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RESEARCH ARTICLE

MYCOLOGICAL ASSESSMENT OF INDOOR AIR QUALITY: CROSS-SECTIONAL STUDY OF SELECTED PRIVATE HOSPITALS IN DUTSE, JIGAWA STATE, NORTHWEST NIGERIA

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ABSTRACT

The purity of breathable air in an indoor environment is one of the factors that determines how healthy the inhabitants are. In order to evaluate the mycological indoor air quality of a few chosen private hospitals in Dutse metropolitan, this study was carried out. To choose the three (3) private hospitals that agreed to the study's conduct, a purposive sampling technique was used. The settle plate method was adopted to isolate fungi in the morning, afternoon, and evening using eighty one (81) sterile sabouraud dextrose agar (SDA) plates. Following that, established microbiological techniques were used to identify the fungal isolates. The indoor environment of the private hospitals were extensively contaminated with fungal aerosols, according to the results, with mean fungal loads in the morning (4680 CFU/m^3), afternoon (3566 CFU/m^3), and evening (3016.33 CFU/m^3). However, the mean fungal load obtained in Dr. Bashir hospital (4966 CFU/m^3) was significantly ($p< 0.05$) different from other private hospitals while the mean fungal loads obtained across all the private hospitals were not significantly ($p> 0.05$)different from each other. *Penicillium* spp. (23.46%), *Aspergillus flavus* (7.41%), *Mucor* spp. (17.28%), *Rhizopus* spp. (13.58%) and *Aspergillus niger* (23.46%) were isolated across the private hospital indoor environment. The findings in this study indicate that fungal aerosols were able to accumulate in the examined indoor environment of the hospitals regardless of the sampling intervals, suggesting that they may have the ability to act as a reservoir of fungal infections. Therefore, it is advised that safety precautions should be taken in order to lessen fungal contamination in the hospitals' indoor environment.

KEYWORDS

Fungi, Air quality, Private hospitals, Wards, Dutse, Nigeria

1. INTRODUCTION

An invisible gas called air is mostly composed of nitrogen and oxygen. For people, animals, and plants, it is one of the fundamental necessities of existence. Our health condition and level of productivity are significantly influenced by the air we breathe (Quarcoo et al., 2012; Adeleye et al., 2018; Božić et al., 2019). The term "indoor air quality" refers to the air quality conditions that can be found in homes, offices, schools, and other public spaces (Adeleye et al., 2022a). Fungi, which are widely distributed and pose a severe hazard to public health in indoor environments, are among the complex variety of microorganism species and intermediate products found in indoor air, including moulds, bacteria, viruses, and volatile microbial organic compounds (Jalili et al., 2021). Toxins, allergens, volatile microbial organic compounds, live and dead microorganisms, fragments, and other substances are all present in complex amounts in indoor environments (World Health Organization (WHO), 2021).

The most significant issue in indoor spaces, including residential houses, schools, universities, hospitals, and care facilities, is the presence of airborne microorganisms (Jalili et al., 2021). Environmental attributes like relative humidity and temperature determine the availability of indoor fungi which invariably lead to the development of many human diseases (Onmek et al., 2020). Immunosuppressed patients, such as those undergoing hematopoietic stem cell transplantation, chemotherapy for leukemia, or acquired immune deficiency syndrome (AIDS), are increasingly developing these infections (Lal et al., 2017). According to fungi typically enter a building through the heating, ventilation and air conditioning system's exterior air intakes, doors, and windows, as well as pollutants on the structure's materials and contents (Božić et al., 2019). Fungal growth and sporulation may take place in a building if heightened moisture conditions exist there for a long enough time (Mensah-Attipoe and Toyinbo, 2019). There is growing evidence that dirty surfaces and poor indoor air quality are significant potential sources of disease transmission in hospitals (Bonadonna et al., 2021).

These authors reiterated further that hospital airborne microorganisms appear to be safe for healthy individuals but due to patients weakened immune systems, which make them more susceptible to infections, healthcare settings are characterized by a variety of environmental critical circumstances and high infective risk. Practically, in all of the terrains of the planet, there are between 2.2 and 3.8 million different kinds of fungi (Humbal et al., 2018). According to these authors, pathogenic fungi include *Aspergillus, Fusarium, Scedosporium*, and *Mucorales* species. Many health issues are known to be brought on by these fungi, including acute toxicity,

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hypersensitivity (mostly asthma), invasive mycoses, and respiratory issues (Humbal et al., 2018). Nosocomial infections which are also known as hospital-related acquired infections are those that were often absent at the time of admission but are developed after patients get medical attention (Sikora and Zahra, 2022). The danger of catching an infectious disease is extremely high in healthcare settings, although the risks of allergies and acute toxic consequences may be lower (Bonadonna et al., 2021).

