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Isolation and Identification of Airborne Pathogen from a General Hospital Wards in Kaduna Metropolis, Kaduna State, Nigeria

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ABSTRACT
Nosocomial infection poses a significant and pervasive threat to human health, thereby remains a significant concern globally, with airborne pathogens contributing substantially to their transmission. This study was conducted to isolate and identify bacteria and fungi airborne pathogens of some selected wards at Yusuf Danstoho Memorial Hospital, Tudun Wada, Kaduna. The microbial quality of indoor air of five wards which include; Accident and Emergency (A and E) unit, Male Medical Ward (MMW), Male Surgical Ward (MSW), Female Medical Ward (FMW), and Female Surgical Ward (FSW) was conducted. Sedimentation technique using open Petri-dishes containing different culture media was employed, isolates were identified according to standard methods. The isolated bacterial species were identified as *Staphylococcus aureus, Pseudomonas aeruginosa, Klebsiella pneumonia, Escherichia coli, and Micrococcus sp.* from the study. *Pseudomonas aeruginosa* has the highest percentage occurrence of 28.89%, followed by *Staphylococcus aureus* (24.24%), then *Klebsiella pneumoniae* (20.00%), while *Escherichia coli* (15.56%) and *Micrococcus sp* recorded the least (11.11%). Fungi isolates obtained were *Aspergillus spp, Penicellium spp* and *Candida sp.* with *Aspergillus spp*. having the highest occurrence of 52.94%, followed by *Penicellium spp* and *Candida spp* both with 23.52%. The accident and emergency ward (A & E) recorded the highest airborne bacterial and fungal population with 24.44% and 26.47% respectively. The results also showed that airborne bacterial pathogens were present in all the sampled hospital wards. These findings emphasize the need for stringent cleaning and ventilation measures in our hospitals to prevent nosocomial infections.

INTRODUCTION

Airborne pathogens present considerable health hazards in hospital settings, especially in wards housing immune compromised patients.

Nosocomial infections, also known as hospital-acquired infections (HAIs), are infections that develop in patients who were not infected when they were admitted to a hospital or healthcare facility. These infections can also be acquired in the hospital but manifest after the patient is discharged, and they may also be occupational infections among facility employees (Palmer and Onifade 2019).

Nosocomial infections constitute a huge and pervasive hazard to human health, and so remain a major problem worldwide, with airborne pathogens playing a crucial role in their transmission (Chen et al., 2024). In Nigeria, HAIs account for roughly 14.3% of hospitalizations (Olowe et al. 2018).

Airborne pathogens can be transmitted by droplets and aerosols produced by coughing, sneezing, talking, contact with hospital objects, and uncontrolled movement in and out of the hospital setting. These pathogens include *Staphylococcus aureus, Mycobacterium tuberculosis*, and *Pseudomonas aeruginosa, Bacillus species*, *Escherichia coli*, *Cladosporium* sp., *Aspergillus* sp., and viruses (Ekhaise et al., 2008). They may survive in the air for long periods of time and move long distances, particularly in poorly ventilated environments, making hospital wards vulnerable to contamination (Farrington et al. 2019). Patients with open wounds, those having surgery, and those receiving immunosuppressive medications are more likely to become infected in hospital wards. Airborne pathogen infections can result in increased morbidity, longer hospital admissions, increased antimicrobial resistance, a higher financial burden, and premature death (Leung and Chan 2018).

Hospitals, which have a diverse patient population with impaired immune systems, healthcare professionals, and visitors, are high-risk settings for airborne pathogen transmission (Yousefzadeh et al., 2022). The risk is compounded by poorly maintained ventilation systems that do not sufficiently filter or circulate air, increasing the concentration of infectious aerosols in the air.

Studies have demonstrated that the design and upkeep of healthcare facilities have a direct impact on the transmission of airborne illnesses (Li et al., 2007). Furthermore, insufficient infection control techniques, such as routine air disinfection or microbiological air quality monitoring, frequently affect air quality in hospital wards (Bluyssen et al. 2016). This failure leads to the persistence of airborne germs, leading to outbreaks of hospital-acquired infections (HAIs), which are a major source of morbidity.

