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Antimicrobial Activity of a Continuous Visible Light Disinfection System

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Background

- Recent evidence has demonstrated that the contaminated hospital environment is an important source for transmission of epidemiologically-important pathogens (EIP) such as MRSA and VRE.
- An overhead light fixture technology, which continuously and safely disinfects the environment using light-emitting diodes (LEDs) that emit a high-intensity, narrow spectrum (HINS) light has been proposed as an infection prevention strategy.
- This technology uses LEDs to create a narrow bandwidth of high-intensity visible violet light with a peak output of 405nm that react with porphyrin molecules to generate reactive oxygen species that kill microorganisms.
- The purpose of this evaluation was to determine the effectiveness of HINS-light for the reduction of epidemiologically-important pathogens.

Methods

- The new technology was evaluated in two different clinical configurations (White Disinfection Mode and Supplemental Blue-Disinfection Mode).
- In Phase 1, two 2x2 blended-white, ceiling-mounted fixtures were used which provided both disinfection and ambient white illumination for use in normal clinical conditions in an occupied room (surface irradiance ~0.12-0.16 mW/cm² measured at the pathogen location).
- In Phase 2, a higher-level of disinfection was studied with the addition of a 2x4 overhead. This fixture emits only disinfecting (blue) light (surface irradiance=0.34-0.44 mW/cm²).
- The four test organisms were *C. difficile* spores (BI), MRSA (ATCC 43300), VRE (ATCC 51299), and MDR-*A. baumannii* (MDRA). Formica test surfaces were inoculated with 100-500 CFUs of test organisms.
- Once dry, triplicate samples were collected with Rodac plates containing DE Neutralizing Agar at times 0, 1hr, 3hr, 5hr, 6hr, 7hr, 24hr, 48hr, and 72hr then appropriately incubated.
- To accommodate the natural die-off of vegetative bacteria, a control test surface (Formica) was placed in an adjacent area but not exposed to the light disinfection.

