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Major article

Decreasing *Clostridium difficile* health care–associated infections through use of a launderable mattress cover

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Background: The annual incidence of *Clostridium difficile* infection (CDI) in the United States is estimated to be 330,000 cases. We evaluated the impact of using a launderable mattress and bed deck cover on the incidence of hospital-onset CDI in 2 long-term acute care hospitals (LTACHs).

Methods: Two LTACHs began using a launderable mattress and bed deck cover on beds starting in May 2013. One facility had 74 beds, and the other had 30 beds. Covers were changed after every patient. The covers were laundered using hot water, detergent, and chlorine. Rates for CDIs were compared using Poisson regression between the 16 months before use of the launderable cover and the 14 months after the cover started being used.

Results: At hospital A, the use of bedcovers reduced the rate of infection by 47.8% (95% confidence interval [CI], 47.1-48.6), controlling for the rate of handwashing compliance and length of stay in days. At hospital B, the use of bedcovers reduced the rate of infection by 50% (95% CI, 47.5-52.7), controlling for the rate of handwashing compliance and length of stay in days.

Conclusion: The use of a launderable cover for mattresses and bed decks of hospital beds was associated with a decreased rate of health care–associated CDI in 2 LTACHs.

Hospital-associated infections (HAIs) are a major source of morbidity and mortality in the United States. Although many HAIs have decreased in recent years, the incidence and severity of *Clostridium difficile* infection (CDI) has remained problematic.[1] The most recent estimates indicate that there are 453,000 CDIs in the United States each year, with 29,300 deaths.[2] It has been estimated that the additional cost of care for these infections may be as high as $3.2 billion.[3]

There is a large body of evidence showing that patients acquire infections from the hospital room. Studies have shown that patients who are placed in a room previously occupied by a patient who was contaminated with methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus*, or *C difficile* are at increased risk of acquiring these infections.[4-7]

To provide a clean environment for subsequent patients, the typical hospital room undergoes terminal cleaning after the previous patient is discharged. During the terminal cleaning process, the entire room is cleaned and disinfected using chemical cleaners. Studies have shown that, even after terminal cleaning, the major touch points in the room (bed, mattress, handrails, toilet, side table) are still contaminated.[8-12] Previous research has linked many outbreaks of HAIs back to hospital mattresses.[13-18] A recent study questioned the efficacy of detergent wipes for cleaning.[19] The Food and Drug Administration has warned that worn or damaged mattresses may be putting patients at risk of infection.[20]

To ensure the mattress is clean, a launderable cover for the mattress and bed deck was developed. Because the cover is removed and laundered with hot water, chlorine, and detergent, it

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has been shown to provide a significantly cleaner surface for patients than can be provided with terminal cleaning.[21]

To our knowledge, there are no published studies examining the clinical efficacy of using a launderable cover. The purpose of the current research is to evaluate if the use of a launderable cover would decrease the incidence of hospital-onset (HO) CDI in hospitals. CDIs were chosen over other HAIs because of the high incidence of these infections within the hospital environment, the existence of surveillance procedures for CDIs, and the significant clinical and financial impact of these infections to patients and hospitals. It is also important to note that CDIs have continued to increase in frequency, whereas many other HAI rates have decreased.

MATERIALS AND METHODS

In May 2013, 2 long-term acute care hospitals (LTACHs) purchased launderable mattress and bed deck covers (Trinity Bed Protection System; Trinity Guardion, Batesville, IN) and began using them routinely on almost all patient beds. The launderable cover was manufactured using material similar to that found in high-end bed mattresses, and it also encompasses the bed deck, which is the metal surface on which the mattress rests. The covers are manufactured to fit specific models of hospital beds, and a small number of hospital beds cannot, because of their design, be fitted with a cover. Hospital beds used with covers in the current study included VersaCare (Hill-Rom, Batesville, IN), TotalCare (Hill-Rom, Batesville, IN), BurkeBariatric (Hill-Rom, Batesville, IN), Advanta (Hill-Rom, Batesville, IN), Advanta 2 (Hill-Rom, Batesville, IN), CamTec (Cambridge Technologies, Cambridge, MD), and Stryker Secure II (Stryker, Kalamazoo, MI). Mattresses used included low air loss, microclimate, and weight distribution.

