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Original Research Article

The roles of stethoscopes and sphygmomanometers in hospital-acquired infections: a case study of some district hospitals in Enugu state, Southeast Nigeria

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ABSTRACT

Background: Hospital acquired infections (HAIs) are infections that patients acquire while receiving treatments for other conditions. Studies have shown that stethoscopes and sphygmomanometers can act as potential sources of these infections in patients accessing treatment in healthcare facilities. This study aimed to increase awareness among health workers in Nigeria of the potentials of stethoscopes and sphygmomanometers to transmit HAIs.
Methods: Moist swab sticks were used to collect samples from 38 randomly selected stethoscopes and sphygmomanometers from some departments of four district hospitals. Collected samples were cultured using standard microbiological techniques. In addition, self-designed questionnaire was used to assess the knowledge and practice of doctors and nurses on the roles of stethoscopes and sphygmomanometers in HAIs.
Results: About 83.8% of the health workers demonstrated some awareness of the roles of stethoscopes and sphygmomanometers in HAIs. 42.5% cleaned their stethoscopes, while 5% their sphygmomanometers. *Staphylococcus aureus*, (65.9% of stethoscopes), proteus mirabilis, *Pseudomonas aeruginosa* (67.6% of sphygmomanometers), *Streptococcus* and *Coliform* species were isolated. There was no significant difference between the contamination of stethoscopes and sphygmomanometers by the isolates, except for *Pseudomonas aeruginosa* (t=3.49, p=0.04).
Conclusions: Awareness did not match practice in cleaning the stethoscopes and sphygmomanometers in the four facilities. *Staphylococcus aureus* and *Pseudomonas aeruginosa* were the two most common organisms isolated with a significant difference (t=3.49, p=0.04) between stethoscopes and sphygmomanometers in isolation of *Pseudomonas aeruginosa*. To curb HAIs, health workers need to improve on their practice of cleaning stethoscopes and sphygmomanometers.

Keywords: Acquired, Hospital, Infection, Stethoscope, Sphygmomanometer, Role

INTRODUCTION

The stethoscope, invented in France in 1816 by René Laennec at the Necker-Enfants Malades Hospital in Paris, is an acoustic medical device for auscultation or listening to the internal sounds of an animal or human body. Literally, the stethoscope means to look into the chest. Apart from listening to the lungs and heart sounds, the stethoscope is also used for listening to intestinal sounds, and blood flow in arteries and veins. In combination with

a sphygmomanometer, it is commonly used for measurements of blood pressure.

Sphygmomanometer or blood pressure meter, on the other hand, is a device used to measure blood pressure. Its invention in 1881 is being credited to Samuel Siegfried Karl Ritter von Busch.[1] The instrument consists of an inflatable cuff, a measuring unit (the mercury manometer, or aneroid gauge), an inflation bulb and valve for manual instruments. The word sphygmomanometer comes from a combination of the Greek sphygmos (pulse) and the scientific term manometer (pressure meter).

Because the bell and diaphragm of the stethoscope, and the cuff of the sphygmomanometer come into direct contact with the patient's skin, they can act as potential sources of nosocomial or hospital acquired infections in patients accessing treatment in healthcare facilities. Several past studies have already demonstrated the potentials of these instruments to cause nosocomial or hospital acquired infections.[2-12]

Hospital acquired infections (HAIs), are infections that patients acquire during the course of treatment for other conditions.[13] As defined by the World Health Organization, a HAI is an infection acquired in hospital by a patient who was admitted for a reason other than that infection. This includes infections acquired in the hospital but appearing after discharge and also occupational infections among staff of the facility.[14] HAIs characteristically appear 48 hours or more after admission or within 30 days after discharge following in-patient care. However, HAIs do not include the presence of infectious agents that were present or incubating at the time of admission to the hospital.

