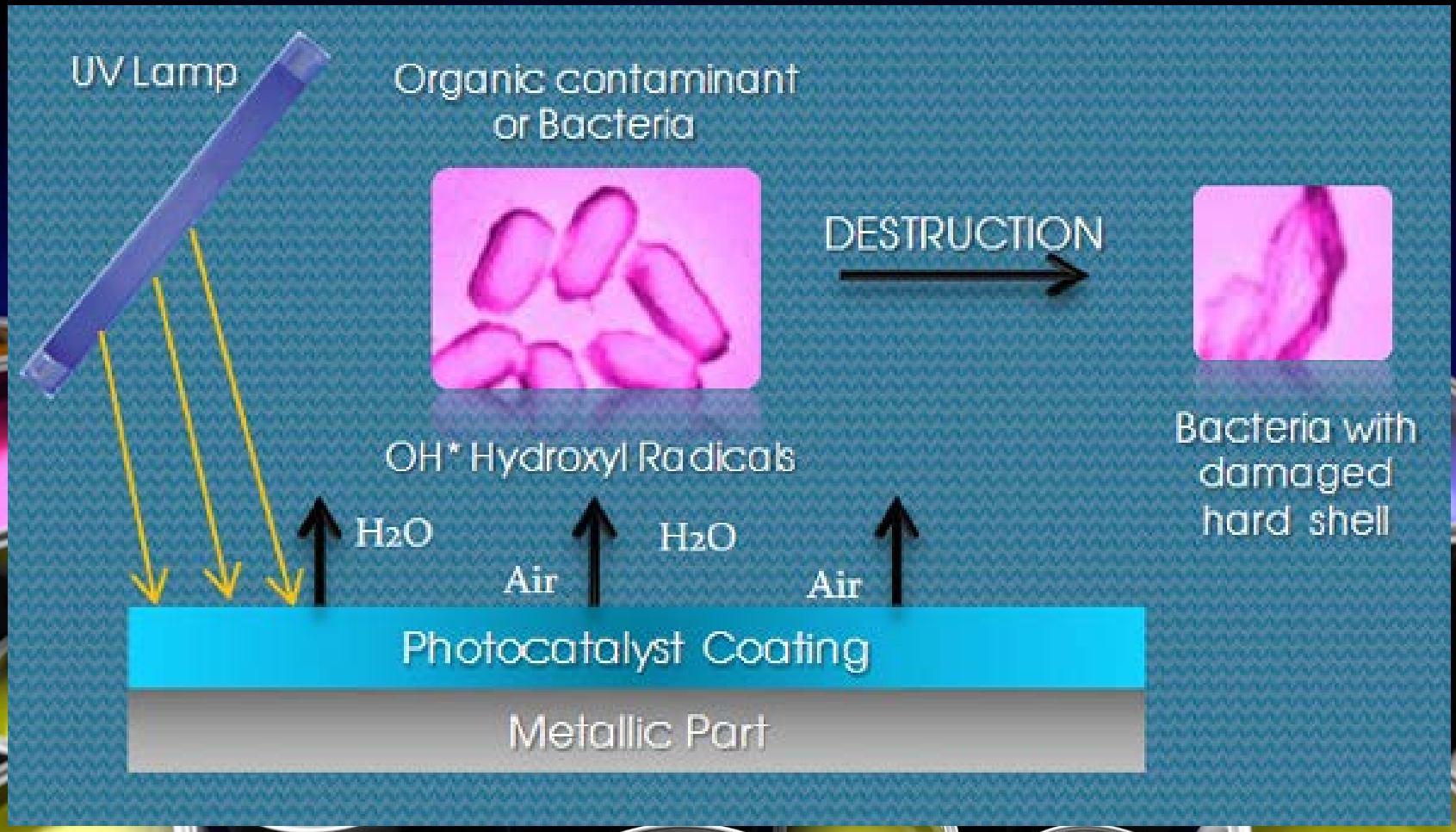
Whitlock et al. JHI 2016

Suggests that compressed salt is an effective antimicrobial surface

Intriguing and hypothesis generating – requires further study

Photoactivated Paints

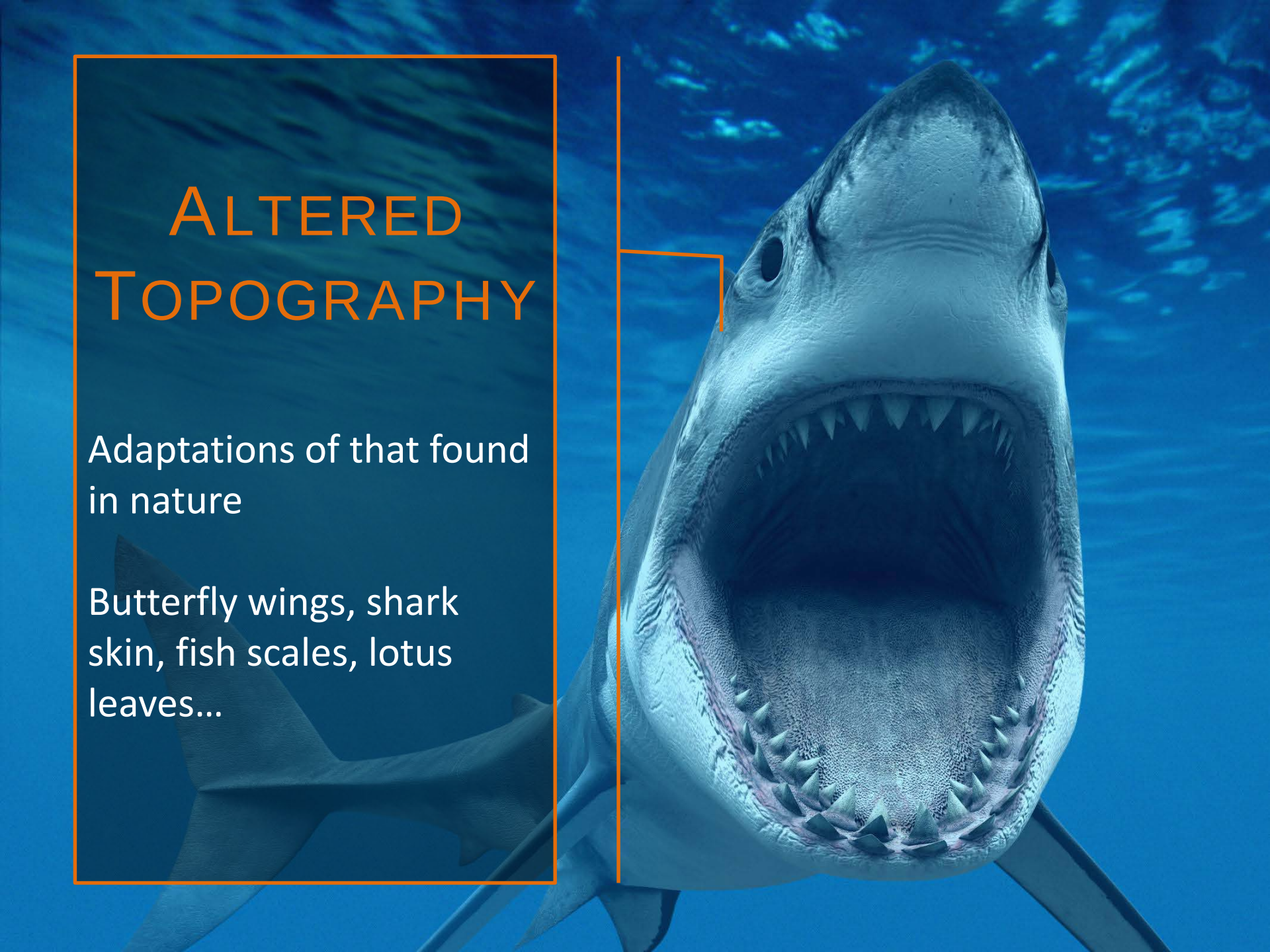
e.g. Titanium dioxide
photoactivated, self-cleaning
UV or fluorescent activation


UV Lamp
Organic contaminant
or Bacteria
DESTRUCTION
Bacteria with
damaged
hard shell
OH* Hydroxyl Radicals
H2O
Air
H2O
Air
Photocatalyst Coating
Metallic Part

Altered Topography

Adaptations of that found in nature

Butterfly wings, shark skin, fish scales, lotus leaves…



GENBMT PILOT PROJECT: HCW/Patient/Environmental Surveillance on the Bone Marrow Transplant Ward

T. WOZNOW [1,2], T. WONG [1,2,3], A. STEFANOVIC [1,2,3], L. HOANG [3,4], M. CROXEN [4], R. BROADY [2,3,5], R. DIXON [6], E.A. BRYCE [1,2,3]

