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## Major Article

## Frequent contamination of nursing scrubs is associated with specific care activities

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**Key Words:**  
Environment  
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**Background:** The objective of this article is to assess health care worker (HCW) and patient care factors associated with bacterial contamination of scrubs.

**Methods:** We performed a cohort study of critical care HCWs. Participants were given 4 sets of new scrubs; each set was sampled 8 times during the 8-month study period on random days in the last 4 hours of the shift. Total colony counts and presence of prespecified pathogenic bacteria were assessed. Generalized estimating equation was used to identify factors associated with contamination.

**Results:** There were 720 samples obtained from 90 HCWs; 30% of samples were contaminated with pathogenic bacteria. Multivariate analysis showed that providing care for patients with wounds (odds ratio [OR], 1.75; 95% confidence interval [CI], 1.17-2.62;  $P < .01$ ) or giving a bath (OR, 1.46; 95% CI, 0.96-2.22;  $P = .07$ ) was associated with higher odds of scrub contamination. A second model showed the average log colony count of bacterial contamination of scrubs was higher when a bath was given (log colony count difference, 0.21;  $P = .05$ ) but lower among HCWs assigned to care for at least 1 patient on contact precautions (log colony count difference, 0.28;  $P < .01$ ).

**Conclusions:** HCW attire was frequently contaminated with bacteria. Providing care for patients with wounds or giving a bath were associated with scrub contamination by pathogenic bacteria. However, the amount of contamination was lower among HCWs who were assigned to care for patients on contact precautions.

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Hospital-acquired infections (HAIs), often caused by multidrug-resistant organisms (MDROs), continue to pose a major problem in the hospital care setting. By 2013, in the United States, the annual cost of treating antibiotic-resistant HAIs was estimated to be \$4 billion, and HAIs are now considered the most common complication of hospital care, affecting approximately 1 in every 20 inpatients.<sup>1</sup> Pathogens responsible for HAIs, including MDROs, are typically spread from patient to patient in the health care setting via health care workers (HCWs) (eg, hands, fomites, attire). HCW attire has recently become a greater focus in the study of horizontal transmission of pathogens. We performed an observational cohort study

of HCWs in critical care settings and sampled scrub uniforms to assess potential HCW and patient care factors associated with bacterial contamination of scrubs.

## METHODS

We assembled a cohort of nurses and patient care technicians in adult intensive and intermediate care units at the University of Maryland Medical Center and the R Adams Cowley Shock Trauma Center as part of a previous study. Methods are described elsewhere,<sup>2</sup> but are also subsequently outlined briefly. This study was approved by the University of Maryland, Baltimore Institutional Review Board.

In this cohort, participants were given 4 new, study-issued scrubs and a specific randomized schedule of wear outlining which scrub set should be worn on which working shift. Participants were instructed to launder scrubs at home as they normally would. During an 8-month study period, each scrub set was sampled twice (for a

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total of 8 samples per HCW) during the HCW's shifts to identify the presence and amount of bacteria contaminating scrubs. Sampling was performed by research staff during the last 4 hours of a 12-hour shift to allow for ample time for bacterial contamination to occur during the shift, representing contamination of a typical nursing shift. Participants were not aware of when sampling would occur.

Sampling was done by study personal using a premoistened double-tipped swab (Remel, Lenexa, KS) that was rubbed over the front of the scrub top in a large W pattern, including the waist and chest, and down the front of both thighs. In addition, a RODAC (BD, Sparks, MD) agar plate was directly stamped onto the scrub top near the belly button. Self-reported information was collected from the participant at the time of sampling, which included scrub laundering habits, the number and quality of patient interactions, and patient care activities performed during the sampling shift.

Enrichment cultures plated to selective media were used to detect gram-negative bacteria, *Staphylococcus aureus*, and *Enterococcus* spp. Bacteria were identified by standard laboratory protocols. Susceptibilities were performed following Clinical and Laboratory Standards Institute guidelines.<sup>3</sup> Gram-negative isolates were considered multidrug resistant with resistance to  $\geq 3$  classes of antibiotics.<sup>4</sup> RODAC plates were used to determine total colony counts; plates were incubated for 48 hours, and colonies were counted using an eCount precise electronic counter (Heathrow Scientific, Vernon Hills, IL). For the purposes of analysis, colony counts  $>500$  were considered too numerous to count and were trimmed at 500. A logarithm transformation was applied to the trimmed colony counts. Additionally, continuous exposure variables were categorized around the median for bivariate and multivariate analyses. Generalized estimating equations with a binomial distribution and a logit link were used to study the associations of prespecified pathogenic bacteria presence with the risk factors. Similarly, generalized estimating equations with a normal distribution and an identity link were used to examine the associations of the logarithm of colony counts with the risk factors. Analysis was performed using GENMOD procedure in SAS version 9.2 (SAS Institute, Cary, NC).

