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ORIGINAL RESEARCH

Newly Cleaned Physician Uniforms and Infrequently Washed White Coats Have Similar Rates of Bacterial Contamination After an 8-Hour Workday: A Randomized Controlled Trial

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BACKGROUND: Governmental agencies in the United Kingdom and Scotland have recently instituted guidelines banning physicians' white coats and the wearing of long-sleeved garments to decrease nosocomial transmission of bacteria.
OBJECTIVE: Our aim was to compare the degree of bacterial and methicillin-resistant *Staphylococcus aureus* contamination of physicians' white coats with that of newly laundered, standardized short-sleeved uniforms after an 8-hour workday and to determine the rate at which bacterial contamination of the uniform ensued.
DESIGN: The design was a prospective, randomized controlled trial.
SETTING: The setting was a university-affiliated public safety-net hospital.
PARTICIPANTS: One hundred residents and hospitalists on an internal medicine service participated.
INTERVENTION: Subjects wore either a physician's white coat or a newly laundered short-sleeved uniform.
MEASUREMENTS: Bacterial colony count and the frequency with which methicillin-resistant *Staphylococcus aureus* was cultured from both garments over time were measured.
RESULTS: No statistically significant differences were found in bacterial or methicillin-resistant *Staphylococcus aureus* contamination of physicians' white coats compared with newly laundered short-sleeved uniforms or in contamination of the skin at the wrists of physicians wearing either garment. Colony counts of newly laundered uniforms were essentially zero, but after 3 hours of wear they were nearly 50% of those counted at 8 hours.
CONCLUSIONS: Bacterial contamination occurs within hours after donning newly laundered short-sleeved uniforms. After 8 hours of wear, no difference was observed in the degree of contamination of uniforms versus infrequently laundered white coats. Our data do not support discarding long-sleeved white coats for short-sleeved uniforms that are changed on a daily basis. ***Journal of Hospital Medicine*** **2011;6:177–182.** © *2011 Society of Hospital Medicine.*

KEYWORDS: MRSA, methicillin-resistant *Staphylococcus aureus*, uniform, contamination, white coat, bare below the elbows.

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In September 2007, the British Department of Health developed guidelines for health care workers regarding uniforms and work wear that banned the traditional white coat and other long-sleeved garments in an attempt to decrease nosocomial bacterial transmission.[1] Similar policies have recently been adopted in Scotland.[2] Interestingly, the National Health Service report acknowledged that evidence was lacking that would support that white coats and long-sleeved garments caused nosocomial infection.[1,3] Although many studies have documented that health care work clothes are contaminated with bacteria, including methicillin-resistant *Staphylococcal aureus* (MRSA) and other pathogenic species,[4–13] none have determined whether avoiding white coats and switching to short-sleeved garments decreases bacterial contamination.

We performed a prospective, randomized, controlled trial designed to compare the extent of bacterial contamination of physicians' white coats with that of newly laundered, standardized short-sleeved uniforms. Our hypotheses were that infrequently cleaned white coats would have greater bacterial contamination than uniforms, that the extent of contamination would be inversely related to the frequency with which the coats were washed, and that the increased contamination of the cuffs of the white coats would result in increased contamination of the skin of the wrists. Our results led us also to assess the rate at which bacterial contamination of short-sleeved uniforms occurs during the workday.

Methods

The study was conducted at Denver Health, a university-affiliated public safety-net hospital and was approved by the Colorado Multiple Institutional Review Board.

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Trial Design

The study was a prospective, randomized, controlled trial. No protocol changes occurred during the study.

Participants

Participants included residents and hospitalists directly caring for patients on internal medicine units between August 1, 2008 and November 15, 2009.

Intervention

Subjects wore either a standard, newly laundered, short-sleeved uniform or continued to wear their own white coats.

