



## Major article

## Use of a daily disinfectant cleaner instead of a daily cleaner reduced hospital-acquired infection rates

Michelle J. Alfa PhD<sup>a,b,\*</sup>, Evelyn Lo MD<sup>b,c</sup>, Nancy Olson BSc<sup>a</sup>, Michelle MacRae<sup>c</sup>, Louise Buelow-Smith RN<sup>c</sup><sup>a</sup> St Boniface Research Centre, Winnipeg, MB, Canada<sup>b</sup> Department of Medical Microbiology, University of Manitoba, Winnipeg, MB, Canada<sup>c</sup> St Boniface Hospital, Winnipeg, MB, Canada

## Key Words:

Methicillin-resistant *Staphylococcus aureus*  
Vancomycin-resistant enterococci  
*Clostridium difficile*  
Housekeeping  
Environmental cleaning**Background:** Documenting effective approaches to eliminate environmental reservoirs and reduce the spread of hospital-acquired infections (HAIs) has been difficult. This was a prospective study to determine if hospital-wide implementation of a disinfectant cleaner in a disposable wipe system to replace a cleaner alone could reduce HAIs over 1 year when housekeeping compliance was  $\geq 80\%$ .**Methods:** In this interrupted time series study, a ready-to-use accelerated hydrogen peroxide disinfectant cleaner in a disposable wipe container system (DCW) was used once per day for all high-touch surfaces in patient care rooms (including isolation rooms) to replace a cleaner only. The HAI rates for methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), and *Clostridium difficile* were stratified by housekeeping cleaning compliance (assessed using ultraviolet-visible marker monitoring).**Results:** When cleaning compliance was  $\geq 80\%$ , there was a significant reduction in cases/10,000 patient days for MRSA ( $P = .0071$ ), VRE ( $P < .0001$ ), and *C difficile* ( $P = .0005$ ). For any cleaning compliance level there was still a significant reduction in the cases/10,000 patient days for VRE ( $P = .0358$ ).**Conclusion:** Our study data showed that daily use of the DCW applied to patient care high-touch environmental surfaces with a minimum of 80% cleaning compliance was superior to a cleaner alone because it resulted in significantly reduced rates of HAIs caused by *C difficile*, MRSA, and VRE.Copyright © 2015 by the Association for Professionals in Infection Control and Epidemiology, Inc. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/3.0/>).

Hospital-acquired infections (HAIs) caused by antibiotic-resistant organisms (AROs), such as vancomycin-resistant enterococci (VRE), methicillin-resistant *Staphylococcus aureus* (MRSA), and *Clostridium difficile*, represent a significant impact on patient morbidity and mortality and financial burden on the health care system.<sup>1-3</sup> It is well known that transmission of AROs can occur via contaminated hands of caregivers either after contact with a patient who carries an ARO or after contact with this patient's environment.<sup>3-7</sup> As such, much effort has been spent improving the hand hygiene compliance of health care providers. There is ample evidence that hospitalized patients who carry or are infected with AROs shed these organisms into their environment, which then becomes a reservoir for subsequent

transmission.<sup>2,4-13</sup> Furthermore, the increased risk of a new patient acquiring an ARO when admitted to a room previously occupied by another patient with this ARO has also been reported.<sup>14-17</sup> There are a number of studies documenting that disinfection of the high-touch areas reduces the load of AROs in the health care environment.<sup>4,6,7,10-13,18</sup> Others have reported that room decontamination using various new technologies (eg, ultraviolet [UV] light, vapors of hydrogen peroxide, peracetic acid) could also eliminate or reduce the presence of viable bacteria and spores in patient rooms.<sup>13,19,20</sup> The Kundrapu et al<sup>4</sup> study demonstrated that reduced microbial load in the patient environment using daily disinfection instead of a nondisinfectant cleaning agent led to reduced presence of AROs on the hands of caregivers.

The Ontario Provincial Infectious Disease Advisory Committee<sup>2</sup> and the U.S. Center for Disease Control and Prevention<sup>3,21</sup> now recommend the use of disinfection, in addition to cleaning, in high-touch patient care environments. However, as reviewed by

\* Address correspondence to Michelle J. Alfa, PhD, St Boniface Research Centre, 351 Tache Ave, Winnipeg, MB, Canada, R2H 2A6.

E-mail address: [malfa@sbr.ca](mailto:malfa@sbr.ca) (M.J. Alfa).

