

Ultraviolet Light Disinfection: The Energy, Time, and Distance to Eradicate Multi-Drug Resistant Organisms and *Clostridium difficile*

Christina Liscynesky, MD¹, Jessica Dyszel, PhD², Mathew A. Vross, MS², Edward Richter PhD², and Julie E. Mangino, MD¹
¹The Ohio State University Wexner Medical Center, Columbus, OH. ²Richter International, Inc., Columbus, OH.

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Abstract

Background: Hospital acquired infections (HAIs) continue to cause patient morbidity and mortality, and increase institutional financial burden. HAIs related to methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE), *Acinetobacter* sp., carbapenem-resistant *Enterobacteriaceae* (CRE), and *Clostridium difficile* (CD) are major infection control concerns. Terminal room cleaning with routine disinfection does not entirely eradicate these agents; ultraviolet (UV) light represents an advancement to the armamentarium to prevent HAIs in subsequent hospital room occupants.

Methods: Hospital acquired isolates, (MRSA, VRE, *Acinetobacter*, CRE and *C. difficile*) were chosen for study with the Surfacide™ UV light emitter. Four surfaces were autoclaved or sterilized by repeat 70% alcohol rinses prior to inoculation. Vegetative bacterial cultures and CD spores were inoculated onto: stainless steel, textured plastic, ceramic, and soft plastic. Each surface was prepared in triplicate with 100µl of culture suspended in 1% buffered peptone with negative controls. Surfaces were air dried overnight, placed at 4 and 8 feet away from the emitter; treated with UV light x 15 minutes.

Results: Investigation with CRE and *Acinetobacter* sp., is ongoing as inoculum size and desiccation (for CRE) and biofilm formation (for *Acinetobacter*) are playing a role. CD spores were subsequently retested by exposure to UV light at varying energies to determine a sporicidal dose at 1 foot. A logarithmic reduction of 2.31 was achieved with 378mJ. A 3.6 logarithmic reduction occurred at 1419 mJ and 2534 mJ; equivalent to a maximum reduction possible as viable spores were reduced below the level of detection.

Conclusion: This UV light emitter was shown to be efficacious against vegetative bacteria such as MRSA and VRE and *C. difficile* spores in a phase 1 trial. Our data is among the first to highlight the amount of UV energy necessary to eradicate *C. difficile* spores.

Background

- Hospital acquired infections (HAIs) cause excess morbidity / mortality, and increase institutional financial burden.
- Methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE), *Acinetobacter* sp., *C. difficile* (*C. diff*) and carbapenem-resistant *Enterobacteriaceae* (CRE) are major infection control concerns.
- Terminal/discharge room cleaning by routine disinfection does not entirely eradicate these microorganisms.
- Ultraviolet (UV) light represents an advancement to room disinfection to prevent potential HAIs in subsequent hospital room occupants.
- Our objective is to determine the precise energy, distance and time to eradicate these micro-organisms.

Methods

Phase 1

- Hospital isolates of MRSA, VRE, *Acinetobacter*, CRE and *C. diff* were studied with the Surfacide™ UV light emitter.
- Representative hospital room surfaces (stainless steel, textured plastic, ceramic, and soft plastic) were autoclaved or sterilized by repeat 70% alcohol rinses prior to inoculation.
- Vegetative bacterial cultures and *C. diff* spores were inoculated on each of 4 surfaces; target was 500,000 CFU/sample. Each surface was prepared in triplicate with 100µl of culture suspended in 1% buffered peptone with negative controls.
- Inoculated surfaces were air dried overnight, placed at 4 ft., treated with 183 mJ, or 8 ft., treated with 47 mJ, of UV light for 15 minutes.
- Energy Equation: $1\text{mJ}/\text{cm}^2 = 1\text{mWs}/\text{cm}^2$
- *C. diff* spores were incompletely eradicated and exposed to various increased energies of 378mJ to 2534 mJ.