Temperature, the quantity of people, the building's physical condition, humidity, lighting, colloidal suspension, organic material, and the availability of food are physicochemical attributes that affect the type of microbes and the number of organisms in the air (Jalili et al., 2021). Another significant determinant of the variety of microorganisms in an area is human activities (Reanprayoon and Yoonaiwong, 2012). The quality of the air entering an area, the quantity of inhabitants, their physical activity and accompanying aerosol production, human traffic, and the level of ventilation are factors that influence indoor air quality in terms of microbiological contamination in a specific place at a certain moment (Basińska et al., 2019). Dust, a useful carrier of airborne contamination, can be produced by human actions like sweeping, moving, waving a handkerchief, and making the bed. Hospital airborne microorganisms have been the subject of numerous investigations (Sudharsanam et al., 2012; Kim et al., 2018). This study was carried out to ascertain the colony-forming units per cubic meter (CFU/m^3) of the indoor air estimated as reported and the density of airborne fungi in the indoor air of selected private hospitals domiciled in Dutse urban (Tong et al., 2017). The conduct of this study was based on the null hypothesis that stated that there is no fungus in the indoor air of the selected private hospitals in Dutse urban.

2. Materials and Methods

2.1 Study Area

The study was carried out in three selected private hospitals in Dutse urban. According to a study, Dutse is the capital of Jigawa State, Nigeria (Adeleye et al., 2022b). The authors reported further that geographically, it lies on latitude of 11°42'8.46" N and longitude of 9°20'2.46" E (Figure 1). It is home to Federal University Dutse which was established in November 2011.

2.2 Description of the Private Hospitals

In Peace clinic, air quality assessment was conducted in the reception unit that has three fans and three patients. It was also conducted in the female ward which has one fan and two windows and lastly in the male ward which has one fan and two windows. In Dr. Bashir hospital air quality assessment was conducted in the reception unit which has two fans, six patients and five relatives of the patients, and in the male ward where there were four patients, three relatives of the patients. Air sampling was equally done in the female ward that has four windows and two fans. There were three patients and ten relatives of the patients during air sampling. In Alkhari clinic air quality assessment was conducted in ward one which has two fans and two windows and with two patients and one relative of the patients, while wards two and three have one fan each, two windows each, with three patients and two relatives of the patients.

