Journey on Environmental Cleaning to UV-C Disinfection to Minimize HAI Cross-transmission risk at The Ohio State University

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Background

- Healthcare associated infections (HAIs):
  - Not present on admission; organisms-often multidrug resistant (MDRO), get to patient from hands of HCW and/or environment
    - MRSA, VRE, CRE, *A. baumannii* (MDRO) and *C. difficile*
    - Minimizing **risk** warrants a multifaceted approach with hand hygiene, antimicrobial stewardship, contact isolation and environmental cleaning/disinfection

Objective

- To share initial research on: environmental cleaning, the Surfacide UV-C emitter system and see a real world study of efficacy.
- Present OSUMC data over 4 years on:
  - Healthcare onset *C. difficile* infections (HO-CDI)
  - Implementation of multi-emitter systems over time

Transmission of Healthcare associated Pathogens

TABLE 2. Effect of the Colonization or Infection Status of the Prior Room Occupant on the Acquisition of Pathogens by Subsequent Occupants of the Same Room

Reference	Setting (study design)	Findings	Variables	Acquired	Did not acquire	Percentage difference	Adjusted ratio (95% CI)
Martinez et al[65] (2003)	ICU, USA (9-month retrospective case-control study)	Placement within a room from which VRE had been cultured was associated with VRE acquisition in the subsequent room occupant	Admitted to room from which VRE had been cultured	13% of 30	2% of 60	87.5	OR: 81.7 (2.2–3,092)
Drees et al[26] (2008)	ICU, USA (14-month prospective cohort study)	Positive VRE room culture results or previous VRE-positive room occupants were associated with VRE acquisition	Positive culture before admission or acquisition	8.0% of 50	4.8% of 588	40.5	HR: 4.3 (1.5–12.5)
			Prior room occupant with VRE	38.0% of 50	20.2% of 588	46.7	HR: 3.8 (2.0–7.3)
			Any room occupant with VRE in past 2 weeks	60.0% of 50	41.8% of 588	30.3	HR: 2.7 (1.4–5.3)
Nseir et al[68] (2010)	ICU, France (12-month prospective cohort study)	Admission to a room previously occupied by an *A. baumannii*– or *P. aeruginosa*–positive patient was associated with acquisition of these pathogens	Prior room occupant with *A. baumannii*	28.1% of 57	7.9% of 454	71.8	OR: 4.2 (2.0–8.8)
			Prior room occupant with *P. aeruginosa*	25.6% of 82	14.9% of 429	41.7	OR: 2.3 (1.2–4.3)
				Prior room occupant status			
				Positive (% acquired)	Negative (% acquired)		
Huang et al[66] (2006)	ICU, USA (20-month retrospective cohort study)	Admission to a room previously occupied by a MRSA- or VRE-positive patient was associated with acquisition of these pathogens	VRE status of prior room occupant	4.5% of 1,291	2.8% of 9,058	37.1	OR: 1.4 (1.0–1.9)
			MRSA status of prior room occupant	3.9% of 1,454	2.9% of 8,697	28.8	OR: 1.4 (1.1–1.8)
Shaughnessy et al[67] (2008)	ICU, USA (18-month retrospective cohort study)	Admission to a room previously occupied by a *C. difficile*–positive patient was associated with *C. difficile* acquisition	*C. difficile* status of prior room occupant	11.0% of 91	4.6% of 1,679	58.3	HR: 2.3 (1.2–4.5)

NOTE. Martinez et al,[65] Drees et al,[26] and Nseir et al[68] compared associations listed in the Variables column in patients who did acquire the pathogen with patients who did not acquire the pathogen; Huang et al[66] and Shaughnessy et al[67] compared the frequency of patients who acquired the pathogen depending on the status of the prior room occupant. CI, confidence interval; HR, hazard ratio; ICU, intensive care unit; MRSA, methicillin-resistant *Staphylococcus aureus*; OR, odds ratio; VRE, vancomycin-resistant enterococci.

CID 2008

Arch of IM 2006

ICHE 2011

OtterJA, Yezli S, French GL. *ICHE* July 2011;32 (7):687-699.

Environmental Cleaning Reduces Microbial Contamination

- Physical action to remove organic / inorganic materials
- Application of a disinfectant
- Monitoring to assure surfaces including high touch surfaces (i.e. bedrails, remote, monitor, tray table, toilet) are cleaned.
  - Little guidance exists on how to best monitor compliance
  - Most research focuses on post cleaning data, with less on actual observations of in room cleaning; limitations of Hawthorne effect with observations
  - Our objective on this first study was to see how do the EVS clean the rooms?