Phase 2

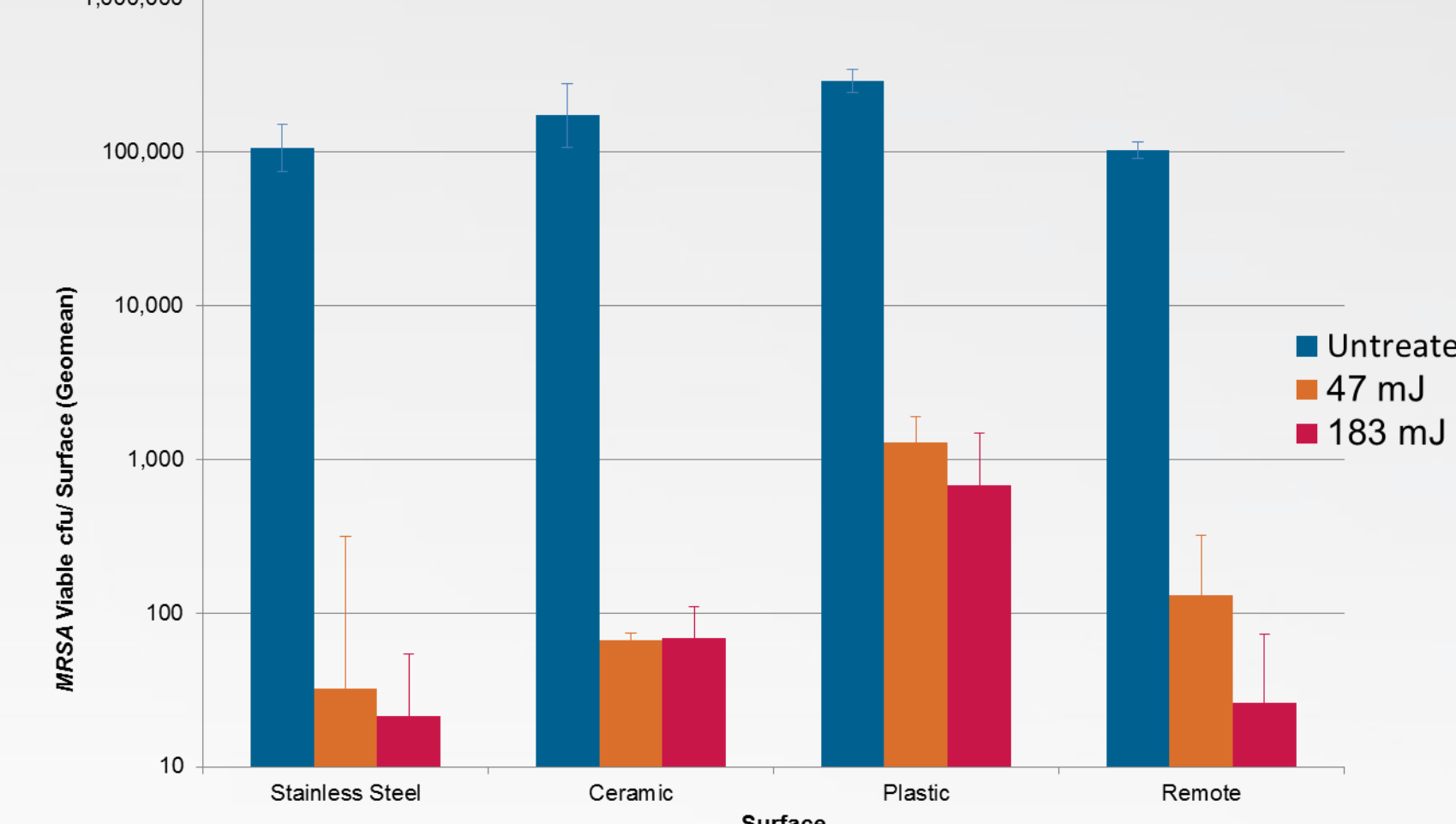
- Ceramic and plastic surfaces only were retested with *C. diff*, CRE and *Acinetobacter* sp.. *C. diff* spores were prepared as prior; CRE and *Acinetobacter* were treated as above plus 0.5% Tween was added prior to re-suspension in peptone buffer.
- Surfaces were placed 4 feet away from a solitary emitter and treated with target energy levels of 1400mJ to 2800 mJ.



