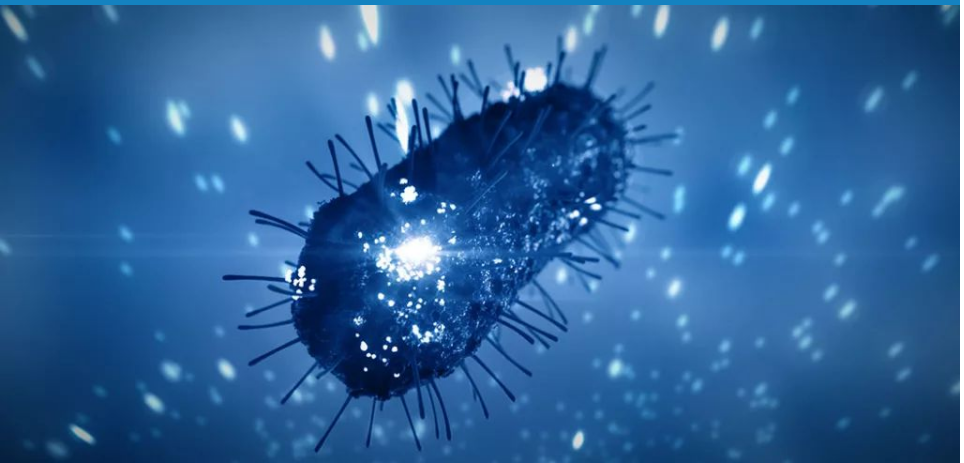
North Dakota
Infection Prevention Conference

UV-C Technology for Enhanced Disinfection: Show Me the Science



UVD ROBOTS

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VP Infection Prevention and Clinical Excellence

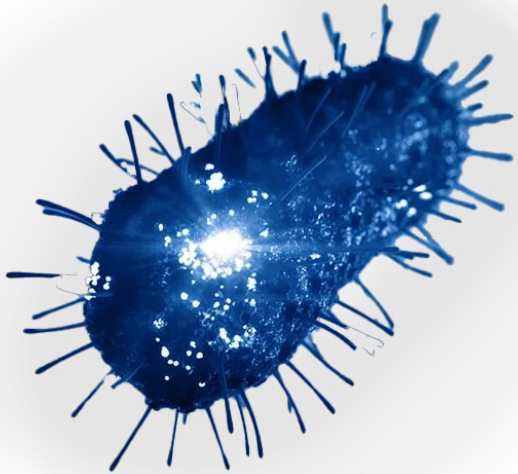
Debra brings over thirty years experience in clinical epidemiology, quality and patient safety. She received a Bachelor of Science degree in clinical laboratory science. She worked in a clinical microbiology laboratory for ten years before transitioning into epidemiology.. She is board certified by CBIC and has maintained this certification for thirty years.

Debra has utilized her leadership and experience to lead clinical roles within industry as Clinical Science Liaison, Clinical Program Manager, and Director of Clinical Affairs for several major companies in healthcare solutions before assuming the role of Vice President, Infection Prevention and Clinical Excellence, for Blue Ocean Robotics.

Objectives

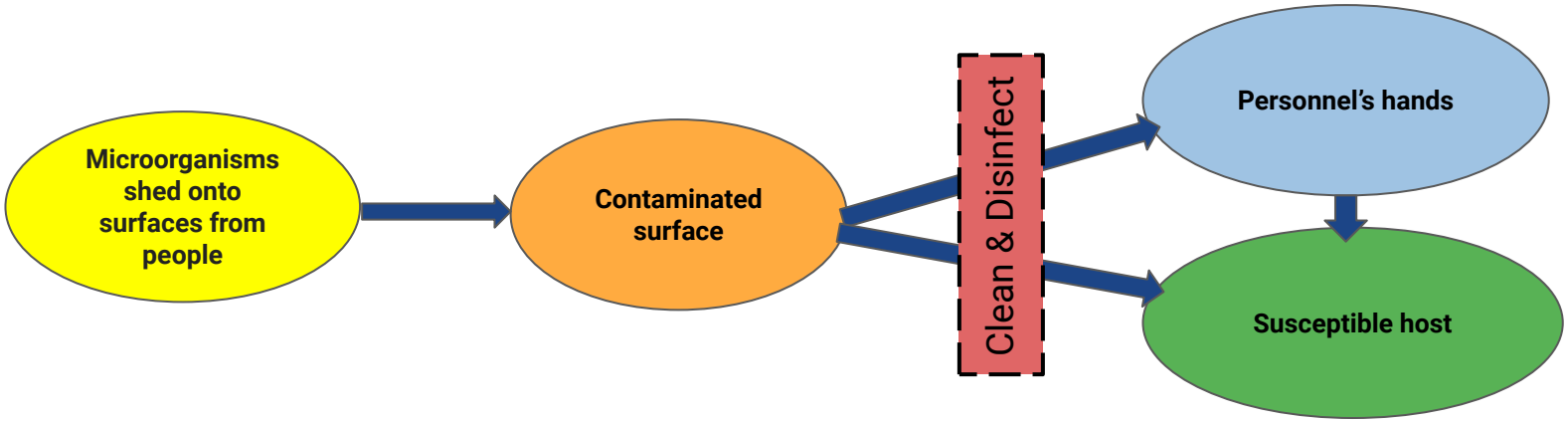
By the end of this program, the learner will be able to:

- **Describe issues** associated with manual environmental cleaning & disinfection
- **Identify** enhanced disinfection technologies
- **Outline benefits** of UV-C disinfection
- **Verbalize factors** to consider for UV-C disinfection implementation
- **Describe** the use of UV-C disinfection and its impact on bioburden reduction



Environmental surfaces contribute to microorganism transmission

- Environment contains diverse population of microorganisms
- Surfaces contaminated with microorganisms can serve as reservoirs
- Contamination of surfaces, including high-touch surfaces, in a room can lead to:
  - transmission to the next person who occupies the room
  - contamination of the hands or clothing of personnel with transmission to other individuals
- Cleaning and disinfection of environmental surfaces is **fundamental** in reducing potential microorganism transmission & acquisition



