Assessment of Air Quality Containing Fungi in Al-Nu'man Teaching Hospital

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ABSTRACT

Background: Fungi are widespread in indoor environments and contribute to various diseases in patients with compromised immune systems. **Objective:** This study aims to assess air quality containing fungi in the indoor environments of Al-Nu'man Teaching Hospital. **Materials and Methods:** The study involved 210 environmental samples collected from various selected parts of the hospital. The samples were carried out on a monthly basis by open plate technique, and then the cultures were examined and evaluated according to morphological and microscopic examination criteria. **Results:** The results showed that the percentage of fungal contamination was 140/210 (66.66%). The highest fungal contamination was recorded in hospital wards 27 (90%), followed by emergency unit 20 (76.92%), burn unit 16 (72.72%), operating theaters 14 (70%), neonatal unit 13 (65%), the dialysis unit 12 (63.15%), obstetrics theaters 10 (58.82%), coronary care unit 9 (56.25%), respiratory care unit 8 (53.33%), hospital kitchen 6 (46.15%), and the lowest contamination was in endoscopy unit 5 (41.66%). Moreover, a total of 137 fungal isolates were obtained, with the highest occurrence and frequency percentages of fungi recorded for *Penicillium* spp. reaching 13.13% and 8.57%, respectively, followed by *Aspergillus niger* reaching 10.21% and 6.66%, respectively, and the lowest occurrence and frequency percentages recorded for *Curvularia* spp. reaching 0.72% and 0.47%, respectively. **Conclusion:** These results demonstrated that all wards and units were heavily contaminated with different types of fungi. Hence, it is essential to take urgent steps to enhance indoor air quality to prevent possible hospital infections.

Keywords: Indoor Air Quality, Fungal Spore, Bio-Aerosols, Nosocomial Infection, Epidemiology.
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1-INTRODUCTION

In recent decades, indoor air quality in hospitals has constituted a major concern due to the prevalence of a diverse spectrum of harmful airborne microorganisms that may contribute to hospital infections (1, 2). According to many reports, nosocomial infections or hospital-acquired infections account for 10% of all patients (3,4). Bio-aerosols are recognized to be responsible for the occurrence of nosocomial infections in hospitalized patients, particularly those who require long-term treatment and critical care (5).

Fungal spores are common bioaerosols and their widespread dispersal can result in various forms (6). Thus, they are considered the greatest threat since they can play a major role in infecting hospital inpatients, and these infections can be fatal systemic infections, especially for persons who are immunocompromised or using immunosuppressive medicines (7). Saprophytic molds and yeasts, including some species of *Alternaria*, *Aureobasidium*, *Aspergillus*, *Cladosporium*, *Penicillium*, and *Candida*, are the most common species of fungal bioaerosols isolated from hospital indoor air, as reported by previous researchers (8, 9, 10).

Generally, fungi among other microbes tend to adapt successfully to a variety of environmental conditions. However, several factors influence the level of fungal contamination in the indoor air of hospital wards and units such

as moisture, construction activities, ventilation, building material, and temperature (11, 12). On the other hand, some opportunistic fungal infections can occur in individuals without any conditions that might facilitate infection. This usually occurs when a huge number of spores from different fungi are inhaled. These spores are small, making it easier to enter and adhere to the different tissues of the body (13). In hospitals, different yeasts and molds infect people directly from one individual to another or they can spread indirectly through contact with air and other medical equipment (14).

Additionally, air conditioning, patients, and visitors may transmit outdoor fungal spores (15). Because of the high-risk individuals who may be sensitive or vulnerable to these harmful biological agents, fungal bioaerosols should be controlled in hospitals (16). An accurate indication of how clean these environments are can be achieved by evaluating the diversity of bioaerosols that exist in the hospital. Therefore, the goal of this study was to investigate the indoor air quality in various units and wards of Al-Nu'man Teaching Hospital to determine how it contributed to the hospital infection rate; as a result, it can help reduce the rate of fungal infection in hospitals.