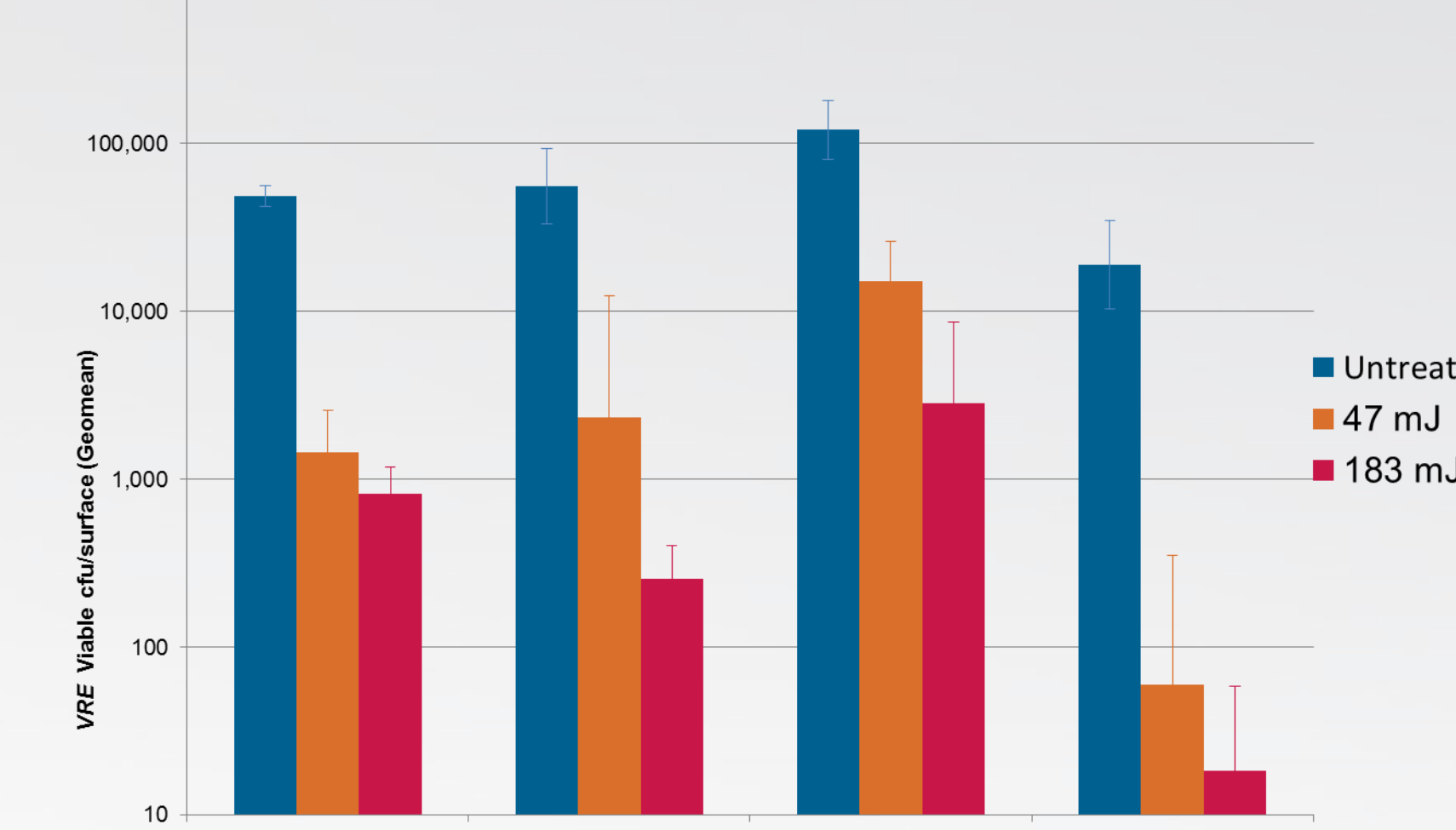
Surfacide™ Multi-Unit UV Emitter

Results: Phase 1

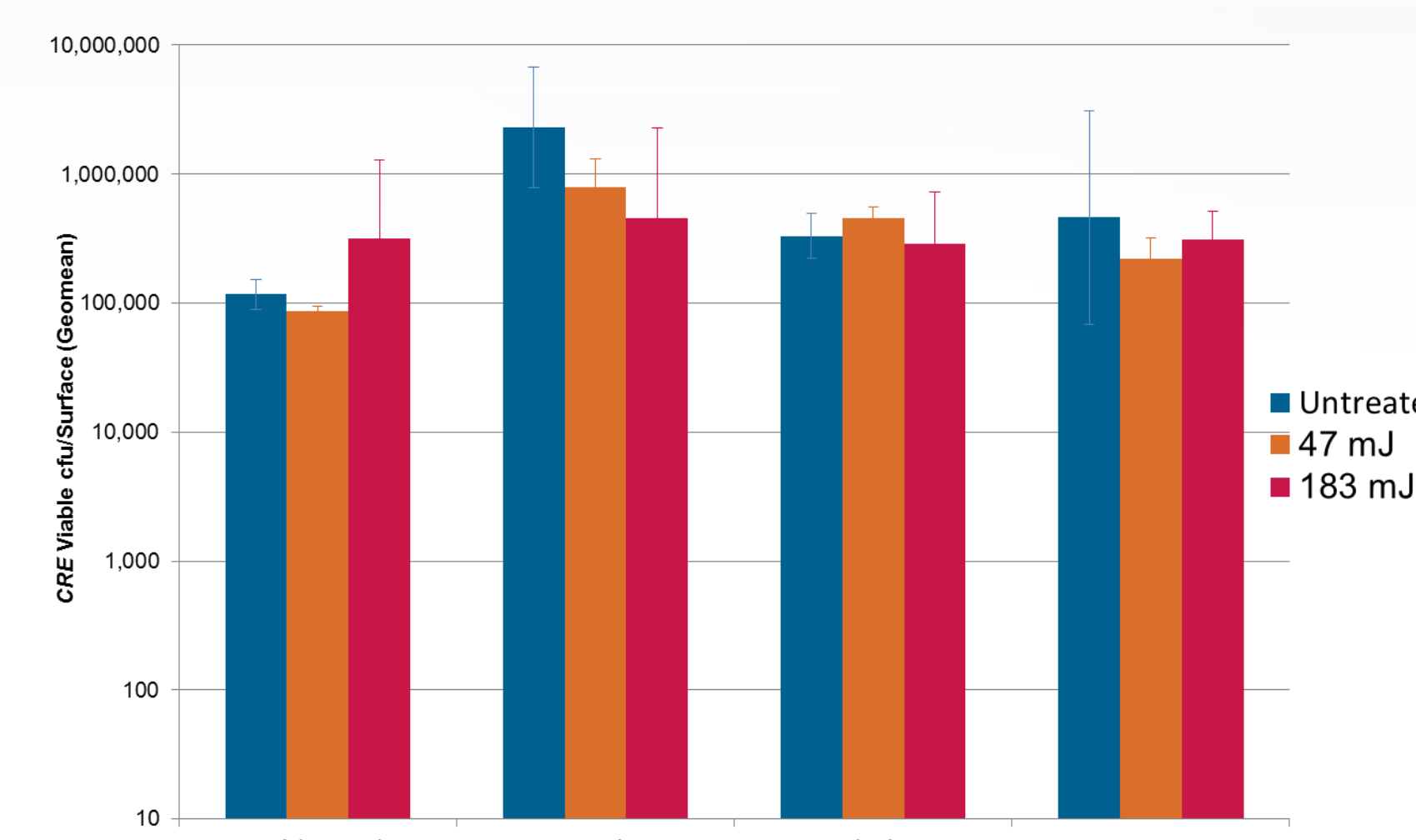
MRSA Exposed to Surfacide for 15 Minutes



