Original Article

Bacterial contamination of stethoscopes used by health workers: public health implications

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Abstract

Background: This study was designed to assess both the potential for bacterial transmission by stethoscopes used by health-care workers in Nigeria and the implications for patient safety and control of hospital-acquired infections.

Methodology: A structured questionnaire was administered to health workers and the surface of the diaphragm of their stethoscopes swabbed for bacteriological analysis using standard techniques.

Results and Conclusions: Of the 107 stethoscopes surveyed, 84 (79%) were contaminated with bacteria; 59 (81%) of the contaminated stethoscopes belonged to physicians and 25 (74%) were from other health workers. Isolates included *Staphylococcus aureus* (54%), *Pseudomonas aeruginosa* (19%), *Enterococcus faecalis* (14%), and *Escherichia coli* (13%). All stethoscopes that had never been cleaned were contaminated while lower levels of contamination were found on those cleaned one week or less before the survey ($\chi^2 = 22.4$, $P < .05$). Contamination was significantly higher on stethoscopes cleaned with only water (100%) compared to those cleaned with alcohol (49%) ($\chi^2 = 30.17$, $P < .05$). Significantly fewer (9%) stethoscopes from health workers who washed their hands after seeing each patient were contaminated when compared with the instruments (86%) of those who did not practice hand washing ($\chi^2 = 23.79$, $P < .05$). *E. coli* showed the highest antibiotic resistance, while *S. aureus* showed the highest antibiotic susceptibility. Strict adherence to stethoscope disinfection practices by health workers can minimize cross-contamination and ensure improved patient safety in hospital environments.

Key words: bacteria, stethoscope, infection, transmission, hospital

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Introduction

Infection transmission in the hospital environment (nosocomial infection) remains a significant hazard for hospitalized patients, and health-care workers are potential sources of these infections. Many pathogens can be transmitted on the hands [1], which is a major reason that all health-care workers must wash their hands before and after seeing each patient [2]. Ttransmission of infections on contaminated medical devices is also possible and outbreaks of hospital-acquired infections have been linked to devices such as electronic thermometers, blood pressure cuffs, stethoscopes, latex gloves, masks, neckties, pens, badges and lanyards, and white coats [1,3-6].

Stethoscopes are commonly used to assess the health of patients and have been reported to be potential vectors for nosocomial infections in various parts of the world [3,7-10]. Following contact with infected skin, pathogens can attach and establish themselves on the diaphragms of stethoscopes and subsequently be transferred to other patients if the stethoscope is not disinfected [11-13].

There are increasing reports of the risk of transmitting antibiotic resistant microorganisms from one patient to another on stethoscopes [3,14,15]. These antibiotic-resistant organisms are capable of initiating severe infections in a hospital environment and could require contact isolation and aggressive treatment to prevent the spread of the organisms [16]. Examples of such antibiotic-resistant organisms are ceftazidime-resistant *Klebsiella pneumonia*, vancomycin-resistant enterococci, methicillin-resistant staphylococci, ciprofloxin-resistant *Pseudomonas aeruginosa*, gentamicin-resistant *P.*

aeruginosa, and penicillin-resistant pneumococci [16-20].

The objectives of this study were to (i) assess stethoscope handling and maintenance practices among physicians and other health workers; (ii) determine the bacterial agents that can contaminate stethoscopes; (iii) determine the antibiotic sensitivity of bacterial isolates from stethoscopes; (iv) evaluate the relationship between stethoscope handling/maintenance practices and stethoscope contamination and; (v) outline the public health implications of stethoscope contamination.

