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Analysis of the role of copper impregnated composite hard surfaces, bed linens and patient gowns in reducing healthcare-associated infection rates

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Abstract

The aim of this study was to evaluate the impact of copper-impregnated composite hard surfaces, bed linens and patient gowns on healthcare-associated infections (HAIs). We took in account potentially confounding factors of new construction and Det Norse Veritas Managing Infection Risk (DNV MIR) certification to mitigate risk of HAIs, multi drug resistant organisms (MDRO) and *Clostridium difficile* HAIs. The study was conducted in the acute care units from three hospitals within a regional healthcare system and these were assessed retrospectively. Facility 1 and Facility 2 shared the circumstance of new construction. Facility 1 and Facility 3 shared the processes of DNV-MIR. Only Facility 1 undertook the intervention of copper-impregnated hard surfaces, bed linens and patient gowns. We compared infection rates (IR) following their normalization per 10,000 patient hospitalization days before and after complete implementation of copper-impregnated composite hard surfaces, bed linens and patient gowns. Facility 1 had a 28% reduction in total *C. difficile* and MDRO IR, while Facilities 2 and 3 had 103% and 48% increases in total IR respectively. Although the rate changes per facility were not statistically significantly changed from baseline ($p>0.05$), there was consistent divergence between the IR at the copper enabled facility and the others. As this divergence occurred when other pertinent factors were constant between them, including new construction and new processes for mitigation of infection risks, these outcomes support the contention that copper-impregnated linens and composite hard surfaces were shown to reduce HAI rates.

Keywords: copper, healthcare associated infections, *Clostridium difficile*, multidrug resistance

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Introduction

Most common healthcare-associated infection (HAI) pathogens can remain viable on surfaces for extended periods of time, in some cases up to months,[1,2] and thus environmental cleaning and disinfection are important processes to reduce pathogen transmission and HAIs.[3] However, only 25-50% of surfaces are routinely cleaned, and surface disinfection procedures in health care settings are frequently inadequate.[4,5] Consequently, the notion that having potent self-disinfecting soft and hard surfaces, in direct or indirect contact with patients, can significantly contribute to reduction of HAIs, is gaining recognition.[6]

Background

Copper, which has potent wide spectrum biocidal properties[7] and platform technologies to permanently incorporate copper oxide into soft and hard surfaces, such as medical textiles and countertops, have been developed.[8-10] Two recently conducted clinical trials examined the effect on HAI of using copper-oxide impregnated medical textiles in long-term care units. One study was open label[11] and the other was a double-blind crossover controlled study.[12] Both studies found statistically significant reductions (24% (p=<0.05), and 29% to 55% (p=<0.001 to 0.02)) in HAI and HAI related events per 10,000 hospitalization days. Recently, in a third trial, Sifri *et al*.[13] investigated the effect of using both copper oxide-containing linens and composite hard surfaces on HAI rates in a 204 bed acute care hospital located in Norfolk, Virginia. Healthcare-associated infection rates obtained from a copper-containing new hospital wing (14,479 patient-days; 72 beds) and the unmodified hospital wing (19,177 patient-days; 84 beds) were compared with those from the baseline (46,391 patient days; 204 beds). The new wing had 78% (*P* = .023) fewer HAIs due to multi-drug resistant organisms (MDROs) or *Clostridium difficile*, 83% (*P* = 0.048) fewer cases of C. *difficile* infection (CDI), and 68% (*P* = 0.252) fewer infections due to MDROs relative to the baseline period. However, the new construction and processes for Det Norse Veritas Managing Infection Risk (DNV MIR) certification may have been confounding variables. In the current study, we analysed the individual contribution of DNV MIR accreditation and new construction as potential confounders in HAI reduction observed in the Sifri *et al*.[13] study by undertaking a retrospective multi facility analysis within a healthcare system.

