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Comparison of terminal cleaning of a medical surface repair patch on hospital mattresses

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KEYWORDS

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ABSTRACT

Background: Hospital mattresses with damaged covers are a potential source of healthcare-acquired infections when they are not restored to an intact state that enables effective cleaning.

Methods: CleanPatch™, a medical surface repair patch that can restore a damaged mattress surface to an intact and cleanable state was evaluated over three months. A total of 120 patches were placed on the centre topside and the mid-bed side of 60 intact Hill-Rom VersaCare® mattresses Cultures were taken from the patches' surface and edge and the adjacent mattress before and after terminal cleaning. The severity and incidence of microbial growth of Methicillin-sensitive *Staphylococcus aureus*, Methicillin-resistant *Staphylococcus aureus*, *Enterococcus* spp., Vancomycin-resistant *Enterococci*, Gram negative enteric bacilli, non-fermenting Gram negative bacilli, and *Clostridium difficile* on CleanPatch™ and the mattress were compared before and after terminal cleaning.

Results: Microbial growth on CleanPatch™ were comparable to the mattress surface.
There were no significant differences in the severity of microbial growth between CleanPatch™ and mattress surface, before and after terminal cleaning.

Conclusion: CleanPatch™ may be an application to extend the life of hospital mattresses, as it did not harbor more bacteria than the mattress it was placed on and could be cleaned as effectively in this study.

INTRODUCTION

The spread of healthcare-acquired infections (HAI) is of serious concern; annually in Canada, there are an estimated 220,000 HAI and approximately 8,000 deaths are attributed to these infections (1). A recent report from the Centers for Disease Control and Prevention estimated the annual direct cost of HAI in the United States to be between $35.7 to $45 billion (2).

It has been established that environmental contamination contributes to the transmission of several healthcare-acquired pathogens. Bed rails and surfaces, supply carts, over-bed tables, and intravenous pumps have been identified as "high-touch" (i.e., frequently touched) surfaces, increasing their likelihood for microbial transmission (3). The hospital mattress can act as a fomite for pathogens, and be a source of cross-contamination. Wear-and-tear and punctures from sharp objects such as needles negate the barrier capabilities offered by mattress covers and allow contamination of the mattress' inner core. Thus, the mattress can act as an environmental reservoir for pathogens, facilitating cross-infection, outbreaks, and in some cases patient death (4-10). These same studies showed that returning the mattress to an intact state enabled proper cleaning and disinfection, resulting in a decrease in pathogen transmission (4). As a result, current infection prevention and control (IP&C) guidelines and procedures in some jurisdictions stipulate that an intact mattress is required in order to effectively and properly clean the mattress surface and decrease the incidence of HAI (11). While effective for IP&C purposes, replacing damaged mattresses can be cost prohibitive, even reducing the number of patient beds available, as there are currently no approved repair practices in place.

To address this issue, Surface Medical developed CleanPatch™, a medical surface repair patch that can restore