Identifying airborne bacterial and fungal pathogens in hospital wards can help guide evidence-based infection control methods, lowering HAIs and improving patient outcomes (Pittet et al., 2016). Despite the high prevalence of HAIs, few studies have been conducted on airborne pathogens in Kaduna hospitals. Previous researches have focused mostly on surfaces and watery pathogens, overlooking airborne infections, hence this study aimed at isolating and identifying bacterial and fungal pathogens from a general hospital wards in Kaduna Metropolis.

Ethical Clearance

Ethical approval was obtained from Health Research Ethics Committee (HREC) of Kaduna State Ministry of Health.

MATERIALS AND METHODS

Study Area

The research was carried out in a General Hospital in Kaduna Metropolis, Kaduna State. It has a latitude of 10.5167° N (10° 31' 0" N) and a longitude of 7.4333° E (7° 26' 0" E) in Kaduna South Local Government Area of Kaduna State. This General hospital is a reputable healthcare institution established to provide comprehensive medical services to patients in Kaduna State and beyond.

Sample Collection

The samples for the study were collected from five different wards in the hospital, these includes: Male Medical ward, Male Surgical ward, Female Medical ward, Female Surgical ward, Accidental and Emergency unit was used for the sampling.

Sedimentation technique which involves the opening of plate with specific culture media was employed for this study (Sekulska 2007). Prepared plates of Nutrient agar, Mannitol Salt agar and Eosin Methylene Blue agar for bacteria and Potatoe Dextrose agar (PDA) for fungal were exposed to air for 30mins at different sites in the respective hospital wards. After sampling, all plates were immediately taken to the Biological Science laboratory, Kaduna State University. The fungal plates were kept at room temperature (25 °C) and read after 72–120 h and bacterial plates were incubated at 37 °C for 24–48 h. The colonies were sub-cultured onto a new fresh medium in order to obtain pure culture.

Media preparation

Culture media such as Nutrient agar, Mannitol Salt agar, Eosin Methylene Blue agar and potato dextrose agar (PDA), were all prepared according to the manufacturer instruction.

Identification of Airborne Pathogen

Identification of bacterial isolates was done according to the methods described by Cheesbrough (2009). Bacterial colonies were initially characterized by morphology and using staining techniques (Gram staining) and further identified by biochemical tests.

Fungal isolates were characterized and identified based on macroscopic and microscopic details with reference to Barnett and Hunter (1998).

Statistical Analysis

Data collected was analyzed using descriptive statistics.

RESULTS AND DISCUSSION

Percentage Occurrence of Airborne Bacteria Isolates in Selected Hospital Wards

A total of 45 Bacteria isolates were recorded belonging to 5 genera. *Pseudomonas aeruginosa* has the highest percentage occurrence of 28.89%, followed by *Staphylococcus aureus* (24.24%), then *Klebsiella pneumoniae* (20.00%), while *Escherichia coli* (15.56%) and *Micrococcus sp* recorded the least (11.11%) as in figure 1. The distribution of pathogen base on the various wards as in Table 1 showed that accident and emergency ward (A&E) had the highest number of isolate (24.22%), followed by Male surgical ward (MSW) and Female surgical ward (FSW) with 20% both and the least was Male medical ward (MMW) and Female medical ward (FMW) with 17.77%.

