The Potential for Nosocomial Infection Transmission by White Coats Used by Physicians in Nigeria: Implications for Improved Patient-Safety Initiatives

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Abstract

Microbiological analysis of swabs taken from the cuffs and pocket mouths of physicians' white coats in an acute care hospital showed that 91.3% of the coats had bacterial contamination. Specifically diphtheroids, *Staphylococcus aureus* and Gram-negative bacilli were isolated. In contrast, comparatively lower rates of bacterial contamination were observed on the white coats (1) of visiting physicians, (2) of the medical unit compared with the rest of the hospital, (3) that were less 1 year old, and (4) that were laundered daily. Further, the white coats of physicians who wore them only when seeing patients had significantly lower bacterial contamination than white coats of physicians who wore theirs during clinical and nonclinical duties (χ^2 = 4.99, df = 1, p < .05). In particular, white-coat cuffs had a higher bacterial load than the mouths of the pockets. The bacterial isolates were resistant to nearly all of the antibiotics tested; the most effective, however, was ciproflox. Results suggest that physicians' white coats may increase nosocomial infection transmission. Proper handling of white coats by physicians and other healthcare workers could minimize cross-contamination and improve patient safety by potentially reducing nosocomial infections.

Introduction

Healthcare-associated infections (HAIs), also known as nosocomial infections, remain a significant hazard for patients and families visiting a hospital or healthcare facility. The World Health Organization (WHO) defines an HAI as an infection occurring in a patient in a hospital or other healthcare facility in whom the infection was not present or incubating at the time of admission. This includes infections acquired in the hospital but appearing after discharge, and also occupational infections among staff of the facility (WHO 2002). At any one time, more than 1.4 million people worldwide are estimated to suffer from infections acquired in hospitals (Tikhomirov 1987; Vincent 2003). Although HAIs are a major public health problem in both developed and developing countries (Pittet 2005), the impact of HAIs is more severe in resource-poor settings, where the rate of infection is estimated to range from 25% to 40% (WHO 2005, 2008). HAIs have been reported to exact a tremendous toll on patients, families and systems of care, resulting in increased morbidity and mortality and increased healthcare costs (Pittet et al. 2005; WHO 2005).

Despite their best intentions, healthcare workers may be potential vectors of disease, disseminating virulent microorganisms among their patients (Saloojee and Steenhoff 2001). Because patients can shed infectious microorganisms into the healthcare environment, by the virtue of their constant contact with patients, healthcare workers are also at risk of transmitting microorganisms. Thus, both patients and healthcare workers can transmit infection through direct contact with patients, as well as through indirect contact with inanimate objects. Items such as stethoscopes (Uneke et al. 2009), masks (Tunevall 1991), neckties (Steinlechner et al. 2002), pens (French et al. 1998), badges and lanyards (Kotsans et al. 2008) and white coats (Treakle et al. 2009) all have the potential to transmit HAIs.

Of these items, the white coat is one of the more established symbols of the medical profession and is probably the item of clothing worn most by physicians (Kazory 2008). The symbolism of the white coat is often recognized by formal ceremonies at which medical school graduates are granted the distinction of wearing one to emphasize the humanistic values of medicine (Branch 1998; Harnett 2001; Wear 1998). The white coat was worn initially for the purpose of protection against cross-contamination, but also because it connotes life, purity, innocence and goodness (Van Der Weyden 2001; Wear 1998). There has been growing concern, however, that these coats may actually play a role in transmitting pathogenic microorganisms in a hospital setting (Loh et al. 2000; Srinivasan et al. 2007; Treakle et al. 2009; Wilson et al. 2007; Wong et al. 1991). This concern is yet to be fully appreciated in healthcare settings, particularly in developing countries, including Nigeria, despite increasing incidence of HAIs in these parts of the world and the dire need to introduce effective patient-safety initiatives. In 2005, WHO Patient Safety Initiative launched the First Global Patient Safety Challenge to galvanize international focus and action on the critical issue of HAIs (WHO 2005). In line with the WHO patient-safety initiative, any potential source of HAIs that could threaten the well-being of individuals within healthcare facilities merits consideration. Thus, investigating the potential of physicians' white coats to transmit HAIs is justified.

