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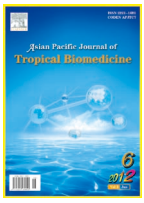

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Microbiological assessment of indoor air of a teaching hospital in Nigeria

Awosika SA[1], Olajubu FA[2*], Amusa NA[3]

[1]*Department of Microbiology, Olabisi Onabanjo University, Ago-Iwoye, Nigeria*
[2]*Department of Medical Microbiology & Parasitology, Olabisi Onabanjo University Teaching Hospital, Sagamu, Nigeria*
[3]*Department of Plant Science & Applied Zoology, Olabisi Onabanjo University, Ago-Iwoye, Nigeria*

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ABSTRACT

Objective: To investigate the quality of indoor air of different wards and units of Olabisi Onabanjo University Teaching Hospital, Sagamu, to ascertain their contribution to infection rate in the hospital. **Methods:** The microbial quality of indoor air of nine wards/units of Olabisi Onabanjo University Teaching Hospital, Sagamu, Nigeria was conducted. Sedimentation technique using open Petri-dishes containing different culture media was employed and samplings were done twice daily, one in the morning shortly after cleaning and before influx of people/patients into the wards/units and the other in the evening when a lot of activities would have taken place in these wards. Isolates were identified according to standard methods. **Results:** Results showed that there was a statistically significant difference ($\chi^2 = 6.0167$) in the bacteria population of the different sampling time whereas it was not so for fungi population ($\chi^2 = 0.2857$). Male medical ward (MMW) and male surgical general (MSG) recorded the highest bacterial and fungal growth while the operating theatre (OT) was almost free of microbial burden. The bacteria isolates were *Staphylococcus aureus, Klebsiella* sp., *Bacillus cereus, Bacillus subtilis, Streptococcus pyogenes* and *Serratia marscences* while the fungi isolates included *Aspergillus flavus, Penicillium* sp., *Fusarium* sp., *Candida albicans* and *Alternaria* sp. *Staphylococcus aureus* was the predominantly isolated bacterium while *Penicillium* sp. was the most isolated fungus. **Conclusions:** Though most of the microbial isolates were potential and or opportunistic pathogens, there was no correlation between the isolates in this study and the surveillance report of nosocomial infection during the period of study, hence the contribution of the indoor air cannot be established. From the reduction noticed in the morning samples, stringent measures such as proper disinfection and regular cleaning, restriction of patient relatives' movement in and out of the wards/units need to be enforced so as to improve the quality of indoor air of our hospital wards/units.

1. Introduction

Patients are primarily admitted into hospital wards for proper management of their ailments, but while on admission some patients acquire other ailments than the one they were admitted for. These are called hospital associated infections (nosocomial infections) which can result from contact with a carrier directly or indirectly through inanimate objects or air.

The quality of indoor air in terms of microbial contamination in a given space at a given time period is said to be determined by the quality of air entering the space, the umber of occupants in the space, their physical activities and resultant aerosol generation, human traffic and the degree of ventilation[1-3]. Dust, which is a good vehicle of airborne contamination, may arise from human activities, such as sweeping, movement, waving of handkerchief and bed making. Sneezing has been described as the most vigorous mechanism of generating millions of droplet into the environment. While the larger droplets fall to the ground or on nearby objects, the smaller ones are rapidly evaporated to their non-volatile residual forms and remain suspended as droplet nuclei[4].

Measures often taken in preventing nosocomial infections include effective use of antiseptics, disinfectants, adequate cleaning, sterilization and isolation of patients with highly infectious diseases[5].

However, less attention is paid to indoor air as been a probable contributing factor to hospital acquired infections. Ishida *et al*[6] reported that airborne bacteria in the hospital environment have been a major source of post-operative

*Corresponding author: Dr. Olajubu FA, Department of Medical Microbiology and Parasitology, Olabisi Onabanjo University Teaching Hospital, Sagamu, Nigeria.
Tel: +234802 393 1914
E-mail: olajubufa@yahoo.com

infection and a serious problem in the Intensive Care Unit[7]. Many of these isolates (bacteria) are shown to be resistant to common antiseptics used in hospitals[8].

Organisms that are often associated with hospital acquired infections are *Staphylococcus aureus*, *Micrococcus* sp., *Pseudomonas* sp., *Proteus* sp., *Escherichia coli*, *Enterobacter*, *Bacillus cereus*, *Cladosporium* sp., *Aspergillus* sp., and viruses[9,10]. *Pseudomonas aeruginosa* has been particularly incriminated in nosocomial infection because of its intrinsic resistance to most antibiotics and its ability to survive and multiply at low temperatures and in disinfectant solutions[11]. Regular microbiological surveillance of the different hospital units, patients' surveillance by the hospital's Infection Control Unit, formulation of antibiotic policy and recommendation to hospital management for implementation of findings will go a long way to reduce nosocomial infections.