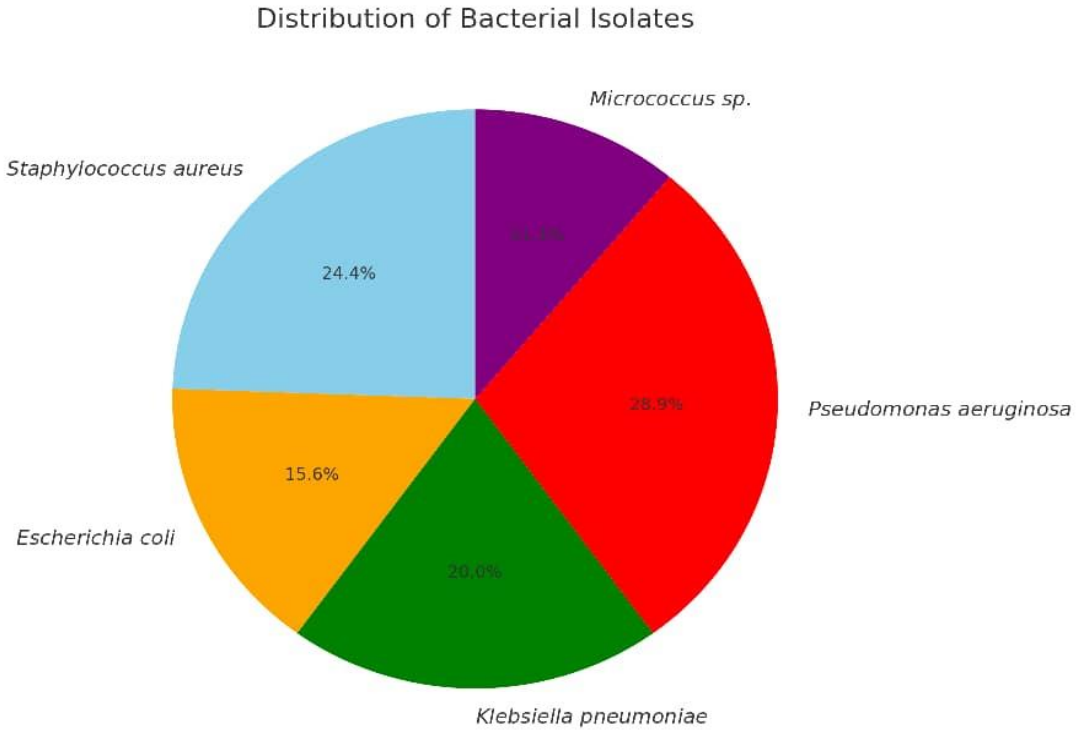

Figure 1: Percentage occurrence of airborne bacteria isolates in selected hospital wards

Table 1: Percentage frequency of occurrences of the isolated bacterial from the selected hospital wards

Ward	S. aureus	E. coli	K. pneumonia	P. aeruginosa	Micrococcus sp
AE	4 (36.36%)	1 (9.09%)	2 (18.18%)	3 (27.27%)	1 (9.09%)
MMW	2 (25.00%)	2 (25.00%)	1 (12.50%)	3 (37.50%)	0 (0.00%)
FMW	1 (12.50%)	2 (25.00%)	3 (37.50%)	1 (12.50%)	1 (12.50%)
MSW	2 (22.22%)	1 (11.11%)	1 (11.11%)	3 (33.33%)	2 (22.22%)
FSW	2 (22.22%)	1 (11.11%)	2 (22.22%)	3 (33.33%)	1 (11.11%)
Total	11 (24.44%)	7 (15.56%)	9 (20.00%)	13 (28.89%)	5 (11.11%)

Keys: AE=Emergency Unit, MMW=Male medical Ward, FMW=Female medical Ward, MSW=Male surgical Ward, FSW=Female surgical Ward

Distribution of Fungal Isolate in the Wards

A total of 34 fungi isolates were obtained from the 5 wards. *Aspergillus spp*. had the highest occurrence of 52.94%, followed by *Penicellium spp* and *Candida spp* both with 23.52%. The distribution of the fungal isolates in all the five ward in Table 2 show that accident and emergency ward (A and E) had the highest occurrence with 26.47%, followed by female medical ward (FMW) with 20.59%, male medical ward (MMW), male surgical ward (MSW) and female surgical ward (FSW) had 17.65% each.

