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Hospital Indoor Airborne Microflora in Private and Government Owned Hospitals in Benin City, Nigeria

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Abstract: The level of airborne microbial load of hospitals indoor is unknown in Benin City, Nigeria. A study of the quality and quantity of airborne microflora in two major hospitals, the Faith Medical Center and Central Hospital in Benin City was carried out to establish standard for future reference. Samples were collected using the settled plate techniques for the enumeration of bacterial and fungal isolates. Each day, the air samples were collected three times: in the morning between 10 and 11 am, in the afternoon between 12 noon and 2 pm and in the evening between 5 and 6 pm. The total heterotrophic microbial population of the five different wards studied from the two hospitals varied from wards to wards. The highest bacterial population was recorded in the evening between time 5 pm and 6 pm compared to the morning and afternoon, ranging from 15 cfu m^{-3} to 47 cfu m^{-3} in the Faith Medical Hospital and 17 cfu m^{-3} to 52 cfu m^{-3} in the Central Hospital, with the children ward recording the highest bacterial counts of 47 cfu m^{-3} and 52 cfu m^{-3} in the Faith Medical Center and Central Hospital respectively. The concentration of fungal population in air of the five different wards in the two hospitals studied was recorded high in the evening, with values ranging from 10 cfu m^{-3} to 53 cfu m^{-3}. At the three different times of study, the male, female, children wards and bacteriological laboratory were observed to record high fungal population in the Faith Medical Center and the Central Hospital. The microbial isolates characterized and identified include six bacterial and four fungal genera, among which are the bacterial isolates: *Staphylococcus aureus, Staphylococcus epidermidis, Escherichia coli, Pseudomonas aeruginosa, Proteus mirabilis and Klebsiella aerogenes* and the fungal isolates include *Aspergillus, Penicillum, Mucor* and *Fusarium*. The degree of frequency of microbial distribution was high in the bacteriological laboratory and female ward and lowest in the operating room (Theater).

Key words: Hospital · Ward · Airborne microflora · Bacteria · Fungi · Time and bioaerosols

INTRODUCTION

Atmospheric pollution is one of the most pressing problems of our age. This pollution has now reached an advance level that posse a potential threat to the health and well being of the people. The atmosphere consists of different component, which enhance or promote the survival of microorganisms in the air. It is composed of 75% nitrogen, 21% oxygen, 0.9% argon, 0.03% carbon dioxide and 0.076% other trace gases, very low concentration of organic and inorganic nutrients and free waters as an irregular internals. The health and well being of the public are affected by the physical, chemical and biological properties of the indoor environment. The quality of the indoor environment, however, is not easily defined or controlled, and can potentially place human occupants at risk [1].

Hospital indoor air contains a diverse range of microbial population. The significance of these microbes is debatable in some quarters, whereas elsewhere it may be considered significant. The importance of the estimation of the quantity and types of airborne microorganisms are that these values can be used as an index for the cleanliness of the environment as well as an index they bear in relation to human health and as source of hospital-acquired infections [1, 2].

Microorganisms are the primary sources of indoor air contamination [3]. The indoor air environment can potentially place patients at greater risk than the outside environment because enclosed spaces can confine aerosols and allow them to build up to infectious levels [4].

The source and spread of organisms inside the hospital are important issues, human related organisms or

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the body normal flora, also found in clothing are spread through shedding during human activities [1]. The organisms, which are particularly spread this way, include *Staphylococcus aureus*, *Micrococcu*s spp, alpha-hemolytic Streptococci and Gram-negative rods. Environmental organisms such as *Bacillus* spp, *Streptomyces* spp and various bacteria of non-medical importance, coming form other sources such as air dust, soil and water add to this collection. Apart from this, ventilation system components can become contaminated with pathogenic microorganisms such as *Legionella pneumophila,* which are subsequently transmitted to the patients [5].

Air movement aids in the transport and dispersal of particles and microorganism. The airborne microorganisms that raise public health hazards concerns are those that are causative agents of infectious disease and allergies. The agents belong to the viruses, fungi and bacteria groups. A quantitative study of the different hospital unit is important. The microbial population in a given environment is influenced by many factors including the number of visitors and the amount of materials brought in from outside. Although there are no established standards for viable or nonviable particulate matter in the operating room or in any other hospital area [1], the number of microorganisms in some hospital areas such as the operating theater (OT) and intensive care unit (ICU) are usually extremely low. This is due to the high sanitary standards as compared to other hospital areas. The exposure to airborne bacteria, fungi, mycotoxins and viruses causes potential biological hazard. Fungal spores concentration and dissemination are important factors [6]. The common genera of fungi frequently isolated form hospital indoor air includes: *Aspergillus*, *Chaetomium* and *Alternaria*.

The majority of bioaerosols is non-pathogenic and cause disease only in sensitized or grossly immunocompromised individuals. It is however, well documented that the hospital environment is a source of acquired infections [7]. For this reason, knowledge of the incidence of microflora in hospitals is important for the understanding of the possible types of infections and allergies that may emanate from them. Furthermore, controlling the microbes in these hospital environments may play a role in the prevention of cross infection.

