Journal of Advances in Biology & Biotechnology

18(1): 1-6, 2018; Article no.JABB.41841
ISSN: 2394-1081

Assessment of Airborne Bacteria in Healthcare Institutions in the University of Port Harcourt, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author NNO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors HOS and EEE managed the analyses of the study. Author EEE managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JABB/2018/41841
Editor(s):
(1) Joana Chiang, Department of Medical Laboratory Science and Biotechnology, China Medical University, Taiwan.
Reviewers:
(1) Bharat Raj Singh, Dr. APJ Abdul Kalam Technical University, India.
(2) Joseph O. Falkinham, Virginia Tech, USA.
Complete Peer review History: http://www.sciencedomain.org/review-history/24823

Original Research Article

Received 5th March 2018
Accepted 14th May 2018
Published 26th May 2018

ABSTRACT

An assessment of airborne bacteria in the different healthcare institutions in the University of Port Harcourt, Rivers State, Nigeria was carried out in this study. Factors considered in this study were crowding, ventilation, degree of human activities around the hospitals, length of exposure of plates, time of sampling, type of health institution, space, sanitary systems and hygiene practice of hospital staff. An investigation of the air quality and quantity of airborne bacteria in the selected health institutions was carried out using the sedimentation method at the sites of study. The following eight bacterial species were isolated during the study: *Bacillus* sp., *Serratia* sp., *Streptococcus* sp., *Micrococcus* sp., *Proteus* sp., *Klebsiella* sp., *Citrobacter* sp. and *Staphylococcus* sp. The occurrence of *Bacillus* sp., *Staphylococcus* sp., *Proteus* sp. and *Serratia* sp. were higher in Lulu Briggs Health Center, while the occurrence of *Streptococcus* sp., *Micrococcus* sp., *Klebsiella* sp. and *Citrobacter* sp. were higher in University of Port Harcourt (UPTH). The relatively higher occurrence of potentially pathogenic bacteria in UPTH may be attributed to the level of complication of the illnesses and medical cases attended to in the hospital compounded by factors such as poor ventilation, relatively high human population and poor anti-infection control practices.

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Keywords: Microbial; air quality; health institutions; University of Port Harcourt; survey.

1. INTRODUCTION

The microbial quality of indoor air in a given space at a particular time period is said to be determined by the quality of air entering the space, the number of occupants in the space, their physical activities and resultant aerosol generation, human traffic and ventilation of the area [1-3].

Dust, is a good vehicle of airborne contamination, it arises from human activities, such as sweeping, movement and bed making. Sneezing has been described as the most frequent mechanism of generating millions of microbial droplets 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].

Patients are primarily admitted into hospital wards for proper management of their illnesses, but while on admission some of them acquire other infections than the ones 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 [4].

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 [5,6]. *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 [7].

More attention is being paid to indoor air as being a probable contributing factor to hospital-acquired infections. Ishida et al. [8] reported that airborne bacteria in the hospital environment have been a major source of post-operative infection and a serious problem in the Intensive Care Unit [9]. Many of the bacteria isolated were shown to be resistant to common antiseptics used in the hospitals. This study, therefore, investigated the microbial quality of indoor air of different wards and units of the two healthcare facilities in the University of Port Harcourt, Rivers State.

2. METHODS

2.1 Study Sites

This study was carried out at the University of Port Harcourt Teaching Hospital and O.B Lulu Briggs Health Center at the University of Port Harcourt, Rivers State, Nigeria. Both institutions lack a functional air-handling system. The study sites were divided into seven units which include the male ward, female ward, male and female toilets, General Outpatient Department (GOPD), surgical ward, emergency and paediatrics wards.

2.2 Sampling

Sedimentation technique using open Petri dishes containing Nutrient Agar culture media for bacteria isolation was exposed for Twenty minutes in the various units, as described by pasquarella et al. [10]. The plates were then incubated at 37^{o}C for 24 hours.

2.3 Identification of Organisms

Bacterial colonies were initially characterized by cultural, morphological and microscopic examinations and further identified by biochemical examination of the isolates according to Bergey's Manual of Determinative Bacteriology [11].

Frequency Of occurrence =n/N*100

Where, n =specific number of particular specie.
N = Total number of isolated organisms.