Outcomes

The primary end point was the percentage of subjects contaminated with MRSA. Cultures were collected using a standardized RODAC imprint method[14] with BBL RODAC plates containing trypticase soy agar with lecithin and polysorbate 80 (Becton Dickinson, Sparks, MD) 8 hours after the physicians started their work day. All physicians had cultures obtained from the breast pocket and sleeve cuff (long-sleeved for the white coats, short-sleeved for the uniforms) and from the skin of the volar surface of the wrist of their dominant hand. Those wearing white coats also had cultures obtained from the mid-biceps level of the sleeve of the dominant hand, as this location closely approximated the location of the cuffs of the short-sleeved uniforms.

Cultures were incubated in ambient air at 35°C-37°C for 18–22 hours. After incubation, visible colonies were counted using a dissecting microscope to a maximum of 200 colonies at the recommendation of the manufacturer. Colonies that were morphologically consistent with *Staphylococcus* species by colony growth and Gram stain were further tested for coagulase using a BactiStaph rapid latex agglutination test (Remel, Lenexa, KS). If positive, these colonies were subcultured to sheep blood agar (Remel, Lenexa, KS) and BBL MRSA Chromagar (Becton Dickinson, Sparks, MD) and incubated for an additional 18–24 hours. Characteristic growth on blood agar that also produced mauve-colored colonies on chromagar was taken to indicate MRSA.

A separate set of 10 physicians donned newly laundered, short-sleeved uniforms at 6:30 AM for culturing from the breast pocket and sleeve cuff of the dominant hand prior to and 2.5, 5, and 8 hours after they were donned by the participants (with culturing of each site done on separate days to avoid the effects of obtaining multiple cultures at the same site on the same day). These cultures were not assessed for MRSA.

At the time that consent was obtained, all participants completed an anonymous survey that assessed the frequency with which they normally washed or changed their white coats.

Sample Size

Based on the finding that 20% of our first 20 participants were colonized with MRSA, we determined that to find a 25% difference in the percentage of subjects colonized with MRSA in the 2 groups, with a power of 0.8 and $P < 0.05$ being significant (2-sided Fisher's exact test), 50 subjects would be needed in each group.

Randomization

Randomization of potential participants occurred 1 day prior to the study using a computer-generated table of random numbers. The principal investigator and a coinvestigator enrolled participants. Consent was obtained from those randomized to wear a newly laundered standard short-sleeved uniform at the time of randomization so that they could don the uniforms when arriving at the hospital the following morning (at approximately 6:30 AM). Physicians in this group were also instructed not to wear their white coats at any time during the day they were wearing the uniforms. Physicians randomized to wear their own white coats were not notified or consented until the day of the study, a few hours prior to the time the cultures were obtained. This approach prevented them from either changing their white coats or washing them prior to the time the cultures were taken.

Because our study included both employees of the hospital and trainees, a number of protection measures were required. No information of any sort was collected about those who agreed or refused to participate in the study. In addition, the request to participate in the study did not come from the person's direct supervisor.

Statistical Methods

All data were collected and entered using Excel for Mac 2004 version 11.5.4. All analyses were performed using SAS Enterprise Guide 4.1 (SAS Institute, Inc., Cary, NC).

The Wilcoxon rank-sum test and chi square analysis were used to seek differences in colony count and percentage of cultures with MRSA, respectively, in cultures obtained: (1) from the sleeve cuffs and pockets of the white coats compared with those from the sleeve cuffs and pockets of the uniforms, (2) from the sleeve cuffs of the white coats compared with those from the sleeve cuffs of the short-sleeved uniforms, (3) from the mid-biceps area of the sleeve sof the white coats compared with those from the sleeve cuffs of the uniforms, and (4) from the skin of the wrists of those wearing white coats compared with those wearing the uniforms. Bonferroni's correction for multiple comparisons was applied, with a $P < 0.125$ indicating significance.

Friedman's test and repeated-measures logistic regression were used to seek differences in colony count or of the percentage of cultures with MRSA, respectively, on white coats or uniforms by site of culture on both garments. A $P < 0.05$ indicated significance for these analyses.

