

ORIGINAL RESEARCH

Bacterial Contamination of Healthcare Workers' Uniforms: A Randomized Controlled Trial of Antimicrobial Scrubs

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BACKGROUND: Healthcare workers' (HCWs) uniforms become contaminated with bacteria during normal use, and this may contribute to hospital-acquired infections. Antimicrobial uniforms are currently marketed as a means of reducing this contamination.

OBJECTIVE: To compare the extent of bacterial contamination of uniforms and skin when HCWs wear 1 of 2 antimicrobial scrubs or standard scrubs.

DESIGN: Prospective, randomized, controlled trial.

SETTING: University-affiliated, public safety net hospital

PARTICIPANTS: Hospitalist physicians, nurse practitioners, physician assistants, housestaff, and nurses (total N = 105) working on internal medicine units.

INTERVENTION: Subjects were randomized to wear standard scrubs or 1 of 2 antimicrobial scrubs.

MEASUREMENTS: Bacterial colony counts in cultures taken from the HCWs' scrubs and wrists after an 8-hour workday.

RESULTS: The median (interquartile range) total colony counts was 99 (66–182) for standard scrubs, 137 (84–289) for antimicrobial scrub type A, and 138 (62–274) for antimicrobial scrub type B ($P = 0.36$). Colony counts from participants' wrists were 16 (5–40) when they wore standard scrubs and 23 (4–42) and 15 (6–54) when they wore antimicrobial scrubs A and B, respectively ($P = 0.92$). Resistant organisms were cultured from 3 HCWs (4.3%) randomized to antimicrobial scrubs and none randomized to standard scrubs ($P = 0.55$). Six participants (5.7%) reported side effects to wearing scrubs, all of whom wore antimicrobial scrubs ($P = 0.18$).

CONCLUSIONS: We found no evidence that either antimicrobial scrub product decreased bacterial contamination of HCWs' uniforms or skin after an 8-hour workday. *Journal of Hospital Medicine* 2013;8:380–385. © 2013 Society of Hospital Medicine

Healthcare workers' (HCWs) attire becomes contaminated with bacterial pathogens during the course of the workday,^{1–12} and Munoz-Price et al.¹³ recently demonstrated that finding bacterial pathogens on HCWs' white coats correlated with finding the same pathogens on their hands. Because of concern for an association between attire colonization and nosocomial infection, governmental agencies in England and Scotland banned HCWs from wearing white coats or long-sleeve garments,^{14,15} despite evidence that such an approach does not reduce contamination.¹²

Newly developed antimicrobial textiles have been incorporated into HCW scrubs,^{16–20} and commercial Web sites and product inserts report that these products can reduce bacterial contamination by 80.9% at 8 hours to greater than 99% under laboratory conditions

depending on the product and microbe studied.^{16,17,19} Because there are limited clinical data pertaining to the effectiveness of antimicrobial scrubs, we performed a prospective study designed to determine whether wearing these products reduced bacterial contamination of HCWs' scrubs or skin at the end of an 8-hour workday.

METHODS

Design

The study was a prospective, unblinded, randomized, controlled trial that was approved by the Colorado Multiple Institutional Review Board and conducted at Denver Health, a university-affiliated public safety net hospital. No protocol changes occurred during the study.

Participants

Participants included hospitalist physicians, internal medicine residents, physician assistants, nurse practitioners, and nurses who directly cared for patients hospitalized on internal medicine units between March 12, 2012 and August 28, 2012. Participants known to be pregnant or those who refused to participate in the study were excluded.

Intervention

Standard scrubs issued by the hospital were tested along with 2 different antimicrobial scrubs (scrub A

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and scrub B). Scrub A was made with a polyester microfiber material embedded with a proprietary antimicrobial chemical. Scrub B was a polyester-cotton blend scrub that included 2 proprietary antimicrobial chemicals and silver embedded into the fabric. The standard scrub was made of a polyester-cotton blend with no antimicrobial properties. All scrubs consisted of pants and a short-sleeved shirt, with either a pocket at the left breast or lower front surface, and all were tested new prior to any washing or wear. Preliminary cultures were done on 2 scrubs in each group to assess the extent of preuse contamination. All providers were instructed not to wear white coats at any time during the day that they were wearing the scrubs. Providers were not told the type of scrub they received, but the antimicrobial scrubs had a different appearance and texture than the standard scrubs, so blinding was not possible.

