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Reviewed work(s):
Source: *Infection Control and Hospital Epidemiology,* (-Not available-), p. 000
Published by: The University of Chicago Press on behalf of The Society for Healthcare Epidemiology of America
Stable URL: http://www.jstor.org/stable/10.1086/664045
Accessed: 19/01/2012 15:52

ORIGINAL ARTICLE

A Crossover Trial of Antimicrobial Scrubs to Reduce Methicillin-Resistant *Staphylococcus aureus* Burden on Healthcare Worker Apparel

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BACKGROUND. The impact of antimicrobial scrubs on healthcare worker (HCW) bacterial burden is unknown.

OBJECTIVE. To determine the effectiveness of antimicrobial scrubs on hand and apparel bacterial burden.

DESIGN. Prospective, crossover trial.

SETTING AND PARTICIPANTS. Thirty HCWs randomized to study versus control scrubs in an intensive care unit.

METHODS. Weekly microbiology samples were obtained from scrub abdominal area, cargo pocket, and hands. Mean log colony-forming unit (CFU) counts were calculated. Compliance with hand hygiene practices was measured. Apparel and hand mean log CFU counts were compared.

RESULTS. Adherence measures were 78% (910/1,173) for hand hygiene and 82% (223/273) for scrubs. Culture compliance was 67% (306/460). No differences were observed in bacterial hand burden or in HCWs with unique positive scrub cultures. No difference in vancomycin-resistant enterococci (VRE) and gram-negative rod (GNR) burden was observed. A difference in mean log methicillin-resistant *Staphylococcus aureus* (MRSA) CFU count was found between study and control scrubs for leg cargo pocket (mean log CFUs, 11.84 control scrub vs 6.71 study scrub; $P = .0002$), abdominal area (mean log CFUs, 11.35 control scrub vs 7.54 study scrub; $P = .0056$), leg cargo pocket at the beginning of shift (mean log CFUs, 11.96 control scrub vs 4.87 study scrub; $P = .0028$), and abdominal area pocket at the end of shift (mean log CFUs, 12.14 control scrubs vs 8.22 study scrub; $P = .0054$).

CONCLUSIONS. Study scrubs were associated with a 4–7 mean log reduction in MRSA burden but not VRE or GNRs. A prospective trial is needed to measure the impact of antimicrobial impregnated apparel on MRSA transmission rates.

Infect Control Hosp Epidemiol 2012;33(3):000-000

Healthcare-associated infections are associated with significant morbidity and mortality.[1] Reduction of healthcare-associated infections is possible through implementation of evidence-based measures and by closing hospital epidemiology knowledge gaps.[2] Some authorities advocate active detection and isolation of patients colonized or infected with methicillin-resistant *Staphylococcus aureus* (MRSA) on hospital admission.[3] Others advocate horizontal programs targeting all antibiotic-resistant pathogens, including MRSA.[4]

Bacterial contamination of physician scrubs occurs within hours after donning newly laundered, short-sleeved uniforms.[5] Bacterial contamination of surgical scrubs has also been reported.[5,6] Butler[7] developed an in vitro model of lab coat contamination and transmission with MRSA, vancomycin-resistant enterococci (VRE), and pan-resistant *Acinetobacter baumannii*.

Hospital textiles may contribute to the transmission of pathogens through indirect contact via the hands of hospital staff and by means of aerosols.[8-10] Antimicrobial textiles may reduce bioburden in clinical settings.[8] Antimicrobial copper oxide has been impregnated in linens and in respiratory masks.[11,12] Cotton textiles impregnated with citric acid have antibacterial properties against MRSA.[13] The Vestex technology VTT-003 uses a proprietary method to impregnate natural, synthetic, and blended fabrics with an organosilane-based quaternary ammonium antimicrobial agent and a fluoroacrylate copolymer emulsion that repels blood and body fluids. Thus, Vestex-treated scrubs protect hospital per-

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Received June 28, 2011; accepted October 17, 2011; electronically published January 6, 2012.