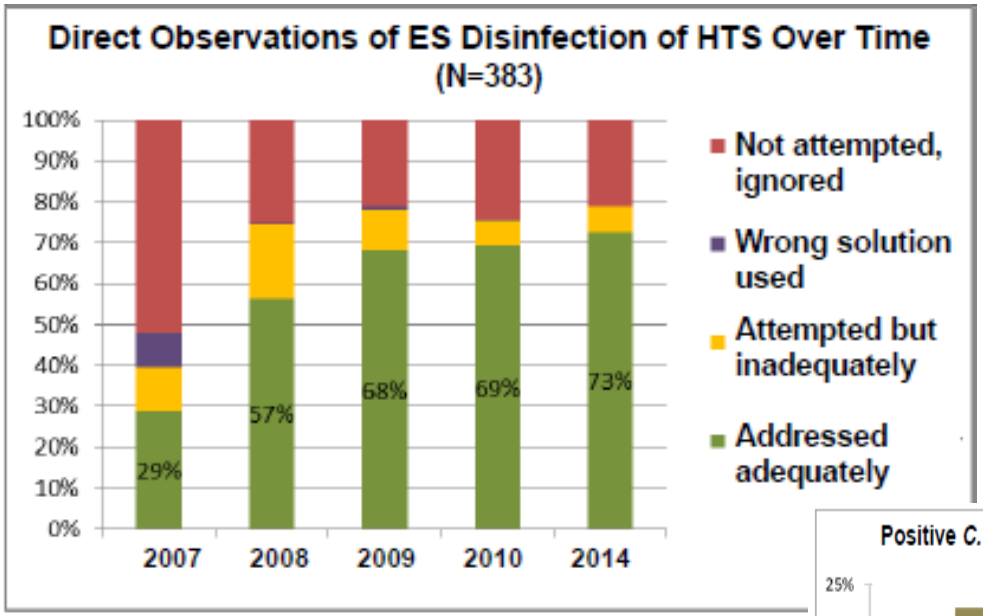
Mulvey D. *Jour of Hosp Infection* 2011 77;25-30
Penno K. *AJIC* 2017; 45:1208-13

Environmental Cleaning at the Cornerstone of Decreasing HAIs including *C. difficile* (Methods)

- Our focus was on inpatient units with highest HO-CDI rates
- Reviewed EVS policies; created observation checklist
  - Adequate= entire surface cleaned w/ approved solution
  - Attempted, but inadequate= only partial surfaces
  - Not attempted= ignored
  - Wrong cleaning agent= attempted, but non-approved solution
- IRB approved: introduction of observer, informed of intent
- Observations begun after an in-service with photos/written basics; third party EVS company in 5th year of study
- In 5th year, incorporated fluorescent targeted technology and environmental culturing for *C. difficile*.

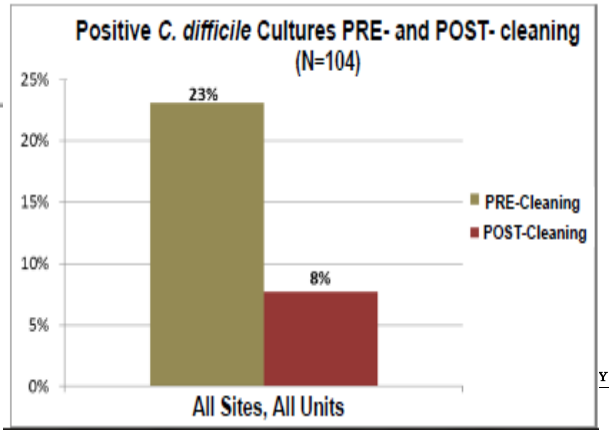
K Woods, JE Mangino Abstract 1374 IDSA 2014

Environmental Cleaning at the Cornerstone of Decreasing HAIs and CDI (Results)



Year 5:

In rooms without the observer, fluorescent markers confirmed ~64% surfaces cleaned (same units)



- Real time observations= 1 way to assess compliance
- Made recommendations to get to "adequate"
- Sustainable improvement requires ongoing re-education, monitoring, time

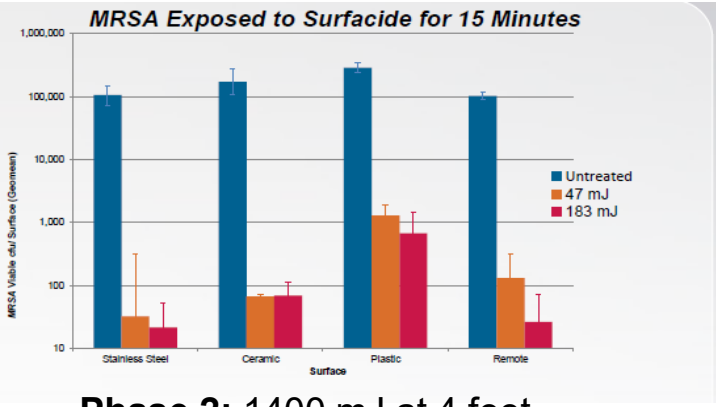
UV Disinfection: Energy Time and Distance to Eradicate MDRO and CDI

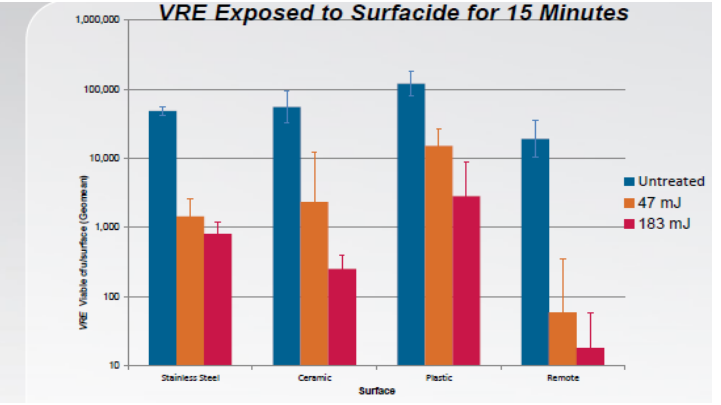
- A Surfacide™ UV-C emitter was created and asked to determine energy, distance and time to eradicate organisms.
- Hospital isolates: MRSA, VRE, *A. baumannii, CRE* and *C. diff* were inoculated on 4 representative surfaces: soft (remote) and textured hard plastic (bedrail), ceramic (tile) and stainless steel (faucet) autoclaved/ sterilized (3x4 in surfaces)
- Vegetative bacteria+*C. diff* spores inoculated on each surface;
  - Target of 500,000 CFU/cm^2; each surface was prepared in triplicate w/100µliters buffered peptone and controls
  - Surfaces air dried, placed at 4ft. (183mJ/cm^2) and 8 ft. (47mJ/cm^2) x15minuntes
  - Energy output initially developed based on prior publications
    - 22-26 mJ/cm^2 could be adequate?