Although there are no studies that directly link white coats with infection transmission, the fact that they could be contaminated with nosocomial pathogens suggests the need for further research. Researchers have reported that the actual use of white coats and how often they are changed varies greatly among individual physicians and specialties (Wong et al. 1991). Therefore, health workers' attitudes to white-coat usage and handling could influence the potential of these coats to transmit nosocomial infections and are worth investigating. To the best of our knowledge, no studies have examined the contributory role of white coats in the transmission of nosocomial infection in healthcare settings in Africa. The hypothesis in this study is that the microbial assessment of physicians' white coats can provide valuable information that could help establish the potential for nosocomial infection transmission by these coats.

The objectives of the study therefore are threefold:

1. To assess the profile of microbial contamination of the white coats used by physicians,
2. To evaluate the relationship between white-coat contamination and white-coat usage and handling practices by doctors, and

3. To assess the susceptibility of microbial isolates to various antibiotics commonly used in acute practice.

Materials and Methods

Study Population/Sampling Technique

The study was conducted from September 2008 to February 2009 and involved the physicians of Ebonyi State University Teaching Hospital (EBSUTH) Abakaliki, in southeastern Nigeria. Participants were drawn from different medical specialties and units. The units and number of participants included Accident and Emergency (24), Medical (23), Obstetrics and Gynecology (14), the Out-patient department (9), Pediatrics (14) and Surgery (19) and included consultants, registrars, residents and house officers. The term "consultants" refers to the most senior physicians, most of whom are visiting; "registrars" refers to physicians undergoing training in their specialty who have yet to complete the first part of the training requirement for medical fellowship; "senior registrars" are physicians undergoing training in their specialty who have already completed the first part of the training requirement for medical fellowship; "house officers" are physicians who have completed their medical training and are undergoing an internship. The study was approved by the Infectious Diseases Research Division of the Department of Medical Microbiology of the Faculty of Clinical Medicine, Ebonyi State University Abakaliki. The authors met with the physicians in the hospital during working hours, told them about the research and solicited their participation. Those who volunteered to participate were enrolled into the study. Written informed consent was obtained from each participant prior to the start of the study. Each participant completed an anonymous study questionnaire soliciting information regarding his or her specialty/unit, cadre and white-coat usage practices (e.g., length of usage, frequency of washing, number of white coats possessed, type of cleaning agents used and frequency of usage in the hospital). The physicians had not previously been informed about the research in order to avoid the Hawthorne effect. All information collected from participants was treated with the utmost confidentiality, and data collection and analysis were designed in such a way that it is impossible to link responses to specific participants.

In Nigeria, physicians generally use long-sleeved, knee-length white coats. For this study, the usage of a white coat was defined as the approximate length of time the doctor wore the coat while on duty. Each doctor's white coat was sampled using two saline-moistened swab sticks. The first swab was taken from the cuff and second from the pocket mouth. These sites were chosen because they are where microbial contamination was thought to be greatest in concentration (Loh et al. 2000; Wong et al. 1991). The samples were labelled and transferred to the Medical Microbiology Laboratory of Ebonyi State University Abakaliki for analysis. All laboratory analyses were done within 1 hour of sample collection.

Laboratory Investigation

The swabs collected were directly inoculated on blood agar and nutrient agar. The pairs of inoculated media were incubated aerobically at 37 oC for 24 hours and then examined for bacteria growth according to standard protocol (Cheesbrough 2000). The authors isolated bacteria by assessing colony characteristics and Gram reaction, and the following five tests: (1) catalase and coagulase, (2) hemolysis, sugar fermentation and other biochemical tests including indole production, citrate utilization and urease activity, (3) triple sugar iron (TSI) agar tests (for glucose, sucrose and lactose fermentation), (4) gas and hydrogen sulphide production tests, and (5) oxidase tests, according to previously described protocols (Cheesbrough 2000). Three or more colony-forming units were considered before assigning species as contaminant. Bacterial isolates were subjected to antibiotic sensitivity analysis using the Kirby Bauer disc diffusion method (Cheesbrough 2000; WHO 2003). The disc used was commercially available (Optun Laboratories Nig Ltd., Lagos Nigeria) and contained several antibiotics – ciprofloxacin, norfloxacin, gentamycin, erythromycin, clindamycin, cephalexin, co-trimoxazole, ampiclox, floxapen, augmentin, nitrofurantoin, tetracyclin, amoxicillin, tarvid, ampicillin, cefuroxine and chloramphenicol. These antibiotics are commonly used in Nigeria and are available at drug stores within the study area.

