


Are Stethoscopes, Coats, and Pagers Potential Sources of Healthcare Associated Infections?

Global Pediatric Health
Volume 7: 1–7
© The Author(s) 2020
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/2333794X20969285
journals.sagepub.com/home/gph


Harbir S. Arora, MD^{1,2}, Deepak Kamat, MD, PhD³, Swati Choudhry, MD⁴, Basim I. Asmar, MD^{1,2}, and Nahed Abdel-Haq, MD^{1,2}

Abstract

We conducted a study to determine the rate of bacterial colonization of stethoscopes, coats, and pagers of residents at a pediatric residency training program as compared to that of badges, sleeves, and pagers of non-patient care staff (control group). Among 213 cultures obtained from 71 residents, 27 potential pathogens were isolated from 22 residents (27/213, 12.7%) as compared to 10 potential pathogens out of 162 samples obtained from 54 control participants (10/162, 6.2%) ($P = .0375$). The most common pathogen isolated from residents and control participants was methicillin sensitive *Staphylococcus aureus* (MSSA). The source of positive cultures among the residents was the stethoscope (8/22, 36.3%), pager (8/22, 36.3%), and coat sleeve (11/22, 50%). The rates of colonization with potential pathogens were higher among residents than control participants and about 12% of residents' stethoscopes, coats and pagers were colonized with bacterial pathogens. These are potential sources of nosocomial transmission of pathogenic organisms.

Keywords

Stethoscope, coat, pager, healthcare associated infections

Received June 26, 2020. Received revised September 2, 2020. Accepted for publication September 30, 2020.

Introduction

Healthcare-associated infections (HAIs), also known as nosocomial infections, are responsible for significant morbidity, mortality, and increased health care costs among hospitalized patients.^{1,2} It is estimated that, in the US, HAIs occur in 5% to 10% of acute care hospitalizations, which amount to more than 2 million episodes per year. HAIs are among the top 10 causes of death in the US and are responsible for almost 99 000 deaths annually.^{3,4} It is estimated that more than \$ 9.8 billion are spent in treating these infections in the US annually.⁵ It is also observed that approximately 70% of HAIs are caused by antibiotic resistant organisms and this resistance among the clinically important HAIs is increasing rapidly.⁶⁻⁸

There are multiple sources or vectors for HAIs. Suboptimal infection control practices among the health care providers and the hospitals lead to spread of HAIs among hospitalized patients. Proper hand hygiene by health care providers should be able to reduce the spread

of HAIs. However, there are other sources of infection, such as items of clothing including white coat, neck-ties and equipment such as stethoscopes and pagers, which may also play an important role in the spread of HAIs and this has demonstrated in previous studies.^{9,10}

None of the studies have, however, simultaneously cultured the pagers, the cuffs of the white coats and the stethoscopes of the same physicians. Proper control groups were also not included. We, therefore, conducted a study by getting simultaneous cultures from a group of pediatric residents' pagers, white coat cuffs, and stethoscopes. We concomitantly enrolled a control group that

¹Children's Hospital of Michigan, Detroit, MI, USA

²Wayne State University, Detroit, MI, USA

³UT Health Sciences Center San Antonio, San Antonio, TX, USA

⁴Baylor College of Medicine, Houston, TX, USA

Corresponding Author:

Nahed Abdel-Haq, Division of Infectious Diseases, Children's Hospital of Michigan, 3901 Beaubien Blvd, Detroit, MI 48201, USA.
Email: nabdel@dmc.org



included hospital employees who have no direct patient care responsibilities but work in the same environment. The aim of the study was to determine whether any of these items of clothing and equipment acquire any organism or of a set of microorganisms known to be associated with nosocomial infections. This has become particularly important in the current era of infections caused by methicillin resistant *Staphylococcus aureus* (MRSA) and resistant Gram negative pathogens.

Methods

Recruitment and Sampling

Pediatric residents were approached to participate in the study. A control group consisting of hospital workers who have no direct patient care responsibilities was also included in the study. The control group consisted of ward and department secretaries and clerks (inpatient and outpatient), courier service employees, security personnel, and librarians. The study was conducted at Children's Hospital of Michigan, Detroit, MI between June 2012 and June 2016.