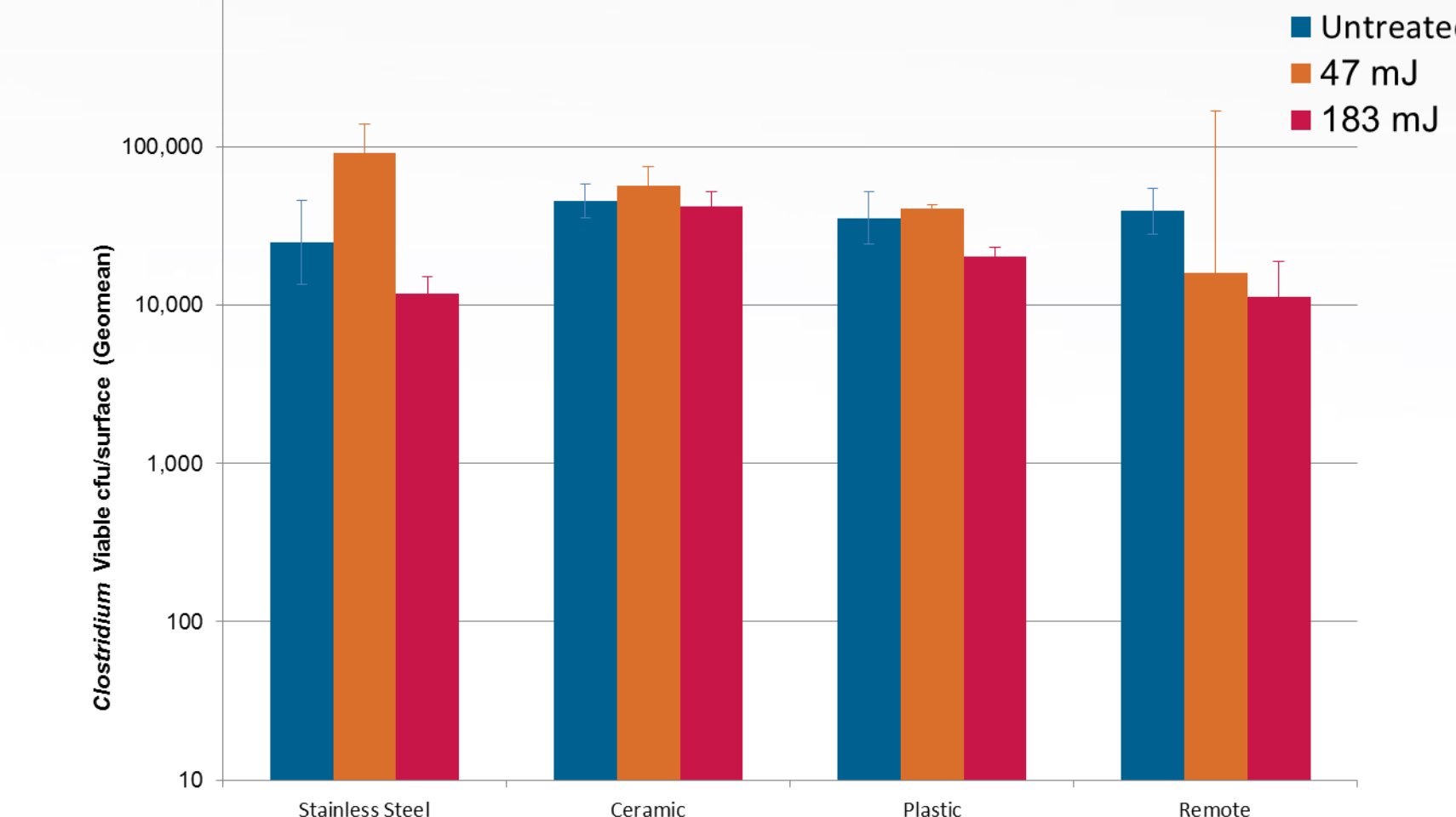
VRE Exposed to Surfacide for 15 Minutes



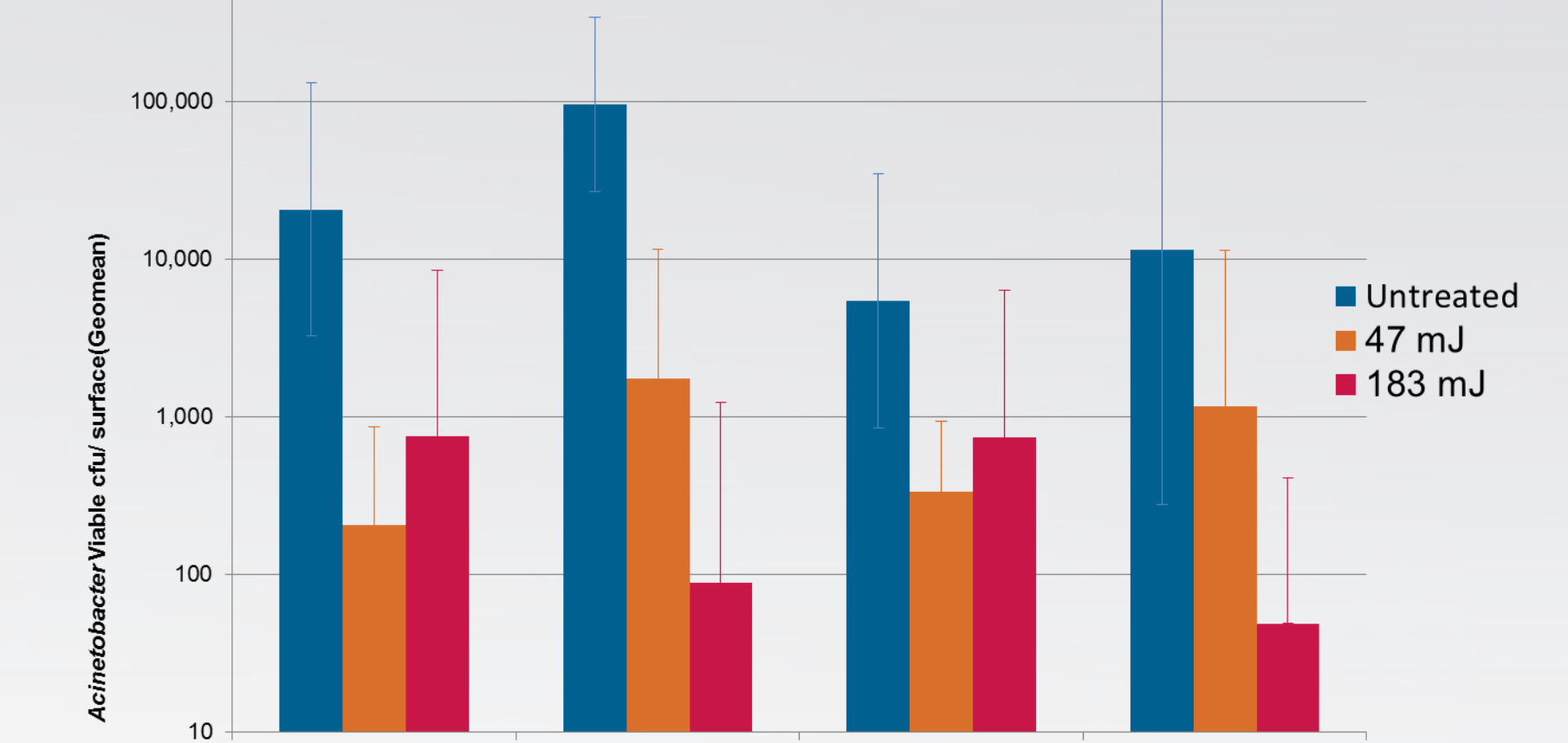