Statistical analysis

Differences between proportions were assessed by Chi-square analysis. Statistical significance was set at 0.05.

Results

A total of 103 physicians participated in this study. Of the 103 white coats screened, 94 (91.3%) were contaminated with bacteria. The various bacterial agents isolated are shown in Table 1. Most were diphtheroids (52.1%); no case of mixed contamination was observed. White coats from females were slightly more contaminated (93.9%) than those of their male counterparts (90.0%) (Table 2); however, this difference was not statistically significant ($\chi^2 = 0.44$, df = 1, $p > .05$). All the sampled white coats of physicians from the Pediatrics and Accident/Emergency units had bacterial contamination. In contrast, the white coats of physicians from the Medical unit had the lowest contamination. Again, this difference was not statistically significant ($\chi^2 = 8.69$, df = 5, $p > .05$). Among the different cadres of physicians, the consultants' white coats had the lowest rate of bacterial contamination. Once again this was a trend only and was not statistically significant ($\chi^2 = 2.18$, df = 4, $p > .05$). These results are summarized in Table 2.

Table 1. Bacterial isolates from white coats of physicians in Ebonyi State University Teaching Hospital, Abakaliki, Nigeria

Bacteria isolates	No. (%) isolates	95% confidence interval
Staphylococcus aureus	18 (19.1)	11.2–27.0
Pseudomonas aeruginosa	9 (9.6)	3.6–15.6
Diphtheroids	49 (52.1)	42.0–62.2
Gram-negative bacilli	18 (19.1)	11.2–27.0
Total	94 (91.3)	85.9–96.7

Table 2. Relationship between physician's sex, cadre and specialty and bacterial contamination of white coats

Parameter assessed	No. of white coats examined	No. (%) of white coats contaminated	95% confidence interval
Specialty/unit			
Male	70	63 (90.0)	83.8–96.2
Female	33	31 (93.9)	85.7–100.0
Total	103	94 (91.3)	85.9–96.7
Specialty/unit			
Surgery	19	17 (89.5)	75.6–100.0
Pediatrics	14	14 (100.0)	100.0–100.0
Medical	23	18 (78.3)	61.9–94.7

Table 2. Continued

O&G	14	13 (92.9)	79.0–100.0
A&E	24	24 (100.0)	100.0–100.0
OD	9	8 (88.9)	68.3–100.0
Total	103	94 (91.3)	85.9–96.7
Cadre			
House officers	62	58 (93.5)	87.3–99.7
Registrars	15	13 (86.7)	69.2–100.0
Snr. Registrars	15	13 (86.7)	69.2–100.0
Consultants	6	5 (83.3)	53.6–100.0
Others	5	5 (100.0)	100.0–100.0
Total	103	94 (91.3)	85.9–96.7

O&G = Obstetrics and Gynecology; A&E = Accident and Emergency; OD = Out-patient department.

The relationship between physicians' white-coat usage and handling practices and bacterial contamination is shown in Table 3. White coats in use for less than 1 year had the least contamination (χ^2 = 5.13, df = 3, p > .05). Also, white coats belonging to physicians who had more than one had lower bacterial contamination (χ^2 = 2.42, df = 3, p > .05).

Finally, white coats that were washed daily had a relatively lower rate of bacterial contamination (χ^2 = 1.88, df = 3, p > .05). While these results showed promising trends, they were not significant. White coats of physicians who used them only during clinical duties had a significantly lower rate of bacterial contamination compared with those used during both clinical and nonclinical duties (χ^2 = 4.99, df = 1, p< .05). These results are summarized in Table 3.

