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Brief Report

Self-sanitizing copper-impregnated surfaces for bioburden reduction in patient rooms

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Key Word:
Surface disinfection

Novel self-sanitizing copper oxide-impregnated solid surfaces have the potential to influence bioburden levels, potentially lowering the risk of transmission of pathogens in patient care environments. Our study showed persistently lower microbial burden over a 30-hour sampling period on a copper-impregnated tray table compared with a standard noncopper surface in occupied patient rooms after thorough initial disinfection.

Surface contamination plays a role in the transmission and spread of health care-acquired infections.[1] Patients admitted to rooms where previous patients were positive for methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus*, or *Clostridium difficile* are at 2-3 times higher risk for acquiring these organisms compared with patients in rooms where the previous occupant was not positive.[2] Although studies have shown that surface disinfection through standard cleaning practices decreases environmental contamination with these pathogens, standard disinfection practices alone have generally been shown to be inadequate.[3] As a result, several novel, no-touch disinfection technologies, such as mercury-based or pulsed xenon ultraviolet (UV) light disinfection, have been incorporated into hospital cleaning protocols to enhance the disinfection process.[3] However, these technologies have their own limitations. For example, UV light cannot reach surfaces in shadows, and UV light devices cannot be used when a patient is in the room.[3,4] Copper oxide-impregnated self-sanitizing solid surfaces (SSSCu) may provide a promising strategy for keeping bioburden low at all times.[5] Currently, there is a lack of evidence on the effectiveness of SSSCu in reducing surface contamination in a real-world hospital setting.[6] This study examined the effect of a novel SSSCu surface on microbial burden of tray tables in a real-world hospital setting.

MATERIALS AND METHODS

This study was conducted at a 120-bed Veterans Affairs hospital in Temple, TX. The research protocol was approved by expedited review by the institutional review board and safety committee at the Central Texas Veterans Health Care System (Temple, TX). Samples for aerobic bacterial colony (ABC) count were obtained 3 times per day over a 2-day period from an SSSCu bedside tray table (treatment) (EOS^{Cu} Surfaces LLC, Norfolk, VA) placed inside 11 occupied patient rooms, and from a non-SSSCu tray table covered with standard laminate (control) placed inside 11 occupied patient rooms. The arm attribution was based on convenience determined by availability of the sampler and nursing information that a patient would stay for at least 2 days. Control rooms included 5 nonisolation precaution and 6 isolation precaution rooms, whereas treatment rooms included 6 nonisolation precaution and 5 isolation precaution rooms. All isolation patients were under methicillin-resistant *Staphylococcus*

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The copper-impregnated over-bed tabletop used in this study was donated to Central Texas Veterans Health Care System by EOS surfaces under a cooperative research and development agreement. EOS^{Cu} Surfaces LLC, Norfolk, VA, did not participate in the study design or in the collection, analysis, and interpretation of data, the writing of the report, or in the decision to submit the manuscript for publication.

Conflicts of interest: None to report.

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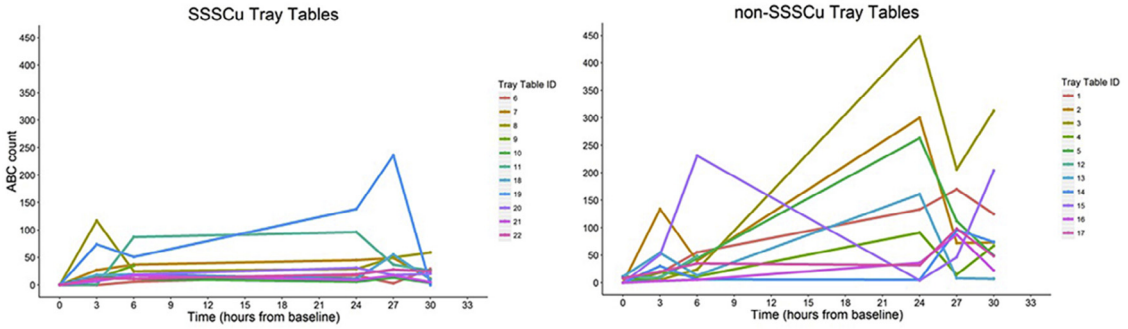

Fig 1. Microbial burden over time for 11 copper oxide-impregnated self-sanitizing solid surfaces (SSSCu) and 11 non-SSSCu tray tables.