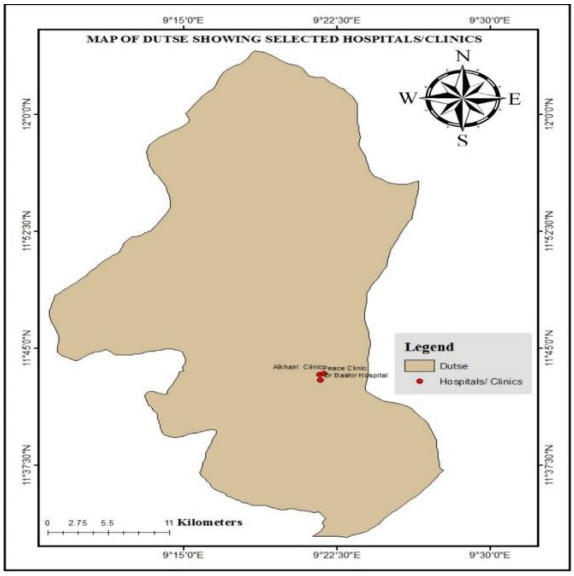

Figure 1: A map showing the study area

2.3 Sample Size and Sampling Technique

Three hospitals that consented to the conduct of the study were purposively selected for air sampling. Twenty-seven samples were collected from each selected hospital wards, where eighty-one (81) samples were obtained. Air sampling was done using settle plate methods. A sensitive weighing balance machine was used to measure 105.3 g of sabouraud dextrose agar (SDA) and chloramphenicol (0.081g) into a conical flask and then dissolved in distilled water (1620 mL) according to the manufacturer's instructions. Chloramphenicol was added to inhibit the growth of broad-spectrum bacteria on the agar plates during incubation (Sa'id and Salihu, 2017). The culture media was autoclaved and aseptically poured into eighty-one (81) sterilized petri dishes. Each plate was labelled with a sample number and the time of sample collection. Petri dishes containing SDA were transported to the hospitals in sealed plastic bags as done (Kalwasińska et al., 2012). The plates were placed in the indoor environment of hospitals at about one (1) meter above the ground representing human breathing zone (Adeleye et al., 2018). Each plate was exposed for ten (10) minutes. After this exposure, the agar plates were covered and immediately taken to the laboratory in sealed plastic bags. The agar plates were subsequently incubated for 5 days at 25 °C (Sa'id and Salihu, 2017).

2.4 Enumeration and Identification of Fungal Isolates

The enumeration of the fungal colonies was done with an electric colony counter leading to the generation of fungal colony forming units (CFU). Afterwards, the colony forming units per cubic meter (CFU/m^3) of the fungal isolates in the plates were determined using the following equation as outlined (Enitan et al., 2017; Sa'id and Salihu, 2018).

$N = 5a \times 10^4 (bt)^{-1}$

Where N= microbial CFU/m^3 of indoor air

A= number of colonies per Petri dish

b= dish surface area, cm^2

t= exposure time of the petri dish (in minutes).

Fungal colonies that had similar colonial attributes were sub-cultured into sterile SDA plates and further incubated for 5 days at 25 °C. Fungal isolates were identified on the basis of microscopic examination using Lactophenol cotton blue staining and macroscopic characteristics described (Omar-Zahid, 2013).

2.5 Data Analysis

Results obtained on the fungal loads across the hospitals and varying sample collection periods were subjected to analysis of variance (ANOVA) using Proc. GLM of GenStat version 17 and significant means were separated using Duncan Multiple Range Test (DMRT). However, the mean fungal load of the indoor air of the hospitals was used to determine whether it is within a range indicating a level of contamination according to the guidelines established in 1993 by the European Community Commission (Adeleye et al., 2018).

3. Results and Discussion

The results of the fungal loads obtained in the private hospitals during air sampling are presented in Tables 1 to 9. Specifically, on the first day of air sampling in Dr Bashir hospital, it can be observed that the fungal loads ranged between 312 and 1560 CFU/m^3 in the morning, while it ranged between 546 and 936 CFU/m^3 in the afternoon and also ranged between 0 and 624 CFU/m^3 in the evening (Table 1). On the second day of air sampling in the same hospital environment, the fungal loads recorded in morning ranged between 468 and 1326 CFU/m^3 while it ranged between 0 and 702 CFU/m^3 in the afternoon and ranged between 0 and 390 CFU/m3 in the evening (Table 2). On the third day of air sampling, it can be observed that the fungal loads ranged between 312 and 936 CFU/m^3 in the morning while it ranged between 390 and 780 CFU/m^3 in the afternoon and also ranged between 0 and 312 CFU/m^3 in the evening (Table 3). The highest fungal load recorded in Peace clinic on the first day of air sampling when there were patients in the morning between 8 and 9 am was 1404 CFU/m^3 while the lowest fungal load recorded when there were fewer patients in the afternoon and evening was 0 CFU/m^3. On the second day of air sampling in Peace clinic, the fungal loads recorded ranged between 156 and 624 CFU/m^3 in the morning, 0 and 324 CFU/m^3 in the afternoon while it ranged between 0 and 546 CFU/m^3 in the evening (Table 4).

Table 1: Fungal load obtained in Dr Bashir hospital on the first day of air sampling

Location	Label	Time	Period	CFU/m³
Male ward	SDA_{74}	8 am- 9 am	Morning	1560
Female ward	SDA_{32}	8 am- 9 am	Morning	1170
Reception	SDA_{39}	8 am- 9 am	Morning	312
Male ward	SDA_{33}	1 pm- 2 pm	Afternoon	936
Female ward	SDA_{38}	2 pm- 3 pm	Afternoon	702
Reception	SDA_{61}	2 pm- 3 pm	Afternoon	546
Male ward	SDA_{18}	5 pm- 6 pm	Evening	390
Female ward	SDA_{34}	5 pm- 6 pm	Evening	624
Reception	SDA_{19}	5 pm- 6 pm	Evening	0

CFU/m³= Colony forming unit per meter cube

Table 2: Fungal load obtained in Dr Bashir hospital on the second day of air sampling