Table 3. Relationship between white-coat usage/handling practices and bacterial contamination of white coats

Parameter assessed	No. of white coats examined	No. (%) of white coats contaminated	95% confidence interval
Length of time of white coat is in use (yrs)			
<1	34	28 (82.4)	70.0–94.8
1–2	48	46 (95.8)	89.6–100.0
3–4	19	18 (94.7)	84.0–100.0
>4	2	2 (100.0)	100.0–100.0
Total	103	94 (91.3)	85.9–96.7
Number of white coats possessed			
1	19	19 (100.0)	100.0–100.0
2	51	45 (88.2)	79.4–97.0

Table 3. Continued

3	23	21 (91.3)	80.6–100.0
4	10	9 (90.0)	71.9–100.0
Total	103	94 (91.3)	85.9–96.7
Frequency of laundering of white coat per week			
Once	21	20 (95.2)	86.4–100.0
Twice	58	52 (89.7)	80.9–98.5
Thrice	9	9 (100.0)	100.0–100.0
Daily	15	13 (86.7)	69.2–100.0
Total	103	94 (91.3)	85.9–96.7
Frequency of use of white coat in the hospital			
At all times	85	80 (94.1)	88.9–99.5
OWSP	18	14 (77.8)	58.2–97.4
Total	103	94 (91.3)	85.9–96.7

OWSP = only when seeing patients.

A comparative assessment of the level of bacterial contamination on cuffs and pocket mouths was also performed (Table 4). Results indicated that bacterial-colony-forming units per plate greater than 100 were more frequent from swabs obtained from cuffs (47.6%) than from pocket mouths (38.8%). In addition, swabs obtained from cuffs yielded bacterial-colony-forming units per plate ≥300 more frequently than swabs from pocket mouths (20.4% vs. 16.5%) (Table 4).

Table 4. Bacteria contamination of white-coat cuffs and pocket mouth

	Location on white coat	
	Cuffs	Pocket mouth
No. of colony-forming units per plate	**No. (%)**	**No. (%)**
0–99	54 (52.4)	63 (61.2)
100–199	24 (23.3)	16 (15.5)
200–299	4 (3.9)	7 (6.8)
≥300	21 (20.4)	17 (16.5)

Table 5 presents results of antibiotic sensitivity tests, which indicated that the bacterial isolates were resistant to nearly all of the antibiotics assessed. Isolates of *Pseudomonas aeruginosa* and Gram-negative bacilli exhibited the highest resistance to the antibiotics assessed. The most effective antibiotics were ciprofloxacin and clindamycin; however, norfloxacin, gentamycin, cephalexin and tarvid exhibited some measures of effectiveness against *Staphylococcus aureus* and diphtheroids.

Table 5. Antimicrobial susceptibility test of bacterial isolates from white coats

Antibiotics	Abbreviation	Concentration	Bacteria isolates			
			S. aureus	Diphtheroids	*P. aeruginosa*	GNB
Ciproflox	CIP	5 mcg	97.8	100	26.1	34.0
Norfloxacin	NB	10 mcg	28.3	33.5	R	R
Gentamycin	GN	10 mcg	32.6	45.3	R	R
Erythromycin	E	10 mcg	R	R	R	R
Clindamycin	CD	10 mcg	67.4	68.0	69.6	68.1
Cephalexin	CX	30 mcg	37.0	39.8	R	R
Co-trimoxazole	CO	50 mcg	R	R	R	R
Ampiclox	AP	30 mcg	R	R	R	R
Floxapen	FX	30 mcg	R	R	R	R
Augumentin	AU	30 mcg	R	R	R	R
Nitrofurantoin	N	10 mcg	R	R	R	R
Tetracyclin	TE	50 mcg	R	R	R	R
Amoxicillin	AX	20 mcg	R	R	R	R
Tarvid	OF	5 mcg	32.6	33.6	R	R
Chloramphenicol	C	10 mcg	R	R	R	R
Cefuroxine	CF	30 mcg	R	R	R	R
Ampicillin	AM	45 mcg	R	R	R	R

