Bacterial Contamination of Surgical Scrubs and Laundering Mechanisms: Infection

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NOTE: See the print issue of ICT for all tables.

Objective: To assess the bioburden associated with surgical scrub garments separated into eight categories based on single-use/re-usable status, use status (prior to use versus after use), and, for re-usable scrub garments, laundering mechanism (facility-launched, third-party laundered and home-launched). The study’s aim was to determine whether or not this information provided any insight into the safety and efficacy of re-usable versus single-use scrubs and laundering mechanism.

Study Design: Ten sets of surgical scrub garments, top and bottom, were collected from multiple healthcare organizations across the United States for each category (n=20) and evaluated using the Stomacher technique. The number of viable organisms on each garment was enumerated as colony-forming units (CFU) and the average log₁₀ bacterial population and standard deviation associated with each garment was determined. The mean log₁₀CFUs versus configuration were compared using a one-way analysis of variance (ANOVA).

Results: There was no statistically significant difference in mean microbial populations among the facility-launched, third-party-launched or single-use scrubs, prior to use (“clean”). The mean microbial population associated with the home-launched scrubs, prior to use (“clean”), however, was significantly greater than any of the other “clean” garment configurations. In fact, the mean microbial population associated with the home-launched scrubs, prior to use (“clean”), was not significantly different from that of any of the after use (“worn”) garments.

Conclusions: Home-laundering is not as effective as facility or third-party laundering in decontaminating surgical scrub attire. Similarly, home-launched scrubs are not as effectively “clean” as single-use scrubs prior to use. Further study is warranted to identify the bacterial organisms comprising the bioburden and their potential clinical impact, if any, on the development of surgical site infections and transmission of other healthcare-acquired infections (HAIs).

Background
Surgical attire has evolved extensively from the days when surgeons would literally enter the operating theater in their street clothes and, at best, don an operating apron. In fact, it wasn’t until the turn of the 20th century that the importance of surgical barriers was routinely recognized. While there is general consensus today as to what is considered acceptable surgical attire, there remains a significant lack of organizational consensus, even in today’s highly infection-control conscious environment, as to where and how surgical attire is laundered and stored.

The issue of surgical attire laundering and storage is not new. There have been several studies, albeit primarily small-scale studies, which have looked at the laundering issue and drawn conflicting conclusions over the years. However, as healthcare economic pressures worsen, requiring facilities to repeatedly trim operating budgets, and as the risk of healthcare-acquired infections (HAIs), particularly with resistant bacteria, rises, the issue becomes one worthy of renewed study.

Numerous healthcare governing bodies and advisory organizations, including the Association for Professionals in Infection Control and Epidemiology (APIC), the Association for the Advancement of Medical Instrumentation (AAMI), the Association of periOperative Registered Nurses (AORN), the Centers for Disease Control and Prevention (CDC) and the Occupational Safety and Health Administration (OSHA), agree that all surgical attire should be changed whenever it becomes visibly soiled, contaminated, or wet, or at least daily.

Several studies have shown, however, that healthcare workers do not always change their uniforms daily; in fact, one study surveying 196 nurses found that 30 percent did not wear a fresh uniform daily. One would expect that this applies more commonly to healthcare workers’ uniforms that are not visibly soiled. However, this raises concerning questions in light of the 1991 Wong, Nye, and Hollis study which showed that bacterial contamination of physicians’ white coats that were perceived to be “dirty” did not differ significantly from those that were perceived to be “clean.”

It is generally accepted that healthcare workers’ uniforms become contaminated with bacteria during the administration of care, particularly during surgical procedures and wound care. Studies have repeatedly isolated bacteria from the uniforms of healthcare workers, including bacteria that were multi-drug resistant. In fact, in Boyce’s 1997 study of the role of contaminated environmental surfaces as reservoirs of methicillin-resistant Staphylococcus aureus (MRSA), 65 percent of nurses caring for a patient with MRSA in a wound or urine were found to have contaminated their uniforms with MRSA.