Previous studies showed that the microbial flora of the indoor air depends on several factors including the number and hygienic standard of people present [8], the quality of the hospital system [9-12] and mechanical movement within the enclosed space. In poor quality and crowded wards, the higher number of patients confined to a small space results in the build up of airborne microbes shed by the human body. High humidity level results in condensation on surfaces and growth of biological contaminants such as dust, mites and fungi particularly in places where dust and dirt's accumulate. People who stay in the wards may be at a particular risk of exposure to biological pollutant such as molds [13].

Geographical and regional monitoring of indoor microorganisms has not been extensively investigated. The present study was aimed at investigating the quantity and quality of airborne microorganisms in the hospital wards and to set the minimum acceptable standard of tolerable levels of microbial population.

MATERIALS AND METHODS

Study Area: The study was carried out in two-selected hospital, namely the Central Hospital and Faith Medical Center in Benin City, Edo State, government and private owned hospital respectively. The samples for the study were collected from five units in the hospitals, these includes the male ward, female ward, children ward, theater and bacteriological laboratory.

Air Sampling and Microbiological Examination: The microbiological samples were collected from the five units in the hospitals, by exposing the prepared petri dishes containing potato dextrose agar and nutrient agar for a period of 30minutes. Each day, the air samples were collected three times, that is in the morning between 10 and 11am, in the afternoon between 12 noon and 2 pm and in the evening between 5 pm and 6 pm. Upon exposure, the plates were transported to the laboratory for examination. The bacterial culture plates were incubated at 37°C for 24-48 hrs while the fungal culture plates were incubated at room temperature for 3-4 days.

The total number of colony forming units (cfu) was enumerated and converted to organisms per cubic meter air. Bacterial colonies were initially characterized by morphology and microscopic examination and identified further by biochemical tests [14,15]. The fungal colonies were identified according to the manual of Barnett and Hunter [16], the tests were based mainly on gross colonial appearance, microscopic examination of the spore and hyphal characteristics of lactophenol cotton blue preparations.

RESULTS

Microbial Load in Study Areas: The total heterotrophic microbial population of the five different wards studied

Table 1: Concentration of bacterial population in air of five wards in Faith Medical Center and Central Hospital in Benin City (cfu m^{-3})

	Sampling Time		
Study area	10.00am-11.00am	12.00noon-2.00pm	5.00pm-6.00pm
Faith Medical Center			
Male ward	26	27	45
Female ward	46	39	43
Children ward	44	36	47
Theatre	18	39	15
Bacteriology Laboratory	42	39	26
Central Hospital			
Male ward	31	25	50
Female ward	45	44	48
Children ward	49	41	52
Theatre	23	20	17
Bacteriology Laboratory	47	44	31

Table 2: Concentration of fungal population in air of five different wards in Faith Medical Center and Central Hospital in Benin City (cfu m^{-3})

	Sampling Time		
Study area	10.00am-11.00am	12.00noon-2.00pm	5.00pm-6.00pm
Faith Medical Center			
Male ward	32	25	34
Female ward	25	30	22
Children ward	26	22	28
Theatre	18	13	12
Bacteriology Laboratory	26	27	22
Central Hospital			
Male ward	24	20	53
Female ward	20	15	21
Children ward	31	27	33
Theatre	10	8	10
Bacteriology Laboratory	25	25	21

Table 3: Frequency of occurrence of hospital air microorganisms isolated five wards in Faith Medical Center and Central Hospital in Benin City

Microbial isolates	Male ward	Female ward	Children ward	Theatre	Bacteriology Laboratory
Serratia marcescens	++	++	-	++	++
Pseudomonas aeuroginosa	-	+	-	-	-
Escherichia coli	++	++	++	++	++
Staphylococcus aureus	++	++	++	++	++
Staphylococcus epidermidis	++	++	++	++	++
Proteus mirabilis	+	+	+	+	+
Klebsiella aerogenes	+	+	-	+	+
Aspergillus sp	-	++	++	++	++
Penicillium sp	-	++	++	-	++
Fusarium sp	++	-	++	++	++
Mucor sp	++	-	++	-	++

Key: + = positive, ++ = very good, - = negative

from the two hospitals varied from wards to wards (Table 1 & 2). The highest bacterial population recorded in the evening between time 5 and 6 pm compared to the morning and afternoon, ranging from 15 cfu m^{-3} to 47 cfu m^{-3} in the Faith Medical Hospital and 17 cfu m^{-3} to 52 cfu m^{-3} in the Central Hospital, with the children ward recording the highest bacterial counts of 47 cfu m^{-3} and 52 cfu m^{-3} in the Faith Medical Center and Central Hospital respectively. High bacterial population counts were observed in the children, female wards and the bacteriological laboratory in the three different times of studies (Table 1). The concentration of fungal population in air of the five different wards in the two hospitals studied was recorded high in the evening, with values

ranging from 10 cfu m^{-3} to 53 cfu m^{-3} (Table 2). At the three different times of study, the male, female, children wards and bacteriological laboratory were observed to record high fungal population in the Faith Medical Center and the Central Hospital.