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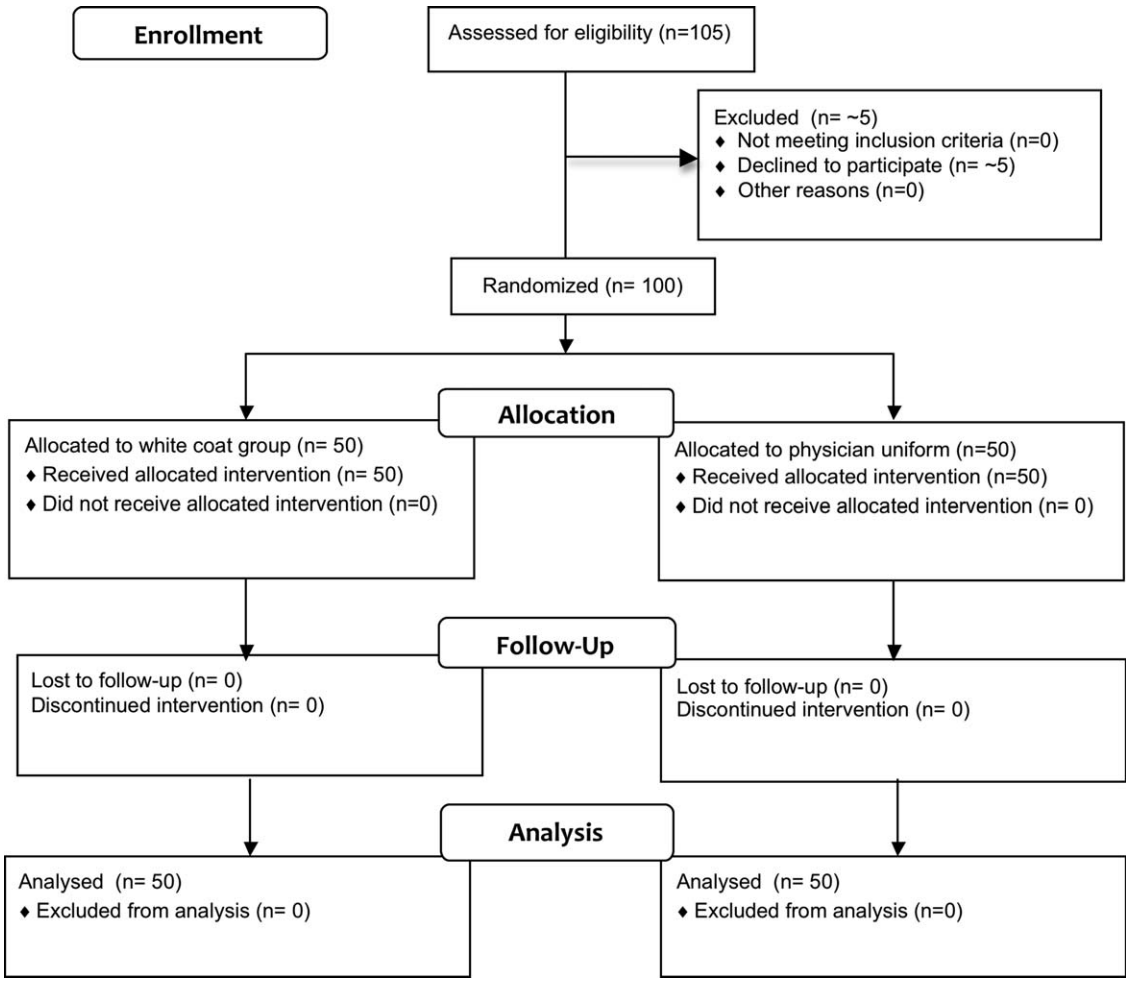

FIGURE 1. Enrollment and randomization.

