aug 2021

healthcarehygienemagazine

BUILDING BRIDGES BETWEEN INFECTION PREVENTION/EPIDEMIOLOGY, SCIENTIFIC R&D, MANUFACTURING AND REGULATORY/COMPLIANCE

vol. 3 no. 8

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Domestic Versus Industrial Laundering and the Implications for Infection Prevention

+ Perioperative Nursing & COVID-19: Leadership and Learning Throughout the Pandemic and Beyond

+ 3 Ps for Post-Pandemic Infection Prevention for Perioperative Patients

Healthcare Personnel Attire: Domestic Versus Industrial Laundering and the Implications for Infection Prevention

By Kelly M. Pyrek

Editor's note

This article is part 2 of a series addressing healthcare textiles and infection prevention; see the July 2021 issue of Healthcare Hygiene magazine for part 1.

One of the truisms of healthcare is that personnel, attire, surfaces and objects are contaminated with microorganisms and that transmission is probable. Debate over the infectious threat posed by healthcare attire (both surgical but primarily non-surgical) is ongoing. Optics dictate that healthcare professionals do not wear scrub uniforms or similar pieces of healthcare attire on the street – now more than ever before in the immediate and lingering stages of COVID-19 – to not telegraph a rampant disregard for the health and welfare of the general public. As Mitchell, et al. (2015) observe, "Healthcare workers often travel to and from healthcare facilities by public transportation wearing their work clothing, creating another route by which microorganisms can be imported into, and exported from, the healthcare environment."

Thanks to the pandemic, a growing number of members of the general public are becoming aware of the presence of pathogenic organisms on pieces of attire such as scrub uniforms – with good reason. Sanon, et al. (2012) conducted a study to investigate the pathogens that nurses potentially take into a public setting outside the work environment. The 10 nurses who participated in the study were given sterilized scrub attire to wear prior to the beginning of their shift, and the scrubs were collected at the end of the shift. Microbial assessment of the scrubs showed that the average bacteria colony growth per square inch was 1,246 for the day shift and 5,795 for the night shift. After 48 hours, methicillin-resistant Staphylococcus aureus (MRSA) was present on four of the scrubs worn during the day shift and three of the scrubs worn during the night shift. Other bacteria present were Bacillus species, Micrococcus luteus, Staphylococcus aureus, Staphylococcus epidermidis, and Micrococcus roseus. Considering public health concerns about antibiotic resistance, the researchers recommended that facilities consider implementing formal policies and procedures regarding the wearing of scrub attire outside of the work environment.

As we know, in addition to the near-patient environment becoming contaminated, healthcare worker attire can also become contaminated during contact with patients, with approximately 10 percent of healthcare personnel gowns becoming contaminated with microorganisms from patients during simulated healthcare activities (Wolfensberger et al., 2018). Healthcare worker uniforms were found to become increasingly contaminated with microorganisms during wear; MRSA, VRE and/or C. difficile were present on 39 percent of nurse's uniforms (1 to >100 colony forming units (CFUs), before their shift, increasing to 54 percent at the end of the shift (Perry, et al., 2001). Similarly, Burden, et al. (2011) demonstrated that freshly laundered doctors' scrub uniforms became increasingly contaminated over an eight-hour shift; within 2.5 hours the pockets alone were contaminated with around 50 CFUs total viable count, increasing to >100 CFUs after eight hours and MRSA was present on 20 percent of the uniforms sampled (Burden, et al., 2011).

Many experts have pointed to the problematic practice of bringing pathogenic organisms to healthcare professionals' home environments. Sehulster (2015) acknowledges that, "Questions have been asked about home laundering of hospital scrubs and uniforms. There have been concerns that home laundering of healthcare attire may expose family members to healthcare-associated pathogens. However, infections in families attributed to home laundering of healthcare attire have not been demonstrated conclusively. As an example, studies have documented that the loss of antimicrobial activity by using wash water temperature of 140 degrees F (60 degrees C) can be compensated with longer wash cycle time, hot air drying, and ironing. Industrial laundering offers many process advantages over home laundering, such as 1) more exact control over all aspects of the process, 2) the ability to tailor wash parameters more accurately to match the soil level of the load, and 3) more

choices in detergent and laundry additives (sours). The current stance is hospital-directed laundering of employee scrubs and uniforms, although home laundering continues to be debated. The Occupational Safety and Health Administration (OSHA) regulations require employers to provide laundry processes for reusable personal protective equipment textiles and healthcare attire or uniforms with visible blood or other potentially infectious material contamination."

Healthcare Personnel Attire and Opportunistic Pathogen Transmission

Healthcare worker movement around the hospital and the potential for the transmission of pathogenic organisms harbored on uniforms, scrubs, white coats and other garments is likely to "represent a better source of substrates for bacterial growth," according to Mitchell, et al. (2015), who add, "Microbes tend to thrive in moisture and protein-rich soil or dirt that may be found on apparel. Thus, apparel can readily acquire, retain and transmit epidemiologically significant pathogens such as MRSA. Typically, healthcare workers will wear the same clothing for one day or more, during which time their apparel will have direct or indirect contact with coworkers, patients and the general public. At the end of a work shift, C. difficile and MRSA can be recovered from the surfaces of nurses' uniforms at counts exceeding 500 colony-forming units (CFU)… [it has been] reported that up to 60 percent of hospital staff uniforms were culture positive for MDROs, based on samples taken from the sleeves, waists and pockets of the work apparel of more than 100 physicians and nurses. Healthcare-associated pathogens were isolated from at least one site on 63 percent of the uniforms."

At the end of a work shift, C. difficile and MRSA can be recovered from the surfaces of nurses' uniforms at counts exceeding 500 colony–forming units (CFU)... [it has been] reported that up to 60 percent of hospital staff uniforms were culture positive for MDROs, based on samples taken from the sleeves, waists and pockets of the work apparel of more than 100 physicians and nurses.

TRSA/Hygienically Clean Healthcare surveys indicate public concern about allowing employees to wear healthcare garments to and from work (and washing them at home) and that infection preventionists believe this practice is an infection risk. A 2015 TRSA study of 700 adults regarding consumer perceptions of linens and uniforms asked respondents if they were concerned about medical professionals bringing germs into the outside world or back to healthcare facilities by wearing healthcare garments outside such facilities. More than two-thirds said they were somewhat or very concerned. The same survey found that more than 8 in 10 respondents believe that professional cleaning will result in cleaner lab coats than a policy that assigns workers to wash their own. Respondents to a 2017 survey of 1,400 infection preventionists at healthcare facilities were almost unanimous (nearly 9 of 10) in their belief that wearing healthcare garments home presents an infection or contamination to those outside; they were nearly as unified (8 in 10) in their contention that wearing scrubs into a hospital from home presents an infection or contamination risk to patients.

These same respondents indicated, however, that 54 percent of their facilities allowed employees to leave work while wearing their scrubs and clean them at home; and 60 percent of facilities allowed employees to wear their scrubs into the hospital before work.