Materials and methods

The study was conducted from October 2007 to October 2008 in the following health facilities located in Ebonyi State in south-eastern Nigeria: The Federal Medical Centre (FMC), Abakaliki; Ebonyi State University Teaching Hospital (EBSUTH), Abakaliki; Holy Family Hospital, Abakaliki; West-End Maternity and Clinic, Abakaliki; Ceno Pharmacy, Abakaliki; Godal Pharmacy, Abakaliki; Grace Hospital, Abakaliki; Presbyterian Joint Hospital, Uburu; Izhia-Mgbo General Hospital, Ezzamgbo; and Primary Health Centre, Isu. Physicians, pharmacists, nurses, and other health workers who make use of personal stethoscopes participated in the study. The study was approved by the Infectious Diseases Research Division of the Department of Medical Microbiology in the Faculty of Clinical Medicine, Ebonyi State University, Abakaliki, and by the management of each of the participating hospitals. After obtaining informed consent from each participant, an anonymous study questionnaire was administered to obtain information on stethoscope usage, handling, and maintenance. The surface of the diaphragm of each stethoscope was swabbed with a sterile swab moistened in sterile saline and transferred to the Medical Microbiology Laboratory of Ebonyi State University, Abakaliki, for analysis. Samples that were obtained in locations outside of Abakaliki were analyzed at the microbiology laboratories of the relevant hospitals. Laboratory analyses were conducted within one hour of sample collection.

Laboratory Investigation

The swabs were inoculated directly onto blood agar and MacConkey agar and incubated aerobically at 37^{o}C for 24 hours before being examined for bacterial growth according to standard methods [21]. When three or more colony forming units (CFU) were obtained on a plate, the organism was regarded as a bacterial contaminant. The authors isolated bacteria by assessing colony characteristics and Gram reaction and by conducting the following tests: catalase and coagulase tests; hemolysis, sugar fermentation, and other biochemical tests including indole production, citrate utilization, and urease activity; triple sugar iron (TSI) agar test (for glucose, sucrose and lactose fermentation); gas and hydrogen sulphide production tests; and oxidase tests.

Antibiotic sensitivity testing was performed on bacterial isolates using the disc diffusion method [21,22] and commercially available discs (Optun Laboratories Nig Ltd, Lagos, Nigeria). Gram-positive discs contained ciprofloxacin, nofloxacin, gentamicin, lincomycin, streptomycin, rifampicin, flucloxacillin, erythromycin, chloramphenicol, and ampicillin-cloxacillin. The Gram-negative discs contained ofloxacin, pefloxacin, ciprofloxacin, ampicillin-cloxacillin, gentamicin, streptomycin, cefalexin, ampicillin, trimethoprim, and nalidixic acid.

These antibiotics are commonly used in Nigeria and are available at drugstores in the study areas.

Statistical analysis

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

Results

A total of 107 stethoscopes were examined, 73 of which were from physicians (medical doctors) and 34 from nurses and other health workers. Of the 107 stethoscopes surveyed, 84 (78.5%) had bacterial contaminants. A total of 59 (80.8%) of the doctors' and 25 (73.5%) of other health workers' stethoscopes were contaminated but the difference was not statistically significant ($\chi^2 = 0.74$, df = 1, $P > .05$. The bacteria isolated included *Staphylococcus aureus* (53.6%), *P. aeruginosa* (19.0%), *Enterococcus faecalis* (14.3%), and *Escherichia coli* (13.1%) (Table 1).

Analysis of the study questionnaire revealed that bacterial contamination was related to the time the stethoscope was cleaned prior to the survey (Table 2); results showed that there was 100% bacterial colonization of stethoscopes that had never been cleaned while the least contamination was found on stethoscopes cleaned one week or less before the survey ($\chi^2 = 22.4$, df = 3, $P < .05$). The highest levels of bacterial contamination were found on

Table 1. Bacterial isolates from stethoscopes of doctors and other health workers

Bacteria isolated	Doctors' stethoscopes	Nurses'/Other health workers' stethoscopes	Total
	No. (%)	No. (%)	No. (%)
S. aureus	36 (80.0)	9 (20.0)	45 (53.6)
P. aeruginosa	11 (68.8)	5 (31.3)	16 (19.0)
E. faecalis	7 (58.3)	5 (41.7)	12 (14.3)
E. coli	5 (45.5)	6 (54.5)	11 (13.1)
Total	59 (70.2)	25 (29.8)	84 (78.5)

stethoscopes cleaned with other cleaning agents (100%) and those that had never been cleaned (95.0%) (Table 3); significantly lower levels of contamination were found on stethoscopes cleaned with alcohol (48.5%) ($\chi^2 = 30.17$, df = 3, $P < .05$).

Sixteen respondents stated they cleaned their stethoscopes after examining each patient and 25.0% of their stethoscopes were colonized by bacteria (Table 4). In contrast, 87.9% of the stethoscopes belonging to people that did not clean their stethoscopes after examining each patient were contaminated ($\chi^2 = 16.36$, df = 1, $P < .05$).