Liscynesky C. et al. Poster 939 IDWeek 2012

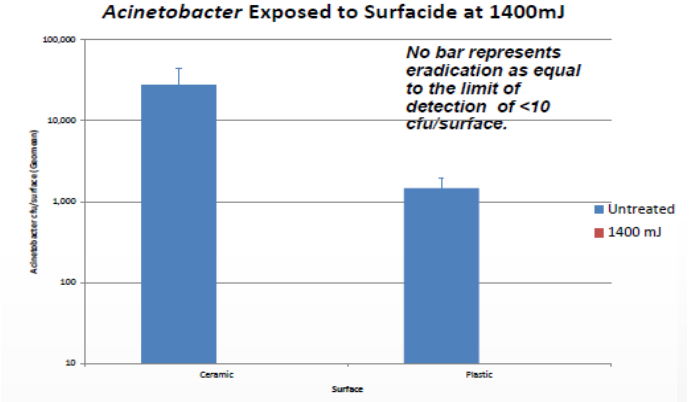
UV Disinfection: Energy Time and Distance to Eradicate MDRO and CDI

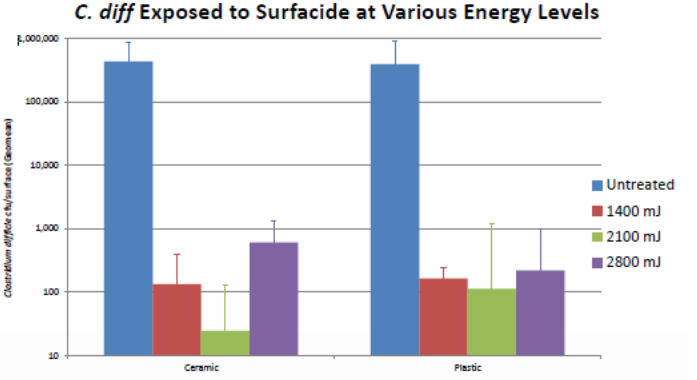
Phase 1: at 8 ft (47mJ) and 4 ft (183mJ)





Phase 2: 1400 mJ at 4 feet





 Liscynesky, C. et al Poster 939 IDWeek 2012

Effect of Surface Type, Orientation, and Energy Delivery on the Efficacy of a UV-C Disinfection system: How much Energy is Enough?

- After OSU phase 1/ 2 studies, goal was to put surfaces in a hospital room location where that surface normally is; estimate UV-C dose to impact reductions, with at least 1500mJ/cm^2 delivery. This represented redesigned increased output.
- *C. diff,* MRSA, VRE, *A. baumannii* and CRE-*KP* were targeted for a minimum inoculum of 5 x 10^5 CFUs/cm^2
  - Inoculated coupons were placed on top of corresponding representative surfaces: ceramic (toilet), smooth and textured plastic (remote, bedrails, monitor), stainless steel, (faucet, sink)
  - No moving of emitters necessary.
  - Data shown as log 10 reductions of CFUs vs controls

Boyce demonstrated that energy delivery is effected by shadows, distance from emitter and surface orientation.

Boyce J et al Impact of Room Location on UVC irradiance dosage and antimicrobial effect Delivered by a mobile UV device. *ICHE* 2016;37;667-672.

Surfacide™ Triple Emitter System (Waukesha, Wi)

