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Major Article

Copper alloy surfaces sustain terminal cleaning levels in a rural hospital

Shannon M. Hinsa-Leasure PhD [a,b,*], Queenster Nartey BA [a], Justin Vaverka BA [a], Michael G. Schmidt PhD [a]

[a] Department of Biology, Grinnell College, Grinnell, IA
[b] Department of Microbiology and Immunology, Medical University of South Carolina, Charleston, SC

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Objective: To assess the ability of copper alloy surfaces to mitigate the bacterial burden associated with commonly touched surfaces in conjunction with daily and terminal cleaning in rural hospital settings.
Design: A prospective intention-to-treat trial design was used to evaluate the effectiveness of cooper alloy surfaces and respective controls to augment infection control practices under pragmatic conditions.
Setting: Half of the patient rooms in the medical-surgical suite in a 49-bed rural hospital were outfitted with copper alloy materials. The control rooms maintained traditional plastic, metal, and porcelain surfaces.
Methods: The primary outcome was a comparison of the bacterial burden harbored by 20 surfaces and components associated with control and intervention areas for 12 months. Locations were swabbed regardless of the occupancy status of the patient room. Significance was assessed using nonparametric methods employing the Mann-Whitney *U* test with significance assessed at $P < .05$.
Results: Components fabricated using copper alloys were found to have significantly lower concentrations of bacteria, at or below levels prescribed, upon completion of terminal cleaning. Vacant rooms were found to harbor significant concentrations of bacteria, whereas those fabricated from copper alloys were found to be at or below those concentrations prescribed subsequent to terminal cleaning.
Conclusions: Copper alloys can significantly decrease the burden harbored on high-touch surfaces, and thus warrant inclusion in an integrated infection control strategy for rural hospitals.

INTRODUCTION

A major concern of health care is the prevalence and substantial acquisition rate with which health care-associated infections (HAIs) occur. In the United States, there are approximately 35.1 million discharges resulting from in-patient care. It is estimated that the rate of HAI acquisition is 1 out of every 25 patients admitted.[1] For 2011, it is estimated that of the approximate 722,000 patients who contracted HAIs, 10% died as a consequence of this adverse event subsequent to hospitalization.[1] The Patient Protection and Affordable Care Act has generated both enhanced scrutiny and added consequence to this alarming rate. Of the more than 3,300 US hospitals evaluated by the Centers for Medicare and Medicaid Services, approximately 23% will lose some funding from Medicare as a consequence of the Hospital Acquired Condition Reduction Program or a so-called quality of care penalty being mandated by section 3008 of the law.[2] Accordingly, HAIs represent a substantial challenge to the industry both in terms of lives influenced and the added financial burden of health care.

Recent interest has focused on high-touch surfaces throughout the hospital and the ability of these surfaces to serve as reservoirs for pathogenic microorganisms, including *Staphylococcus aureus*, *Clostridium difficile*, and vancomycin-resistant enterococci.[3-7] These and other nosocomial pathogens have been found to survive from days to months on dry surfaces, such as those commonly found in hospital settings.[8] Although several different cleaning regimens have

* Address correspondence to Shannon Hinsa-Leasure, PhD, Department of Biology, Grinnell College, 1116 8th Ave, Grinnell, IA 50112.
E-mail address: hinsa@grinnell.edu (S. Hinsa-Leasure).
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been tested, bacteria have been shown to repopulate hospital surfaces, making it very difficult to maintain the current suggested standard for surface-level cleanliness subsequent to terminal cleaning; that is, between 2.5 and 5.0 CFU/cm^2.[3,9-12]

Copper alloys, which are recognized by the Environmental Protection Agency (EPA) as having antimicrobial effectiveness, have been shown in vitro and in vivo to significantly and continuously reduce the number of bacteria, viruses, fungi, and yeasts compared with standard noncopper surfaces.[13-21] Copper alloy surfaces have been shown to kill a majority of bacteria within 2 hours of contact and recent studies have provided insight to the multicomponent mechanism of action attributed to copper on gram-positive and gram-negative bacteria.[22-28] Thus, hospitals are installing these metal surfaces, which are naturally antimicrobial, to decrease the prevalence of microbial pathogens within the built environment.

Recent clinical studies have demonstrated the effectiveness of copper alloy surfaces to reduce the bacterial burden and lower the rate of HAIs, with particular attention to surfaces associated with the built environment of medical intensive care units.[3,9,29-33] However, more than half of HAIs are acquired outside of an intensive care unit.[1] This study expands on previous work to determine the effectiveness of copper alloy surfaces for their ability to sustain the terminal cleaning standard in medical and surgical suite patient rooms, en-suite bathrooms, and 5 other high-touch surfaces external to patient rooms in a rural hospital. Both occupied and unoccupied medical-surgical rooms were studied to determine the background bacterial concentrations or burden. We hypothesized that through the introduction of copper alloy fixtures, furnishings, and equipment, bacterial loads associated with these highly touched surfaces would be sustained at or near the level recommended upon completion of terminal cleaning.