Healthcare facility managers were also questioned in 2015 as part of a business-to-business survey. Nearly half of respondents from such facilities said employees are responsible for laundering their own garments. Only 14 percent of respondents from facilities where individuals have such responsibility said training sessions are held to instruct staff in washing. Nearly half said no training at all is provided. But these respondents recognize the value of professional laundering. Nearly 90 percent of those with an opinion said outsourcing laundry and renting reusable textiles is a plus for reducing liability and that rental is more hygienic.

Inside the healthcare institution, great variability exists among laundering policies and attitudes toward transmissibility of pathogens via textiles.

As Mitchell, et al. (2015) confirm, "Healthcare workers may have options to launder their work clothing, or some institutions may offer onsite industrial laundering for scrubs, lab coats and other apparel. Generally, industrial laundry procedures are sufficient to return garments and textiles free of microbial contamination. However, as Fijan, et al. discovered, no procedure is foolproof, and even if the laundering process itself produces nearly sterile garments, post-laundering practices (sorting, folding and stacking) can re-contaminate clean laundry unless housekeeping personnel maintain a high level of vigilance. Fijan, et al. concluded that insufficient antimicrobial laundry procedures can result in spreading micro-organisms throughout even the clean areas of laundry facilities. They found that: 1) workers can re-contaminate clean laundry unless they receive regular training and education on proper hygiene and work area cleaning and disinfecting procedures; and 2) regular cleaning and disinfecting of all laundry areas, especially the clean laundry area, is necessary to prevent the recontamination of laundered textiles during the post-laundry handling processes such as sorting, ironing, folding and packing. Fijan et al. specifically investigated the potential for hospital textiles to transmit rotaviruses and noted that rotavirus RNA could be detected in hospital laundry rinse water after the washing process, even after using accepted laundering procedures, and on laundered textiles, environmental surfaces in the laundry area and the hands of laundry workers."

Vera, et al. (2016) provide some food for thought around recommendations for laundering of scrub uniforms and acknowledge that there is no nationally sanctioned scrub laundering method adopted as the standard: "Practices for decontaminating scrubs have been largely left to institutional policy. Healthcare facilities often rely on organizational experts in infection control, such as the CDC, OSHA and AORN, during policy development. The CDC offers no recommendation on how or where to launder

> *If the possibility exists that microorganisms could be transferred to family members, community members, patients, and other HCP, as well as place the person wearing the scrub attire at risk due to the ineffectiveness of home-laundering, then HCP have the ethical and moral duty to take the proper steps in preventing that possibility from occurring."*

scrubs. Conversely, AORN opines that after daily use, reusable surgical attire should be laundered in a facility-approved laundry. Furthermore, OSHA states that employers are required to launder employee-owned scrubs that have become visibly contaminated during work and concludes that scrubs not soiled with blood or virulent matter may be laundered at home. When developing a surgical scrub policy, policymakers would be prudent to use the available evidence to establish a guideline for scrub uniform decontamination. Because of varying perceptions and lack of definitive evidence supporting one laundering method over another, data elicited in these studies would best be regarded in an equitable manner when one is establishing and enforcing a facility uniform policy. It is reasonable to allow for self-laundering of scrub uniforms by staff if they follow standard recommendations for employing a proper decontamination process at home. To ensure proper decontamination of scrubs, specific guidance should be provided for a home-laundering program to include recommendations derived from available research. Studies show that home laundering in temperatures between 40 degrees C and 60 degrees C is equally effective at decontaminating garments if proper decontamination measures are undertaken."

In an October 2020 FAQ, The Joint Commission clarified issues around whether it requires employers to launder surgical scrubs or other uniforms. It emphasized that requirements do not apply to any attire that has been designated by the organization as personal protective equipment (PPE) as defined by Occupational Safety and Health Department (OSHA): specialized clothing or equipment worn by an employee for protection against a hazard. General work clothes (e.g., uniforms, pants, shirts or blouses) not intended to function as protection against a hazard are not considered to be personal protective equipment.)

Joint Commission standards do not require employers to launder surgical scrubs or other attire; however, its Leadership Standard LD.04.01.01 requires healthcare organizations to adhere to applicable federal (OSHA), state and local regulations (licensing requirements), and if deemed, Centers for Medicare and Medicaid (CMS) Conditions of Participation and/or Conditions of Coverage. The Joint Commission (2019) indicates that the hierarchical approach to infection control standards should be used to guide development of infection control related policies and procedures for laundering surgical scrubs or attire that is not designated as PPE and is worn in the healthcare setting.

The Joint Commission (2020) says the applicable elements to consider include the following:

- The OSHA Bloodborne Pathogen Standard requires that all clothing, including scrubs and personally owned attire such as uniforms or street clothing, which have been visibly soiled with blood or other potentially infectious materials, be laundered by the employer at no cost to the employee.
- For surgical scrubs, uniforms, or other attire not considered personal protective equipment and which are not visibly contaminated, organizations should determine if there any requirements that the facility provide clean attire to staff to perform their job duties. For example, some states require that hospitals and ambulatory-care facilities provide hospital-laundered scrubs for healthcare workers working in the restricted or semi-restricted areas. State requirements may be more stringent and prescriptive than those from OSHA.

As The Joint Commission (2020) notes, "To our knowledge, CMS does not have any requirements for laundering surgical attire or uniforms. But as recommended by The Joint Commission and CMS, organizations should consult evidence-based guidelines for best practices and consider their adoption. Examples of guidelines include the Guideline for Surgical Attire from the Association of periOperative Registered Nurses (AORN), the AST Guidelines for Best Practices for Laundering Scrub Attire from the Association of Surgical Technologists and the statement on operating room attire from the American College of Surgeons."

It is important to distinguish the locations in which healthcare attire is worn, as more stringent policies tend to be applied toward surgical attire to prevent surgical site infections (SSIs).

Attire in Surgical Services

The Association of Surgical Technologists (AST)'s Guidelines for Best Practices for Laundering Scrub Attire (2017) note that, "… Most of the evidence in studies establish that home-laundering is ineffective for removing microorganisms from scrub attire and thus, the possibility exists that patients, healthcare personnel (HCP), and the community is at-risk for developing life-threatening infections when scrub attire is home laundered. Additionally, biofilms can form inside washing machines and the biofilm containing the microbes introduced into the washing machine by used scrub attire are more resistant to chemicals and temperatures." AST (2017) adds, "If the possibility exists that microorganisms could be transferred to family members, community members, patients, and other HCP, as well as place the person wearing the scrub attire at risk due to the ineffectiveness of home-laundering, then HCP have the ethical and moral duty to take the proper steps in preventing that possibility from occurring. Patients place their trust in HCP to provide the safest care possible daily and supporting home-laundering violates that trust."

