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

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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

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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

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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, postgraduate 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, 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 \( \chi^2 \) 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,
Number of cultures 213 162
Positive cultures 25 10 (∏ = 0.0375)
Site of isolation
• Coat sleeve 9 5
• Stethoscope/badge 8 2
• Pager 8 3

6.2%) (∏ = 0.0375) (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 baumanii (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 (∏ = 0.639). 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, ∏ = 0.596. 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 ∏ = 0.0628. 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 form 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 baumanii strains isolated from 2 different pagers of control participants.
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%. Beer et al 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. 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 immuno compromised.

It has been demonstrated that gram-positive bacteria are transmitted more readily from environmental surfaces, followed by viruses and gram-negative bacteria. Gram negative organisms are frequently isolated from the hospital environment and may colonize the skin, but have been implicated in healthcare associated infections. 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. However, in our study, we isolated Acinetobacter baumanii from the sleeves of the coat and pagers of 2 controls. Other Acinetobacter species were isolated from the pagers of 2 residents. Acinetobacter baumanii can be found in the surrounding hospital environment of colonized patients and in room humidifiers. 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. 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. In a study from Israel, up
to 60% of hospital staff uniforms including physicians and nurses were colonized with potential pathogens including drug-resistant organisms. A study from Tanzania has shown that up to 73% of white coats screened were contaminated with bacteria. Another study has demonstrated that 23% of coats worn by health professional were colonized with Staphylococcus aureus including 4% with MRSA. White coat bacterial contamination has been widely variable and ranged from 23% to 95% in different studies. 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. Higher isolation of S. aureus seems to correlate with more patient contact and in areas with increased risk of environmental contamination. In our study, we isolated different organisms from coats including staphylococci and Gram negative organisms. MRSA strains were isolated concurrently 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. In addition to white coat sleeves, others have reported pockets as a common source of bacterial colonization.

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. However, others have reported that contamination rates of coats may not correlate with the length of time that they are used.

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. 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. 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.

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. 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

| Organism                     | Site of culture |
|------------------------------|-----------------|
| Enterococcus sp.             | Coat            |
| MSSA                         | Badge and pager|
| MSSA                         | Badge and coat  |
| MRSA                         | Coat            |
| Acinetobacter baumanii       | Pager and coat  |
| Acinetobacter baumanii       | Pager           |
| Rhizobium radiobacter        | Coat            |
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.

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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

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