The Kruskal-Wallis and chi-square tests were utilized to test the effect of white coat wash frequency on colony count and MRSA contamination, respectively.

All data are presented as medians with 95% confidence intervals or proportions.

Results

Participant Flow

Fifty physicians were studied in each group, all of whom completed the survey. In general, more than 95% of potential participants approached agreed to participate in the study (Figure 1).

Recruitment

The first and last physicians were studied in August 2008 and November 2009, respectively. The trial ended when the specified number of participants (50 in each group) had been enrolled.

Data on Entry

No data were recorded from the participants at the time of randomization in compliance with institutional review board regulations pertaining to employment issues that could arise when studying members of the workforce.

Outcomes

No significant differences were found between the colony counts cultured from white coats (104 [80–127]) versus newly laundered uniforms (142 [83–213]), $P = 0.61$. No significant differences were found between the colony counts cultured from the sleeve cuffs of the white coats (58.5 [48–66]) versus the uniforms (37 [27–68]), $P = 0.07$, or between the colony counts cultured from the pockets of the white coats (45.5 [32–54]) versus the uniforms (74.5 [48–97], $P = 0.040$. Bonferroni corrections were used for multiple comparisons such that a $P < 0.0125$ was considered significant. Cultures from at least 1 site of 8 of 50 physicians (16%) wearing white coats and 10 of 50 physicians (20%) wearing short-sleeved uniforms were positive for MRSA ($P = .60$).

Colony counts were greater in cultures obtained from the sleeve cuffs of the white coats compared with the pockets or mid-biceps area (Table 1). For the uniforms, no difference in colony count in cultures from the pockets versus sleeve cuffs was observed. No difference was found when

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TABLE 1. Bacterial and MRSA Contamination of White Coats and Newly Laundered Uniforms

	White Coat (n = 50)	*P*	Uniforms (n = 50)	*P*
Colony count, median (95% CI)				
Sleeve cuff	58.5 (48–66)	< 0.0001	37.0 (27–68)	0.25
Pocket	45.5 (32–54)		74.5 (48–97)	
Mid-biceps area of sleeve	25.5 (20–29)			
MRSA contamination, n (%)				
Sleeve cuff	4 (8%)	0.71	6 (12%)	0.18
Pocket	5 (10%)		9 (18%)	
Mid-biceps area of sleeve	3 (6%)			

comparing the number of subjects with MRSA contamination of the 3 sites of the white coats or the 2 sites of the uniforms (Table 1).

No difference was observed with respect to colony count or the percentage of subjects positive for MRSA in cultures obtained from the mid-biceps area of the white coats versus those from the cuffs of the short-sleeved uniforms (Table 2).

No difference was observed with respect to colony count or the percentage of subjects positive for MRSA in cultures obtained from the volar surface of the wrists of subjects wearing either of the 2 garments (Table 3).

The frequency with which physicians randomized to wearing their white coats admitted to washing or changing their coats varied markedly (Table 4). No significant differences were found with respect to total colony count ($P = 0.81$), colony count by site (data not shown), or percentage of physicians contaminated with MRSA ($P = 0.22$) as a function of washing or changing frequency (Table 4).

Sequential culturing showed that the newly laundered uniforms were nearly sterile prior to putting them on. By 3 hours of wear, however, nearly 50% of the colonies counted at 8 hours were already present (Figure 2).

Harms

No adverse events occurred during the course of the study in either group.

Discussion

The important findings of this study are that, contrary to our hypotheses, at the end of an 8-hour workday, no significant differences were found between the extent of bacterial or MRSA contamination of infrequently washed white coats compared with those of newly laundered uniforms, no difference was observed with respect to the extent of bacterial or MRSA contamination of the wrists of physicians wearing either of the 2 garments, and no association was apparent between the extent of bacterial or MRSA contamination and the frequency with which white coats were washed or changed. In addition, we also found that bacterial contamination of newly laundered uniforms occurred within hours of putting them on.