Osawa et al documented the presence of MRSA on 80 percent of physicians’ white coats during two MRSA outbreaks at a teaching hospital. Other studies, such as Copp, Mailhot, et al’s 1986 study, have shown that whereas scrub are worn throughout the work day and whether or not they are removed and put on again significantly impacts the bacterial contamination of the attire. What is concerning, however, is the...
data that suggests uniforms “enter” healthcare facilities already contaminated. Callaghan, in her 1998 study, looked at the bacterial colony counts on surgical uniforms at varying time points during a shift and found no statistically significant difference in the degree of bacterial contamination of uniforms sampled at several sites and at several times throughout the day, including the start of shift.4 Alarming, another study found that 39 percent of healthcare workers’ uniforms tested were positive for VRE, MRSA, and C. difficile at the start of shift.5 Assuming surgical attire is changed daily, and laundered attire is worn to work each day, these findings would certainly suggest that the laundering mechanism is potentially failing to achieve uniform decontamination.

Given the importance of creating a surgical environment which is as clean as possible, and the emphasis by payors to decrease cross-contamination and HAIs in healthcare facilities at large, the subject of where and how surgical attire is laundered becomes an extremely important issue. A survey of healthcare staff in the UK’s NHS trust revealed that 90 percent of that staff took responsibility for the laundering of their uniforms. They reported that home-laundering of healthcare workers’ uniforms deserves close scrutiny.6 Some studies have shown no significant evidence suggesting that home-laundering in general is inferior to facility or commercial laundering, particularly if combined with tumble drying and/or ironing.6,7 22 The CDC, in its Guidelines for Environmental Infection Control, does not currently prohibit home-laundering; however, it concedes that there is a paucity of data studying the issue.23

There have been several studies which have raised troubling questions about the safety and efficacy of the home-laundering of surgical attire.4, 8-10 The issue is complicated by the introduction of potentially contaminated garments into the home environment. A recent French study demonstrated transmission of MRSA from healthcare workers who had acquired it in their hospital to members of their households.24 The fact that MRSA has been documented on healthcare workers’ uniforms previously18 combined with evidence of MRSA cross-contamination in the home environment, certainly suggests that exposing households to contaminated uniforms poses significant threats. Furthermore, how effective is home-laundering? Gerba and Kennedy looked at the virucidal capacity of a typical home-laundering process (wash cycle with detergent alone, rinse cycle and a 28-minute permanent press drying cycle) and found that significant concentrations of the tested viruses (adenovirus, rotavirus, and hepatitis A virus) survived the process.9 They further demonstrated that these viruses could be transferred from the contaminated garments to uncontaminated garments.9 Perry, Marshall and Jones documented the presence of Vancomycin-resistant enterococcus (VRE), methicillin resistant Staphylococcus aureus (MRSA), and Clostridium difficile on home-laundered uniforms prior to the commencement of duty, suggesting the inadequacy of the home-laundering process in eradicating these organisms.5 Treakle et al., in a study looking at the prevalence of Staphylococcus aureus (S. aureus) on physicians’ white coats, demonstrated that those coats colonized with S. aureus were more likely to have been laundered in a “personal facility.”26

Guidelines have been set for home-laundering of soiled surgical attire, particularly that contaminated with body fluids, by several authoritative associations and organizations such as AAMI, AORN, CDC, and OSHA.3,15,16,23 There remains, for obvious reasons, an inability to ensure that these guidelines are followed. Furthermore, while some data suggests that insufficient temperature control in home-laundering cannot guarantee uniform decontamination,10 other investigators suggest that, even when guidelines are followed, newer energy-saving domestic washing machines may actually provide lower wash temperatures than indicated.8 These same machines may also offer less vigorous washing cycles.8

In light of the potential risks associated with home-laundering and the paucity of evidence surrounding it, this study was undertaken to provide additional insight into the subject. The aim was to compare the aerobic bacterial bioburden associated with surgical scrub attire separated into different categories based on their single-use/reusable status, use (worn versus clean) status, and, for the reusable scrubs, laundering mechanism (facility-laundered, third-party/commercial-laundered, and home-laundered).