2- MATERIAL AND METHODS

2.1 Collection of Samples

The assessment of air quality containing fungi was performed at Al-Nu'man Teaching Hospital in the city of Baghdad, Iraq, during a period of four months from January to April 2023, and 210 samples were examined. The samples were taken by using sterile, moistened swabs from various parts of the hospital environment, including burn unit, coronary care unit (CCU), respiratory care unit (RCU), emergency unit, dialysis unit, neonatal units endoscopy unit, obstetrics theatres, operating theaters, hospital wards, and hospital kitchen.

2.2 Air Sampling Procedure

Air samples were collected through the use of the open plate method, in which standard Petri dishes supplemented with Sabouraud dextrose agar culture media with chloramphenicol (sedimentation plates), were used to collect biological particles for sediment quality assessment and exposed to air for a certain time (17,18). These dishes were placed at a height of 15–30 cm above the ground and left there for 100–150 minutes. Between 9:00 and 10:00 am, and to avoid outside contamination during samples' collection, all windows were closed. After that, the plates were sent to the laboratory for microbiological analysis, where they were placed in the incubator for seven to ten days at 32 °C. Then the microscopic and morphological characteristics were used to identify the fungal colonies. For fungal observation and staining, a preparation of lactophenol blue-soaked cotton wool was used (19).

Frequency Percentage:

The percentage frequency of species isolated was calculated by applying the following formula (18).

$$\text{Percentage Frequency} = \frac{\text{The number of isolates of the same species}}{\text{The total number of isolates of all kinds}} \times 100$$

Occurrence Percentage:

The percentage for the Occurrence of each species isolated was calculated according to the following equation (18).

$$\text{Percentage of Emergence} = \frac{\text{The number of samples that appeared to show one type}}{\text{The total number of isolates of all kinds}} \times 100$$

3-RESULTS

3.1. Fungal Contamination in the Hospital Wards and Units

According to the findings of the present study, the indoor air quality in each hospital ward and units examined was contaminated with various fungi. The present results revealed that the percentage of fungal contamination in all units and wards was 140/210 (66.66%). However, the highest levels of fungal contamination were observed in

hospital ward 27 (90%), followed by emergency unit 20 (76.92%), burn unit 16 (72.72%), operating theaters 14 (70%), neonatal unit 13 (65%), dialysis unit 12 (63.15%), obstetrics theaters 10 (58.82%), CCU unit 9 (56.25%), RCU unit 8 (53.33%), hospital kitchen 6 (46.15%), and finally endoscopy unit 5 (41.66%), which exhibited the lowest contamination as shown in Table (1) and Figure (1).

Table (1): Percentages of fungal contamination in the hospital wards and units

Location	Number of Samples	Total Swabs Showing Fungal Growth	Fungal Contamination (%)
Hospital Wards	30	27	90
Emergency Unit	26	20	76.92
Burn Unit	22	16	72.72
Operating Theaters	20	14	70
Neonatal Unit	20	13	65
Dialysis Unit	19	12	63.15
Obstetrics Theaters	17	10	58.82
CCU Unit	16	9	56.25
RCU Unit	15	8	53.33
Hospital Kitchen	13	6	46.15
Endoscopy Unit	12	5	41.66
Total	210	140	66.66