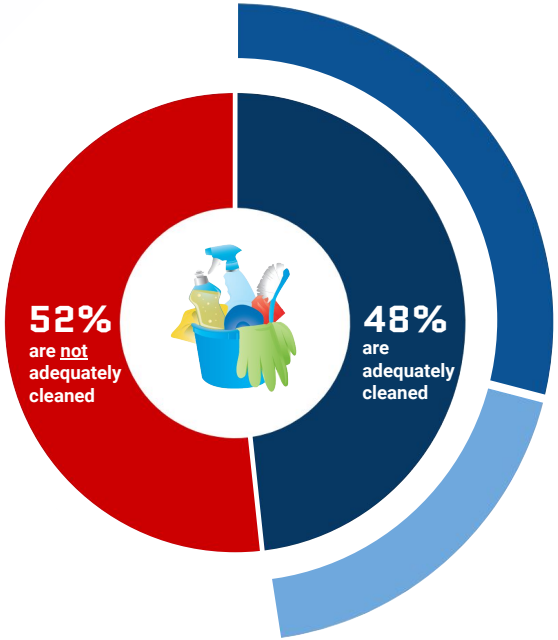
Manual cleaning & disinfection is not enough

52% of high touch surfaces are not cleaned or disinfected properly with manual approach

Studies show that **only 48% of high touch surfaces are cleaned thoroughly during manual cleaning.**

This means that more than half of high touch surfaces, **52%**, are **not adequately cleaned.**

High Touch Surfaces
Cleaned & **Disinfected** During Manual Cleaning



Note: **Thoroughness of Disinfection Cleaning (TDC)** refers to how well the room has been cleaned and disinfected. TDC is measured by observations with a fluorescent marking gel. A gel is placed on high-touch surfaces in a room prior to cleaning. After a person has cleaned the room, UV-light is used to identify gels that have not been removed.

Source: Carling P: Improving Cleaning of the Environment Surrounding Patients in 36 Acute Care Hospitals. ICHE 2008, vol. 29:11, pp 1035-1041.
Source: Carling P: Methods for assessing the adequacy of practice and improving room disinfection. Am J Infect Control 2013, 41:S20-25.

Barriers leading to gaps

- **Product**
  - Proper supplies for environment (not frequently reported)
- **People**
  - Training-Gaps in knowledge observed
    - 2 content areas observed—disinfection and microorganism knowledge
      - correct use of 1-step disinfectant, use of UV light devices, contact time
      - inability to identify common microorganisms spread via environment
  - Lack of resources— FTEs
  - Interruptions by individuals in the area & co-workers
- **Process**
  - Time constraints — 30% reported insufficient time to complete tasks, need for rapid room turnover, ad hoc disinfection requests, and understaffing
  - Disinfection process impeded by occupant's personal clutter
  - Communication problems — ie. when rooms ready for disinfection, lack of clarity about disinfection responsibilities (EVS or others?)

S.C.N. Hewage et al. / American Journal of Infection Control 49 (2021) 919–927

Risk of organism acquisition from prior room occupants

Table 1 Overview of studies.

Study	Publication year	Study duration	Study setting (country)	Study design	Organisms evaluated
Huang et al. [13]	2005	20 months	USA	Cohort	VRE, MRSA
Mitchell et al. [16]	2014	24 months	Australia	Cohort	MRSA
Datta et al. [12]	2011	20 months	USA	Cohort	VRE, MRSA
Ajao et al. [24]	2013	93 months	USA	Cohort	ESBL-producing Gram negative
Drees et al. [20]	2008	14 months	USA	Cohort	VRE
Nseir et al. [14]	2011	12 months	France	Cohort	*A. baumannii*, ESBL-producing Gram negative *P. aeruginosa*
Shaughnessy [25]	2011	16 months	USA	Cohort	*C. difficile*
Zhou [19]	2019	72 months	USA	Cohort	VRE
Anderson [2,3]	2017 & 2018	28 months	USA	RCT	VRE, MRSA, *C. difficile*
Ford [17]	2016	93 months	USA	Cohort	VRE
Fraenkel [15]	2021	72 months	Sweden	Cohort	Norovirus

Note: VRE, vancomycin-resistant enterococci; MRSA, meticillin-resistant *Staphylococcus aureus*; ESBL, extended spectrum b-lactamase; *C. difficile*, *Clostridioides difficile*. Anderson 2017 and 2018 are the same study. Data from both of Anderson's papers were used to provide data to answer the research question.

B.G. Mitchell, J. McDonagh, S.J. Dancer et al., Risk of organism acquisition from prior room occupants: An updated systematic review, Infection, Disease & Health, https://doi.org/10.1016/j.idh.2023.06.001

Previously contaminated rooms increase organism acquisition risk

- 235% increased risk of organism acquisition for an individual to occupy same room as a previous individual that had *C. difficile* (11% prior person w/CDI vs 4.6% prior person w/o CDI)[1]
- 40% increased odds to individual if prior room occupant had MRSA or VRE[2]
- Admission to a room previously occupied by a carrier of MDR *P. aeruginosa* or *A. baumannii* is independent risk factor for acquisition by subsequent room occupant[3]

[1] Shaughnessy MK, Micielli RL, DePestel DD, Arndt J, Strachan CL, Welch KB, et al. Evaluation of hospital room assignment and acquisition of Clostridium difficile infection. ICHE. (2011)
[2] Huang SS, Datta R, Platt R. Risk of acquiring antibiotic-resistant bacteria from prior room occupants. Arch Intern Med. (2006)
[3] Nseir et.al. Risk of acquiring multidrug-resistant Gram-negative bacilli from prior room occupants in the intensive care unit. Clin Microbiol Infect (2011)

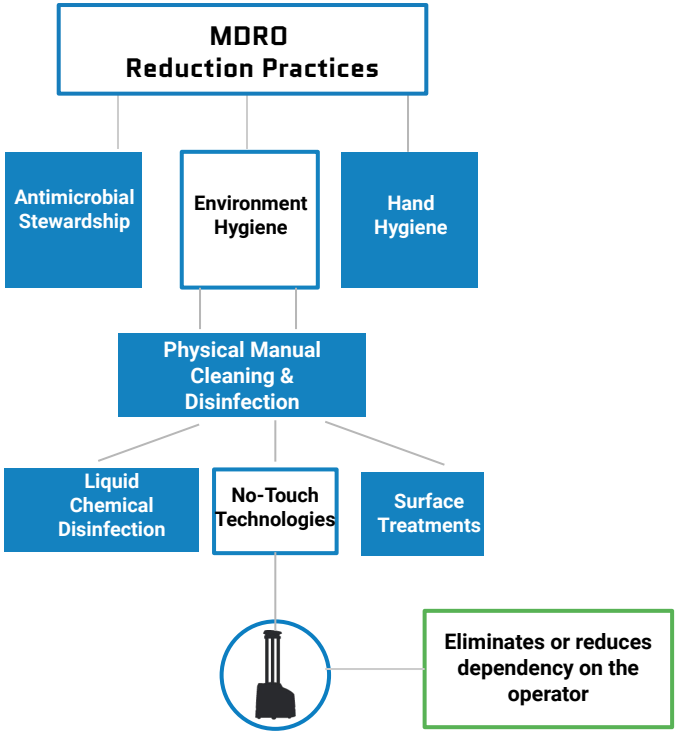
Reduction of organisms requires a bundled approach including No-Touch Disinfection Technologies for enhanced disinfection