TABLE 2. Bacterial and MRSA Contamination of White Coats Cultured in Mid-Biceps Area of Sleeves Versus Newly Laundered Uniforms Cultured at the Sleeve Cuff

	White Coat Mid-Biceps (n = 50)	Uniform Sleeve Cuff (n = 50)	*P*
Colony count, median (95% CI)	25.5 (20–29)	37.0 (27–68)	0.07
MRSA contamination, n (%)	3 (6%)	6 (12%)	0.49

TABLE 3. Bacterial and MRSA Contamination of Volar Surface of Wrists of Subjects Wearing White Coats Versus Short-Sleeved Uniforms

	White Coat (n = 50)	Uniform (n = 50)	*P*
Colony count, median (95% CI)	23.5 (17–40)	40.5 (28–59)	0.09
MRSA Contamination, n (% of subjects)	3 (6%)	5 (10%)	0.72

Interpretation

Numerous studies have demonstrated that white coats and uniforms worn by health care providers are frequently contaminated with bacteria, including both methicillin-sensitive and -resistant *Staphylococcus aureus* and other pathogens.[4–13] This contamination may come from nasal or perineal carriage of the health care provider, from the environment, and/or from patients who are colonized or infected.[11,15] Although many have suggested that patients can become contaminated from contact with health care providers' clothing and studies employing pulsed-field gel electrophoresis and other techniques have suggested that cross-infection can occur,[10,16–18] others have not confirmed this contention,[19,20] and Lessing and colleagues[16] concluded that transmission from staff to patients was a rare phenomenon. The systematic review reported to the Department of Health in England,[3] the British Medical Association guidelines regarding dress codes for doctors,[21] and the department's report on which the new clothing guidelines were based[1] concluded there was no conclusive evidence indicating that work clothes posed a risk of spreading infection to patients. Despite this, the Working Group and the British Medical Association recommended that white coats should not be worn when providing patient care and that shirts and blouses should be short-sleeved.[1] Recent evidence-based reviews concluded that there was insufficient evidence to justify this policy,[3,22] and our data indicate that the policy will not decrease bacterial or MRSA contamination of physicians' work clothes or skin.

The recommendation that long-sleeved clothing should be avoided comes from studies indicating that cuffs of these garments are more heavily contaminated than other areas[5,8] and are more likely to come in contact with patients.[1] Wong and colleagues[5] reported that cuffs and lower front pockets

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TABLE 4. Effect of White Coat Wash Frequency on Colony Count and MRSA Contamination

White Coat Washing Frequency	Number of Subjects (%)	Total Colony Count (All Sites), Median (95% CI)	Number with MRSA Contamination, n (%)
Weekly	15 (30%)	124 (107–229)	1 (7%)
Every 2 weeks	21 (42%)	156 (90–237)	6 (29%)
Every 4 weeks	8 (16%)	89 (41–206)	0 (0%)
Every 8 weeks	5 (10%)	140 (58–291)	2 (40%)
Rarely	1 (2%)	150	0 (0%)

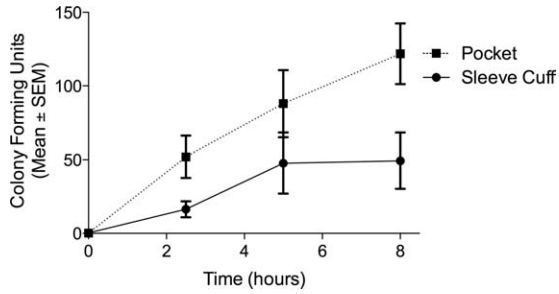

FIGURE 2. Time course of bacterial contamination after donning newly laundered uniforms.