Materials and Methods

Study setting

This study was conducted in three Sentara Healthcare hospitals: Sentara Leigh Hospital, in Norfolk VA, Sentara Princess Anne Hospital and Sentara Virginia Beach General Hospital, both in Virginia Beach VA. Sentara Leigh Hospital (hereafter termed Facility 1) consisted of two 1970s era-clinical towers. One of these towers was replaced with a new hospital tower by early 2014 and the second one was replaced by a new tower in April 2015. In both new towers the patient rooms and select patient care clinical areas are outfitted with 16% copper oxide (weight/weight) impregnated composite countertops and moulded 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. Form-fitting copper impregnated composite moulded surfaces included over-the-bed tray tables and bed rails.[13] In addition, all patient gowns, pillowcases, fitted and flat sheets, washcloths, bath towels, bath blankets, and thermal blankets in both new towers are copper-impregnated woven linens (Cupron Medical Textiles; Cupron Inc.). Additionally, the hospital achieved DNV-MIR accreditation on October 2014 (see below) for hospital processes in place starting in 2013. Sentara Princess Anne Hospital (hereafter termed Facility 2) was newly constructed in August 2011. Sentara Virginia Beach General Hospital (hereafter termed Facility 3) had also achieved DNV MIR accreditation in October 2014. Facilities 2 and 3 where chosen as controls to Facility 1 based upon analogous capacities, being geographically co-located in coastal Virginia, and additional similarities outlined in Table I. The trends of the infection rates of each the three facilities studied were compared between the Baseline Period (January–November 2013) and the Assessment Period (April-December 2015).

Infection prevention and control program

Healthcare-associated infection prevention measures and practice improvement were implemented consistently across all facilities between the Baseline

Table I. Overview of the three facilities used in this analysis.

Facility	1	2	3
City	Norfolk	Virginia Beach	Virginia Beach
State	VA	VA	VA
Geographic Classification	Urban	Urban	Urban
Number of Employees	1,371	1,144	1,421
ICU Days	5,781	4,914	4,101
Total Facility Square Footage	560,957	378,663	532,992
Average Length of Stay	4.3	4.9	4.8
Total Acute Days	63,083	57,162	58,997
Total Medicare Inpatient Days	27,090	20,685	30,530
Total Medicaid Inpatient Days	2,752	2,542	2,008
Adjusted Patient Days	145,821	123,429	125,369
Bed Utilization Rate	64.10%	84.10%	71.80%
Number of Medicaid Discharges	575	462	269
Number of Medicare Discharges	5,913	3,911	5,824
CC/MCC Rate	0.59	0.64	0.60
Surgical CMI	2.44	2.69	2.87
Medical CMI	1.29	1.20	1.17
Case Mix Index	1.65	1.50	1.56
Payor Mix: Private/Self-Pay/Other	52.70%	59.40%	44.80%
Payor Mix: Medicaid	4.40%	4.40%	3.40%
Payor Mix: Medicare	42.90%	36.20%	51.70%
Number of Discharges	14,525	11,687	12,308
Number of Staffed Beds	250	160	225
Average Daily Census	160.2	134.6	161.6

Period and the Assessment Period. Hospital room cleaning and disinfection was performed by an environmental services program, which used education, cleaning checklists and monitoring of cleaning thoroughness using Dazo® fluorescent marking gel (Ecolab, St. Paul, MN) in a quality assessment program. Routine daily and terminal cleaning used quaternary ammonium disinfectants, except for patients with CDI, where a hypochlorite product was used. Isolation precautions practices were in accordance with professional guidelines in place at Sentara Healthcare system. Processes for insertion, maintenance, and removal of urinary and vascular catheters were comparable across the facilities.

Surveillance cultures for MRSA, VRE or other MDRO colonization were not routinely performed. Neither ultraviolet light nor hydrogen peroxide was used for environmental decontamination. Routine chlorhexidine gluconate bathing was performed for select patient populations (orthopaedic surgery, intensive care unit (ICU) patients, and patients with central venous catheters) equivalently across the three hospitals during the study. Unit level hand hygiene compliance rates were assessed through an ongoing, anonymous auditing program by infection prevention and unit-based staff; no major changes in the hand hygiene program occurred during the study period.

In October 2014, Det Norske Veritas/Germanischer Lloyd (DNV GL) designated Sentara Leigh Hospital and Sentara Virginia Beach General Hospital as a Managing Infection Risk Center for Excellence, based on the efforts of hospital staff and leadership to reduce healthcare-associated infectious disease risk and facilitate collaborative practice improvement that had begun in 2013 and continued throughout the study period.