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Donskey<sup>6</sup> and Otter et al,<sup>5</sup> the impact of effective decontamination of the environmental reservoir on the rate of HAIs caused by AROs is still unclear.

To effectively assess the role of environmental disinfection in HAI transmission, it is critical to confirm that the surface was actually wiped with the disinfectant.<sup>4,7,8,12</sup> The Ontario Provincial Infectious Disease Advisory Committee<sup>2</sup> recommends the use of either Ultraviolet-visible marker (UVM) or adenosing triphosphate as methods for monitoring cleaning compliance (CC) of high-touch patient care environments.

The objective of the current study was to prospectively evaluate whether daily hospital-wide use of disinfectant cleaner in place of the existing nondisinfected cleaner could lead to a significant reduction of HAI rates for MRSA, VRE, and *C difficile*.

## MATERIALS AND METHODS

### Setting

This study was undertaken in a 538-bed acute care tertiary hospital in Canada. The study started in November 2012 and continued for 52 weeks. The medicine, cardiac, surgery, and women and child wards with admitted patients were included. A second acute care tertiary hospital in the same city was used as a comparator hospital that used a nondisinfected cleaner throughout all patient care areas and only used a disinfectant cleaner for *C difficile* isolation rooms. The intervention hospital has an older patient population with longer hospital stays compared with the nonintervention hospital.

### Design

This was an interrupted time series study design with a control group. This was a prospective study. At the intervention site, HAI rates (cases/10,000 patient days) for VRE, MRSA, and *C difficile* on all wards with admitted patients were tabulated each week. The definition of hospital-acquired VRE, MRSA, and *C difficile* prior to and during the intervention period followed the Manitoba health guidelines.<sup>22</sup> The UV-visible marker system previously described by Alfa et al<sup>12</sup> has been in use at the intervention site for the last 7 years. This monitoring process continued during the intervention period to confirm if surfaces had been wiped with disinfectant cleaner. However, the frequency of monitoring was increased to ensure the HAI rates each week could be stratified based on CC. Two patient care rooms on each of the 15 study wards were assessed each week (ie, 30 rooms/week), whereas historically, approximately 15 patient care rooms were monitored throughout the hospital per week. Monitoring was done by marking approximately 15 of 35 potential high-touch sites in the bedroom and bathroom. The rooms on each ward were selected randomly each week, and the 15 high-touch sites selected varied from week to week. As per the hospital's existing monitoring benchmark, cleaning was considered acceptable provided that a minimum of 80% of the UV-visible marks were partially or completely removed. At the control hospital site (nonintervention site), the hospital-wide HAI data were also tabulated prospectively, but this site did not use a cleaning monitoring protocol.

### Participants

As per hospital policy, on admission, known MRSA- or VRE-positive patients were placed on contact precautions and where

possible were admitted to a single room. Patients of unknown status were screened on admission for MRSA and VRE based on risk factors established by the Manitoba health guidelines.<sup>23</sup> Only hospital-acquired carriage or infection of VRE or MRSA were included in the HAI rate determinations. Both the Manitoba health guidelines and Canadian National Infection Surveillance Program (CNISP) data combine carriage and infection related to VRE and MRSA in their HAI definitions and rates. MRSA screening of hospitalized patients was done by direct culture on MRSASelect chromogenic media (Bio-Rad Laboratories, Mississauga, ON, Canada), with results provided 24 hours after inoculation. VRE screening of hospitalized patients was done using VRE Selective Broth (Oxoid, Nepean, ON, Canada), with positive broths (blackening of broth and loss of fluorescence) subcultured to VREselect chromogenic media (Bio-Rad Laboratories, Mississauga, ON, Canada). Results were generally available 48-72 hours after inoculation. *C difficile* infection was diagnosed using a previously described multistep algorithm.<sup>24</sup>

