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State of the Science Review

Bacterial contamination of medical providers' white coats and surgical scrubs: A systematic review

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Background: Horizontal transmission of bacteria, especially multidrug-resistant organisms (MDROs), remains an important concern in hospitals worldwide. Some studies have implicated provider attire in the transmission of organisms within hospitals, whereas others have suggested that evidence supporting this notion is limited.
Methods: PubMed was searched for publications between 1990 and 2018 to identify studies of bacterial contamination of, or dissemination of, bacteria from physician, nursing, or trainee attire, with a specific focus on white coats and surgical scrubs. A total of 214 articles were identified. Of these, 169 were excluded after abstract review and 33 were excluded after in-depth full manuscript review.
Results: Twenty-two articles were included: 16 (73%) cross-sectional studies, 4 (18%) randomized controlled trials, and 2 (9%) cohort studies. Results are organized by microbial contaminants, antibiotic resistance, types of providers, fabric type, antimicrobial coating, and laundering practices. Provider attire was commonly colonized by MDROs, with white coats laundered less frequently than scrubs. Studies revealed considerable differences among fabrics used and laundering practices.
Conclusions: Findings suggest that provider attire is a potential source of pathogenic bacterial transmission in health care settings. However, data confirming a direct link between provider attire and health care–associated infections remain limited. Suggestions outlined in this article may serve as a guideline to reduce the spread of bacterial pathogens, including MDROs, that have the potential to precipitate hospital-acquired infections.

Horizontal transmission of bacteria, especially multidrug-resistant organisms (MDROs), remains an important concern in hospitals worldwide.[1,2] Bacteria can be harbored on provider attire, including white coats and surgical scrubs.[3] Whether such apparel is responsible for the spread of infection remains controversial.

Some studies have implicated provider attire in the transmission of organisms within hospitals,[2,4,5] whereas others have suggested that evidence supporting this notion is limited.[6-8] It is not surprising, then, that there is no standard guideline concerning management of provider attire, with varying practices among countries, regions, facilities, and departments.[4,9] Regions, such as the United Kingdom (UK), have implemented guidelines that prohibit physicians from wearing white coats and long-sleeved clothing to decrease nosocomial infections.[10] The United States, however, has yet to implement a broad-based policy regarding physicians' clothing.

In the 1950s and 1960s, wearing of surgical scrubs was largely confined to hospitals; in fact, many hospitals forbade their wearing outside the surgical suite. As a logical consequence, all laundering was done in hospital laundries. The same could be said for white coats (and white pants and skirts), which were provided to hospital personnel daily and freshly laundered. In the 1970s, these standards rapidly eroded. Scrubs were worn around the hospital and even outside the hospital, and ordinary street clothing was increasingly worn by personnel. With increased wearing of white coats and scrubs outside the hospital, home-laundering has become routine but may be less successful in eradicating microbial contamination.

The white coat, symbolic of the practice of medicine, has long been embedded within medical culture and tradition.[11,12] Most, but not all,

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studies have found that patients associate white coats with higher levels of confidence and overall quality of care.[4,13-20] Dancer and Duerden[8] suggested that the UK's recently implemented 'bare below the elbows' (BBE) policy and near-disappearance of the white coat has marred the physician-patient relationship, with less respect toward providers. However, other findings suggest that patient comfort, satisfaction, trust, and confidence in physicians is unlikely to be affected by practitioner's attire.[4,21] Patients appear to regard scrubs as being the most hygienic and to value white coats (or formal attire) for professionalism, with BBE attire a lower preference. However, once informed of the potential risks associated with attire, patients were willing to change their preferences, valuing hygiene over formal attire.[7,22-24] Bond et al[23] have suggested that an alternative policy supporting scrubs in inpatient settings and formal attire in outpatient settings be explored.

The literature on provider attire preference is not nearly as strong. An overwhelming majority of health care workers (HCWs) believe attire is an important factor in patient care.[25] Most providers view the white coat as a favorable part of their attire, but Garvin et al[25] found that physicians were more likely than patients to be concerned about their unhygienic nature.[26] Moreover, attire preferences among providers largely depend on the specialty and setting in which they practice.[4,23]

The purpose of this systematic review is to review and consolidate findings of studies regarding bacterial contamination of white coats and surgical scrubs worn by health care providers—including physicians, nurses, and trainees—and their potential role in disseminating infectious agents in the hospital setting.