Outcomes

The primary end point was the total bacterial colony count of samples obtained from the breast or lower front pocket, the sleeve cuff of the dominant hand, and the pant leg at the midthigh of the dominant leg on all scrubs after an 8-hour workday. Secondary outcomes were the bacterial colony counts of cultures obtained from the volar surface of the wrists of the HCWs' dominant arm, and the colony counts of methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), and resistant Gram-negative bacteria on the 3 scrub types, all obtained after the 8-hour workday.

Cultures were collected using a standardized RODAC imprint method²¹ with BBL RODAC plates containing blood agar (Becton Dickinson, Sparks, MD). Cultures were incubated in ambient air at 35° to 37°C for 18 to 22 hours. After incubation, visible colonies were counted using a dissecting microscope to a maximum of 200 colonies as recommended by the manufacturer. Colonies morphologically consistent with *Staphylococcus* species were subsequently tested for coagulase using a BactiStaph rapid latex agglutination test (Remel, Lenexa, KS). If positive, these colonies were subcultured to sheep blood agar (Remel) and BBL MRSA CHROMagar (Becton Dickinson) and incubated for an additional 18 to 24 hours. Characteristic growth on blood agar that also produced mauve-colored colonies on CHROMagar was taken to indicate MRSA. Colonies morphologically suspicious for being VRE were identified and confirmed as VRE using a positive identification and susceptibility panel (Microscan; Siemens, Deerfield, IL). A negative combination panel (Microscan, Siemens) was also used to identify and confirm resistant Gram-negative rods.

Each participant completed a survey that included questions that identified their occupation, whether they had had contact with patients who were known

to be colonized or infected with MRSA, VRE, or resistant Gram-negative rods during the testing period, and whether they experienced any adverse events that might relate to wearing the uniform.

Sample Size

We assumed that cultures taken from the sleeve of the control scrubs would have a mean (\pm standard deviation) colony count of 69 (\pm 67) based on data from our previous study.¹² Although the companies making the antimicrobial scrubs indicated that their respective products provided between 80.9% at 8 hours and >99% reduction in bacterial colony counts in laboratory settings, we assumed that a 70% decrease in colony count compared with standard scrubs could be clinically important. After adjusting for multiple comparisons and accounting for using nonparametric analyses with an unknown distribution, we estimated a need to recruit 35 subjects in each of 3 groups.

Randomization

The principal investigator and coinvestigators enrolled and consented participants. After obtaining consent, block randomization, stratified by occupation, occurred 1 day prior to the study using a computer-generated table of random numbers.

Statistics

Data were collected and managed using REDCap (Research Electronic Data Capture; Vanderbilt University-The Institute for Medicine and Public Health, Nashville, TN) electronic data capture tools hosted at Denver Health. REDCap is a secure Web-based application designed to support data collection for research studies, providing: (1) an intuitive interface for validated data entry, (2) audit trails for tracking data manipulation and export procedures, (3) automated export procedures for seamless data downloads to common statistical packages, and (4) procedures for importing data from external sources.²²

Colony counts were compared using a Kruskal-Wallis 1-way analysis of variance by ranks. Bonferroni's correction for multiple comparisons resulted in a $P < 0.01$ as indicating statistical significance. Proportions were compared using χ^2 analysis. All data are presented as medians with interquartile range (IQR) or proportions.