This study therefore was aimed at investigating the quality of indoor air of different wards and units of Olabisi Onabanjo University Teaching Hospital (OOUTH), Sagamu, to ascertain their contribution to infection rate in the hospital. It will also provide a baseline information on the quality of indoor air which before now was not available.

2. Materials and methods

2.1. Study area

OOUTH, Sagamu, is a tertiary health institution located in the Southwestern part of Nigeria. It has two hundred and forty bed spaces and this was the study area. Nine wards/units were used for sample collection and these included male medical ward (MMW), female medical ward (FMW), children's ward (CHW), neonatal unit (NNU), male surgical specialty (MSS), male surgical general (MSG), female surgical ward (FSW), operating theatre (OT) and accident & emergency unit (A&E). The study was carried out between May and June, 2010.

2.2. Sampling procedure

Sedimentation technique using open Petri dishes containing different culture media was used[12]. Three plates of each medium were distributed at different parts of wards/units examined. The samplings were done at the morning hours (8.00-10.00 am) and evening periods (4.00-6.00 pm). The plates containing the culture media (blood agar and Sabouraud dextrose agar) were exposed and allowed to stay for 20 minutes, after which the plates were covered and transferred to the hospital's Microbiology Laboratory Unit for incubation. The blood agar plates were incubated at 37 ℃ for 48 hours while the Saboraud dextrose agar plates were incubated for 3-5 days at 28 ℃. The total numbers of colony forming units (cfu) were enumerated. The identification of the isolates was done according to standard procedures[13,14].

2.3. Statistical analysis

The data thus generated were analyzed by simple mean value, percentage and test of significance using *Chi*-square[15].

3. Results

3.1. Bacteria distribution

A total number of nine wards/units were studied. The bacterial population was higher (56.83%) among the evening samples than the morning samples (43.17%). MSG was the most contaminated among the wards during the morning sampling (26.67%) while 31.65% was recorded in MMW in the evening samples, thus making it the most contaminated ward for the evening session. NNU, OT and A&E had low bacterial contamination in their indoor air (Table 1).

Table 1
Number and percentage of airborne bacterial population in air of the sampled wards/units (cfu).

Study area	Sampling time	
	Morning (8.00-10.00 am)	Evening (4.00-6.00 pm)
MMW	15 (25.00)	25 (31.65)
FMW	5 (8.33)	8 (10.13)
CHW	5 (8.33)	11 (13.92)
NNU	2 (3.33)	2 (2.53)
MSS	4 (6.67)	3 (3.80)
MSG	16 (26.67)	16 (20.25)
FSW	11 (18.33)	12 (15.19)
OT	1 (1.67)	-
A&E	1 (1.67)	2 (2.53)
Total	60 (100.00)	79 (100.00)

3.2. Fungi distribution

Plates from the nine ward/units for evening samples yielded 16 cfu of fungi as against 14 from the morning samples. The distribution showed that MSG had the highest growth (28.57%) in the morning session whereas the medical wards recorded the highest growth in the evening session with 31.25% and 25.00% for MMW and FMW, respectively. MSS and OT had no fungal growth while NNU and A&E yielded one and two cfu of fungi, respectively as shown in Table 2.

Table 2
Number and percentage of airborne fungal population in air of the sampled units (cfu).

Study area	Sampling time	
	Morning (8.00-10.00 am)	Evening (4.00-6.00 pm)
MMW	1 (7.14)	5 (31.25)
FMW	3 (21.43)	4 (25.00)
CW	3 (21.43)	2 (12.50)
NNU	1 (7.14)	-
MSS	-	-
MSG	4 (28.57)	2 (12.50)
FSW	2 (14.29)	1 (6.25)
OT	-	-
A & E	-	2 (12.50)
Total	14 (100.00)	16 (100.00)

Table 3
Frequency of occurrence of isolates from the sampled units.

Isolates	FMW	MMW	CHW	NNU	MSS	MSG	FSW	OT	A&E
Staphylococcus aureus	2	6	1	1	2	4	3	1	1
Bacillus cereus	1	5	2	–	–	2	2	–	–
Klebsiella sp.	5	6	2	1	1	6	3	–	–
Serratia marscences	–	–	–	–	–	2	–	–	–
Bacillus subtils	–	6	5	–	–	1	–	–	1
Streptococcus sp.	–	2	1	–	1	1	1	–	–
Aspergillus flavus	1	2	1	–	–	1	–	–	–
Penicillium sp.	2	2	1	–	–	2	1	–	1
Fusarium sp.	–	1	–	–	–	–	1	–	1
Candida albicans	–	–	1	1	–	–	–	–	–
Alternaria sp.	1	1	–	–	–	1	–	–	–

3.3. Frequency of isolation

Staphylococcus aureus was the predominantly isolated bacteria, being isolated in all the six plates used in MMW and found in all the wards/units sampled. This was closely followed by *Klebsiella* sp. and *Serratia marscences* was isolated only in MSG and the only bacteria isolated in OT was *Staphylococcus aureus*. The A&E had a cfu of *Staphylococcus aureus* and *Bacillus subtilis* as shown in Table 3. *Penicillium* sp. was isolated in six of the nine wards/units sampled with the highest frequency in MMW. *Aspergillus flavus* was isolated in 4 wards/units of the sampled areas of the hospital. *Candida albicans* was isolated in the paediatric sections of the hospitals *i.e.* CHW and NNU. There was no fungus isolated from OT.