3. RESULTS AND DISCUSSION

Table 1 shows the average bacteria counts recorded in each of the hospitals for a four-day period, with bacteria count from UPTH ranging from 17.9 to 19.8 CFU/min, with an average of 18.9 CFU/min, higher than counts from Lulu Briggs Health Center which ranged from 11.1 – 11.6 CFU/min with an average of 11.4 CFU/min. Results recorded from the study were considerably higher than the range of 6.6 – 9.8 CFU/min recorded in a similar study by Awosika et al. [4]. The relatively high rates in this study might be attributed to poor and deficient hygienic conditions, high population and most probably low degree of cleanness and minimal disinfection procedures against airborne bacteria, which may all be proportional to an increase in bacterial growth rate.

Table 1. Average bacteria counts of air borne organisms

Location	Average bacterial count (CFU/min)				
	Day 1	Day 2	Day 3	Day 4	Average
UPTH	17.9	19.3	18.5	19.8	18.9
LULU BRIGGS	11.1	11.5	11.6	11.4	11.4

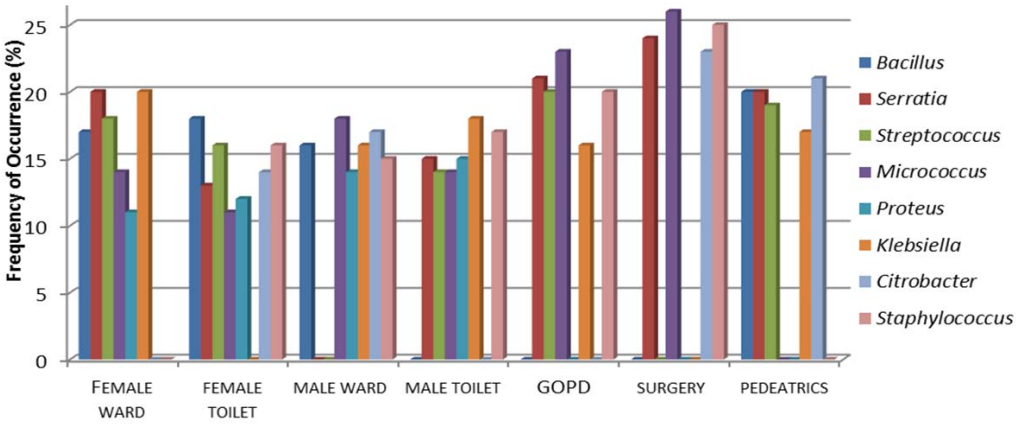

Fig 1: Frequency Distribution Of Airborne Bacteria Isolated From UPTH

Bacteria isolated from the University of Port Harcourt teaching hospital included; the Figure 1 shows the distribution of bacteria isolated from UPTH, which are: *Bacillus* sp., *Serratia* sp., *Streptococcus* sp., *Micrococcus* sp., *Proteus* sp., *Klebsiella* sp., *Citrobacter* sp. and *Staphylococcus* sp. The occurrence of *Bacillus* sp. ranged from 16 -20%, in all units except surgery, GOPD and the male toilet, the highest occurrence of *Bacillus* sp. was recorded in the pediatrics unit (20%), with the least occurrence recorded in the female ward (16%). The highest occurrence of *Serratia* sp. was found in the Surgery ward (24%), with the least occurrence recorded in the female toilet (13%). *Serratia* sp. was not found in the male ward. *Streptococcus* sp. was present in all units with occurrence frequency ranging from 14 – 18% except the surgical unit and male toilet where no occurrence of *Streptococcus* was recorded. The highest occurrence of *Micrococcus* sp. was found in the surgery ward unit (26%), while the female toilet had the least occurrence (11%) with no occurrence of Micrococcus in the pediatrics unit. The highest occurrence of *Proteus* sp. was found in the male toilet (15%), with the female ward having the least occurrence (11%) and no occurrence in the surgery, pediatrics and GOPD wards. *Klebsiella* sp. had the highest occurrence in the female ward (20%) and the least occurrence in the male toilet and GOPD (16% each) and no occurrence in female and surgery wards. The highest occurrence of *Citrobacter* sp. was in the surgery ward (23%) with the least occurrence in the female toilet (14%) and no occurrence in female ward, male toilet and GOPD. *Staphylococcus* sp. had a high occurrence of 25% in the surgery ward and its least occurrence of 15% in the male ward, with no occurrence in female and pediatrics wards. The bacteria isolated are in agreement with similar studies conducted by Awosika et al. [4] and Ekhaise and Ogboghodo, [12]. The occurrence of potentially pathogenic bacteria such as *Klebsiella* sp., *Staphylococcus* sp. and *Streptococcus* sp. is however relatively lower than those recorded in a study by Qudiesat et al. [13], with an average of 24%, 38% and 42% frequency of occurrence respectively. Awosika et al. [4] suggested that these variations in bacterial frequency of occurrence may be partly due to weather conditions in addition to other environmental factors such as geographic location/composition of the locations.

