American Journal of Infection Control 000 (2019) 1–3

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Brief Report

In situ evaluation of a persistent disinfectant provides continuous decontamination within the clinical environment

Michael G. Schmidt PhD *, Sarah E. Fairey BS, Hubert H. Attaway MS, MBA

Department of Microbiology and Immunology, Medical University of South Carolina, Charleston, SC

Key Words:
US EPA-registered hospital disinfectants
Bioburden
Built environment
Health care–associated infection

Microbial bioburden associated with the built environment can impact the rate of health care–associated infection acquisition; higher bioburden results in a greater incidence of health care–associated infections. Two disinfectants registered by the US Environmental Protection Agency and a trial disinfectant were evaluated for their ability to limit the establishment of bioburden subsequent to application under in situ conditions on patient bed rails within a medical intensive care unit. Bioburden samples were collected immediately prior to disinfection and at 1, 6, and 24 hours after application. The trial disinfectant was engineered to provide continuous disinfection over a 24-hour period. Each disinfectant was able to significantly control bioburden for the first hour. In comparison, the persistent agent was found superior for all time points when compared to a dilutable quaternary ammonium agent, and it was significantly better for controlling bioburden for 2 of the 3 times points for the disinfectant with ethanol and quaternary ammonium as its agent.

BACKGROUND

Health care–associated infections (HAIs) are a major public health concern as they cause substantial morbidity and mortality. As early as 1990, Weinstein[1] estimated that between 20% and 40% of HAIs were the result of transference from the hands of health care personnel and/or from the built health care environment. Salgado and colleagues[2] found that when the bioburden levels of 6 common patient-room objects were correlated against HAI acquisition, a lower cumulative bioburden for objects and surfaces resulted in significantly fewer infections. The built hospital environment contributes to this problem, as it serves as a substantial reservoir for microbes that can easily be transferred among patients, health care staff, and visitors. Reducing HAIs has been achieved through the implementation of low-technology and low-cost interventions such as hand hygiene and cleaning with subsequent disinfection of the surfaces within the built clinical environment. Hand washing has been shown to be the single most effective intervention for lowering this risk but struggles with maintaining sufficient rates of compliance.[3] Environmental cleaning and disinfection of the built environment using Environmental Protection Agency (EPA)-approved disinfectants have also been shown to mitigate the risk of microbial transference. Attaway and colleagues[4] showed that the typically discontinuous application of EPA-registered disinfectants allows bioburden to quickly become re-established to levels equivalent to those seen prior to disinfection, thereby restoring the risk of transfer. This study evaluated the in situ effectiveness of a disinfectant designed to provide persistent disinfection.

METHODS

A persistent disinfectant, Firebird F130 (70% ethanol and <1% mixed quaternary ammonium chloride compounds along with proprietary agents designed to increase longevity on surfaces; Microban, Huntersville, NC), hereafter referred to as Disinfectant 1, was evaluated in concert with two commonly used EPA-registered hospital disinfectants: CaviCide (Disinfectant 2; Metrex, Orange, CA) and Virex II 256 (Disinfectant 3; Diversey, Charlotte, NC). Two independent trials were conducted where Disinfectant 1 was tested separately against Disinfectant 2 and Disinfectant 3. The agents were used to disinfect the rails associated with the beds of patients under care within the medical intensive care unit of the Medical University of South Carolina. The study protocol was submitted to the university's institutional review board and deemed exempt. Exclusion criteria included excluding data from assessment for patients who were discharged

* Address correspondence to Michael G. Schmidt, PhD, Department of Microbiology and Immunology, Medical University of South Carolina, 173 Ashley Ave, Charleston, SC 29425

E-mail address: schmidtm@musc.edu (M.G. Schmidt).

Funding/support: This work was supported by an unrestricted research grant from Microban Inc. The views, opinions, and/or findings presented here are those of the authors alone.