Methods

Test Articles

The test article population was comprised of surgical scrub garments (scrubs) collected from 18 geographically diverse areas and divided into eight categories based on single-use/reusable and use status. The eight categories included: reusable scrubs laundered by the facility in which they were used (clean); reusable scrubs laundered by the facility in which they were used, after use (worn); reusable scrubs laundered in the user’s home (clean); reusable scrubs laundered in the user’s home, after use (worn); reusable scrubs laundered by a third party (clean); reusable scrubs laundered by a third party, after use (worn); packaged single-use non-woven scrubs (for this study, Barrier® scrubs) prior to use (clean); and packaged single-use non-woven scrubs, after use (worn). Ten sets of surgical scrub garments, top and bottom, were collected from each category (n=20). Each individual “clean” article originated from its source’s usual dispensing venue, be it cart, automated dispensing unit, or cabinet, with the exception of single-use non-woven scrub garments prior to use (clean) which were collected from their manufacturer’s distribution center. Home-laundered scrubs were brought from home after laundering and subjected to the same collection process. All worn scrubs were collected at the end of one daily shift. Test articles were collected in a standardized manner involving placement in a plastic bag in which it was sealed, assigned a number and labeled (for example T1: Test Article Top Surgical Scrub Garment, Bag #1). Each bag was then placed in a standardized cooler with identical ice packs and shipped to the laboratory within 24 hours of collection. The sealed scrubs were then placed in the laboratory freezer upon receipt and all scrubs were processed within two weeks of receipt. Blinding of certain study personnel was not possible due to obvious physical differences among the test articles; however, laboratory personnel counting colonies on the TSA plates were blinded to the source of each sample.

Table 1: Test Configurations

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<thead>
<tr>
<th>Test Article</th>
<th>Description</th>
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<tr>
<td>T1</td>
<td>Re-useable scrubs laundered by the facility in which they were used, prior to use (clean)</td>
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Study Design

This screening evaluation determined the total aerobic bacterial bioburden of the surgical scrub garments separated into the eight categories on the basis of reusable/single-use, use (prior to use versus after use) status, and, for re-usable scrubs, laundering mechanism. Each test article (surgical scrub top or bottom) was evaluated to determine an average log$_{10}$ bacterial population associated with each garment category and the standard deviation of the data. Upon receipt in the laboratory, each test article was transferred aseptically to a stomacher bag to which a 500 mL aliquot of Butterfield's Phosphate Buffer solution with surfactants (BPP++) was added. Each bag was subsequently sealed to prevent leakage and then massaged vigorously in a calibrated manner for five minutes, timed using a calibrated minute/second timer. Aliquots of the rinseate from each article were serially diluted and plated using Tryptic Soy Agar (TSA) and incubated at 30°C ±2°C for approximately 72 hours. Following incubation, the colony-forming units (CFU) were enumerated manually using a hand-tally counter, and the number of viable organisms that were recovered from each article was determined. All laboratory procedures were performed in accordance with Good Laboratory Practices, as specified in 21 CFR Part 58 and in accordance with BioScience Laboratories, Inc., Standard Operating Procedures. One protocol deviation occurred during the study but had no adverse effect upon the study outcome. The deviation involved technician error in recording the stop time for the massage of test articles T43 and B74; however, due to the use of calibrated minute/second timers to assure a massage time of at least 5 minutes, there was no adverse effect on the study results.

Statistical Analysis

The CFU/article and the log$_{10}$ CFU/article recovered were calculated accordingly:

- **CFU/article** = CFU counted per article = (Cx)
- **log$_{10}$ CFU/article = log$_{10}$(Cx)**

The MiniTab statistical computer package was used for all statistical calculations. Descriptive statistics and confidence intervals were generated using the 0.05 level of significance for Type I (alpha) error. In order to evaluate the gross difference between the microbial populations recovered from each of the eight test articles, the mean log$_{10}$ CFUs versus configuration were compared using a one-way ANOVA with a pooled standard deviation, albeit at a sample size smaller than necessary for a fully powered analysis.

Results

The mean microbial populations (as measured by mean log$_{10}$ CFU/article) for Test Article #1, re-usable scrubs laundered by the facility in which they were used (clean)(4.3600); Test Article #5, re-usable scrubs laundered by a third party (clean)(4.2659); and Test Article #7, packaged single-use non-woven scrubs prior to use (clean)(4.2230), were not statistically different. However, the mean microbial populations recovered from Test Article #3, reusable scrubs laundered in the user’s home (clean)(5.8303), were significantly different from and greater than the other “clean” article configurations. In fact, the mean log$_{10}$ CFU/article recovered from Test Article #3, reusable scrubs laundered in the user’s home (clean), was not significantly different from the mean log$_{10}$ CFU/article recovered from any of the “worn” article configurations.

The mean microbial populations recovered from Test Article #2, reusable scrubs laundered by the facility in which they were used, after next use (worn)(6.0176), Test Article #8, packaged single-use non-woven scrubs, after next use (worn)(5.8824), and Test Article #4, reusable scrubs laundered in the user’s home, after next use (worn)(6.3779) were not statistically different. The mean microbial population recovered from Test Article #6, reusable scrubs laundered by a third party, after next use (worn)(5.3133), was not statistically different from the mean microbial population recovered from Test Article #8, packaged single-use non-woven scrubs, after next use (worn)(5.8824), but was significantly different from and less than the mean microbial population recovered from Test Article #2, reusable scrubs laundered by the facility in which they were used, after next use (worn)(6.0176) and Test Article #4, reusable scrubs laundered in the user’s home, after next use (worn)(6.3779).