a damaged mattress surface to an intact state. This study was undertaken with the aim of independently evaluating CleanPatch™ in a clinical setting to see how well the product performed. The primary objective of this study was to compare microbial growth on hospital mattresses with those on the CleanPatch™, both before and after terminal cleaning. A secondary objective was to assess the physical performance of CleanPatch™ in a clinical setting over the duration of the study.
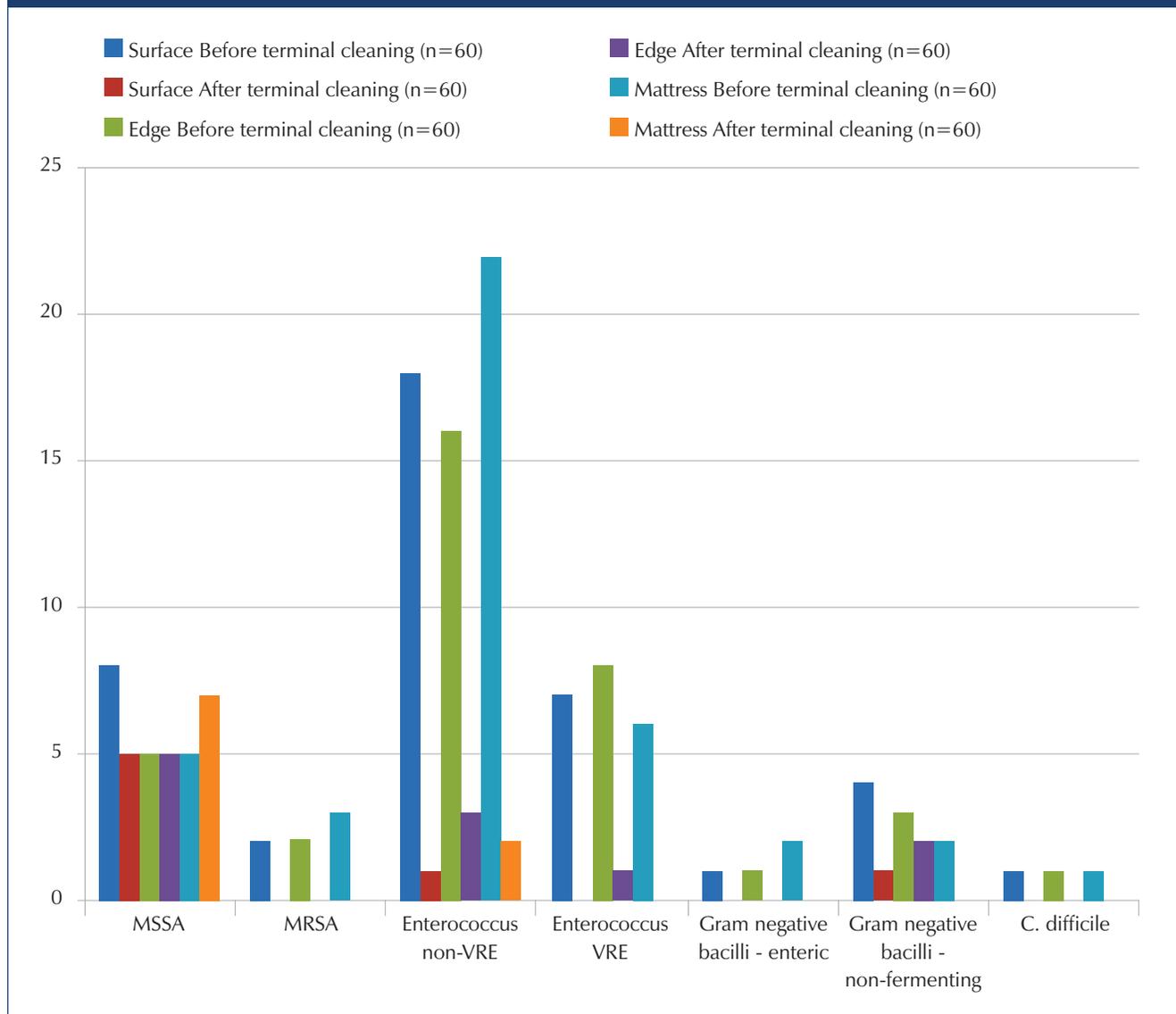
METHODS
This study was conducted between October 28, 2012 and January 28, 2013, on two high-risk medical inpatient units at a tertiary, acute care hospital in western Canada. A total of 120 CleanPatch™ were applied to 60 Hill-Rom VersaCare®

mattresses across the two units. CleanPatch™ was applied to two locations on each mattress: 1) centre on the topside, an area prone to fecal contamination ("mattress top") and 2) mid-bed of the side ("mattress side"). The Conjoint Health Research Ethics Board at the University of Calgary was consulted during the planning phases of this project. Ethics approval was not required for the project as patient or provider information was not gathered as part of the research.

Physical performance assessment
Visual assessments of CleanPatch™ on mattress top and mattress side were conducted weekly by two individuals to evaluate its physical performance in the clinical setting. Photographs were taken of CleanPatch™ before and after

FIGURE 1: Total Number of CleanPatch™ Surface, CleanPatch™ Edge, and Mattress Surface with Microbial Growth from Broth or Solid Agar Cultures Before and After Terminal Cleaning by Microbial Organism – Mattress Top

Legend:
- Surface Before terminal cleaning (n=60)
- Surface After terminal cleaning (n=60)
- Edge Before terminal cleaning (n=60)
- Edge After terminal cleaning (n=60)
- Mattress Before terminal cleaning (n=60)
- Mattress After terminal cleaning (n=60)

terminal cleaning for each CleanPatch™ swabbed during the study. These assessments continued for 12 months from the start of the study.