Only 28.5% of the stethoscopes from the 13.1% of health workers who washed their hands after seeing each patient were contaminated compared to 86.0% of stethoscopes from those who did not practice hand washing ($\chi^2 = 23.79$, $P < .05$) (Table 5).

The antibiotic sensitivity testing indicated that the bacterial isolates were resistant to most of the antibiotics assessed (Table 6). Isolates of *E. coli* showed the highest levels of resistance and were susceptible to only two of the antibiotics (ciprofloxacin and streptomycin). *Staphylococcus aureus* showed the least resistance, being susceptible to ciprofloxacin, nofloxacin, gentamicin, lincomycin, streptomycin, ofloxacin, pefloxacin). The most effective antibiotics against all contaminants were ciprofloxacin and streptomycin.

Discussion

The result of this study revealed that as many as 78.5% of the stethoscopes surveyed were contaminated by bacteria which is comparable to the observations of previous studies that found 71% to 100% of stethoscopes were colonized by various bacteria [7,8,23-26]. Although most of the organisms isolated in these studies were considered non-pathogenic, a significant percentage of the isolates were potentially pathogenic. The implication of the findings is that the stethoscope might be a vector playing an important role in the transmission of potential pathogenic microorganisms, as well as in the spread of antibiotic-resistant strains in the hospital environment.

The stethoscopes used by physicians were more contaminated (80.8%) than those used by other health workers (73.5%). Although the difference was not statistically significant, the fact that physicians use stethoscopes more frequently than other health workers might explain the higher rate of bacterial contamination. Marinella and others [25] had reported earlier that physicians' stethoscopes generally had a higher bacterial load than nurses' stethoscopes. *S. aureus* was the most common bacterial agent isolated from the stethoscopes studied (53.6%). Previous investigations have indicated its occurrence on 15.8% to 89% of stethoscopes

Table 2. Time when stethoscope was last cleaned and bacterial contamination

	Doctors' stethoscopes		Nurses'/Other health workers' stethoscopes		Total	
Time	No.	No. (%) with bacteria	No.	No. (%) with bacteria	No.	No. (%) with bacteria
≤ 1 **week** ago	30	18 (60.0)	22	13 (59.1)	52	31 (59.6)
2 – 4 **weeks** ago	12	11 (91.7)	0	0 (0.0)	12	11 (91.7)
≥ 5 **weeks** ago	5	4 (80.0)	1	1 (100.0)	6	5 (83.3)
Never	26	26 (100.0)	11	11 (100.0)	37	37 (100.0)
Total	73	59 (80.8)	34	25 (73.5)	107	84 (78.5)

Table 3. Agents used in cleaning stethoscopes and bacterial contamination

	Doctors' stethoscopes		Nurses'/Other health workers' stethoscopes		Total	
Parameters	No.	No. (%) with bacteria	No.	No. (%)with bacteria	No.	No. (%) with bacteria
Soap/Water	6	3 (50.0)	2	2 (100.0)	8	5 (62.5)
Spirit/Alcohol	22	12 (54.5)	11	4 (36.4)	33	16 (48.5)
Others	2	2 (100.0)	4	4 (100.0)	6	6 (100.0)
Nil	43	42 (97.7)	17	15 (88.2)	60	57 (95.0)
Total	73	59 (80.8)	34	25 (73.5)	107	84 (78.5)

Table 4. Cleaning of stethoscopes after seeing each patient and bacterial colonization

	Doctors' stethoscopes		Nurses'/Other health workers' stethoscopes		Total	
Parameters	No.	No. (%)with bacteria	No.	No.(%) with bacteria	No.	No. (%)with bacteria
Yes	8	3 (50.0)	8	1 (12.5)	16	4 (25.0)
No	65	56 (83.6)	26	24 (92.3)	91	80 (87.9)
Total	73	59 (80.8)	34	25 (73.5)	107	84 (78.5)

Table 5. Hand washing after seeing each patient and bacterial colonization of stethoscopes.