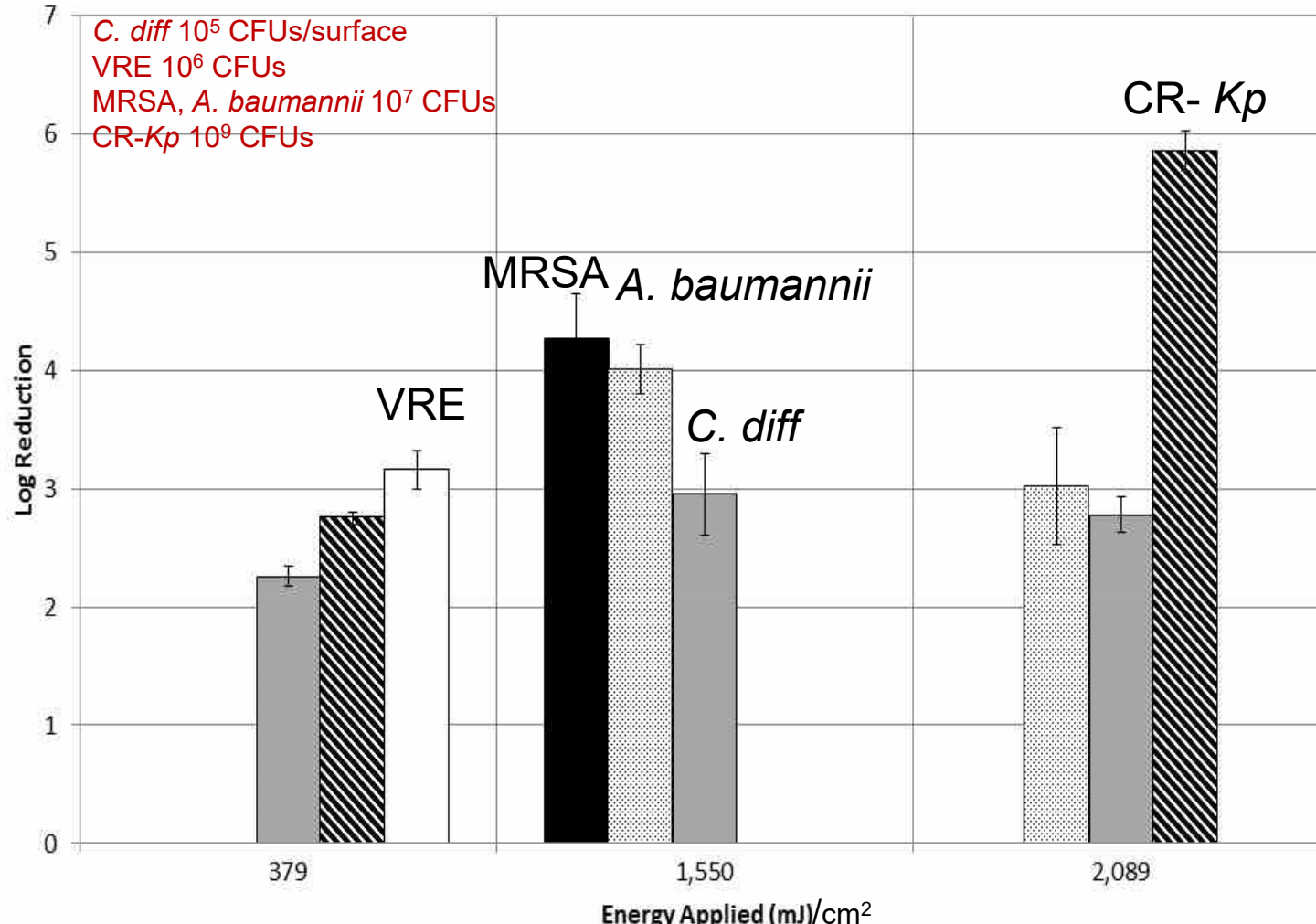
- 1 tower is 77 in. tall and 23 in. wide
- Position to minimize shadows (i.e. indirect surfaces) with 3 towers to deliver more energy in less time w/ reduced distance in one cycle.
- Laser mapping measures room size, objects, determines disinfection time
  - Studies done in room 256 sq meters + bathroom of 46 sq meters
- Electronic touch screen tablet controls emitters remotely

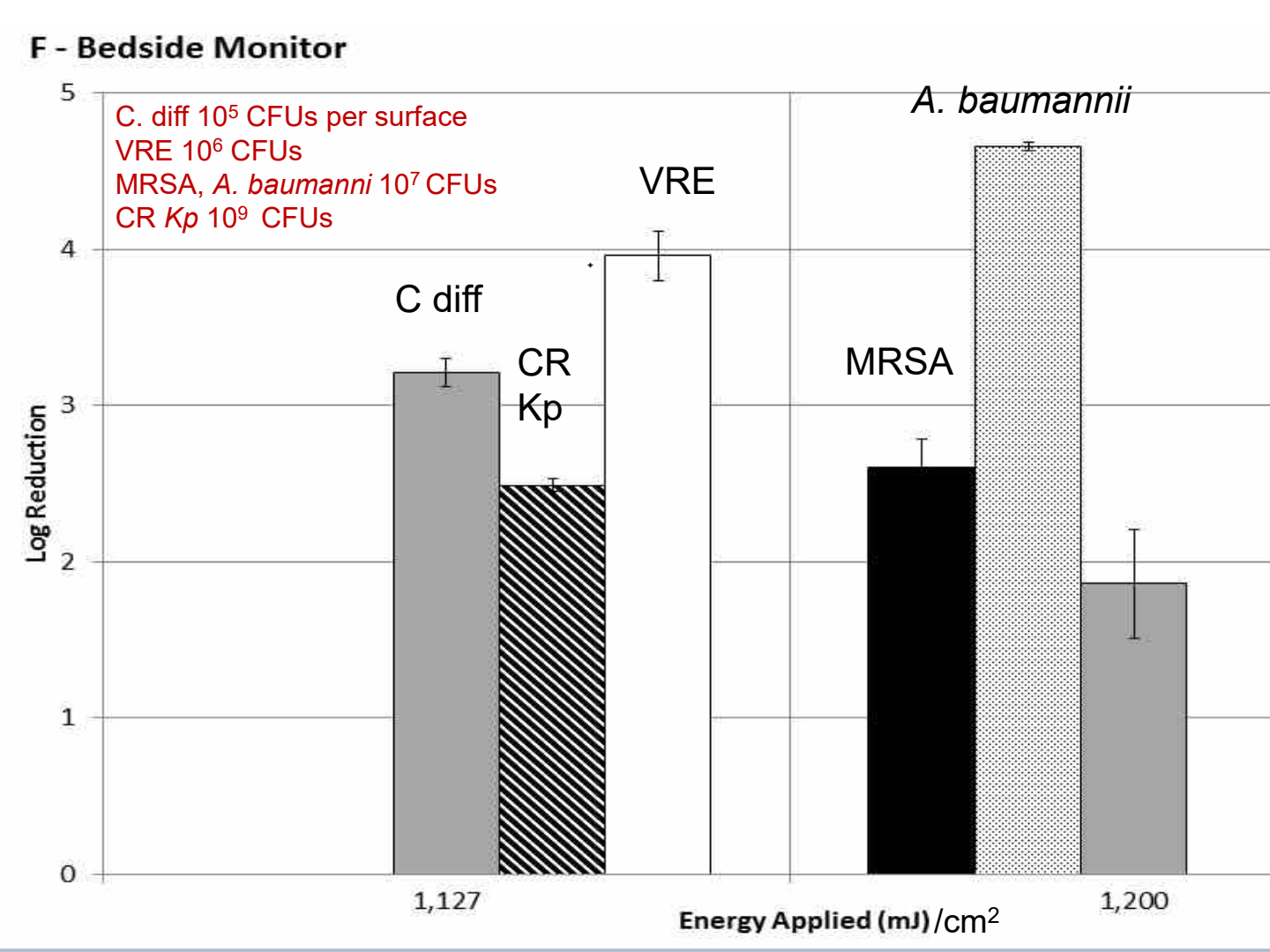
- Energy delivered ranged from 47-4,518 mJ/cm^2 over 3 study times and not all organisms were studied at each mJ/cm^2