1. Division of Medical Microbiology and Infection Prevention and Control, 2. Vancouver Coastal Health, B.C., 3. University of British Columbia, 4. B.C. Public Health Microbiology and Reference Laboratory, Provincial Health Services Authority, 5. Leukemia/Bone Marrow Transplant Program, 6. Coalition for Health Acquired Infection Reduction (CHAIR) Canada

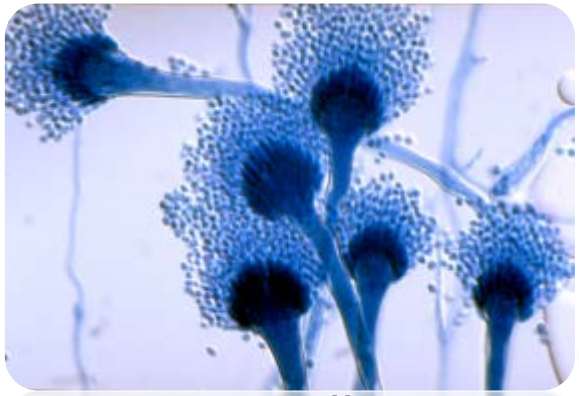
Acknowledgements

The patients, the Nursing staff of the BMT Unit, UBC & VGH Hospital Foundation, Mr. George Poling, CHAIR Canada, BCCDC Provincial Laboratory, VGH Medical Microbiology Laboratory, Genome BC

Bacteria and Other Microbes Live Everywhere in the Environment

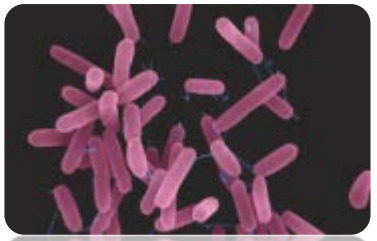
There are 10 times more bacteria on our bodies than our own cells!