Table 2: Percentage frequency of occurrences of the fungal isolates from the selected hospital wards

S/N	WARD	*Aspergillus spp.*	*Penicillium spp.*	*Candida spp.*
1	A and E	6 (33.33%)	2 (25%)	1 (12.5%)
2	MMW	4 (22.22%)	1 (12.5%)	1 (12.5%)
3	MSW	3 (16.67%)	1 (12.5%)	2 (25%)
4	FSW	2 (11.11%)	3 (37.5%)	1 (12.5%)
5	FMW	3 (16.67%)	1 (12.5%)	3 (37.5%)
	TOTAL	18 (52.94%)	8 (23.52%)	8 (23.52%)

Keys: S/N – Serial Number. A and E – Accident and Emergency\. MMW – Male Medical Ward. MSW – Male Surgical Ward. FSW – Female Surgical Ward. FMW – Female Medical Ward.

Discussion

It is estimated that in developing countries, nosocomial infections concern above 25% of hospitalized patients, and in the developed countries from 5 to 10% (Wenzel et al., 1999), and their presence induces an extension in the length of hospitalizations (Madebo et al., 2022). Nosocomial 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 (Ekhaise et al., 2010). As a result, the indoor air quality of hospitals is a major concern. This study isolated airborne bacterial and fungal organisms. Bacteria were found to be more prevalent than fungi, which is consistent with the findings of (Palmer and Onifade 2019; Mousavi et al., 2019; and Bolookat et al., 2018), who also observed greater levels of bacteria in hospital bioaerosols. This could be attributed to the availability of additional sources and more favorable environmental circumstances, such as an insufficient ventilation system, which promote bacteria development.

The bacteria isolated from the hospital wards in this study were *Staphylococcus aureus, Pseudomonas aeruginosa, Klebsiella pneumonia, Escherichia coli, and Micrococcus sp*., this is in consistent with the study of Madebo et al. (2022) that reported *S. aureus*, *P. aeruginosa, K. pneumoniae,* and *E. coli*, with 39.8%, 27.96%, 20.34%, and 11.86%. This study reported *Pseudomonas aeruginosa* as the most predominant bacteria with the occurrence of 28.89%, this is in conformity with the study of Montazeri et al. (2020) who reported *Pseudomonas spp*. as the main Gram-negative bacteria isolated from hospital wards, but in contrast with the study conducted in eastern Ethiopia which reported a 35% prevalence of *S. aureus* (Naruka et al. 2017), and Uganda in which *S. aureus* was the leading contaminant of the hospital (Obbard and Fang 2003) , the work of Ekhaise et al. (2011) in Benin City that reported *Staphylococcus aureus* as the dominant Bacteria, and also *Staphylococcus aureus* was found to be predominant bacteria with the occurrence of 22.81%, from hospital surfaces in Akure Metropolis, Ondo State (Palmer and Onifade 2019).

Pseudomonas aeruginosa had relatively high frequency probably because it require moisture for survival and growth, so their presence may be attributed to the existence of a wash-room in the vicinity of the sampling area or cleaning and moping activities during sampling (Rughooputh 2001). Since *pseudomonas* species are resistant to many disinfectants, it is difficult to eradicate them from hospitals (Naruka et al., 2017). *Pseudomonas aeruginosa* has been observed in infections of all parts of the body, especially infections of the kidneys and urinary tract (Khan et al*.,* 2017). *P. aeruginosa* associated infection is a recognized public health threat. It does not only cause morbidity but also increases the stay of the patient in the hospital and thereby increases the cost of treatment (Awoke 2011). *Pseudomonas aeruginosa* was closely followed by *Staphylococcus aureus* with the occurrence (24.24%). The prevalence of *Staphylococcus aureus*, in the hospital environment, could be attributed to its easy way of transmission through the throat, skin, cuts, boils, nails and nasopharynx (Ekhaise et al., 2008), and its resistant to dry condition (Stockwell et al., 2019). *Staphylococcus aureus* has been incriminated in various diseases such as post-operative infections, urinary tract infections, skin infections, respiratory infections and food poisoning (Murray et al., 1995). Increase in hygiene, will go a long way in combating infections by *Staphylococcus aureus* in these hospital environments. *Klebsiella sp*. one of the isolate from this study are associated with urinary tract infection among catheterized patients and immuno compromised patients.