Healthcare-associated infection surveillance and definitions

Healthcare-associated infection surveillance was performed retrospectively through the existing Infection Prevention and Control Program of the hospital and was not blinded from the locations of the events. The primary endpoint was the incident rate (IR) of hospital-onset (HO) infections, using National Healthcare Safety Network (NHSN) definitions, due to an MDRO or *C. difficile* for patients admitted to acute care unit rooms during the study period. Multi-drug resistant organisms included meticillin-resistant *Staphylococcus aureus*, (MRSA) vancomycin-resistant enterococci (VRE), expected-spectrum beta-lactamase producing *Enterobacteriaceae* (ESBL), *Acinetobacter baumannii* (multi-drug resistant), and carbapenem-resistant *Enterobacteriaceae* (CRE). Hospital-onset was defined as events that occurred on or after hospital day four, utilizing NHSN rules. The location of attribution was assigned to the inpatient location where the HO infection occurred, following (when applicable) the NHSN transfer rule for events that occurred the day of or after a patient transfer or discharge.

Secondary endpoints of the study included IRs of HO MDRO infections, HO CDI. Incident rates of HO infections due to MDROs and/or *C. difficile* were calculated based on the total number of patient-days of acute care unit occupancy.

Statistical analysis

Infection rates were estimated by Poisson regression with offset (weighing of cases by exposure) defined as logarithm of patient days. The dependent variable in our model was infection count at each of the three hospitals examined. The model included two, independent, fixed factors: Periods (Baseline and Assessment) and Facility (the three hospitals from which data was collected). Separate regressions were fit for CDI, all MDRO infections and total infections (*C. difficile* + all MDRO). Least squares means were used to compare the factor effects. All data were normalized to 10,000 patient days.

Results

The total number of patient days per each period and each Facility studied and the total incidence of *C. difficile* and MDRO infections studied, including when normalized to 10,000 patient days, are summarized in Table II. In Facility 1, compared to the Baseline Period, in the Assessment Period there was a 28% reduction in the total IR per 10,000 patient days of all studied infections (Table II and Figure 1). In contrast, in Facilities 2 and 3 there were 103% and 48% increases, respectively, in the total IR per 10,000 patient days of all studied infections (Table II and Figure 1). When analysing only the *C. difficile* or total MDRO IR per

10,000 patient days, in Facility 1 there were 25% and 33% reductions, respectively, in the Assessment Period as compared to the Baseline Period (Table II and Figures 2 and 3). Again, in contrast to Facility 1, in Facilities 2 and 3, there were 27% and 47% increases in the IR of CDI per 10,000 patient days (Table II and Figure 2), and similarly in Facilities 2 and 3, there were 787% and 53% increases in the IR of total MDRO infections per 10,000 patient days (Table II and Figure 2).

Discussion

In this study, the authors attempted to establish the impact of three variables upon HAI rates using a multi-site analysis within a healthcare system. Using three facilities with similar populations, geographical locations, and infection prevention practices, the impact of new construction, DNV-MIR accreditation and copper impregnated composite hard surfaces, bed linens and patient gowns was analysed.

While the *C. difficile* HAI rates and the combined *C. difficile* and MDRO HAI infection rates increased in comparable facilities (Facility 2, Facility 3) the same rates declined in Facility 1. The noteworthy increase in MDRO cases at Facility 2 from one case (2013) to seven (2015) as outlined in Table II despite HAI prevention methods being implemented consistently across the facilities and between the baseline and the assessment periods highlights the low incidences and rates of infections at these facilities. The MDRO infections at Facility 2 were MRSA, and were unrelated to one another. While no statistically significant results could be obtained in most cases, most probably due to the very low rates of infections, the differences in the infection trends between the three facilities was very consistent. These results suggest reduced or no role for new construction or new hospital accreditation standard upon HAI rates, and that published declines by Sifri *et al.*[13] in *C. difficile* and MDRO HAI rates were attributable to copper impregnated composite hard surfaces, bed linens and patient gowns. This multi facility analysis within a healthcare system supports the role that copper oxide infused soft and hard surfaces may have in reducing HAI in an acute medical care facility.