The frequency distribution of the mostly isolated bacterium (*Staphylococcus aureus*) and fungus (*Penicillium* sp.) was presented in Figure 1.

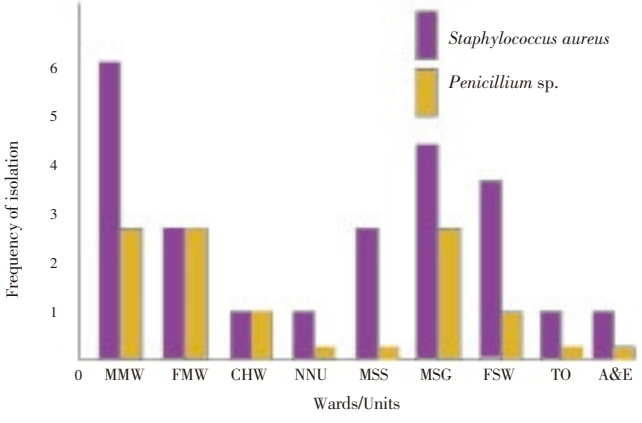

Figure 1. Frequency of occurrence of *Staphylococcus aureus* and *Penicillium* sp. from the sampled units.

4. Discussion

Hospital associated infections have been linked with many factors among which is the microbial quality of the indoor air of different wards and units of each hospital[1]. This type of infection occurs in 5% of all acute care hospitalization in the United State and has been reported to be responsible for the death of one out of every five thousand patients attending an American hospital[17]. In Nigeria, the rate of nosocomial infection ranges between 2.7%–3.8%[18,19], but 4.0% at OOUTH before this study. This calls for looking at every possible measure to control the rise including (among other investigations) examining the quality of indoor air of the hospital wards and units.

It was on this background that a qualitative study of the different hospital wards/units of OOUTH was carried out. This study revealed that MMW recorded the highest indoor airborne bacteria population and closely followed by MSG. At the time of this study, the two wards were at their maximum capacity, this invariably will attract more patient relative in and out of these wards thereby increasing the shedding of bacteria and agitation of air. However, in a similar study by Ekhaise *et al*[1], A&E recorded the highest airborne bacterial and fungal population, this is at variance with this study in which A&E and OT were the least burdened units of the hospital. The structural design and regular scrubbing of the OT and restriction of movement in and out of it might be responsible for the low bacteria burden of its indoor air. No fungal element was isolated from the OT and MSS. MSW and MSG again recorded the highest indoor airborne fungal population.

The microbial isolates included six bacteria and five fungi which are *Staphylococcus aureus*, *Bacillus cereus*, *Klebsiella* sp., *Serratia merscences*, *Bacillus subtilis*, *Streptococcus pyogenes* for the bacteria isolates while the fungi isolates includes *Aspergillus flavus*, *Penicillium* sp., *Fusarium* sp., *Candida albicans* and *Alternaria* sp. Some of these clinical isolates have been reported by earlier researchers[8,9,20,21]. *Staphylococcus aureus* as the most frequently isolated bacterium from this study has been incriminated in various diseases such as post operative infections, urinary tract infections, skin infections, respiratory infections and food poisoning[22,23]. Proper control measures such as increase in hygiene are required to combat infections by *Staphylococcus aureus* in these hospital wards and units. *Bacillus* sp. are spore forming organisms that can survive for longer period of time and can cause serious medical problems, hence proper program for eliminating it must be put in place. *Klebsiella* sp. and *Streptococcus pyogenes* are associated with urinary tract infection among catheterized patients and immuno–

compromised patients[24,25], though not isolated from any of the patients on admission during the study, (surveillance report) their isolation in this study calls for more adequate control measures. The isolation of *Aspergillus flavus*, a medically important fungus for aflatoxin production, a neurotoxigenic substance, and which can also cause lung infection should not be overlooked just as *Candida albicans* which are isolated from the neonatal wards where they can cause neonatal conjunctivitis. Improving hygiene might suffice in the affected wards/units.

The monthly surveillance of the hospital's Infection Control Unit for the months of this study showed that two hospital associated infections are caused by *Pseudomonas aeruginosa* in MMW and FMW among patients with indwelling catheter. Since no *Pseudomonas* sp. was isolated in this study, the role of contaminated indoor air could not be correlated in these infections. However, since the isolated bacteria and fungi could be pathogenic if contact is established with patients, it is pertinent that their presence should be controlled.

Regular surveillance, cleaning and restriction of patients relative might be among the strict measures necessary to reduce or totally eliminate the microbial load of indoor air of this hospital wards and units.

Conflict of interest statement

We declare that we have no conflict of interest.

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