Although, several causative agents have been implicated in the aetiology of HAIs, the most frequently isolated organisms are *Staphylococcus aureus*, including methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus*, *Pseudomonas aeruginosa*, *Acinetobacter baumannii* and coagulase negative *Staphylococcus* (CNS), among others.[15] The origin of these organisms are usually traceable to two main sources which are endogenous and exogenous sources. Endogenous sources are caused by micro-organisms from the patient's own flora, i.e. the resident in the patient, whereas exogenous sources are caused by micro-organisms acquired by exposure to other patients, hospital personnel, visitors and medical devices, among others.

HAIs are commonly predisposed to by such factors as the availability of a susceptible host (e.g. advanced age, immunosuppression, malnutrition and incapacitation), the presence of an inanimate hospital environment (e.g. soiled linen, biomedical waste, used equipment and instruments), and the impact of invasive diagnostic and therapeutic procedures and long surgical procedures.

In the HAI process, any organ system may be involved. However, of particular importance are the use of various devices or breach of the intact skin which predispose to these infections. Based on these two factors, four types of HAIs are commonly distinguished. These are catheter-associated urinary tract infections, ventilator-associated pneumonia (VAP), central line-associated blood stream infections, and surgical site infections (SSIs) and skin and soft tissue infections (SSTIs).

Although, HAIs can be transmitted through various routes, the most common routes of transmission include contact (both direct and indirect), airborne, common vehicle and vector borne.

Transmission of HAIs through the use of stethoscopes and sphygmomanometers is usually via indirect contact of the contaminated diaphragms of stethoscopes (or bells) and the inner surfaces of sphygmomanometer cuffs with the patient's skin. Skin sepsis, which could arise from a breach of the intact skin, constitutes the major infection caused by *Staphylococcus aureus* (a major isolate from the diaphragms (or bells) of stethoscopes and inner surfaces of sphygmomanometer cuffs) acquired through skin contact with these instruments.

Within the hospital setting, the risk of HAIs varies from one unit to another. The hospital areas that carry the greatest risk of acquiring these infections include intensive care units (ICUs), dialysis units, organ transplant units, burns units, operation theatres, delivery rooms and post-operative wards.[13]

The initial management of HAIs entails the use of empiric treatment, which has to be broad enough to ensure coverage of most of the suspected pathogens. The choice of empiric antibiotic therapy before microbiology is available requires surveillance data on a regular basis of predominant organisms in the hospital, surveillance of the current resistance patterns of these organisms, and identification of outbreaks of HAIs involving one or more prevalent organisms.[16] However, the definitive management of HAIs depends on the culture and sensitivity patterns of the causative micro-organisms.

For the prevention of HAIs, the most commonly employed strategies include the elimination of endogenous nosocomial pathogens (to reduce oropharyngeal, intestinal, and skin colonization), use of methods to prevent cross-contamination and to control various sources of nosocomial pathogens that can be transmitted from patient to patient, or from personnel to patient and use of prophylaxis in post-operative and high risk patients (burns patients and patients in ICUs, among others).

The disease burden attributable to HAIs is quite enormous. According to one estimate by WHO, approximately 15% of all hospitalized patients suffer from HAIs.[17] The distribution of this prevalence is

however, not the same among the high, middle and low income countries as the frequency of overall infections in low income countries is three times higher, than in high income countries.[18] In high income countries, the incidence is between 3.5% and 12%, whereas in middle and low income counties, it varies between 5.7% and 19.1% respectively.

In Sub-Sahara Africa, available data show that the incidence of HAIs ranges from 2% to 49% with the prevalence varying between 1.6% to 28.7% in Burkina Faso, Tanzania, Ghana, Mali, Cameroon, Uganda, Burundi, Congo DR and Senegal.

In Nigeria and Ethiopia, the total prevalence attributable to surgical wards has been reported to vary from 5.7% to 45.8%, with the later having an incidence as high as 45.8%.[19]

The economic burden of treatment of HAIs is expectedly staggering, in view of the attributable disease burden. For example, in March 2009, the CDC estimated the overall annual direct costs of healthcare associated infections that ranged from 28-45 billion US dollars.[20]

HAIs are one of the leading causes of death, prolonged hospital stay, increased use of drugs, the need for isolation and use of additional laboratory and other diagnostic studies.[21] 3-10.9% of HAIs often result in mortality in most developed countries.[19] Expectedly, this could even be higher in developing countries because of the higher disease burden.