R = Resistant.; GNB=Gram negative bacteria

Discussion

The findings of this investigation clearly indicate that white coats used by physicians can harbour a very high load of bacterial agents and may play a contributory role in the transmission of nosocomial infections in healthcare settings. This study elaborates on earlier research that suggests that physicians' white coats may contribute to transmitting pathogenic microorganisms in a hospital environment (Loh et al. 2000; Srinivasan et al. 2007; Treakle et al. 2009; Wilson et al. 2007; Wong et al. 1991). In this study, up to 91.3% of the white coats screened were contaminated with bacteria. This is consistent with other studies in this area that showed white-coat contamination ranging from 23% to 95% (Pilonetto et al. 2004; Srinivasan et al. 2007; Treakle et al. 2009; Wong et al. 1991). The high rate of bacterial contamination of white coats may be associated with the following two facts: First, patients continuously shed infectious microorganisms in the hospital environment, and physicians are in constant contact with these patients. Therefore, there is a high probability of cross-contamination. Second, it has been demonstrated that microorganisms can survive between 10 and 98 days on fabrics found in hospitals, such as those used for white coats, including cotton, cotton and polyester, or polyester materials (Chacko et al. 2003).

Diphtheroids, *Staphylococcus aureus*, and Gram-negative bacilli were the most frequently isolated microorganisms from the white coats of physicians in this study. This is consistent with the spectrum of bacterial agents isolated in similar investigations (Pilonetto et al. 2004; Srinivasan et al. 2007; Wong et al. 1991). These microorganisms are frequently found in the hospital environment and are mainly skin commensals, but they have also been implicated as causative agents of nosocomial infection (Loh et al. 2000; Nester et al. 2004). Thus, a patient's skin can be a source of contamination for the physician's white coat as he or she attends to patients. Boyce et al. (1997) reported that up to 65% of nurses who had performed patient care activities on patients with methicillin-resistant *Staphylococcus aureus* (MRSA) in a wound or urine had MRSA-contaminated nursing uniforms or gowns. Physicians' hands are another principal source of white-coat contamination with pathogens frequently found in the hospital environment. A number of earlier studies have demonstrated that compliance with hand-hygiene protocols among all healthcare workers, including physicians, is poor (Harris et al. 2000; Pittet et al. 2000). Lack of hand hygiene undoubtedly enhances contamination of white coats, since they are often touched by the physicians in the course of their work.

The white coats of physicians from the Pediatrics and Accident/Emergency specialties were more contaminated than those of physicians from the Medical specialty. Wong et al. (1991) reported that *Staphylococcus aureus* was less likely to be isolated from the white coat of a physician in a medical specialty than from a physician in a surgical or other specialty. A similar finding was also reported by Srinivasan et al. (2007). This may be connected with the lower patient contact in the medical specialty compared with other specialties. Consultants' white coats were the least contaminated compared with other cadres of physicians. Although the difference in the trend was not significant statistically, the fact that consultant physicians see fewest patients compared with other categories of physicians might explain this observation.

The results of this study suggest that there is a relationship between white-coat usage and handling practices and bacterial contamination. Lower rates of white-coat contamination were observed among physicians whose coats were less than 1 year old, among doctors who possessed up to four white coats and among those who laundered their coats daily. These results are consistent with previous work in this area (Pilonetto et al. 2004; Srinivasan et al. 2007; Treakle et al. 2009; Wong et al. 1991). Thus, the manner in which the white coat is used or handled by a physician can largely determine the likelihood of its harbouring and potentially transmitting pathogens. Wong et al. (1991) noted that the level of bacterial contamination did not vary with the length of time a coat had been in use, but it increased with the degree of usage by the individual physician. This is further demonstrated in our study, in which the white coats of physicians who used them only when seeing patients had a statistically significantly lower rate of bacterial contamination than the coats of their counterparts who used theirs during clinical and nonclinical duties. Consequently, there has been controversy over whether white coats should be worn in nonclinical areas such as the canteen and libraries.

