Environmental Health Engineering and Management Journal. 2026;13:1314
http://ehemj.com
doi 10.34172/EHEM.1314
Environmental Health Engineering and Management Journal

Original Article

Health Risk Assessment, Determining, and Identifying the Fungal Aerosol in the Operating Room Air of Hospitals in Southwestern Iran

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Abstract
Background: Nosocomial infection (NIs) is caused by pathogenic reactions related to the infectious agent itself or its toxins in the hospital. Air pollution can include fungal and bacterial pollutionwhich are among the main factors for the prevalence of NIs. This study aimed to determine the quantitative and qualitative amount of fungal aerosol in the indoor air of hospital operating rooms.
Methods: In this descriptive-analytical study, the concentration of fungal aerosol in operating rooms was studied. Sampling of fungal aerosol was done by Quick Take 30 with a flow rate of 28.3 L/min and a duration of 5 minutes on Sabro dextrose agar culture medium containing chloramphenicol antibiotic.
Results: Based on the findings of the study, it was found that the average total fungal aerosol density in public and private sector hospitals was 9.8 and 4.1 CFU/m^3, respectively. The highest prevalence of isolated fungi during the sampling period in the public hospital was *Trichophyton* with an average frequency of 52.5% and in the private sector hospital was *Aspergillus* with an average frequency of 41.5%. The results showed that for fungal aerosol, the health risk assessment indicated that occupants in the indoor air of hospital operating rooms had an acceptable exposure risk (hazard index < 1).
Conclusion: The results of this study showed that *Trichophyton* and *Aspergillus* are the most dominant fungal aerosols identified in both studied hospitals. According to the standard of the World Health Organization (WHO), the concentration of fungal aerosol was lower than the indoor air standard.
Keywords: Bioaerosol, Hospital, Fungal, Airborne, Indoor environment
Citation: Hormati M, Jaafarzadeh Haghighifard N, Abbasi Montazeri E, Ghanbari S, Fouladi Dehaghi B, Ghomeishi A, et al. Health risk assessment, determining, and identifying the fungal aerosol in the operating room air of hospitals in Southwestern Iran. Environmental Health Engineering and Management Journal. 2026;13:1314. doi: 10.34172/EHEM.1314.

Article History:
Received: 31 March 2024
Revised: 16 July 2024
Accepted: 30 July 2024
ePublished: 5 February 2026

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Introduction

Nosocomial infections caused by airborne fungi are serious health problems, and on average, 10% of the total 75% of microorganisms are infectious, especially in developing countries (1,2). The air quality inside the hospital, and especially important parts such as operating rooms, ICU departments, blood, transplantation, burns, and dialysis, is an important part of complying with hospital protocols, and due to many reasons, such as weakness, the physical and mental health of operating room patients is very important in terms of fungal infection (3).

Based on the report of the WHO, 15% of all hospitalized patients suffer from these infections because of non-observance of standard precautions by the healthcare staff, non-correct hand washing and hand hygiene, the existence of old equipment, unfavorable monitoring, and exposure to pathogens through different sources in the environment (2,4,5). Among the most important consequences of nosocomial infections are the increase in the duration of hospitalization of patients in the hospital, the mortality and morbidity of patients, the increase in costs due to the prolongation of the stay of patients, and diagnostic and treatment measures (6,7).

Airborne fungi in terms of number and type in closed hospital environments can be the same as the outside environment (8). This pollution can be from the devices and equipment inside the hospital, or from the purified or unpurified air of the outside environment, where the amount of indoor pollution is higher than the outside (9). One of the ways to cause and transmit hospital infections is breathing in polluted air. These types of infections are spread in the surrounding air through sneezing, coughing, and talking as bioaerosols and remain suspended in the air after drying and causing disease (10).

Diseases caused by hospital air pollution appear in different forms, such as irritation of the eyes, nose, throat, headache, and allergies. Fungal infections are one of the main factors in causing allergic reactions, which themselves cause skin and respiratory sensitivities (11). Pneumonia is the most common hospital infection caused by the Aspergillus fungal infection. This infection often occurs in immunosuppressed individuals, such as patients admitted to the intensive care unit (12). Superficial fungal infections are often present in tropical countries. This disease is usually limited to the layers of the skin, hair, and nails, which are mostly caused by dermatophyte fungi, yeast, especially Candida species, and non-dermatophyte filamentous fungi, which directly affect the keratin tissue and are associated with the symptoms of ringworm and oral thrush (13).