Culture collection

During the study period, the surface and edge of CleanPatch™ ("CleanPatch™ surface" and "CleanPatch™ edge," respectively) as well as the adjacent mattress surface ("mattress surface") were swabbed immediately before and immediately after a terminal clean post-patient discharge with a sterile cotton-tipped swab applicators pre-moistened with Amies liquid in a transport tube. Each discharge resulted in 12 samples, totaling 720 samples for 60 discharges over the course of the study. Microbial testing and identification of select pathogens (i.e., Methicillin-sensitive *Staphylococcus*

aureus, Methicillin-resistant *S. aureus*, *Enterococcus* spp., Vancomycin-resistant Enterococci, Gram negative enteric bacilli, non-fermenting Gram negative bacilli, and *Clostridium difficile*) were carried out according to standard widely used protocols and procedures in clinical microbiology.

Swabs were placed into one ml of tryptic soy broth (TSB) and vortexed vigorously for 10 seconds. Columbia Blood Agar (CBA) plates were uniformly inoculated with 100 μl of this suspension and incubated at 37°C in O2. Another 100ul of this TSB was inoculated to ½ MacConkey agar (MAC) plate and spread as BA. The remaining 800ul of TSB was split. Half was added to 3ml Brain Heart Infusion Broth (BHI) broth containing cefoxitin (8ug/ml), ciprofloxacin (1ug/ml), 5mg/ml yeast extract, 0.1% L-cysteine and 0.1% taurocholate. This broth was incubated anaerobically at 37°C for 96 hours.

FIGURE 2: Total Number of CleanPatch™ Surface, CleanPatch™ Edge, and Mattress Surface with Microbial Growth from Broth or Solid Agar Cultures Before and After Terminal Cleaning by Microbial Organism – Mattress Side
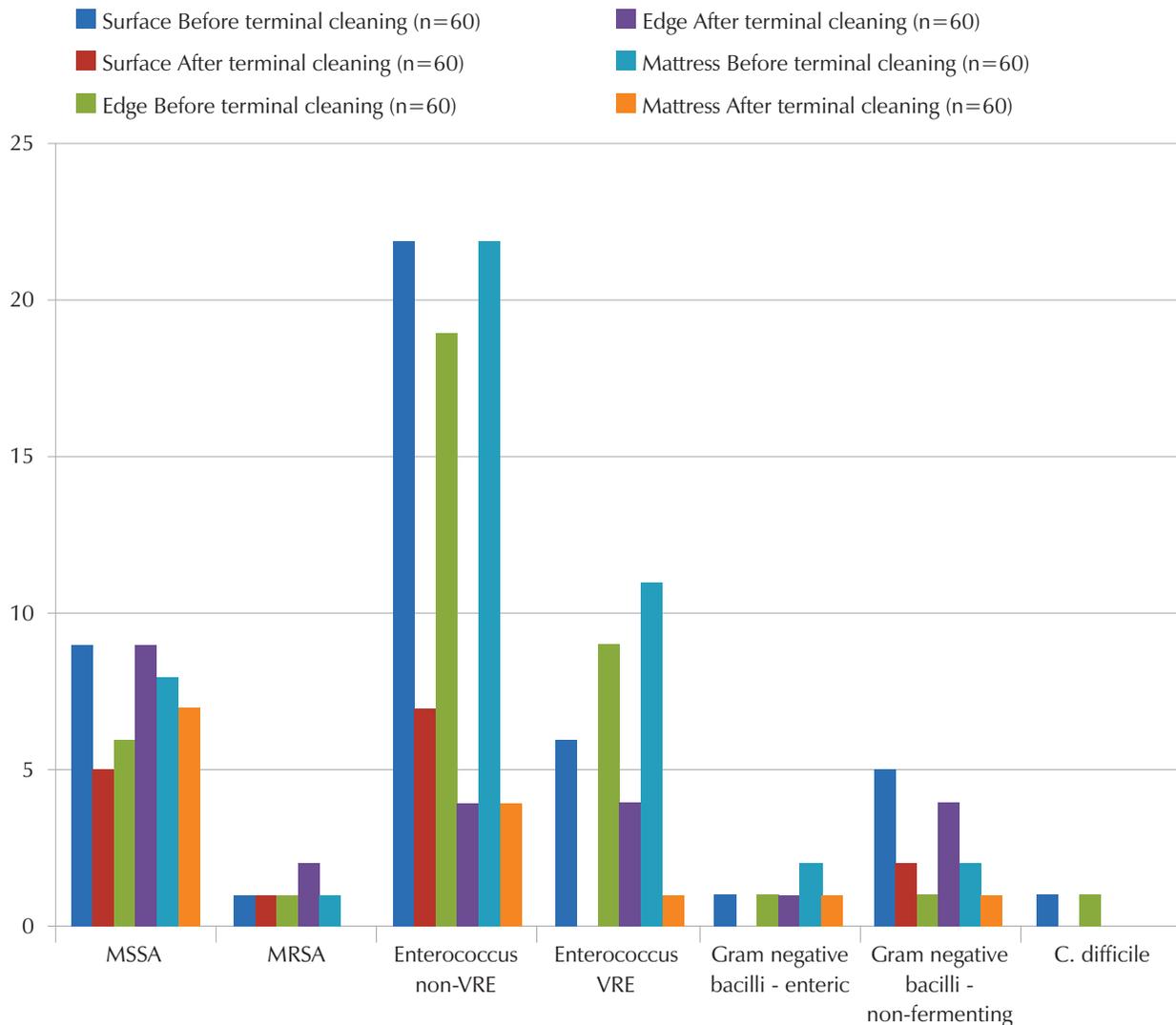
TABLE 1: Scoring Scale of the Amount of Microbial Growth for Each Pathogen*

