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The Monitoring of Fungal Contamination in Indoor Air of Two Hospitals in Shiraz

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ABSTRACT

Introduction: Hospitals, as one of the important elements in the health system, play an important role in patient's health. Fungi are one of the effective parameters on indoor air quality. This study aimed to compare of fungal contamination of two hospitals in Shiraz City.

Materials and Methods: Sampling was conducted based on NIOSH 0800 standard (1.5 meters above the ground level with one stage Anderson and Sabaroud dextrose agar enriched chloramphenicol as the growth media) in January-September 2017. The investigated wards included pathological laboratory, emergency rooms, neonatal specialist care, radiology, operating room, and maternity ward. The results showed that the variation and concentration of fungi were higher in hospital X than hospital Y, which was located in an agricultural area far from the city center.

Results: The predominant fungi were *Monillia*, *Aspergillus*, and *Penicillium* in hospital Y, while they were *Aspergillus* and *Penicillium* in hospital X. The highest concentrations were found in emergency and laboratory wards. With regard to higher fungal contamination of hospital X and its different location, it can be concluded that the geographical properties and outdoor air are effective factors on indoor air contamination at hospitals.

Conclusion: Appropriate management of patients' admission and visiting time can be effective on indoor air contamination at hospitals. Furthermore, efficient ventilation using high-efficiency particulate air and appropriate devices for elimination of fungi level are recommended to this end. Moreover, these parameters can provide physical and psychometric health problems for patients' careers and other health workers.

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Introduction

Hospitals, as one of the structures of the health system, play an important role for patient's health. To achieve this goal, coherent structures are built according to the legal criteria. These criteria should be adjusted to ensure the comfort and safety of patients and personnel. However, enough attention has not been paid to all these factors and many problems rose in this field. Lack of attending to such criteria increases severity of the illness or causes new problems. In most developing countries, including Iran, changes in the pattern of diseases has led to an influx of many patients into large hospitals in urban areas [1]. Compliance with

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the health and safety standards is very important and increases the hospitals' performance in providing services [2]. One of these conditions is improving the indoor air quality by removing the microbial contamination, especially by decreasing the airborne fungal density. Since the fungi are saprophytic in the environment, light, and small, they are easily transmitted by small airways and spread in different regions. Although these spores are common in the open air, they can be problematic in high concentrations in the internal environment, especially when sensitive and vulnerable groups are exposed to them [3]. In this way, further studies are required on the diversity and density of fungal contamination in these places to provide initial information on the compliance with the criteria and guidelines about the hospital air. Moreover, comparisons of hospitals that offer the same level of services showed that the hospital's status, geographical location, and even management affected the level of air contamination. In other studies, the fungal contamination at indoor air of hospitals was investigated. Some of them showed that the concentration of fungi at the outdoor air was more than the indoor air and significant difference was observed between fungi concentration at different wards [4]. Therefore, geographic location, outdoor space, and wards of the hospital are effective factors on fungal contamination. On the other hand, hospital patients are considered as vulnerable groups of the community, who are commonly exposed to fungal infections [5]. Therefore, investigating these factors can be a way to consider physical principles of hospital structures, find the more efficient locations to build new hospitals, and provide better and more efficient services. In Iran, 40% of the population belongs to the children from birth to adolescence. Infection is one of the main causes of child mortality. Regarding the involvement of fungal agents in hospital infections, it is important to identify and control pathogen fungi. Therefore, this study aimed to investigate the fungal contamination of two specialized maternal and child care hospitals in two different locations in Shiraz.

Materials and Methods

Location study

Shiraz is one of the megacities of southwest Iran with a geographical location of 29°36´37" North and 52°31´52" West with warm and dry weather. According to the recent census, the city's population is estimated as 1.5 million [5]. This study aimed to investigate the diversity of fungal species in internal air of the two different hospitals in Shiraz.

Air sampling method

Sampling was conducted per month in January-September 2017. The sampling was carried out with three repetitions at a height of 1.5 meters above the ground level. In this study, air samples were taken according to the NIOSH 0800 using the Anderson single-stage sampler. The sampling rate was 28.3 L/min; the sampling time was 8 minutes; the time chosen was based on the pilot sample. Before Anderson sampling, sampler was disinfected with 70% alcohol. The samples were taken from different wards of the two hospitals including pathological laboratory, emergency rooms, neonatal specialist care, radiology, operating room, and maternity ward because this wards were similar in both hospitals.

Microbial experiment

Sabaroud dextrose agar was used as the growth media for fungi that enriched chloramphenicol for suppression of growth bacteria. Then, the media were incubated at 25°C during 2-7 days. After growth of the fungal colonies, they were identified by slide culture and optical microscopy (×400).

Statistical analysis

Descriptive statistics, such as mean and standard deviation were used to determine the concentration of fungi in different parts of both hospitals.