A bundled approach

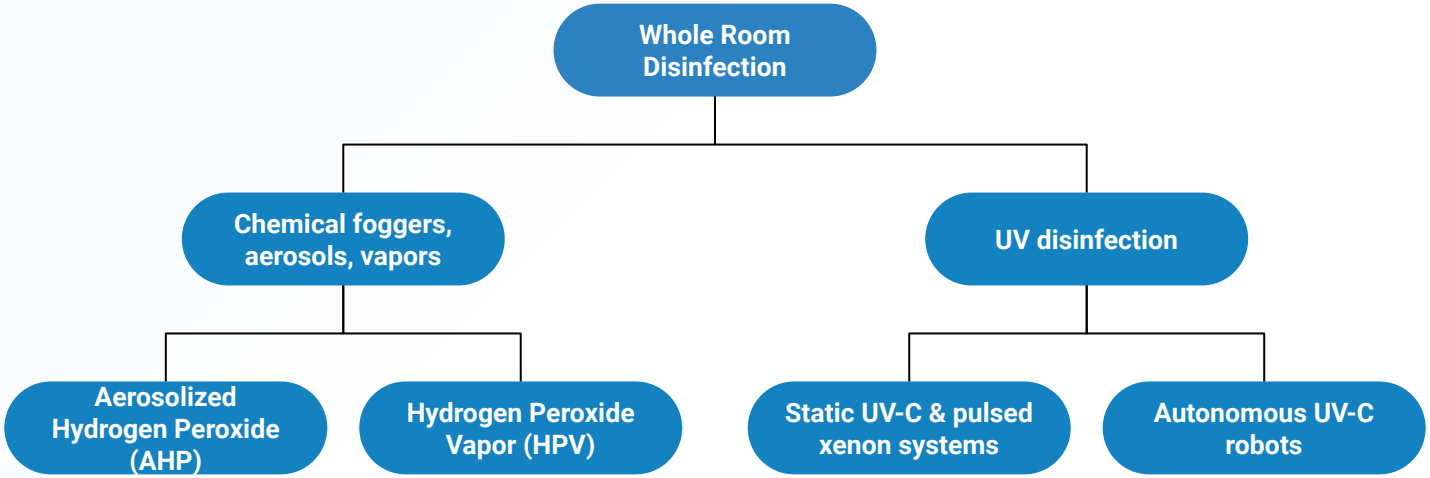
Hand Hygiene

Antimicrobial Stewardship

Environmental (C&D) Cleaning & Disinfection



Enhanced disinfection solutions



On the market since 2005
Hydrogen peroxide as consumables
Low initial investment, high running and operational costs

On the market since 2009-2010

Autonomous UV-C disinfection robots enters market in 2018

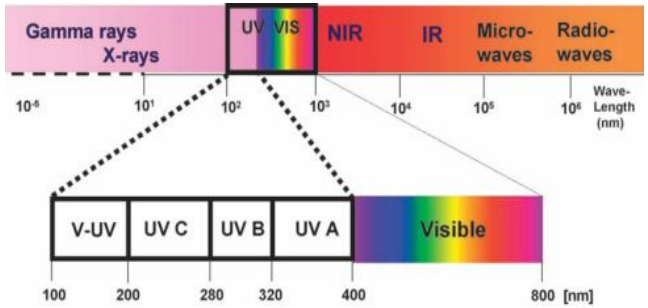
UV-C is a disinfection method that has been proven to be effective compared to other methods

"Ideal" NTD system	Aerosolized hydrogen peroxide	Vaporized hydrogen peroxide	UV-C	Pulsed xenon
Short cycle time < 1 hour	X	X	✔	✔
High level of efficacy (6 log sporicidal reduction)	X/✔	✔	X/✔ dependent time/distance	X/✔ dependent time/distance
Pathogens not culturable from surface after cycle	X	✔	X	X
Easy to operate	✔	X	✔	✔
Fully automated operation	✔	✔	X/✔	X
Immediate room entry after cycle	X	X	✔	✔
No required room sealing	X	X	✔	✔
Homogeneous distribution	X	✔	X/✔	X
Evidence clinical impact	X/✔	✔	✔	X/✔

Decontamination in Hospitals and Healthcare. https://doi.org/10.1016/B978-0-08-102565-9.00015-7

Ultraviolet Germicidal Irradiation (UVGI)

- **Ultraviolet germicidal irradiation describes light in the germicidal range of 200-320 nm for disinfection of surfaces**
  - UV-A 320-400 nm
  - UV-B 280-320 nm
  - UV-C 200-280 nm
- **UVGI alters microorganism's nucleic acids**
  - creates reaction between 2 thymine molecules
  - increased light = increased thymine dimers
  - results in replication failure
  - eventual cell death
- **Most effective at UV-C 260-265 nm**

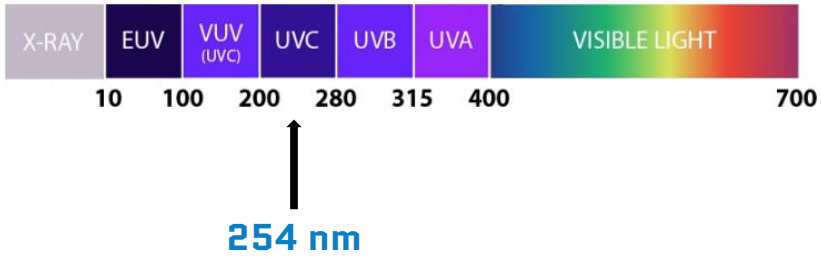


What is UV-C?

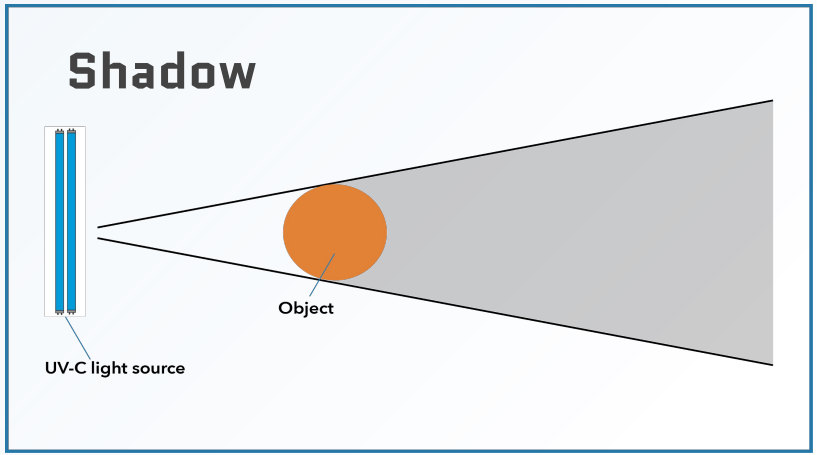
UV-C (200-280 nm wavelength) is an **environmentally friendly** method of inactivating bacteria, mold, and fungi, without use of harmful chemicals.