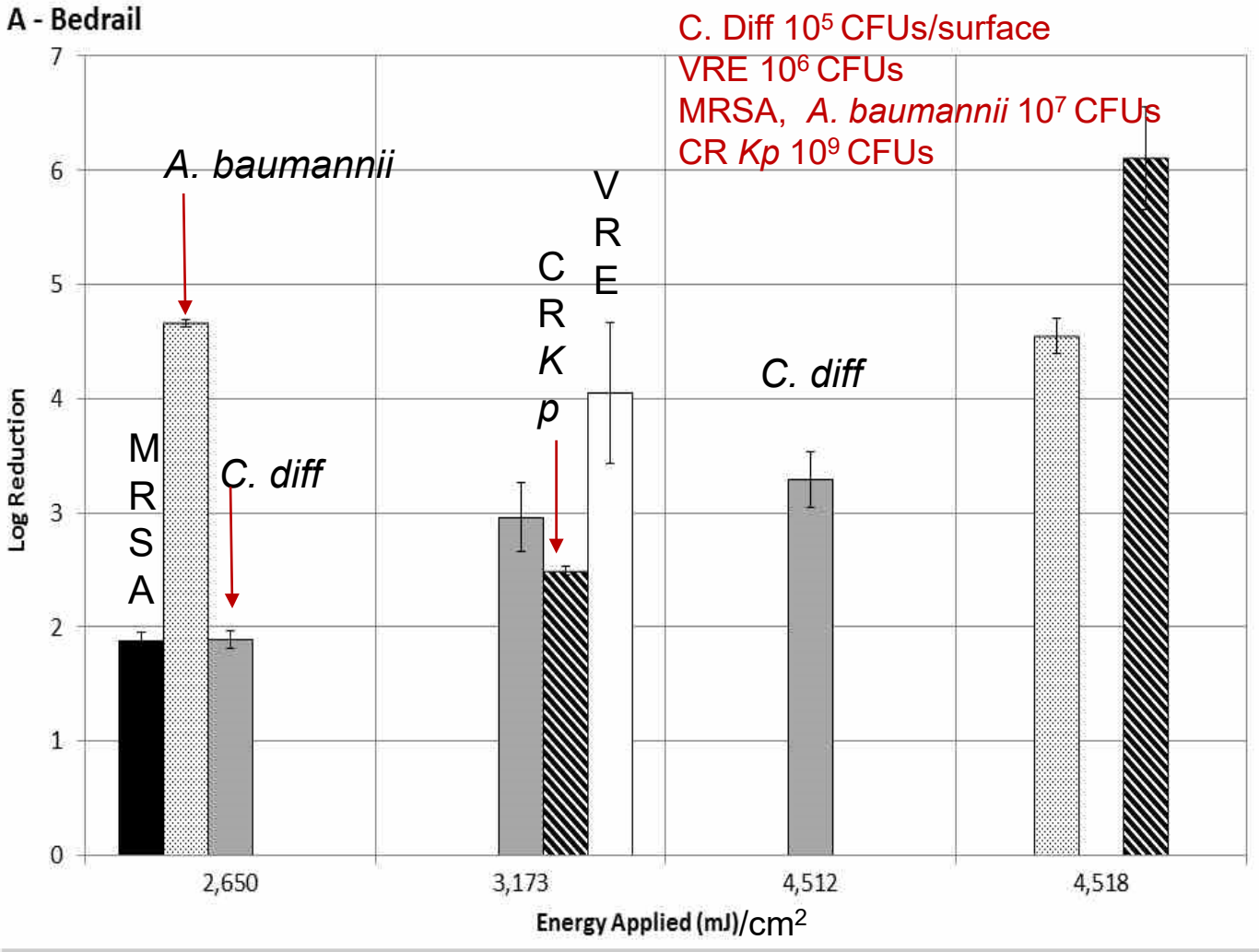
(1 J=1000mJ or 1,000,000μWs)

E - Toilet Seat

Data bars not present at energy level indicate organism was not tested at that energy level.