MATERIALS AND METHODS

Study site

The study was conducted at the Grinnell Regional Medical Center (GRMC), which is a 49-bed hospital located in Grinnell, IA. The medical-surgical suite included 18 patient rooms, with a total of 23 patient beds. Each patient room has an en-suite bathroom. A majority of the patients were ambulatory, regularly moving within their rooms, bathrooms, and hallways.

Cleaning regimen

Patient rooms were cleaned daily and were subjected to terminal cleaning upon patient discharge following the established protocol prescribed by the hospital. For the control rooms, High Dilution Disinfectant 256 (Spartan Green Solutions, Maumee, OH) was used for daily and terminal cleaning. For rooms with copper components (intervention arm) OxivirTB (Sealed Air Diversey Care, Charlotte, NC) was used for and daily and terminal cleaning. OxivirTB was used on the copper components to help maintain their appearance and to minimize bias as a consequence of appearance imperfections. There was no difference in efficacy of disinfection between the 2 disinfectants (data not shown). Rooms housing patients positive for *C difficile*, were subjected to an alternate disinfection protocol. Diffense (Spartan Chemical, Maumee, OH) or Clorox Bleach Germicidal Cleaner (Chlorox Company, Oakland, CA) was used to disinfect both the control and rooms with the copper alloy surfaces (intervention). All cleaners were used as prescribed by the manufacturers. All sinks and overbed tables were polished bimonthly with Wrights Copper Cream (Weiman, Gurnee, IL) to maintain the color and uniformity of finish, according to the manufacture's recommendations, because EPA-registered copper alloys are equivalently and continuously antimicrobial regardless of appearance.

Study design and sample collection

A prospective intention-to-treat trial design was used to evaluate the effectiveness of cooper alloy surfaces and the concurrent control surfaces under pragmatic conditions for an ability to augment existing infection control practices at GRMC. The primary outcome of the study was the bacterial burden associated with frequently touched surfaces in proximity to patients and patient care providers. GRMC has HAI acquisition rates too low for statistical comparisons.

The bacterial burden was measured by the weekly collection of samples from a total of 20 surfaces and objects, over the course of 12 months. Sampling was conducted as described by Attaway et al.[3] Upon recovery of the sample from each component, each wipe was placed into 3 mL PBS-LT (phosphate-buffered saline with 0.5% Tween80 and 0.07% lecithin). Samples were vortexed, diluted as necessary, and enumerated by plating onto TSA + 5% sheep's blood agar (TSAII; Becton Dickinson and Company, Sparks, MD) with subsequent incubation at 37°C for 48 hours.

Before the intervention 17 high-touch objects were sampled routinely over the course of a 10-week period before installation of surfaces and objects fabricated from or surfaced with, a copper-nickel alloy (C706) that contained 90% copper by weight (Fig 1). The patient rooms on a single side of the hallway in the medical-surgical suite were outfitted with listed components fabricated using EPA-registered copper alloys. There were 13 single rooms, 6 of which were outfitted with copper alloy components. Of the 5 double rooms, 3 contained copper alloy components.

All samples taken during the preintervention period were from occupied patient rooms. Following installation of the copper components, items were sampled in occupied and unoccupied rooms. An unoccupied room was defined as an empty patient room that had received terminal cleaning and was not housing a patient at the time of sampling. The date of the terminal cleaning was not collected. Although it is considered important, the sample size of the current study would not support our ability to assess significance. Rails associated with the medical-surgical unit beds were sampled from the control rooms. A copper equivalent medical-surgical unit bed was not fabricated for the intervention. The rails on a stretcher bed (7500 Guardian Series ± copper rails; Pedigo, Vancouver, WA) used by emergency departments and for patient transport were evaluated.

Additionally, 4 objects resident outside of patient rooms were studied, including sinks and faucet handles in staff lounges, keyboards located at nurse and physician stations, and American Disabilities Act automatic door opener push plates.

Statistical analysis

As a result of individualized care provided to patients, the microbial burden in the built clinical environment is not normally distributed on surfaces. Given this nonparametric distribution of the microbial burden resident on the surfaces sampled and the limited number of samples collected from each of the 39 components assessed (average, 21 occupied rooms and 18 unoccupied rooms), values exceeding the 99% confidence interval from within each component were excluded from analysis to account for the variability in the precision of sampling (SAS software, Version 9.4, Cary, NC). Of 1,392 samples recovered and enumerated, 42 of 871 collected from occupied rooms (4.95%) and 31 from the 551 components assessed from unoccupied rooms (5.95%) were deemed outliers and excluded from subsequent analysis. The final datasets were analyzed using the Mann-Whitney U test with a significance level at $P < .05$ using Prism 6 software (GraphPad Software, Inc, LaJolla, CA).