Swabs were taken from the stethoscope diaphragms, lab coat cuffs from each resident as well as from pager surfaces. Cultures were obtained from each resident in the afternoon. The purpose was to get information on the acquisition of pathogenic bacteria during patient care and also hopefully provide indirect evidence on whether or not infection control measures were followed. The following demographic data were collected: date and time of culture, sites cultured, resident gender, post-graduate year and clinical service or specialty, unit/floor of rotation, last time lab coat was laundered, and last time the diaphragm of the stethoscope was cleaned.

In control participants, cultures were obtained from sleeves of coats or long shirts, front surface of badges (as opposed to stethoscopes in study subjects), and pagers when available. Demographic data collection for control subjects included only gender and type of service such as secretary, librarian, etc.

Microbiology

Methodology: Saline-moistened cotton sterile swabs were used to obtain cultures from the diaphragms of stethoscopes, pagers, badges, and the cuffs of lab coats. Swabs were transferred to the microbiology laboratory at Detroit Medical Center main laboratory within 2 hour of collection.

Swabs were streaked on blood and MacConkey agar plates, and these were read for pathogen screen. Further identification and susceptibility testing were performed

for suspected pathogenic bacteria using MicroScan Conventional Panels (Beckman Coulter, Brea, CA, USA).

Data Analysis

Data were summarized as total numbers (column percentages) for categorical variables and median (interquartile range) for continuous variables. Comparisons were made using the χ^2 test where appropriate. A finding would be considered statistically significant if the two-sided *P* value was less than .05. All analyses were conducted using Intercooled Stata software, version 8.2 (StataCorp, College Station, TX, USA).

Ethical Approval and Informed Consent

The study was approved by Wayne State University Institutional Review Board (IRB#0910210MP2E). All study participants consented to the study and were provided with an "Information Sheet" of the study in place of an informed consent form prior to enrollment.

Results

A total of 71 residents and 54 control participants were included in the study. Among residents, 48 were females; 28 were post graduate level (PGY) 1, 23 were PGY2, and 20 were PGY3. At time of obtaining cultures 5 residents were rotating in the outpatient general pediatric clinics and the rest were from residents rotating in different inpatient units including General Pediatrics (21) Infectious Disease (ID) (20), Hematology-Oncology (9), Newborn Nurse/Neonatal Intensive Care Unit (8), Pediatric Intensive Care Unit (3), Nephrology (3), and Cardiology (2).

The control participants included 54 non-health care providers including 48 females working in the same hospital building. The majority were secretaries in different units. All reported no direct contacts with patients. There were 7 control participants who had positive cultures for 10 organisms. The sites of positive cultures were coat, pager and badge in 5, 3, and 2 individuals respectively.

For controls, the time since coat was cleaned varied but 45% had cleaned their coats within the last day and 63% within the last 2 days. Among the 5 control participants who had positive cultures, 2 cleaned their coats at 1 day and 1 of each cleaned coat at 2 days, 2 weeks, and 3 weeks.

Among 213 cultures obtained from 71 residents, 22 (31% were positive for 27 pathogens (27/213, 12.7%) as compared to 10 positive cultures of pathogens out of 162 samples obtained from 54 control subjects (10/162,

Table 1. Sites of Positive Cultures in Residents and Controls.

Variable	Residents (71)	Controls (54)
Number of cultures	213	162
Positive cultures	25	10 ($P = .0375$)
Site of isolation		
• Coat sleeve	9	5
• Stethoscope/badge	8	2
• Pager	8	3