Location	Label	Time	Period	CFU/m³
Male ward	SDA_{44}	8 am- 9 am	Morning	1326
Female ward	SDA_{46}	8 am- 9 am	Morning	1014
Reception	SDA_{55}	8 am- 9 am	Morning	468
Male ward	SDA_{47}	1 pm- 2 pm	Afternoon	0
Female ward	SDA_{49}	2 pm- 3 pm	Afternoon	546
Reception	SDA_{66}	2 pm- 3 pm	Afternoon	702
Male ward	SDA_{75}	5 pm- 6 pm	Evening	390
Female ward	SDA_{79}	5 pm- 6 pm	Evening	156
Reception	SDA_{65}	5 pm- 6 pm	Evening	0

CFU/m³= Colony forming unit per meter cube

Table 3: Fungal load obtained in Dr Bashir hospital on the third day of air sampling

Location	Label	Time	Period	CFU/m³
Male ward	SDA_{28}	8 am- 9 am	Morning	936
Female ward	SDA_{26}	8 am- 9 am	Morning	702
Reception	SDA_{73}	8 am- 9 am	Morning	312
Male ward	SDA_{77}	1 pm- 2 pm	Afternoon	780
Female ward	SDA_{77}	2 pm- 3 pm	Afternoon	624
Reception	SDA_{29}	2 pm- 3 pm	Afternoon	390
Male ward	SDA_{62}	5 pm- 6 pm	Evening	0
Female ward	SDA_{67}	5 pm- 6 pm	Evening	312
Reception	SDA_{48}	5 pm- 6 pm	Evening	0

CFU/m³= Colony forming unit per meter cube

Table 4: Fungal load obtained in Peace clinic on the first day of air sampling

Location	Label	Time	Period	CFU/m³
Male ward	SDA_{7}	8 am- 9 am	Morning	1404
Female ward	SDA_{4}	8 am- 9 am	Morning	702
Reception	SDA_{30}	8 am- 9 am	Morning	468
Male ward	SDA_{40}	1 pm- 2 pm	Afternoon	780
Female ward	SDA_{9}	2 pm- 3 pm	Afternoon	624
Reception	SDA_{11}	2 pm- 3 pm	Afternoon	0
Male ward	SDA_{16}	5 pm- 6 pm	Evening	390
Female ward	SDA_{22}	5 pm- 6 pm	Evening	312
Reception	SDA_{51}	5 pm- 6 pm	Evening	0

CFU/m³= Colony forming unit per meter cube

Table 5: Fungal load obtained in Peace clinic on the second day of air sampling

Location	Label	Time	Period	CFU/m³
Male ward	SDA_{6}	8 am- 9 am	Morning	624
Female ward	SDA_{41}	8 am- 9 am	Morning	312
Reception	SDA_{42}	8 am- 9 am	Morning	156
Male ward	SDA_{21}	1 pm- 2 pm	Afternoon	312
Female ward	SDA_{25}	2 pm- 3 pm	Afternoon	324
Reception	SDA_{80}	2 pm- 3 pm	Afternoon	0
Male ward	SDA_{50}	5 pm- 6 pm	Evening	390
Female ward	SDA_{53}	5 pm- 6 pm	Evening	0
Reception	SDA_{56}	5 pm- 6 pm	Evening	546

CFU/m³= Colony forming unit per meter cube

Table 6: Fungal load obtained in Peace hospital on the third day of air sampling

Location	Label	Time	Period	CFU/m³
Male ward	SDA_{45}	8 am- 9 am	Morning	936
Female ward	SDA_{81}	8 am- 9 am	Morning	702
Reception	SDA_{72}	8 am- 9 am	Morning	546
Male ward	SDA_{76}	1 pm- 2 pm	Afternoon	390
Female ward	SDA_{57}	2 pm- 3 pm	Afternoon	234
Reception	SDA_{23}	2 pm- 3 pm	Afternoon	0
Male ward	SDA_{60}	5 pm- 6 pm	Evening	390
Female ward	SDA_{68}	5 pm- 6 pm	Evening	468
Reception	SDA_{64}	5 pm- 6 pm	Evening	0

