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Major Article

Reduced health care-associated infections in an acute care community hospital using a combination of self-disinfecting copper-impregnated composite hard surfaces and linens

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Background: The purpose of this study was to determine the effectiveness of copper-impregnated composite hard surfaces and linens in an acute care hospital to reduce health care-associated infections (HAIs).
Methods: We performed a quasiexperimental study with a control group, assessing development of HAIs due to multidrug resistant organisms (MDROs) and *Clostridium difficile* in the acute care units of a community hospital following the replacement of a 1970s-era clinical wing with a new wing outfitted with copper-impregnated composite hard surfaces and linens.
Results: The study was conducted over a 25.5-month time period that included a 3.5-month washout period. HAI rates obtained from the copper-containing new hospital wing (14,479 patient-days; 72 beds) and the unmodified hospital wing (19,177 patient-days) were compared with those from the baseline period (46,391 patient-days). The new wing had 78% ($P = .023$) fewer HAIs due to MDROs or *C difficile*, 83% ($P = .048$) fewer cases of *C difficile* infection, and 68% ($P = .252$) fewer infections due to MDROs relative to the baseline period. No changes in rates of HAI were observed in the unmodified hospital wing.
Conclusions: Copper-impregnated composite hard surfaces and linens may be useful technologies to prevent HAIs in acute care hospital settings. Additional studies are needed to determine whether reduced HAIs can be attributed to the use of copper-containing antimicrobial hard and soft surfaces.

Important progress has been made to reduce health care-associated infections (HAIs) in the United States during the past decade. However, despite important reductions in certain HAIs, the nation has not yet reached the goals for HAI reduction set by the Department of Health & Human Service's 2009 *National Action Plan to Prevent Health Care-Associated Infections: Road Map to Elimination.*[1] Continued improvement in HAI rates will require sustained promotion and use of proven infection prevention strategies; however, there is a need for new and innovative methods to prevent HAIs.

Development of HAIs are complex processes, involving both host factors and exposure to health care-associated pathogens. Hospital environments play a crucial role in the transmission of health care-associated pathogens. The ability of health care-associated pathogens, such as methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus* (VRE), extended-spectrum β-lactamase producing Enterobacteriaceae (ESBL), multidrug-resistant *Acinetobacter* spp, and carbapenem-resistant Enterobacteriaceae (CRE), to remain viable on inanimate surfaces for extended periods of time facilitate their trafficking between patients and health care providers in complex health care environments.[2,3] The spore-forming bacterium *Clostridium difficile* is able to survive for months in a clinical environment.[3] Environmental contamination may serve as a reservoir for nosocomial pathogens, which may then be transmitted to patients through the hands of health care workers, patient care equipment, or direct contact with a contaminated environment.[3-5] Supporting this hypothesis, efforts to reduce environmental bioburden have been shown to reduce transmission of microbial pathogens and development of HAIs in hospitalized patients.[6,7] However, studies suggest

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only 25%-50% of all hospital surfaces are routinely cleaned, and enhanced surface cleaning practices in health care settings are difficult to sustain.[8-10] New, "no-touch" automated decontamination technologies, such as ultraviolet light and hydrogen peroxide, have been introduced to supplement surface disinfection in healthcare environments.[11] However, these technologies have several limitations, including the need for integration into standard housekeeping practices, use that is restricted to unoccupied rooms during terminal cleaning, need for supervised use to avoid accidental worker or patient exposures, and significant capital expenditures.

Recently, self-disinfecting surfaces have been proposed as a means to reduce new acquisition of nosocomial pathogens and reduce the incidence of HAIs. Copper has potent biocidal activity and is receiving increasing attention for potential applications in health care settings.[12,13] Copper oxide-impregnated composites have been developed that can be incorporated into hard surface countertops and molded hard surfaces and woven into textiles.[13-15] In this study, we investigated the real-world application of this technology following the replacement of a 1970s-era hospital wing with a 124-bed tower outfitted with copper-containing composite hard surfaces and linens.