F - Bedside Monitor
C. diff 10^5 CFUs per surface
VRE 10^6 CFUs
MRSA, A. baumanni 10^7 CFUs
CR Kp 10^9 CFUs
A. baumannii
VRE
C diff
CR
Kp
MRSA
Log Reduction
5
4
3
2
1
0
1,127
1,200
Energy Applied (mJ)/cm2


A - Bedrail
C. Diff 10^5 CFUs/surface
VRE 10^6 CFUs
MRSA, A. baumannii 10^7 CFUs
CR Kp 10^9 CFUs
A. baumannii
MRSA
C. diff
CRKp
VRE
C. diff
Log Reduction
0
1
2
3
4
5
6
7
2,650
3,173
4,512
4,518
Energy Applied (mJ)/cm2

The Effect of Ultraviolet Light on *C. difficile* Spore Recovery Versus Bleach Alone

TABLE 1. *Clostridium difficile* Culture Results: Effectiveness of Manual Cleaning Versus UV-C

	Post Bleach CFUs		Post UV-C CFUs	
Site	≥10 CFUs	<10 CFUs	≥10 CFUs	<10 CFUs
Over-bed table	13	41	0	54
Toilet seat	9	65	0	74
Computer keyboard	3	19	1	43
Bathroom doorknob	2	20	0	22
Faucet handles	2	39	0	41
Bed side rails	1	3	0	4
Bedside commode	1	11	0	12
Recliner chair table	1	6	0	7
Call light	0	2	0	2

NOTE. CFU, colony-forming units; UV-C, ultraviolet light at 254 nanometers.

N=476 cultures

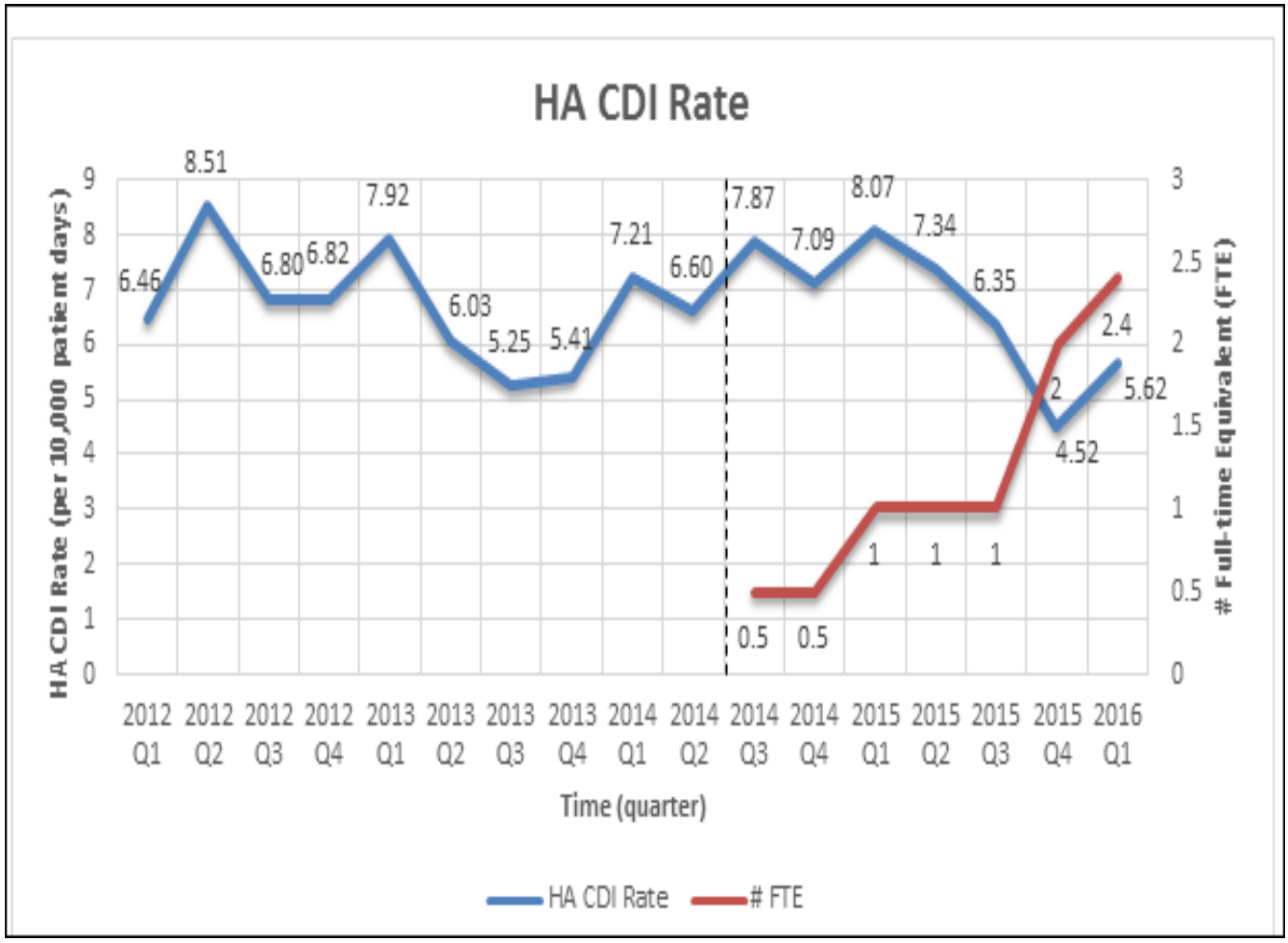
Post bleach
32/328 (13%) + w/ ≥10CFU

Post UV
1/238 (0.4%) + (keyboard had 10CFU)