Bone Marrow Transplant Patients are Especially Vulnerable to Healthcare-Associated Infections

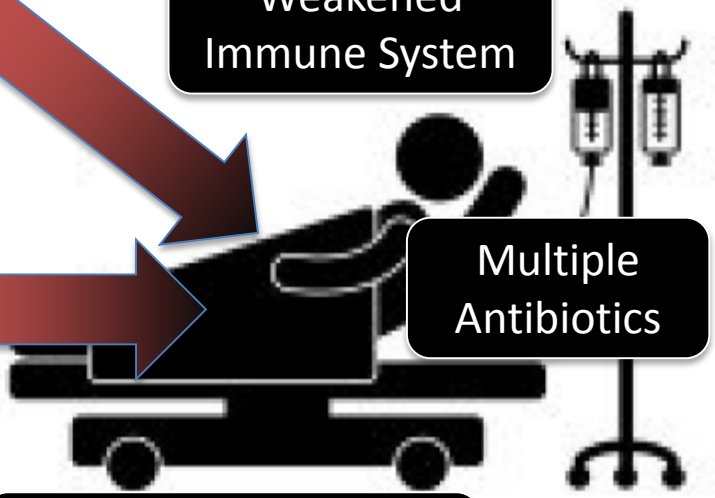


Aspergillosis

Weakened Immune System



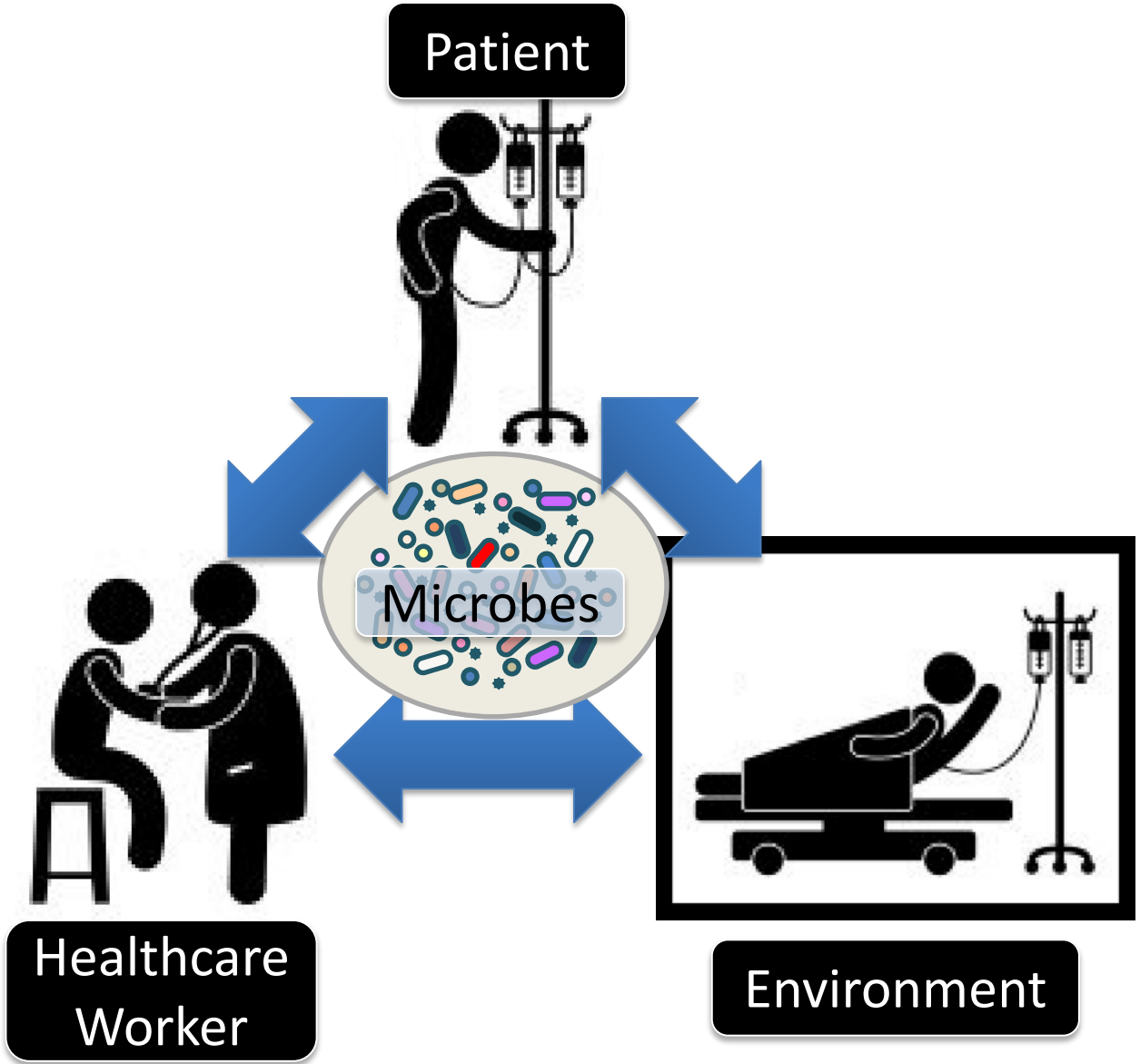
Clostridium difficile



Multiple Antibiotics

Treatment Requires Lengthy Hospital Stay

Understand HOW and WHEN Microbes are Transmitted in BMT Patients



Pilot Study: Impact of Re-engineered rooms in Bone Marrow Transplant Patients

Regular Room versus **Re-engineered Room**

Objectives

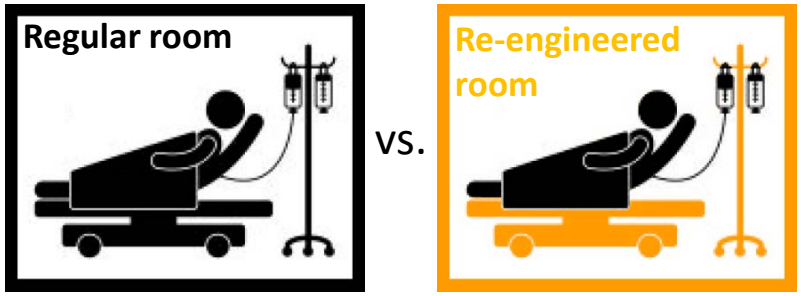
- Assess the impact of re-engineered BMT rooms on microbial bioburden
- Assess the impact of re-engineered BMT rooms on HCW bacterial flora
- Assess the feasibility of collecting specimens and maintaining re-engineered rooms over a one-year period