METHODS

Search strategy

PubMed was searched from 1990 through 2018 to identify studies of bacterial contamination or dissemination of bacteria from physician, nurse, or trainee attire, with a specific focus on white coats and surgical scrubs. Search terms included: 'white coat,' 'white coat AND infection,' 'white coat infection risk,' 'white coat contamination,' 'white coat clean,' 'white coat launder,' 'physician white coat,' 'physician AND infection transmission,' 'doctor AND infection transmission,' 'nosocomial infection AND white coats,' 'physician attire AND infection,' 'trainee,' 'medical students,' 'nurses,' 'nursing students,' 'nurse white coat,' 'nurse AND infection transmission,' 'nurse AND infection transmission,' nursing attire AND infection,' 'bacterial contamination of white coats,' 'surgical scrubs,' 'scrubs,' 'scrubs AND infection,' 'surgical scrubs AND infection,' and 'bacterial contamination of surgical scrubs.' Articles referenced in works retrieved in this fashion were also reviewed.

Data extraction and selection criteria

A systematic review of all relevant clinical studies was conducted. Studies were classified into categories based on scope of study (contamination analysis, laundering analysis, spread of bacteria, and provider/patient perspective on attire of health care providers). We excluded case reports, manuscripts not available in English, systematic reviews, and editorials on initial review of titles and abstracts.

On full-text review of eligible manuscripts, common reasons for exclusion of articles that passed initial screening included: (1) insufficient data collection or reporting, (2) studies of HCW uniforms other than white coats or scrubs, or (3) focus on handwashing, equipment, blood products, surgical site infections, or disposable gowns and equipment used in operating rooms. Articles with insufficient data collection or reporting generally did not report an objective (quantitative) measure of colonization of organisms on the attire studied.

Quality assessment

Two investigators (S.G. and S.K.) independently reviewed all titles and abstracts for inclusion. Full texts of eligible studies were evaluated for compliance with inclusion criteria. The information extracted included study design, statistical analysis, and, when available, types of contaminating bacteria, antibiotic resistance of isolates, fabric type, site of contamination, type of laundering facility, frequency of laundering, water temperature, types of HCW, and overall perception of provider attire cleanliness. Few publications contained all of this information.

RESULTS

Literature search

Our search terms identified 604 citations. After we excluded articles that did not align with the scope of our article and duplicates, 214 articles were left for review. A total of 169 were initially excluded based on title and abstract review criteria, leaving 45 full-text articles to be reviewed. This in-depth screening led to exclusion of 33 additional articles, leaving 22 to be included in this systematic review (Fig 1).[27] These articles are listed in Table 1.

Microbial contaminants

Eleven studies presented data on microbial contamination of white coats (Table 2). The most common method of detecting these contaminants was taking swabs of various areas of white coats and scrubs, including collars, pockets, sleeves, and sides. These swabs were then plated and cultured in the microbiology departments of each institution to determine individual isolates. Data on organisms that are regarded as nonpathogens, such as *Bacillus* spp, were generally not included. *Staphylococcus aureus* was the most commonly studied organism. Others included coagulase-negative staphylococci, gram-negative bacilli, and *Clostridium difficile*.[2,28-30,34,41] Antibiotic-resistant organisms included methicillin-resistant *S aureus* (MRSA) and vancomycin-resistant *Enterococcus* (VRE).[7,48] Our search failed to reveal articles addressing antibiotic-resistant gram-negative rods.

Treakle et al[30] studied white coats from grand round attendees, including attending physicians and surgeons, and trainees. Twenty-three percent of white coats were contaminated with *S aureus*; 18% of these isolates were methicillin-resistant. *S aureus* contamination was more common in residents working in inpatient settings. Surgeons' white coats were more likely to contain *S aureus* than those of physicians in medical specialties. The highest rate of MRSA colonization was found on white coats of attending physicians.