 0899-823X/2012/3303-00XX$15.00. DOI: 10.1086/664045

TABLE 1. Apparel and Hand Culture Compliance by Participant and Overall

Participant no.	Time in study, weeks	Crossovers	Apparel samples collected, *n*	Hand samples collected, *n*
1	16	3	86	52
2	12	2	30	22
3	16	3	45	30
4	16	3	54	32
5	16	3	86	58
6	16	3	78	52
7	16	3	69	42
8	16	3	87	56
9	16	3	68	48
10	16	3	91	60
11	12	2	51	38
12	16	3	61	40
13	16	3	73	52
14	16	3	80	52
15	16	3	91	52
16	16	3	94	60
17	16	3	68	46
18	16	3	76	50
19	16	3	90	62
20	4	0	25	16
21	16	3	55	44
22	16	3	60	36
23	16	3	77	50
24	12	2	56	34
25	16	3	48	38
26	16	3	60	44
27	8	1	44	24
28	16	3	33	22
29	16	3	58	40
30	16	3	73	48
31	8	1	15	12
32	8	1	18	12
Total	458		2,000	1,324

NOTE. Number of potential samples: apparel, 2,748; hands, 1,832. Overall compliance with microbiology samples: apparel, 73%; hands, 72%.

sonnel from exposure to blood, body fluids, and microorganisms. We assessed the effectiveness of Vestex antimicrobial scrubs in limiting the bacterial burden, including MRSA, of healthcare worker (HCW) hands and clothing in a clinical setting.

METHODS

A 4-month, randomized, blinded, prospective trial was conducted in an 18-bed medical intensive care unit (ICU) at an 820-bed academic medical center. The unit is managed by a dedicated critical care team. The study was approved by the Institutional Review Board at Virginia Commonwealth University.

All participants voluntarily signed informed consent documents. HCWs were randomized to 4 pairs of identically appearing control scrubs or study scrubs, each set consisting of trousers and shirt. Scrubs had 2 abdominal pockets and 1 cargo leg pocket. At each crossover, all HCWs exchanged their study or control scrubs with the study coordinator. A crossover study design was employed to minimize sampling bias, and crossovers occurred every 4 weeks. Each participant served as his/her control twice.

All HCWs received identical hand hygiene educational sessions every 4 weeks from the infection prevention department. Compliance with hand hygiene practices was assessed by a single trained observer utilizing a standardized data collection tool. A total of 100 hours of hand hygiene observation throughout the ICU was performed. Study participation stipulated that each HCW would wear the study-supplied scrubs for all clinical shifts during the study period. Noncompliance with wearing scrubs per protocol was documented if a HCW was observed not wearing any component of the supplied apparel. Compliance with wearing scrubs per protocol was measured by a member of the study team.

TABLE 2. Comparison of Apparel Summary (Overall) Study versus Control Scrubs (31 Participants Total)

Variable	Study scrub, *n* (%)	Control scrub, *n* (%)	*P*
HCWs with MRSA on leg cargo pocket	9/31 (29)	14/31 (45)	.4042
HCWs with MRSA on abdominal area	13/31 (42)	16/31 (52)	.7103
HCWs with VRE on leg cargo pocket	0/31 (0)	1/31 (3)	1.0000
HCWs with VRE on abdominal area	1/31 (3)	1/31 (3)	.4795
HCWs with GNR on leg cargo pocket	3/31 (10)	3/31 (10)	.6831
HCWs with GNR on abdominal area	4/31 (13)	4/31 (13)	.7237

NOTE. Thirty-one participants completed at least 1 crossover during the study protocol. GNR, gram-negative rod; HCW, healthcare worker; MRSA, methicillin-resistant *Staphylococcus aureus*; VRE, vancomycin-resistant enterococci.

Each HCW underwent once weekly, unannounced, garment and hand cultures. The scrub pant cargo pocket and abdominal area were chosen for culture because these were areas of high touch and high bacterial colonization potential. Two samples were obtained from the garment abdominal area, each at the start and the end of shift. Two samples were obtained from each cargo pant pocket at the start and the end of shift. An apparel culture opportunity was defined as a beginning-of-shift culture of the right and left abdominal pockets and the single leg cargo pocket as well as an end-of-shift culture of the right and left abdominal pockets and the single leg cargo pocket, for a total of 6 microbiologic samples per apparel culture opportunity. A hand culture opportunity was defined as a beginning-of-shift right and left hand culture and an end-of-shift right and left hand culture, for a total of 4 samples per hand culture opportunity.