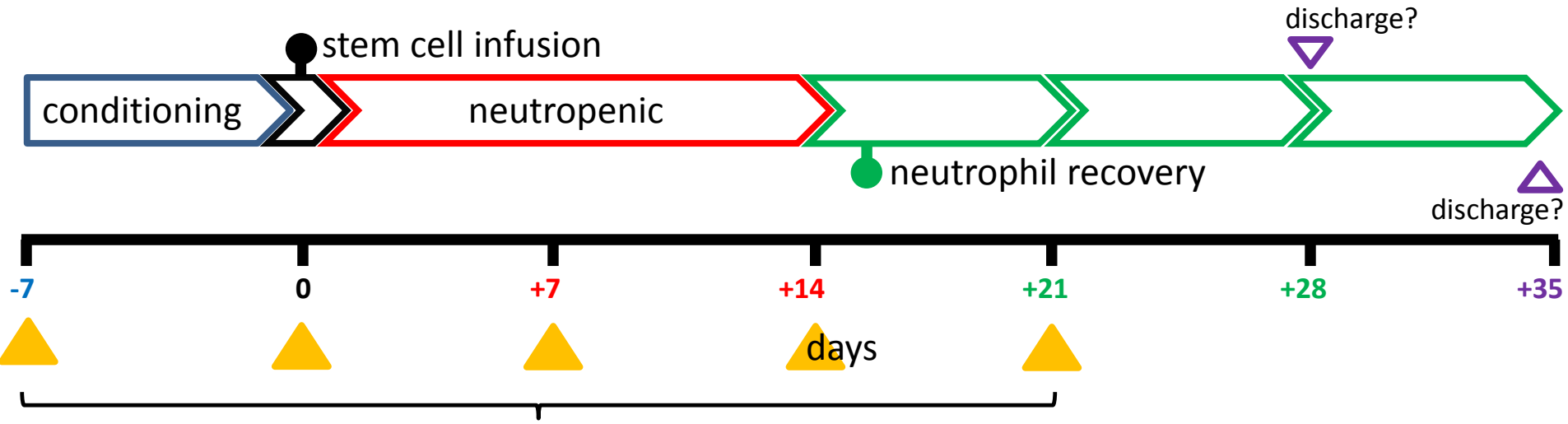
Methods

- One year pilot: nine AML patients undergoing Bone Marrow Transplant (BMT) randomized to standard or re-engineered room for ENTIRE duration of stay
- Weekly sampling of a) seven high touch surfaces b) Air (SAS Dual Head Air Sampler) and c) Water (membrane filtration method)
- Weekly sampling of the Healthcare worker and consented patients
  - HCWs = nares, hands, perineum
  - Patients = Baylor wash, stool sample, axillae

USE CONVENTIONAL MICROBIOLOGY TO IDENTIFY TARGET ORGANISMS AND GENOMICS TO LOOK AT THE MICROBIOME (STILL IN PROGRESS)