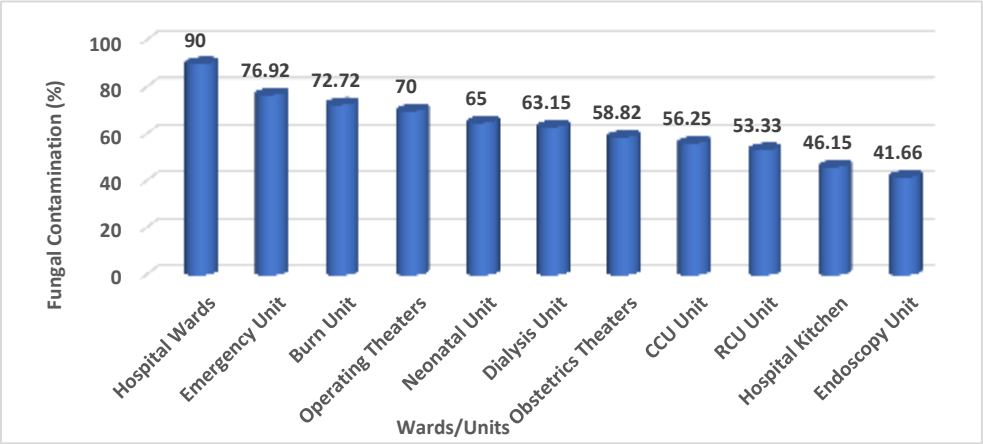

Figure (1): Fungal contamination percentages in hospital wards and units

3.2. Fungal Isolation and Identification

In the current study, 137 fungal isolates were studied and identified as belonging to 5 genera, including 40 isolates of *Aspergillus* spp., followed by *Penicillium* spp. possessed 18 isolates, *Alternaria* spp. with 13 isolates, yeast spp. with 11 isolates, *Rhizopus* spp. with 10 isolates, *Fusarium* spp. with 9 isolates, *Mucor* spp. with 9 isolates, *Aureobasidium* spp. with 7 isolates, *Cladosporium* spp. with 6 isolates, *Cryptococcus* spp. with 5 isolates, *Locladium* spp. with 5 isolates, *Rhodotorula* spp. with 3 isolates, and *Curvularia* spp. with 1 isolate. The highest occurrence and frequency percentages of fungi were recorded for *Penicillium* spp., reaching 13.13% and 8.57%, respectively, followed by *A. niger*, reaching 10.21% and 6.66%, respectively. In contrast, the lowest occurrence and frequency

percentages were recorded for *Curvularia* spp., reaching 0.72% and 0.47%, respectively, as summarized in Table (2) and Figure (2).

Table (2): Percentages of occurrence and frequency of fungi isolated from hospital wards/units

Hospitals Isolates	**No. of isolates**	**Frequency (%)**	**Occurrence (%)**
Aspergillus niger	14	10.21	6.66
Aspergillus flavus	12	8.75	5.71
Aspergillus fumigatus	9	6.56	4.28
Penicillium spp.	18	13.13	8.57
Alternaria spp.	13	9.48	6.19
Yeast species spp.	11	8.02	5.23
Rhizopus spp.	10	7.29	4.76
Fusarium spp.	9	6.56	4.28
Mucor spp.	9	6.56	4.28
Aureobasidium spp.	7	5.10	3.33
Cladosporium spp.	6	4.37	2.85
Cryptococcus spp.	5	3.64	2.38
locladium spp.	5	3.64	2.38
Rhodotorula spp.	3	2.18	1.42
Aspergillus nidulans	3	2.18	1.42
Aspergillus terrus	2	1.45	0.95
Curvularia spp.	1	0.72	0.47
Fungal isolation No.	137		

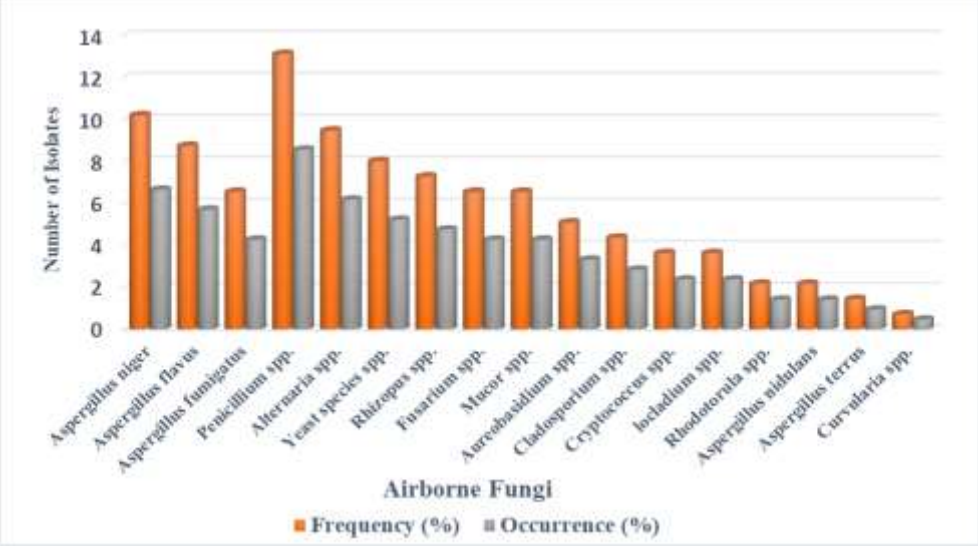

Figure (2): The species and genus fungal isolates and the frequency and occurrence percentages