Bioaerosols are related to a wide range of health endpoints, including weakening of lung function, inflammation and irritation in the respiratory system, contagious and infectious diseases, allergies, cancer, acute toxic effects, secondary problems for patients and visitors (14). Regarding the level of risk of these biological factors, factors such as the concentration of these factors in the air, the duration of exposure, and the type of equipment used to control inhalation concentration can be mentioned. But the association of pathogenic microorganisms with suspended particles is one of the factors of hospitalization due to respiratory problems, upper respiratory tract infection, and pneumonia. Among the fungal infectious agents, Aspergillus is the most common cause of hospital fungal infection, which significantly threatens patients hospitalized in intensive care units, cancer, operating rooms, and organ transplants (15). Due to the rapid growth of population, entry of various pollutants into the environment and human food cycle, development of technology, change of lifestyle, and emergence of new diseases, the need for medical centers and surgeries has increased day by day were the most important reason for conducting this study and our innovative aspect in this study was the simultaneous investigation of teaching (public) and private sector hospitals.

Considering that every person may need surgery several times during their life, therefore, it is necessary to check the operating rooms in terms of having complete sanitary conditions and standards.

This study aimed to investigate health risk assessment, determining and identifying the fungal bioaerosols in the operating room air of Dezful hospitals in southwestern Iran.

Materials and Methods

Sampling location

This descriptive-analytical study was conducted to investigate the concentration of fungal aerosol in the operating rooms of two public (Ganjavian) and private sector hospitals (Ayatollah Nabavi) in Dezful city, located at 32°22′43″N and 48°24′52″E (Figure 1).

There wasn't any human involvement in the study. In total, 9 operating rooms of a public hospital and 4 operating rooms of a private sector hospital were randomly used as sampling sites. Air samples were taken according to the NIOSH-0800 guidelines (16,17). Sampling was done once

Figure 1. Location of the studied hospitals in Dezful city

a week for 6 months (24 weeks), and a total of 96 samples were taken (4 samples were taken every week, so that 2 samples were taken for the public hospital, one sample was taken before the operation, and one sample was taken during the operation process. This study was carried out from October 2022 to March 2023 in a Ganjavian and Ayatollah Nabavi hospital, which was located in the southwest of Iran. All samples were taken throughout two periods of the day: morning and afternoon. Also, this process was done for public and private sector hospitals, and studied for both hospitals (Figure 1). In addition, each stage of sampling was performed before and during the operation.

Research design

Sabouraud dextrose agar (SDA) containing chloramphenicol was used for fungal aerosol samples. The culture medium was prepared in such a way that, according to the instructions, 39 grams of powder per 1000 cc or 1 liter of water is suitable. But for sampling in this research, the plates containing the culture medium were prepared one day before sampling, with the amount of 3.9 grams of powder per 100 cc of distilled water. Finally, by putting cotton on the Erlenmeyer lid, it was placed in an autoclave with a pressure of 121 atmospheres and a time of 20 minutes to sterilize the culture medium. The plates containing the sterile culture medium were actively placed in the NIOSH-0800 instructions using the Quick Take device at a height of 1.5 m from the ground and at a distance of 1 m from the door and window with a flow rate of 28.3 l/min for 5 minutes (17-19). At the end of sampling, the plates were immediately transferred to the laboratory with specifications (date, time, and place) and incubated at a temperature of 24-25°C for 5-7 days (20). Equipment used for sampling, colony growth, and measuring environmental conditions is shown in Figure 2.

It should be noted that before each sampling, all parts of the device were sterilized with 70% alcohol disinfectant. The concentration of fungal aerosol in the air was expressed as the number of colony-forming units per cubic meter of air (CFU/m^3) (equation 1) (21). Also, due to the relationship between the concentration of fungal aerosol and environmental conditions, temperature and humidity were recorded by hygrometers and thermometers in operating rooms (22).

$$CFU/m3 = 1000\ C/TQ \qquad (1)\ (23)$$

Figure 2. Equipment used for sampling, colony growth, and measuring environmental conditions.

Where C is the number of grown colonies, T is sampling time, and Q is sampling air flow.

Identification of fungal bioaerosols

In the stage after incubation, the number of colonies grown in the plates was counted. Finally, to identify the genus of fungal aerosol, various methods were used, including differential methods such as surface staining and microscopic features, such as the shape and size of the fungal colony, and comparing the colonies with the mycological atlas "DESCRIPTIONS OF MEDICAL FUNGI" (24).

Quality Control and Quality Assurance

Microscopic and macroscopic analyses were used to find the genera (18). The 10X, 40X, and 100X objectives are used for specimen observation. Also, in this study, lactophenol blue was used for the microscopic examination (18). The presence of conidia, spores' identification was based on taxonomic keys by Carrillo (2003) (18,25).