6.2%) ($P = .0375$) (Table 1). The most common pathogen isolated from residents was methicillin sensitive *Staphylococcus aureus* (MSSA) (11/22, 50%). Other pathogens isolated from residents included 2 of each methicillin resistant *Staphylococcus aureus* (MRSA), 1 group B *Streptococcus*, 2 *Pseudomonas luteola*, 2 *Micrococcus* species, and 3 *Acinetobacter radioresistans*; and 1 of each *Neisseria sp.*, Gram negative bacilli non lactose fermenter (Table 2). The source of positive cultures among the residents was the stethoscope (8/22, 36.3%), pager (8/22, 36.3%), and coat sleeve (11/22, 50%) (Table 2). The pathogens isolated from controls included 4 MSSA (4/7, 57.1%) 3 *Acinetobacter baumannii* (3/7, 42.8%) and one of each (1/7, 14.3%) *Enterococcus* species, *Rhizobium radiobacter* and MRSA (Table 3). There was no difference in the rates of colonization with non pathogenic organisms that included coagulase negative *Staphylococcus*, *Corynebacterium sp.*, and *Bacillus sp.* between residents and control group (data not shown).

Time since coat was cleaned among residents ranged 1 to 120 days (Mean: 13.4 days, Median: 7 days, Mode: 7 days). Of the 71 residents, 48 (68%) indicated that they cleaned their stethoscopes the same day cultures were obtained. Twenty two residents reported cleaning stethoscopes 1-14 days prior to obtaining culture (Mean: 2.68 days, Median: 1.5 days, Mode: 1 day). One PGY1 resident indicated that the stethoscope was never cleaned.

Of those residents who had positive cultures, all reported cleaning their stethoscopes same day or the day before except one who reported never cleaning the stethoscope and the culture grew *Pseudomonas luteola*. Regarding coats, residents who had positive cultures reported cleaning their coats 3-28 days prior to obtaining culture (Mean: 10.2 days, Median 7 days, Mode 3 and 7: 2 each).

There was no significant difference in rates of detection of potential pathogens among residents in regards to level of training. Positive cultures were obtained from 8 of 28 PGY1 residents, 9 of 13 PGY2 residents, and 8 of

20 PGY3 residents ($P = .639$). In addition, we have not found significant difference in rates of detection of potential pathogens in regards to residents' clinical rotations. Most patients with community acquired soft tissue infections are admitted to ID inpatient service. When we compared ID residents with the rest of the study group, there was no difference in rates of isolation of potential pathogens: 9 of 20 versus 19 of 51, $P = .596$. However, *Staphylococcus aureus* stains were isolated more frequently from ID residents (6/20, 30%) compared to other residents (5/51, 9.8%) but was not statistically significant $P = .0628$). All 11 *Staphylococcus aureus* stains (MSSA and MRSA) were isolated from residents rotating in ID service unit (6) and General Pediatric service units (5).

Discussion

Healthcare personnel clothing and devices have been investigated as vectors of transmission of nosocomial infections in multiples studies. These studies suggest that common equipment used by health care workers may serve as potential reservoirs and a vector of nosocomial infections.⁹ The present study sought to evaluate bacterial contamination of stethoscopes, coats, pagers, and badges in residents and to compare them with a group of other ancillary workers at a children's hospital. Our study has shown that white coats, stethoscopes, and pagers may get colonized with bacterial organisms which may play a role in transmission in the healthcare environment. *Staphylococcus aureus* was the most common isolated pathogen. However, other potential pathogens including Gram negative bacteria that may have infection control implications were also isolated from both groups.

The pager is a frequently used item among health care personnel especially among physicians including residents. Studies have shown that pagers frequently harbored organisms.¹¹⁻¹³ Pathogenic bacteria were isolated from 14% to almost 50% of cultured pagers.^{11,12} The most commonly isolated pathogen was *Staphylococcus aureus*. MRSA was infrequently isolated (3%) from pagers.¹³ In a study of hospital pagers, microorganisms were isolated from all tested pagers; *S. aureus* was isolated from 21%.¹³ In our study 8 organisms were isolated from 71 tested resident pagers and 3 of 54 control pagers harbored potential pathogens. The most commonly isolated organism was MSSA which accounted for 4/8 of organisms recovered from resident pagers and 1/3 organisms from control pagers. The rest were Gram negative organism including 2 *Acinetobacter baumannii* strains isolated from 2 different pagers of control participants.

Table 2. Organisms Isolated From 22 of 71 Residents According to Clinical Rotation, Level of Training and Site of Culture.