	Doctors' stethoscopes		Nurses'/Other health workers' stethoscopes		Total	
Parameters	No.	No. (%) with bacteria	No.	No. (%)with bacteria	No.	No. (%)with bacteria
Yes	6	3 (50.1)	8	1 (12.5)	14	4 (28.5)
No	67	56 (83.6)	26	24 (92.3)	93	80 (86.0)
Total	73	59 (80.8)	34	25 (73.5)	107	84 (78.5)

Table 6. Antimicrobial susceptibility of bacterial isolates from stethoscopes.

Antibiotics	**Concentration**	**Bacteria**			
		S. aureus	***P. aeruginosa***	***E. faecalis***	***E. coli***
Ciprofloxacin	10 mcg	100.0**	33.3	66.7	33.3
Nofloxacin	30 mcg	33.3	R	R	R
Gentamicin	10 mcg	33.3	R	R	R
Lincomycin	30 mcg	33.3	33.3	R	R
Streptomycin	30 mcg	66.7	66.7	33.3	66.7
Rifampicin	10 mcg	R	R	R	R
Flucloxacillin	30 mcg	R	R	R	R
Erythromycin	30 mcg	R	R	R	R
Chloramphenicol	20 mcg	R	R	R	R
Ampicillin-Cloxacillin	30 mcg	R	R	R	R
Ofloxacin	10 mcg	33.3	R	R	R
Pefloxacin	10 mcg	33.3	R	33.3	R
Amoxicillin-Clavulanic Acid	30 mcg	R	R	R	R
Cefalexin	10 mcg	R	R	R	R
Nalidixic acid	30 mcg	R	R	R	R
Trimethoprim	30 mcg	R	R	R	R
Ampicillin	30 mcg	R	R	R	R

*****mcg = microgram; **Figures represent percentage of isolates susceptibile; R = 100% of isolates resistant;

surveyed [3,25-28]. *Staphylococcus aureus* is known to have developed resistance to conventional antibiotics [29] and this was the case in our study. Similarly, the other bacteria isolated were resistant to most antibiotics assessed. The development of antibiotic resistance by bacterial agents is worrisome and has been described as a serious public health concern. This is particularly the case in developing countries where dysfunctional health services, inadequate drug supplies, non-adherence to treatment strategies, self-medication, and dubious drug quality favor the emergence and persistence of antibiotic resistance [29].

Although we did not show that stethoscopes can transmit infections, we did show stethoscopes were contaminated with pathogenic bacteria and that poor stethoscope cleaning/disinfection practices were significantly associated with this contamination. In particular, all stethoscopes that had never been cleaned were contaminated while the lowest levels of contamination were seen with stethoscopes cleaned one week or less before the survey. As even short periods of contact between a patient's skin and the stethoscope can result in transfer of bacteria [30] there is a need for strategies to decrease bacterial contamination of stethoscopes. Previous studies were consistent with the findings of this study, with only 0-3% of health-care providers cleaning their stethoscopes regularly [7,25,26] and just 10% cleaning them when they were soiled with blood or human secretions [20].

It was of interest to note that stethoscopes belonging to health workers who practiced hand hygiene were less likely to be contaminated than those belonging to individuals with poor hand hygiene. Failure to wash hands could facilitate the introduction of pathogens onto devices that the health workers use frequently, such as stethoscopes. The World Health Organization recently noted that hand hygiene is fundamental in ensuring patient safety and should be performed in a timely and effective manner in the process of care [2].

In this study the importance of cleaning the stethoscope with a disinfectant was demonstrated. Comparatively fewer bacterial colonies were obtained from stethoscopes of individuals who cleaned them with soapy water or alcohol. This is similar to the findings of Marinella and others [25], who found that bacterial isolates from stethoscopes were significantly reduced after they were cleaned with isopropyl alcohol, sodium hypochlorite, or benzalkonium chloride.

Strategies to minimize the transmission of infection from stethoscopes have been proposed, including the use of disposable stethoscopes, especially for clinical high-risk environments, and the use of a single-use, silicone membrane over the stethoscope head to create a prophylactic barrier [31]. Although these strategies could minimize the risk of stethoscope transmission of infections, they are unaffordable to most health workers and health facilities in developing countries. Instead hospitals should develop more rigorous programs and protocols for stethoscope disinfection as a standard of care [27]. Strict adherence to stethoscope disinfection practices by health workers will minimize cross-contamination and ensure improved patient safety in hospitals.

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