Score	Amount of microbial growth	Growth on Plate	Growth in Broth	Number of Colonies
0	No growth	No	No	0
1	Growth in broth only	No	Yes	Trace
2	Trace growth (+/-)	Yes	Yes	10-15
3	+ Growth	Yes	Yes	15-50
4	++ Growth	Yes	Yes	50-250
5	+++ Growth	Yes	Yes	250-1000
6	++++ Growth	Yes	Yes	>1000

*MSSA, MRSA, Enterococcus spp – non-VRE, VRE, gram negative enteric bacilli, non-fermenting gram negative bacilli, C. difficile

TABLE 2: Overall Incidence of Microbial Growth* Alone or in Combination from either Broth or Solid Agar Cultures Before and After Terminal Cleaning

Mattress location	CleanPatch™ surface (incidence (%))		CleanPatch™ edge (incidence (%))		Mattress surface (incidence (%))	
	Before terminal cleaning (n=60)	After terminal cleaning (n=60)	Before terminal cleaning (n=60)	After terminal cleaning (n=60)	Before terminal cleaning (n=60)	After terminal cleaning (n=60)
Mattress top	31 (51.67)	7 (11.67)	28 (46.67)	11 (18.33)	31 (51.67)	9 (15.00)
Mattress side	34 (56.67)	13 (21.67)	30 (50.00)	18 (30.00)	33 (55.00)	13 (21.67)

*MSSA, MRSA, Enterococcus (non VRE and VRE), Gram negative bacilli (enteric and non-fermenting), and C. difficile