The results of this study suggest that bacterial-colony-forming units per plate greater than 100 were more frequent on cuffs than on pocket mouths. This was not unexpected since cuffs are in constant contact with the skin of both patients and physicians. Of particular public health significance was the high level of antibiotic resistance exhibited by the bacterial isolates from the coats. These antibiotic-resistant microorganisms are particularly important because they are capable of initiating severe nosocomiasis in a hospital environment and often require contact isolation and aggressive treatment to prevent their spread (Nester et al. 2004; WHO 2000, 2003).

In conclusion, the transmission of HAIs through both patients and healthcare workers in developing countries remains an important patient-safety issue (WHO 2010). This is despite the resolution of the World Health Assembly WHA55.18, which urged member states to establish and strengthen science-based systems necessary for improving patient safety and the quality of healthcare (WHO 2006). Unfortunately, there are few patient-safety initiatives aimed at preventing nosocomial infection in many healthcare settings in developing countries. Where such programs exist, they usually focus on high-risk invasive diagnostic and therapeutic healthcare tools. The importance of less critical healthcare tools such as physicians' white coats tends to be underestimated (Schiff 2006). This study demonstrates that white coats are capable of harbouring pathogens. Another critical issue highlighted in this study is the association between white-coat contamination and noncompliance with hand-hygiene guidelines. Limiting this contamination is the rationale behind the time-honoured advice for all to wash their hands before and after seeing each patient. There is substantial evidence that hand antisepsis reduces the incidence of HAIs (Lam et al. 2004; Pittet et al. 2000; Rosenthal et al. 2005). Hand hygiene is therefore a fundamental action for ensuring patient safety, and it should occur in a timely and effective manner in the process of care. Since most hospital-acquired pathogens are transmitted from patient to patient via the hands of healthcare workers, handwashing is the simplest and most effective, proven method to reduce the incidence of nosocomial infections (Pittet 2000). Therefore, a patient-safety initiative capable of reducing the incidence of HAIs in a low-income setting must incorporate hand hygiene and effective white-coat handling and maintenance guidelines.

Successful and sustained hand-hygiene improvement can be achieved by implementing multiple actions to tackle different obstacles and behavioural barriers associated with compliance. The WHO multimodal hand-hygiene improvement strategy has been proposed to translate into practice the WHO recommendations on hand hygiene (WHO 2009). The key components of the strategy are (1) system change: ensuring that the necessary infrastructure is in place to allow healthcare workers to practise hand hygiene, (2) training/education: providing regular training on the importance of hand hygiene based on the "My 5 Moments for Hand Hygiene" approach, (3) evaluation and feedback: monitoring hand-hygiene practices and infrastructure, along with related perceptions and knowledge among healthcare workers, (4) reminders in the workplace: prompting and reminding healthcare workers about the importance of hand hygiene and the appropriate indications and procedures for performing it, and (5) institutional safety climate: creating an environment and the perceptions that facilitate awareness-raising about patient-safety issues while guaranteeing consideration of hand-hygiene improvement.

Based on the findings of this study, a patient-safety initiative could consider incorporating the following as policy components for effective white-coat handling and maintenance: (1) make a yearly purchase of white coats mandatory, (2) make the possession of two or more white coats at any point in time compulsory, (3) make weekly washing of white coats mandatory, (4) ban the use of white coats during nonclinical duties, e.g., in libraries and cafeterias, (5) involve both hospital management and physician associations in promoting compliance, (6) establish an audit or feedback mechanism to monitor compliance, (7) institute incentives, including awards, to encourage adherence to effective white-coat handling and maintenance, (8) promote a white-coat-hygiene campaign, and (9) institute policy reforms on white-coat handling and maintenance.

Finally, this study was not without some limitations. It is pertinent to state that we have not been able to unequivocally demonstrate that the white coats could actually transmit pathogenic microorganisms. A more complex study design is required accomplish this. Future research in this area might focus on implementing the suggested patient-safety initiatives and evaluating their impact on white-coat contamination and reduction of HAIs.