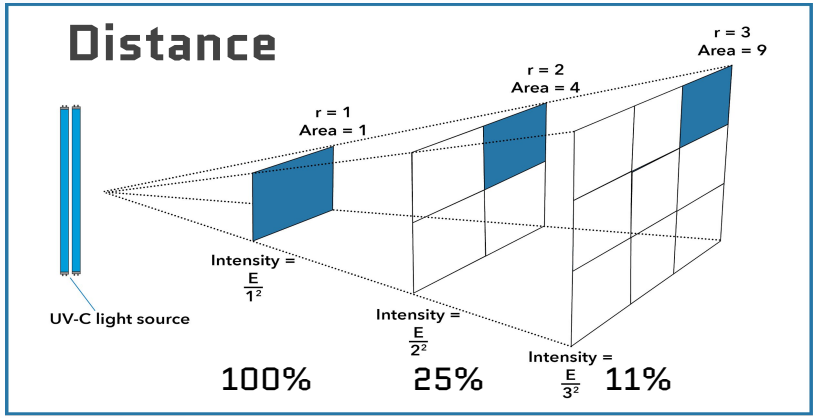
Peak germicidal wavelength **~260 nm**

Low vapor pressure (LVP) mercury lamps radiate **~90-95% of energy at 254 nm.** optimizing germicidal effectiveness



UV-C Light and device design





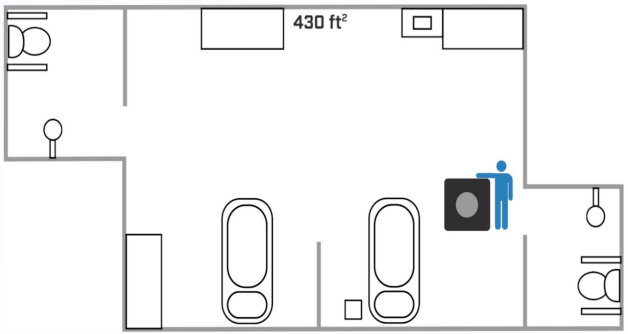
UV-C device design

- Bulbs vary in strength and number
  - LVP mercury lamps 40-1,000 Watts
  - ex. 8 (180 W)=1,440 W vs. 8 (75 W)=600 W energy
- Tower bulb placement with or without reflectors
  - 360 degree disbursement or less
- Static vs. autonomous (self-navigating)
- Safety features to avoid human exposure incidents

Types of UV-C devices

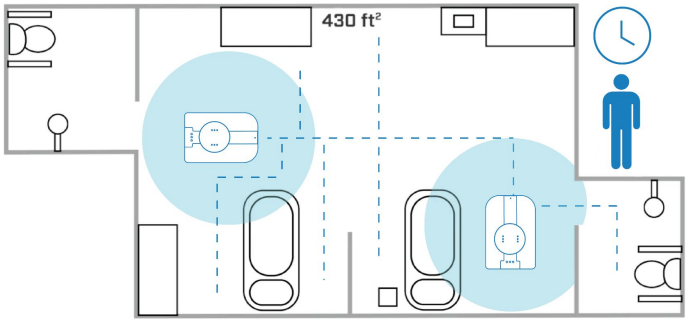
Static

- User puts into room and plugs in
- May require 1 or more disinfection cycles
- May require moving device 1 or more times to cover room and bathroom
- Risk of over exposure to some surfaces
- Risk of under exposure to some surfaces
- Shadowing limitations
- Increased user time/effort



Autonomous

- Room mapped, robot drives into room
- Robot navigates to disinfection points
- Shorter disinfection times due to close proximity to surfaces
- Less risk of over exposure
- Less risk of under exposure
- Reduced shadowing
- Reduced user time/effort



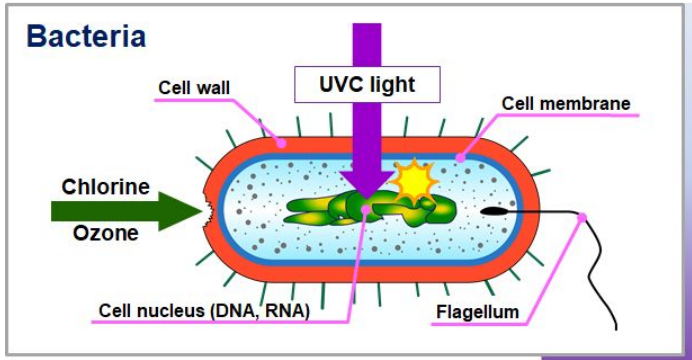
UV Exposure - material degradation with UV Dose

UV effects on material - dose absorption

Level of UV induced degradation	Type of material
Completely unaffected regardless UV dose applied	• **metals** - no absorption of UV light • **ceramics** - no absorption of UV light • **some classes plastics/polymers** - UV resistant coating applied
Relatively resistant in normal use, over many years	• **A wider range of plastics/polymers** - often the plastics are relatively resistant to UV. Drugs are typically stored in glass or plastic containers that likely have low UV absorption • **Wood surfaces**
Less resistant in a normal use, could change over weeks or months.	• **polyurethane foams -** this class of materials are mechanically weak, their physical bonding structure is weak, they are not dense, the transmission of the UV light goes deeper into the structure. • **textiles -** quality of the textile (colours type and the paints used), but very dependent on color and surface treatment • **softer plastics -** mechanically weak structures that can be weakened by UV light due to breaking of carbon-carbon bonds
Non resistant due to high absorption of UV light, The time expected to see the effect, could take days, weeks or months.	• **unframed (no glass) oil paintings** • **plants** - prolonged UV exposure at high levels may cause plants to wilt and die. In indoor environments, plants may be exposed to levels of damaging UV irradiation that they cannot adequately deal with. Plants can be protected by removing them from the area, placing them in a UV shadow zone or be covered with curtains.

https://uvsolutionsmag.com/articles/2019/uv-degradation-effects-in-materials-an-elementary-overview/