CRE Exposed to Surfacide for 15 Minutes



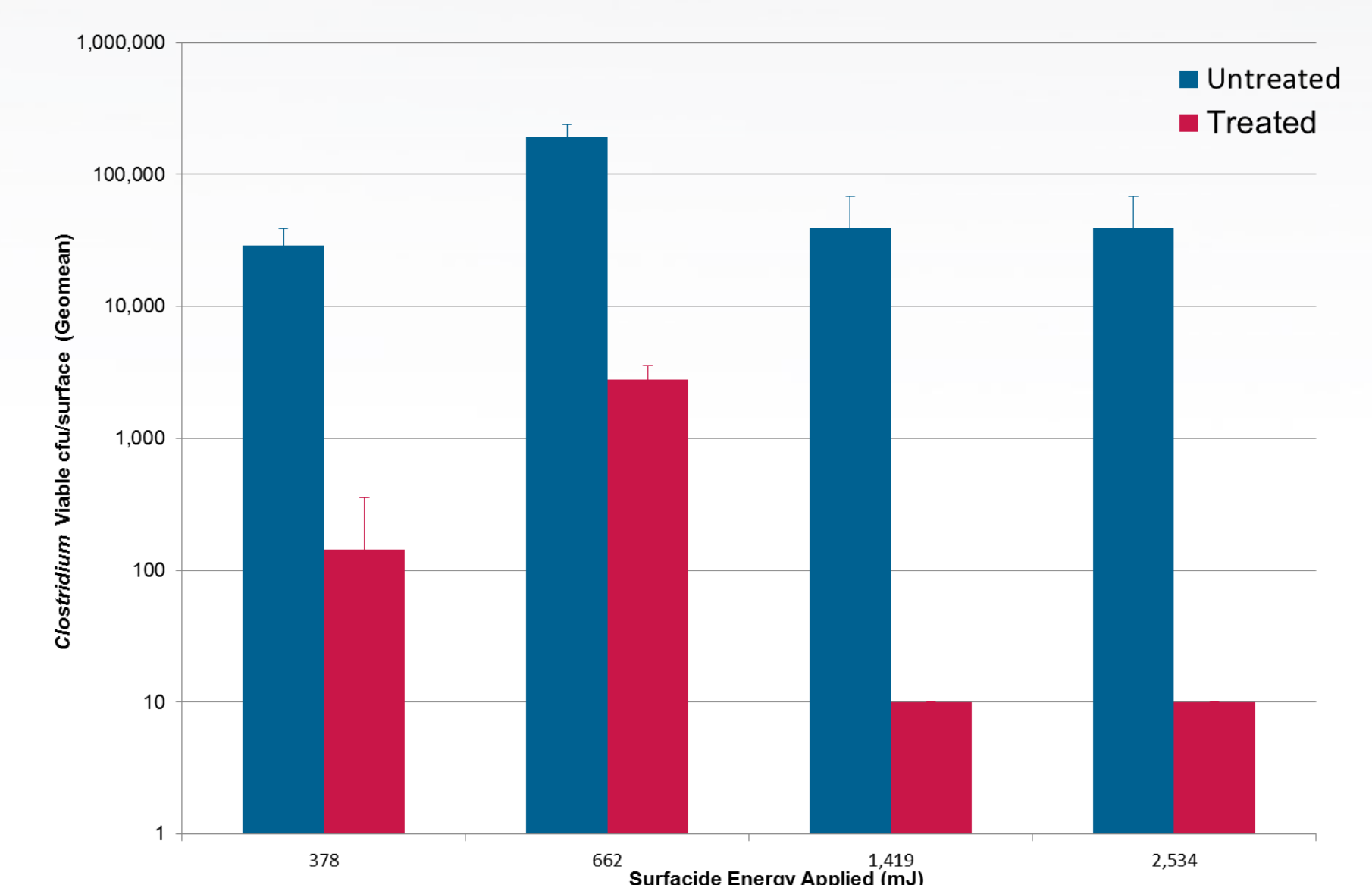
C. diff Exposed to Surfacide for 15 Minutes



