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Study on Bacteria Associated with White Coats of Healthcare Workers in Two Tertiary Hospitals, Mashhad, Iran

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ABSTRACT

Background: Health care-associated infections are an important cause of morbidity and mortality in hospitals. Reports have shown that nurses' uniforms are sources of health care-associated infection transmission. The present study assessed the rate of bacterial contamination of healthcare worker's white coats in two tertiary hospitals in Mashhad, Iran.

Methods: 300 healthcare workers participated in the study from July to October 2011. Samples were obtained with a sterile swab from the outer surfaces of three sites of the white coat including the cuff, pocket mouth of the dominant hand and abdominal region. The samples were examined according to standard procedures.

Results: Overall, 1220 microorganisms belonging to 13 different genera were isolated from a total of 900 samples. All 300 white coats were contaminated by bacteria of which 282 (94%) were pathogenic. The abdominal region had significantly higher number of isolates than the pocket and sleeve ($p = 0.02$). The white coats of "cardiac surgery ICU" and "surgery ward" had the mean highest number of isolates. Gram-positive *Bacilli* (36.1%) were the most common isolates followed by *Staphylococcus aureus* (28%) and coagulase-negative *Staphylococci* (24.8%).

Conclusion: Health care workers' white coats are contaminated with a variety of bacteria. In order to reduce cross contamination from white coats to patients, re-educational programs and stricter rules of laundering and changing white coats are suggested.

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Introduction

Health care-associated infections (HAIs) usually become evident 48 hours (i.e., the typical incubation period) or more after admission (1). The prevalence of these infections is estimated to be about 5-10% in developed and 25% in developing countries (2, 3). Center for disease control and prevention (CDC) estimated that 1.7 million HAIs occurred in US hospitals in 2002 and were associated with approximately 99,000 deaths (4). Although difficult, many of these infections (~15-32%) seem to be preventable (5).

The first step in controlling health-care associated infections is identifying the probable source of infectivity in each hospital. With increasing levels of multiple antibiotic resistant bacteria in hospital settings, the role of environmental factors in the spread of infection is being examined (6). Reports have shown that an important spread of infection from patient to patient is via clothes. Nurses' uniforms and other hospital garments have been indicated to play a possible role in transmitting pathogenic bacteria such as *Staphylococcus aureus* in the hospital environment (7-9). Therefore, the presence of bacteria on white coats and their possible dissemination should be studied. The present study investigated the presence of bacterial contamination on healthcare workers white coats in Imam Reza and Quaem hospitals of Mashhad, Iran.

Material and Methods

This descriptive cross-sectional study was carried out from July 2011 to October 2011. 300 health care workers which included medical students (23%), physicians (20%) and nurses (57%) participated in the study. 198 (66%) of white coats were from Imam Reza Hospital and 102 (34%) from Quaem Hospital. Participants were requested to fill out a checklist assessing demographic data, the duration that their white coat had been in use, whether they had a spare white coat and days since their coat had been laundered. Also, the cleanliness of the coat in appearance was graded as clean, moderately clean or dirty by a single observer and the participant himself / herself.

All study supplies were obtained from Merck Company (Germany). Samples were taken by three members of the research team with a sterile swab from the outer surface of three sites of the white coat; the cuff and pocket mouth of the dominant hand, and the abdominal region. These are the regions with the highest probability of contamination (10). 4 cm^2 areas of each region were sampled with moist swabs and swabs were immediately inoculated in brain-heart infusion (BHI) broth tubes. After 24 to 48 h of incubation in 35°C, the broths were examined for growth; if positive, then the BHI was subcultured on blood agar plates (trypticase soy agar with 5% sheep's blood); Blood agar plates were evaluated qualitatively by colony shape, hemolysis pattern, biochemical tests, gram staining and microscopy. Independent T test and one-way ANOVA were used for analyzing the data with SPSS ver.16.0.

Results

Overall, 1220 microorganisms belonging to 13 different genera were isolated from a total of 900 samples. All 300 white coats were contaminated of which 282 (94%) were contaminated with pathogenic bacteria. Pathogenic bacteria were *S. aureus*, coagulase-negative *Staphylococcus*, *Streptococci* spp., *Acinetobacter* spp., *Klebsiella pneumoniae*, *Enterobacter aerogenes*, *Pseudomonas aeruginosa* and *Escherichia coli (Table 1).* One (0.3%), 14 (4.7%) and 285 (95%) of the white-coats had respectively one, two and more than two different microorganisms.