RESULTS

We screened 118 HCWs for participation and randomized 109, 37 in the control and antimicrobial scrub group A, and 35 in antimicrobial scrub group B (during the course of the study we neglected to culture the pockets of 2 participants in the standard scrub group and 2 in antimicrobial scrub group A). Because our primary end point was total colony count from cultures taken from 3 sites, data from these 4 subjects could not be used, and all the data from these 4 subjects were excluded from the primary analysis; 4

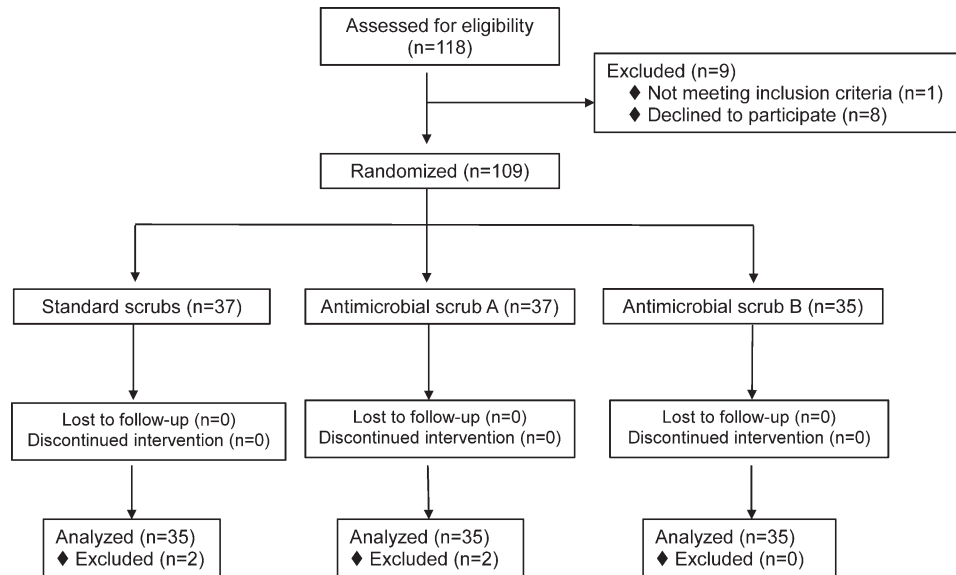


FIG. 1. Enrollment and randomization.

additional subjects were subsequently recruited allowing us to meet our block enrollment target (Figure 1). The first and last participants were studied on March 12, 2012 and August 28, 2012, respectively. The trial ended once the defined number of participants was enrolled. The occupations of the 105 participants are summarized in Table 1.

Colony counts of all scrubs cultured prior to use never exceeded 10 colonies. The median (IQR) total colony counts from all sites on the scrubs was 99 (66–182) for standard scrubs, 137 (84–289) for antimicrobial scrub type A, and 138 (62–274) for antimicrobial scrub type B ($P = 0.36$). We found no significant differences between the colony counts cultured from any of the individual sites among the 3 groups, regardless of occupation (Table 2). No significant difference was observed with respect to colony counts cultured from the wrist among the 3 study groups (Table 2). Comparisons between groups were planned *a priori* if a difference across all groups was found. Given the non-significant P values across all scrub groups, no further comparisons were made.

Fifty-five participants (52%) reported caring for patients who were known to be colonized or infected with an antibiotic-resistant organism, 16 (46%) randomized to wear standard scrubs, and 20 (57%) and 19 (54%) randomized to wear antimicrobial scrub A or B, respectively ($P = 0.61$). Of these, however, antibiotic-resistant organisms were only cultured from the scrubs of 2 providers (1 with 1 colony of MRSA from the breast pocket of antimicrobial scrub A, 1 with 1 colony of MRSA cultured from the pocket of antimicrobial scrub B [$P = 0.55$]), and from the wrist of only 1 provider (a multiresistant Gram-negative rod who wore antimicrobial scrub B).

Adverse Events

Six subjects (5.7%) reported adverse events, all of whom were wearing antimicrobial scrubs ($P = 0.18$). For participants wearing antimicrobial scrub A, 1 (3%) reported itchiness and 2 (6%) reported heaviness or poor breathability. For participants wearing antimicrobial scrub B, 1 (3%) reported redness, 1 (3%)