Risk assessment

Calculating the probability of any particular amount of adverse health consequences happening over a predetermined length of time is known as risk assessment, and it is an indicator of hazard and dose (26). The EPA's risk assessment guideline recommends that separate discussions are necessary for carcinogenic and non-carcinogenic outcomes due to the distinct methodologies used to analyze these two forms of chemical toxicity (27).

This research used quantified hazard indexes (HIs) to evaluate both non-carcinogenic effects using the associated reference dose (RfD) and carcinogenic effects utilizing the appropriate slope factor (SF).

The average daily dose (ADD) is often used to quantify as well as convey the level, frequency, and duration of human exposure to hazardous agents or substances in the environment around them and through inhalation (ADDinh), calculated (26,28), as shown in Eq. (2)

$$ADD_{inh}\left(CFU/(kg/d)\right) = \frac{C \times IR \times ED}{BW \times AT} \tag{2}$$

In this regard, the anticipated amount of culturable bioaerosols is indicated as C (CFU/m^3), whereas ADD_{inh} (CFU/m^3) indicates the expected daily intake (Table 1) (29). The duration of exposure is ED (d). The average daily inhalation rate is IR (m^3/d). BW is body weight (kg) (Table 1). AT is the average time (d) (Table 1).

Table 1. Parameters used in calculating ADD_{inh} (29)

Parameter	Unit of measurement	Hospital
IR	m^3/d	15.5
ED	d	0.125
BW	Kg	60
AT	days	1

The evaluation of health risks is conducted through qualitative as well as quantitative techniques. The quantitative risk assessment method used in the present research focused on assessing carcinogenic effects using the hazard quotient (HQ) score, defined by Eq. (3) (30-32).

$$HQ = \frac{ADD}{RfD} \tag{3}$$

The hazard quotient index, HQ (dimensionless), is calculated by dividing the ADD (CFU/m^3) by RfD (CFU/m^3 day^{-1}), for the fungi bioaerosols. The reference dose (RfD) can be estimated by the reference concentration (RfC) as shown in Eq. (4) (33), and the WHO recommended 500 CFU/m^3 of fungi as the RfC (33).

$$RfD = \frac{RfC \times IR}{BW} \tag{4}$$

Hazard index (HI) is the sum of HQ, defined by Eq. (5).

$$HI = \Sigma HQ_i \tag{5}$$

Data analysis

Data were summarized using Excel 2021 and analyzed by SPSS 26 software. Descriptive statistics such as Mean, Min, Max, and standard deviation were used to analyze the data. Also, the Chi-square test was used to compare different fungal aerosols in the studied hospitals before and during the operation.

Results

In the present study, the operating rooms of Dezful city hospitals were investigated in terms of the analysis of fungal aerosol and their concentration in terms of CFU/m^3. Table 2 shows the average, minimum, maximum, and standard deviation of fungal aerosol concentration during and before surgery in different hospitals.

In Table 2, which is related to the concentration of fungal aerosol in a private sector hospital, the highest average concentration before surgery is related to the *Aspergillus* genus, with an average of 1.71, and the lowest concentration is related to the *Rhizopus* genus, with an average of 0.00.

The rate of *Aspergillus* during the operation has a significant difference between public and private hospitals ($P = 0.003$). In the private hospital, before the operation, the mean of *Aspergillus* is significantly higher during the operation ($P = 0.030$) (Table 2).

As can be seen in Figure 3, the comparison of the number of colonies grown before and during the operation in two hospitals shows that the highest number of colonies in the public hospital is related to the genus *Trichophyton*, and during the operation, while the highest number of fungal aerosol colonies in the private sector hospital is related to the genus *Aspergillus*, and before the operation.

As it is clear from Figure 3 and Table 3, in the state

Table 2. Descriptive statistics of the number of fungal aerosol colonies detected before and during the operation process in the government and the private sector hospital (CFU/m^3)

Fungi	Sampling time	Public		Private		*P* value
		Mean (Sd)	Min-Max	Mean (Sd)	Min-Max	
Aspergillus	Before	2.0 (1.91)	0-5	1.71 (2.42)	0-7	0.516
	During	2.0 (2.38)	0-7	0.85 (1.21)	0-3	0.003
P value		1.00		0.030		
Trichophyton	Before	2.85 (4.98)	0-14	1.28 (1.38)	0-4	0.038
	During	4.28 (6.62)	0-19	0.85 (1.46)	0-3	<0.001
P value		0.234		0.141		
Penicillium	Before	1.14 (1.86)	0-5	0.42 (0.78)	0-2	0.015
	During	0.07 (1.38)	0-3	0.14 (0.37)	0-1	0.203
P value		0.132		0.027		
Rhizopus	Before	0.57 (1.13)	0-3	0.0 (0.0)	0-0	….
	During	0.57 (0.78)	0-2	0.42 (0.53)	0-1	0.273
P value		1.00		….		
other	Before	0.42 (0.78)	0-2	0.0 (0.0)	0-0	….
	During	0.14 (0.37)	0-1	0.14 (0.37)	0-1	1.00
P value		0.027		….		