### Intervention

The historically used cloths (cotton rags) and PERdiem (Diversey Inc, Mt Pleasant, WI) cleaning agent, which was used at a 1:64 use dilution (not a disinfectant at this use dilution), were replaced with Accel INTERvention (Virox Technologies, Oakville, ON, Canada), which is a ready to use 0.5% (weight/volume) accelerated hydrogen peroxide disinfectant and cleaner that was used in a disposable wipe (Diversey Inc, Mt Pleasant, WI) and bucket system (Virox Technologies, Oakville, ON, Canada). This product is referred to as the disinfectant cleaner wipe (DCW) and is a 1-step surface disinfectant with a 1-minute contact time against vegetative bacteria, enveloped and nonenveloped viruses, and mycobacteria. The control hospital site continued to use the PERdiem cleaner (1:64 use dilution) with cotton rags. This product is referred to as the cleaner with cotton rags (CCR) and there are no disinfectant label claims at this use dilution. The DCWs were used daily throughout the intervention hospital in all high-touch patient care areas and for all patient-shared items. The CCR continued to be used daily for all floors and for nonpatient care areas at both the intervention and nonintervention hospitals. The housekeeping staff at the intervention site were trained in the use of the containerized disposable wipe system prior to the commencement of the study. For each patient zone, 2 wipes were used for the bed, bedside table, chair, and leading edge of the privacy curtain. The common zone used 1 wipe for the room door knob, computer keyboard and mouse, and other items in the common area; 3 wipes were used in the bathroom (includes the door knob). If a commode was present, a dedicated wipe was used whether in the patient or bathroom zone. This disposable wipe cleaning protocol was applied to isolation and nonisolation rooms and discharge rooms. All discharges also included more wipes for the mattress, bedframe, and inside of drawers and the removal of any patient supplies and the replacement of privacy curtains in isolation discharge rooms. The number of wipes used for patient-shared items depended on the size of the item.

Housekeeping personnel at the intervention hospital received same day feedback on CC based on UV-visible marker monitoring and were asked to reclean sites that were not adequately cleaned (this feedback process had been in place for >7 years prior to the start of the DCW study). The control hospital continued to use a CCR system and did not use a cleaning monitoring program.

The University of Manitoba Research and Ethics Committees approved this study. Patient consent was not sought out because patient care was not affected, and the DCWs were already approved and cleared for sale by Health Canada.

### Collation and interpretation of data

The infection prevention and control departments at the intervention and control hospitals were responsible for collation of the HAI rates (cases/10,000 patient days), and the environmental services department at the intervention hospital was responsible for collation of CC for each study ward for the 52 study weeks. This HAI and CC data were entered into a Microsoft Excel (Microsoft Corp, Redmond, WA) spreadsheet. The HAI data for the intervention period were compared with that for the previous 3 years (ie, nonintervention period). The HAI data from the intervention hospital were also compared with the control hospital. Both intervention and nonintervention hospital sites were acute care teaching hospitals that had used the same cleaning agent for the previous 4 years; however, the nonintervention hospital had not implemented a CC monitoring process.