This view is supported by those expressed in a report from the National Institute for Occupational Safety and Health (NIOSH). The *Report to Congress on Workers' Home Contamination Study Conducted Under the Workers' Family Protection Act* states that, "Infectious agents are included as hazardous substances to the extent that pathogens can be transported on a worker's person or clothing," and that home laundering of contaminated clothing exposes the launderer and others in the household to potential pathogens. Additionally, the report noted "the possibility appears to exist for bloodborne diseases such as HIV or HBV to be transported home on a worker's clothing soiled with body fluids from an infected person."

AST (2017) makes the following recommendations:

- Scrub attire should be laundered in an accredited HDO or commercial laundry facility to reduce the risk of cross-contami-

Research conducted on nursing and physician uniforms noted that bacterial counts on uniforms are higher at the end of the work shift, suggesting bacteria are spread through patient contact.

nation at home, community, and perioperative environment. The facility or commercially laundered scrub attire should be donned by all surgery personnel prior to entering a semi-restricted or restricted area of the surgery department.

- Clean, freshly laundered scrub attire should be protected from contamination when transported from the HDO laundry or commercial laundry facility to the storage area.
- The surgery department should review the policies and procedures regarding handling and laundering soiled scrub attire on an annual basis.
- Certified scrub techs should complete continuing education to remain current in their knowledge of handling and laundering soiled scrub attire.

As Vera, et al. (2016) acknowledge, "Establishing a relationship between contaminated scrubs and SSI incidence is difficult because of the vast causes of SSI. Moreover, the risk is dependent on the number and type of microbes, as well as resistance of the host. It is acknowledged that uniforms worn by healthcare workers become contaminated with microorganisms during patient care, notably during surgical procedures. It is logical to infer that SSIs may result from microbes present on scrubs worn by OR personnel. Given the importance of establishing the cleanest surgical conditions for the prevention of SSI, the proper laundering of scrubs is a major issue for staff."

The researchers add, "It has been identified that up to 60 percent of healthcare personnel's uniforms may be contaminated with microorganisms. A myriad of publications emphasizes the bacteria-carrying ability of hospital uniforms throughout workday activities. Research conducted on nursing and physician uniforms noted that bacterial counts on uniforms are higher at the end of the work shift, suggesting bacteria are spread through patient contact …The presence of pathogens and potential for vehicular transmission via scrub uniforms has been identified in both small-scale studies and randomized controlled trials. Whether this is clinically significant depends on whether scrubs are found to be pathogenic in environments where extreme cleanliness is imperative, such as the OR."

They continue, "There is some evidence that ineffective washing of facility-laundered surgical scrubs (FLSS) is linked with SSIs. One case report describes a microbial link between scrubs contaminated with large amounts of Bacillus cereus during prolonged neurologic surgery time, resulting in meningitis for two postoperative patients. It was later discovered that the infection was the result of improperly washed contaminated facility laundry rather than surgical time and exposure of scrubs to the wound site."

The literature notes that scrubs improperly decontaminated in the home setting may be linked to SSI. For example, a polymicrobial outbreak in patients who had undergone cardiac surgery is affirmed in one report, which cited microbial contamination in 14 of 22 postsurgical patients. Involved staff members' wearing of scrubs and uniform jackets that had been home-laundered was reported as a strong correlate.

In a nonexperimental study of OR surgical attire conducted as the result of an increase in multidrug-resistant organisms and HAIs, Nordstrom, et al. (2012) took swatches from unwashed, hospital-laundered, home-laundered, new cloth, and disposable scrub attire and tested them for the presence of microorganisms. The researchers found that the home-laundered scrub attire had a significantly higher total bacterial count than the facility-laundered attire, and they found no significant difference in bacterial counts between hospital-laundered, unused, or disposable scrub attire. The researchers concluded that although it is not known how contaminated scrub attire contributes to the spread of HAIs, hospital administrators and infection preventionists need to consider the potential for transmission of infection versus cost savings to the facility if home laundering is allowed. The researchers advised that health care workers be made aware of the risks of home laundering and be provided with instructions for best methods for home laundering in order to reduce the risk of infection.

Vera, et al. (2016) articulate the differences between FLSS and domestic laundering: "Facility laundering is the decontamination of textiles at accredited facilities following industry standards … Facility laundering typically uses a continuous-batch washing machine that decontaminates the items in the wash load at a minimum of 65 degrees C for a minimum of 10 minutes, but more commonly at a temperature of 71 degrees C for 3 minutes using bleach for grossly contaminated items. In comparison, home laundering is the process of laundering uniforms in the home setting using a domestic home washing machine and dryer. Domestic washing machines typically operate at temperatures of 60 degrees C for 30- to 40-minute cycles but can reach higher wash temperatures of 90 degrees C. Newer domestic washing machines using the Energy Star technology consume 37 percent less energy and 50 percent less water than their counterparts. The trend toward lower temperature and water consumption and lack of regulation over home laundering has incited theoretical concerns of uniforms being ineffectively decontaminated in the home. Laundering of scrub uniforms at 71 degrees C, per CDC recommendations, is not achievable using most home washing and evidence suggests that bacterial eradication from clothing is less effective using lower temperatures."

These researchers point to what they believe is a draw in the debate between industrial laundering and domestic laundering: "Evidence comparing facility and home laundering of surgical scrubs in SSI prevention is lacking. The only study comparing these methods has concluded no difference exists in efficacy. The perceived advantage of regulatory bodies overseeing laundering facilities should be carefully stated because microbial testing is not a standard in facility-laundered textiles; thus, continual levels of contamination are not assessed. Finally, there is no compelling

evidence that reveals home-laundered surgical scrubs (HLSS) are inferior to FLSS in SSI prevention, and unchanged SSI rates at hospitals that have initiated home-laundering programs suggest that home laundering may provide an acceptable choice for decontaminating scrubs."

A stronger stance against home laundering of surgical attire was taken by the Association of periOperative Registered Nurses (AORN) in the 2004 revision of the organization's Recommended Practices for Surgical Attire. Braswell and Spruce (2012) refer to this RP as "the least popular recommendation," and explain, "Based on the number of questions and comments that AORN received from constituents when the recommendation was first introduced at the 2010 AORN Congress in Denver, and when the RP document was in the public comment phase during the summer of 2010, the RP document was revised and then submitted for a second public comment phase. When the RP document was featured at the 2011 AORN Congress in Philadelphia, there continued to be questions surrounding the recommendation that surgical attire not be home laundered."

Questions continue to this day, despite the RP reflecting the evolution of the evidence-based research since then. As Braswell and Spruce (2012) note, "…AORN maintains the statement 'Home laundering of surgical attire is not recommended.' However, the revised RP document does not provide perioperative nurses with suggestions for home laundering of soiled surgical attire. The RP document now states, 'Home laundering may not meet the specified measures necessary to achieve a reduction in antimicrobial levels in soiled surgical attire,' and details those measures in more depth."