Fig. 2. Shows that bacteria such as *Bacillus* sp., *Serratia* sp., *Streptoccoccus* sp., *Micrococcus* sp., *Proteus* sp., *Klebsiella* sp., *Citrobacter* sp. and *Staphylococcus* sp. were isolated from the male and female toilets, male and female wards and the waiting area of the O.B. Lulu Briggs Health Center.

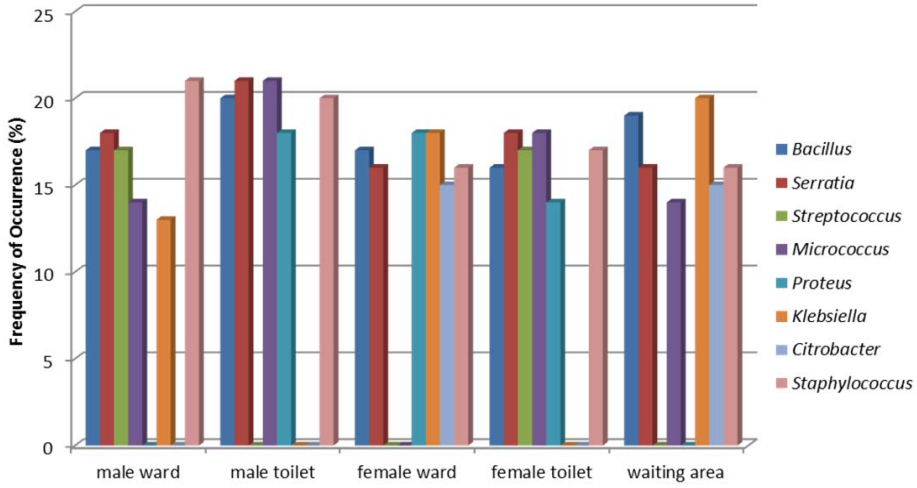

Fig 2: Frequency Distribution Of Airborne Bacteria Isolated From Lulu Briggs Health Center

The occurrence of *Bacillus* sp. was highest in the male toilet (20%) and least in the female toilet (19%). The male toilet had the highest occurrence of *Serratia* sp. (21%), and the least occurrence was in the waiting area (16%). *Streptococcus* sp. had an occurrence of 17% in the male ward and female toilets with no occurrence recorded in the other areas sampled. The highest occurrence of *Microccocus* sp. was recorded in the male toilet (21%), with the least occurrence of 14% recorded in the male ward and waiting area, and no occurrence recorded in the female ward. The highest occurrence of *Proteus* sp. was recorded in the male toilet and female ward (18% each), with the least occurrence of 14% recorded in the female toilet and no occurrence in the waiting area and male ward. No occurrence of *Klebsiella* sp. was recorded in the male toilets and female toilets, while the highest occurrence was recorded in the waiting area (20%) and the least occurrence in the male ward (13%). *Citrobacter* sp. had an occurrence of 15% in the female ward and waiting area, while no occurrence was recorded in other units sampled. The highest occurrence of *Staphylococcus* sp. was in the male ward (21%), and the least occurrence was in the waiting area (16%). In similar studies by Awosika et al. [4] and Qudiesat et al. [13] it was suggested that these occurrence of bacteria are related to the activities carried out in the various units. The isolation of *Klebsialla* sp. and *Staphylococcus* sp. in the waiting area was considered normal as most sick people and their relatives sit at the waiting area before they are attended to by the doctors or nurses, as recorded in similar studies [4,12].