Acinetobacter Exposed to Surfacide for 15 Minutes

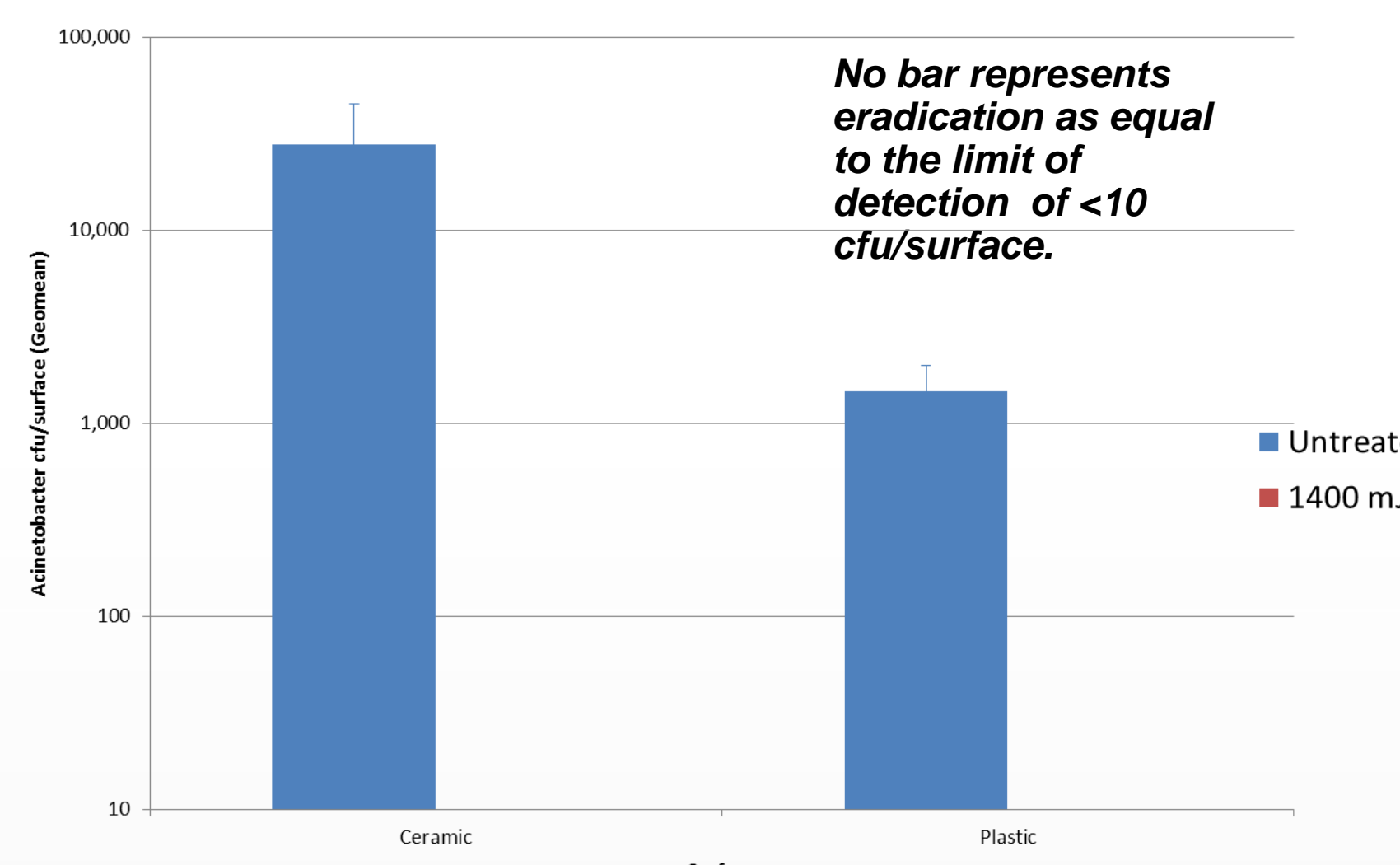


C. Diff on Stainless Steel Exposed to Surfacide at 1-foot

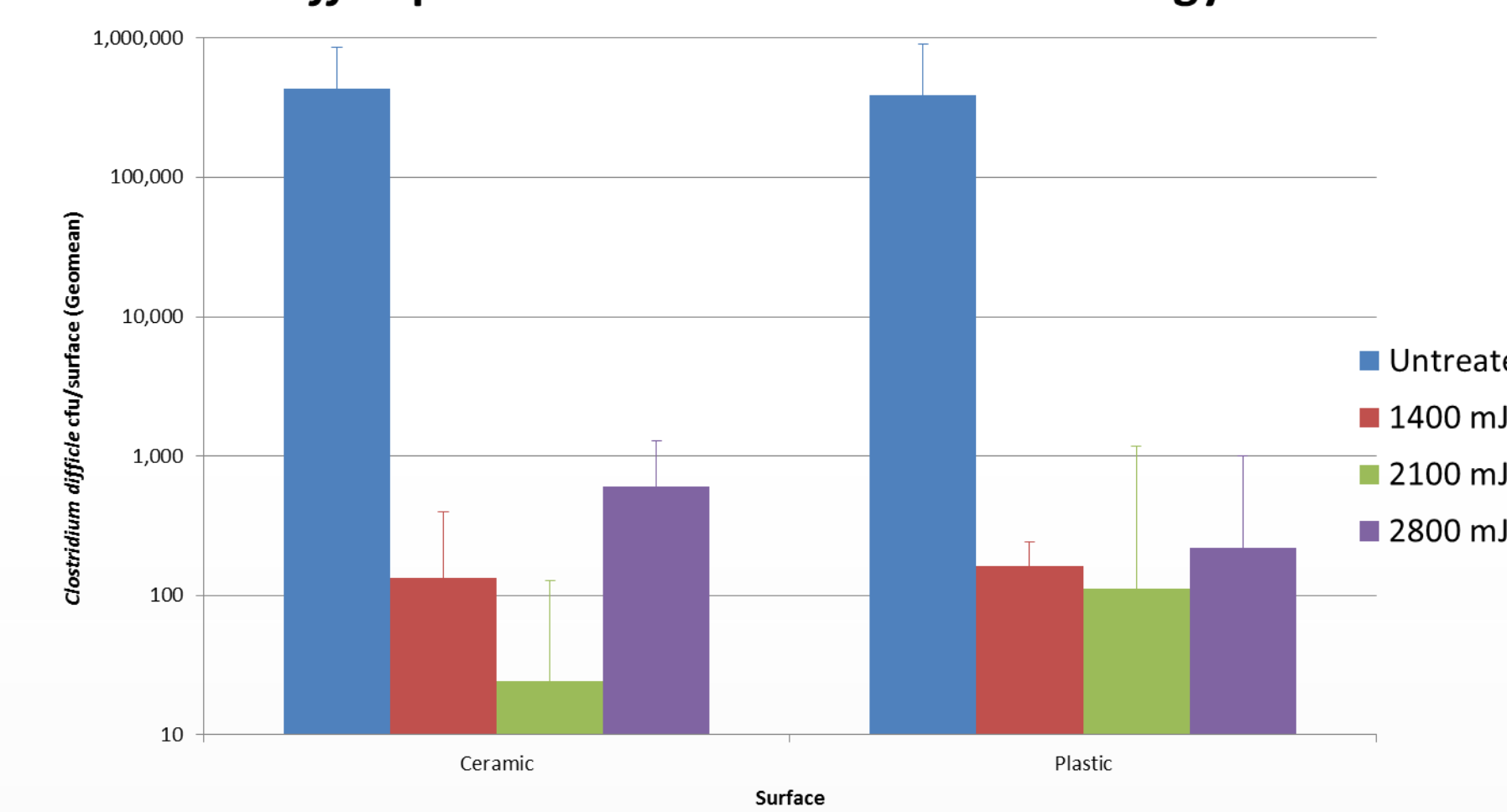


Results: Phase 2

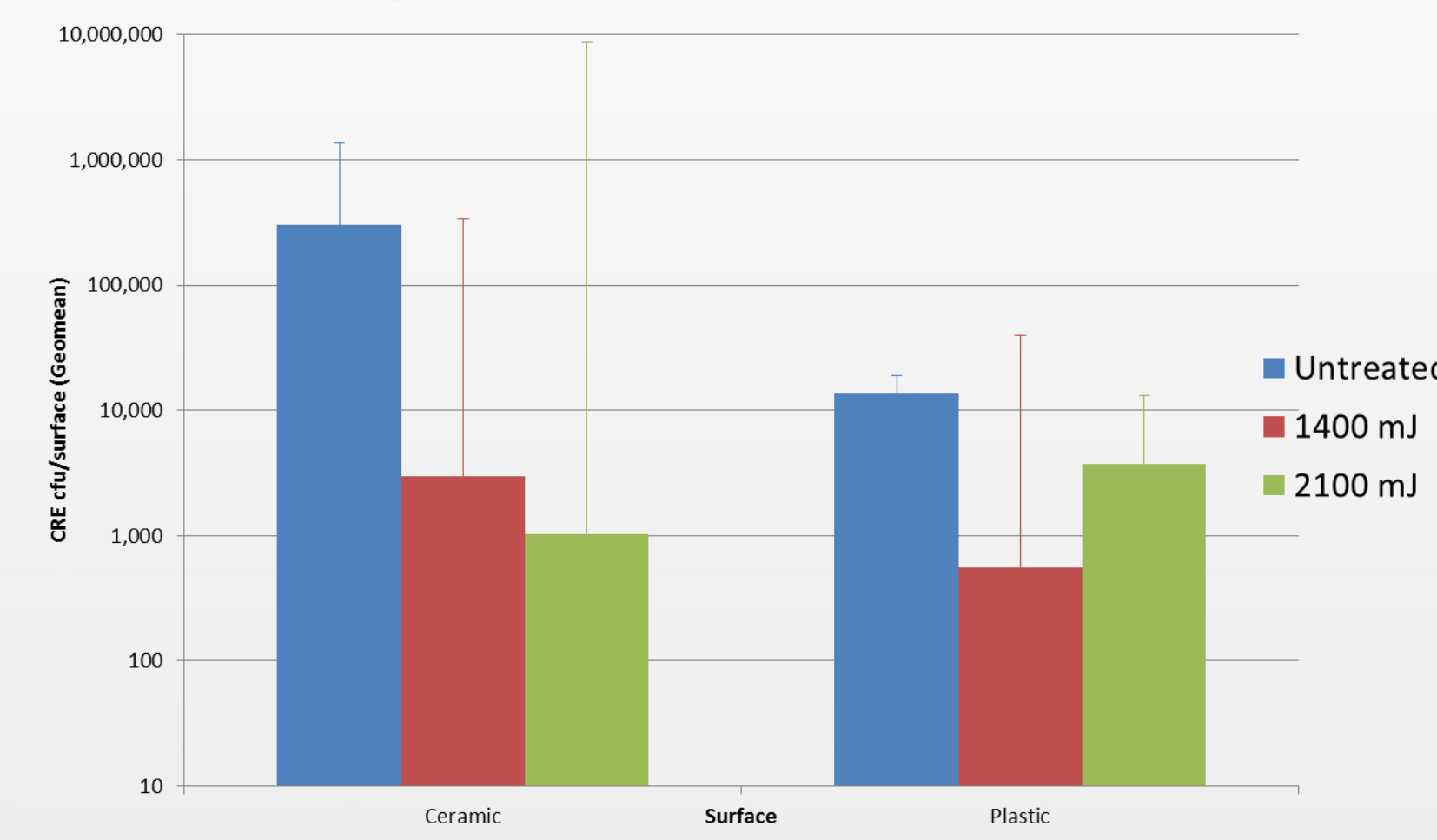
Acinetobacter Exposed to Surfacide at 1400mJ



C. diff Exposed to Surfacide at Various Energy Levels



CRE Exposed to Surfacide at 1400 and 2100mJ



Discussion

- MRSA and VRE were easily eradicated in phase 1 with lowest energy, 47mJ.
- Based on phase 1, phase 2 evaluated higher energy levels needed to kill CRE, *Acinetobacter*, and *C. diff* spores.