TABLE3: Severity of Microbial Growth

Location		Mattress Top				Mattress Side			
		Mean	SEM	Max	p-value*	Mean	SEM	Max	p-value*
Comparing before and after terminal cleaning on CleanPatch™ surface, CleanPatch™ edge, and mattress surface									
CleanPatch™ surface	Before	1.1	0.22	10	<0.001	1.05	0.18	6	<0.001
	After	0.13	0.05	2		0.37	0.12	6	
CleanPatch™ edge	Before	0.83	0.18	9	0.002	1.02	0.23	10	<0.009
	After	0.23	0.07	2		0.53	0.14	6	
Mattress surface	Before	1.18	0.24	9	<0.001	1.28	0.29	13	<0.001
	After	0.27	0.09	2		0.32	0.09	3	
Comparing CleanPatch™ surface to mattress surface before and after terminal cleaning									
Before terminal cleaning	CleanPatch™	1.1	0.22	10	0.8	1.05	0.18	6	<0.491
	Mattress	1.18	0.24	9		1.28	0.29	13	
After terminal cleaning	CleanPatch™	0.13	0.05	2	0.181	0.37	0.12	6	<0.738
	Mattress	0.27	0.09	2		0.32	0.09	3	
Comparing CleanPatch™ edge to mattress surface before and after terminal cleaning									
Before terminal cleaning	CleanPatch™	0.83	0.18	9	0.254	1.02	0.23	10	<0.469
	Mattress	1.18	0.24	9		1.28	0.29	13	
After terminal cleaning	CleanPatch™	0.23	0.07	2	0.761	0.53	0.14	6	<0.182
	Mattress	0.27	0.09	2		0.32	0.09	3	

SEM = Standard error of mean; Min value for all locations = 0

CBA plates were read at 24 and 48 hours and any organisms suspected of being *S. aureus*, *Enterococcus*, coliform or non-fermenter, fungus or yeast, were subcultured to appropriate media. MAC plates were read at 24 and 48 hours, working up isolates as necessary. Using tube coagulase, Denim Blue agar (DB) and oxacillin and cefoxitin discs, *S. aureus* were determined to be MRSA or MSSA**.** Using bile esculin, m-Enterococcus media with and without Vancomycin (4ug/ml), and Vanco disc confirmed VRE and Enterococcus not VRE. Growth on MAC and MAC with ceftriaxone was used to determine coliforms and NFB. Tests including oxidase, triple sugar iron (TSI) and other pertinent tests were used to presumptively identify these organisms. Yeast and fungus were sub cultured for presumptive identification.

The *C. difficile* Spore Recovery Broth was subbed to taurocholate cycloserine cefoxitin fructose agar (TCCFA) and read after incubation anaerobically for 72 hours, providing vegetative *C. difficile* cells. The remaining BHI broth went back to the anaerobic chamber for further 96 hours of incubation. Then, an equal amount of absolute ethanol was added and the broth was shocked for one hour. The broth was centrifuged, supernatant removed, and the pellet inoculated to TCCFA. This plate was incubated anaerobically for 72 hours, providing the *C. difficile* spores. The other half of the TSB had 2ml of additional TSB added to it. This broth was incubated at 37°C in O2 for 24 hours (or 48 hours) then subbed to CBA, phenylethyl alcohol blood agar, DB, m-*Enterococcus* agar, m-*Enterococcus* agar with 4ug/ml, MAC and MAC with ceftriaxone. These plates were read at 24 and 48 hours and work-up done as stated above. All significant isolates were frozen in BHI with 20% glycerol at -86°C.

Statistical analysis
Each culture was analyzed for incidence and severity of microbial growth. For incidence, each culture was scored twice to either have (1) or not have (0) any microbial growth and microbial growth of each of the pathogens listed above. For severity, each culture was scored according to the amount of microbial growth by each of the same pathogens recovered from each swab. The scoring was conducted by the Medical Laboratory Technologist as per the scoring scale in Table 1. Two-sample, two-tailed t-test was used to determine whether there were any differences between the areas swabbed. Incidence and severity of microbial growth were summarized using descriptive statistics. Statistical analysis was performed using Microsoft Excel 2010 for Windows.

RESULTS
There were 720 samples collected over the course of three months. The vast majority (118/120) of the CleanPatch™ remained intact and did not show any wrinkling, bubbling, flagging or tearing over the duration of the study. Of the other two patches, one showed excessive wrinkling less than two months after placement, and the other CleanPatch™

showed flagging at approximately two months of placement. Longer-term durability of a sub-set of CleanPatch™ (72) continued to be evaluated for oneyear from the start of the study with all 72 have remained adhered, showing no visible signs of physical damage or tear.

Severity of Microbial Growth
The descriptive statistics of the severity of microbial growth before and after terminal cleaning, and on CleanPatch™ surface and CleanPatch™ edge relative to the mattress surface, are provided in Table 2.