Number of positive bacteria isolates on white coats from Quaem Hospital was significantly higher than those from Imam Reza hospital (t = 4.64, df = 298, $p < 0.001$). There was no significant difference between the two hospitals in correspondence with the number of genera (t = 1.89, df = 298, $p = 0.06$) and pathogenic bacteria (t = 0.70, df = 298, $p = 0.49$) found on white coats.

Table 1. Frequency of different microorganisms detected on three regions of the white coats

Microorganism	White coats contaminated		Frequency of Isolates							
			Cuff		Pocket		Abdominal region		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Gram-positive *Bacillus*	238	(79.3)	138	(35.2)	142	(35.9)	160	(37)	440	(36.1)
Staphylococcus aureus	211	(70.3)	118	(30.1)	102	(25.8)	121	(28)	341	(28)
coagulase-negative *Staphylococcus*	193	(64.3)	93	(23.7)	108	(27.3)	102	(23.6)	303	(24.8)
Streptococci spp.	28	(9.3)	8	(2)	14	(3.5)	8	(1.9)	30	(2.5)
Tetrad	24	(8)	9	(2.3)	5	(1.3)	15	(3.5)	29	(2.4)
Acinetobacter spp.	18	(6)	6	(1.5)	7	(1.8)	10	(2.3)	23	(1.9)
Klebsiella pneumoniae	16	(5.3)	6	(1.5)	5	(1.3)	8	(1.9)	19	(1.6)
Enterobacter aerogenes	12	(4)	5	(1.3)	3	(0.8)	5	(1.2)	13	(1.1)
Pseudomonas aeruginosa	4	(1.3)	6	(1.5)	3	(0.8)	2	(0.5)	11	(0.9)
Escherichia coli	1	(0.3)	0	(0)	0	(0)	1	(0.2)	1	(0.1)
Mucor	2	(0.7)	0	(0)	2	(0.5)	0	(0)	2	(0.2)
Candida spp.	6	(2)	3	(0.8)	3	(0.8)	0	(0)	6	(0.5)
Acremonium	1	(0.3)	0	(0)	1	(0.3)	0	(0)	1	(0.1)
Nocardia	1	(0.3)	0	(0)	1	(0.3)	0	(0)	1	(0.1)
Total	300	(100)	392	(100)	396	(100)	432	(100)	1220	(100)

181 (60.3%) of the participants were female. No significant difference was found between white coats of female and male participants in terms of frequency (t = 0.77, df = 298, $p = 0.44$) and genera of bacteria isolated (t = 0.95, df = 298, $p = 0.34$). The number of pathogenic isolates was

significantly higher in white coats of nurses than that of medical students (SE = 0.168, CI = 95% $p = 0.015$), but neither had significant difference with white coats of physicians. There was no significant difference among the contamination of white coats of nurses ($F_{(4,171)} = 0.249$, $p = 0.9$) or physicians ($F_{(2, 58)} = 0.094$, $p = 0.9$) or medical students ($F_{(3, 67)} = 1.52$, $p = 0.2$) with varying educational degrees. Number of isolates was not significantly higher on the white coats perceived dirty than those perceived clean ($p > 0.05$).

The abdominal region was contaminated with a significantly higher number of isolates than the pocket and cuff regions ($F_{(2,899)} = 4.371$, $p = 0.013$, Table 1). No significant association was found between time since laundering or weekly and daily usage of the white coats and the total number of isolates and pathogenic isolates. Also, there was no association between the coats' total isolates or organism diversity and the participants' working shift or whether they owned a spare coat. However, lower rate of positive isolates was observed on white coats of personnel working in a single ward ($t = 2.61$, $df = 234$, $p = 0.01$) (*Table 2*).