Study Design





Patient, environment and healthcare worker sampling

REENGINEERED PATIENT ROOM

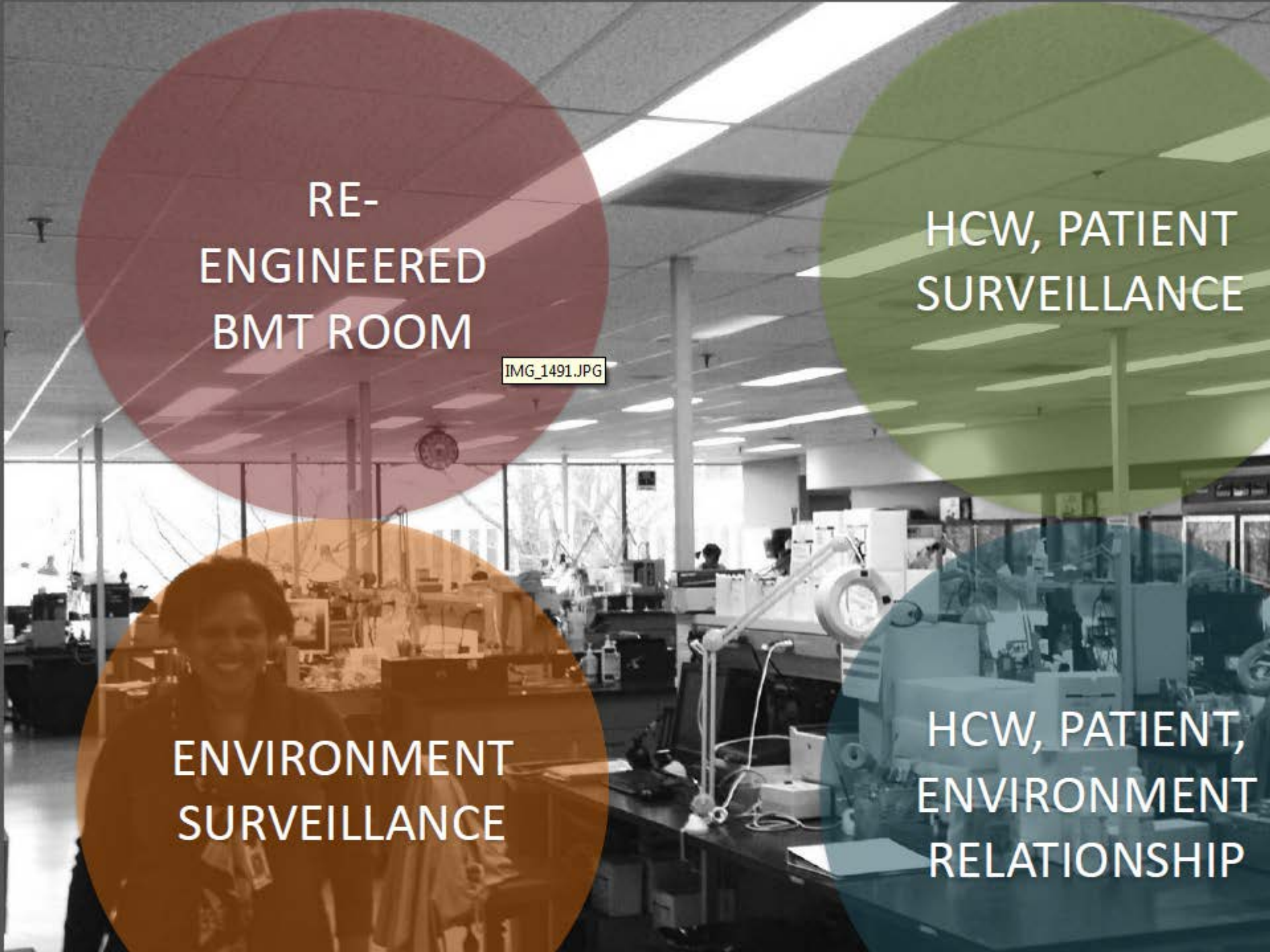
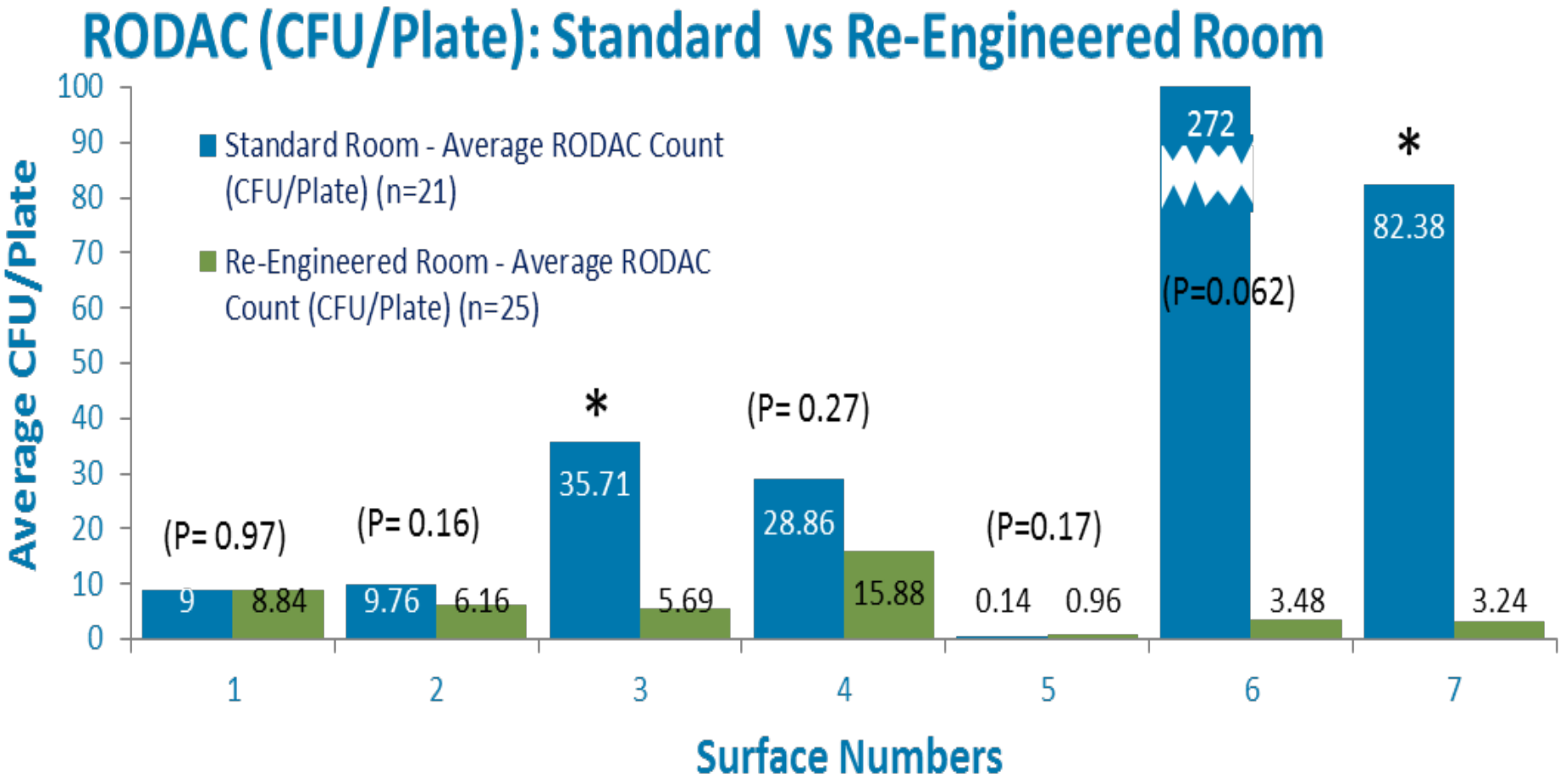
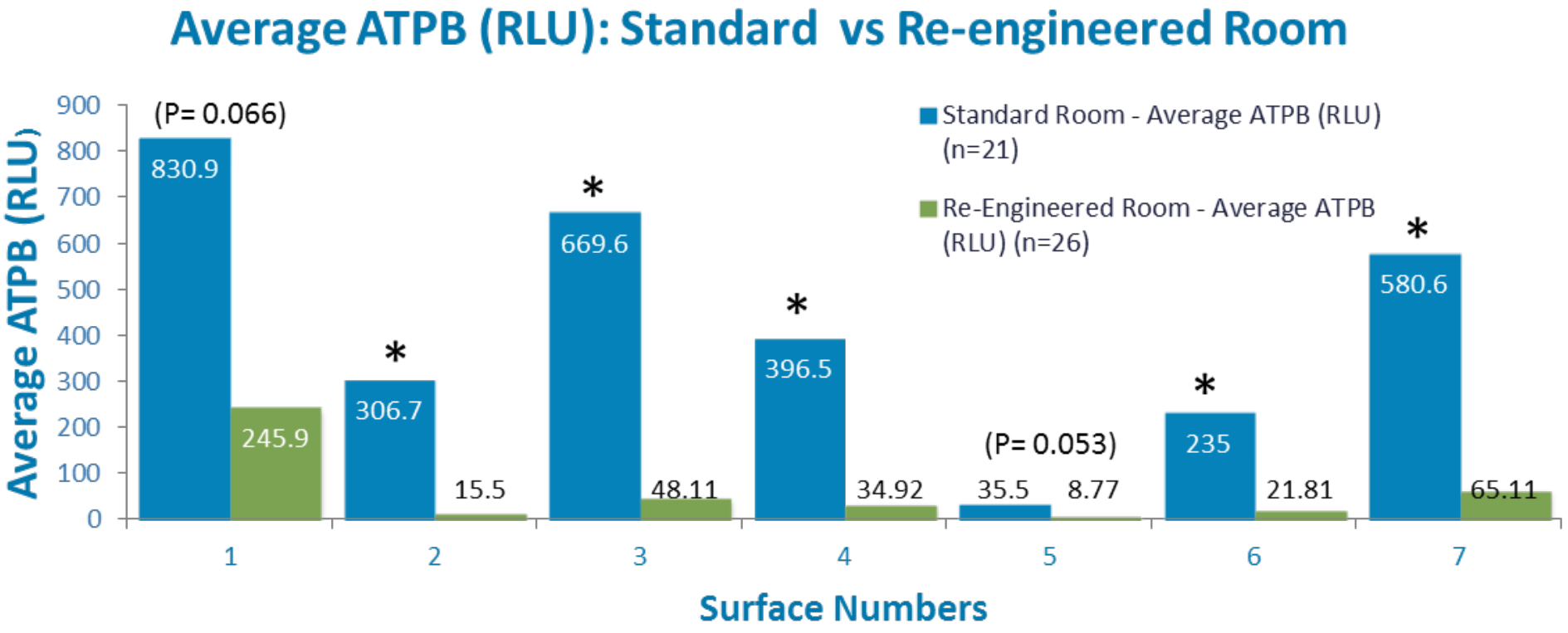