CFU/m³ = Colony forming unit per meter cube

Table 7: Fungal load obtained in Alkhari clinic on the first day of air sampling

Location	Label	Time	Period	CFU/m³
Ward 1	SDA_{5}	8 am- 9 am	Morning	780
Ward 2	SDA_{36}	8 am- 9 am	Morning	624
Ward 3	SDA_{8}	8 am- 9 am	Morning	390
Ward 1	SDA52	1 pm- 2 pm	Afternoon	546
Ward 2	SDA_{13}	2 pm- 3 pm	Afternoon	234
Ward 3	SDA_{70}	2 pm- 3 pm	Afternoon	0
Ward 1	SDA_{12}	5 pm- 6 pm	Evening	390
Ward 2	SDA_{3}	5 pm- 6 pm	Evening	468
Ward 3	SDA_{15}	5 pm- 6 pm	Evening	0

CFU/m³ = Colony forming unit per meter cube

Table 8: Fungal load obtained in Alkhari clinic on the second day of air sampling

Location	Label	Time	Period	CFU/m³
Ward 1	SDA_{1}	8 am- 9 am	Morning	156
Ward 2	SDA_{17}	8 am- 9 am	Morning	624
Ward 3	SDA_{69}	8 am- 9 am	Morning	234
Ward 1	SDA_{27}	1 pm- 2 pm	Afternoon	546
Ward 2	SDA_{55}	2 pm- 3 pm	Afternoon	312
Ward 3	SDA_{78}	2 pm- 3 pm	Afternoon	234
Ward 1	SDA_{10}	5 pm- 6 pm	Evening	390
Ward 2	SDA_{43}	5 pm- 6 pm	Evening	1248
Ward 3	SDA_{54}	5 pm- 6 pm	Evening	0

CFU/m³ = Colony forming unit per meter cube

Table 9: Fungal load obtained in Alkhari clinic on the third day of air sampling				
Location	Label	Time	Period	CFU/M^3
Ward 1	SDA_2	8 am- 9 am	Morning	156
Ward 2	SDA_{37}	8 am- 9 am	Morning	702
Ward 3	SDA_{24}	8 am- 9 am	Morning	234
Ward 1	SDA_{31}	1 pm- 2 pm	Afternoon	468
Ward 2	SDA_{35}	2 pm- 3 pm	Afternoon	312
Ward 3	SDA_{20}	2 pm- 3 pm	Afternoon	156
Ward 1	SDA_{14}	5 pm- 6 pm	Evening	390
Ward 2	SDA_{63}	5 pm- 6 pm	Evening	546
Ward 3	SDA_{71}	5 pm- 6 pm	Evening	1248

CFU= Colony forming unit per meter cube

On the third day in Peace hospital, the highest fungal load recorded was 936 CFU/m^3 while the lowest fungal load deduced was 0 CFU/m^3 (Table 6). During indoor air sampling in Alkhari clinic on the first day, the fungal loads ranged between 390 and 780 CFU/m^3 in the morning, 0 and 546 CFU/m^3 in the afternoon while it ranged between 0 and 468 CFU/m^3 in the evening, (Table 7). The fungal loads detected on the second day in Alkhari clinic ranged between 0 and 1248 CFU/m^3 in the evening whereas the fungal loads recorded ranged between 234 and 390 CFU/m^3 in the afternoon and ranged between 156 and 624 CFU/m^3 in the morning (Table 8). On the third day in Alkhari clinic, the fungal loads detected ranged between 156 and 702 CFU/m^3 in the morning whereas the fungal loads ranged between 156 and 468 CFU/m^3 in the afternoon and ranged between 390 and 1248 CFU/m^3 in the evening (Table 9). Overall, during air sampling in the morning, the total indoor fungal load (7800 CFU/m^3) obtained in Dr. Bashir hospital was the highest followed by Peace Clinic which had a total indoor fungal load of 5850 CFU/m^3. From the results recorded in this study, it can be pinpointed that regardless of the sampling periods, all the three private hospitals examined for indoor air mycological quality were heavily contaminated with fungal aerosol.

Table 10 shows the mean fungal load obtained during air sampling in the three hospitals while Table 11 presents the effects of hospitals on indoor fungal load recorded. In the morning during air sampling, the mean fungal load recorded in Dr. Bashir hospital was 867 CFU/m^3 while the mean fungal load recorded in the evening in Alkhari clinic was 520 CFU/m^3 (Table 10). It can be seen that the mean microbial loads recorded across the three private hospitals are not significantly ($p>0.05$) different from each other at (Table 11).