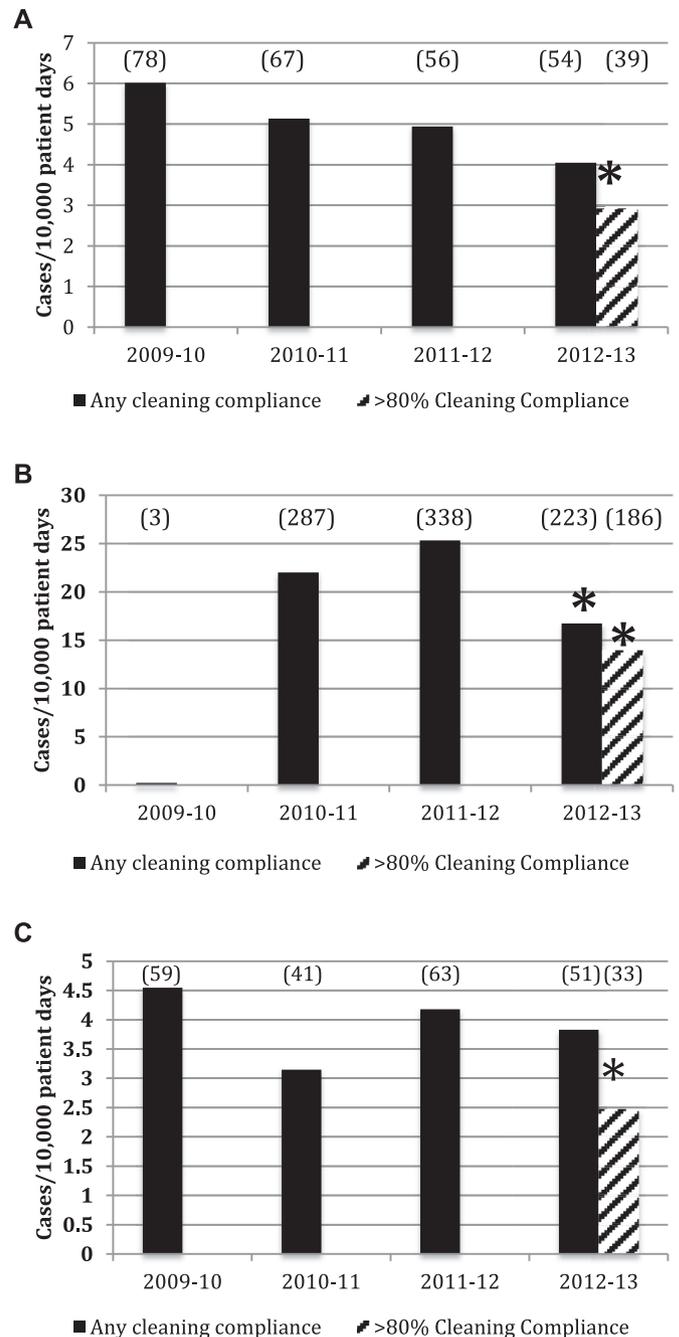
### Statistical methods

MRSA, VRE, and *C difficile* rates were compared between intervention and historical periods using univariate Poisson models with patient days used to standardize their unequal time periods. Results are therefore presented as rates and ratios. When modeling the effect of the intervention on VRE rates, historical periods with zero VRE cases (control period 3 years before the study) were excluded from the analyses because they would artificially bias the results in favor of the control period. PROC GENMOD of SAS version 9.3 (SAS Institute, Cary, NC) was used for all analyses.

### RESULTS

The change from a cleaner applied using cotton rags to a disinfectant cleaner applied using disposable wipes was the only change to housekeeping services over the 52-week study period (November 2012–November 2013) at the intervention hospital. Hand hygiene practices, antibiotic prescribing practices, use of hygiene bags (Hygie, Brossard, QC, Canada) for *C difficile* patients, and isolation practices remained unchanged over the study period. In addition to the study period, the HAI rates for the previous 3 years for the study wards at the intervention hospital site were also tabulated and matched to cover the same historical months. Figure 1 shows this data for MRSA, VRE, and *C difficile*. When the CC was  $\geq 80\%$ , there was a significant reduction in cases/10,000 patient days for MRSA ( $P = .0071$ ; Wald 95% confidence limits, 1.402–0.8884), VRE ( $P \leq .0001$ ; Wald 95% confidence limits, 0.0365–0.4476), and *C difficile* ( $P = .0005$ ; Wald 95% confidence limits, 0.2637–0.9470). For any CC level, there was still a significant reduction in the cases/10,000 patient days for VRE ( $P = .0358$ ; Wald 95% confidence limits, 0.0440–1.2802). We also tracked HAIs caused by small round enteric viruses and multidrug-resistant gram-negative bacteria, but there were no HAIs related to these pathogens over the study period at the intervention hospital.

Table 1 presents the CC over the 52 weeks for the study wards at the intervention hospital site. The top high-touch sites for all study wards that were tracked in the patient bathroom included the following: bathroom sink (4,228 marked with 86.5% CC), tap (3,608 marked with 90.7% CC), toilet bowl (2,948 marked with 85.1% CC), toilet seat (2,541 marked with 86.4% CC), and soap dispenser (2,065 marked with 84.5% CC). The top high-touch sites in the patient room included the following: bedrail (18 marked with 88.9% CC), overbed table (107 marked with 95.4% CC), call button (648 marked with 82.1% CC), floor (1,287 marked with 88.7% CC), and commode (235 marked with 84.3% CC). The marking of bedrails was



**Fig 1.** Hospital-acquired infection rates over the 52-week intervention study compared with the same weeks over the previous 3 years. (A) Hospital-acquired infection rates for *Clostridium difficile*, (B) hospital-acquired infection rates for vancomycin-resistant enterococcus, and (C) hospital-acquired infection rates for methicillin-resistant *Staphylococcus aureus*. The numbers in parentheses above each bar represent the total number of cases per year. The intervention bars denoted by \* represent significant reductions in cases/10,000 patient days compared with the previous 3 years. (For vancomycin-resistant enterococcus, only the previous 2 years could be compared because there were virtually no cases in 2009–2011).

infrequent because of patients occupying the bed at the time UVM was performed and supervisors not wanting to disturb the patients.