In providing a rationale for this RP, Braswell and Spruce (2012) note, "Wearing surgical attire and appropriate personal protective equipment in the semi-restricted and restricted areas of healthcare facilities promotes personnel safety and helps ensure cleanliness in the perioperative environment. It is understood that the human body and the various surfaces in the perioperative setting are sources of microbial contamination and microbe transmission. Clean surgical attire helps to minimize the introduction of microorganisms and lint from healthcare personnel to clean items and the environment. Although there is no direct link between nonsterile surgical attire and the impact on surgical site infections, it seems prudent to minimize a patient's exposure to a surgical team member's skin, mucous membranes, or hair. Using a healthcare-accredited laundry facility is preferred because accredited facilities follow industry standards. The Healthcare Laundry Accreditation Council provides voluntary accreditation to those laundry facilities that process healthcare textiles and incorporate Occupational Safety and Health Administration (OSHA) and Centers for Disease Control and Prevention (CDC) guidelines, including establishing quality control monitoring and using processes based on industry standards; regularly testing water quality; monitoring wash loads and recording data; and routinely monitoring laundry processes, such as correct measurement of chemicals, correct water temperatures, mechanical action, and the duration of the washing cycle."

Home washing machines may not have the adjustable parameters or controls required to achieve the necessary thermal measures (e.g., water temperature); mechanical measures (e.g., agitation); or chemical measures (e.g., capacity for additives to neutralize the alkalinity of the water, soap, or detergent) to reduce microbial levels in soiled scrub attire.

In the most up-to-date RP (2021), AORN states, "Wear clean surgical attire when entering the semi-restricted and restricted areas. Wearing clean surgical attire may protect patients from exposure to microorganisms that could contribute to an SSI. After each daily use, launder scrub attire at a healthcare-accredited laundry facility, the healthcare organization according to state regulatory requirements, or the healthcare organization according to CDC recommendations for laundering in the absence of state requirements."

AORN's 2021 RP continues, "Wearing attire that is laundered at a healthcare-accredited laundry facility or at the healthcare organization in accordance with state regulatory requirements provides control of the laundering process and helps ensure that effective laundering standards have been met. Home laundering is not monitored for quality, consistency, or safety. Home washing machines may not have the adjustable parameters or controls required to achieve the necessary thermal measures (e.g., water temperature); mechanical measures (e.g., agitation); or chemical measures (e.g., capacity for additives to neutralize the alkalinity of the water, soap, or detergent) to reduce microbial levels in soiled scrub attire."

AORN'S Guidelines for Perioperative Practice: Surgical Attire (2021) points out that, "Moderate-quality evidence demonstrates that scrubs become contaminated with bacteria during the workday, including potentially pathogenic organisms that can be transmitted to other people or the environment. Several studies have found that microorganisms can survive the home laundering process due to low water temperature and household detergents and can be transferred to other garments. Biofilm may form in home washing machines, which can be transferred to other clothing and textiles washed in the same machine."

The 2021 AORN guideline on surgical attire makes the following recommendations:

• Prevent contamination of laundered surgical attire during transport to the healthcare facility.

As AORN (2021) explains, "Preventing clean surgical attire from contamination during transport from the laundry facility to the healthcare facility helps prevent physical damage to the surgical attire and minimizes the potential for contamination from the external environment."

•Transport laundered surgical attire in enclosed carts or containers and in vehicles that are cleaned and disinfected regularly.

• Store laundered surgical attire in enclosed carts, cabinets, or dispensing machines that are cleaned and disinfected regularly.

As AORN (2021) explains, "Storing laundered surgical attire in clean enclosed carts, cabinets or dispensing machines helps prevent contamination. Storing clean attire in a facility locker with personal items from outside of the facility may contaminate the clean scrub attire."

• Scrub attire that has been penetrated by blood, body fluids, or other potentially infectious materials must be removed immediately or as soon as possible, and replaced with clean attire. [Regulatory requirement]

As AORN (2021) explains, "Changing contaminated, soiled, or wet attire may reduce the potential for contamination and protect personnel from exposure to potentially pathogenic microorganisms."

• Scrub attire contaminated with visible blood or body fluids must remain at the healthcare facility for laundering. [Regulatory requirement]

• Contaminated scrub attire must be bagged or containerized at the location where it was used and not be rinsed or sorted. [Regulatory requirement]

As AORN (2021) explains, "Rinsing or sorting contaminated reusable attire may expose the health care worker to blood, body fluids, or other potentially infectious materials."

• Remove surgical attire before leaving the healthcare facility.

As AORN (2021) explains, "The benefits of removing surgical attire before leaving the facility outweigh the harms. Moderate-quality evidence supports changing out of surgical attire into street clothes when leaving the building to reduce the potential for healthcare workers to transport pathogenic microorganisms from the facility or health care organization into the home or community."

• Establish and implement a process for managing personal clothing that may be worn under scrub attire, including the type of fabrics (non-linting) that may be worn under scrub attire, the amount of fabric that may extend beyond the scrub attire (a crew neck collar under V-neck scrub attire), laundering frequency (daily), and laundering method (facility laundering, home laundering).

• A conditional recommendation from AORN (2021) is that personal clothing contaminated with blood, body fluids, or other potentially infectious materials must remain at the healthcare facility for laundering. [Regulatory requirement]

Attire in Other Clinical, Non-Surgical Settings

The 2021 AORN RP indicates that some evidence supports home laundering within specific parameters. For example, Lakdawala, et al. (2011) conducted a nonexperimental investigation of the effect of low-temperature washing cycles by assessing the amount of bioburden on healthcare workers' uniforms before and after laundering. The researchers concluded that a washing cycle of 140 degrees F (60 degrees C) for 10 minutes was sufficient to decontaminate hospital uniforms and decrease the bacterial load by at least a 7-log reduction. The uniforms could become re-contaminated after laundering, but the organisms could be easily removed by ironing, the researchers said.

In another study, Patel, et al. (2006) sought to determine the effectiveness of home laundering in removing Staphylococcus aureus from scrub attire.

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).

The researchers cut hospital-laundered scrub attire into squares, inoculated them with S aureus, and washed them at a typical household laundry temperature of 104 degrees F (40 degrees C) and a higher temperature of 140 degrees F (60 degrees C). The researchers concluded that the lower temperature did not remove S aureus; however, adding sequential tumble drying or ironing reduced the number of bacteria to an undetectable level. Washing at 140 degrees F (60 degrees C) produced a greater reduction in total viable organisms compared with washing at 104 degrees F (40 degrees C). The researchers concluded that scrub attire can be safely washed at 104 degrees F (40 degrees C) if tumble-dried for 30 minutes or ironed.

Bearman, et al. (2014) acknowledged what the authors deemed "a paucity of data on the optimal approach to healthcare personnel (HCP) attire in clinical, non-surgical areas. Attire choices should attempt to balance professional appearance, comfort, and practicality with the potential role of apparel in the cross-transmission of pathogens resulting in HAIs."