- In phase 2, 1400mJ at 4 ft. led to a 3 log reduction in *C. diff* spores and complete eradication of *Acinetobacter*.
- CRE results were variable and require further study. This may be secondary to biofilm production.

Conclusion

- UV light is effective in eradicating MRSA, VRE, *Acinetobacter* and *C. diff* spores.
- Distance of emitter from inoculated surfaces impacts eradication rates.
- Previously occupied patient care rooms at OSUWMC will be tested with the 3 emitter technology.

References

- Nerandzic MM, Cadnum JL, Pultz MJ, Donskey CJ. Evaluation of an automated ultraviolet radiation device for decontamination of *Clostridium difficile* and other healthcare-associated pathogens in hospital rooms. *BMC Infect Dis.* 2010 Jul 8;10:197.
- Otter JA, Yezli S, French GL. The role played by contaminated surfaces in the transmission of nosocomial pathogens. *Infect Control Hops Epidemiol.* 2011 Jul;32(7):687-99.
- Shaughnessy MK, Micielli RL, DePestel DD, Arndt J, Strachan CL, Welch KB, Chenoweth CE. Evaluation of hospital room assignment and acquisition of *Clostridium difficile* infection. *Infect Control Hosp Epidemiol.* 2011 Mar;32(3):201-6.

Contact: Christina.Liscynesky@osumc.edu