In Nigeria, there appears to be a dearth of studies on stethoscopes and sphygmomanometers as sources of HAIs. Nevertheless, one of the few documented studies had demonstrated that 80.1% of the stethoscopes used by medical students of a teaching hospital in the country had bacterial contamination with *Staphylococcus aureus* and *Pseudomonas aeruginosa* as the major isolates.[5]

The present study therefore aims to increase awareness among health workers (in Enugu State of Nigeria) of the potentials of contaminated stethoscopes and sphygmomanometer cuffs to cause HAIs.

METHODS

This was a prospective study involving four District Hospitals in Enugu State; Awgu, Oji, Udi, and Agbani District Hospitals.

Enugu State, which is the area of the study is bounded on the south by Abia and Imo states, on the north-east by Benue state, on the north-west by Kogi State, on the east by Ebonyi State and on the west by Anambra State. The State has an area of about 7,161 km^2, a population of 3,267,837 people.[22] In 2012, its population was estimated to be over 3.8 million people.

A sample size of 38 stethoscopes and 38 sphygmomanometers selected through random sampling was used for the study. Samples were collected from General Outpatient Department (GOPD), Wards and Ante Natal Clinics (ANC) of four district hospitals. In three of the hospitals, 10 stethoscopes and 10 sphygmomanometers were sampled per hospital while in the fourth, samples were collected from 8 stethoscopes and 8 sphygmomanometers. Swab sticks moistened with sterile 0.9% physiologic saline and rubbed on the entire surface of the diaphragm of each stethoscope and the entire inner surface of each sphygmomanometer cuff were used to collect the samples which were subsequently cultured using standard microbiological techniques. Where growth occurred, results were read as the number of colonies forming units (CFUs) and identification of the isolated micro-organisms was also carried out.

Structured self-designed questionnaire was used to assess the knowledge and practice of health workers on the awareness of the roles of stethoscopes and sphygmomanometers in HAIs.

Data were collected over a period of twelve (12) weeks, from the beginning of October to the end of December 2018. Collected data were analysed as descriptive statistics of proportions (%), and t-test of mean difference using Maxstat (version 3.60) statistical software. P-value of ≤0.05 was considered significant.

RESULTS

Table 1 shows knowledge and the practice of health workers (doctors and nurses) in the prevention of HAIs. From the table, it is seen that awareness of HAIs was highest in facility D (100%), followed by facilities B and C (80% in both), and then facility A (75%). Mean awareness of HAIs was 83.8%.

Table 1: Knowledge and practice in prevention of HAIs.

Awareness (in %) about HAIs Facilities	Proportion (in %) that clean/ decontaminate	
	Stethoscope	Sphygmo-manometer
A	75	50	0
B	80	40	0
C	80	40	20
D	100	40	0
Mean	83.8	42.5	5

Table 1 also shows the practice of cleaning/ decontamination of stethoscopes and sphygmo-manometers. In facility A, 50% of the health workers cleaned their stethoscopes, while in facilities B, C and D it was 40% that did so. On the average, 42.5% of health workers cleaned their stethoscopes. In cleaning/

decontamination of sphygmomanometers, only 20% of the health workers in facility C did so, while in the other three facilities, cleaning/decontamination of sphygmomanometers was 0%.

Table 2: Isolates and their degrees of contamination of the stethoscopes (N=38).