We measured the number and percent of unique study participants with MRSA-, VRE-, and gram-negative rod (GNR)-positive cultures by scrub type at the beginning and the end of shift. We calculated mean log colony-forming unit (CFU) count of MRSA, VRE, and GNRs on apparel and hands by scrub type and by shift time. An anonymous, 8-item, 1–5 Likert scale questionnaire was administered at study end to assess self-reported compliance with scrub use, infection control practices, and acceptability of antimicrobial impregnated scrubs.

MICROBIOLOGIC METHODS

Garment cultures were collected with a collection swab by a 15-second up and down rub (Copan Diagnostics). Specimens were immediately transported to the clinical microbiological laboratory. Each swab was inoculated into enrichment broths to increase the isolation rate of *S. aureus*. After incubation, the broths were serially diluted and plated onto Trypticase soy agar to determine CFUs. After incubation at 37°C for 24

TABLE 3. Comparison of Apparel Summary Study versus Control Scrubs at Beginning and End of Shift (31 Participants Total)

Variable	Study scrub, *n* (%)	Control scrub, *n* (%)	*P*
Beginning of shift			
HCWs with MRSA on leg cargo pocket	7/31 (23)	8/31 (26)	1.0000
HCWs with MRSA on abdominal area	6/31 (19)	11/31 (35)	.3320
HCWs with VRE on leg cargo pocket	0/31 (0)	0/31 (0)	NA
HCWs with VRE on abdominal area	0/31 (0)	0/31 (0)	NA
HCWs with GNR on leg cargo pocket	2/31 (6)	0/31 (0)	.4795
HCWs with GNR on abdominal area	3/31 (10)	2/31 (6)	1.0000
End of shift			
HCWs with MRSA on leg cargo pocket	6/31 (19)	9/31 (29)	.6056
HCWs with MRSA on abdominal area	11/31 (35)	9/31 (29)	.8231
HCWs with VRE on leg cargo pocket	0/31 (0)	0/31 (0)	NA
HCWs with VRE on abdominal area	0/31 (0)	0/31 (0)	NA
HCWs with GNR on leg cargo pocket	1/31 (3)	3/31 (10)	.6171
HCWs with GNR on abdominal area	1/31 (3)	2/31 (6)	1.0000

NOTE. Thirty-one participants completed at least 1 crossover during the study protocol. GNR, gram-negative rod; HCW, healthcare worker; MRSA, methicillin-resistant *Staphylococcus aureus*; NA, not applicable (sample size is not sufficiently representative to compute a *P* value); VRE, vancomycin-resistant enterococci.

TABLE 4. Comparison of Difference in Apparel Mean Log Colony-Forming Unit (CFU) Count Overall and at Beginning and End of Shift

	Mean log CFU count				
	Study (samples, *n*)	Control (samples, *n*)	Difference	SE of difference	*P*
Overall					
MRSA					
Leg cargo pocket	6.71 (12)	11.84 (16)	5.13	1.1493	.0002
Abdominal area	7.54 (25)	11.35 (25)	3.81	1.2300	.0056
VRE					
Leg cargo pocket	0 (0)	12.68 (1)	12.68	NA	NA
Abdominal area	12.68 (1)	12.27 (5)	0.41	2.8917	.9013
GNR					
Leg cargo pocket	4.41 (1)	13.02 (1)	8.61	NA	NA
Abdominal area	9.14 (3)	10.36 (2)	1.22	3.4376	.7569
Beginning and end of shift					
MRSA					
Leg cargo pocket					
Before shift	4.59 (4)	11.97 (8)	7.38	1.5095	.0028
After shift	6.86 (8)	11.92 (8)	5.06	2.4136	.0600
Abdominal area					
Before shift	4.97 (4)	10.58 (12)	5.61	4.8707	.2949
After shift	8.22 (21)	12.14 (13)	3.92	1.2848	.0054
VRE					
Leg cargo pocket					
Before shift	0.00 (0)	0.00 (0)	0.00	NA	NA
After shift	0.00 (0)	12.68 (1)	12.68	NA	NA
Abdominal area					
Before shift	0.00 (0)	0.00 (0)	0.00	NA	NA
After shift	12.68 (1)	12.27 (5)	0.41	2.8917	.9013
GNR[a]					
Leg cargo pocket					
Before shift	4.41 (1)	0.00 (0)	4.41	NA	NA
After shift	0.00 (0)	13.02 (1)	13.02	NA	NA
Abdominal area					
Before shift	6.63 (1)	7.60 (1)	0.97	NA	NA
After shift	11.72 (2)	13.12 (1)	1.40	6.4247	.8628