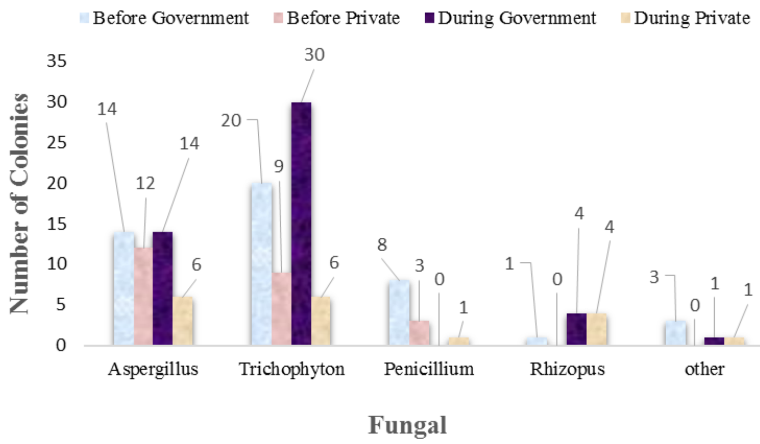

Figure 3. Comparison of the number of colonies grown before and during the operation in the two studied hospitals

hospital, the number of grown colonies was higher before the operation compared to after the operation. But in the private sector hospital, the exact opposite has happened, and the number of fungal colonies during the operation is more than that before the operation.

As shown in Figure 4, the highest percentage of fungi isolated in the public hospital before and during the operation were *Trichophyton* (44% and 61%) and *Aspergillus* (30% and 29%), respectively.

Figure 5 shows the overall schematic of colonies grown in the sampling and atlas, and microscopic photos.

Health Risk Assessment

The results of this study, based on Equations (2), (3), and (4), the mean HI values of fungal aerosol in the indoor air of hospital operating rooms were all lower than 1, suggesting that the exposure risks in the operating rooms of two public and private sector hospitals in Dezful city were acceptable. For fungi, the HI value in public hospitals was significantly higher than in private sector hospitals ($P<0.05$).

Discussion

According to Table 2, the highest average concentration of fungal aerosol before the operation in the public hospital was related to the *Trichophyton* genus, with an average of 2.85 CFU/m^3, and the lowest concentration was found to be related to the *Rhizopus* genus, with an average of 0.57 CFU/m^3 (Table 2). Also, in the same table, the highest average fungal concentration during the operation in the public hospital was related to the *Trichophyton* genus, with an average of 4.28 CFU/m^3, and the lowest average fungal aerosol concentration was reported to be related to the *Penicillium* genus with an average of 0.70 CFU/m^3

Table 3. Chi-square test analysis to compare different hospitals before and during the operation in terms of different fungal aerosols

Type of operation	Hospital	*Aspergillus*	*Trichophyton*	*Penicillium*	*Rhizopus*	*Other*	Chi-square (*P* value)
Before	Public	14	20	8	1	3	4.09 (0.394)
	Private sector	12	9	3	0	0	
During	Public	14	30	0	4	1	7.45 (0.114)
	Private sector	6	6	1	4	1	