Table 2. Mean number of microorganisms per white coat differentiated by work situation, frequency of usage and laundry habits

Category		No. of coats sampled	Isolate		Species	
			Total	Pathogenic	Total	Pathogenic
Work shift (s)	one	124	4.1 ns	2.59 ns	2.48 ns	1.65 ns
	over one	176	4.04	2.44	2.55	1.64
Work location (s)	one	158	3.99 *	2.46 ns	2.51 ns	1.65 ns
	over one	78	4.4	2.55	2.67	1.67
Owns spare coat	no	172	4.1 ns	2.47 ns	2.54 ns	1.62 ns
	yes	60	4.03	2.5	2.57	1.75
Hours used per day	< 4 hours	9	3.78	1.89	2.22	1.33
	> 4 hours, < 8 hours	149	4.15	2.58	2.52	1.66
	> 8 hours, < 12 hours	84	3.83	2.35	2.45	1.55
	> 12 hours, < 16 hours	25	4.16	2.88	2.44	1.76
	> 16 hours, < 20 hours	33	4.27	2.42	2.82	1.79
Days used per week	≤ 4 days	60	4.08 ns	2.65 ns	2.42 ns	1.6 ns
	> 4 days	240	4.06	2.47	2.54	1.6
Time since last launder	1 day	27	3.89	2.63	2.52	1.7
	2 days	32	3.81	2.22	2.38	1.5
	3 days	46	4.46	2.83	2.72	1.7
	7 days	109	4.16	2.56	2.55	1.6
	14 days	38	4.0	2.21	2.32	1.3
	> 14 days	21	3.95	2.05	2.52	1.5

ns In a column means within a category are not significantly different ($p > 0.05$)

*** In a column means within a category are significantly different ($p < 0.05$)**

There was a significant difference among wards of the hospitals in terms of the total number of isolates ($F_{(11, 299)} = 2.56$, $P = 0.004$), number of pathogenic isolates ($F_{(11, 299)} = 3.02$, $p = 0.001$) and diversity of pathogenic microorganisms ($F_{(11, 299)} = 2.70$, $p = 0.003$). White coats of "cardiac surgery ICU" and "surgery ward" had the mean highest number of positive isolates (*Table 3*).

Table 3. Number of samples and isolates collected from white coats in different wards

Ward	Number of samples (coat × region)	Total isolates		Pathogenic isolates	
		No.	%	No.	%
Burn	66	78	6.4	70	9.3
Cardiac surgery ICU	33	54	4.4	33	4.4
Cardiology	24	36	3	17	2.3
Dermatology	6	7	0.6	5	0.7
Ear nose and throat	18	26	2.1	19	2.5
Emergency	81	105	8.6	56	7.5
Hemodialysis	48	69	5.7	39	5.2
Infectious Disease	168	204	16.7	118	15.7
Internal Medicine	264	368	30.2	221	29.4
Microbiology	39	53	4.3	26	3.5
Pediatric Ward	93	127	10.4	83	11.1
Surgery	60	93	7.6	64	8.5
Total	900	1220	100	751	100

Gram-positive *Bacilli* (36.1%) were the most common isolates followed by *S. aureus* (28%), coagulase-negative *Staphylococci* (24.8%) and *Streptococci* spp. (2.5%) *(Table1).* With regard to pathogenic bacteria, 250 (70.3%) and 230 (64.3%) out of 300 white coats were contaminated by *S. aureus* and coagulase-negative *Staphylococci*, respectively. The fungus *Mucor* was identified on 2 white coats, one from burn ward of Imam Reza hospital and the other from the internal ward of Quaem hospital. Candida species were indentified from 6 white coats in burn, cardiac surgery ICU and hemodialysis wards. The pocket region had the highest prevalence of fungi (*Table 1*).

Discussion

The present study suggests that healthcare workers' white coats were contaminated with potentially pathogenic microorganism particularly *S. aureus* and *Streptococci*. It is reasonable to expect the contamination of white coats with microorganisms because of the frequency of patient contact and the busy schedule of healthcare workers as demonstrated by many researchers (9, 11-13). Pathogenic bacteria contaminated 94% of the white coats (*Table 1*). The contamination rate may vary depending on the place and time of sampling as Perry *et al*. reported that 22 out of 57 uniforms (39%) sampled at the commencement of duty were positive increasing to 31 (54%) at the end of duty (9). However, in the present study white coats were sampled randomly during duty. Similarly, Akbari *et al* in a hospital of Khoramabad, Iran also indicated that all white coats sampled were contaminated by microorganisms in at least one region of the coat (7). Sampling at three sites of white coats in three hospitals in UK, Loh *et al* found that all the white coats were contaminated to varying degrees (11). Investigations from other countries showed

white coats' contamination ranging from 23% to 95% (14, 15).