Organism	Population (in cfu) per facility					
	A	B	C	D	Total	Mean
Staphylococcus aureus	179	49	282	648	1158 (65.9%)	30.5
Proteus mirabilis	0	126	0	130	256 (14.6%)	6.7
Coliform species	0	0	274	0	274 (15.6%)	7.2
Pseudomonas aeruginosa	0	26	0	0	26 (1.5%)	0.7
Streptococcus species	0	42	0	0	42 (2.4%)	1.1

Table 2 shows the isolates and their degrees of contamination of the stethoscopes in the four facilities. As shown in the table, *Staphylococcus aureus* was the most commonly isolated organism from stethoscopes (65.9%) (648 cfu from facility D, 282 from C, 179 from A and 49 from B) with a mean of 30.5 cfu per stethoscope for the four facilities. The second most commonly isolated organism was *Coliform* species (15.6%) (274 cfu from facility C) with a mean of 7.2 cfu. The least commonly isolated organisms were *Proteus mirabilis* (14.6%) (130 cfu from facility D, and 126 cfu from B), with a mean of 6.7 cfu., *Streptococcus* species (42 cfu from B), and *Pseudomonas aeruginosa* (26 cfu also from B).

Table 3: Isolates and their degrees of contamination of the sphygmomanometers (N=38).

Organism	Population (in cfu) per facility					
	A	B	C	D	Total	Mean
Staphylococcus aureus	268	211	44	0	523 (23.8%)	13.82
Proteus mirabilis	38	58	0	0	96 (4.4%)	2.5
Coliform species	22	0	0	0	22 (1%)	0.6
Pseudomonas aeruginosa	118	308	648	410	1484 (67.6%)	39.1
Streptococcus species	0	0	0	70	70 (3.2%)	1.8

Table 4: Relationship between isolates from stethoscopes and sphygmomanometers.

Organism (mean in CFUs)	Site (stethoscope/sphygmomanometer) Facilities					
	A	B	C	D	t	p
Staphylococcus aureus	22/34cfu	5/21cfu	28/4cfu	65/0cfu	0.80	0.48
Proteus mirabilis	0/5cfu	13/6cfu	0/0cfu	13/0cfu	1.02	0.35
Pseudomonas aeruginosa	0/15cfu	3/31cfu	0/65cfu	0/41cfu	3.49	0.04
Streptococcus species	0/0cfu	4/0cfu	0/0cfu	0/7cfu	0.47	0.67
Coliform species	0/3cfu	0/0cfu	27/0cfu	0/0cfu	0.85	0.46

Table 3 shows the isolates from sphygmomanometers and their degrees of contamination in the four facilities. As shown in the table, *Pseudomonas aeruginosa* was the most commonly isolated organism (67.6%) (648 cfu from facility C, 410 cfu from D, 308 cfu from B, and 118 cfu from A) with a mean of 39.1 cfu per sphygmomanometer for the four facilities. The second most commonly isolated organism was *Staphylococcus aureus* (23.8%) (268 cfu from facility A, 211 cfu from B, 44 cfu from C, and 0 cfu from D) with a mean of 13.8 cfu per sphygmomanometer. The third most commonly isolated organism was *Proteus mirabilis* (58 cfu from facility B, and 38 cfu from A, facilities C and D had no *Proteus mirabilis*) with a mean of 2.5 cfu. *Coliform* species were isolated from only one facility (22 cfu from facility A).

Table 4 shows the relationship between the degrees of contamination of the stethoscopes and sphygmomanometers by different organisms isolated from them. From the table, it is seen that there was a

significant difference between the degree of contamination of the stethoscopes and sphygmomanometers by *Pseudomonas aeruginosa* (t=3.49, p=0.04). The other isolated organisms (*Proteus mirabilis, Staphylococcus aureus, Streptococcus* species and *Coliform* species) did not show any significant difference between the stethoscopes and sphygmomanometers.

DISCUSSION

It has long been known that the diaphragms and bells of stethoscopes randomly sampled in a healthcare setting, such as a hospital, are almost universally contaminated by potential nosocomial pathogens-methicillin-resistant *Staphylococcus aureus*, *Clostridium* difficile, resistant Gram-negative bacilli, and even viruses.[23] Studies have further shown that wiping the head of a stethoscope with a 70% alcohol pledget or wiping it with the antiseptic used for hand hygiene or a hospital surface disinfectant greatly reduces the bio-burden of aerobic bacterial contamination.[5,24]