Results

This study aimed to compare the fungal contamination at indoor space of two hospitals in Shiraz. First, the total concentration of airborne fungi was investigated. Then, the predominant fungal species of all wards were identified. The results are expressed as the following.

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In figure 1, mean concentration of the total fungi is expressed.

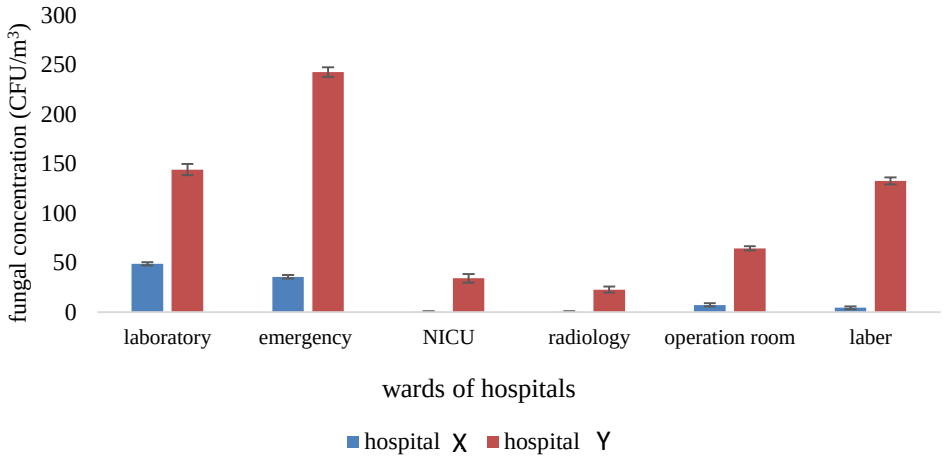

Figure 1: The mean concentration of total fungi in indoor air

As shown in Figure 1, the concentration of total fungi in hospital Y was higher than X. In hospital Y, the highest concentration of fungi was detected in the laboratory, while the lowest was observed in the radiology and operation rooms. In hospital Y, the highest and the lowest concentrations of fungi were isolated from emergency and radiology wards, respectively. Table 1 shows the guidelines of fungal concentration at indoor air pollution.

Results of the examined fungal diversity in Hospital X are shown in Table 2.

Table 1: Guidelines of fungal concentration (CFU/m^3)

Guideline(CFU/m3)	Level
ACGIH	500
NIOSH	500
EU	500
IRSST	2000

NIOSH= National Institute for Occupational Safety and Health
ACGIH= American Conference of Governmental Industrial Hygienists
EU= European Union
IRSST= Institut de recherche Robert-Sauvé en santé et en sécurité du travail

Table 2: The concentration of fungal species in different parts of hospital X

	Hospital X Concentration of airborne fungi (CFU/m^3)				
	Aspergillus Flavus	***Aspergillus Niger***	***Penicillium***	***Psilomyces***	***Monilia***
Laboratory	13.27	4.42	30.97	0	0
Emergency	0	8.85	26.5	0	0
NICU	0	0	0	0	0
Radiology	0	0	0	0	0
Operating room	0	7.07	0	0	0
Maternity Ward	0	0	0	4.42	0

The detected species in this hospital was *Aspergillus Flavus*, *Niger*, *Penicillium*, and *Peosilomyces*. Moreover, the species' diversity in the laboratory was more than other parts, including *Aspergillus flavus*, *Niger*, and *Penicillium*. The highest density of fungi was found in hospital X, which was related to *Penicillium* with concentrations of 30.97 and 26.5 CFU/m^3 in laboratory and emergency departments, respectively. In addition, in some of

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the examined areas, such as NICU and Radiology, no fungus was identified.

Table 3 shows the variation and density of the airborne fungi in different parts of hospital Y.

Table 3: Concentrations of Fungal Species in Different Parts of the Hospital Y

	Hospital Y Concentration of Fungi (CFU/m^3)						
	Flavus	***Niger***	***Penicillium***	***Pesilomyces***	***Monilia***	***Fumigatus***	***Mucorus***
Laboratory	3.78	7.57	26.5	0	106.06	0	0
Emergency	18.94	34.09	30.3	3.78	151.5	3.78	0
NICU	0	3.78	15.15	3.78	11.36	0	0
Radiology	0	0	3.78	0	7.57	0	11.36
Operating room	0	0	11.36	18.94	26.51	0	7.57
Maternity ward	0	11.36	7.57	0	113.64	0	-

As shown in Table 3, seven fungal species were identified in this hospital, including Aspergillus *Flavus*, *Niger*, *Fumigatus*, *Penicillium*, *Paecilomyces*, *Monellia*, and *Mucor*. The fungal diversity was higher in the laboratory than other wards, but among this species, only the Mocur was not identified. The highest density of fungi (1.51 CFU/m^3) detected in the Emergency department was related to Monilia.