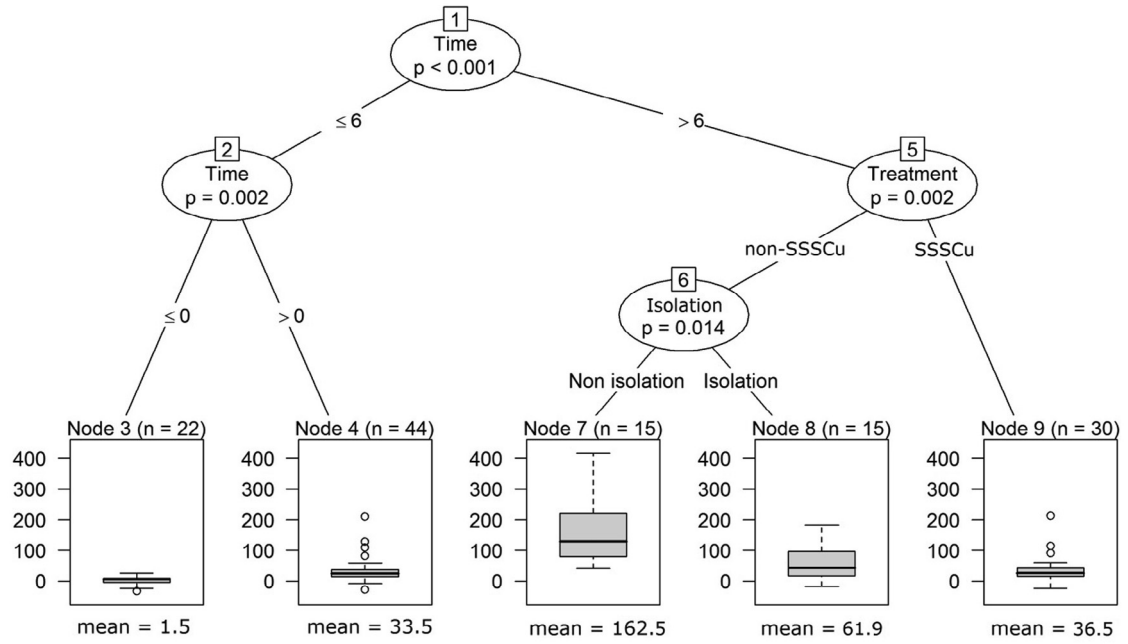

Fig 2. Unbiased Random Effects/EM (RE-EM) tree.

aureus precautions per hospital policy. Immediately before sampling at hour 0, the tray table was cleaned with 10% sodium hypochlorite wipes (Clorox Healthcare, Oakland, CA). Samples were taken at hours 0, 3, 6, 24, 27, and 30. The environment samples were collected from adjacent areas using Rodac tryptic soy agar contact plates (Hardy Diagnostics, Santa Maria, CA) for ABC with a surface area of 25 cm^2. After collection, the samples were incubated at 35°C for 24 hours. Colony forming units were counted and recorded. Analysis was completed using an unbiased Random Effects/EM (RE-EM) regression tree for longitudinal data modeling ABC count as a function of treatment condition, isolation status, and time, with a random intercept for tray table identification number. Regression trees are nonparametric techniques with power comparable to traditional regression methods but with added ability to model complex interactions that cannot be modeled using traditional regression methods. This analysis was performed using the unbiased RE-EM tree proposed by Fu and Simino[7] using the package "party" in R version 3.2.3 (R Foundation for Statistical Computing, Vienna, Austria).[8]

RESULTS

Plots of the microbial burden over time for non-SSSCu and SSSCu tray tables are shown in Figure 1.

The mean ABC count (95% confidence interval based on 30,000 bootstrap replicates) for 6 occasions over 30 hours for 22 rooms ranged from 0.2 CFU/25 cm^2 (95% CI, 0-0.4 CFU/25 cm^2) for SSSCu and 1.9 CFU/25 cm^2 (95% CI, 0-4.9 CFU/25 cm^2) for non-SSSCu at hour 0, to a count of 18.9 CFU/25 cm^2 (95% CI, 11.0-32.5 CFU/25 cm^2) for SSSCu and a count of 98.2 CFU/25 cm^2 (95% CI, 56.2-176.3 CFU/25 cm^2) for non-SSSCu at hour 30.