Representing the Society for Healthcare Epidemiology of America (SHEA) workgroup on HCP attire, Bearman, et al. (2014) recommended:

- Appropriately designed studies should be funded and performed to better define the relationship between HCP attire and HAIs.
- Until such studies are reported, priority should be placed on evidence-based measures to prevent HAIs (hand hygiene, appropriate device insertion and care, isolation of patients with communicable diseases, environmental disinfection).
- Specific approaches to practice related to HCP attire outlined by the authors may be considered by individual facilities; however, in institutions that wish to pursue these practices, measures should be voluntary and accompanied by a well-organized communication and education effort directed at both HCP and patients.

Regarding frequency of laundering, Bearman, et al. (2014) observed, "Optimally, any apparel worn at the bedside that contacts the patient or patient environment should be laundered after daily use. In our opinion, white coats worn during patient care should be laundered no less frequently than once a week and when visibly soiled. White coats worn by HCP who care for very few patients or by HCP who are infrequently involved in direct patient care activities may need to be laundered less frequently than white coats worn by HCP involved with more frequent patient care. At least weekly laundering may help achieve a balance between microbial burden, visible cleanliness, professional appearance, and resource utilization."

Regarding home laundering, Bearman, et al. (2014) observed, "Whether HCP attire for non-surgical settings should be laundered at home or professionally remains unclear. If laundered at home, a hot-water wash cycle (ideally with bleach) followed by a cycle in the dryer is preferable. A combination of washing at higher temperatures and tumble drying or ironing has been associated with elimination of both pathogenic Gram-positive and Gram-negative bacteria."

The authors point to a survey of 337 SHEA members and members of the SHEA Research Network (21.7 percent response of 1,550 members) regarding their institutions' policies for HCP attire. According to Bearman, et al. (2014), "Although 43 percent of respondents stated that their hospitals issued scrubs or uniforms, only 36 percent of facilities actually laundered scrubs or uniforms. A small number of hospitals provided any type of guidance on home laundering: 13 percent provided specific policies regarding home laundering, while 38 percent did not." The authors concluded, "The benefit of institutional laundering of HCP scrubs versus home laundering for non-OR use remains unproven."

Associations representing certified commercial healthcare laundries disagree.

The Case for Institutional Laundering

As a whitepaper from TRSA observes, "A Bioscience Laboratories, Inc. study found significantly greater contamination among home-laundered attire than scrubs laundered by the healthcare facility or outsourced for laundering. After home laundering, scrubs still contained soil: about as much soil as those worn for a day that had been facility- or third-party laundered."

In that study, Twomey, et al. (2009) sought 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-laundered, third-party laundered and home-laundered). The study's aim was to determine whether this information provided any insight into the safety and efficacy of re-usable versus single-use scrubs and laundering mechanism.

Ten sets of surgical scrub garments, top and bottom, were collected from multiple U.S. healthcare organizations for each category. The number of viable organisms on each garment was enumerated as colony-forming units (CFU) and the average log 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). The researchers found that there was no statistically significant difference in mean microbial populations among the facility-laundered, third party-laundered or single-use scrubs, prior to use ("clean"). The mean microbial population associated with the home-laundered 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-laundered scrubs, prior to use ("clean"), was not significantly different from that of any of the after use ("worn") garments.

Twomey, et al. (2009) thus concluded that home-laundering is not as effective as facility or third-party laundering in decontaminating surgical

scrub attire. Similarly, home-laundered 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).

The TRSA whitepaper explains that home laundering technology may not be sufficient: "The typical water temperature of home washers poses another threat to meeting the standard of producing hygienically clean linen. Washing machines typically operate at temperatures of 140 degrees F (60 degrees C) for 30- to 40-minute cycles. Lower temperature is a key to improving home washing efficiency: newer domestic washing machines using Energy Star technology consume 37 percent less energy and 50 percent less water than their counterparts."

Good for the environment but perhaps not so good for killing pathogenic microorganisms. As the TRSA whitepaper continues, "Thus, laundering scrubs uniforms at 160 degrees F (71 degrees C) per CDC recommendations is not achievable using most home washing machine temperatures and evidence suggests that bacterial eradication from clothing is less effective using consumer chemistry at lower temperatures." The whitepaper adds, "Some studies have found that washing uniforms at 140 degrees F to 150 degrees F (60 degrees to 65 degrees C) can decontaminate with proper drying or ironing after the wash—another practice that may not be consistent."

The TRSA whitepaper notes, "The United States has lagged in preventing garment contamination. No regulation stops employees from wearing their healthcare garments to and from work. Nor is there a nationally sanctioned scrub laundering method adopted as the standard of care. The CDC offers no recommendation on how or where to launder garments. OSHA states that 'employers are required to launder employee-owned scrubs that have become visibly contaminated during work and scrubs not soiled with blood or virulent matter may be laundered at home.'" (Vera, et al., 2016)

The COVID-19 Impact on Healthcare Attire Laundering

Owen and Shivkumar, et al. (2021) investigated the environmental stability of human coronaviruses HCoV-OC43 and HCoV-229E on different textile fiber types and the persistence of HCoV-OC43 on textiles during domestic and industrial laundering. This study demonstrated that human coronaviruses (5 log10 50 percent tissue culture infective doses [TCID50]) remain infectious on polyester for more than 72 hours, cotton for more than 24 hours, and polycotton for more than six hours. The researchers found that HCoV-OC43 was also able to transfer from polyester to PVC or polyester after 72 hours. Under clean conditions, HCoV-OC43 was not detectable on cotton swatches laundered with industrial and domestic wash cycles without temperature and detergent (≥4.57-log10-TCID50 reduction), suggesting that the dilution and agitation of wash cycles are sufficient to remove human coronaviruses from textiles. In the presence of interfering substances (artificial saliva), ≤1.78 log10 TCID50 HCoV-OC43 was detected after washing domestically without temperature and detergent, unlike industrial laundering, where the virus was completely removed. However, no infectious HCoV-OC43 was detected when washed domestically with detergent.

As the researchers note, "Synthetic textiles such as polyester could potentially act as fomites of human coronaviruses, indicating the importance of infection control procedures during handling of contaminated textiles prior to laundering. This study provides novel evidence that human coronaviruses can persist on textiles for up to three days and are readily transferred from polyester textile to other surfaces after 72 hours of incubation. This is of particular importance for the domestic laundering of contaminated textiles such as healthcare uniforms in the UK and U.S., where there may be a risk of cross-contaminating the domestic environment. It was demonstrated that human coronaviruses are removed from contaminated textiles by typical domestic and commercial wash cycles, even at low temperatures without detergent, indicating that current healthcare laundering policies are likely sufficient in the decontamination of SARS-CoV-2 from textiles."