Several studies presented data on microbial contamination of surgical scrubs (Table 3). In comparing precall and postcall scrubs, Krueger et al[35] found significant increases in contamination rates at most sites. A total of 268 of 300 (89%) worn resident scrubs were colonized with bacteria compared to 123 of 300 (41%) of unworn scrubs. These differences were statistically significant for *S aureus,* coagulase-negative staphylococci and micrococci. All *S aureus* were methicillin-susceptible *S aureus* (MSSA); no MDROs were identified. Similarly, Scott et al[43] reported that 15 of 85 (17.6%) worn scrubs had MSSA-positive swabs, with no isolated MRSA. Thom et al[47] found that 217 of 720 (30.1%) scrubs were colonized with potentially pathogenic bacteria.

A few studies presented data on both white coats and scrubs. Munoz-Price et al[33] recovered 26 *S aureus* isolates from 119 scrubs and white coats, including 4 of 21 (19%) MRSA isolates specifically from scrubs. *Acinetobacter* spp was isolated from 11 of 97 (11%) scrubs; all isolates were meropenem-susceptible. Wiener-Well et al[32] found resistant pathogens in 3 of 32 (9%) cultures from scrubs versus

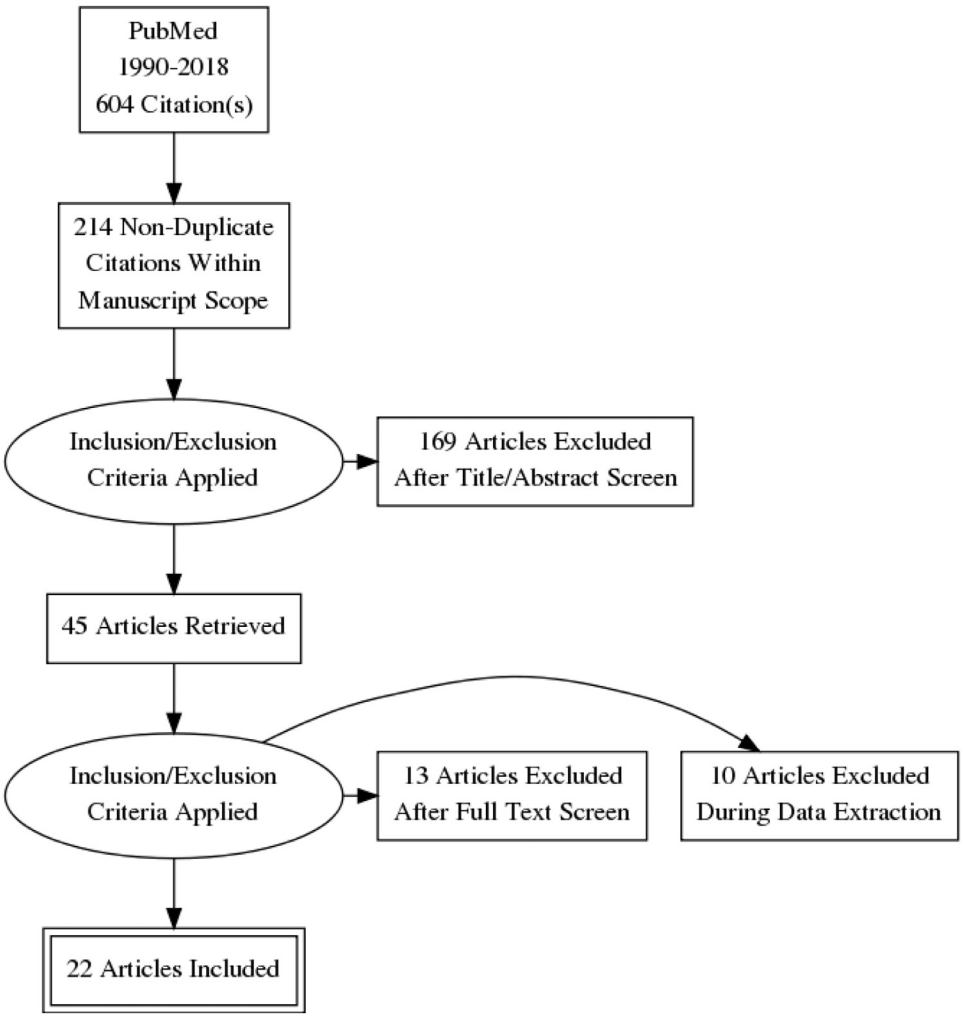

Fig 1. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) diagram of study search strategy.