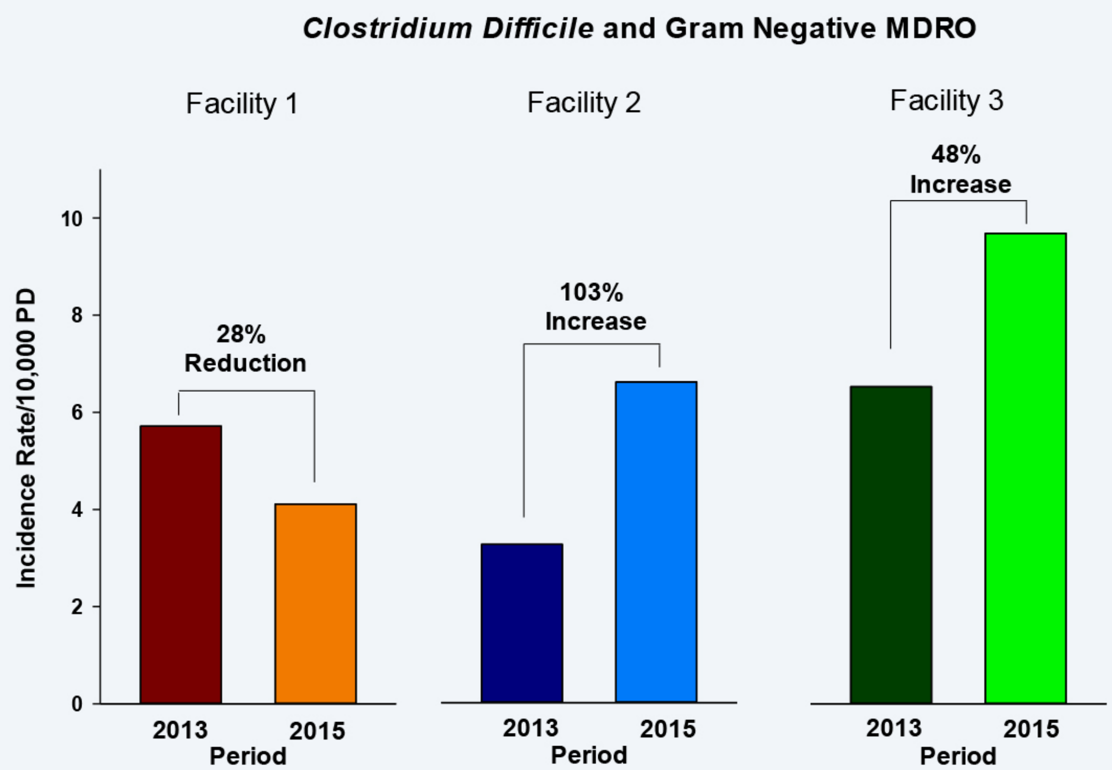

Figure 1. Total incidence rates of infections

Table II. Total number of patient days per each period and each Facility studied, and total cases and rates (per 10,000 patient days) of *C. difficile* and MDRO infections

	Sentara Leigh				Sentara Princess Anne				Sentara Virginia Beach Hospital			
	Periods		Incidence Rate Ratio	P-Value	Periods		Incidence Rate Ratio	P-Value	Periods		Incidence Rate Ratio	P-Value
	2013	2015			2013	2015			2013	2015		
Patient Days	45508	34055			30704	24242			50554	33052		
Total Infection Cases	26	14	--	--	10	16	--	--	33	32	--	--
Total Infections /10,000 patient days	5.713	4.111	0.72	>0.05	3.257	6.600	2.03	>0.05	6.528	9.682	1.48	>0.05
Cases of *C. difficile* Infections	16	9	--	--	9	9	--	--	25	24	--	--
C. difficile Infections /10,000 patient days	3.516	2.643	0.75	>0.05	2.931	3.713	1.27	>0.05	4.945	7.261	1.47	>0.05
Cases of all MDRO Infections	10	5	--	--	1	7	--	--	8	8	--	--
MDRO Infections /10,000 patient days	0.22	0.15	0.67	>0.05	0.03	0.29	8.87	0.04	0.16	0.24	1.53	>0.05