To determine if there were any major confounding factor(s) that occurred within the regional health care facilities, the HAI rates over the study year and the 3 historical years for the intervention and nonintervention hospitals were tabulated and are shown in Figure 2. There was an outbreak of VRE that began at both the

**Table 1**  
Ultraviolet-visible marker monitoring of cleaning compliance for study wards during a 1-year intervention period

Ward	Average cleaning compliance over 52 weeks	Percentage of 52 weeks with $\geq 80\%$ cleaning compliance
Cardiac 1	85.6	75.5
Cardiac 2 (2 areas)	82.5/93.3	75.0/97.5
Cardiac surgery ICU	93.3	92.1
Surgery 1	86.3	89.7
Surgery 2	84.3	75.0
Surgery 3	84.3	79.2
Surgery/medicine ICU	91.7	91.4
Medicine 1	84.1	70.8
Medicine 2	83.7	68.0
Medicine 3	82.3	68.8
Medicine 4	82.9	72.9
Medicine 5	85.8	79.6
Women and child 1	87.2	80.5
Women and child 2	84.7	75.8
Women and child 3	83.4	90.0

ICU, intensive care unit.

intervention and nonintervention site 2 years before the current study was undertaken. There were no changes in hand hygiene, antibiotic stewardship, isolation practices, cleaning practices, or housekeeping training at the nonintervention or intervention site over the 52-week study period.

## DISCUSSION

A number of studies have assessed various environmental disinfection interventions in an attempt to reduce HAIs; however, these previous studies were confounded by a lack of housekeeper compliance monitoring, targeting only intensive care unit (ICU) or discharge rooms, or by implementation of multiple changes in addition to the disinfectant intervention.<sup>7,18,25</sup> Our study is the first prospective, hospital-wide assessment of a disinfectant cleaner applied by DCWs as a routine daily practice in all patient care areas over a prolonged timeframe that has shown a significant reduction in MRSA, VRE, and *C difficile* HAI rates when housekeeping compliance was  $\geq 80\%$ .

The Eckstein et al<sup>7</sup> study demonstrated that even 5,000 ppm bleach was not effective at eliminating VRE or *C difficile* from patient care environments when routine housekeeping staff performed the cleaning. The authors concluded this was likely caused by lapses in application of the intervention product by housekeepers, and they identified the need to monitor housekeeping CC. Our study supports the conclusions from Eckstein et al<sup>7</sup> and demonstrated that when UVM was used and  $\geq 80\%$  CC was achieved, the rates of HAI because of VRE, *C difficile*, and MRSA were significantly reduced for the DCWs (intervention period) but not with the CCR (historical, preintervention period).

As reviewed by Donskey,<sup>6</sup> environmental disinfection interventions fall into 3 categories including the following: disinfectant product substitution, improving effectiveness of cleaning practice, or use of automated, whole-room disinfection technologies. The current study falls into the disinfectant product substitution category but differs from the 7 other studies reviewed by Donskey<sup>6</sup> in that housekeeping CC was monitored and the intervention was hospital-wide and not just used for isolation rooms, discharge rooms, or ICUs. Furthermore, the impact of the intervention on HAI rates for VRE, MRSA, and *C difficile* was evaluated in the current study, whereas 6 of the 7 studies reviewed by Donskey<sup>6</sup> focused on *C difficile* and 1 addressed MRSA only. In the current study, the biggest impact of the intervention (ie, use of a disinfectant cleaner vs a cleaner only) was on VRE rates. This is likely