Rotation	Level of training PGY	Organism	Site of culture
Infectious diseases	2	MSSA	Stethoscope
Infectious diseases	2	MSSA	Stethoscope and Pager
Infectious diseases	2	MRSA	Stethoscope and coat
Infectious diseases	3	MSSA <i>Pseudomonas luteola</i>	Pager
Infectious diseases	2	MSSA	Coat
Infectious diseases	3	GBS	Coat
Infectious diseases	2	<i>Bacillus cereus</i>	Coat
Infectious diseases	3	GNB, NLF <i>Micrococcus</i> sp. (×2)	Stethoscope coat
Infectious diseases	3	MSSA	Coat
General pediatrics	1	<i>Acinetobacter radioresistans</i>	Coat
General pediatrics	1	MSSA	Stethoscope
General pediatrics	1	MSSA	Stethoscope
General pediatrics	1	<i>Pseudomonas luteola</i>	Stethoscope
General pediatrics	1	MSSA	Pager
General pediatrics	1	MSSA	Pager
General pediatrics	1	MSSA	Coat
Hematology/oncology	2	<i>Acinetobacter radioresistans</i>	Pager
Hematology/oncology	1	<i>Pseudomonas oryzihabitans</i>	Pager
Newborn nursery	2	<i>Bacillus cereus</i>	Coat
Newborn nursery	2	<i>Bacillus cereus</i>	Coat
Cardiology	2	<i>Neisseria</i> sp.	Stethoscope
Nephrology	3	<i>Acinetobacter radioresistans</i>	Pager

MSSA, Methicillin susceptible *Staphylococcus aureus*. MRSA, Methicillin resistant *Staphylococcus aureus*.

The time of cleaning the pagers may influence isolation of organisms. Singh et al have demonstrated that disinfection with 70% isopropyl alcohol reduced the colony count by an average of 94%.¹³ Beer et al¹¹ demonstrated that the 0.5% chlorhexidine-70% isopropyl alcohol wipes were more efficacious in eliminating all bacterial growth on pagers than 70% isopropyl alcohol. However, it remains unclear how frequent the cleaning is needed. Cleaning of pagers was not a common practice among physicians and residents in our hospital, thus data on cleaning was not collected. In another study only 12% of healthcare workers cleaned their pagers.¹³ However, our findings suggest that regular disinfection of pagers should be implemented by health care workers to prevent spread of potential pathogens including invasive Gram negatives such as *Acinetobacter* species.

Coagulase negative *Staphylococcus* and *Corynebacterium* species were isolated from a substantial number of participants in our study. Although these organisms are considered skin contaminants and were isolated from both study groups, they may become potential pathogens in intensive care or hematology/oncology units where patients are acutely ill and immunocompromised.^{14,15}

It has been demonstrated that gram-positive bacteria are transmitted more readily from environmental surfaces, followed by viruses and gram-negative bacteria.¹⁶

Gram negative organisms are frequently isolated from the hospital environment and may colonize the skin, but have been implicated in healthcare associated infections.¹⁷ Gram negative organisms and enterococci are infrequently isolated from pagers and stethoscopes. This may be related to the fact that these organisms need a warm and moist environment to survive which is not typically found on such equipment.¹⁸ However, in our study, we isolated *Acinetobacter baumannii* from the sleeves of the coat and pagers of 2 controls. Other *Acinetobacter* species were isolated from the pagers of 2 residents. *Acinetobacter baumannii* can be found in the surrounding hospital environment of colonized patients and in room humidifiers.¹⁹ *Enterococcus* species was isolated from the sleeves of 1 coat. In contrast to Gram negative organisms, *Staphylococcus aureus* is able to survive for extended periods of time on dry surfaces which may explain why this organism has been found to be the most common isolated organism in different studies including ours.²⁰ Although stethoscopes tend to be cleaned by healthcare workers, pagers are rarely cleaned and are touched frequently before and after examining patients without being cleaned.

Pathogenic bacteria were isolated from healthcare worker uniforms such as coats in our study and by others indicating these uniforms may serve as potential sources of nosocomial infections.^{10,21} In a study from Israel, up

Table 3. Organism Isolated From 7 of 54 Control Participants and Site of Culture.