Results

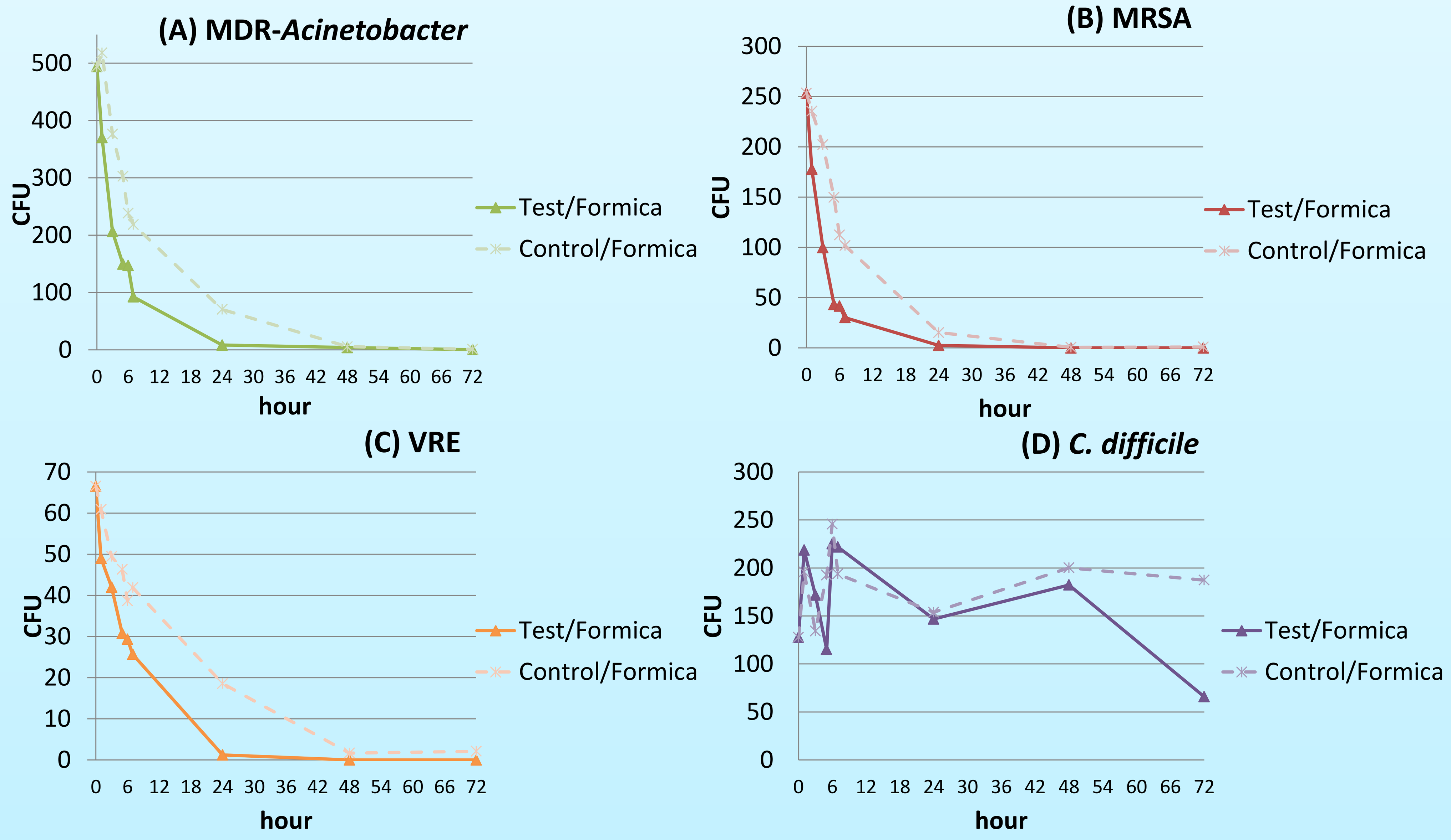

Figure 1. Survival in MDR-*Acinetobacter* (A), MRSA (B), VRE (C), and *C. difficile* (D) with Blue Light