had greater contamination than did the backs of white coats, but no difference was seen in colony count from cuffs compared with pockets. Loh and colleagues[8] found greater bacterial contamination on the cuffs than on the backs of white coats, but their conclusion came from comparing the percentage of subjects with selected colony counts (ie, between 100 and 199 only), and the analysis did not adjust for repeated sampling of each participant. Apparently, colony counts from the cuffs were not different than those from the pockets. Callaghan[7] found that contamination of nursing uniforms was equal at all sites. We found that sleeve cuffs of white coats had slightly but significantly more contamination with bacteria than either the pocket or the midsleeve areas, but interestingly, we found no difference in colony count from cultures taken from the skin at the wrists of the subjects wearing either garment. We found no difference in the extent of bacterial contamination by site in the subjects wearing short-sleeved uniforms or in the percentage of subjects contaminated with MRSA by site of culture of either garment.

Contrary to our hypothesis, we found no association between the frequency with which white coats were changed or washed and the extent of bacterial contamination, despite the physicians having admitted to washing or changing their white coats infrequently (Table 4). Similar findings were reported by Loh and colleagues[8] and by Treakle and colleagues.[12]

Our finding that contamination of clean uniforms happens rapidly is consistent with published data. Speers and colleagues[4] found increasing contamination of nurses' aprons and dresses comparing samples obtained early in the day with those taken several hours later. Boyce and colleagues[6] found that 65% of nursing uniforms were contaminated with MRSA after performing morning patient-care activities on patients with MRSA wound or urine infections. Perry and colleagues[9] found that 39% of uniforms that were laundered at home were contaminated with MRSA, vancomycin-resistant enterococci, or *Clostridium difficile* at the beginning of the work shift, increasing to 54% by the end of a 24-hour shift, and Babb and colleagues[20] found that nearly 100% of nurses' gowns were contaminated within the first day of use (33% with *Staphylococcus aureus*). Dancer[22] recently suggested that "if staff were afforded clean coats every day, it is possible that concerns over potential contamination would be less of an issue." Our data suggest, however, that work clothes would have to be changed every few hours if the intent were to reduce bacterial contamination.

Limitations

Our study has a number of potential limitations. The RODAC imprint method only sampled a small area of both the white coats and the uniforms, and accordingly, the culture data might not accurately reflect the total degree of contamination. However, we cultured 3 areas on the white coats and 2 on the uniforms, including areas thought to be more heavily contaminated (sleeve cuffs of white coats). Although this area had greater colony counts, the variation in bacterial and MRSA contamination from all areas was small.

We did not culture the anterior nares to determine if the participants were colonized with MRSA. Normal health care workers have varying degrees of nasal colonization with MRSA, and this could account for some of the 16%-20% MRSA contamination rate we observed. However, previous studies have shown that nasal colonization of healthcare workers only minimally contributes to uniform contamination.[4]

Although achieving good hand hygiene compliance has been a major focus at our hospital, we did not track the hand hygiene compliance of the physicians in either group. Accordingly, not finding reduced bacterial contamination in those wearing short-sleeved uniforms could be explained if physicians in this group had systematically worse handwashing compliance than those randomized to wearing their own white coats. Our use of concurrent controls limits this possibility, as does that during the time of this study, hand hygiene compliance (assessed by monthly surreptitious observation) was approximately 90% throughout the hospital.

Despite the infrequent wash frequencies reported, the physicians' responses to the survey could have overestimated the true wash frequency as a result of the Hawthorne effect. The colony count and MRSA contamination rates observed, however, suggest that even if this occurred, it would not have altered our conclusion that bacterial contamination was not associated with wash frequency.

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Generalizability

Because data were collected from a single, university-affiliated public teaching hospital from hospitalists and residents working on the internal medicine service, the results might not be generalizable to other types of institutions, other personnel, or other services.

In conclusion, bacterial contamination of work clothes occurs within the first few hours after donning them. By the end of an 8-hour work day, we found no data supporting the contention that long-sleeved white coats were more heavily contaminated than were short-sleeved uniforms. Our data do not support discarding white coats for uniforms that are changed on a daily basis or for requiring health care workers to avoid long-sleeved garments.

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