Organism	Site of culture
<i>Enterococcus</i> sp.	Coat
MSSA	Badge and pager
MSSA	Badge and coat
MRSA	Coat
<i>Acinetobacter baumannii</i>	Pager and coat
<i>Acinetobacter baumannii</i>	Pager
<i>Rhizobium radiobacter</i>	Coat

to 60% of hospital staff uniforms including physicians and nurses were colonized with potential pathogens including drug-resistant organisms.²² A study from Tanzania has shown that up to 73% of white coats screened were contaminated with bacteria.²³ Another study has demonstrated that 23% of coats worn by health professionals were colonized with *Staphylococcus aureus* including 4% with MRSA.²⁴ White coat bacterial contamination has been widely variable and ranged from 23% to 95% in different studies.^{24,25} The source of contamination can be bacterial shedding from patients to the hospital environment or direct shedding from the patients' skin onto the white coats.^{26,27} Higher isolation of *S. aureus* seems to correlate with more patient contact and in areas with increased risk of environmental contamination.²³ In our study, we isolated different organisms from coats including staphylococci and Gram negative organisms. MRSA strains were isolated concomitantly from the coat and stethoscope of a resident. It was also isolated from the coat of a control participant. This suggests that coats may serve a vector of transmission of *S. aureus* and other bacteria between patients in the hospital environment as was previously reported.²⁴ In addition to white coat sleeves, others have reported pockets as a common source of bacterial colonization.²⁸

In our study, 12.6% of white coats of residents and 9.2% of the control group participants coats were contaminated with potential pathogens. The residents who had positive cultures of their coat sleeves had cleaned their coats at a median of 7 days prior to obtaining cultures which is relatively long but was similar to the other residents. In contrast, 63% of control group participants in our study reported cleaning their coats within the 2 previous days. Among the five control participants who had positive cultures, 3 reported cleaning coats within previous 2 days and 2 cleaned their coats 2 and 3 weeks earlier. Studies have shown that lower rates of contamination were noted when white coats were laundered daily.^{23,24} However, others have reported that contamination rates of coats may not correlate with the length of time that they are used.^{29,30}

In our study 68% of residents reported cleaning their stethoscopes the same day cultures were obtained. Of those residents who had positive cultures, all except one reported cleaning their stethoscopes same day or the day before. Previous studies have shown that only 22% of healthcare workers were regularly cleaning their stethoscopes.³¹ Studies have shown that the rates of isolation of *S. aureus* varied among healthcare workers in different units. MRSA was found on the gowns and uniforms of 65% healthcare workers involved in care activities of MRSA infected patients as well as on the gloves of 42% of healthcare workers who had contact with the environment of MRSA patients.³² In addition, we have not found significant difference in rates of detection of potential pathogens in regards to residents' clinical rotations. However, there was a trend to isolate *Staphylococcus aureus* stains more frequently from ID residents than others (30% vs 9.8%) likely due to higher exposure to patients with soft infections among ID residents. In addition, the detection rate of potential pathogens among residents was similar regardless of the post graduate training level. The hands of the healthcare workers may be another source of contamination of white coats and pagers with organisms that are present in the hospital environment.^{33,34}

There are no standard rules for cleaning equipment, stethoscopes, and coats. However, according to our hospital policy, residents, and faculty members are expected to clean their stethoscopes top to bottom with 70% ethyl alcohol wipes before after each patient exam. Regarding coats, residents and faculty members are expected to wash or change their coats when soiled or at regular intervals not to exceed 2 weeks using hospital grade laundry. Pagers are expected to be cleaned with hospital approved germicidal wipes.

Regular cleaning of equipment and coats needs to be emphasized as an infection control measure. However, hand washing and barrier protection remain the simplest and most effective measures in infection prevention. Hand washing has been shown to prevent carriage of potential pathogens as well reduce mortality caused by nosocomial infections.³⁵ However, compliance with hand washing remains a challenge in hospital settings. It is possible that hand washing can reduce colonization of equipment used by healthcare workers including stethoscopes and pagers. Our study suggests that practicing hand hygiene should not be limited to health care workers in direct patient care but should include all ancillary workers in the hospital environment.