Conflicts of interest: None to report.

https://doi.org/10.1016/j.ajic.2019.02.013

Table 1
Disinfection activity of Disinfectant 1 persists for up to 24 hours

Agent	Pre-disinfection concentration (CFU/100 cm^2)	Median burden observed (CFU/100 cm^2)			Is the post disinfection concentration significantly lower than the pre-disinfection concentration ($P \leq .05$)?			Is Disinfectant-1 Burden Significantly Lower than Disinfectant-2 or Disinfectant-3 ($P \leq .05$)?			% Burden remaining subsequent to disinfection		
		1 h post	6 h post	24 h post	1 h post	6 h post	24 h post	1 h post	6 h post	24 h post	1 h post	6 h post	24 h post
Disinfectant 1	675	30	120	300	<.0001	<.0001	.0141	No	Yes	Yes	4%	18%	44%
Disinfectant 2	990	30	450	630	<.0001	.0151	.1442	.5408	<.0001	.0347	3%	45%	64%
Disinfectant 3	480	135	540	735	.0043	.7125	.3063	Yes	Yes	Yes	28%	113%	153%
Disinfectant 1	360	30	150	150	<.0001	.0035	.0063	.0039	0.0034	.0002	8%	42%	42%

NOTE: Two independent trials were conducted: Disinfectant 1 (n = 135) concurrently with Disinfectant 2 (n = 136) and Disinfectant 1 (n = 120) concurrently with Disinfectant 3 (n = 129).
CFU, colony forming unit.

during the 24-hour period of the study. Normal patient care and visitation continued throughout the course of each study. Health care workers and visitors were blinded as to the conduct or intent of the ongoing studies.

The resident microbial bioburden associated with the rails of a patient's bed was assessed for a total of 132 occupied single-patient rooms containing either Stryker InTouch Critical Care Beds or Stryker S3 MedSurg Beds equipped with air-mattress support (Stryker, Kalamazoo, MI). Occupied beds were selected based on the likelihood that the patient would remain with the same bed for the 24-hour sampling period. Each disinfectant was equivalently applied separately, according to the manufacturers instructions, to the upper surface of the bed rails and allowed to evaporate. Bioburden was recovered and enumerated essentially as described by Attaway et al[4] immediately prior to disinfection and at 1, 6, and 24 hours subsequent to application of the disinfectant. Briefly, a 100-cm^2 template was placed onto the bed rail, whereupon a 2-in × 1-in Kimtech Pure CL5 wipe (Kimberley-Clarke Professional, Roswell, GA) premoistened with 200 μL of phosphate buffered saline, 0.5% Tween 80, and 0.07% lecithin was used to liberate the microbes using uniform pressure and motion (5 strokes horizontally and 5 strokes vertically) for a total of 10 strokes, with the bacteria being enumerated as previously described.[4] Bioburden was recovered from 65 beds disinfected with Disinfectant 1, 34 beds disinfected with Disinfectant 2, and 33 beds disinfected with Disinfectant 3. Differences of efficiency of disinfection among the agents were assessed using pairwise comparisons using the Mann-Whitney test with a significance level (P) assessed as less than 5% ($P < .05$) using Prism 6 software (GraphPad, San Diego, CA).

RESULTS

The continuous disinfecting activity of Disinfectant 1 was evident from a comparison of the bioburden recovered (aerobic colony forming units per 100 cm^2) from bed rails disinfected by this agent in the 2 trials (Table 1). Bioburden was found to be significantly lower for 1, 6, and 24 hours post-disinfection, suggesting that the trial disinfectant retained activity subsequent to its application to bed rails. This observation was remarkable considering how quickly microbes have been reported to be reintroduced to the rails of occupied beds.[4,5]

In contrast, Disinfectant 3 was only able to maintain its disinfection activity for up to 1 hour after application, given that the median bioburden for samples collected at 6 and 24 hours indicated reintroduction of microbes to bed rails subsequent to disinfection. As demonstrated previously, Disinfectant 2, similar in composition to Disinfectant 1, exhibited significant population rebound within 6 hours of its application. Its antimicrobial activity continued to wane, failing to significantly control bioburden at the 24-hour time point.