In the middle of the COVID-19 pandemic, the Association for Linen Management (ALM) issued a statement addressing laundering of personal work attire and emphasized that its guidance is "not to be used for laundering any textile provided by your healthcare facility to serve as personal protective equipment (PPE). PPE is specialized clothing or equipment worn by an employee for protection against a hazard. General work clothes, e.g., uniforms, pants, shirts, or blouses, not intended to function as protection against a hazard are not considered to be PPE." Helping healthcare personnel determine the options, in its *Interim Guidance for Healthcare Personnel Home Washing Personal Uniform/Scrub Apparel During the COVID-19 Pandemic*, ALM advises on the two approaches, and makes the following recommendations:

• **Option 1:** Laundered by Healthcare Laundry Service. ALM supports the option to have these garments laundered by a healthcare laundry service, preferably an accredited operation, which can process the scrubs in a commercial setting that adheres to the CDC's guidelines for processing healthcare textiles.

• **Option 2:** Laundered at Home. If the hospital does not provide laundering for uniforms/scrub apparel, ALM provides the following steps for healthcare personnel to launder personal work apparel at home to provide clean uniforms/scrubs for reuse while best protecting their families from COVID-19.

❶ It is ideal for healthcare personnel to change from their uniform/scrub apparel while at the hospital, before beginning their commute home. Place the worn garments in a bag to bring them into the house.

❷ Do not shake these garments during handling. While the virus that causes COVID-19 has not been proven to be an airborne virus, unnecessarily manipulating the garments could distribute lint and pathogens from patients into the air.

❸ Wash the uniform/scrub apparel separately from any family textile products.

❹ Use appropriate detergents and bleach based on the apparel manufacturer's label instructions. Both chlorine-based bleach and oxygen-based bleach products can be effective in the wash process for inactivating viruses.

❺ Wash on the hottest water temperature setting recommended by the garment manufacturer and avoid short/rapid cycles.

❻ After closing the washer, clean and disinfect according to directions of your chosen EPA-certified disinfectant product. Wipe down the machine door, handles, and buttons, as well as doorknobs and other surface areas you may have touched in the laundry room during the process. If the bag used to bring the apparel items home is disposable, discard the bag. If the bag is not disposable, wipe the bag handle/straps and interior with an appropriate detergent-disinfectant.

❼ Immediately wash your hands or use an alcohol-based hand sanitizer.

❽ After the wash cycle is completed, remove the garments from the washer and place immediately into the dryer. Dry the load completely on the warmest cycle recommended by the garment manufacturer.

Efficacy of Domestic Laundering

As we have seen, there is debate around the efficacy of laundry processes, particularly around home-laundering of healthcare attire. Researchers point to some evidence to suggest that potentially pathogenic microorganisms survive this kind of domestic laundering, particularly when conducted at low temperatures. As experts note, a significant disadvantage of domestic laundering is the lack of control and monitoring for decontamination compared to industrial laundering.

As Mitchell, et al. (2015) explain, "While industrial laundry practices and procedures may be problematic regarding ensuring that 'clean' clothes are truly free of microbial contamination, laundering at home may not be a safe solution. Wright, et al. recently described the investigation of a cluster of three instances of Gordonia bronchialis sternal infection. After ruling out environmental contamination, the researchers identified a nurse anesthetist as the source of the outbreak. Four separate strains of G. bronchialis were isolated from her scrubs, axilla, hands and handbag. The investigators also obtained cultures from her nurse roommate, and grew G. bronchialis from that nurse's axilla, hands and scrubs. To decontaminate her home, the nurse anesthetist disposed of the washing machine that she had been using to launder her work uniforms. After disposal of the machine, the nurse anesthetist's and her roommate's scrubs, hands, nares and scalps all tested negative for G. bronchialis and the infection outbreak ceased."

Mitchell, et al. (2015) continue, "Uncertainties about the effectiveness of home laundering are further illustrated in another study which reported that 39 percent of nurses' uniforms laundered at home were contaminated with MDROs at the beginning of the work shift. The laundry conundrum is further complicated because, even if the laundering procedures, whether at home or at work, produce clean textiles, bacterial recontamination of these surfaces will occur within hours of donning newly laundered uniforms. The previously mentioned home-laundered nurses' uniforms showed an increase in contamination from 39 percent at the beginning of the work shift to 54 percent by the end of the day. A separate analysis indicated that 100 percent of nurses' gowns were contaminated within the first day of use, and 33 percent of those were contaminated with S. aureus. Burden, et al. found that uniforms that were almost sterile prior to donning accumulated nearly 50 percent of their eight-hour-measured CFU count after only three hours of wear. Those researchers also found no significant differences in CFU counts from previously worn lab coats vs newly laundered uniforms, sleeve cuffs of either type of garment, or the pockets of lab coats vs uniforms. Results of the cultures showed that 16 percent of the lab coats and 20 percent of the short-sleeved uniforms were positive for MRSA. Burden et al. concluded that reducing bacterial contamination of healthcare workers' clothing made of conventional fabrics would require changing work clothes every few hours."

Owen and Laird (2020) say that outbreak case studies have provided preliminary evidence for the transmission of infection by contaminated domestic washing machines, suggesting that contaminated healthcare worker uniforms could pose a risk of transmitting potential pathogens back into the clinical environment. Microorganisms, particularly thermotolerant species or spores, can survive industrial laundering processes. Few published studies have investigated the survival of viruses during domestic laundering, which is of particular importance during the COVID-19 pandemic to prevent any risk of cross-contamination of SARS-CoV-2 from healthcare worker uniforms.

As Owen and Laird (2020) observe, "There is some evidence to suggest that potentially pathogenic microorganisms survive domestic laundering, particularly where conducted at low temperatures rather than those recommended by uniform policies. Adequate decontamination of healthcare worker uniforms is of particular importance during the COVID-19 pandemic to reduce any potential transmission via this route. Critically, industrial laundering processes are routinely monitored to ensure that textiles are decontaminated, and infection control procedures are in place to minimize potential cross-contamination (such as maintenance of washing machines, routine environmental disinfection, and the physical separation of areas for clean and dirty linen) which is not possible with domestic laundering. The lack of control and monitoring associated with domestic laundering, and the lack of compliance with domestic laundering policies (Riley, Laird, et al., 2015) poses the risk of undetected inadequate decontamination and cross contamination to both the domestic and clinical environments (Riley, et al., 2017). Indeed, outbreak case studies have indicated the transmission of infection by contaminated domestic washing machines (Wright, et al., 2012). In-house or industrial laundering of healthcare worker uniforms would mitigate this risk due to implementation of process controls and microbiologically validated wash cycles."

With great variance in the U.S., it may be helpful to see what's happening across the pond. Two studies conducted at De Montfort University in the UK on the domestic laundering practices of nurses and their implications in terms of bacterial survival and contamination have highlighted several key factors that need consideration when assessing the safety of domestically laundering healthcare uniforms.