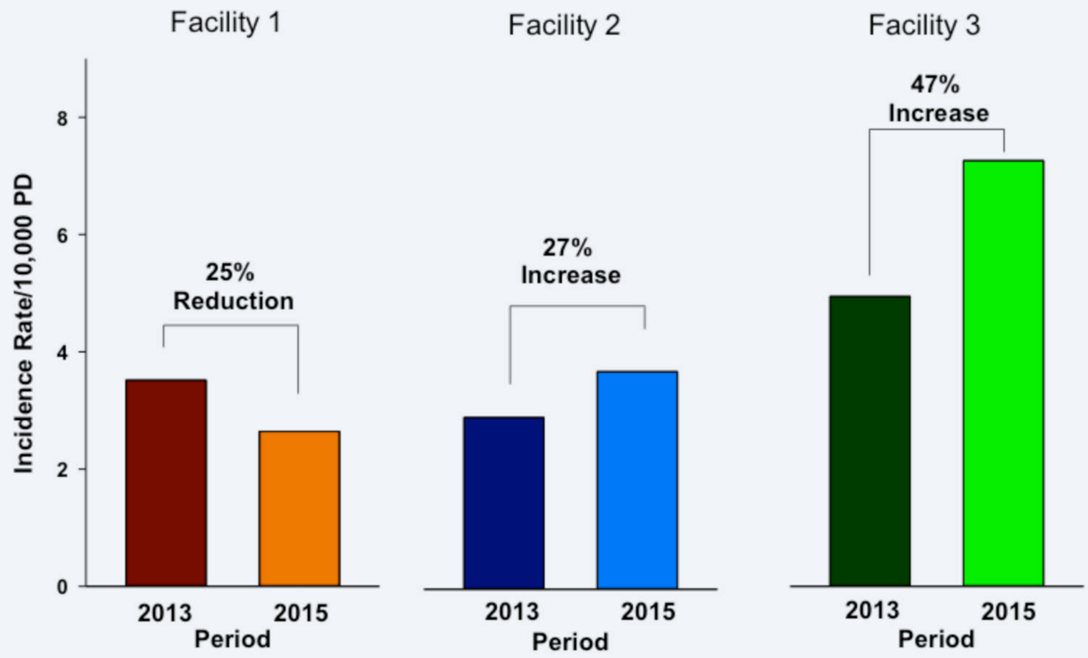

Figure 2. Total incidence rates of Clostridium difficile infections

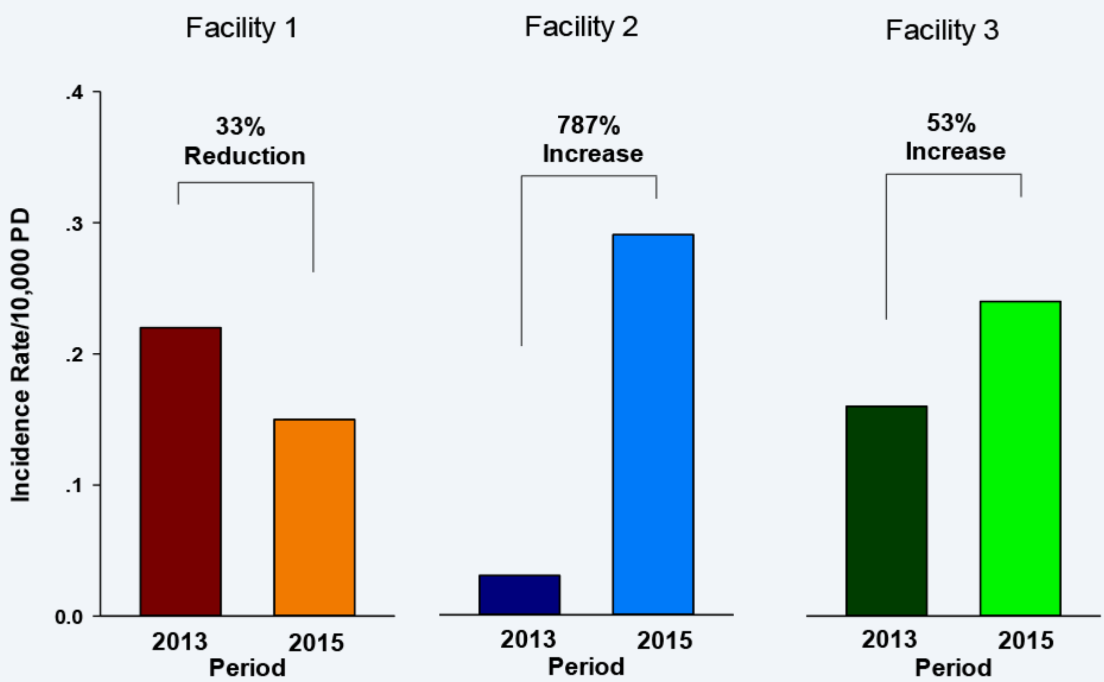

Figure 3. Total incidence rates of all MDRO infections

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