In the present study, 83.8% of the health workers (doctors and nurses) demonstrated some awareness of the ability of stethoscopes and sphygmomanometers to act as sources of HAIs. However, this awareness was not matched with the appropriate actions for the prevention of HAIs as only 42.5% of the health workers in the four facilities cleaned their stethoscopes occasionally, while almost none of them made efforts to clean or decontaminate their sphygmomanometers (only 5% did so). This finding compares with what had been reported in a previous study in which 47% of the health workers cleaned their stethoscopes once in a year.[2]

Although viruses, fungi and parasites are recognized as sources of HAIs, bacterial agents still remain the most commonly recognized cause.[13] The main bacterial agents implicated are *Staphylococcus aureus* (including Methicillin-resistant *Staphylococcus aureus*, MRSA), vancomycin-resistant *Enterococcus*, *Pseudomomas aeruginosa*, *Acinetobacter baumanii*, coagulase-negative *Staphylococcus*, *Streptococcus*, *Proteus mirabilis*, Corynebacterium, among others.[15,9] Isolates from the present study include *Staphylococcus aureus, Proteus mirabilis, Pseudomonas aeruginosa, Streptococcus* species and *Coliform* species.

The prevalence of HAIs is not the same across the various units of a hospital. Studies have shown that Intensive Care Units (ICUs) of hospitals have the highest prevalence of HAIs in the hospital setting.[25] The settings of the present study include secondary health facilities (District Hospitals). In these hospitals, ICUs are non-existent, therefore samples were collected from consulting rooms, general wards and ante-natal clinics (ANCs). *Staphylococcus aureus* which was isolated in 65.9% of stethoscopes (23.3% of sphygmomanometers) and *Pseudomonas aeruginosa* isolated in 67.6% of sphygmomanometers (1.5% of stethoscopes) were the most commonly isolated organisms from these instruments. These findings are comparable to those of a group of Nigerian researchers who reported that 80.1% of stethoscopes used by medical students in Nigeria were contaminated by *Staphylococcus aureus* and *Pseudomonas aeruginosa*.[5]

The isolated organisms from the present study were mainly from the consulting rooms in the Out-patient Departments (OPDs) where there is usually high patient traffic. Probably because of this high patient traffic, the health workers do not always remember to clean or decontaminate their stethoscopes after every use.

The study also found the inner surfaces of sphygmomanometers to be slightly more contaminated than the diaphragms of the stethoscopes (67.65 versus 65.9%). This could possibly result from the wider surface area of the sphygmomanometer cuff being more prone to contamination by micro-organisms than the smaller surface area of the stethoscope head. Again, the majority of the contaminated sphygmomanometers were from the OPDs. This finding is in tandem with what had been reported in a previous study which found that 90% of the contaminated sphygmomanometers were from the OPD.[10]

Although, the sphygmomanometers were found to be more contaminated than the stethoscopes, the difference between them in contamination by the isolated organisms, was not significant, except in the case of contamination by *Pseudomonas aeruginosa* (t=3.49, p=0.04).

CONCLUSION

Among health workers in the four facilities, awareness (83.8%) did not match the practice (42.5% cleaned their stethoscopes, whereas only 5% their sphygmomanometers) of cleaning/decontamination of stethoscopes and sphygmomanometers. *Staphylococcus aureus* (in 65.9% of cases) and *Pseudomonas aeruginosa* (in 67.6% of the cases) were the two most commonly isolated organisms from stethoscopes and sphygmomanometers respectively. In view of the findings of this study, the health workers of the four facilities need to improve on their practice of care for stethoscopes and sphygmomanometers by cleaning the head (diaphragm and bell) of the stethoscope with 70% ethyl alcohol before and after every use, and cleaning the inner surface of the sphygmomanometer cuff once every day, or washing the sphygmomanometer cuff periodically, in order to control the skin type of HAIs. In addition, the use of barrier in the form of disposable sticky paper/tissue (the type of material used in making disposable face masks) arm bands applied on the upper arms of patients prior to the application of sphygmomanometer cuffs for blood pressure checks is another suggested measure which could help in the control of the spread of HAIs.

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