References

Boyce, J.M., G. Potter-Bynoe, C. Chenevert and T. King. 1997. "Environmental Contamination Due to Methicillin Resistant *Staphylococcus aureus:* Possible Infection Control Implication." *Infection Control and Hospital Epidemiology* 18: 622–27.

Branch, W.T. Jr. 1998. "Deconstructing the White Coat." [Editorial] *Annals of Internal Medicine* 129: 740–2.

Chacko, L., S. Jose, A. Isac and K.G. Bhat. 2003. "Survival of Nosocomial Bacteria on Hospital Fabrics." *Indian Journal of Medical Microbiology* 21(4): 291.

Cheesbrough, M. 2000. *District Laboratory Practice in Tropical Countries Part 2.* Cambridge, UK: Cambridge University Press.

French, G., Rayner, D., Branson, M., Walsh M. 1998. "Contamination of doctors' and nurses pens with nosocomial pathogens." *Lancet* 351(9097):213.

Harnett, P.R. 2001. "Should Doctors Wear White Coats?" *Medical Journal of Australia* 174: 343–4.

Harris, A.D., M.H. Samore, R. Nafziger, K. Dirosario, M.C. Roghmann and Y.A. Carmeli. 2000. "Survey on Handwashing Practices and Opinions of Healthcare Workers." *Journal of Hospital Infection* 45: 318–21.

Kazory, A. 2008. "Physicians, Their Appearance, and the White Coat." *The American Journal of Medicine* 121(9): 825–8.

Kotsans, D., C. Scott, E.E. Gillespie and T.M. Korman. 2008. "What's Hanging around Your Neck? Pathogenic Bacteria on Identity Badges and Lanyards." *Medical Journal of Australia* 188(1): 5–8.

Lam, B.C., J. Lee and Y.L. Lau. 2004. " Hand Hygiene Practices in a Neonatal Intensive Care Unit: a Multimodal Intervention and Impact on Nosocomial Infection." *Pediatrics* 114: e565–71.

Loh, W., V.V. Ng and J. Holton. 2000. "Bacterial Flora on the White Coats of Medical Students." *Journal of Hospital Infection* 45(1): 65–8.

Nester, E.W., D.G. Anderson, C.E. Roberts, N.N. Pearsall and M.T. Nester. 2004. *Microbiology: A Human Perspective 4th Edition.* New York: McGraw Hill Companies, Inc.

Pilonetto, M., E.A. Rosa, P.R. Brofman, D. Baggio, F. Calvário, C. Schelp, A. Nascimento and I. Messias-Reason. 2004. "Hospital Gowns as a Vehicle for Bacterial Dissemination in an Intensive Care Unit." *Brazilian Journal of Infectious Diseases* 8(3): 206–10.

Pittet, D. 2000. "Improving Compliance with Hand Hygiene in Hospitals." *Infection Control and Hospital Epidemiology* 21: 381–6.

Pittet, D., S. Hugonnets and S. Harbarth. 2000. "Effectiveness of a Hospital-Wide Programme to Improve Compliance with Hand Hygiene." *Lancet* 356: 1307–12.

Pittet, D. 2005. "Infection Control and Quality Health Care in the New Nillenium." *American Journal of Infection Control* 33(5): 258–67.

Pittet, D., B. Allegranzi, H. Sax, L. Bertinato, E. Concia, B. Cookson, J. Fabry, H. Richet, P. Philip, R.C. Spencer, B.W. Ganter and S. Lazzari. 2005. "Considerations for a WHO European Strategy on Health-Care-Associated Infection, Surveillance, and Control." *The Lancet Infectious Diseases* 5: 242–50.

Rosenthal, V.D., S. Guzman and N. Safdar. 2005. "Reduction in Nosocomial Infection with Improved Hand Hygiene in Intensive Care Units of a Tertiary Care Hospital in Argentina." *American Journal of Infection Control* 33: 392–7.

Saloojee, H. and A. Steenhoff. 2001. "The Health Professional's Role in Preventing Nosocomial Infections." *Postgraduate Medical Journal* 77: 16–9.