Limitations of our study include a single center study. The number of controls and the cultures obtained from them were less than those of the pediatric residents. It is also possible that some participants were not able to recall the accurate times when their personal items were

last cleaned. In addition, the coats were washed at different time intervals and the conditions of cleaning of the coats among study participants were not included in the data analysis. This may be another study limitation.

Acknowledgments

We thank Ronald Thomas, PhD for assistance with statistical analysis.

Author Contributions

HSA, SC: Data Collection and analysis, critical revision of the first draft and contribution to intellectual content. DK, BIA: Conception or design of the work, critical revision of the first draft and contribution to intellectual content. NAH: Conception or design of the work, data analysis and interpretation, drafting and finalizing the article. All authors approved the final version of the manuscript to be published.

Declaration of Conflicting Interests


The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by a grant from Children's Research Center of Michigan and Children's Hospital of Michigan Foundation.

ORCID iD

Harbir S. Arora  <https://orcid.org/0000-0001-8393-2863>

Nahed Abdel-Haq  <https://orcid.org/0000-0001-6957-4756>

References

- Emori TG, Gaynes RP. An overview of nosocomial infections, including the role of the microbiology laboratory. *Clin Microbiol Rev.* 1993;6:428-442.
- Yalcin AN, Hayran M, Unal S. Economic analysis of nosocomial infections in a Turkish university hospital. *J Chemother* 1997;9:411-414.
- Haque M, Sartelli M, McKimm J, Abu Bakar M. Health care-associated infections – an overview. *Infect Drug Resist.* 2018;11:2321-2333.
- Klevens RM, Edwards JR, Richards CL Jr, et al. Estimating health care-associated infections and deaths in U.S. hospitals, 2002. *Public Health Rep.* 2007;122:160-166.
- Zimlichman E, Henderson D, Tamir O, et al. Health care-associated infections: a meta-analysis of costs and financial impact on the US health care system. *JAMA Intern Med.* 2013;173:2039-2046.
- Burke JP. Infection control – a problem for patient safety. *N Engl J Med.* 2003;348:651-656.
- Jones RN. Resistance patterns among nosocomial pathogens: trends over the past few years. *Chest.* 2001; 119:397s-404s.
- Sievert DM, Ricks P, Edwards JR, et al. Antimicrobial-resistant pathogens associated with healthcare-associated infections: summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2009-2010. *Infect Control Hosp Epidemiol.* 2013;34:1-14.
- Haun N, Hooper-Lane C, Safdar N. Healthcare personnel attire and devices as fomites: a systematic review. *Infect Control Hosp Epidemiol.* 2016;37:1367-1373.
- Mitchell A, Spencer M, Edmiston C Jr. Role of healthcare apparel and other healthcare textiles in the transmission of pathogens: a review of the literature. *J Hosp Infect.* 2015;90:285-292.
- Beer D, Vandermeer B, Brosnikoff C, Shokoples S, Rennie R, Forgie S. Bacterial contamination of health care workers' pagers and the efficacy of various disinfecting agents. *Pediatr Infect Dis J.* 2006;25:1074-1075.
- Namias N, Widrich J, Martinez OV, Cohn SM. Pathogenic bacteria on personal pagers. *Am J Infect Control.* 2000; 28:387-388.
- Singh D, Kaur H, Gardner WG, Treen LB. Bacterial contamination of hospital pagers. *Infect Control Hosp Epidemiol.* 2002;23:274-276.
- Becker K, Heilmann C, Peters G. Coagulase-negative staphylococci. *Clin Microbiol Rev.* 2014;27:870-926.
- Oliveira A, Oliveira LC, Aburjaile F, et al. Insight of genus corynebacterium: ascertaining the role of pathogenic and non-pathogenic species. *Front Microbiol.* 2017;8:1937.
- Rusin P, Maxwell S, Gerba C. Comparative surface-to-hand and fingertip-to-mouth transfer efficiency of gram-positive bacteria, gram-negative bacteria, and phage. *J Appl Microbiol.* 2002;93:585-592.
- Taneja N, Emmanuel R, Singh M, Sharma M. Hospital environment contamination with Gram-negative bacteria is as common and important as that with Gram-positive bacteria in an overloaded tertiary care hospital in India. *J Hosp Infect.* 2005;59:164-165.
- Gould D, Chamberlain A. Gram-negative bacteria. The challenge of preventing cross-infection in hospital wards: a review of the literature. *J Clin Nurs.* 1994;3:339-345.
- Wong D, Nielsen TB, Bonomo RA, Pantapalangkoor P, Luna B, Spellberg B. Clinical and pathophysiological overview of Acinetobacter infections: a century of challenges. *Clin Microbiol Rev.* 2017;30:409-447.
- Chaibenjawong P, Foster SJ. Desiccation tolerance in Staphylococcus aureus. *Arch Microbiol.* 2011;193:125-135.
- Wong D, Nye K, Hollis P. Microbial flora on doctors' white coats. *BMJ.* 1991;303:1602-1604.
- Wiener-Well Y, Galuty M, Rudensky B, Schlesinger Y, Attias D, Yinnon AM. Nursing and physician attire as possible source of nosocomial infections. *Am J Infect Control.* 2011;39:555-559.
- Mwamungule S, Chimana HM, Malama S, Maima G, Kwenda G, Muma JB. Contamination of health care