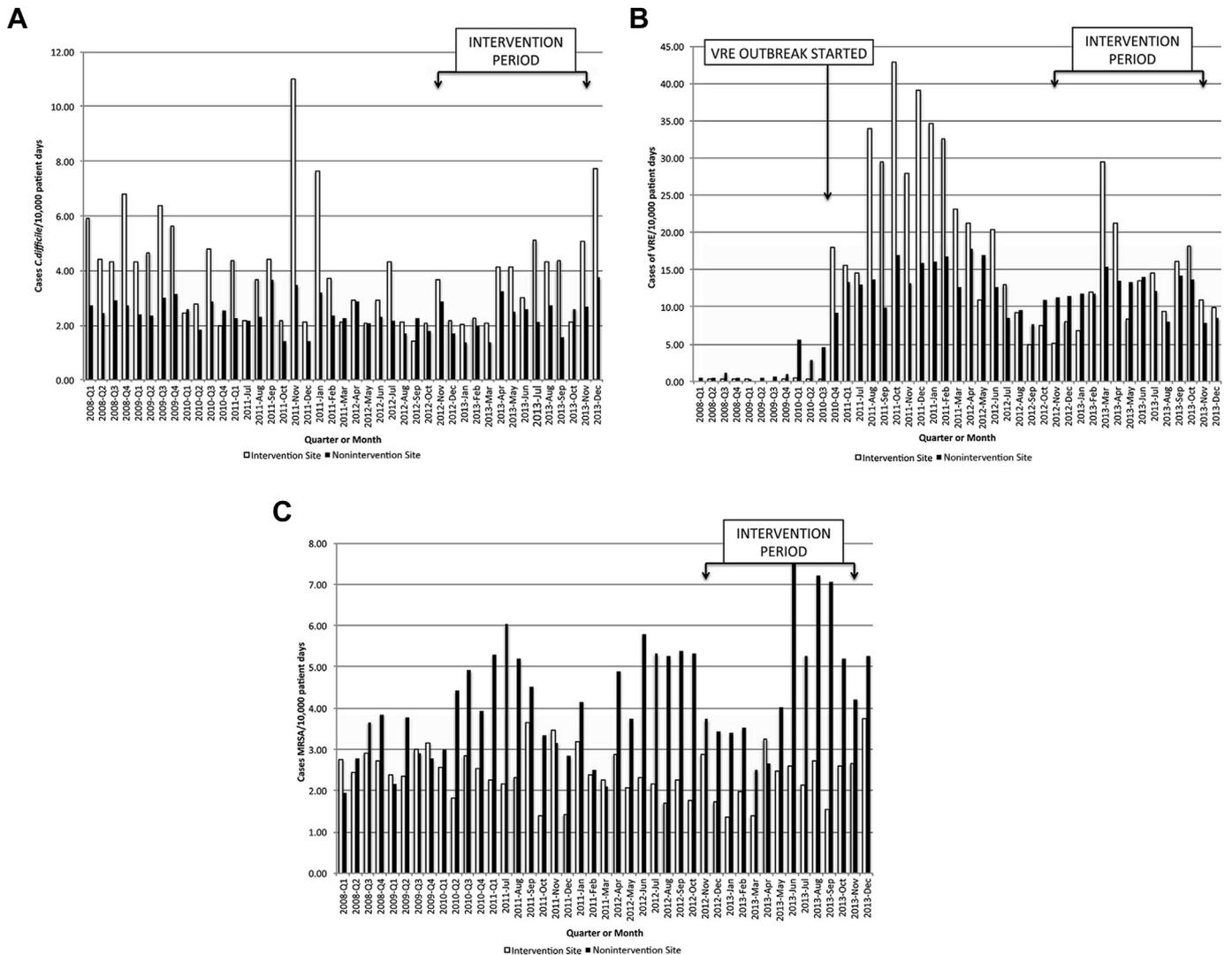
because there was a VRE outbreak that started 2 years prior to the study. As such, the HAI rate in this facility for VRE prior to the intervention was high (25 cases/10,000 patient days) relative to the CNISP Canadian national benchmark of 9.39 cases/10,000 patient days.<sup>26</sup> The MRSA and *C difficile* HAI rates prior to starting the intervention were below the CNISP Canadian national benchmarks of 11.43 cases/10,000 patient days and 6.04 cases/10,000 patient days, respectively.<sup>26</sup> Despite being below the CNISP benchmarks, the disinfectant intervention was still able to significantly reduce the HAI rates of MRSA and *C difficile* when  $\geq 80\%$  CC was achieved. To our knowledge, our study is the first to document that the DCW tested, which is a disinfectant cleaner with some sporicidal activity, can be an effective alternative to 5,000 ppm bleach for reducing *C difficile* HAI rates. The historical HAI rates indicated that the nonintervention hospital has always had lower *C difficile* HAI rates compared with the intervention hospital. This is likely because the intervention hospital has an older patient population with longer hospital stays compared with the nonintervention hospital. Our data support the value of routine daily use of a chemical formulation that has disinfectant label claims for high-touch sites in patient care areas compared with daily use of a chemical formulation that is a cleaner only.

Unlike the Kundrapu et al<sup>4</sup> study where research staff were used because routine housekeeping staff CC was  $< 10\%$ , we were able to demonstrate that this disinfection cleaning protocol could be sustained over a prolonged timeframe by regular housekeeping staff provided that they were given weekly feedback to ensure they maintained at least 80% CC.