4-DISCUSSION

In hospitals, the spores of fungus usually spread in the surrounding air, which may lead to numerous respiratory illnesses like rhinitis and asthma that might arise in humans (20). Therefore, it is very important to have a qualitative understanding of how these fungi are spreading in our hospitals. The variance in the quantity and identification of fungal isolates among the selected research studies can be explained by a variety of factors, including collecting techniques, various exposure locations, identification by conventional or molecular approaches, seasons, air humidity, human activities, and temperature (21, 8, 22).

In the current study, a high percentage of fungal contamination (66.66%) was identified in the selected units and wards. Such contamination may have been caused by relevant environmental factors, especially humidity and temperature. Hospital wards showed the highest levels of fungal contamination (90%), followed by emergency rooms (76.92%), whereas endoscopic units (41.66%) had the lowest levels. Based on the results of this study, the *Aspergillus, Penicillium, Alternaria, Yeast, Fusarium, Zygomycota, Aureobasidium Cladosporium, Cryptococcus, locladium,* and *Curvularia* species were the most prevalent fungi identified. The findings of our study are comparable to those of previous studies that identified related fungi in indoor environments (23, 24, 25). In other words, the isolated fungi species here are common in indoor environments.

According to the findings of this study, *Aspergillus* spp. were the first prominent fungal isolates observed. The prevalence of *Aspergillus* in the environments of hospitals is cause for serious concern, particularly because of its potential for producing allergens that are discharged into the air, affecting the health of those who are allergic patients and an increase in the concentration of this species indoors would worsen asthma symptoms (26). It explains that the small size of their spores causes them to spread for a long time, which is vital for their environment and transmission to the patient (27).

It is worth mentioning that, because of the prevalence of these species (*A. niger, A. flavus,* and *A. fumigatus*) and the fact that they are the main contaminating fungus, they displayed high frequency and occurrence percentages. However, in all the units and wards in this investigation, *A. niger* exhibited a higher occurrence than other species; our findings are comparable with the results of previous studies (28, 29).

Penicillium species came in second in terms of the number of species isolated. The significance of *Penicillium* as an allergen-producing fungus and its presence in indoor air environments are currently being recognized (30). Similar findings had been reported previously by Sepahvand *et al*., (31), in five hospitals, who demonstrated that *Penicillium* was the most prevalent genus of isolated fungi detected in the indoor environments of these hospitals.

Similarly, a study conducted in the hospital oncology unit indicated that *Penicillium* is the most frequent genus in air samples during the investigation of the prevalence of fungus in the hospital indoor air (32). The third most common species was *Alternaria* spp. This genus is regarded as an opportunistic fungus that has been detected in immunocompromised patients, including onychomycosis, osteolytic lesions, and skin lesions (33).

Regarding yeast species, *Rhodotorula* spp., and *Cryptococcus* spp. were isolated as dominant species, with no evidence of any *Candida* species like *Candida albicans*. The primary reason for this is that Candida is primarily of endogenous origin, with no substantial external source other than relatives, the hands of healthcare staff or families, or contaminated instruments (34).

Aureobasidium species, another yeast-like organism, is an opportunistic pathogen that causes systemic and pulmonary infections in both humans and animals. They are exceptionally adaptable organisms that may colonize unusual places, such as indoor environments of humans, including hospitals (35). *Fusarium* species have been linked to a variety of opportunistic illnesses in humans. For instance, there is keratomycosis or mycotic keratitis in the cornea and onychomycosis in the nails (36). Also, *Mucor* spp. and *Rhizopus* spp., two Zygomycetes fungi determined in the present study, cause infections in the brain through the nose (37).