Before use, each cover is laundered according to the standards of the Centers for Disease Control and Prevention (CDC) and manufacturers, including 180°F water, detergent, use of chlorine, and drying at temperatures >160°F. The cover was light table inspected after each laundering, and if damaged, it was patched using a thermal patch. If the damage could not be repaired, the cover was taken out of service. Each cover is then reverse rolled to prevent contamination of the patient surface by any bacteria that might still be present on the bed after terminal cleaning. All covers are color coded to facilitate correct cover use by housekeeping staff. After training, all environmental service employees could install the covers in approximately 2 minutes. After discharge, the cover is rolled up on itself in order not to transmit any pathogens to the underlying mattress.

The LTACHs were both in Indiana and had all private rooms. In hospital A, which had 74 beds and was built 10 years ago, covers were changed after patient discharge or after 30 days, and a new cover was placed after terminal cleaning and patient admission. At hospital B, which had 30 beds and was built 75 years ago, the covers were also changed every 2 weeks for patients who remained hospitalized. The period from January 1, 2012-April 30, 2013, served as the baseline period for establishing the rate of CDI. The period for the new launderable cover started in May 2013 and ran through June 2014. All CDIs were calculated based on the actual number of hospital-associated CDIs divided by the number of patient days for that month. Both facilities used nucleic acid amplification test–based assay for *C difficile* detection during both time periods of the study. All data were collected retrospectively from the infection control reports of both facilities for 2013 and 2014. Handwashing data were unavailable for 1 month in the preintervention period for hospital A and for 2 months in the preintervention period for hospital B. These data were left missing, and the Poisson regression models were calculated without these data. All other analyses and all tables and figures contain complete data. For 2012, laboratory reports of CDIs were analyzed using the recommended procedures from the CDC.[22] The launderable cover could be used on 95% of the beds at both facilities. All beds, even those in beds without covers, were included with calculating CDI rates.

Although the 2 facilities used different cleaning companies, there was no change during the study periods. The methods of cleaning and chemicals used were unchanged during the 2 time periods. Infection control surveillance was the same during both study periods, and there were no other infection control interventions initiated. Both facilities use bleach when a room has been contaminated with *C difficile*. Hospital A uses a quaternary ammonium compound by Diversey (Racine, Wisconsin), and hospital B uses a phenol cleaner, Wex-Cide (Wexford Labs, Kirkwood, MO). All covers used at both facilities were laundered at the same laundry. Ten different administrative persons perform 3 observations each month (30 total observations monthly) to determine handwashing compliance in both facilities. To get credit for handwashing, the employee must wash their hands both as they enter and exit the patient room.

A significant concern in LTACHs is the development of pressure ulcers. Introduction of the launderable cover between the patient and mattress created, at least, the hypothetical concern that this new interface could have a detrimental effect on the development of pressure ulcers at these LTACHs. This issue is in part addressed by the fact that the launderable cover is made of similar material as the permanent mattress cover, and they are constructed to allow for vapor-moisture transmission. This design feature is intended to prevent the development of pressure ulcers by allowing moisture to move through the cover and away from the patient. To evaluate any effect that the launderable cover usage may have had on the development of pressure ulcers, we reported the number of stage II pressure ulcers that occurred at each facility during both study periods.

Definitions

The HO CDIs were identified according to the CDC's National Healthcare Safety Network definitions. An HO CDI is defined as an infection starting on day 4 or later of hospital admission or within 4 weeks after discharge.

Data analysis

Descriptive statistics were used to report the number of infections, number of patient days, handwashing compliance, length of stay, acuity (case-mix index), and rate of CDI per 10,000 patient days. The case-mix index is calculated by taking the total of all patient's diagnosis-related group weights and dividing it by the total number of patients. Poisson regression was used to compare the monthly counts of CDI, adjusted for patient days, at both facilities during the 2 study periods. The rate of CDI, handwashing compliance, acuity, and average length were included in the analysis. All data analyses were performed using SPSS 22.0 (IBM, Armonk, NY). Graphics were produced using SPSS and R (2.15.3; R Development Core Team, Vienna, Austria).

Human studies

The study was reviewed and approved by the Institutional Review Board of Saint Vincent Health.

RESULTS

Hospital A

There were 35 HO CDIs and 29,747 patient days in the preintervention period and 15 HO CDIs and 26,083 patient days in the

Table 1
Descriptive statistics for handwashing, acuity, and length of stay by hospital

	Preintervention			Postintervention		
Parameter	Median	IQR	Range	Median	IQR	Range
Hospital A						
Handwashing compliance rate	97	93-98	73-100	91	88-100	64-100
Acuity	1.47	1.40-1.52	1.15-1.73	1.51	1.46-1.56	1.37-1.70
Length of stay (d)	31	29-33	27-40	34	33-40	31-43
Hospital B						
Handwashing compliance rate	96	94-100	90-100	99	96-100	81-100
Acuity	1.34	1.21-1.45	1.05-1.96	1.17	1.11-1.27	0.99-1.68
Length of stay (d)	31	26-34	18-42	30	27-36	23-42

IQR, interquartile range.