Clinical efficacy of UV-C on microorganisms



UVC irradiation

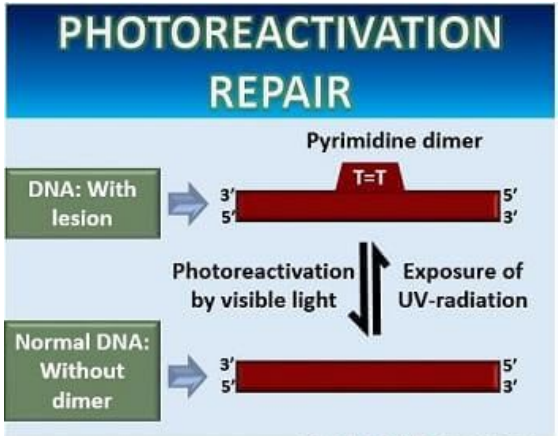
Modification of DNA/RNA structure in cell nucleus*

*Concerning viruses, DNA/RNA genome is found inside the virus core, covered by a protein shell ("capsid")

"Inactivation" blocks cell growth by stopping cell division

Fungal Spores	Bacterial Spores	Mycobacteria	Vegetative Bacteria	Viruses
Aspergillus versicolor	*Bacillus anthracis*	*Mycobacterium tuberculosis*	*Staphylococcus aureus*	Influenza viruses
Penicillium chrysogenum	*Bacillus cereus*	*Mycobacterium bovis*	*Streptococcus pyogenes*	Measles
Stachybotrys chartarum	*Bacillus subtilis*	*Mycobacterium leprae*	*Escherichia coli*	**Coronavirus**
			Pseudomonas aeruginosa	Smallpox
			Serratia marcescens	

LEAST SUSCEPTIBLE — 253.7 nm — MOST SUSCEPTIBLE

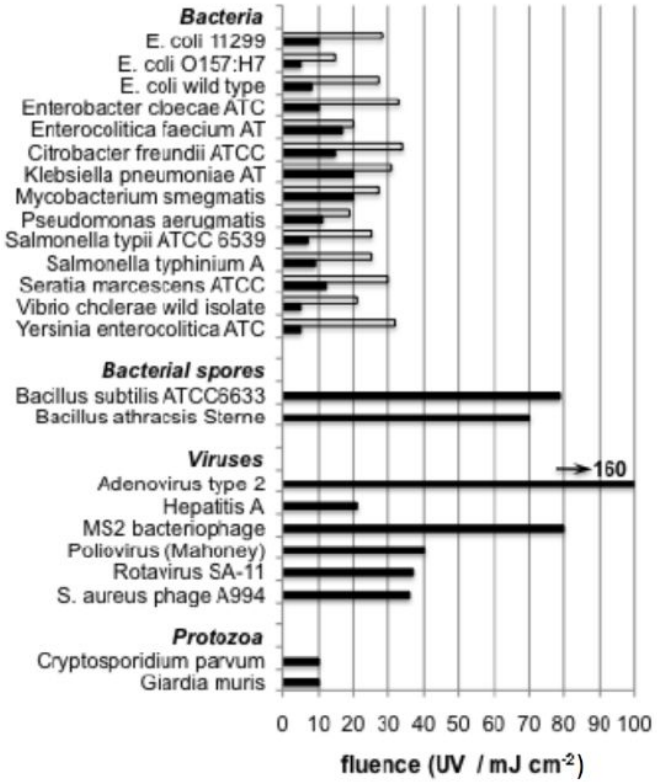


Can multidrug-resistant organisms become resistant to UV light following serial exposures?

- MRSA, CRE *K. pneumoniae* (KPC), metallo-β-lactamase-producing *K.pneumoniae* (MBL) were serially exposed to 25 growth-irradiation cycles of UV produced by a xenon-based UV (Xe-UV) lamp for 5 minutes or a mercury-based UV (Hg-UV) lamp for 10 minutes.
- After each UV exposure cycle, the surviving CFUs were measured and compared with the initial inoculum of each cycle for each strain
- Postexposure colony counts remained low (3-100 colonies) throughout the 25 serial exposures to both xenon- and mercury-based UV.
- Whole-genome sequencing (WGS) analyses performed on these 3 strains demonstrated no significant genetic changes after multiple UV irradiation cycles.
- Exposure of MDROs to UV from 2 different UV sources did not cause UV resistance after 25 serial exposures
- UV disinfection is unlikely to generate UV-resistant hospital flora.

Choi H, Chatterjee P, Hwang M, Stock EM, Lukey JS, Zeber JE, Jinadatha C. Can multidrug-resistant organisms become resistant to ultraviolet (UV) light following serial exposures? Characterization of post-UV genomic changes using whole-genome sequencing. Infect Control Hosp Epidemiol. 2022 Jan;43(1):72-78. doi: 10.1017/ice.2021.51. Epub 2021 Mar 22. PMID: 33749567

Log reductions with UV-C



Log reduction affected by variables:

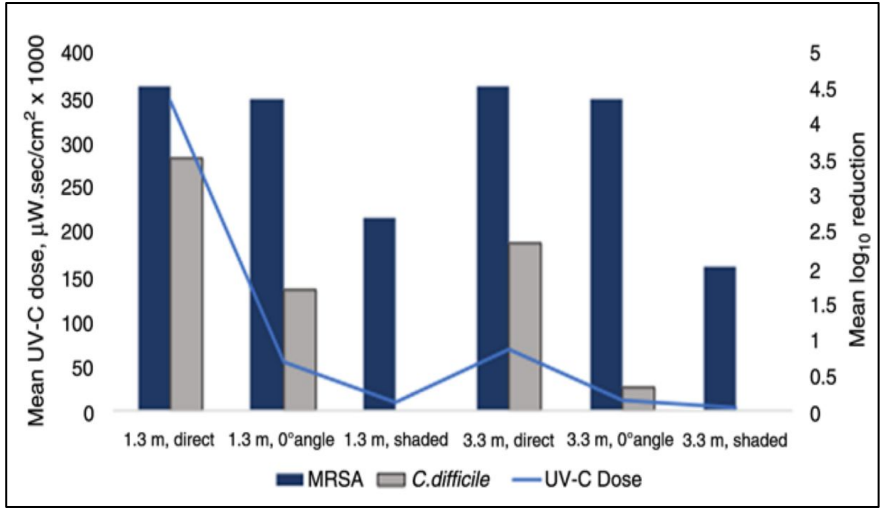
- amount of irradiance generated by the UV lamp(s)
- the distance from the lamp to the exposed surface
- the angle at which the UV strikes the surface
- whether surface is in direct line of sight of the lamp or receives light that has been reflected off other objects