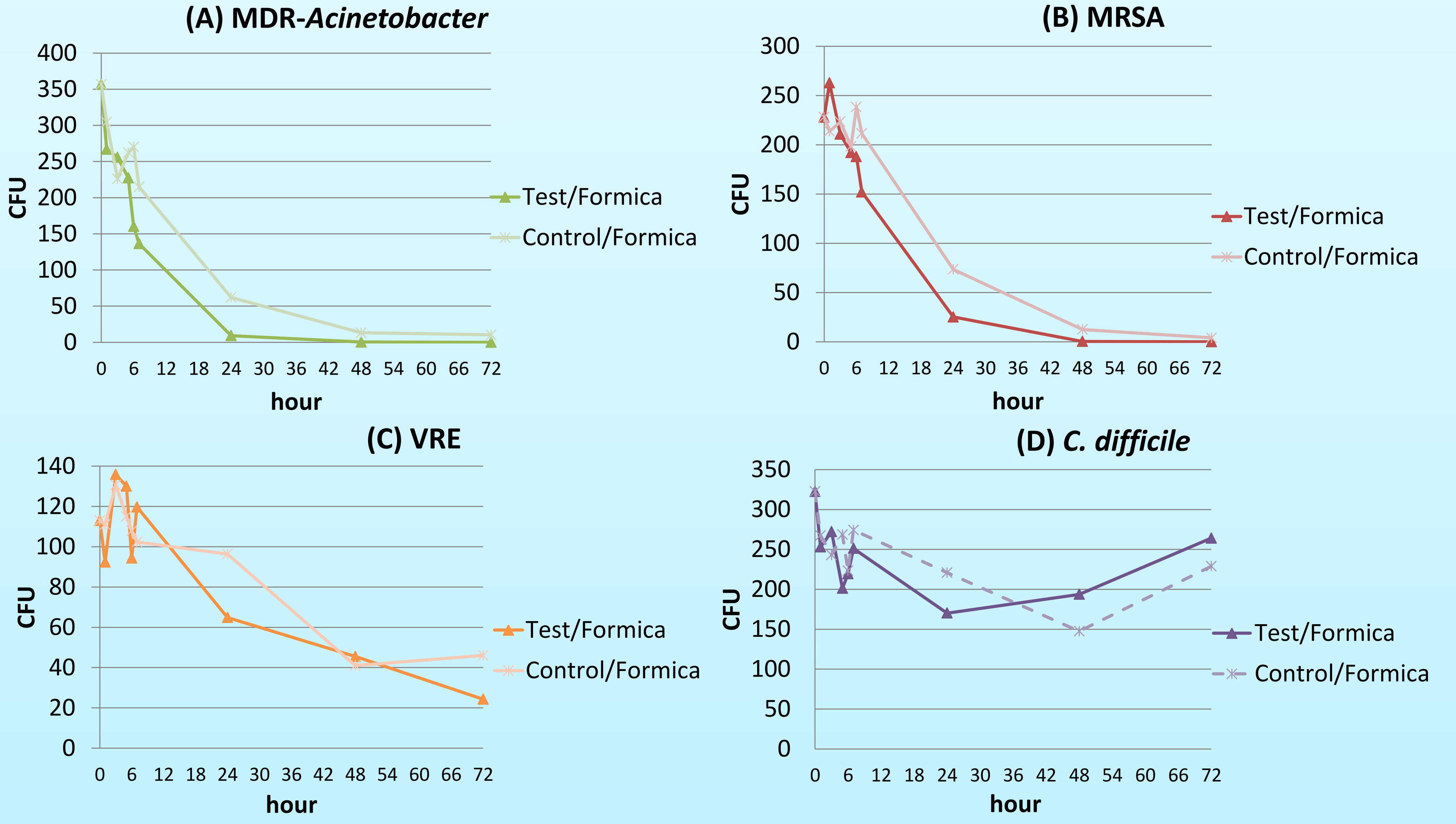

Figure 2. Survival in MDR-*Acinetobacter* (A), MRSA (B), VRE (C), and *C. difficile* (D) with White Light

Table 1. Time to specified percent reductions of epidemiologically-important pathogens with "blue" light and "white" light.

Treatment	Pathogen	Time (least number of hours) to achieve microbial reduction 25%	50%	90%	100%	Maximum reduction achieved (%)
Blue light	MRSA		3	48	48	100
	VRE	5	24	24	48	100
	MDR-*Acinetobacter*	1	5	NA	NA	88
	C. difficile	5	72	NA	NA	65
White light	MRSA	7	24	48	72	100
	VRE	24	NA	NA	NA	47
	MDR-*Acinetobacter*	6	24	48	72	100
	C. difficile	5	NA	NA	NA	25

NA, not achieved. MRSA, methicillin-resistant *Staphylococcus aureus*; VRE, vancomycin-resistant *Enterococcus*, MDR-*Acinetobacter*, multidrug resistant *Acinetobacter*.

Results Summary

- These results demonstrated that the 405nm light inactivated three vegetative bacteria (MRSA, VRE, MDRA) on surfaces with contact times of 1-72hr.
- Statistical differences ($p<0.05$) were observed using "blue" light for VRE at 24 and 48 hours, for MRSA at 3, 5, 6 and 7 hours, for MDR-*Acinetobacter* at 5, 6, 7, and 24 hours, and for *C. difficile* spores at 5 and 72 hours.
- The "white" light demonstrated no statistically improved reduction (i.e., $p>0.05$) at any time point compared to control die-off for VRE, MDR-*Acinetobacter*, and *C. difficile* but there was a statistical difference for MRSA at 1, 7, 24 and 48 hours.
- The inactivation was more significant when the surface irradiance was increased by adding the blue light.

Conclusions

- We demonstrated that the "blue" light significantly reduced both vegetative bacteria and spores at some time points over a 72 hour exposure period.
- In addition to episodic disinfection (e.g., UV), this continuous light disinfection technology could be considered for several healthcare decontamination applications (e.g., OR).
- Given that environmental surfaces in patient's room are often not thoroughly disinfected plus that recontamination occurs rapidly it is important to develop either methods of continuous disinfection or a germicide with persistent antimicrobial effectiveness.
- Whether these reductions are sufficient to reduce healthcare-associated infections requires further studies.

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