Table 2
Parameter estimates for Poisson regression models by hospital

			95% CI		Hypothesis test				95% CI	
Parameter	Coefficient	SEM	Lower	Upper	Wald χ^2	*df*	Sig.	Exp(B)	Lower	Upper
Hospital A										
(Intercept)	1.455	0.051	1.356	1.554	823.996	1	<.0001	4.285	3.880	4.732
Bed cover	−0.737	0.008	−0.754	−0.721	7,683.707	1	<.0001	0.478	0.471	0.486
Handwashing compliance rate	−0.005	0.000	−0.006	−0.004	145.485	1	<.0001	0.995	0.994	0.996
Length of stay (d)	−0.005	0.001	−0.007	−0.003	29.166	1	<.0001	0.995	0.993	0.997
Hospital B										
(Intercept)	−18.353	0.485	−19.304	−17.403	1,432.926	1	<.0001	0.000	0.000	0.000
Bed cover	−0.692	0.026	−0.743	−0.641	700.369	1	<.0001	0.500	0.475	0.527
Handwashing compliance rate	0.167	0.005	0.157	0.176	1,113.763	1	<.0001	1.181	1.170	1.193
Length of stay (d)	0.053	0.002	0.049	0.057	667.882	1	<.0001	1.055	1.051	1.059

CI, confidence interval; *Sig.*, significance.

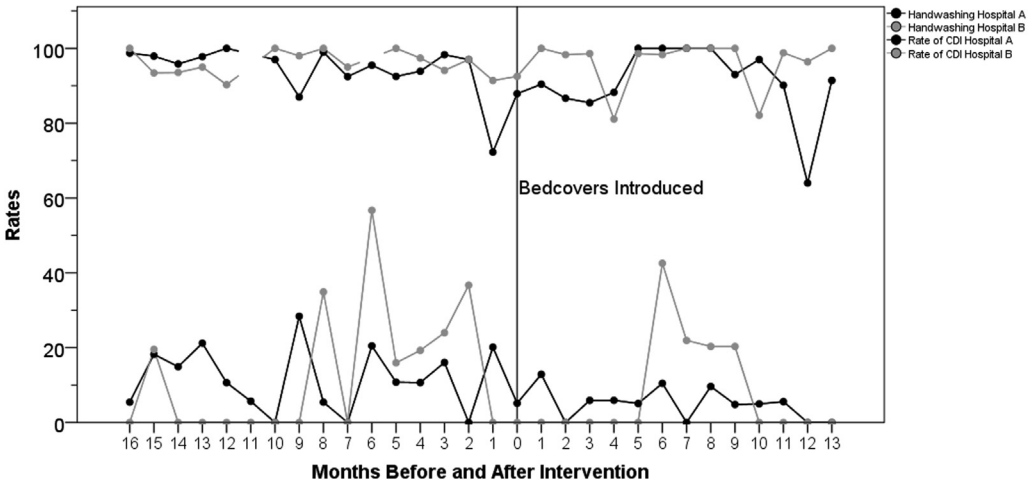

Fig 1. Handwashing and CDI, Clostridium difficile infection, rates before and after introduction of the bed cover. *CDI*, *Clostridium difficile* infection.

postintervention period. The mean age preintervention was 66 ± 1 years, and postintervention it was 65 ± 2 years. The median handwashing compliance rate was 97% preintervention (range, 72%-100%) and 91% postintervention (range, 64%-100%). Descriptive statistics for handwashing rates, acuity, and length of stay for the pre- and postintervention periods are reported in Table 1.

Poisson regression results indicated that the use of bedcovers reduced the rate of infections by 47.8% (95% confidence interval [CI], 47.1-48.6), controlling for the rate of handwashing compliance and length of stay in days. The rate of handwashing compliance was a statistically significant contributor to the model, though the effect size was small (IRR [incident rate ratios], 0.995; 95% CI, 0.994-0.996). Length of stay was also a statistically significant contributor to the model, although the effect size was small (IRR, 0.995; 95% CI, 0.993-0.997) (Table 2, Fig 1). Acuity was not a significant predictor and was removed from the model.

There were 14 stage II ulcers in the preintervention period (median rate per 1,000 patient days per month, 0%; range, 0%-2%) and 10 stage II ulcers in the postintervention period (median rate per 1,000 patient days per month, 0%; range, 0%-1%).