Fig. 3 shows the comparison of average bacterial frequency of occurrence in UPTH and Lulu Briggs Health Center, the occurrence of *Bacillus* sp., *Staphylococcus* sp., *Proteus* sp. and *Serratia* sp. were higher in Lulu Briggs Health Center, while the occurrence of *Streptococcus* sp., *Micrococcus* sp., *Klebsiella* sp. and *Citrobacter* sp. were higher in UPTH. The relatively higher occurrence of potentially pathogenic bacteria in UPTH may be attributed to the level of complication of the illnesses and medical cases attended to in the hospital and compounded by factors such as poor ventilation, relatively high human population and poor anti-infection control practices as observed in similar studies [4,12,13].

Ekhaise et al. [1] reported the isolation of *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Escherichia coli, Bacillus* sp. *Proteus mirabilis* and *Streptococcus sp.,* with *Staphylococcus aureus* being the most prevalent bacterial isolate in a related study in University of Benin Teaching Hospital (UBTH), while Lateef [14] reported *Staphylococcus aureus* as a cause of infections of the skin, deeper tissue and organs, pneumonia and *Serratia marcescens* causes bacteriuria. These microorganisms are known primary agents of nosocomial infections in hospitals. Similar variety of aero-biota was isolated in a hospital in a desert country according to Maier et al. [15].

The sedimentation (settle plate) technique used in this study, though a useful method for assessing air contamination by microorganisms, has the limitation of being able to detect only viable microorganisms and can give a false negative in undisturbed rooms with still air.

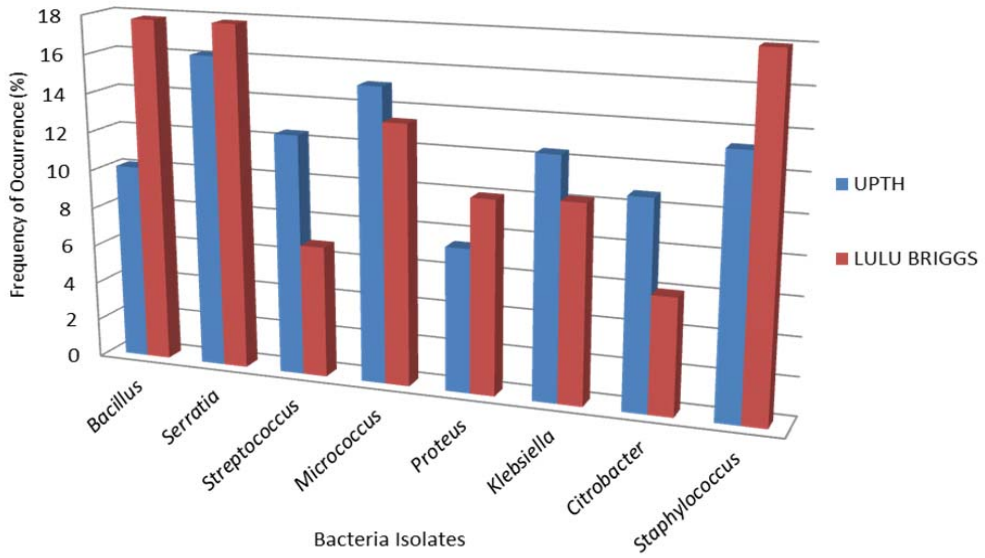

Fig. 3: Frequency Distribution Of Airborne Bacteria Isolated From UPTH and LULU Briggs Health Center

4. CONCLUSION

The results from this study showed that UPTH had a higher occurrence of potentially pathogenic airborne bacteria in indoor air. These high rates in UPTH might be attributed to poor and deficient hygienic conditions, low degree of cleanness and minimal disinfection procedures against airborne bacteria which might raise the airborne bio-contaminants. Another factor is the population in UPTH, the number of beds, patients, personnel, and visitors occupying the hospital building, which were observed to be significantly higher than those in Lulu Briggs Health Center.

The results generated in this study clearly suggest that regardless of time of day, indoor environment allows bioaerosols build up which could potentially lead to infections in the health institutions. Thus, hospitals should have enhanced practice of good sanitation protocols and infection control measures. Regular monitoring of hospital aero-biota is particularly recommended especially with the recent outbreak of the Ebola virus.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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