Fig. 6 UV-C dose required for 4 $\log_{10}$ units (99.99%) inactivation of bacteria, spores, viruses, and protoza. The bars represent conditions "in the presence of photoreactivating light" (open bars) and "in the absence of photoreactivating light" (solid bars). Note: *S. aureus* A994 full genus name: *Staphylococcus aureus* [17]. Used with permission

Volume 126, Article No. 126016 (2021) https://doi.org/10.6028/jres.126.016 Journal of Research of the National Institute of Standards and Technology

Factors impacting log reduction

- UV-C doses at 5-minute cycle on various locations in a room
- Measurements taken with a radiometer (light meter)
- Corresponding log_{10} reductions in MRSA and *C. difficile* spores
- Results show impact
  - distance
  - orientation of surfaces
  - shading
- Greatest exposure direct line at 4 ft (1.3 m)
- UV drops horizontal and shaded areas and of course at further distances 10 ft (3.3 m)
- MRSA more susceptible >3 log except shaded areas
- *C. diff* >3 log only at direct at 4 ft.



Boyce JM and Donskey CJ. (2019). Understanding ultraviolet light surface decontamination in hospital rooms: A primer. Infection Control & Hospital Epidemiology,

Practical method to measure UV-C dose

- Ability to measure UV-C dose is helpful for:
  - To provide comparative data for different devices
  - To assess delivery of UV to different sites within a room
  - To confirm that devices are operating correctly (quality control)
- Intensity of UV-C irradiance & dose received at a point in the room can be measured quantitatively using calibrated radiometric UV-C sensors
  - range in price from several hundred dollars to >$1,000
  - measurement of irradiance is not practical for routine monitoring
- Inexpensive qualitative photochromic UV-C test cards can provide rough estimates of the UV-C doses delivered

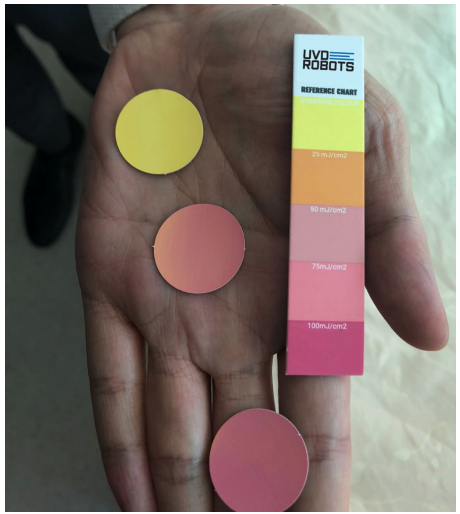
Introduction & Meaning of Dosimeters

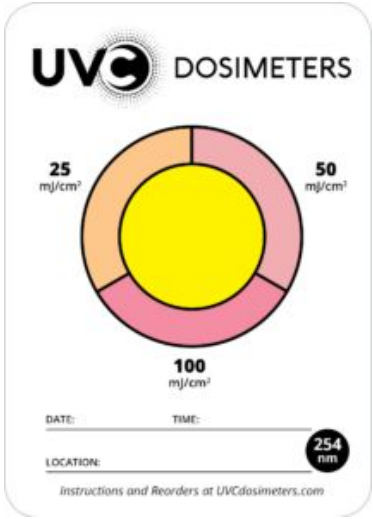
No Exposure | MRSA Dose | *C. difficile* Spore Dose

Site # and orientation	5 min each side of bed	Shaded (Y/N)	Distance (in.)	5 min each side adjusted	10 min each side adjusted	Shaded (Y/N)	Distance (in.)	15 min single position	45 min single position	Shaded (Y/N)	Distance (in.)
1) Headboard facing wall vertical		Y	55			Y	42			Y	111
2) Chart vertical		Y	56			N	73			N	73
3) Footboard facing wall vertical		Y	49			N	29			N	29
4) Floor corner horizontal		N	68			N	55			N	55
5) Footboard horizontal		N	49			N	29			N	29
6) Tabletop horizontal		N	32			N	24			N	24
7) Table edge vertical		N	32			N	24			Y	24
8) Table underside horizontal		N	32			N	24			N	24
9) Soap Dispenser vertical		N	83			N	32			N	36
10) Headboard facing device vertical		N	55			N	42			N	111
11) Bedrail 2 shaded vertical		N	24			N	24			Y	74
12) Drawers horizontal		N	34			N	48			N	98
13) Bedrail 2 underside horizontal		N	24			N	24			Y	73
14) Call Button horizontal		N	40			N	36			N	54
15) Bedrail 1 shaded vertical		N	24			N	49			Y	49
16) Chair horizontal		N	45			N	24			N	94
17) Doorknob vertical		N	59			N	73			N	73
18) Bedrail 1 top horizontal		N	24			N	49			N	73
19) Bedrail 1 underside horizontal		N	24			N	49			N	73
20) Floor near patient horizontal		N	24			N	50			N	50
21) Footboard facing device vertical		N	49			N	29			N	29
22) Dresser vertical		N	24			N	36			N	98
23) Vital signs monitor vertical		N	45			N	20			N	122
24) Drawers vertical		N	34			N	48			N	73
25) Bedrail 2 vertical		N	24			N	24			N	73
26) Bedrail 1 vertical		N	24			N	49			N	73
27) Bedrail 2 top horizontal		N	24			N	24			N	73

UV-C dosimeters

Starting colour	25 mJ /cm2	50 mJ /cm2	75 mJ /cm2	100 mJ /cm2





Cadnum JL, et al. (2021). Ultraviolet-C (UV-C) monitoring made simple: Colorimetric indicators to assess delivery of UV-C light by room decontamination devices. Infection Control & Hospital Epidemiology

Validation of colorimetric dosimeters

- Researchers evaluated color changes with UVC dose and log reductions of MRSA and *C.difficile* spores
- Also assessed indicators for use in different areas of room
- Carriers w/10^6 organisms positioned vertically to lamp at height of 34 inches and 36 inches from the center of the UV-C bulb.
- Colorimetric indicators were adjacent to carriers
- Exposed to UV-C for varying times resulting in UV-C dose 5,000, 10,000, 25,000, 46,000, 50,000, 75,000, and 100,000 µJ/cm^2 (radiometer measurement) (5-100 mJ/cm^2)
- Observed final color changes, and calculated log reductions post exposure
- **Results:**
  - **UV-C induced color changes of 2 colorimetric indicators correlated well with pathogen log reduction**
  - **In rooms, use of a colorimetric indicator highlighted that shaded sites may receive suboptimal dosing.**