DISCUSSION

In comparing the efficiency of the 2 EPA-registered disinfectants (Disinfectant 2 and Disinfectant 3) to the persistent activity engineered into Disinfectant 1, it was found that Disinfectant 1 was significantly better at limiting the establishment of bacteria on bed rails. The activity of Disinfectant 1 was significantly better than that of Disinfectant 3 for all time points and was superior for 2 of the 3 time points evaluated for Disinfectant 2 (Fig 1). In the one instance where Disinfectant 1 was found not to be significantly different than Disinfectant 2, a possible explanation might be attributed to the alcohol activity coincident to the composition included in both disinfectants. Given that Disinfectant1 has components to facilitate its persistence and Disinfectant 2 lacks such factors, an absence of persistent activity by Disinfectant 2 may be accounted for by evaporation of the residual alcohol to a level

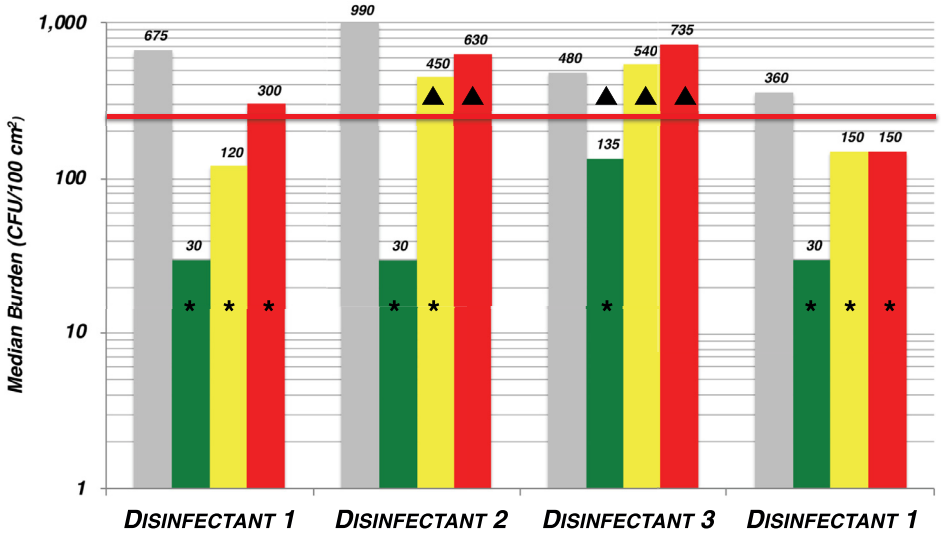

Figure 1. In situ evaluation of three disinfectants for ability to limit the establishment of microbial bioburden onto rails of occupied beds subsequent to disinfection. Three disinfectants were evaluated for an ability to limit the establishment of bioburden subsequent to disinfection. Bioburden samples were collected immediately prior to disinfection (grey columns), and 1 hour (green columns), 6 hours (yellow columns) and 24 hours (red columns) subsequent to the application of the named disinfectants. Median concentrations of aerobic colony forming units recovered (CFU/100cm^2) are reported from two independent trials; Disinfectant-1-1 (Sampled 135 times using 34 rooms/beds) concurrently with Disinfectant-2 (Sampled 136 times using 34 rooms/beds) and Disinfectant-1-2 (Sampled 120 times using 31 beds/rooms) concurrently with Disinfectant-3 (Sampled 129 times using 33 beds/rooms); *denotes bioburden was significantly lower than its pre-disinfection concentration. p denotes Disinfectant-1 bioburden for the equivalent time point was significantly lower than its concurrent comparator (Disinfectant-2 or Disinfectant-3) for the specific time point. Red line at 250 CFU/cm^2 denotes targeted concentration recommended upon completion of terminal cleaning.

where it was insufficient to control establishment or regrowth of microbes on the rails of patient-occupied beds.