METHODS

Study setting

The study was conducted at Sentara Leigh Hospital, a community hospital in Norfolk, VA, that averages more than 14,000 admissions per year and has specialty services in orthopedic, gynecologic, urologic, and comprehensive breast care. The study was conducted during the replacement of a 1970s-era clinical wing with a new hospital wing in November 2013. All rooms in both the existing hospital and the new wing were single-occupancy beds. The room size was 118 sq ft in the existing hospital and 250 sq ft in the new wing. Room amenities in the existing hospital included a bathroom with a sink and toilet; rooms in the new wing had bathrooms that included a shower in addition to a sink and toilet. The new wing included 3 24-bed general acute care units as well as a single 20-bed intensive care unit (ICU) and single 24-bed intermediate medical care unit (IMCU). Because no comparable ICU or IMCU level beds remained in the old hospital wing, patients admitted to the ICU and IMCU within the defined period of evaluation were excluded from the analysis. Obstetric, neonatal, and newborn nursery patients were also excluded from the analysis. For the final analysis, the study compared 204 acute care hospital beds of the original hospital from November 15, 2012-November 16, 2013 (baseline period), and 72 and 84 acute care hospital beds in the new wing and the old wing, respectively, from March 1-December 31, 2014 (assessment period). During a 3.5-month washout period between November 17, 2013, and February 28, 2014, the new hospital wing was opened and the study linens were deployed in its units.

Patient rooms and select patient care clinical areas of the new wing were outfitted with 16% copper oxide (weight/weight) impregnated composite countertops and molded surfaces (Cupron Enhanced EOS Solid Surfaces; Cupron Inc, Richmond, VA, and EOS Surfaces LLC, Norfolk, VA), targeting high-touch surfaces. Countertops included sinks, vanities, patient room desks, computer stations, soiled utility rooms, and nurse workstations (Fig 1). Form-fitting copper-impregnated composite molded surfaces included over-the-bed tray tables and bed rails (Fig 1). Between December 1, 2013, and February 14, 2014, copper-impregnated woven linens (Cupron Medical Textiles; Cupron Inc) were sequentially deployed in units of the new wing (1 new unit every few weeks) but not in the old wing. The linens included patient gowns, pillowcases, fitted and flat sheets, washcloths, bath towels, bath blankets, and thermal blankets (Fig 1). Health care workers did not wear copper-impregnated clothing.

The copper-impregnated linens were beige in color, whereas standard linens were white. Additionally, the copper-composite hard surfaces of the new wing had a characteristic beige color. Educational materials about the products were provided to the patients, explaining the reason for their distinctive colors. Consequently, staff and most patients and visitors were aware of assertions for the antimicrobial activity of the copper-composite hard surfaces and linens. Patients were assigned to room based on bed availability and in some cases, clinical specialty of the unit. Nursing personnel, physicians, therapy staff, and support staff were shared across units; in general, nurses tended to remain unit-based, whereas physicians and other staff tended to move between units. Environmental services personnel coordinated deployment of copper-impregnated linens to the new wing alone, and audits by management staff of the units and infection preventionists (IPs) ensured their correct placement. Laundering protocols were the same for both sets of linens and were in accordance with established protocols. Patients were prospectively assessed for the development of potential allergic reactions to copper. Patients who developed possible skin hypersensitivity reactions due to the products were referred to dermatology for dermatologic evaluation.

Fig 1. Photographs of representative copper-impregnated composite hard surface and linen products used during the study. (A) Copper-impregnated sheets. (B) Copper-impregnated washcloths and bath towel. (C) Copper-impregnated patient gowns. (D) Molded copper-composite over-the-bed tray table and bed rails and bed with copper-impregnated sheets and blankets. (E) Nurse station with copper-composite hard surfaces. (F) Close-up view of copper-composite hard surface.