TABLE 1. Demographics

	All Subjects, N = 105	Standard Scrub, n = 35	Antimicrobial Scrub A, n = 35	Antimicrobial Scrub B, n = 35
Healthcare worker type, n (%)				
Attending physician	11 (10)	5 (14)	3 (9)	3 (9)
Intern/resident	51 (49)	17 (49)	16 (46)	18 (51)
Midlevels	6 (6)	2 (6)	2 (6)	2 (6)
Nurse	37 (35)	11 (31)	14 (40)	12 (34)
Cared for colonized or infected patient with antibiotic resistant organism, n (%)	55 (52)	16 (46)	20 (57)	19 (54)
Number of colonized or infected patients cared for, n (%)				
1	37 (67)	10 (63)	13 (65)	14 (74)
2	11 (20)	4 (25)	6 (30)	1 (5)
3 or more	6 (11)	2 (12)	1 (5)	3 (16)
Unknown	1 (2)	0 (0)	0 (0)	1 (5)

TABLE 2. Colony Counts by Location and Occupation

	Total (From All Sites on Scrubs)	Pocket	Sleeve Cuff	Thigh	Wrist
All subjects, N = 105					
Standard scrub	99 (66–182)	41 (20–70)	20 (9–44)	32 (21–61)	16 (5–40)
Antimicrobial scrub A	137 (84–289)	65 (35–117)	33 (16–124)	41 (15–86)	23 (4–42)
Antimicrobial scrub B	138 (62–274)	41 (22–99)	21 (9–41)	40 (18–107)	15 (6–54)
P value	0.36	0.17	0.07	0.57	0.92
Physicians and midlevels, n = 68					
Standard scrub	115.5 (72.5–173.5)	44.5 (22–70.5)	27.5 (10.5–38.5)	35 (23–62.5)	24.5 (7–55)
Antimicrobial scrub A	210 (114–289)	86 (64–120)	39 (18–129)	49 (24–86)	24 (3–42)
Antimicrobial scrub B	149 (68–295)	52 (26–126)	21 (10–69)	37 (18–141)	19 (8–72)
P value	0.21	0.08	0.19	0.85	0.76
Nurses, n = 37					
Standard scrub	89 (31–236)	37 (13–48)	13 (5–52)	28 (13–42)	9 (3–21)
Antimicrobial scrub A	105 (43–256)	45.5 (22–58)	21.5 (16–54)	38.5 (12–68)	17 (6–43)
Antimicrobial scrub B	91.5 (60–174.5)	27 (13–40)	16 (7.5–26)	51 (21–86.5)	10 (3.5–43.5)
P value	0.86	0.39	0.19	0.49	0.41

NOTE: Data are presented as median (interquartile range).

reported itchiness, and 1 (3%) reported heaviness or poor breathability.

DISCUSSION

The important findings of this study are that we found no evidence indicating that either of the 2 antimicrobial scrubs tested reduced bacterial contamination or antibiotic-resistant contamination on HCWs' scrubs or wrists compared with standard scrubs at the end of an 8-hour workday, and that despite many HCWs being exposed to patients who were colonized or infected with antibiotic-resistant bacteria, these organisms were only rarely cultured from their uniforms.

We found that HCWs in all 3 arms of the study had bacterial contamination on their scrubs and skin, consistent with previous studies showing that HCWs' uniforms are frequently contaminated with bacteria, including MRSA, VRE, and other pathogens.^{1–12} We previously found that bacterial contamination of HCWs' uniforms occurs within hours of putting on newly laundered uniforms.¹²

Literature on the effectiveness of antimicrobial HCW uniforms when tested in clinical settings is limited. Bearman and colleagues²³ recently published the results of a study of 31 subjects who wore either standard or antimicrobial scrubs, crossing over every 4 weeks for 4 months, with random culturing done weekly at the beginning and end of a work shift. Scrubs were laundered an average of 1.5 times/week, but the timing of the laundering relative to when cultures were obtained was not reported. Very few isolates of MRSA, Gram-negative rods, or VRE were found (only 3.9%, 0.4%, and 0.05% of the 2000 samples obtained, respectively), and no differences were observed with respect to the number of HCWs who had antibiotic-resistant organisms cultured when they were wearing standard versus antimicrobial scrubs. Those who had MRSA cultured, however, had lower mean log colony counts when they were

wearing the antimicrobial scrubs. The small number of samples with positive isolates, together with differences in the extent of before-shift contamination among groups complicates interpreting these data. The authors concluded that a prospective trial was needed. We attempted to include the scrub studied by Bearman and colleagues²³ in our study, but the company had insufficient stock available at the time we tried to purchase the product.