NOTE. GNR, gram-negative rod; MRSA, methicillin-resistant *Staphylococcus aureus*; NA, not applicable (sample size is not sufficiently representative to compute a *P* value); SE, standard error; VRE, vancomycin-resistant enterococci.
[a] *Escherichia coli*, *Serratia marcescens*, *Klebsiella pneumoniae*.

hours, colonies were counted and expressed as CFUs/mL. Undiluted broths were streaked onto a Mannitol salt agar plates. The Mannitol salt agar plates were further incubated for 24 hours at 37°C and examined for growth. The identification of *S. aureus* was confirmed by gram staining, production of catalase, and results of Staphaurex latex agglutination test (Remel). Susceptibility testing was performed by disk diffusion following the method recommended by the Clinical and Laboratory Standards Institute.[14] Oxacillin resistance was confirmed by using BBL CHROMagar MRSA (BD Diagnostics). *Staphylococcus aureus* antibiotic susceptibility was determined by conventional methods as recommended by the Clinical and Laboratory Standards Institute.[14] Control strains for all assays included MRSA ATCC 43300 and methicillin-sensitive *S. aureus* (MSSA) ATCC 25923.

VRE were identified on Enterococcosel agar (BD) containing 6 μg/mL of vancomycin and incubated for 48 hours at 35°C under aerobic conditions. Black (esculin-positive) colonies were subcultured onto a blood agar plate for purity. Enterococcal isolates were confirmed with a compatible gram stain, negative catalase reaction, positive pyrrolidonyl arylamidase test, and growth in 6.5% sodium chloride. VRENFS ATCC 51299 and *Enterococcus faecalis* ATCC 29212 were used as controls. GNRs were investigated by using Columbia sheep blood agar (BD) and MacConkey agar (bioMérieux).

MICROBIOLOGIC SAMPLING OF HANDS

Sterile plastic bags (29.2 cm × 31.8 cm) were placed on the subjects' right and left hands. Aliquots of 30 mL of Trypticase soy agar broth were added to each bag in sterile conditions. The bag was secured at the wrist, and the hands were uni-

TABLE 5. Comparison of Healthcare Worker (HCW) Hand Culture Results Study versus Control Scrubs (31 Participants Total)

Variable	Study scrub, *n* (%)	Control scrub, *n* (%)	*P*
Beginning of shift			
HCWs with MRSA hand culture positive	10/31 (32)	6/31 (19)	.2457
HCWs with VRE hand culture positive	6/31 (19)	4/31 (13)	.7315
HCWs with GNR hand culture positive	12/31 (39)	14/31 (45)	.6067
End of shift			
HCWs with MRSA hand culture positive	9/31 (29)	11/31 (35)	.5869
HCWs with VRE hand culture positive	4/31 (13)	2/31 (6)	.6713
HCWs with GNR hand culture positive	2/31 (6)	5/31 (16)	.4248

NOTE. Thirty-one participants completed at least 1 crossover during the study protocol. GNR, gram-negative rod; MRSA, methicillin-resistant *Staphylococcus aureus*; VRE, vancomycin-resistant enterococci.

formly massaged by a member of the study team for 1 minute. A 5-mL aliquot was obtained from the bag and placed into a sterile tube. The tubes were further incubated at 37°C for 24 hours followed by dilution, plating, and counting of colonies (CFUs/mL), as previously described.[15] Identification of MRSA, VRE, and GNRs was performed as described above.

STATISTICAL ANALYSES

The crossover design was analyzed using the generalized linear mixed model (GLIMMIX) procedure in SAS (ver. 9.2; SAS Institute). The CFU counts were log transformed in order to fulfill the normality assumption. Differences in mean log CFU apparel and hand counts were estimated and tested in the LSMEANS statement of the GLIMMIX procedure.

The McNemar test and the Fisher exact test were used to examine differences between the proportions of HCWs with positive MRSA, VRE, GNR, and MSSA cultures in the study and control group. All *P* values were 2 sided. A Bonferroni correction was performed to account for multiple significance tests.