Another pathogen isolated from this study that is also of medical concern is *E. coli* (15.56%). Though *E. coli* is a normal microbiota in the human bowel, Alteri and Mobley (2012) reported that some strains are capable of causing intestinal/diarrheal and extra-intestinal infections. *E. coli* causes urinary tract infections and intra-abdominal infections in which can range from cystitis to life threatening sepsis (Ejrnaes 2011). Ollor *et al*. (2022) in Port Harcourt, Nigeria, documented *Micrococcus* sp. as a minor airborne pathogen, which is in consistent with its overall low prevalence in this study (11.11%).

Fungi isolated include *Aspergillus sp*., *Penicillium sp*. and *Candida sp*. (Ekhaise *et al*., 2011) and Ekhaise *et al*. (2008) isolated the same microbial isolates, *with Aspergillus sp* been the most predominant fungi with frequency occurrence of 52.94%, this agrees with the report of

(Ekhaise et al., 2011) that observed *Aspergillus sp*. and *Penicilium sp*. to be the most prevalent fungal isolates. *Aspergillus fumigatus* was found to be predominant fungi with frequency occurrence of 36.84%, (Palmer and Onifade 2019). This is in contrast with the work of Nasiri et al. (2021) that reported *Penicillium* sp. (27%) as the most predominant isolated. *Aspergillus* spp. are major fungal pathogens associated with airway diseases (Enoch et al*.,* 2006). The intensity of *Aspergillus* infection depends on the status of the host immune and can range from a hypersensitivity reaction to fatal invasive pulmonary disease (Enoch et al*.,* 2006). *C. albicans*, is microbiota in humans found in the gut, vaginal and gastrointestinal, and is an opportunistic fungus, causing disease in individuals with a weakened immune system (Witchley et al*.,* 2019).

According to the study of the various hospital wards, the accident and emergency ward (A&E) has the greatest airborne bacterial and fungal population (24.44% and 26.47%, respectively). This is consistent with the study of Ekhaise et al. (2010), who reported a high mean bacterial and fungal load in the Accident and Emergency Ward (AEW) of 72.22 and 40.0, respectively, which was significantly different from all other wards, but it contradicts the study of Awosika et al. (2012), who found that A&E was the least burdened unit in the hospital. The outcome could be attributable to the high rate of in and out movement of individuals, because the accident and emergency ward acts as the primary entry point into the hospital, before patients are referred to the assigned unit. In a comparable study, Awosika et al. (2012) found that male medical ward (MMW) and male surgical general (MSG) had the highest bacterial and fungal growth. This contradicts the findings of this study, which found that MMW was one of the hospital's least burdened wards, but it agrees with the report that MSG (Male surgical general) had the second highest bacterial load, which was attributed to the high number of patients, which invariably attracts more patients relatives in and out of these wards, increasing bacterial shedding and air movement. 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.

CONCLUSION

There was a significant presence of airborne bacterial and fungal infections in the hospital ward. According to the study, bacteria outnumber fungus as the most common microorganisms discovered in hospital environments. Bacteria isolates included *Staphylococcus aureus, Pseudomonas aeruginosa, Klebsiella pneumonia, Escherichia coli, and Micrococcus* spp*, while fungus included Aspergillus* spp.*, Penicellium* spp.*, and Candida* spp., all of which are associated with nosocomial infections. All hospital wards were polluted with one or more airborne diseases. The hospital plays an important role in the transmission of common nosocomial infections, the extent of which is determined by the facility's hygienic conditions. It is recommended that strong measures be implemented to control the rising microbial burden in the hospital environment. This is vital because the hospital is a place where people go to get better and live longer lives; it should not be used to spread diseases and harm people's health.

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