Gross and colleagues²⁴ found no difference in the mean colony counts of cultures taken from silver-impregnated versus standard scrubs in a pilot crossover study done with 10 HCWs (although there were trends toward higher colony counts when the subjects wore antimicrobial scrubs).

Antibiotic-resistant bacteria were only cultured from 3 participants (2.9%) in our current study, compared to 16% of those randomized to wearing white coats in our previous study and 20% of those randomized to wearing standard scrubs.¹² This difference may be explained by several recent studies reporting that rates of MRSA infections in hospitals are decreasing.^{25,26} The rate of hospital-acquired MRSA infection or colonization at our own institution decreased 80% from 2007 to 2012. At the times of our previous and current studies, providers were expected to wear gowns and gloves when caring for patients as per standard contact precautions. Rates of infection and colonization of VRE and resistant Gram-negative rods have remained low at our hospital, and our data are consistent with the rates reported on HCWs' uniforms in other studies.^{2,5,10}

Only 6 of our subjects reported adverse reactions, but all were wearing antimicrobial scrubs ($P = 0.18$). Several of the participants described that the fabrics of the 2 antimicrobial scrubs were heavier and less breathable than the standard scrubs. We believe this difference is more likely to explain the adverse reactions reported than is any type of reaction to the specific chemicals in the fabrics.

Our study has several limitations. Because it was conducted on the general internal medicine units of a single university-affiliated public hospital, the results may not generalize to other types of institutions or other inpatient services.

As we previously described,¹² the RODAC imprint method only samples a small area of HCWs' uniforms and thus does not represent total bacterial contamination.²¹ We specifically cultured areas that are known to be highly contaminated (ie, sleeve cuffs and pockets). Although imprint methods have limitations (as do other methods for culturing clothing), they have been commonly utilized in studies assessing bacterial contamination of HCW clothing.^{2,3,5}

Although some of the bacterial load we cultured could have come from the providers themselves, previous studies have shown that 80% to 90% of the resistant bacteria cultured from HCWs' attire come from other sources.^{1,2}

Because our sample size was calculated on the basis of being able to detect a difference of 70% in total bacterial colony count, our study was not large enough to exclude a lower level of effectiveness. However, we saw no trends suggesting the antimicrobial products might have a lower level of effectiveness.

We did not observe the hand-washing practices of the participants, and accordingly, cannot confirm that these practices were the same in each of our 3 study groups. Intermittent, surreptitious monitoring of hand-washing practices on our internal medicine units over the last several years has found compliance with hand hygiene recommendations varying from 70% to 90%.

Although the participants in our study were not explicitly told to which scrub they were randomized, the colors, appearances, and textures of the antimicrobial fabrics were different from the standard scrubs such that blinding was impossible. Participants wearing antimicrobial scrubs could have changed their hand hygiene practices (ie, less careful hand hygiene). Lack of blinding could also have led to over-reporting of adverse events by the subjects randomized to wear the antimicrobial scrubs.

In an effort to treat all the scrubs in the same fashion, all were tested new, prior to being washed or previously worn. Studying the scrubs prior to washing or wearing could have increased the reports of adverse effects, as the fabrics could have been stiffer and more uncomfortable than they might have been at a later stage in their use.

Our study also has some strengths. Our participants included physicians, residents, nurses, nurse practitioners, and physician assistants. Accordingly, our results should be generalizable to most HCWs. We also confirmed that the scrubs that were tested were nearly sterile prior to use.

In conclusion, we found no evidence suggesting that either of 2 antimicrobial scrubs tested decreased

bacterial contamination of HCWs' scrubs or skin after an 8-hour workday compared to standard scrubs. We also found that, although HCWs are frequently exposed to patients harboring antibiotic-resistant bacteria, these bacteria were only rarely cultured from HCWs' scrubs or skin.

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