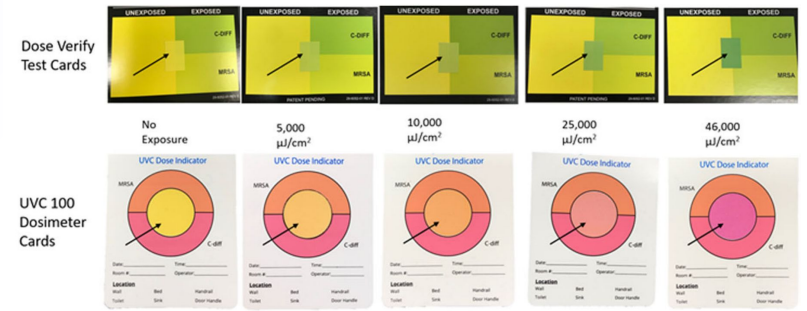
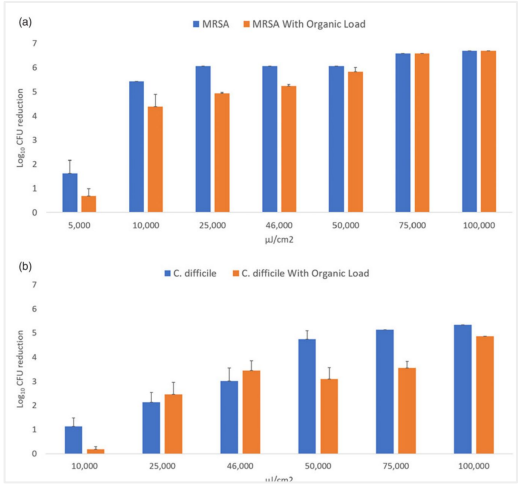


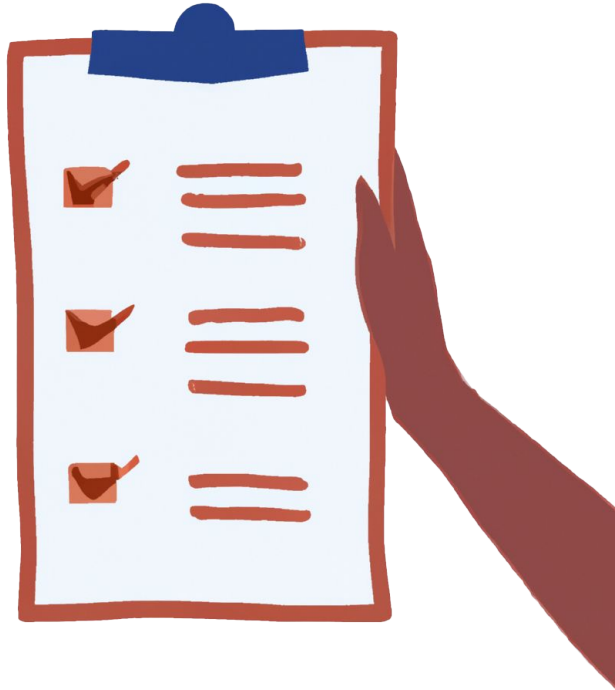
Fig. 1. Pictures of the 2 colorimetric indicators studied showing the color changes associated with increasing doses of ultraviolet-C (UV-C) light. Arrows point to the central rectangles (Dose Verify test cards) or circles (UVC 100 dosimeter cards) that indicate the level of UV-C exposure.



Cadnum JL, et al. (2021). Ultraviolet-C (UV-C) monitoring made simple: Colorimetric indicators to assess delivery of UV-C light by room decontamination devices. Infection Control & Hospital Epidemiology

Validation & reporting data for UV-C cycles

- Validation and reporting data may be incorporated into established objective monitoring program (CDC Level II program)
- Results of the objective monitoring program can be used in ongoing educational/feedback to team members
- Results of the objective monitoring program and interventions to optimize the thoroughness of terminal room cleaning and disinfection should be a standing agenda item for quality committees
- Refer to vendor reporting system capability & dosimeter testing

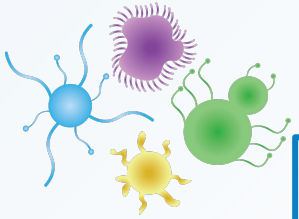


https://www.cdc.gov/hai/toolkits/evaluating-environmental-cleaning.html

Show me the Science

UV-C disinfection and impact on bioburden reduction

Logical pathway to bioburden reduction

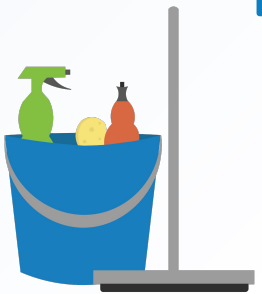


Previously contaminated rooms increase the risk of organism transmission

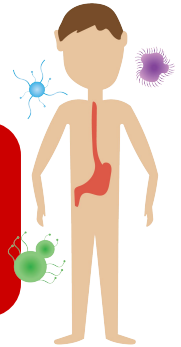
Specific organisms reside on environmental surfaces for long periods of time

Environmental bioburden leads to organism acquisition

Studies show manual cleaning & disinfection as inadequate leaving gaps in bioburden reduction



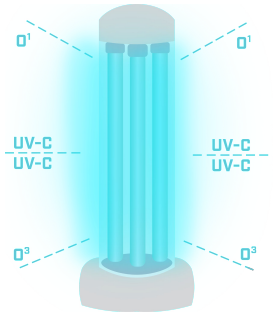
Individual acquires organism



UV-C breaks chain of organism transmission

Enhanced disinfection with UV-C further reduces specific microorganisms

Improved cleaning & disinfection decreases acquisition of organisms



Do bacterial genetic differences matter with UV-C?