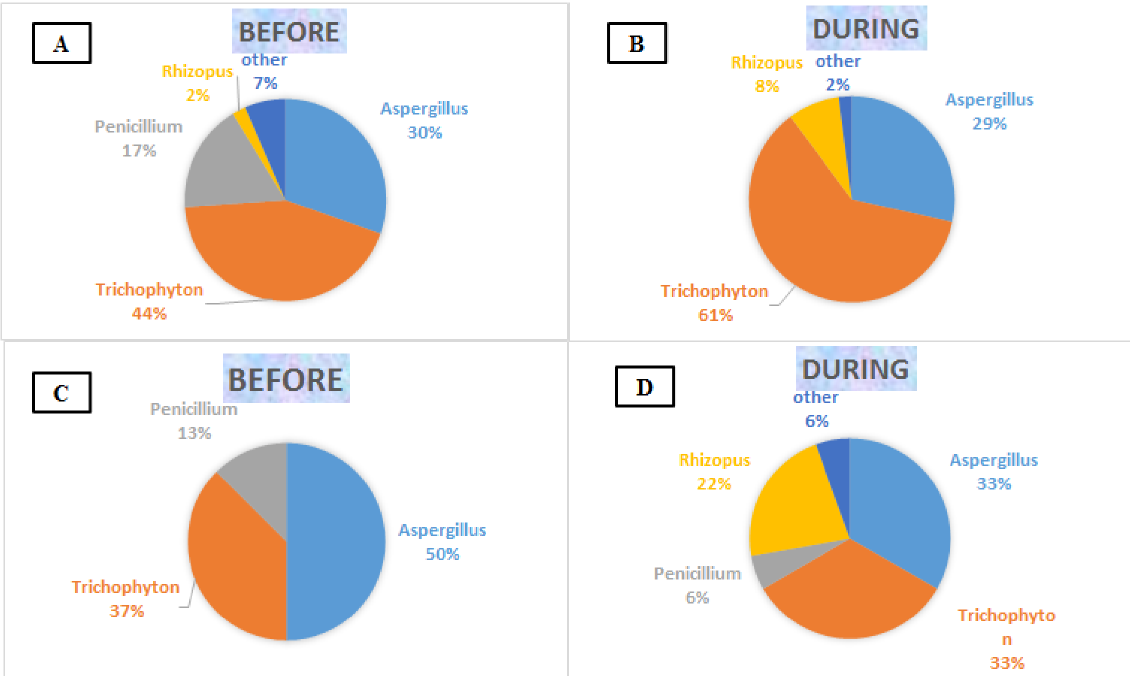

Figure 4. Colony percentage of fungal aerosol grown before and after the operation in the two studied hospitals. A and B are public hospitals, and C and D are private sector hospitals

(Table 2). The results obtained are consistent with the study of Emuren et al in 2016 (34). This finding can be due to the ability of the *Aspergillus* genus to grow in dry environments and survive for a relatively long time in operating rooms compared to other bioaerosols (23,35).

Based on the results of the study by Asif et al *Cladosporium* (47%), *Aspergillus* (7.1%), *Penicillium* (7.1%), *Alternaria* (6.2%), *Geotrichum* (3.7%), and *Oocladium* (3.2%) were the most abundant fungal species included in the hospital building air (36). Since *Trichophyton* fungus is associated with skin and nail infections and growth in moist areas of the body, such as armpits and under the toes, one of the main reasons for the predominant presence of this fungus is the lack of personal hygiene among employees and patients, as well as the type of operation performed.

The number of people and their activities, the efficiency of the ventilation system, temperatures, and humidity are the main factors affecting fungal contamination in health centers (23).

Based on the results shown in Table 2, the highest average fungal aerosol concentration during the operation in this hospital was related to the genus *Aspergillus* and *Trichophyton*, with an average of 0.85 CFU/m^3, and the lowest average was reported for *Penicillium* with an average of 0.14 CFU/m^3 (Table 2). Also, in the present study, there was no significant relationship between the concentration of fungal aerosol during and before the operation ($P < 0.05$). Similar studies confirm these results (22,37). Some studies found a significant relationship between the concentration of fungal aerosol in different parts, which is not consistent with the results of the present study (38). Many studies in the past emphasize our results and the presence of fungal aerosol in hospital environments (39-43).

Camargo Caicedo et al in 2023 evaluated fungal aerosols in a public library with natural ventilation in the District of Santa Marta, Colombia (18). They reported that concentrations in the air were up to 1197.0 CFU/m^3, with a mean value close to 150 CFU/m^3. Higher values during the morning samples were noted. Seven genera of fungi were found, among which *Aspergillus* and *Curvularia* were the most abundant genera (18).

The results of the study by Nasiri et al in 2019 determined that *Penicillium* (27%) was the most predominant isolated fungi (1). The results revealed that the level of bacteria and fungi responsible for nosocomial infections in the air