Discussion

How or where surgical scrub suits are laundered has been a matter of controversy in healthcare for quite some time. The results of this study shed new light on the practice of home-laundering by demonstrating that the bioburden associated with “clean” home-laundered scrubs were significantly greater than those associated with all of the other “clean” scrubs facility-laundered, third party-laundered, and single-use, non-woven. These results raise troubling questions about the efficacy of home-laundering, especially against the backdrop of earlier data showing the presence of organisms on home-laundered uniforms at the beginning of the work day. Even more troubling and perhaps the single-most important finding of the study, is that, according to these results, a healthcare professional beginning his/her shift in home-laundered scrubs would essentially be wearing scrubs with the same quantity of organisms as the scrubs of a healthcare professional finishing a shift -- that is to say, used or worn scrubs. Given the concern for and evidence showing that cross-infection can occur from inanimate surfaces such as surgical attire, this data is particularly concerning.
statistical difference between the bioburden associated with facility-laundered, third-party-laundered, and single-use scrubs, any of these options clearly become preferable to home laundered scrubs in terms of minimizing the risk of cross-contamination. Interestingly, however, once again in their study of physicians’ white coats, Treakle et al. found that “characteristics associated with increased likelihood of MRSA colonization over MSSA (methicillin-sensitive Staphylococcus aureus) colonization included….washing the white coat in the hospital laundry.” This does raise the question of how well all laundering practices are monitored in terms of following guidelines on a consistent basis. Finally, knowing there is the potential for inconsistency, we pose the question: do single-use scrubs present a safer alternative?

This study certainly has limitations beyond sample size. Types of procedures (elective surgical procedure vs. wound care, etc) to which each garment was exposed and duration of the daily shift during which each garment was worn, were not evaluated. The scrubs’ storage in their respective facilities and the means of dispensing (cart vs. automated dispenser vs. cabinet, etc) was not evaluated in terms of the effect on the bioburden. Questions have been raised before about the effect storage circumstances have on the contamination risk for scrubs, not to mention similar risks posed during the transfer of home-laundered scrubs back to the facility. The circumstances surrounding the transfer of the home-laundered scrubs back to the facility were not addressed in this study and certainly may have had some effect on their contamination. We raise the question as to whether the conditions surrounding the transfer of home laundered scrubs from home to facility would most likely replicate the transport methodology the practitioner uses for their home laundered scrubs on a daily basis. The specific laundering processes were not addressed. The scrubs were randomly selected from facilities that either laundered their scrubs internally or outsourced them to a third-party laundering service. Temperatures, detergents and/or disinfectants, drying times, etc were not factored into the evaluation. Similarly, details regarding the home-laundering process were not obtained; however, one could certainly argue that, given the inability, under any circumstances, to oversee and guarantee the home-laundering process, that information would not be pertinent.

These results clearly suggest the need for further study, in particular, the need to identify the specific organisms comprised in these bioburden. Additionally, the questions that must be answered are whether there is a clinical significance to these organisms on surgical attire and whether there is a relationship between this bioburden and surgical site infections (SSIs) or other HAIs? With SSIs being the most common nosocomial infection among surgical patients and accounting for 22 percent of all HAIs according to the CDC, these questions deserve closer inspection. It makes intuitive sense that bacterial exposure from surgical scrub garments could potentially contribute to the development of SSIs. Given the impact SSIs and other HAIs have on patient morbidity and mortality, healthcare expenditure and the significant issue of anti-microbial resistance, all healthcare practices with the potential to influence the development of these infections need to be carefully evaluated. This study would suggest that the home-laundering of surgical scrub attire cannot be supported, and thus, should be re-evaluated by those healthcare organizations and recommending bodies currently allowing it.

Acknowledgements

Study performed by: Bioscience Laboratories, Inc. of Bozeman, Mont. Study sponsored by: Mölnlycke Health Care, Inc.

Carolyn L. Twomey, RN, BSN, is global head of clinical services for Mölnlycke Health Care, Inc.

Heather Beitz, BA, Med, is director of clinical research for Mölnlycke Health Care, Inc.

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