3 of 52 (6%) cultures from white coats. Similarly, Anderson et al[46] found that 4 of 120 (3%) scrubs (including untreated scrubs and scrubs with antimicrobial coating) were contaminated with MRSA and 1 of 120 (1%) scrubs became contaminated with VRE.

Antibiotic resistance

Banu et al[2] and Uneke and Ijeoma[31] determined antibiotic resistance of isolates found on white coats. Gram-positive cocci were highly resistant to penicillin, erythromycin, and clindamycin. Multiple drug-resistant organisms, including MRSA and VRE, were reported in several studies, but microbial susceptibility data was not provided for gram-negative rods except for Uneke and Ijeoma,[31] who determined *Pseudomonas aeruginosa* to be resistant to ciprofloxacin.

Types of providers

No studies compared attire contamination among HCWs, such as nurses, medical students, interns, residents, fellows, faculty, and other care staff. Duroy and Le Coutour,[49] however, found that white coats were over-sized for 50% of medical students, with a positive association between loose fitting clothing and contamination.

Thom et al[47] determined that specific care activities were associated with higher rates of scrub contamination. For example, nurses caring for patients with wounds had more attire contamination than nurses caring for patients without wounds.

Fabric type

The most common fabrics used to make white coats are cotton, polyester, or cotton/polyester blend.[44,45] Data comparing contamination rates of these fabrics are inconclusive. Gupta et al[45] found that bacterial counts on blend fabric were 60% and 36% higher than polyester after a first and second shift, respectively ($P < 0.05$). However, Takashima et al[50] reported that polyester, acrylic, and wool are all strong carriers of *S aureus* and *P aeruginosa* with high binding potential. Cotton was found to have a much lower ratio of binding to these microbes.

Neely and Maley[51] and Chacko et al[52] concluded that survival of contaminants on polyester, cotton, or blend fabrics is largely variable based on the specific microbe. Chacko et al[52] determined that bacteria can survive from 10-98 days depending on the fabric, with polyester alone having the shortest survival time compared to cotton and blend fabrics. Specifically, *S aureus* can survive from 10-26 days, *P aeruginosa* from 18-98 days, *Escherichia coli* from 7-48 days, and *Enterococcus faecalis* from 8-10 days. Gupta et al[45] found that *E coli* was the most frequent (47.8%) organism isolated from polyester white coats, followed by staphylococci (19.1%). Streptococci were the least frequent (2%).

Table 1
Studies included in systematic review

Author, year	Number of participants/samples	Study design	Type of health care worker description & setting (attire)
Wong et al, 1991[28]	100 HCWs	Cross-sectional	Physicians at an urban general hospital (white coats)
Loh et al, 2000[29]	100 HCWs	Cross-sectional	Medical students at an urban multidisciplinary medical school covering 3 hospitals (white coats)
Treakle et al, 2009[30]	149 HCWs	Cross-sectional	Attending, fellows, residents, students, and other at medical/surgical grand rounds in a large teaching hospital (white coats)
Uneke and Ijeoma, 2010[31]	103 HCWs	Cross-sectional	Physicians in an acute care hospital (white coats)
Burden et al, 2011[10]	100 HCWs	Prospective randomized controlled trial	Residents and hospitalists at a university-affiliated public hospital (white coats)
Wiener-Well et al, 2011[32]	135 HCWs; 238 samples	Cross-sectional	Physicians and nurses in a university-affiliated hospital (white coats/scrubs)
Banu et al, 2012[2]	100 HCWs	Cross-sectional	Medical students and interns at a tertiary care hospital (white coats)
Munoz-Price et al, 2012[33]	119 HCWs	Cross-sectional	Physicians, nurses, technicians, therapists, and other ancillary staff at a university-affiliated teaching hospital (white coats/scrubs)
Cataño et al, 2012[34]	159 HCWs	Cross-sectional	Health workers in an urban academic tertiary-level teaching hospital (white coats)
Krueger et al, 2012[35]	30 HCWs; 300 samples	Cross-sectional	Residents in a large medical center (scrubs)
Nordstrom et al, 2012[36]	90 HCWs	Cross-sectional	Operating room personnel in a single hospital (scrubs)
Bearman et al, 2012[37]	30 HCWs; 2,000 samples	Randomized controlled trial (crossover)	Critical care team in university medical center (scrubs)
Munoz-Price et al, 2013[38]	160 HCWs	Cross-sectional	Physicians at departmental weekly conferences in a hospital (white coats/scrubs)
Burden et al, 2013[39]	105 HCWs	Randomized controlled trial	Internal medicine hospital staff at a university-affiliated hospital (scrubs)
Boutin et al, 2014[40]	90 HCWs; 720 samples	Cohort (longitudinal)	Nurses and patient care technicians in a large medical center (scrubs)
Qaday et al, 2015[41]	180 HCWs	Cross-sectional	Physicians and medical students at a referral and teaching hospital (white coats)
Mwamungule et al, 2015[42]	107 HCWs	Cross-sectional	All health workers wearing white coats in a university teaching hospital (white coats)
Scott et al, 2015[43]	89 HCWs	Cross-sectional	Student nurses in an urban hospital setting (scrubs)
Gupta et al, 2016[44]	10 HCWs	Cross-sectional	Nurses at a tertiary care government hospital (white coats)
Gupta et al, 2017[45]	10 HCWs	Cross-sectional	Nurses at a tertiary care hospital (white coats)
Anderson et al, 2017[46]	40 HCWs; 2,185 samples	Randomized controlled trial (crossover)	Nursing staff in medical/surgical ICUs in tertiary care hospital (scrubs)
Thom et al, 2018[47]	90 HCWs; 720 samples	Cohort (longitudinal)	Nurses and patient care technicians in a large medical center (scrubs)