Comparing the intervention period to the previous years (matched for the same months), the overall reduction of VRE rates was significant regardless of the CC rate and resulted in an avoidance of 115 cases of VRE. This likely reflects the significant role of environmental contamination in transmission of VRE within health care settings during high incidence periods and the value of using a disinfectant cleaner (instead of a cleaner only) to reduce the overall microbial level (even if the CC does not reach at least 80% every week). For *C difficile*, there were 2 cases avoided; for MRSA, there were 12 cases avoided regardless of CC levels during the intervention period. The number of cases avoided was increased when CC was  $> 80\%$ . It will be of interest to assess the incidence rates over upcoming years to determine how low the HAI rates can go when environmental cleaning and disinfection continue to be at an optimal level.

To our knowledge, our study is the first to show that routine daily use of a disinfectant cleaner (instead of a cleaner only) for all patient care high-touch sites in isolation and nonisolation rooms could result in additional benefit beyond what could be achieved when the same disinfectant cleaner was used only in isolation rooms. This improvement in HAI rates when DCWs were used hospital-wide supports the role of environmental reservoirs in HAI transmission before the patient is known to have MRSA, VRE, or *C difficile* (ie, prior to being placed on isolation precautions).

A limitation of this study was that no environmental cultures were performed. This was because in our previous study, DCWs were compared with CCR and the former was shown to significantly reduce the load of *C difficile* spores in the toilets of patients on isolation precautions for this infection.<sup>12</sup> In this previous study, only if CC for the DCWs and the CCR was  $\geq 80\%$  was the data included in the analysis (ie, same approach as used in the current study). As such, it was thought to be unnecessary to do cultures in the present study. Another limitation of this study is that a containerized wipe system was used in place of the cotton rags used historically, making it difficult to dissect out the role of a better application by wipes versus better microbial killing by the disinfectant chemistry in the reduction of ARO HAIs. However, our



**Fig 2.** HAI rates at the nonintervention hospital site before and during the intervention period at the intervention hospital site. The white bars represent the intervention hospital site, and the black bars represent the nonintervention hospital site. (A) *Clostridium difficile* HAI rates, (B) VRE HAI rates, and (C) MRSA HAI rates. The HAI rates were tabulated based on the fiscal year (ie, April 1–March 31 each year) and are not stratified by cleaning compliance at either site. In 2008–2011, the HAI rates were reported by quarter with April 1–June 30 being the first quarter, July 1–September 30 being the second quarter, October 1–December 31 being the third quarter, and January 1–March 31 being the fourth quarter. The start of the VRE outbreak is indicated in part B, and the intervention period from November 2012–November 2013 for the intervention hospital site is also indicated in parts A–C. There were no significantly different HAI trends in the nonintervention hospital site over the intervention period compared with the previous 3 years. HAI, hospital-acquired infection; MRSA, methicillin-resistant *Staphylococcus aureus*; VRE, vancomycin-resistant enterococcus.

previous study, where the same application system (cotton rags) was used for both products, supports the improved microbial killing of the disinfectant cleaner compared with the cleaner only. A third limitation of this study was that it is not possible to control for all potential confounders. We do know that there were no changes to hand hygiene, antibiotic stewardship and prescribing practices, fecal containment, or cleaning protocols over the course of the study period for the intervention and nonintervention hospitals. Furthermore, our data for the nonintervention hospital show that the HAI rates during the study period do not change compared with the previous 3-year rates. Although we could not control for all confounders, there were no identifiable major region-wide changes that could have accounted for the HAI rate changes documented in the intervention hospital over the study period.

In conclusion, our study found that when DCWs were applied on a daily basis to patient care high-touch environmental surfaces with a minimum of 80% compliance, the rates of HAIs caused by *C. difficile*, MRSA, and VRE were significantly reduced. This study indicated that to achieve HAI reduction there were 3 key

components. These included the following: a clearly defined housekeeping protocol with education (including an assessment of the adequacy of housekeeper performance), routine housekeeping CC monitoring with staff feedback and a minimum of 80% compliance expected, and use of an effective disinfectant cleaner. It is clear from our data that HAIs caused by AROs were not completely eliminated by the use of a disinfectant cleaner instead of a cleaner but the combination of the 3 key components did ensure that the ARO HAI rates are near to or below the CNISP benchmarks.

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