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Phenotypic variation in clinical S. aureus isolates

- Evaluated effect of virulence factors in clinical *S. aureus* isolates on tolerance against UV-C radiation.
  - pigmentation
  - catalase activity
  - biofilm formation
- Ceramic tiles were inoculated with 9 genetically different strains of *S. aureus* and exposed to UV-C (22 mJ/cm^2, 50 mJ/cm^2)
- Log reduction values were determined post irradiation.
- All isolates were reduced by 4.75-5.94 log.
- Observed phenotypic differences for *S. aureus* strains did not affect efficacy of UV-C disinfection.
- **Clinical environments that may be contaminated with naturally occurring variations of *S. aureus* can be inactivated with use of UV-C disinfection**

Tolerance of clinical vanco-resistant E. faecium isolates

- Evaluated impact of UV-C on genetically different VRE strains, incl. linezolid-resistant isolate.
- Ceramic tiles inoculated with isolates of VRE & compared to ceramic tiles with test organism *Enterococcus hirae* ATCC 10541
- Tiles positioned at a distance of 1 m. and 1.5 m and irradiated for 20 seconds, resulting in a UV-C doses of 22 mJ/cm^2, 50 mJ/cm^2
- Log reduction values were calculated post exposure
- Susceptibility to UV-C varied among the strains studied.
- Results indicate that UV-C doses reported in the literature (22 mJ/cm^2) are adequate for reduction of common reference strains (ATCC)
- **Reduction of tolerant patient VRE-isolates may need longer exposure to UV-C.**

Knobling, B., Franke, G., Carlsen, L., Belmar Campos, C., Büttner, H., Klupp, E.M., Maurer, P.M.; Knobloch, J.K. Phenotypic Variation in Clinical S. aureus Isolates Did Not Affect Disinfection Efficacy Using Short-Term UV-C Radiation. Microorganisms 2023, 11, 1332

Knobling et al. Tolerance of clinical vancomycin-resistant Enterococcus faecium isolates against UV-C light from a mobile source. Antimicrobial Resistance & Infection Control (2023) 12:63

Comparison of multiple UV devices in environmental setting- bioburden reduction

Experiment:

- 8 different UV devices evaluated in a room
- Carriers inoculated with *C. difficile* spores, MRSA, VRE and light soil- placed on 5 areas of a table
- 4 mins UV exposure, log reductions calculated

Results:

- 4 standard vertical tower low-pressure mercury devices achieved ≥2 log reductions in VRE and MRSA and ~1 log reductions in *C. difficile* spores
- pulsed-xenon device resulted in less reduction in the pathogens (P<.001).
- 3 non standard LVP mercury devices (ie adjustable bulbs, autonomous, 3 tower unit) achieved >2 log reductions in VRE and MRSA and ~3 log reductions in *C. difficile* spores
- **Low vapor pressure mercury devices were significantly more effective than the pulsed-xenon device**

Cadnum JL, et al. (2019). A comparison of the efficacy of multiple ultraviolet light room decontamination devices in a radiology procedure room. Infection Control & Hospital Epidemiology 2019, 40, 158–163. doi: 10.1017/ice.2018.296

Decontamination of targeted organisms from rooms using UV-C device

- Prospective cohort study at 2 facilities; convenience sample 39 individuals with 1 of 3 targeted organisms (VRE, *Acinetobacter*, or *C. difficile*) after discharge
- Environmental sites cultured before/after UV-C but prior to standard terminal cleaning
  - 5 high touch surfaces: rail, table, chair arm, overbed table, and sink counter (additional bathroom for *C.diff* rooms; Rodac plates used; cultures done in triplicate
- Cultured 229 environmental surfaces from 39 rooms during the 15-month study period.
  - 142 samples obtained from 27 rooms of VRE occupants
  - 77 samples obtained from 10 rooms of *C. difficile* occupants
  - 10 samples obtained from 2 rooms of *Acinetobacter* occupants
- Total # CFUs of target organisms from all sites decreased from 1,488 to 66 following use of the UV-C device (1.35 $\log_{10}$ reduction; P< .0001)

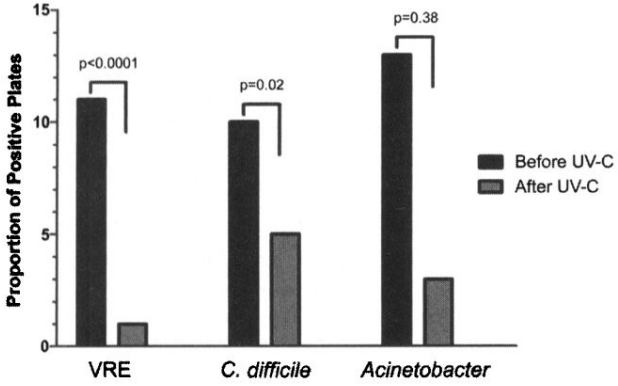

FIGURE 1. Change in proportion of positive plates for target organisms before and after use of an automated ultraviolet-C emitter.

Use of UV-C device decreases targeted organisms from rooms

Anderson, D., Gergen, M., Smathers, E., Sexton, D., Chen, L., Weber, D., & Rutala, W. (2013). Decontamination of Targeted Pathogens from Patient Rooms Using an Automated Ultraviolet-C-Emitting Device. Infection Control & Hospital Epidemiology, 34(5), 466-471. doi:10.1086/670215

Benefits of Enhanced Terminal Room Disinfection Study [BETR-D]

- Cluster-randomized, crossover trial 9 facilities (CDC Epicenter)
- Rooms of individuals with one of the targeted organisms were terminally disinfected w/one of four strategies:
  - quat (standard)
  - **quat/UV-C**
  - **bleach**
  - **bleach/UV-C**

  (enhanced)
- Next person admitted to the room was considered exposed and monitored
- The primary outcome was the incidence of acquisition of target organisms (MRSA,VRE, C.diff, MDR-Acinetobacter)
- Microbiological assessment of 92 seed rooms showed all enhanced strategies decreased bioburden-largest decrease occurred in the UV group
- Persons admitted to enhanced terminally cleaned rooms were 10-30% less likely to acquire the same organism
- **Largest risk reduction when UV-C device was added to standard**

	[Stand.]	[Enhanced Strategies]		
	Quat	**Quat /UV-C**	**Bleach**	**Bleach/UV-C**
mean CFU/room	60.8	3.4	11.7	6.3
% reduction		94%	81%	90%
acquisition rate	2.3	1.6	1.9	2.2
% reduction		30%	17%	4%

Anderson DJ, et.al.; CDC Prevention Epicenters Program. Enhanced terminal room disinfection and acquisition and infection caused by multidrug-resistant organisms and Clostridium difficile (the Benefits of Enhanced Terminal Room Disinfection study): a cluster-randomised, multicentre, crossover study. Lancet. 2017 Feb 25;389(10071):805-814. doi: 10.1016/S0140-6736(16)31588-4. Epub 2017 Jan 17. PMID: 28104287; PMCID: PMC5935446.

In summary

- Enhanced disinfection technologies reduce bioburden left by gaps in manual cleaning and disinfection
- Implementation of UV-C technology has many benefits over other options
- Not all UV-C devices are the same and several factors should be taken into consideration:
  - Static vs autonomous
  - Device design including number & strength of bulbs, presence of reflectors, safety features
  - Disinfection time for efficacy & efficiency
  - Ability to validate UV-C exposure
  - Ability to provide disinfection reports
- Studies have shown that UV-C has been used to reduce surface bioburden and elevate environmental hygiene


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