HCWs, health care workers; *ICU*, intensive care unit.

Antimicrobial coating

Some fabrics are impregnated with antimicrobial substances such as organosilane-based quaternary ammonium, fluoroacrylate copolymer emulsion, complex compounds with a silver alloy, and chitosan. Three of 4 studies found no significant difference in isolates between antimicrobial scrubs and control scrubs.[37,39,40,46] For example, Burden et al[39] found no significant difference in colony counts at the end of a work day when comparing standard scrubs with those impregnated with proprietary antimicrobial chemicals with or without silver embedded in the fabric. Similarly, Boutin et al[40] found no difference in overall pathogenic bacteria, *S aureus*, *Enterococcus* spp, or gram-negative rods in scrubs treated with chitosan. However, 4.4% of antimicrobial-treated scrubs had MRSA, VRE, or multidrug resistant gram-negative rods compared to 7.8% of nontreated scrubs ($P = 0.06$). Bearman et al[37] discovered a significant 4-7 mean log reduction in MRSA with antimicrobial scrubs (organosilane-based quaternary ammonium and fluoroacrylate copolymer emulsion) versus control scrubs. This difference was not observable for VRE and gram-negative rods.

Laundering

Four studies revealed variability in average laundering frequency, with estimates ranging from 5%-65% of HCWs laundering their white coat ≤1 time every 2 weeks.[2,30,41,49] Surveys have shown students only launder white coats once every 3.5 weeks and even wear the same pair of scrubs over multiple days.[43,49]

Data show that providers launder white coats at home 64%-89% of the time.[2,30] Nordstrom et al[36] found higher bacterial contamination on home-laundered scrubs and unwashed scrubs compared with hospital-laundered and disposable scrubs. Of home-laundered scrubs, 44% tested positive for coliform bacteria, compared to 0% of those laundered in the hospital.

Limited literature exists regarding the details of laundering practices.[45] Bearman et al[4] found the greatest degree of eradication of gram-positive and gram-negative bacteria when washing at high temperatures was followed by tumble drying and ironing. Students reported using variable water temperatures when washing scrubs and only 5.6% use bleach. Scott et al[43] concluded that 35.7% of scrubs remained MSSA positive after home laundering. Finally, Munoz-Price et al[33,38] found a higher percentage of white coats to be contaminated than scrubs (45.4% vs 28.8%). White coats were also laundered less frequently than scrubs (12.4 ± 1.1 days vs 1.7 ± 0.1 days).