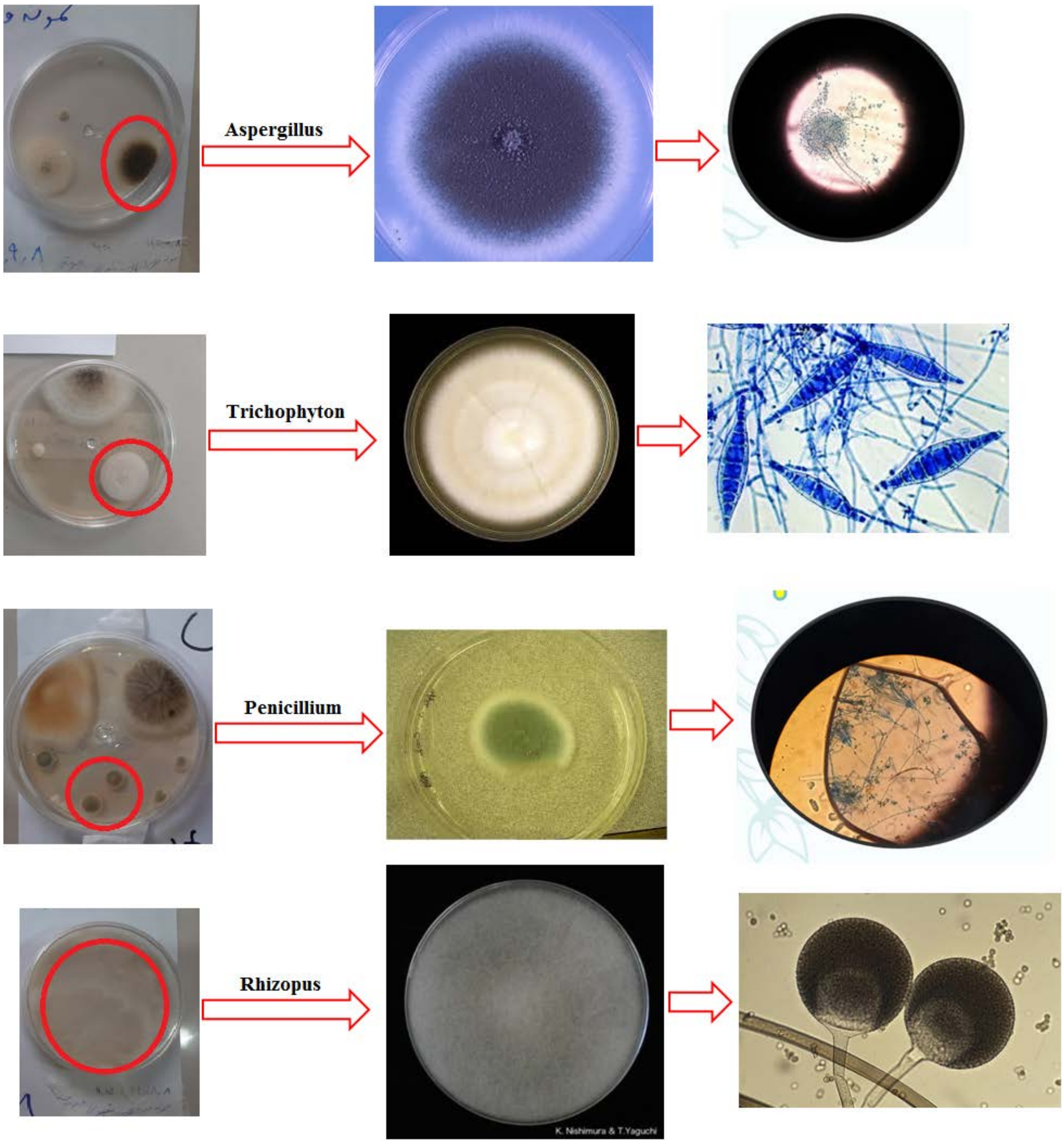

Figure 5. Sampling photo, atlas photo, and microscopic photos of grown mushroom colonies

of this hospital is very low (1).

The mean concentration of *Trichophyton* is significantly lower in the private hospital before ($P=0.038$) and during ($P<0.001$) the operation (Table 2). The mean concentration of *Penicillium* is significantly lower in the private hospital just before the operation ($P=0.015$). The mean concentration of *Penicillium* in the private hospital is significantly lower during the operation than before the operation ($P=0.027$) (Table 2). The mean concentration of other factors in the public hospital is significantly lower during the operation than before ($P=-0.027$) (Table 2).

These results are consistent with the results of many studies and emphasize the prevalence and spread of *Aspergillus* fungus in the hospital environment and operating rooms (38,44-49). The average concentration of fungal aerosol in public and private sector hospitals is 9.8 and 4.1 CFU/m^3, respectively, which are lower than the indoor air guidelines of the World Health Organization (WHO) and Canada's National Health and Welfare, which is equal to 150 CFU/m^3. Many studies are not consistent with the results obtained in the present study regarding the comparison of the concentration of fungal aerosol with the standards (20,38,50-52). But some of the studies are consistent with the present study due to the proportion of fungal aerosol concentration with the standards (53,54). In this study, a strong relationship between the type of surgery performed and the concentration of fungal aerosol was observed, such that infectious procedures such as amputation, arthroplasty, hernia and hemorrhoid removal, and lipomatic surgery had a great effect on the number and concentration of fungal aerosol. This result is consistent with the results obtained by Abdullahi (41).