In the RE-EM regression tree, there was no statistically significant difference in ABC count between the SSSCu and the non-SSSCu surfaces at hours 0, 3, and 6, because the difference between hour 0 and hours 3-6 was determined by time ($P = .002$), not treatment group (Fig 2). For hours 24, 27, and 30, there was a statistically significant difference ($P = .002$) in ABC count between the SSSCu (mean, 36.5 CFU/25 cm^2) and the non-SSSCu tray table. The ABC count for non-SSSCu tray tables in isolation status rooms (mean, 61.9 CFU/25 cm^2) was significantly different ($P = .014$) from counts for the non-SSSCu tray table in nonisolation rooms (mean, 162.5 CFU/25 cm^2). This isolation status effect was not seen for the SSSCu tray table.

DISCUSSION

Our study showed that the SSSCu surfaces accumulated lower bioburden over time compared with the non-SSSCu surfaces.

Although the 2 surfaces had similar bioburdens during the first few hours after artificially resetting the counts to zero by cleaning, they showed marked differences in bioburden accumulation on the second day (hours 24-30). Thus for hours 24, 27, and 30, there was a statistically significant difference between the ABC counts for SSSCu compared with non-SSSCu surfaces.

Within the SSSCu surface samples and within the non-SSSCu samples, the ABC counts were similar at hours 24, 27, and 30, indicating a possible ceiling to bioburden accumulation. Our findings are consistent with published literature on copper-alloy surfaces. Schmidt et al[9] saw an increase in bioburden over the first 6-9 hours. In a separate study, Schmidt et al[10] found the microbial burden ceiling at day 7 was around 700-800 CFU/100 cm^2 of ABC for noncopper alloy surfaces and 150-200 CFU/100 cm^2 for copper alloy surfaces, which is similar to our findings. These results suggest that although inoculation of the surfaces is similar (as reflected by similar bioburden within the first few hours) after an adequate incubation time, the microbial burden increases on non-SSSCu surfaces and reaches a ceiling, whereas remaining the same or decreasing slightly on SSSCu surfaces.[9] In addition, our results show that isolation status is an important predictor of ABC count for non-SSSCu surfaces but not for SSSCu surfaces. Although this study is too small to draw conclusions, these results also suggest that an SSSCu surface may mitigate an isolation status effect where rooms without isolation precautions accumulate more bioburden than rooms with isolation precautions. A possibility is that contact precautions limit the introduction of bacteria from health care workers to patient environments, but further research is needed to explain this finding.

Our pilot study was devised to study bioburden accumulation on 2 different surfaces in a real-world hospital environment. We did not control or account for variability in processes. Further, this small study was limited to assessing the microbial burden of ABC on tray tables. Results may differ for other high-touch surfaces. In addition, the sample size was small and the microbial burden was assessed at only 6 time points over a 2-day period for most rooms (91%).

CONCLUSIONS

Despite these limitations, the results suggest that a novel SSSCu solid surface may indeed result in persistently lower microbial burden compared with a standard noncopper surface in a real-world hospital setting.

References

1. Han JH, Sullivan N, Leas BF, Pegues DA, Kaczmarek JL, Umscheid CA. Cleaning hospital room surfaces to prevent health care-associated infections: a technical brief. Ann Intern Med 2015;163:598-607.
2. Huang SS, Datta R, Platt R. Risk of acquiring antibiotic-resistant bacteria from prior room occupants. Arch Intern Med 2006;166:1945-51.
3. Jinadatha C, Quezada R, Huber TW, Williams JB, Zeber JE, Copeland LA. Evaluation of a pulsed-xenon ultraviolet room disinfection device for impact on contamination levels of methicillin-resistant *Staphylococcus aureus*. BMC Infect Dis 2014;14:187.
4. Hacek DM, Ogle AM, Fisher A, Robicsek A, Peterson LR. Significant impact of terminal room cleaning with bleach on reducing nosocomial *Clostridium difficile*. Am J Infect Control 2010;38:350-3.
5. Monk AB, Kanmukhla V, Trinder K, Borkow G. Potent bactericidal efficacy of copper oxide impregnated non-porous solid surfaces. BMC Microbiol 2014;14:57.
6. O'Gorman J, Humphreys H. Application of copper to prevent and control infection. Where are we now? J Hosp Infect 2012;81:217-23.
7. Fu E, Simonoff JS. Unbiased regression trees for longitudinal and clustered data. Comput Stat Data Anal 2015;88:53-74.
8. Hothorn T, Hornik K, Zeileis A. Unbiased recursive partitioning: a conditional inference framework. J Comput Graph Stat 2006;15:651-74.
9. Schmidt MG, Attaway HH, 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.
10. Schmidt MG, Attaway HH, 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.