Discussion

In this study, the concentration of fungal airborne was higher in hospital Y than hospital X. According to table 1, the concentrations of total fungi in both hospitals were lower than the investigated guidelines. Therefore, the risk assessment of fungi airborne was low in this hospital. Moreover, the predominant species were Aspergillus, Penicillium, and *Monilia* in both hospitals. In indoor air, saprophytic fungi were abundant, so that *Aspergillus* species predominated in most hospital and occupational environments [6]. In other hospitals, in other cities, *Penicillium* species, *Aspergillus Niger*, *Cladosporium*, and *Candida* were dominant [7]. According to other studies of *Cladosporium*, the dominant species in the hospital were in different cities of Iran and the lowest concentration was related to Rotundolaz [8]. In Arak, the highest density was associated with the oncology and CCU and the dominant species were *Aspergillus* and *Candida* [4]. In Egypt, species of *Aspergillus*, *Alternaria*, *Penicillium*, and *Chladosporium* were dominant species [9]. In a French hospital, *Aspergillus* species were about 24% of the fungal species, whereas *Aspergillus fumigatus* were detected in 6% of the samples [10]. *Aspergillus fumigatus* infection in the French hospital was more than 40 CFU/m^3 and in the hallways of the hematologic department was about 6 times greater than that of other parts [11]. However, in the present study, most diversity of fungi was observed in the laboratory and emergency wards. The difference was due to the type of hospital, hospital location, number of patients and visitors, climate conditions, geographical location, and laboratory conditions such as incubation temperature and culture medium [12]. Since hospital X is located in the middle of the city and the urban overpass, more pollutants are possible to enter from vehicles; while Hospital Y is located outside the metropolitan area, surrounded by greenery and pastures. Additionally, the number of admitted patients, the number of visits to hospitals, and the diversity of referral diseases were higher in the first hospital. Although it is often argued that the source of fungal spores in intrinsic air is related to the structure and conditions of the building, fungal contamination can be caused by colonies that grow on trees, plants, and bushes and enter the interior through the door and window [13]. Such conditions have been observed in hospital Y, which is located in a geographical area with agricultural and garden land. The presence of airborne fungi in the hospital can be a risk factor for the workers and patients' health [7]. In this way, more attention should be paid to prevent entering the fungal spores from the outside. One of the most important diseases in this case is asthma [14], which is estimated as the most

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prevalent disease at the age of 0 to 18 years. Furthermore, pathogenicity of fungi has a significant correlation with the age and gender of children [15], which is the case in the studied hospitals, majority of children and pregnant women are among the vulnerable groups. In addition, admitted patients to the NICU are newborns under the age of one and their susceptibility to pathogens is higher. As a result, the risk of pathogenicity in hospital Y is higher than hospital X (Table 2 and 3).

The concentration and diversity of fungi in the emergency department were higher in both hospitals than the other treatment wards (Table 2 and 3), because the traffic and air turbulence in emergency ward have been higher than the other sections. The fungal contamination is directly related with air, which is a major contributor to the transmission and diffusion of fungal spores. To decrease contamination, special equipment should be used for endangered patients, excessive movement should be prevented in hospital corridors, windows should be closed, and application of fungal materials should be banned [11]. One of the effective measures can be use of air conditioning or HEPA filter, which easily and efficiently traps fungal spores and helps to isolate the sensitive environments. However, in both hospitals, the emergency department was often used for adults and children with less severe diseases. Spore is produced and dispersed in the environment if suitable constructions exist, such as temperature, humidity, and building materials. In addition, cooling, heating, and ventilation systems are also important factors in diffusion of the airborne fungi and consequently, creation of hospital infections among patients [4,16]. The pathology laboratory is another part of this study with high diversity and density of fungal contamination. The dominant fungi in this part include Aspergillus, Penicillium, and Cladosporium, but the dominance of Aspergillus species was higher. Than the others pathogenicity of fungi in the human body is mainly related to Aspergillus species and considering the presence of this species in the laboratory, the risk of pathogenicity for laboratory personnel is high and requires further investigation.

Conclusion

In this study, the variation of fungal species was investigated in two specialized hospitals. The concentration of fungal species is lower than the WHO, EPA, and EU guidelines. The diversity of fungal species in hospital Y was higher than X. Hospital X is located in the urban area and hospital Y outside the city, near the northern highway of Shiraz and between the agricultural and garden lands. The dominant species in both hospitals were *Aspergillus*, *Penicillium*, and *Monilia* with most diversity in the lab and emergency department. In this way, initial investigations for locating the hospital, use of air conditioning and HEPA filters, improvement of the management system for patient admission, hours and types of visits, and improvement of the microbial quality of the hospital's internal air are essential. Furthermore, further studies are also needed.

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Conflict of interest

The authors declare no conflict of interest regarding publication of this article.

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