RE-
ENGINEERED
BMT ROOM
IMG_1491.JPG
HCW, PATIENT
SURVEILLANCE
ENVIRONMENT
SURVEILLANCE
HCW, PATIENT,
ENVIRONMENT
RELATIONSHIP

TABLE 1: Microbial Bio-Burden Standard vs Re-Engineered Rooms

Environment	*Units*	*Standard Room*	*Engineered Room*	*p-Value*
Surfaces	Average CFU/Plate	62.6 (n=147)	6.32 (n=175)	0.0083
	Average RLU	434.4 (n=147)	62.9 (n=182)	0.0001
Water	Average CFU/plate	26.5 (n=20)	0.08 (n=25)	0.0007
Air	Average CFU/plate	14.2 (n=21)	15.6 (n=25)	0.8145



1. Overbed table 2. Bedside table 3. Chair armrest 4. Bedrail. 5. Wall console 6. Toilet seat 7. Bathroom sink



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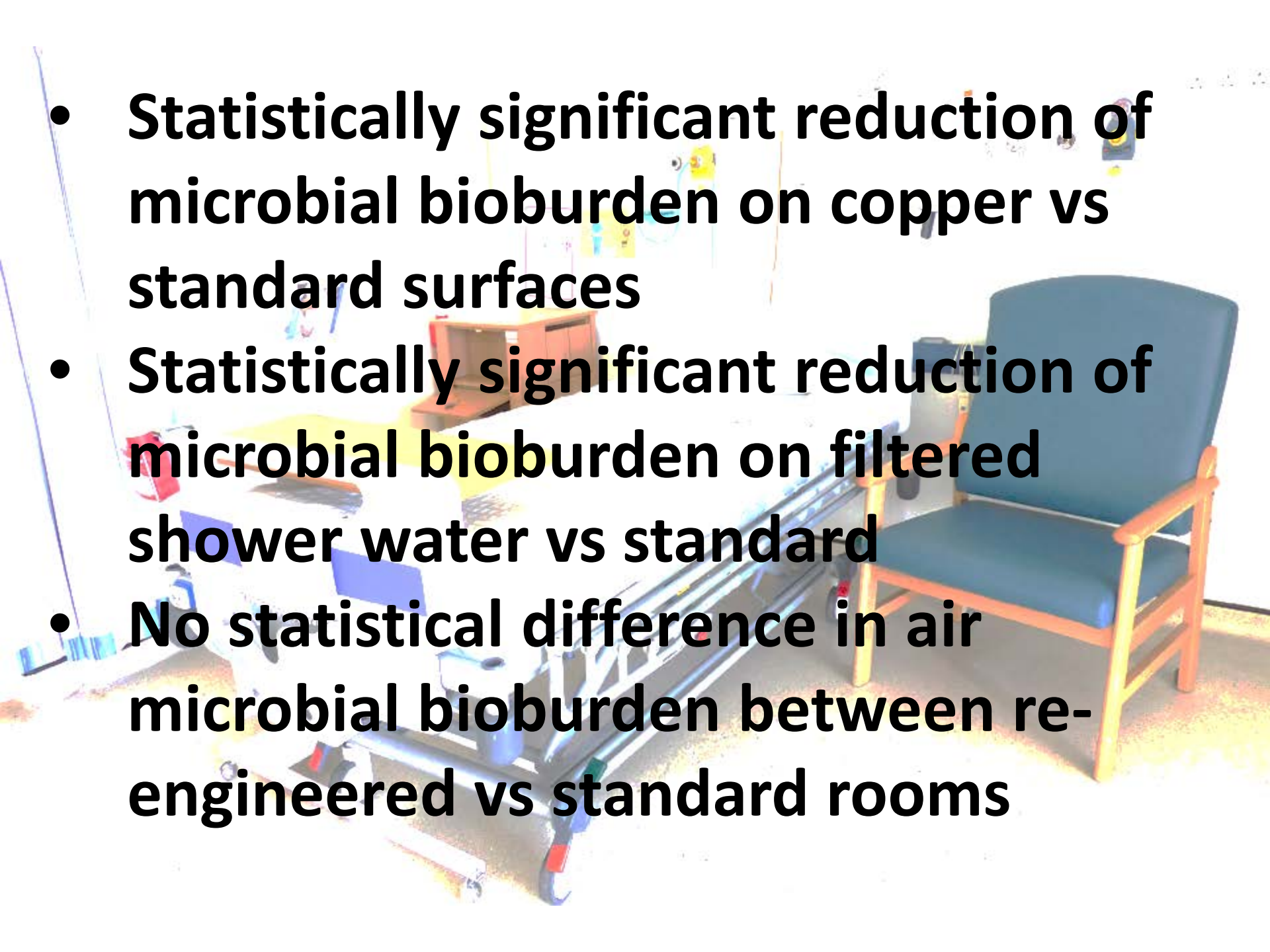
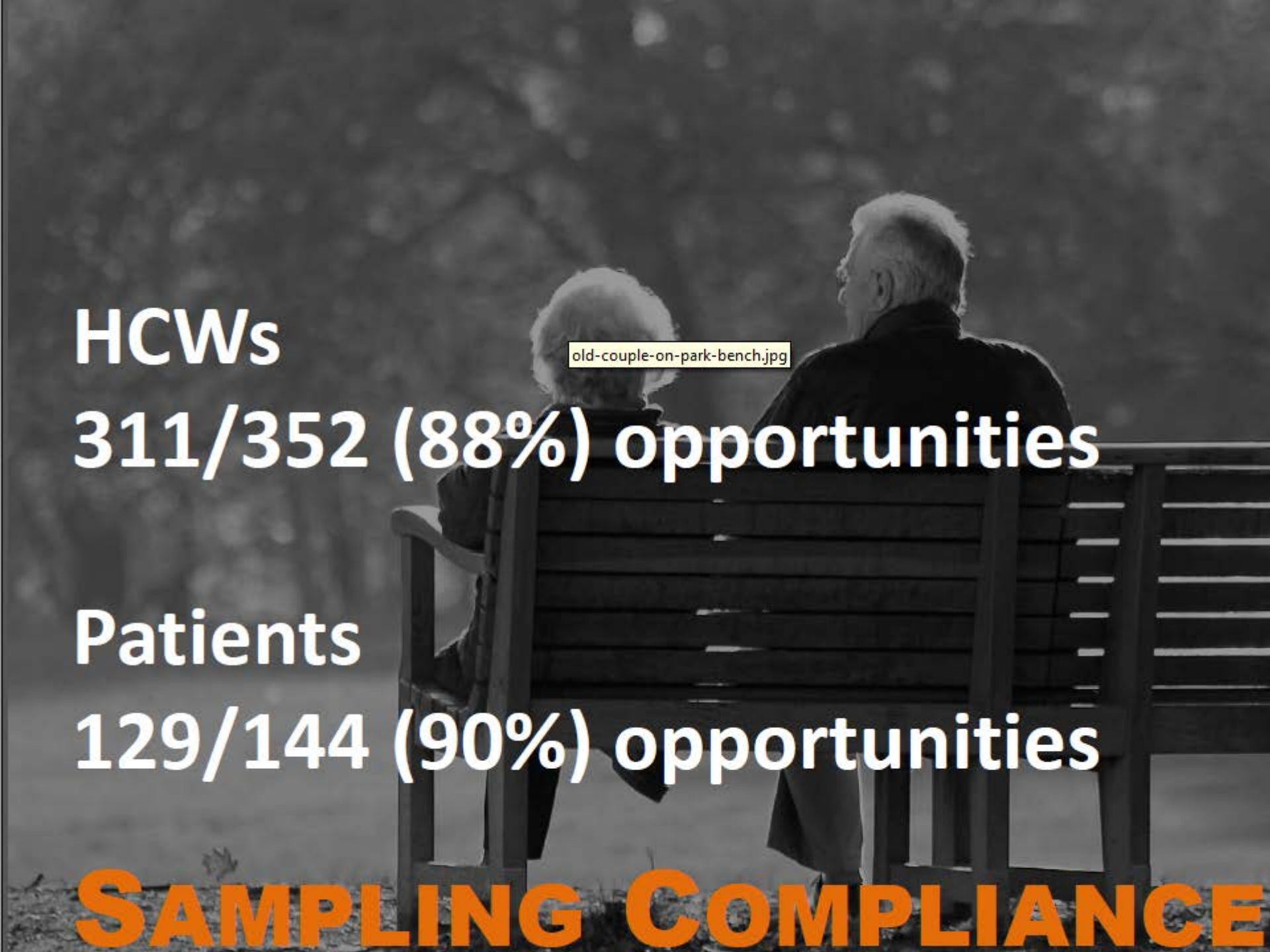