The most common type of microorganism found on various sites was gram-positive *Bacillus* species (79.3% of white coats, table 1), most previous studies recorded lower rates of this bacterium (11, 12, 15). Gram-negative bacilli and other forms of microbes which are considered environmental micro-organisms with no clinical significance and skin commensals such as coagulase-negative *staphylococci* were also found which is consistent with previous studies (15-18).

A total of 341 isolates of *S. aureus* were found on 211 white coats, which was the most common pathogen isolated. Whereas studies by Wong *et al*, Loh *et al*, and Akbari *et al* reported that coagulase-negative *staphylococci*, diphtheroid species and *Acinetobacter* spp. were the most common isolates; these authors found *S. aureus* in only 29 out of 100, 5 out of 100 and 1 out of 340 white coats, respectively (7, 11, 15). *S. aureus* is considered as a long persistent microorganism on inanimate surfaces and found to be responsible for the majority of infections in our hospitals. The low rate of *S. aureus* in the above mentioned studies might be due to the fact that only physicians were included, whereas in our study we also evaluated the white coats of nurses who usually contact the patients more frequently.

No significant correlation was found between bacterial prevalence and educational degrees within each group of physicians, nurses, and medical students. Nurses had significantly more pathogenic isolates on their white coats compared medical students. Possible explanations are that nurses have frequent close contact with patients and wear their white coats in different areas of the hospital when not necessary and are also not aware of the potential relationship between the carriage of bacteria on white coats and nosocomial infections (8). Furthermore, the results demonstrated that most healthcare workers laundered their white coats one week before the date of sampling (*Table 2*).

Among three sites selected for examination of white coats, the abdominal region was the most contaminated. Pilonetto *et al* also found that bacterial counts in samplings at the end of work period were higher in the abdominal region than in the cuffs (14). In contrast, some studies reported pockets and sleeves as the most contaminated sites (11, 15, 17). Based on colony count, Burden *et al* reported no difference in microbial contamination between pockets and sleeve cuffs (19). During clinical examination or giving services to patients, abdominal site of white coats seems to be the most common region in close contact with patients and their beds. Specific postures of personnel during duty and frequent contact of abdominal site with unwashed hands might be considered as behaviors contributing to the present findings; although such behaviors were not monitored in this study.

In this survey, time since laundering and the duration of white coat usage did not influence the number of isolates on white coats. This is in correspondence with Treakle *et al* findings in which no association was found between time since laundering and contamination by *S. aureus* (12). Similarly in Loh's study there was no correlation between the frequency of laundering and the bacterial contamination at any of the sample sites (11). Burden *et al* also

indicated no significant difference between the extents of bacterial contamination of infrequently and newly-washed coats (19). These data suggest that once worn the coats may quickly become contaminated, or that laundry techniques may have little effect on removing microorganisms.

White coats of "cardiac surgery ICU" and "surgery ward" had the mean highest number of positive isolates. Studies of Akbari *et al* in a hospital in Iran indicated that emergency and surgery wards had the most contaminated white coats (7). Wong *et al* showed that *S. aureus* was significantly less likely to be isolated from the white coat of a doctor in a medical specialty than from a doctor in a surgical or other specialty (15). Surgery ward and ICU should be considered as the high risk wards for transmission of nosocomial infectious, suggesting that preventive observations for cross contamination should be taken seriously during invasive procedures.

This study has some limitations. First, even though this is the largest study of its kind, the data were collected from two tertiary hospitals; therefore the results might not be generalized to other hospitals or services. Second, our sampling technique in which each participants' white coat was swabbed in 3 specific regions, may have been less effective than that used in previous studies, in which blood agar plates were touched directly to the clothing item. We did not use blood agar, because of concerns that doing so could decrease participation due to concerns over possible staining of the white coat (12). In this study however, all samples were taken by three trained research members contributing to more identical swabbing. Finally, the study did not evaluate the transmission mechanism of microorganisms from patients to white coats and vice versa, further studies should be carried out to precisely demonstrate the role of white coats in the spread of nosocomial infections.