There were limitations to the study. First, as patients were present in each bed evaluated, the heterogeneity of shedding of microbes from patients, coupled with the acuity of care required from staff for individual patients, may have influenced the recovery of microbes from the rails of the beds. However, the patient variable was not formally controlled for in subsequent analysis of the data. Given that the investigators had no way to control for shedding or acuity of care required for individual patients, it is suggested that the data presented reflect real-world performance that users might anticipate if they elect to use a persistent disinfectant. A second limitation to the study is inherent to the methodology used to recover the in situ microbes resident on bed-rail surfaces. Although every attempt was made not to sample in the same location, the act of accidentally sampling an area that had been previously sampled may have resulted in higher concentrations being recorded for Disinfectant 1, as the action of sampling may have removed the disinfectant.

CONCLUSIONS

The use of a disinfectant with continuous or persistent disinfectant activity offers the infection control community a new opportunity to limit the re-establishment of bacteria on critical touch surfaces within the built environment. Multiple infection control bundles have shown that infection control risk mitigation strategies integrating hand hygiene with room cleaning can be effective, but to date only solid copper surfaces have been successfully deployed to consistently demonstrate an ability to minimize the microbial burden found in the built clinical environment.[5–8] The agent evaluated here, Disinfectant 1, represents a first-of-its-kind disinfectant that offers an ability to debulk the built environment of microbes while addressing the limitations inherent to using EPA-registered disinfectants for daily cleaning—namely, rebound of the biofilm affiliated with surfaces or the introduction of new bioburden secondary to care and housing of patients. The finding that Disinfectant 1 was able to significantly control bioburden on bed rails, a critical touch surface, for up to 24 hours during active patient care warrants further investigation. Salgado and colleagues[2] were able to demonstrate that, when the inherent microbial bioburden of an occupied patient room was kept low, the risk of acquisition of HAIs was similarly reduced. Whether the continuous disinfection ability of the properties of Disinfectant 1 will translate into a lower risk of HAI acquisitions remains to be determined.

References

1. Weinstein RA. Epidemiology and control of nosocomial infections in adult intensive care units. Am J Med 1991;91:179S-84S.
2. Salgado CD, Sepkowitz KA, John JF, Cantey JR, Attaway HH, Freeman KD, et al. Copper surfaces reduce the rate of healthcare-acquired infections in the intensive care unit. Infect Control Hosp Epidemiol 2013;34:479-86.
3. WHO. WHO guidelines on hand hygiene in health care. First global patient safety challenge: clean care is safer care. Geneva (Switzerland): World Health Organization; 2009.
4. Attaway HH 3rd, Fairey S, Steed LL, Salgado CD, Michels HT, Schmidt MG. Intrinsic bacterial burden associated with intensive care unit hospital beds: effects of disinfection on population recovery and mitigation of potential infection risk. Am J Infect Control 2012;40:907-12.
5. Schmidt MG, Attaway HH 3rd, Fairey SE, Steed LL, Michels HT, Salgado CD. Copper continuously limits the concentration of bacteria resident on bed rails within the intensive care unit. Infect Control Hosp Epidemiol 2013;34:530-3.
6. Hinsa-Leasure SM, Nartey Q, Vaverka J, Schmidt MG. Copper alloy surfaces sustain terminal cleaning levels in a rural hospital. Am J Infect Control 2016;44:e195-203.
7. Schmidt MG, Attaway HH 3rd, Sharpe PA, John J Jr, Sepkowitz KA, Morgan A, et al. Sustained reduction of microbial burden on common hospital surfaces through introduction of copper. J Clin Microbiol 2012;50:2217-23.
8. Schmidt MG, von Dessauer B, Benavente C, Benadof D, Cifuentes P, Elgueta A, et al. Copper surfaces are associated with significantly lower concentrations of bacteria on selected surfaces within a pediatric intensive care unit. Am J Infect Control 2016;44:203-9.