The average of the total severity of microbial growth on CleanPatch™ surface, CleanPatch™ edge and the mattress surface were reduced after terminal cleaning on both mattress top and mattress side. There were significant differences in the severity of microbial growth before versus after terminal cleaning on both areas of CleanPatch™ and mattress surface among the mattress top cultures and mattress side cultures. Of both the mattress top cultures and mattress side cultures, no significant difference in the severity of microbial growth was found between CleanPatch™ surface and mattress surface, nor CleanPatch™ edge and mattress surface, before and after terminal cleaning.

Incidence of Microbial Growth
An overview of the overall incidence of any microbial growth from either broth or solid agar cultures before and after terminal cleaning from CleanPatch™ surface, CleanPatch™ edge, and mattress surface for both mattress top and mattress side is provided in Table3. For both the mattress top and mattress side, the microbial growth on CleanPatch™ surface and CleanPatch™ edge, and mattress surface was reduced after terminal cleaning.

Incidence of Microbial Growth by Pathogen
There were slight differences in the incidence of microbial growth across the different organisms between mattress top and mattress side; however, the patterns of growth before and after terminal cleaning were comparable between the two mattress locations (Figures 1 & 2). In both mattress areas sampled, the incidence rate of growth of enteric Gram-negative bacilli and *C. difficile* were the lowest while *Enterococcus* spp, including strains of VRE, was the highest.

The incidence of growth was primarily reduced or remained unchanged in the majority of the locations after terminal cleaning; however, there was an increase in non-fermenting Gram-negative bacilli and MSSA recovered from some of the areas on the mattress top and the mattress side after terminal cleaning.

DISCUSSION
In this independent evaluation of CleanPatch™, the incidence of bacterial growth was comparable between CleanPatch™ and the adjacent mattress, before and after terminal cleaning. Also, pathogenic growth decreased in all three areas after terminal cleaning, with the exception of MSSA, and enteric

Gram-negative bacilli, and non-fermenting Gram-negative bacilli. There are several possible explanations for these findings: housekeeping staff could be carriers of the organisms, sanitization equipment could be contaminated by the microbes, the order in which the surfaces have been cleaned may impact the spread of the potential pathogens, or some of the pathogens were simply missed in the pre-terminal clean swab. Despite these increases and the uncertainty of their cause, it is important to note that cleaning effectively reduced the frequency of the majority of the organisms. This indicates that the CleanPatch™ does not harbor any more (or less) organisms than the hospital mattress, and is comparable in cleanability. CleanPatch™ performed well in the clinical setting over the three-month duration of the study and remained intact for one year since the start of the study.

While this study shows promising results for CleanPatch™, there were limitations to the study. First, while it was intended that CleanPatch™ be placed on all mattresses on both units observed in this study, there were mattresses occupied by bed-ridden patients and could not have CleanPatch™ applied to them. Second, as the primary objective was to assess whether microbial growth on CleanPatch™ is comparable to a hospital mattress surface, CleanPatch™ was only placed on undamaged mattresses. Third, this study did not use random sampling, as the research associate (RA) was limited to collecting data on specific days of the week due to laboratory capacity. Data collection was facilitated by a unit clerk who was responsible for paging the RA when a patient was discharged. However, due to the busy nature of the environment, there were instances when unit clerks were unable to notify the RA, who was then unable to collect samples from those particular mattresses. Finally, the clinical setting of the study resulted in various uncontrolled factors that may have affected the results. For example, while housekeepers are required to follow standard cleaning procedures, there remains variability in their cleaning practices; Pearce and Conly (13) found that the average time of cleaning ranged from 37.96 minutes during the day shift, to 38.5 minutes during the afternoon shift, to 26.5 minutes during the night shift. Some of the housekeepers were concerned that their workflow would be affected by the study, and some had questions about how the results from the study would be used to assess the quality of their work; these concerns may have resulted in variations from typical cleaning practices. However, the authors believe that the sample size was sufficient to account for these uncontrolled factors.

This study, testing an innovative way to repair the damaged surface of a hospital mattress, shows promising results. CleanPatch™ could be a cost effective solution to repair the damaged surface of a hospital mattress, as it can be applied within minutes without skilled training or practice, eliminating mattress downtime for damage repair.

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