POWER CALCULATION

Power calculations were done a priori. Using data from Schoeller Technologies and the 2-group *t* test of equal means in nQuery Advisor (ver. 7.0), we computed the power needed to detect a 20% difference in the mean CFU counts between study and control scrubs. With a sample size ($n = 20$ per group), a mean CFU count of 28.39, and a common standard deviation of 5.678, we estimated 86% power to detect a 20% difference in the mean CFU counts between study and control scrubs at the 0.05 level of significance.

RESULTS

Thirty-two HCWs were enrolled in the 4-month study. Thirty-one HCWs completed at least 1 subsequent crossover, 28 HCWs completed 2 crossovers, and 25 HCWs completed the entire protocol.

Overall hand hygiene adherence was 78% (910/1,173). Hand hygiene adherence was 69% (410/592) before patient contact and 85% (500/585) after patient contact. General hand hygiene adherence was similar across each study month (appendix). Overall compliance with wearing scrubs per protocol was 82% (223 observed compliant/273 scrub compliance opportunity observations performed).

There were 458 participant-weeks in the study (Table 1). Each week allowed for 1 apparel culture opportunity and hand culture opportunity per HCW. With each apparel culture opportunity and hand culture opportunity, there were, respectively, 6 and 4 potential microbiologic samples. A total of 2,000 microbiologic samples were from apparel and 1,324 microbiologic samples were from hands. Of these, 1,019 apparel cultures were from study scrubs and 981 were from control scrubs. Hand culture samples were obtained from 649 HCWs wearing study scrubs and from 675 HCWs wearing control scrubs. Overall compliance with apparel culture opportunity and hand culture opportunity microbiologic sampling was 2,000/2,748 (73%) and 1,324/1,832 (72%).

There were 37 MRSA isolates from study scrubs and 41 from control scrubs. There were no VRE isolated from study scrubs versus 1 from the control scrubs. There were 3 GNR isolates from study scrubs and 4 from control scrubs. The GNRs identified were *Escherichia coli* (5), *Serratia marcescens* (1), and *Klebsiella pneumoniae* (1). From the hand cultures, there were 26 MRSA isolates (4% of hand cultures) from HCWs wearing study scrubs and 21 MRSA isolates (3% of hand cultures) from HCWs wearing control scrubs. No VRE were recovered in the hand culture samples from either group. There were 13 GNR isolates (2% of hand cultures) from HCWs wearing study scrubs and 5 GNR isolates (0.7% of hand cultures) from HCWs wearing control scrubs. The GNRs identified in the hand cultures were *E. coli* (10), *K. pneumonia* (5), and *S. marcescens* (3).

Data from the 31 participants who completed at least 1 crossover during the study protocol were used for comparison of microbiologic endpoints. No differences were observed in frequency or percent of HCWs with MRSA-, VRE-, or GNR-

TABLE 6. Differences in Mean Log Colony-Forming Unit (CFU) Count Hand Cultures in Study versus Control Scrubs

	Mean log CFU count				
	Study (samples, *n*)	Control (samples, *n*)	Difference	SE of difference	*P*
MRSA	12.28 (26)	12.37 (21)	0.09	0.9796	.9309
VRE	0.00	0.00	0.00	NA	NA
GNR[a]	10.72 (13)	12.88 (5)	2.16	1.8344	.2565

NOTE. GNR, gram-negative rod; MRSA, methicillin-resistant *Staphylococcus aureus*; NA, not applicable (sample size is not sufficiently representative to compute a *P* value); SE, standard error; VRE, vancomycin-resistant enterococci.

[a] *Escherichia coli*, *Serratia marcescens*, *Klebsiella pneumoniae*.

positive cultures by scrub type, shift time, or anatomic location (Tables 2, 3).

Table 4 summarizes differences in apparel mean log CFU count both overall and at the beginning and the end of shift. A statistically significant difference in mean log MRSA CFU count was detected between study and control scrubs on the leg cargo pocket (11.84 mean log CFU control scrub vs 6.71 mean log CFU study scrub; $P = .0002$) and on the abdominal area (11.35 mean log CFU control scrub vs 7.54 mean log CFU study scrub; $P = .0056$). After adjustment with Bonferroni criterion, the above tests remained significant at or below the 0.025 significance level. No difference was detected in overall mean log CFU counts of VRE or GNRs by scrub type.