- workers' coats at the University Teaching Hospital in Lusaka, Zambia: the nosocomial risk. *J Occup Med Toxicol*. 2015;10:34.
24. Treakle AM, Thom KA, Furuno JP, Strauss SM, Harris AD, Perencevich EN. Bacterial contamination of health care workers' white coats. *Am J Infect Control*. 2009; 37:101-105.
 25. Pilonetto M, Rosa EA, Brofman PR, et al. Hospital gowns as a vehicle for bacterial dissemination in an intensive care unit. *Braz J Infect Dis*. 2004;8:206-210.
 26. Boyce JM, White RL, Spruill EY. Impact of methicillin-resistant *Staphylococcus aureus* on the incidence of nosocomial staphylococcal infections. *J Infect Dis*. 1983; 148:763.
 27. Muto CA, Jernigan JA, Ostrowsky BE, et al. SHEA guideline for preventing nosocomial transmission of multidrug-resistant strains of *Staphylococcus aureus* and enterococcus. *Infect Control Hosp Epidemiol*. 2003; 24:362-386.
 28. Manian FA, Ponzillo JJ. Compliance with routine use of gowns by healthcare workers (HCWs) and non-HCW visitors on entry into the rooms of patients under contact precautions. *Infect Control Hosp Epidemiol*. 2007;28: 337-340.
 29. Banu A, Anand M, Nagi N. White coats as a vehicle for bacterial dissemination. *J Clin Diagn Res*. 2012;6:1381-1384.
 30. Burden M, Cervantes L, Weed D, Keniston A, Price CS, Albert RK. Newly cleaned physician uniforms and infrequently washed white coats have similar rates of bacterial contamination after an 8-hour workday: a randomized controlled trial. *J Hosp Med*. 2011;6:177-182.
 31. Bernard L, Kereveur A, Durand D, et al. Bacterial contamination of hospital physicians' stethoscopes. *Infect Control Hosp Epidemiol*. 1999;20:626-628.
 32. Boyce JM, Potter-Bynoe G, Chenevert C, King T. Environmental contamination due to methicillin-resistant *Staphylococcus aureus*: possible infection control implications. *Infect Control Hosp Epidemiol*. 1997;18:622-627.
 33. Varghese D, Patel H. Hand washing. Stethoscopes and white coats are sources of nosocomial infection. *BMJ*. 1999;319:519.
 34. Harris AD, Samore MH, Nafziger R, DiRosario K, Roghmann MC, Carmeli Y. A survey on handwashing practices and opinions of healthcare workers. *J Hosp Infect*. 2000;45:318-321.
 35. Rhee V, Mullany LC, Khatri SK, et al. Maternal and birth attendant hand washing and neonatal mortality in southern Nepal. *Arch Pediatr Adolesc Med*. 2008;162:603-608.