Schiff, N. 2006. *Specific Risks in a Health Care Facility.* Retrieved January 12, 2008. < http://www.schiff-consulting.com/healthcarerisks.html>.

Srinivasan M., A. Uma, A. Vinodhkumaradithyaa, S. Gomathi and P. Thirumalaikolundusubramanian. 2007. "The Medical Overcoat – Is It a Transmitting Agent for Bacterial Pathogen?" *Japanese Journal of Infectious* Diseases 60: 121–2.

Steinlechner, C., G. Wilding and N. Cumberland. 2002. "Microbes on Ties: Do They Correlate with Wound Infection?" *Annual Royal College of Surgeons of England* 84(9): 307–9.

Tikhomirov, E. 1987. "WHO Programme for the Control of Hospital Infections." *Chemiotherapia* 3: 148–51.

Treakle, A.M., K.A. Thom, J.P. Furuno, S.M. Strauss, A.D. Harris and E.N. Perencevich. 2009. "Bacterial Contamination of Health Care Workers' White Coats." *American Journal of Infection Control* 37(2): 101–5.

Tunevall, T.G. 1991. "Postoperative Wound Infections and Surgical Face Masks: a Controlled Study." *World Journal of Surgery* 15: 383–7.

Uneke, C.J., Ogbonna, A., Oyibo, P.G., Ekuma, U. 2009. "Bacteriological assessment of stethoscopes used by medical students in Nigeria: implications for nosocomial infection control." *World Health and Population* 10(4):53-61.

Van Der Weyden, M.B. 2001. "White Coats and the Medical Profession: Time to Rediscover the Symbol of Our Purpose and Our Pride?" [Editorial] *Medical Journal of Australia* 174: 324–5.

Vincent, J.L. 2003. "Nosocomial Infections in Adult Intensive Care Units." *Lancet* 361: 2068–77.

Wear, D. 1998. "On White Coats and Professional Development: the Formal and the Hidden Curricula." *Annals of Internal Medicine* 129: 734–7.

Wilson, J.A., H.P. Loveday, P.N. Hoffman and R.J. Pratt. 2007. "Uniform: an Evidence Review of the Microbiological Significance of Uniforms and Uniform Policy in the Prevention and Control of Healthcare-Associated Infections. Report to the Department of Health (England)." *Journal of Hospital Infection* 66(4): 301–7.

Wong, D., Nye, K., Hollis, P. 1991. "Microbial Flora on Doctors' White Coats." *British Medical Journal* 303(6817): 1602–4.

World Health Organization. 2010. *10 Facts on Patient Safety.* Retrieved February 8, 2010. <http://www.who.int/features/factfiles/patient_safety/en/index.html>.

World Health Organization. 2000. *Overcoming Antimicrobial Resistance.* Retrieved September 2, 2008. <www.who.int/infectious-disease-report/2000/>.

World Health Organization. 2002. *Prevention of Hospital-Acquired Infections: a Practical Guide 2nd Edition.* Geneva: World Health Organization.

World Health Organization. 2003. *Manual for the Laboratory Identification and Antimicrobial Sensitivity Testing of Bacterial Pathogens of Public Health Importance in the Developing World.* WHO/DCS/CSR/RMD/2003.6. Geneva: World Health Organization.

World Health Organization. 2005 "Global Patient Safety Challenge Launched." [Press release] Retrieved September 17, 2008. <http://www.findarticles.com/p/articles/mi_m0FSL/is_1_83/ai_n16100927/print>.

World Health Organization. 2006. "Patient Safety." Fifty-Ninth World Health Assembly A59/22. Provisional Agenda Item 11.16 4 May 2006. Retrieved January 12, 2008. <http://www.who.int/patientsafety/events/06/wha/en/index.html>

World Health Organization. 2009. *Save Lives: Clean Your Hand. Guide to Implementation. A Guide to the Implementation of the WHO Multimodal Hand Hygiene Improvement Strategy.* WHO/IER/PSP/2009.02. Geneva: World Health Organization.