Frequency of Air Microbial Population: Table 3 shows the frequency of distribution of the hospital air microorganisms isolated from five different wards in the Faith Medical Center and Central Hospital in Benin City. Seven bacterial isolates and four fungal isolates were isolated. Among the bacterial isolates *Escherichia coli, Staphylococcu aureus, Staphylococcus epidermidis and Proteus mirabilis* were observed to be the most prevailing isolates in all the units investigated, while *Aspergillus* sp. and *Fusarium* sp. were the fungal isolates most commonly frequent in all the units studied. The degree of frequency of microbial distribution was high in the bacteriological laboratory and female ward and lowest in the operating room (Theater).

DISCUSSION

In this study, six species of bacterial isolate, *Staphylococcus aureus, Staphylococcus epidermidis, Escherichia coli, Pseudomonas aeruginosa, Proteus mirabilis and Klebsiella aerogenes* and four species of fungal isolates, which include *Aspergillus* sp*, Penicillum* sp*, Mucor* sp*, Fusarium* sp were consistently isolated from the five different hospital units investigated. These genera of bacteria and fungi have been shown to be amongst the most common bacterial and fungal species often isolated from the air [13]. Jaffal *et al.,* (1997) isolated *Staphylococcus aureus*, Staphylococci (CNS) *Micrococcus* spp, alpha hemolytic Streptococci, Diphtheroid bacilli, Gram negative bacilli, *Bacillus* spp, *Streptomyces* spp, unidentified bacteria and fungi from male, female, pediatric, female surgical and male surgical wards respectively, intensive care unit and operating theater. The fungal genera were *Alternaria, Aspergillus, Chaetomium, Penicillum* and *Verticullum*.

Quantitative study of different hospital units showed that the children ward and female ward had the highest total bacterial count followed by the bacteriology laboratory. The high microbial counts recorded for the public hospital (Central Hospital) as compared to the private hospital (Faith Medical Center), could be due to the subsidizes rate of the public hospital so as to accommodate more people, compared to the private hospital, where high fees are charged and are not within the reach of the poor people in the society. These findings could be explained by many factors including the number of visitors visiting the children and female wards, which exceeded visitors in other hospital units. It was also noted that the amount of materials brought from outside such as personal belongings. These are recognized as sources of hospital contamination. Although there are no established standards for viable or non-viable particulate in theater or in other hospital areas, the number of microorganisms in the theater was extremely low. This was anticipated due to high sanitary standards in this area as compared to other hospital areas. Human activities such as talking, walking, laughing, sweeping, all contribute to the microbial load in the air of this hospital. This result also confirms with report of Okhuoya and Okaraedje [17], which human population and activities affects concentration of bacteria, which are released through human activities such as brisk movement, talking, coughing and sneezing.

Many studies on microbial contaminants in indoor air have been recorded by several investigators in different environments such as hospitals (Jaffal *et al*., 1997), residential buildings (Jaffal *et al*., 1997), agricultural settings [18].

The concentration of potentially pathogenic organisms in the hospital air was low compared to the concentration of pathogenic bacteria carried out in an European study using an Anderson air sampler, pathogenic bacteria accounted for 30% of all isolates (Williams *et al*., 1965), but it included *Streptomyces* spp as human pathogens but in the study reported by Jaffal *et al* (1997), *Streptomyces* spp was considered an environmental microorganism. The low concentration of pathogenic organisms in the air could possibly be due to the fact that there was no strong air current to distribute the bacteria from the reservoirs (patients). Pathogenic organisms associated with wound infections would be expected in high concentration in certain hospital areas. They do not seem to be airborne and therefore their mode of transmission is most likely via direct physical contact of staff and patients.

The fungal genera obtained in this study were few compared to the seventeen genera isolated by Ayanru (1981). However Ayanru sampled an agricultural setting while this work was on hospital wards hence the two studies cannot really be compared. Besides, Ayanru used the Anderson sampling method, while in this study, the settle plate method was used.

From this study, *Staphylococcus aureus, Escherichia coli, Proteus mirabilis* appeared to be the

most prevalent bacteria species. *Staphylococcus* is known to be easily carried in the nasopharynx, throat, skin, cuts, boils, nails and as such can easily contribute to the microflora in the hospital environment. *E. coli* which is coliforms makeup approximately 10% of microorganism of the humans and are used as the indicator organisms (Prescott *et al*., 2005). It is commonly associated with water and its presence in the environment reflects the degree of purity of the water used for various purposes e.g. floor cleaning and other activities in the hospital wards.

Aspergillus spp was the most common fungi isolated (Jaffal *et al.,* 1997) reported that *Aspergillus, Chaetomium and Alternaria* were the most common genera frequently isolated from indoor environments and air conditioning systems. The most common of them, *Aspergillus*, is occasionally involved in incidence of aspergillosis, ear and skin infections.

It is therefore important to evaluate the quality of the air we breathe whether indoor or outdoor, especially in the hospital environments. The number and type of airborne microorganisms can be used to determine the degree of cleanliness as well as to determine the source of human discomfort.

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