There was a statistically significant lower mean log CFU MRSA count on the leg cargo pocket at the beginning of a shift in the study versus control scrub groups (4.87 mean log CFU vs 11.96 mean log CFU; $P = .0028$) and on the abdominal area pocket at the end of a shift in the study versus control scrub groups (8.22 mean log CFU vs 12.14 mean log CFU; $P = .0054$). After adjustment with the Bonferroni criterion, the above tests remained significant at the 0.0125 level of significance No differences were detected in mean log CFU counts of VRE or GNRs by scrub type.

No difference was observed in the number and percent of HCWs with hand cultures positive for MRSA, VRE, and GNRs by either scrub type or shift time (Table 5). There was no difference observed in hand mean log CFU count for MRSA (12.37 mean log CFU in control arm vs 12.28 mean log CFU in study arm; $P = .93$), VRE (negative cultures for both control and study arms), or GNR (12.88 mean log CFU in control arm vs 10.72 mean log CFU in study arm; $P = .26$) when wearing study versus control scrubs (Table 6).

Twenty-one participants completed the questionnaire for a response rate of 68% (21/31). Each set of scrubs was reportedly laundered an average of 1.5 times per week. Ten percent (2/21) of respondents strongly agreed/agreed that study participation increased their hand hygiene practices, and 90% (19/21) reported "excellent" hand hygiene adherence. Seventy-six percent (16/21) of respondents strongly agreed/agreed that they were compliant with wearing scrubs per protocol. Twenty-four percent (5/21) of respondents strongly agreed/agreed that the use of antimicrobial impregnated scrubs would better control bacterial hand colonization, and 29% (6/21) strongly agreed/agreed that antimicrobial impregnated scrubs would better control hospital-acquired infections.

DISCUSSION

In our randomized, blinded, crossover trial in a medical ICU to determine the effectiveness of Vestex antimicrobial scrubs on the bacterial burden of HCW hands and clothing, overall adherence with wearing scrubs per protocol was 82%. Adherence with scrub and hand culture per protocol was 73% and 72%, respectively. Participating HCWs were undecided about whether antimicrobial impregnated apparel would either decrease hand colonization or impact hospital-acquired infection rates. Such survey data support the blinded study design.

No statistically significant differences were observed in the proportion of HCWs colonized with MRSA, VRE, or GNRs by scrub type. We observed, however, a statistically significant, 4–7 log decrease in overall mean log CFU MRSA count in study scrubs. In addition, a statistically significant 7 log decrease in mean log CFU MRSA count on the leg cargo pocket was observed in study scrubs at the beginning of shift. Last, a statistically significant 4 log decrease in mean log CFU MRSA count on the abdominal area pocket was observed in study scrubs at shift's end. No differences were observed for VRE and GNRs.

Previously, Vestex-treated fabric demonstrated in vitro activity against *S. aureus*, MRSA, *K. pneumoniae* (carbapenemase resistant), multidrug-resistant *A. baumannii*, and *Clostridium difficile*.[16,17] Thus, the absence of an observed impact on VRE and GNR microbial burden by study scrubs may reflect the already low baseline HCW apparel exposure to these pathogens and is not necessarily a reflection of a reduced antimicrobial effect.

In the United Kingdom, there is a "bare below the elbows" initiative for patient care.[18] The National Health System policy bans ties, long sleeves, jewelry, and white coats during clinical activities. The goal is to reduce pathogen cross-transmission by minimizing patient contact with contaminated, infre-

quently laundered items while concurrently promoting vigorous hand hygiene to the hands and forearms. An in vitro model of lab coat cross-transmission supports this hypothesis.[7] All scrubs utilized in our protocol were short sleeved, consistent with the practice of bare below the elbows.

Evidence-based strategies for infection prevention include hand hygiene, invasive device "bundles," and use of personal protective equipment by HCWs.[19-27] State-of-the-art practices exist for sterilization and disinfection of the inanimate environment.[28] Wenzel et al[4] argue that a horizontal, population-based infection prevention program utilizing evidence-based processes can be applied to favorably influence rates of infection at all major anatomic sites. A horizontal, non-pathogen-based infection prevention strategy calls for hospital-wide, maximal implementation of evidence-based practices. This includes maximal adherence to hand hygiene, central line insertion checklists, head of bed elevation for ventilated patients, ventilator and urinary catheterization bundles, and chlorhexidine bathing of patients.