DISCUSSION

The focus on reducing the spread of bacteria in US hospitals during the past several decades has been centered on handwashing and sterilization of medical equipment.[53,54] Less attention has been directed toward the potential for spread of pathogens from HCW attire. Even with an increasingly negative public perception of health care professionals wearing uniforms outside of the workplace, providers and trainees continue to do so, posing a health risk of potentially spreading bacteria, especially MDROs.[6]

Data suggests that white coats have a higher degree of contamination than scrubs; uncoincidentally, they are laundered less frequently and at home rather than in the hospital.[33,38] A return to earlier practices, namely confining the wearing and laundering of scrubs to hospitals, would clearly reduce bacterial contamination. Hospital laundering of white coats is less commonly done, but similar arguments favor this practice.[45] The variation in microbial eradication by home laundering techniques can be linked to a lack of education and formal guidelines

Table 2
Microbial contamination of white coats

Manuscript	Banu et al, 2012[2]	Qaday et al, 2015[41]	Treakle et al, 2009[30]	Wong et al, 1991[28]	Uneke and Ijeoma, 2010[31]	Loh et al, 2000[29]	Cataño et al, 2012[34]	Gupta et al, 2017 [45]; 1st Shift	Gupta et al, 2017 [45]; 2nd Shift	Munoz-Price et al, 2012[33]	Wiener-Well et al, 2011[32]
Total # of cultures[a], positive cultures[b], white coats[c], or colony forming units (CFUs)[d]	128[b]	180[c]	149[c]	100[c]	103[c]	100[c]	52[b]	1222.5[d]	2322.5[d]	22[c]	52[a]
S aureus	91 (71%)	120 (67%)	34 (23%)	29 (29%)	18 (17%)	5 (5%)	-	-	-	7 (32%)	10 (19%)
MRSA	4 (4%)*	-	6 (4%)	0	-	0	-	-	-	0	-
MSSS	-	-	-	-	-	-	30 (58%)	-	-	-	-
MRSS	-	-	-	-	-	-	5 (10%)	-	-	-	-
Staphylococcus spp	-	-	-	-	-	100 (100%)	-	276 (23%)	444 (19%)	-	-
Enterobacteriaceae	-	3 (2%)	-	-	18 (17%)	-	-	553 (45%)	1109.5 (48%)	-	4 (8%)
Salmonella	-	-	-	-	-	-	-	40.5 (3%)	51.5 (2%)	-	-
Klebsiella	-	-	-	-	-	-	-	136.5 (11%)	173.5 (7%)	-	-
Acinetobacter spp	-	-	-	-	-	7 (7%)	-	-	-	7 (32%)	17 (33%)
Pseudomonas aeruginosa	19 (15%)	9 (5%)	-	-	9 (9%)	-	-	185 (15%)	428 (18%)	-	1 (2%)
Enterococcus	-	-	-	-	-	-	-	-	-	1 (5%)	-
VRE	-	-	0	-	-	-	-	12 (1%)	70.5 (3%)	0	-
Skin flora	18 (14%)	-	-	-	-	-	-	-	-	14 (64%)	-
Diphtheroids	-	-	-	-	49 (48%)	12 (12%)	-	-	-	-	-
Streptococcus spp	-	-	-	-	-	-	-	19.5 (2%)	45.5 (2%)	-	-
Bacillus	-	-	-	-	-	-	13 (25%)	-	-	-	-
Gram-negative	-	-	-	-	-	3 (3%)	-	-	-	-	-
Gram-negative rods	-	-	-	-	-	-	4 (8%)	-	-	-	-
MDROs	-	-	-	-	-	-	-	-	-	-	3 (6%)

NOTE: All percentages are based on the total for each specific column. A hyphen indicates not reported.
CFU, colony forming units; *MDRO*, multidrug-resistant organism; *MRSA*, methicillin-resistant *Staphylococcus aureus*; *MRSS*, methicillin-resistant staphylococcal spp; *MSSS*, methicillin-sensitive staphylococcal spp; *VRE*, vancomycin-resistant enterococci.
*Denotes number of white coats as n (% of total white coats).