Table 10: Mean fungal load obtained during air sampling in the three hospitals.									
	Dr. Bashir Hospital			Peace Clinic			Alkhari Clinic		
TD	M	A	E	M	A	E	M	A	E
FL (CFU/m^3)	867	581	208	650	296	277	433	312	520

TD= Time of the day; FL= Fungal load; M= Morning; A= Afternoon; E= Evening

Table 11: Effect of Hospital on The Fungal Loads Recorded	
Hospital	Fungal load
Alkhari	422^a
Dr Bashir	537^a
Peace	408^a
LSD (0.05)	156.3
SE (±)	52.1
	NS

Means with the same letter (s) are not significantly different from each other at $p>0.05$ using Least Significant Difference (LSD), SE = standard error, NS = not significant

Table 12 shows the effect of time on fungal load recorded while Table 13 shows the interaction of the hospitals with air sampling time and the fungal loads recorded. It can be seen that there is a significant ($p< 0.05$) difference in the fungal load obtained in the morning compared with the fungal loads obtained in the afternoon and evening that show no significant ($p> 0.05$) difference (Table 12). There is no significant ($p> 0.05$) difference between the fungal loads obtained in Alkhari clinic during indoor air sampling (Table 13). During indoor air sampling in Dr. Bashir hospital, results obtained indicate that there is no significant ($p> 0.05$) difference in the fungal loads obtained in the morning and afternoon while there is significant ($p< 0.05$) difference in the fungal load obtained in the evening (Table 13). In peace clinic, there is significant ($p< 0.05$) difference in the fungal load obtained in the morning compared with the other time of the day (afternoon and evening) that recorded no significant ($p> 0.05$) difference in the fungal loads obtained (Table 13). The variation witnessed in terms of fungal load density can be attributed to the number of patients, relatives of the patients and staff of the hospitals that were present during air sampling. Variation in the density of fungal load in a typical workplace owing to the influence of human activities has been reported (Adeleye et al., 2022a).

Table 12: Effect of time on the fungal loads recorded across the hospitals	
Time	Fungal load
Morning	635.0^a
Afternoon	396.2^b
Evening	335.1^b
LSD (0.05)	156.3
SE (±)	52.1

Means with the same letter (s) are not significantly different from each other at $p>0.05$ using Least Significant Difference (LSD), SE = standard error

Table 13: Interaction of the hospitals with time on the fungal loads recorded		
Hospital	Time	Fungal load
Alkhari clinic	Morning	433.3^{bcde}
Alkhari clinic	Afternoon	312.0^{cde}
Alkhari clinic	Evening	520.1^{bcd}
Dr Bashir hospital	Morning	821.8^a
Dr Bashir hospital	Afternoon	580.7^{abc}
Dr Bashir hospital	Evening	208.0^e
Peace clinic	Morning	650.0^{ab}
Peace clinic	Afternoon	296.0^{cde}
Peace clinic	Evening	277.3^{de}

Means with the same letter(s) are not significantly different from each other at $p>0.05$ using Duncan's multiple range test.

Table 14: Identified Fungi and their Characteristics in Dr. Bashir Hospital		
Colonial Attributes	Microscopic Characteristics	Fungi Identified
Pin like black growth	Non-branched conidiophore with bulb end carries conidia like sun rays.	*Aspergillus niger*
Cotton like white growth spotted with black colour	Sporangia contain spores, have rhizoids	*Rhizopus* spp.
Pin like black growth	Non-branched conidiophore with bulb end carries conidia like sun rays.	*Aspergillus niger*
Green or Green-greyish colour colonies	Brush-like conidiophore carries conidia	*Penicillium* spp.
Cotton like white growth spotted with black colour.	Sporangia contain spores, do not have rhizoids.	*Mucor* spp.

The most frequent fungal isolates identified in the indoor hospital environment are *penicillium* spp. and *Aspergillus niger* with a percentage frequency of 23.46% and 23.46% respectively, while the least occurred fungal isolate is *Aspergillus flavus* with a percentage frequency of 7.41% (Table 17). These results agree with the reports of who isolated moulds belonging to the genera PENICILLIUM and ASPERGILLUS from the indoor air of some Norwich schools, Danish schools and two hospitals in the Bakhtiari province, southwest of Iran respectively (Würtz et al., 1999; Meklin, 2002; Jalili et al., 2021). The findings are also in agreement with the report on the detection of *Aspergillus* spp., *Penicillium* spp. and *Rhizopus* spp. as the dominant fungal isolates in an indoor environment (Naga et al., 2015). In addition, this present study agrees with the report of on the detection of *Penicllium* spp. and *Aspegillus* spp. in the indoor environment of their study area (Kumari et al., 2015). The detection of fungi in the indoor air of the hospitals examined in this study can be attributed to the presence of favourable factors that aid their presence in the indoor air.