An extension of a horizontal strategy includes apparel bioburden reduction with passive, textile-based antimicrobial technologies. Bacterial contamination of HCW uniforms during routine patient care has been reported.[29] One study reported that 30% of respondents did not change uniforms daily.[30] These highlight the potential cross-transmission risk of colonized apparel if garments frequently contact patients and invasive devices. Prospective trials are needed to assess the impact of antimicrobial scrubs on hospital-acquired infection rates.

Our study has several strengths. To minimize bias, we utilized a prospective, randomized protocol to assess the microbial impact of the study scrubs. The scrubs appeared identical, and HCWs were blinded to scrub type. We utilized a crossover design that allowed all participants to serve as both study and control subjects, further minimizing bias. The study had sufficient power to detect a microbiologic difference in the scrubs. We used dedicated, trained study personnel for hand hygiene adherence, scrub compliance monitoring, and microbiology sample collection. This minimized error and data collection bias. Prior analysis confirmed that Vestex antimicrobial performance persists for up to 50 laundering cycles using a wash protocol of 26 minutes at 140°F with nonbleach detergent.[31] All participants were instructed to launder their scrubs in hot water using nonbleach detergent. Because each set of antimicrobial scrub was laundered an average of 1.5 times weekly, it is not likely that the Vestex antimicrobial effect was diminished and negatively impacted outcomes.

Study limitations include a short duration (16 weeks) and testing at a single clinical unit. Thus, our findings are difficult to generalize beyond our study population. Although study personnel collecting microbiology samples were not blinded to scrub type, laboratory personnel were blinded. We did not collect data on device-associated infection rates; thus, the impact of antimicrobial scrubs on hospital-acquired infections remains unknown. Our institution does not routinely perform active detection and isolation for MRSA or VRE on hospital admission.[32] Nevertheless, after employing multiple evidence-based infection prevention interventions, our institution has significantly reduced the rate of device-associated infections by >40% in each ICU.[32] This may have blunted our ability to detect significant bacterial colonization on the hands and apparel of HCWs. In addition, microbiology samples were not genetically identified by pulsed field gel electrophoresis. As a result, no genotypic data are available for comparison of HCW and patient strains of MRSA, VRE, or GNRs.

Our study adds to the body of literature on the potential clinical utility of apparel with antimicrobial properties. The antimicrobial scrubs tested were associated with decreased MRSA apparel microbial bioburden. However, no difference was observed for VRE or GNR bioburden. When bundled with known infection prevention strategies such as hand hygiene, antimicrobial impregnated apparel may limit the bacterial burden of the inanimate environment. For settings with high rates of hospital-acquired infections with drug-resistant pathogens such as MRSA, the use of antimicrobial apparel may be a useful adjunct to other infection prevention measures. A prospective trial is needed to assess the incremental impact of antimicrobial impregnated apparel on the control of hospital acquired infections.

ACKNOWLEDGMENTS

Financial support. This study was funded by an investigator-initiated grant from Vestex Technologies. The sponsor played no role in the design, conduct, interpretation, or summary of this investigation.

Potential conflicts of interest. K.E. reports that she worked as a full-time study coordinator from 2008 to 2010. After completing her employment at Virginia Commonwealth University, she worked as a consultant to Vestagen Technical Textiles on an ad hoc basis. All other authors report no conflicts of interest relevant to this article. All authors submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and the conflicts that the editors consider relevant to this article are disclosed here.

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APPENDIX

HAND HYGIENE ADHERENCE

During the first month, hand hygiene compliance was 67% (63/94) before patient contact and 85% (80/94) after patient contact. During the second month, hand hygiene compliance was 70% (153/218) before patient contact and 84% (179/213) after patient contact. During the third month, hand hygiene compliance was 66% (105/160) before patient contact and 86% (137/160) after patient contact. During the fourth month, hand hygiene compliance was 74% (89/120) before patient contact and 88% (104/118) after patient contact.

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