<10=0-9 CFUs

OR 0.027; P<0.001

Liscynesky C et al *ICHE 2017:1116-7.*


HA CDI Rate
HA CDI Rate (per 10,000 patient days)
Full-time Equivalent (FTE)
Time (quarter)
2012 Q1
2012 Q2
2012 Q3
2012 Q4
2013 Q1
2013 Q2
2013 Q3
2013 Q4
2014 Q1
2014 Q2
2014 Q3
2014 Q4
2015 Q1
2015 Q2
2015 Q3
2015 Q4
2016 Q1
6.46
8.51
6.80
6.82
7.92
6.03
5.25
5.41
7.21
6.60
7.87
7.09
8.07
7.34
6.35
4.52
5.62
0.5
0.5
1
1
1
2
2.4
HA CDI Rate
FTE

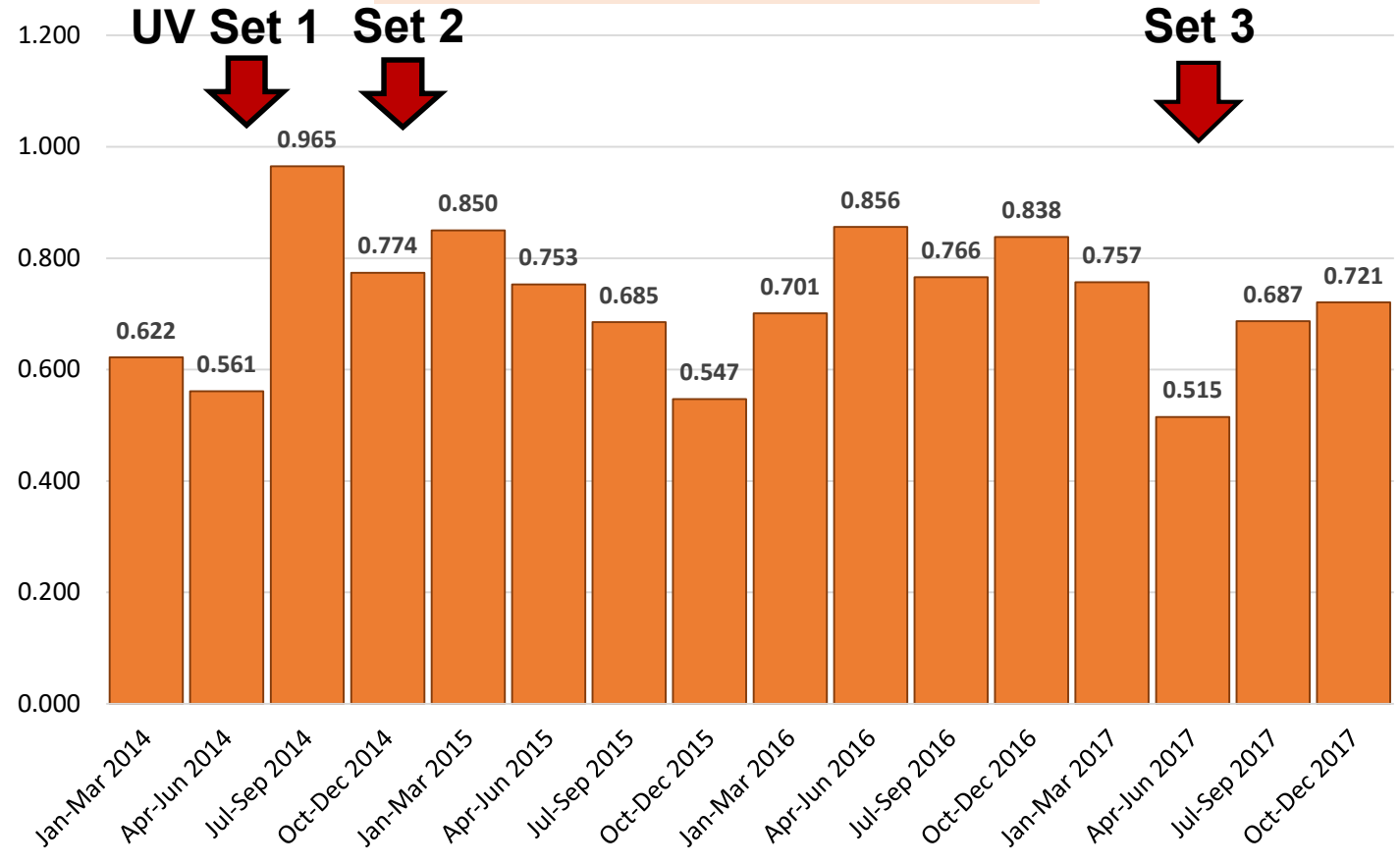
University Hospitals Ultraviolet-C Treatments