Table 15: Identified Fungi and their Characteristics in Peace Hospital

Colonial Attributes	Microscopic Characteristics	Fungi Identified
Pin like black growth	Non-branched conidiophore with bulb end carries conidia like sun rays	*Aspergillus niger*
Green or Green-greyish colour colonies	Brush-like conidiophore carries conidia.	*Penicillium* spp.
Pin like green growth	Non-branched conidiophore with bulb end carries conidia	*Aspergillus flavus*
Cotton like white growth spotted with black colour.	Sporangia contain spores, do not have rhizoids.	*Mucor* spp.

Table 16: Identified Fungi and their Characteristics in Alkhari Hospital

Colonial Attributes	Microscopic Characteristics	Fungi Identified
Pin like black growth	Non-branched conidiophore with bulb end carries conidia like sun rays.	*Aspergillus niger*
Pin like green growth	Non-branched conidiophore with bulb end carries conidia	*Aspergillus flavus*
Green or Green-greyish colour colonies	Brush-like conidiophore carries conidia	*Penicillium* spp.
Cotton like white growth spotted with black colour	Sporangia contain spores, have rhizoids.	*Rhizopus* spp.
Cotton like white growth spotted with black colour.	Sporangia contain spores, do not have rhizoids.	*Mucor* spp.

Table 17: Isolated Fungi Frequency of Occurrence

Fungi Isolates	Number of Isolates	Frequency
Aspergillus niger	19	23.46%
Mucor spp.	14	17.28%
Rhizopus spp.	11	13.58%
Aspergillus flavus	6	7.41%
Penicillium spp.	19	23.46%
No growth	12	14.81%

Our findings also agree with the submission regarding the detection of 41% *Penicillium* spp. and 24% *Aspergillus* spp. in the indoor hospital environment of their study area (Jalili et al., 2021). The findings in this study equally are similar to the results obtained by who reported the isolation of fungi; *Penicillium* spp, *Aspergillus* spp, *Aspergillus niger, Mucor* spp. *Penicillium piceum, Penicillium aurantiogriseum*, and *Aspergillus oryzae* in an indoor environment of University of Benin, Nigeria and hospital environment of a teaching hospital in Maceió, state of Alagoas, Brazil respectively (Amengialue et al., 2017; Pedrosa et al., 2022). It also coincides with the report on the detection of *Penicllium* spp. and *Aspegillus* spp. indoor environments of selected schools and hospitals respectively (Kumari et al., 2015; Belizario et al., 2021). According to a study, these fungi are considered potential candidates involved in the establishment of sick building syndromes (Sa'id and Salihu, 2017). The fungi; *Penicillium* spp., *Aspergillus niger, Rhizopus* spp., *Aspergillus flavus* and *Mucor* spp. isolated in this study have been reported by as pathogens of humans and often associated with clinical manifestations of asthma, urticarial, cancer, atopic dermatitis, allergy, conjunctivitis and rhinitis (Baxi et al., 2016; Sa'id and Salihu, 2017).

4. Conclusion

The results obtained in this study have clearly suggested that regardless of the time of the day, indoor environment allows aerosols build up which could serve as potential risk factors for spread of infections in the indoor environment of these private hospitals. Five fungal species; *Penicillium* spp., *Rhizopus* spp., *Aspergillus niger, Mucor* spp. and *Aspergillus flavus* were isolated in this study. The isolated fungi can cause nosocomial infections such as allergies, conjunctivitis, rhinitis, urticarial, asthma, cancer and atopic dermatitis to the health workers, patients, patient's relatives visiting in the hospitals. The null hypothesis earlier stated is hereby rejected based on the fact that fungi were detected in the hospitals where indoor air assay was done. Based on the findings recorded in this study, routine and periodical monitoring of indoor fungal bioaerosols should be implemented in the hospitals so as to check the quality of air therein. Hospital workers, patients and patients' relatives should wear face mask while in the hospital environment for their safety.

Ethical Compliance

The authors have followed ethical standards in the conduct of the research and preparation of the manuscript.

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