Table 3
Microbial contamination of surgical scrubs

Manuscript	Krueger et al, 2012[35]; Precall scrubs	Krueger et al, 2012[35]; Postcall scrubs	Scott et al, 2015[43]	Thom et al, 2018[47]	Munoz-Price et al, 2012[33]	Wiener-Well et al, 2011[32]
Total number of cultures[a] or scrubs[b]	300[a]	300[a]	85[a]	720[a]	97[b]	32[a]
S aureus	0	33 (11%)	15 (18%)	116 (16%)	11 (11%)	4 (13%)
Coagulase-negative staphylococci	94 (31%)	271 (90%)	-	-	-	-
MRSA	0	0	0	-	-	-
Enterobacteriaceae	-	-	-	-	-	1 (3%)
Enterobacter cloacae	-	-	-	12 (2%)	-	-
Enterobacter aerogenes	-	-	-	2 (0.3%)	-	-
Escherichia coli	-	-	-	3 (0.4%)	-	-
Serratia marcescens	-	-	-	7 (1%)	-	-
Proteus mirabilis	-	-	-	3 (0.4%)	-	-
Klebsiella spp	-	-	-	27 (4%)	-	-
Acinetobacter spp	-	-	-	52 (7%)	11 (11%)	14 (43%)
Pseudomonas aeruginosa	-	-	-	13 (2%)	-	2 (6%)
Enterococcus	-	-	-	21 (3%)	3 (3%)	-
VRE	-	-	-	-	0	-
Skin flora	-	-	-	-	66 (68%)	-
Micrococci	-	51 (17%)	-	-	-	-
Viridans streptococci	8 (3%)	-	-	-	-	-
Gram-positive rods	34 (11%)	28 (9%)	-	-	-	-
Gram-negative	-	-	-	113 (16%)	-	-
MDROs	0	0	0	44 (6%)	-	3 (9%)

NOTE: All percentages are based on the total for each specific column. A hyphen indicates not reported.
MDRO, multidrug-resistant organism; *MRSA*, methicillin-resistant *Staphylococcus aureus*; *VRE*, vancomycin-resistant enterococci.

on how to properly clean HCW attire. Improved training could be provided on best practices. Additionally, an ideal fabric that minimizes bacterial colonization has not been identified; in fact, studies to date present conflicting results. More robust research, preferably controlled trials, needs to be conducted to determine the binding potential and length of survival of microbes on various fabrics.

Our study shows that many investigators have documented bacterial colonization of hospital attire. It is important to note, however, that a direct relationship between bacterial contamination of HCW's clothing and hospital-acquired infection has, to our knowledge, not been demonstrated.[2,28-35,41-43,45,47] In fact, some experts argue that there is little to implicate an association between the 2.[6-8] Hambraeus[5] has demonstrated that bacteria can be transferred from nursing gowns to both patients and bed linens. However, there is no definitive evidence that has linked bacterial colonization of attire with health care–associated infections (HAIs). One sole exception to this is a case series conducted by Barrie et al,[55] in which 2 patients were diagnosed with *Bacillus cereus* meningitis status postneurosurgery. An investigation concluded that lint from bed linens contaminated with *B cereus* spores likely served as the transmission source, eventually resulting in wound infection.[56]

Strategies to reduce bacterial contamination of white coats include sanitizing sleeves and pockets regularly in addition to altering the coat itself by shortening the overall length and sleeves.[9] In 2007, the UK Department of Health implemented BBE, a dress code requiring HCWs to wear attire with short sleeves or rolled up sleeves, and no white coats, jewelry, ties, watches, or rings when seeing patients at the bedside, to decrease nosocomial infections. This initiative was associated with a decrease in HAIs over a 5-year period, from 8.2% in 2006 to 6.4% in 2011. The policy is also now reflected in UK legislation.[57] Presumably, BBE allows for maintenance of proper hand hygiene, which has proven to be cost-effective in the reduction of nosocomial infections.[58] Bearman et al[4] reviewed hospital policies regarding HCW attire of 7 US institutions, finding that each outlined generic dress code requirements specifying professional attire, but did not address specifics aside from operating room attire (scrubs, masks, head covers, and footwear). Only 1 institution provided recommendations for physicians, and that was the BBE policy. Widespread adoption of similar provider attire policies may be beneficial for countries such as the United States

The use of proprietary antimicrobial coating on scrubs has increased in the last decade to combat colonization of bacteria on

Table 4
Suggestions for ways to reduce bacterial colonization of health care worker attire