QRT	FISCAL YEAR	UV Treated	Isolation / Discharge	Restroom	OR	CATH PACU IPR	TOTAL	FTE
2014 QRT 3	14	July	11	0 0			11	0.5
	14	Aug	3	0			3	0.5
	14	Sept	8	0			8	0.5
2014 QRT 4	14	Oct	6	0			6	0.5
	14	Nov	11	0			11	0.5
	14	Dec	8	0			8	0.5
2015 QRT 1	15	Jan	3	0			3	0.5
	15	Feb	14	70			84	1
	15	Mar	15	100			115	1
2015 QRT 2	15	April	20	80		3	103	1
	15	May	14	40		10	64	1
	15	June	15	62		12	89	1
2015 QRT 3	15	July	0	45	0	0	45	1
	15	Aug	0	88	0	0	88	1
	15	Sept	0	30	0	0	30	1
2015 QRT 4	15	Oct	0	0	0	0	0	1
	15	Nov	68	5	0	0	73	2
	15	Dec	35	131	8	5	179	2
2016 QRT 1	16	Jan	47	377	0	0	424	2.4
	16	Feb	75	508	0	0	583	2.4
	16	Mar	43	738	30	53	864	2.4
2016 QRT 2	16	April	30	905	29	80	1044	2
	16	May	15	845	54	135	1049	2
	16	June	31	778	63	171	1043	2
2016 QRT 3	16	July	15	629	62	77	783	2
	16	August	23	488	79	166	756	1.8
	16	Sept	41	248 ◊◊	62	115	466	1.8
2016 QRT 4	16	Oct	24	388	65	362	839	1.8
	16	Nov	18	410	65	167	660	1.8
	16	Dec	69	243	54	132	498	2
2017 QRT 1	2016	Jan						
	2016	Feb						
	2016	Mar						

◊◊Lost data on tablet– (250 treatments estimate)

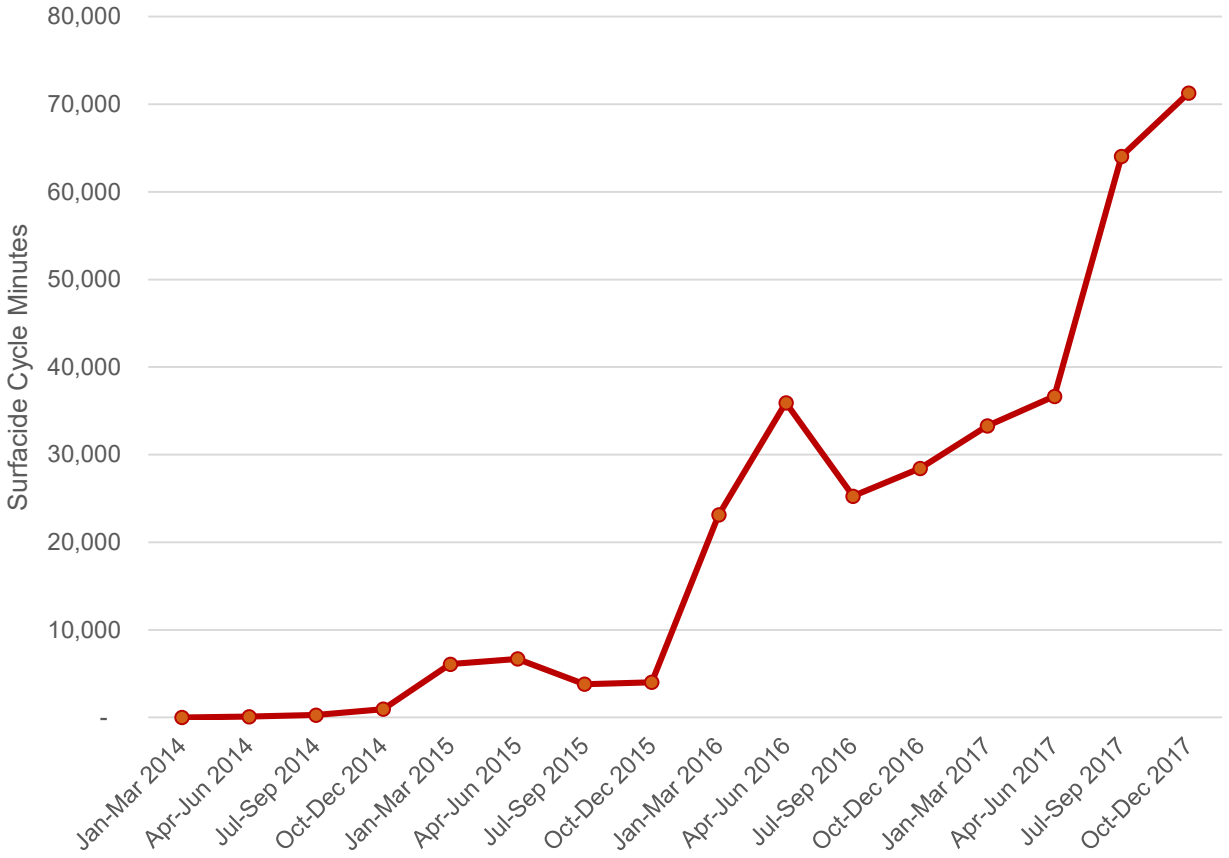
2016 Q 3 staffing shortage-- UV tech did discharge room cleaning

OSUWMC CDI Standardized Infection Ratio



- 2014 SIR based on NHSN CMS Baseline Set 1
- 2015- 2017 SIR based on NHSN CMS Baseline Set 2

OSUWMC: Total Surfacide Cycle Minutes



Conclusions

- Environmental cleaning alone is rarely optimal.
- This multi-emitter system Surfacide™ showed:
  - Vegetative organisms are quicker to eradicate than spores;
  - Varying surface, orientation, organism burden and distance determines actual amount of energy delivered
    - Minimizing distance from emitter(s) to surfaces, maximizes energy delivered
  - Laser technology maps objects before each cycle to determine size of room, surfaces and length of cycle
  - Real world experience w/ *C. difficile* spores before and after UV-C validated efficacy
- Close collaboration of Clinical Epidemiology and EVS has led to improved healthcare onset *C. difficile* rates (HO-CDI) and much increased pride by EVS.

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Thank YOU!

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