Hospital B

There were 11 HO CDIs and 8,466 patient days in the preintervention period and 5 HO CDIs and 6,767 patient days in the postintervention period. The mean age preintervention was 65 ± 2

years, and postintervention it was 65 ± 3 years. The median handwashing compliance rate was 96% preintervention (range, 90%-100%) and 99% postintervention (range, 71%-100%). Descriptive statistics for handwashing rates, acuity, and length of stay for the pre- and postintervention periods are reported in Table 1.

In the second hospital, Poisson regression results again indicated that the use of bedcovers reduced the rate of infections by 50% (95% CI, 47.5-52.7), controlling for the rate of handwashing compliance and length of stay in days. The rate of handwashing compliance was a statistically significant contributor to the model, although in a different direction than for hospital A (IRR, 1.181; 95% CI, 1.170-1.193). Length of stay was also a statistically significant contributor to the model, although again in a different direction than hospital A. Again, the effect size was small (IRR, 1.055; 95% CI, 1.051-1.059) (Table 2, Fig 1). Acuity was not a significant predictor and was removed from the model.

There was 1 stage II ulcer in the preintervention period and 2 stage II ulcers in the postintervention period.

DISCUSSION

The use of a launderable cover for mattresses and bed decks of hospital beds was associated with significantly decreased rates of health care onset CDIs by 50% (50% in 1 facility, and 47.8% in the other) in 2 LTACHs. The covers were applied to 95% of the beds at the facilities, can be used on most commercially available hospital beds, and require minimal training of nursing and environmental services staff.

The hospital mattress is clearly one of the highest touch points for patients when they are in a hospital room. As such, these must be adequately decontaminated between patients. Unfortunately, multiple studies have shown that current processes of cleaning after each patient (terminal cleaning) do not adequately protect future patients.[4-7] Currently, most hospitals use Environmental Protection Agency—registered disinfectants that are not approved for use on soft surfaces (eg, mattresses). Additionally, most top hospitals do not actually follow the manufacturers' recommendations for use of these chemicals.[23] A recent study showed that, although these disinfectants did decrease levels of bacterial contamination on bedrails by 99%, bacteria survived and the levels of contamination rebounded by 30% in only 6.5 hours.[24]

Although there were no formal time and motion studies done, the use of the launderable covers should improve room turnover times because the bed surface is no longer grossly contaminated and there is not time required to remove blood and organic material from the mattress. The contaminated launderable cover is simply removed from the bed and sent to the laundry, which makes for a more standardized process. Also, damage to mattresses is a common problem and can lead to contamination and HAIs.[18] The Food and Drug Administration has warned that the use of disinfectants can result in damage to the mattresses and cause them to become fluid permeable.[20] Use of the launderable cover should prevent damage to the underlying mattress, which can cost up to $5,000 to replace, if damaged.

This study only examined CDIs because the overall rate was high enough for the study to be done in a feasible time frame. However, it is a logical conclusion that the use of the launderable cover should help decrease other HAIs that have been linked to environmental transmission (eg, methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus*).

The prevention of CDIs in the hospital can help prevent morbidity and mortality among hospitalized patients. Recent studies have shown that CDIs have a mortality rate of 9.3% and that attributable costs for an HO CDI may be as high as $15,397.[2,25] It is important for hospitals to find ways to decrease the chance of acquiring CDI, and improved environmental cleaning, along with improved handwashing and antibiotic stewardship, is an important part of any effective strategy.

LIMITATIONS

This study has a number of limitations. The study was only performed at 2 facilities within 1 health care system. Many factors can lead to decreased CDI rates, including antibiotic stewardship, improved handwashing, deceased use of proton pump inhibitors, and improved environmental cleaning. We were unable to quantify any changes in antibiotic usage during the study because data were unavailable; however, there were no initiatives to improve antibiotic stewardship during the study periods. If antibiotic usage did decrease, this may have explained some of the decrease in CDI rates that were observed. We were also unable to quantify any changes in use of proton pump inhibitors during the study. There were no other initiatives in place to decrease CDIs during the study period. Handwashing and length of stay had only a small effect on CDI rates at both institutions, but the effect was opposite at the 2 sites. However, using the regression model to control for these differences, the decrease in CDIs was 50% at both institutions.

CONCLUSIONS

Control of hospital-acquired infections, especially *C difficile*, requires a comprehensive approach, including strict handwashing, antimicrobial stewardship, and excellent environmental hygiene. The addition of a launderable mattress and bed deck cover was feasible and was associated with a 50% decrease in HO CDIs within the 2 LTACHs.

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