In conclusion, the study demonstrated that white coats were contaminated with a variety of pathogenic bacteria in our tertiary hospitals. According to the results and with the possibility of cross contamination from personnel to patients, preventive cautions must be taken into account. We suggest healthcare workers to use a particular white coat for each ward in order to reduce transmission of bacteria between hospital wards. It is also advised that health care workers with more frequently usage of white coats be supplied with sufficient number of white coats to insure lower contamination. Furthermore, in order to achieve minimum contact with patients and bacteria contaminated surfaces, considering a standard posture for examination and surgery procedures are suggested. Re-educational programs for heath care workers and stricter rules of washing and changing white coats may help reduce bacterial contamination.

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Conflict of Interest

None declared conflicts of interest.

References

1. Garner JS, Jarvis WR, Emori TG, *et al*. CDC definitions for nosocomial infections, *Am J Infect Control* 1988; **16** (3): 128-40.
2. Amini M, Javanmard A, Davati A, *et al*. Bacterial colonization in tracheal tubes of ICU patients. *Iran J Pathol* 2009; **4** (3): 123-7.
3. Pittet D, Allegranzi B, Storr J, *et al*. Infection control as a major World Health Organization priority for developing countries. *J Hosp Infect* 2008; **68** (4): 285-92.
4. Klevens RM, Edwards JR, Richards CL, *et al*. Estimating health care-associated infections and deaths in US hospitals, 2002. *Public Health Rep* 2007; **122** (2): 160.
5. Clements A, Halton K, Graves N, *et al*. Overcrowding and understaffing in modern health-care systems: key determinants in meticillin-resistant *Staphylococcus aureus* transmission. *Lancet Infect Dis* 2008; **8** (7): 427-34.
6. Blythe D, Keenlyside D, Dawson SJ, *et al*. Environmental contamination due to methicillin-resistant *Staphylococcus aureus* (MRSA). *J Hosp Infect* 1998; **38** (1): 67-9.
7. Akbari M, Davoodzadeh M, Roozbahaie R, *et al*. Study on the different pathogens collected from personnel's white coats of Khoramabad Ashayer Shohada hospital during 2002-2003. *The Iranian Quarterly Research Journal of Lorestan University of Medical Sciences, Yafte* 2005; **25** (2): 11-6.
8. Callaghan I. Bacterial contamination of nurses' uniforms: a study. *Nurs Stand* 1998; **13** (1): 37-42.
9. Perry C, Marshall R, Jones E. Bacterial contamination of uniforms. *J Hosp Infect* 2001; **48** (3): 238-41.
10. Pissiotis CA, Komborozos V, Papoutsi C, *et al*. Factors that influence the effectiveness of surgical gowns in the operating theatre. *Eur J Surg* 1997; **163** (8): 597-604.
11. Loh W, Ng VV, Holton J. Bacterial flora on the white coats of medical students. *J Hosp Infect* 2000; **45** (1): 65-8.
12. Treakle AM, Thom KA, Furuno JP, *et al*. Bacterial contamination of health care workers' white coats. *Am J Infect Control* 2009; **37** (2): 101-5.
13. Uneke CJ, Ijeoma PA. The potential for nosocomial infection transmission by white coats used by physicians in Nigeria: implications for improved patient-safety initiatives. *World Health Popul* 2010; **11** (3): 44-54.
14. Pilonetto M, Rosa EAR, Brofman PRS, *et al*. Hospital gowns as a vehicle for bacterial dissemination in an intensive care unit. *Braz J Infect Dis* 2004; **8**: 206-10.
15. Wong D, Nye K, Hollis P. Microbial flora on doctors' white coats. *BMJ* 1991; **303** (6817): 1602-4.
16. Grabsch EA, Burrell LJ, Padiglione A, *et al*. Risk of environmental and healthcare worker contamination with vancomycin resistant *Enterococci*

during outpatient procedures and hemodialysis. *Infect Control Hosp Epidemiol* 2006; **27** (3): 287-93.

17. Muhadi SA, Aznamshah NA, Jahanfar S. A cross sectional study of microbial contamination of medical students white coat. *Mal J Microbiol* 2007; **3** (1): 35-8.
18. Zachary KC, Bayne PS, Morrison VJ, *et al*. Contamination of gowns, gloves, and stethoscopes with vancomycin-resistant *Enterococci*. *Infect Control Hosp Epidemiol* 2001; **22** (9): 560-4.
19. Burden M, Cervantes L, Weed D, *et al*. 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** (4): 177-82.