In a study conducted in four hospitals, Riley, et al. (2015) found that not all healthcare workers were following their hospital's policies on the laundering and aftercare of uniforms. Their study also demonstrated variation between hospitals on recommended wash temperatures, and incomplete guidance regarding the use of detergents, the drying of uniforms and whether to wash them separately from other items of clothing. The researchers' questionnaire, administered to 265 healthcare staff in nursing, administration, housekeeping and allied services, revealed that 43.7 percent laundered their uniforms below the UK recommendation of 60 degrees C; 33 percent washed them at 40 degrees C and 5 percent at 30 degrees C. The majority (91 percent) of respondents reported they used a detergent in the wash cycle with their uniforms; 37 percent of respondents used a biological detergent; 35 percent used a non-biological detergent; and 14 percent used a 'two-in one' detergent.

Two years later, Riley, et al. (2017) showed no significant difference in the activity of biological and non-biological detergents against microorganisms at similar wash temperature conditions. The questionnaire from the 2015 study revealed that 26 percent of respondents wore their uniform for two or more shifts before washing it, longer than the recommended wash after every shift.

- Critically, industrial laundering processes are routinely monitored to ensure that textiles are decontaminated, and infection control procedures are in place to minimize potential cross–contamination (such as maintenance of washing machines, routine environmental disinfection, and the physical separation of areas for clean and dirty linen) which is not possible with domestic laundering.

It also showed that 78 percent of staff had their uniforms for more than 18 months before these were replaced by new ones.

The 2017 study involved recreating in a laboratory setting nurses' most common laundering practices established by the 2015 study and assessing the survival of Staphylococcus aureus and Escherichia coli on cotton and polyester fibers. The data showed that both bacteria were able to survive on polyester for up to seven days and on cotton for up to 21 days.

As Laird, et al. (2018) observe, "This raises the question of the storage of dirty uniforms at home, especially regarding potential cross-contamination with surfaces in the home environment. Mixed polyester and cotton (65 percent/35 percent) and 100 percent polyester fabric samples inoculated with high bacterial loads – to mimic a worst-case scenario – were washed at 40 degrees C and 60 degrees C using biological detergent. To determine whether cross-contamination could occur in the wash, sterile samples were included. The 40 degree C wash did remove most microorganisms, but the cells that were left were in excess of 1,000, and similar numbers had been transferred to the sterile items. This highlights the risk that other items of clothing in the home could become contaminated, or that domestically laundered uniforms could re-contaminate the home and/or healthcare environment. That said, other factors need to be considered, such as: 1) Drying practices that could further reduce microbial load; in cases where visible soiling occurred, the most highly contaminated uniforms being classed as infectious and thus laundered industrially; 2) The levels at which microorganisms start to be infectious. Studies in a real-life setting are required. Although the data collected by Riley, et al. (2017) concurs with (UK recommendations] in that most microorganisms are removed from textiles at lower washing temperatures, the risk that surviving microorganisms may be present needs to be fully quantified. When the samples were washed at 60 degrees C, no microorganisms were detected, which supports the recommendation that uniforms should be washed at a minimum temperature of 60 degrees C."

Laird, et al. (2018) point out that providing healthcare personnel with enough items of attire so they can change uniform after every shift is an ongoing issue: "As shown by Riley, et al. (2015), there may be limited on-site facilities for nurses to change in and out of their uniforms, and if they exist, they may be far from the wards. Some hospitals have on-site laundries for staff, but nurses still prefer to wash their uniforms at home (Patel, et al., 2006). This could be because they do not have enough uniforms to wash them after each shift, and because of the time required to visit the on-site changing and laundering facilities after a shift. The guidance on domestic laundering may be vague, unclear or patchy, as found in the four hospitals surveyed, thus not giving staff clear instructions. Nurses moving between [hospitals] may receive contradictory information, as local policies can be inconsistent. The cost of regularly laundering uniforms at high temperatures could be one reason why temperatures below the recommended 60 degrees C are used. Another reason could be consumer information circulating in the media saying that lower temperatures and 'quick wash' cycles are more environmentally friendly. Other potential issues around wash temperatures are that domestic washing machines are difficult to regulate, no two machines perform a cycle in the same way, and aging machines often fail to reach the required wash temperature. Further research is needed to determine why guidelines are not always followed and how compliance can be improved. The laundering of uniforms at 40 degrees C may present a risk of cross-contamination risks, and this needs to be fully researched and quantified."

Owen and Laird (2020) note that few published studies have investigated the survival of viruses during domestic laundering, which is of particular importance during the COVID-19 pandemic to prevent any risk of cross-contamination of SARS-CoV-2 from healthcare worker uniforms: "There do not appear to be any published studies that have investigated the survival of coronaviruses during laundering. Enteric viruses have been found to survive domestic laundering; 3.6–4.1 log10 rotavirus, hepatitis A virus and adenovirus survived in a cold (20 degrees C to 23 degrees C) wash with domestic detergent, with the removed virus mainly being transferred on to sterile textile in the wash (2.7–3.3 log10). In a wash with household bleach (114-125 mg/l free chlorine in wash water) in addition to detergent, 1.8–2.6 log10 rotavirus, hepatitis A and adenovirus survived (Gerba and Kennedy, 2007). The effect of temperature upon inactivation of the viruses was not determined and could improve the reductions observed and it cannot be concluded as to the survival of viruses on textiles laundered at 60 degrees C as recommended by U.K. Department of Health (2010) and NHS (2020)."

A concern with domestic washing is the lack of routine microbiological testing compared to industrial laundering which could lead to undetected contamination of healthcare worker uniforms with potential pathogens, emphasize Owen and Laird (2020), who add, "Domestic washing machine are often colonized with microorganisms which can be deposited onto textiles during laundering, posing a risk of cross contamination in the clinical environment (Patel, Murray-Leonard & Wilson, 2006; Wright et al., 2012; Babic et al., 2015; Callewaert et al., 2015; Schmithausen et al., 2019) Domestic washing machine equipment failure poses a further risk of inadequate decontamination of textiles (Sooklal, et al., 2014), domestic washing machines often fail to reach the programmed temperatures (Patel, et al., 2006; Bloomfield, et al., 2015). There is also an increasing use of low temperature and short wash cycles to improve energy efficiency, and due to the unsuitability of some fabrics for higher wash temperatures (Honisch, et al. 2014; Bloomfield, et al., 2015). In this manner, a lack of compliance with uniform policies may also increase the risk of contamination with potential pathogens (Riley, et al., 2015). Another concern with domestic laundering is the potential contamination of domestic surfaces during handling of the contaminated uniforms."

- As Mitchell, et al. (2015) summarize, "The literature illustrates that healthcare textiles, including uniforms or apparel, are a vector for transmission of microorganisms that cause infections and illnesses in healthcare workers, patients and the community.