Montazeri et al in 2019 assessed microbiological analysis of bacterial and fungal bioaerosols from the burn hospital of Yazd (Iran) (23). They reported that fungal contamination was higher in the derm ward (110 CFU/m^3) than in other sampling sites. Also, their result showed that the most prevalent fungal genera isolated from the hospital air samples were *Penicillium* (n = 73, 76%), *Alternaria* (n = 51, 53.1%), *Aspergillus niger* (n = 40, 41.7%), and *Aspergillus flavus* (n = 34, 35.4%), respectively (23), which is consistent with the results of our study.

Figure 3 showed that the highest number of colonies in the public hospital is related to the genus *Trichophyton* during the operation, while the highest number of fungal aerosol colonies in the private sector hospital is related to the genus *Aspergillus* before the operation. According to a study conducted by Favero et al human skin and hair are among the important places for the presence of fungal aerosol in the operating room, which is consistent with the results of the present study (55). In addition, in the public hospital, the number of *Aspergillus* and *Rhizopus* colonies was reported to be equal before and during the operation. And during the operation, the growth of the *Penicillium* colony was not reported. This is while in the private sector hospital, the growth of the *Rhizopus* colony has been reported only during surgery. According to the results of this study, in the private sector hospital, the exact opposite has happened, and the number of fungi colonies during the operation is more than that before the operation (Figure 3 and Table 3). The results obtained in this part are consistent with similar studies (37).

As Figure 4 shows, in the private sector hospital, the most fungi isolated before the operation were *Aspergillus* (50%) and *Trichophyton* (37%), and during the operation, *Aspergillus* and *Trichophyton* (33%) were recorded as the most grown fungi. The conducted study is consistent with other studies in terms of the type of recorded fungi (23,36,56).

According to the results obtained from the present study in Figure 5, the concentration and number of mushroom colonies grown in private sector hospitals are less than those in public hospitals, and factors such as the population density of personnel and patients in operating rooms, lack of personal hygiene personnel such as not changing socks and washing feet, unnecessary traffic in operating rooms, not changing centrifugal ventilators on time, the type of operations performed and the lack of sanitary conditions in the building, disinfection and inappropriate surfaces and environment before and after the operation and lack of proper training in this regard can be effective in creating a contaminated environment in sensitive places such as the operating room.

The results of the present study showed that the temperature changes in the sampling stations fluctuated a little and were in the range of 22-28℃, while the humidity fluctuations were in a wider range and in the range of 10-60%.

Due to the potential for a variety of infectious airborne microorganisms to cause nosocomial infections, contamination of indoor air is a threat to the environment, especially in healthcare facilities, as well as operating rooms (57). During the sampling period, temperatures and moisture levels remained mostly stable and had no apparent effect on the microbial loads that were found. Higher values of these variables are usually beneficial to microbial growth (57).

Epidermal exposure and inhalation of fungal aerosols in health centers that are somewhat dependent on environmental conditions such as temperature, humidity, and the ambient air environment can cause different health endpoints among patients, accompanying the patient, visitors, and health care workers (HCW).

According to one-way ANOVA analyses, neither the shifts nor the seasons' ambient temperatures and humidity levels were found to differ significantly from one another. Research has shown that high humidity significantly affects the growth of biological contaminants (58). According to Hansen et al, there was a significant correlation between both humidity and temperature and the concentrations of fungi that grew at 22°C (59). Hwang et al found a notable association between overall airborne microorganisms and temperature, but not moisture (57).

Health Risk Assessment

Our study calculated the ADD of airborne culturable fungi via inhalation contact in the indoor air of hospital operating rooms based on their concentrations. Then, according to Equations (2), (3), and (4), the hazard index (HI) could be estimated. HI of personal exposure is the sum of the HQ of indoor, inhalation, and skin.

The mean HI values of fungal aerosol in the indoor air of hospital operating rooms were all lower than 1, suggesting that the exposure risks in the operating rooms of two public and private sector hospitals in Dezful city were acceptable. For fungi, the HI value in public hospitals was significantly higher than in private sector hospitals ($P < 0.05$).

Similar studies are shown in the table below. The presence of different concentrations of fungi in operating rooms indicates the transmission of secondary contamination to clients and patients. Considering the sterility of operating room equipment and the continuous disinfection of surfaces, the air inside these places should be considered as one of the factors of infection transmission (60,61).