## RESULTS

There were 720 samples obtained from 90 HCWs (79 nurses and 11 patient care technicians) over the 8-month study period during the last 4 hours of their shift. As presented in the primary study, 30% (217/720) of scrubs were contaminated with pathogenic bacteria, and the mean log colony count  $\pm$  SD of the sampled scrubs was  $3.9 \pm 1.1$ .<sup>2</sup> All subsequent data reported here are newly reported for the purposes of this article. *S aureus* was recovered from 116 (16%) samples, *Enterococcus* spp were recovered from 21 (3%) samples, gram-negative bacteria were recovered from 113 (16%) samples, and a MDRO (eg, methicillin-resistant *S aureus*, vancomycin-resistant enterococci, multidrug-resistant gram-negative bacteria) was recovered from 44 (6%) samples. The gram-negative bacteria were speciated as follows: 46.0% (52/113) *Acinetobacter baumannii*, 18.6% (21/113) *Klebsiella pneumoniae*, 11.5% (13/113) *Pseudomonas aeruginosa*, 10.6% (12/113) *Enterobacter cloacae*, 6.2% (7/113) *Serratia marcescens*, 5.3% (6/113) *Klebsiella oxytoca*, 2.7% (3/113) *Proteus mirabilis*, 2.7% (3/113) *Escherichia coli*, and 1.8% (2/113) *Enterobacter aerogenes*.

Sixty-nine (77%) participants worked in the intensive care unit, and the remainder worked in intermediate care. On the day of sampling, participants were assigned to care for an average  $\pm$  SD of  $2.4 \pm 2.2$  patients and had reported interacting with  $5.5 \pm 3.2$  patients; median age of scrubs was 16.5 days (interquartile range, 7-29) and on average they were washed  $2.9 \pm 1.9$  times. In all but 2 study visits, HCWs reported either wearing new scrubs or laundering

scrubs before wear. Participants reported interacting with patients who had a wound on 73% of the sampling days (523/720), on a ventilator 70% of the sampling days (505/720), with a tracheostomy 56% of the sampling days (401/720), with diarrhea 52% of the sampling days (377/720), and under contact precautions 68% of the sampling days (488/720). Participants had given a patient a bath on the day of sampling 29% of the time (206/720).

Participants who gave a patient a bath ( $P = .02$ ) or provided care for a patient with a wound ( $P < .01$ ) were more likely to have pathogenic bacteria identified from scrubs. No factors were associated with identification of either *S aureus* or *Enterococcus* spp (data not shown); however, gram-negative bacteria were more likely to be identified if the participant gave a bath or provided care for a patient with a wound ( $P < .01$ ), diarrhea ( $P = .02$ ), tracheostomy ( $P = .04$ ), or on mechanical ventilation ( $P = .05$ ). Participants who wore scrubs that were  $>16$  days old (compared with  $<16$  days) had increased total bacterial colony counts recovered from scrubs (3.97 vs 4.20 colony forming units;  $P = .04$ ), whereas participants who took care of patients on contact precaution isolation had decreased total bacterial colony counts (4.29 vs 3.98 colony forming units;  $P = .01$ ). Full bivariate results are presented in Tables 1 and 2.

The first multivariate model showed that providing care for patients with wounds was associated with higher odds of scrub contamination with pathogenic bacteria compared with those who did not take care of patients with wounds (odds ratio, 1.75; 95% confidence interval, 1.17-2.62;  $P < .01$ ). Giving a patient a bath was marginally associated with higher odds of scrub contamination (odds ratio, 1.46; 95% confidence interval, 0.96-2.22;  $P = .07$ ).

A second multivariate model examined factors associated with differences in total bacterial colony counts. The average log colony count of bacterial contamination of scrubs was higher among HCWs who gave a patient a bath during that shift (log colony count difference, 0.21;  $P = .05$ ) when compared with HCWs that did not bathe a patient. HCWs who wore scrubs that were  $>16$  days old also had a trend toward greater bacterial contamination after their shift when compared with HCWs who wore new scrubs (log colony count difference, 0.15;  $P = .08$ ). Finally, bacterial contamination was lower among HCWs who were assigned to care for at least 1 patient on contact precautions (log colony count difference, 0.28;  $P < .01$ ).

## DISCUSSION

In this cohort of critical care nursing staff, we found HCW attire to be frequently (30%) contaminated with bacteria in a typical patient care shift. Providing care for patients with wounds or giving a patient a bath were associated with scrub contamination by pathogenic bacteria. Giving a patient a bath was also associated with an increase in the average log bacterial colony count found on scrubs. The amount of bacterial contamination was lower among HCWs who were assigned to care for at least 1 patient on contact precautions.

Our data are consistent with the growing body of evidence for HCW attire being a potential reservoir of pathogenic organisms.<sup>5-10</sup> Studies in which HCW attire has been cultured support our finding that bacterial contamination is common.<sup>5-10</sup> In a study performed by Wiener-Well et al, HCW attire was sampled in the clinical setting and found to be contaminated with pathogenic bacteria up to 50% of the time.<sup>6</sup> To our knowledge, our study is the first to examine the relationship between HCW activities and cumulative scrub contamination at the end of a shift. We found that scrubs were more likely to be contaminated based on the types of patients HCWs cared for (ie, those with wounds) and the types of activities HCWs performed (ie, giving a bath). Several studies have examined contamination of HCW attire or personal protective equipment after a single patient care interaction and have similarly found associations between contamination and HCW behaviors.<sup>11-15</sup>

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