Honisch, et al. (2014) investigated the effect of temperature and duration of the laundering process with and without activated oxygen bleach (AOB)-containing detergent on the hygienic effectiveness of laundering. They found that it is possible to compensate for the loss of hygiene effectiveness of laundering at lower temperatures using detergents with activated oxygen bleach or by extending the wash cycle time. Cotton test swatches were contaminated with Staphylococcus aureus, Enterococcus hirae, Pseudomonas aeruginosa, Candida albicans and Trichophyton mentagrophytes and were washed in a household washing machine using temperatures between 20 degrees C and 60 degrees C and different wash cycle times. The logarithmic microbial reduction factor and cross-contamination were used to indicate the hygienic effectiveness of the washing process. For all tested microorganisms, the temperature needed for decontamination depended on washing time and detergent type. Hygiene effectiveness of laundering was enhanced by inclusion of AOB even at lowest temperatures, except for C. albicans, which was virtually unaffected by AOB. The use of AOB-containing detergents as well as high washing temperatures reduced cross-contamination to sterile swatches included in the load. The researchers concluded that, "Depending on the type of organism, longer wash cycle times or the use of AOB-containing detergents can be used to enhance the hygiene effectiveness of laundering."

As Honisch, et al. (2014) explain, "It is commonly recommended to wash hygienically sensitive textiles such as underwear, bed linens, towels and dish cloths at high temperatures and with a detergent containing activated oxygen bleach to reduce potential infection risks in private households… To obtain the same washing performance as at higher laundry temperatures, lower laundry temperatures must be compensated by enhancing other factors. Increasing the wash cycle time is known to be an effective means of compensating lower washing temperatures in terms of stain removal. To what extent this also applies to hygiene effectiveness regarding eliminating potentially pathogenic microorganisms, which are present on washables, is not sufficiently well known."

In general, Honisch, et al. (2014) found that hygiene effectiveness was increased by increasing the wash cycle time, but the extent of this effect was variable depending on temperature and strain type, and no consistent relationships could be determined. For example, for Staph aureus, at the lowest wash temperature (20.5 degrees C), the log reduction values were in the same range for all cycle times. At higher temperatures, a longer wash cycle time led to higher reduction values; for example, a 5-log reduction could be reached with the 15-minute program at 46.7 degrees C, or with the 90-minute program at 32.3 degrees C. For T. mentagrophytes, the same level of decontamination that was reached at 46.7 degrees C in the 15-minute program, was obtained at 37.2 degrees C in the 90-minute program.

Regarding the impact of using detergent with AOB compared with a non-AOB detergent, Honisch, et al. (2014) found that, for all test organisms except C. albicans, the addition of AOB led to higher reduction values for any given time/temperature combination. For Staph aureus and Ent. hirae, whereas using non-AOB detergent, temperatures of 46.7, 41.8 and 32.3 degrees C were required to achieve 5 or more log reduction at wash cycle times of 15, 45 and 90 minutes, respectively. Using AOB detergent, the same log reduction was achieved using wash cycle time of 15 minutes at 32 degrees C, and 45 minutes at 20 degrees C. For both non-AOB and AOB detergents, the conditions required to produce a 5-log reduction were 46.7 degrees C for a 15-minute cycle, 41.8 degrees C for a 45-minute cycle and 37.2 degrees C for a 90-minute wash cycle. In the case of Ps. aeruginosa, no detectable survivors were obtained on all swatches for all temperatures and wash cycle times, which means that the impact of using an AOB could not be determined.

According to the researchers, a cross-contamination event was recorded when one or more of the test strains were detected at the end of the cycle on the sterile swatch included in the test load. Cross-contamination was observed in three of 32 test runs using AOB detergent, while using non-AOB detergent, cross-contamination was detected in 19 of 40 runs. All cross-contaminations events occurred at temperatures lower than 52 degrees C.

Bloomfield et al. (2013), who conducted a comprehensive review of studies of effects of temperature, wash conditions and detergent formulation on the hygiene effectiveness of laundering, found a lack of standardization of test conditions and the inconsistency in the published data which makes it difficult to propose performance standards for home laundering with confidence.

From their studies of the hygiene effectiveness of laundering, Lucassen, et al. (2013) concluded that, for naturally contaminated towels, a wash temperature of 50 degrees C led to sufficient decontamination of bacteria. Lichtenberg, et al. (2006) concluded that laundering of normally soiled washables at low temperatures with AOB-free detergent is also sufficient to obtain adequate hygiene, if there are no special hygienic requirements such as infections of skin or intestines. By contrast, from a study with naturally contaminated laundry items, Terpstra, et al. concluded that the hygiene performance of washing processes at low temperatures (15 degrees C and 30 degrees C) leaves something to be desired.

Chiereghin, et al. (2020) aimed to compare the performance of decontamination of different domestic laundering with that of industrial laundering. Fourteen naturally contaminated white coats of healthcare workers (five fabric squares from each coat) and fabric squares of artificially contaminated cotton cloth (30 fabric squares per each bacterial strain used) were included. Four domestic laundering procedures were performed; two different washing temperatures (40 degrees C and 90 degrees C) and drying (tumble dry and air dry) were used. All fabric squares were

ironed. Presence of bacterial bioburden on the fabric squares after domestic and industrial laundering was investigated. None of the naturally contaminated fabric squares resulted completely decontaminated after any of the domestic washes. At 24, 48 and 72 hours of incubation, bacterial growth was observed in all the laundered fabric squares. Besides environmental microorganisms, potentially pathogenic bacteria (Acinetobacter lwoffii, Micrococcus luteus, coagulase-negative staphylococci) were isolated. On the artificially contaminated fabric squares, the bioburden was reduced after the domestic laundries; nevertheless, both Gram-negative and -positive pathogenic bacteria were not completely removed. In addition, a contamination of the fabric squares by environmental Gram-negative bacteria was observed. In both the naturally and artificially contaminated fabric squares, no bacterial growth at all the time-points analyzed was observed after industrial laundering, which provided to be more effective in bacterial decontamination than domestic washes. As the researchers noted, "For those areas requiring the highest level of decontamination, the use of specialized industrial laundry services should be preferred."

As Mitchell, et al. (2015) summarize, "The literature illustrates that healthcare textiles, including uniforms or apparel, are a vector for transmission of microorganisms that cause infections and illnesses in healthcare workers, patients and the community. While there is a growing platform of published studies on the topic, the impact is underestimated because of a lack of point source investigations of textiles during outbreaks and cases of infection or illness. Many published papers either begin or end with a statement about the lack of published data in the literature on technical textiles or innovations in apparel. Therefore, healthcare facilities, hospitals, outpatient clinics and academic institutions should use and study newly available controls, and report findings and outcomes in credible published outlets."

The Future of Laundering Healthcare Personnel Attire

Absent a national laundering standard, Vera, et al. (2016) observe, "Many hospitals mandate facility laundering of uniforms. Others allow staff to wash uniforms at home, with no new SSI outbreaks cited. During the current cost-reduction climate of today's healthcare system, HLSS offers a financial solution for facilities. If HLSS programs are instituted, proper decontamination should be enforced and recommendations including proper handling of garments, wash temperatures, drying methods, and storage of HLSS should be provided. Ultimately, the decision to mandate specific surgical scrub laundering methods or guidelines will depend on institutional and provider preference."

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