Table 4 shows a comparison between the previous results of studies similar to the present study.

Conclusion

Based on the findings, the highest prevalence of isolated fungi during the sampling period in the public hospital was *Trichophyton* with an average frequency of 52.5% and in the private sector hospital was *Aspergillus* with an average frequency of 41.5%. Since air causes the displacement of microorganisms, microbial analysis is

Table 4. Previous results of studies similar to the present study

Title	Year	Main Results	Reference
Fungal Assessment of Indoor Air Quality in Wards and Operating Theatres in an Organ Transplantation Hospital	2017	It showed that among the five parts studied, the liver transplant part had the least contamination in terms of fungus in the indoor air. Also, the most important fungal contaminations in operating rooms were Aspergillus and Penicillium, respectively.	(62)
Quantitative and qualitative evaluation of fungal air pollution in different wards of Kamkar Hospital in Qom, 2007	2009	The highest concentration of contamination is related to the infectious department with 300 CFU/M^3, and the lowest concentration of contamination is related to the operating room with a concentration of 94 CFU/m^3.	(9)
Investigation of bacterial and fungal contamination in indoor and outdoor air of Beheshti Hospital in Kashan in 2019	2020	The highest amount of fungal contamination is in the open space of the hospital	(63)
Indoor air quality and diversity of fungi inside and outside the residences of children with a history of allergy in Cuba	2022	The concentration of fungi in the air inside the bedroom was 19-1330 CFU/m^3, which can be classified as poor indoor air quality. And the most common genera, Penicillium, Aspergillus, Cladosporium, and Curvularia were identified in this study.	(64)
Airborne Fungi Spores in Different Wards of Hospitals Affiliated to Kerman University of Medical Sciences	2006	89% of the plates were positive in terms of fungal growth, and the genus Aspergillus flavus has the highest frequency, and yeast has the highest frequency among yeast fungi.	(11)
Investigation of Indoor and Outdoor Fungal Bioaerosols and Environmental Factors in Indoor Air Quality of Nursery Schools	2022	The most common fungus was Penicillium spp. There was a difference in the distribution of fungal genera only in the autumn season. And in general, the load of fungal contamination of the indoor air is related to the outdoor air.	(65)
Study on the relationship between the concentration and type of fungal bio-aerosols at indoor and outdoor air in the Children's Medical Center, Tehran, Iran	2019	The oncohematology department and bone marrow transplantation department had the highest and lowest contamination, respectively. The most common genus isolated from the internal environment was Penicillium, followed by Cladosporium.	(21)
Microbiological assessment of indoor air quality at different hospital sites	2015	The concentration of fungus in OT was less than 1CFU/m^3. In SW (range 1-32 CFU/m^3), indoor air fungus concentration was higher than outside. The most common fungal genera were Penicillium and Aspergillus.	(39)
Invasive pulmonary aspergillosis in hospital and ventilator-associated pneumonias. Seminars in Respiratory and Critical Care Medicine	2020	People with pneumonia associated with hospital-acquired infections and people with ventilator-associated pneumonia are more exposed to Aspergillus fungal infection.	(12)

necessary to improve the quality of sensitive places.

Our study showed that *Trichophyton* and *Aspergillus* are the dominant fungal aerosols in the operating rooms of the studied hospitals. Also, there was no significant difference between the concentration of fungal aerosol measured in the sampling locations and temperature and humidity. To improve the level of air quality inside sensitive places, measures such as designing and using proper ventilation, reducing construction operations that cause pollution near hospitals, reducing unnecessary traffic of people, using pest control systems such as wind curtains in entrance door, installation of foot washing basin, complete change of clothes when entering sensitive places, use of UV rays to disinfect surfaces, control and monitoring humidity and temperature, maintenance and improvement ventilation system, training on proper disinfection of equipment by skilled people, timely replacement of HEPA filters, and prevention of negative pressure conditions in the environment Hospital.

Acknowledgments

This work is part of a funded M.S. thesis of Maryam Hormati, a student at Ahvaz Jundishapur University of Medical Sciences (AJUMS), which is financially supported by AJUMS (ETRC-0107).

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Competing interests

The authors declare that they have no competing interests.

Ethical issues

The Ethics Committee of Ahvaz Jundishapur University of Medical Sciences approved the study protocol. This study was originally approved by Ahvaz Jundishapur University of Medical Sciences (Ethical code: IR.AJUMS.REC.1401.109).

Funding

This work is part of a funded project at Ahvaz Jundishapur University of Medical Sciences (AJUMS), which is financially supported by AJUMS (ETRC-0107).

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