- Actively increase frequency of laundering white coats—at least weekly and when visibly soiled.[4,28] Appropriate guidelines should be established for providers within each specialty based on type and frequency of patient-physician encounters.
- Scrubs should be changed each workday. Providers are encouraged to wear clean scrubs when exiting and returning to a hospital setting, even within a single shift.[59]
- If laundering a white coat or surgical scrubs at home, use a hot-water wash cycle and bleach to eliminate a greater percentage of bacterial contamination. Washing should be followed by heated drying.[4]
- HCWs should own multiple sets of clothing to assure appropriate laundering.[2,4]
- Wash or gel hands appropriately.
- Consider formal adoption of United Kingdom guidelines (no neck ties, bare below the elbows).[57]

Suggestions for hospitals and health care systems to reduce bacterial colonization of health care worker attire

- Determine whether provider attire should be laundered at home or within the institution—if within the hospital, complimentary or reduced-cost laundering services should be offered. Employees should be provided with recommendations for laundering attire outside of the hospital.[4,29]
- Recommend that each department provide multiple white coats and surgical scrubs for HCWs to encourage safe laundering practices.[4]
- Implement guidelines regarding laundering of provider attire outside the hospital.[57]
- Lead an orientation teaching best practices of provider attire maintenance.[49]
- Provide white coat hooks in residents' offices, conference rooms, and throughout hallways within clinical settings.[4]

HCWs, health care workers.

textiles. However, conclusions from several studies in this systematic review reveal no statistically significant differences between standard scrubs and scrubs treated with antimicrobial coating. The possibility remains that these studies may be underpowered.

Effectively reducing the spread of nosocomial infections and MDROs requires effort both by providers and hospital systems, starting with awareness of safe hygiene practices. Duroy and Le Coutour[49] surveyed medical students in clinical rotations, finding that 66.5% of students were dissatisfied by the quality of hospital hygiene training. Almost half reported being unaware of differences between antiseptic and simple handwashing practices.[49] Munoz-Price et al[33] found a statistically significant association between contamination of hands and white coats. Notably, this association was not observed with hands and scrubs, possibly owing to increased frequency of laundering.[33] These findings support a call for action for quality and safety committees to improve hygiene curriculum and provider attire guidelines. Suggestions for HCWs and hospitals are included in Table 4.

This systematic review is not without limitations. Each study provides its own set of guidance based on author opinion/rationale, practical considerations, and evidence of relatively low power. Differences also existed in methodology for culturing and sampling attire with studies searching for and targeting a variable set of isolates. There remains need for more robust research regarding potentially pathogenic bacterial transmission through HCW attire. Moreover, the efficacy of industrial versus domestic laundering of attire remains unexplored on a large scale, with research implicating the dilution of water, water temperature, and bleach level as potential factors in postlaundering microbial contamination of HCW attire.[6,60,61]

A distinction must be made between bacterial colonization and infection. Pathogens such as *S aureus* are often colonized in nasal epithelium, skin, hair, and other locations of healthy individuals. Clinically, however, it is the possibility of infection that is critical—that is, when these contaminants result in activation of pathological processes. Ascertaining the quantitative risk of spread of direct infection from HCW attire is challenging given real-world constraints and difficulty in mitigating confounding factors, even in controlled studies. Data reveal that colonization by MDROs is associated with higher rates of infection and outbreaks in clinical settings.[62,63] This has important implications for providers, especially those who routinely care for immunocompromised or intensive care unit patients.[64] Although there is no definitive evidence that HCW attire directly contributes to HAIs, the evidence that increased colonization can serve as a silent reservoir that causes infection in high-risk groups is compelling.

CONCLUSIONS

Hospitals worldwide are concerned about infection control and have implemented numerous patient safety protocols to combat horizontal transmission of infectious agents. The findings of this review suggest that provider attire is a potential source of transmission for pathogenic bacteria in health care settings. However, data confirming a direct link between provider attire and HAIs remains limited. It seems appropriate to develop protocols needed to reduce contamination of both white coats and surgical scrubs. The suggestions outlined in this article, based on available evidence, may serve as a guideline for health care professionals and hospital systems to reduce the spread of bacterial pathogens, including MDROs, that have the potential to precipitate hospital-acquired infections.

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