- Statistically significant reduction of microbial bioburden on copper vs standard surfaces
- Statistically significant reduction of microbial bioburden on filtered shower water vs standard
- No statistical difference in air microbial bioburden between re-engineered vs standard rooms



HCWs

311/352 (88%) opportunities

Patients

129/144 (90%) opportunities

Sampling Compliance

Staphylococcus aureus carriage

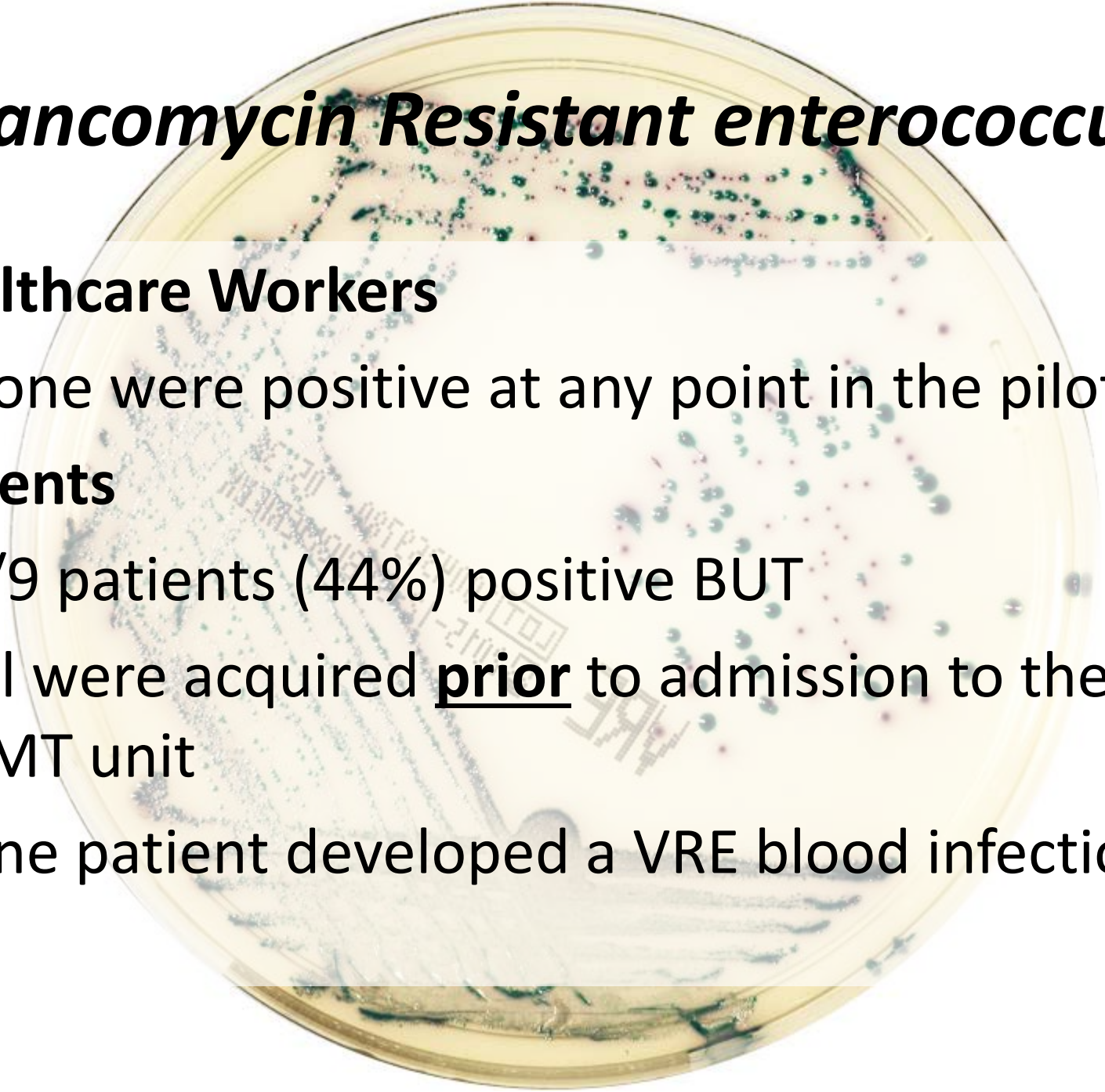
Healthcare Workers

- 9/32 (28%) positive for sensitive S.aureus
  - 5/9 persistently colonized & 2/9 transiently colonized (2/9 HCWs only tested once so colonization persistence is unknown)
  - 1/32 (3%) positive for MRSA (transiently only)

Patients

- 2/9 (22%) positive
- No patients positive for MRSA

Vancomycin Resistant enterococcus



Healthcare Workers

- None were positive at any point in the pilot

Patients

- 4/9 patients (44%) positive BUT
- All were acquired **prior** to admission to the BMT unit
- One patient developed a VRE blood infection

Clostridium difficile

Healthcare workers

- **None were positive at any time in the pilot**

Patients

- **6/9 (72%) positive**
- **1 was acquired at VGH and developed clinical symptoms requiring treatment**
- **The rest had C.difficile prior to admission**

PILOT KEY FINDINGS

1. Low ARO colonization in healthcare workers
2. High ARO colonization in patients
3. High compliance for ARO surveillance
4. Lower microbial counts on re-engineered rooms

Limitations

1. small pilot study
2. surveillance compliance was not 100%

Next Steps

1. BCCDC PHL analysis of genomics data (LH, MC, AK)
2. Take lessons learned to inform larger, multi-center study

1. Durability in a healthcare environment

2. Potential development of resistance to the self-disinfecting “material”

3. Interaction with hospital cleaners/disinfectants

4. Maintenance and operational costs in addition to capital costs

5. Incremental benefit in reducing infections

Innovation is the only way to win

Steve Jobs