The frequency of the genus *Cladosporium* is similarly raised in the hospital environment, as reported by Diongue *et al*.,(38), who demonstrated 91.1% of all isolates linked to this genus in a ward of the hospital. *Cladosporium* spp. appears to be associated with respiratory function damage, which links fungal exposure to a loss in pulmonary function (39). These findings are more pronounced in asthmatic children, as indicated by a previous study (40). Similarly, incidences of infection. Furthermore, *Ulocladium* species is typically regarded as a contaminant, and it may, on rare occasions, cause human infections and can cause phaeohyphomycosis, especially subcutaneous infections (41).

The prevalence of fungal contamination in the units and wards necessitates the attention of the authorities in charge since it may result in secondary infections that are more serious than the initial infections for which the patients came to the hospital for treatment, and complications may ensue, leading to death.

5-CONCLUSION

Indoor air quality is a crucial factor in infection prevention in environments such as hospitals. The current findings demonstrated that nearly all of the wards and units were contaminated by different fungal infections. Therefore, to avoid the spread of these fungi in the environment and prevent mycotic infections in both patients and staff, regular surveillance and stringent hygiene measures should be implemented. For instance, air disinfection systems, checking air conditioning units for standing moisture and cleaning or replacing them as needed, using HEPA filters for high-risk wards, closing windows, controlling entry and exit doors, and limiting or eliminating flowers brought in by patients' visitors are all necessary to prevent mold spores. Additionally, UV lamp control, replacement, and appropriate operation should be performed. In hospitals and other healthcare facilities, sodium hypochlorite is typically used as a disinfectant against fungi and their spores. Other chemicals that are currently available can be utilized.

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تقييم الفطريات المحمولة جواً في مستشفى النعمان التعليمي

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الخلاصة

خلفية عن الموضوع: تنتشر الفطريات في البيئات الداخلية وتساهم في الإصابة بمجموعة متنوعة من الأمراض لدى المرضى الذين يعانون من ضعف في جهاز المناعة. **الهدف:** تهدف هذه الدراسة إلى تقييم الفطريات المحمولة جواً في البيئات الداخلية بمستشفى النعمان التعليمي. **المواد وطرق العمل:** اشتملت الدراسة على 210 عينة بيئية تم جمعها من أجزاء مختلفة من المستشفى. جمعت العينات شهريا عن طريق تعريض الاطباق المفتوحة للهواء ثم فحصت الاوساط وتم تشخيصها وفق الاعتماد على الفحوصات المجهرية و المظهرية. **النتائج:** أظهرت النتائج أن نسبة التلوث الفطري كانت 210/140 (66.66%)، تم تسجيل أعلى تلوث فطري في أجنحة المستشفى 27 (90%)، تليها وحدة الطوارئ 20 (76.92%)، وحدة الحروق 16 (72.72%)، غرف العمليات 14 (70%)، وحدة حديثي الولادة 13 (65%)، وحدة غسيل الكلى 12 (63.15%)، صالة الولادة 10 (58.82%)، وحدة العناية التاجية 9 (56.25%)، وحدة العناية التنفسية 8 (53.33%)، مطبخ المستشفى 6 (46.15%)، وأقل تلوث كان في وحدة التنظير 5 (41.66%). علاوة على ذلك، تم الحصول على إجمالي 137 عزلة فطرية، سجلت *Penicillium* spp. أعلى نسب ظهور وتردد من بين الانواع الاخرى حيث بلغت 13.13% و 8.57% على التوالي، يليها *Aspergillus niger* حيث بلغت 10.21% و 6.66% على التوالي، بينما سجلت *Curvularia* spp. أقل نسب ظهور وتردد.حيث بلغت 0.72% و 0.47% على التوالي. **الاستنتاج:** أظهرت هذه النتائج أن جميع الأجنحة والوحدات كانت ملوثة بشدة بأنواع مختلفة من الفطريات. وبالتالي، من الضروري تحديد خطوات عاجلة لتحسين جودة الهواء الداخلي لمنع العدوى المحتملة في المستشفيات.

الكلمات المفتاحية: جودة الهواء الداخلي، الابواغ الفطرية، الهباء الحيوي، عدوى المستشفيات ، علم الأوبئة.