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GENERAL HOSPITALS INDOOR AIR QUALITY IN LORESTAN, IRAN

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ABSTRACT:

Introduction: One of the important issues faced by most hospitals is an increase in nosocomial infection caused by exposure to airborne bioaerosols such as fungi and bacteria. It may be more dangerous for people who impaired immune systems. The aim of this study was to evaluate fungal contamination of indoor air of different wards of general hospitals of Lorestan, Iran.

Materials and methods: In order to assess microbial air sampling ZEFON Pump, equipped with single-stage cascade BioStage impactor was used. The mobile culture medium used for assessing fungal samples was Sabouraud Dextrose Agar (SDA) with chloramphenicol. Samples transferred to the laboratory and analyzed. Temperature and humidity were measured in different sampling areas.

Results: The highest level of fungal air contamination in different wards of hospitals No. 1, 2, and 3 were respectively in the surgical ICU (178.53 ± 207/20 CFU/m³), operating room (160.11 ± 99.62 CFU/m³), and CS ICU (162.72 ± 110.58 CFU/m³), and the lowest concentration levels were observed in ICU General (94.84 ± 65.89 CFU/m³), NICU (101.35 ± 112.64 CFU/m³) and operating room (70.67 ± 43.27 CFU/m³). The most common fungal agents detected include Cladosporium, Penicillium, Aspergillus, Chrysosporim, Alternaria, Fusarium, Rhizopus, Trichosporn Asahii, Cryptococcus albidus, Rhodotorula glutenis. Also, Aspergillus fumigatus was identified in most hospital wards.

Conclusions: High level of fungal contamination in certain wards of Khorramabad educational hospitals was indicated and an effective control system to reduce the fungi concentration is needed. Moreover, methods such as HEPA filters and UV lamps can use to reduce airborne fungi.

INTRODUCTION

Hospital ambient air contains a wide range of microbial contamination [1]. Attention to the indoor air quality in hospitals is important for several reasons, as many hospitalized patients become sick through airborne organisms [2]. The amount of microbial contamination varies from one ward to another in a particular hospital, or

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from one hospital to another in a different city or geographic area [3]. The presence of high concentrations of airborne microorganisms in indoor environments has raised concerns related to many chronic diseases, infections, and allergies, and the presence of these organisms is an indicator of cleanness of the environment. Investigation of fungal contamination in different hospital wards has been the subject of several studies. These studies have shown that most nosocomial infections have been caused by certain fungi such as Aspergillus, Mucor, Fusarium and Candida spp. [4 - 9]. In recent years, fungal infections in hospitalized patients have grown considerably. Results of studies in American hospitals during 1980 and 1990 have shown that fungal infection has increased from 1% to 4.9% per 1,000 people, and Candida species has accounted for about 79% of infections [10]. In addition, fungal species in the hospital wards could grow on the outer surface of various materials such as organic materials and surgical instruments and form small colonies. Fungal spores caused by the growth of these fungi can cause respiratory problems in patients and hospital staff, which makes it necessary to address molds in wards' indoor air more seriously because they have significant effects on health [4, 5, 11]. Several studies have shown that environmental factors such as temperature, humidity, ventilation and outdoor fungal concentrations can affect indoor air quality [12-15]. Epidemiological studies have also shown a positive correlation between moisture in the house and respiratory deaths among residents [16, 17]. Weather conditions have also been considered as one of the important factors affecting indoor air quality in hospitals, and to improve air quality a ventilation system equipped with HEPA filter can be used [14, 18]. Evaluation of concentration and diversity of bioaerosols in hospitals can be a good indicator for environment cleanness; thus, evaluation of hospital indoor air quality can assist in locating the source of infection that could eventually reduce hospital infection rates [19, 20]. The aim of this study was to evaluate indoor air quality in different wards of general hospitals of Lorestan provinces, Western Iran, so that an overall assessment would be obtained of the current status, and accordingly, the contamination level could be reduced by appropriate planning.

MATERIALS AND METHODS

Study design

This descriptive cross-sectional study was carried out in three main general hospitals of Lorestan provinces, Western Iran during two cold and warm seasons in 2015. In this study, different wards were selected from each hospital to study fungal contamination and indoor air quality, and selection of wards was based on the specialized context of the hospitals and the importance attached to each ward by the in-patients. Hospital wards studied here included the operating room, ICU General, ICU Neurology, ICU surgery, NICU, CSICU, POST ICU, women and men burn wards, and maternity wards.

Air Sampling

Air sampling was done using active and passive sampling methods to determine fungal infection within different spaces. Anderson Sampling Method was used as the active method for sampling bioaerosols, which is one of the methods recommended by the bioaerosol committee of the American Conference of Governmental Industrial Hygienists (ACGIH). Sampling was done using ZEFON pump. The device was placed 1.5-2 m above the floor (human respiratory area). After placing the10 cm diameter plates containing dextrose agar medium with chloramphenicol in the containers of plates, sampling was carried out for 2 minutes in 28.3 L/m of air. Then, fertile mediums were transferred to the laboratory.

In the passive method, 10 cm diameter plates containing dextrose agar medium with chloramphenicol were exposed to the air of the interior space of the wards, with an open lid, based on the 1/1/1 pattern (for 1 h, 1 m high, and 1 m away from the wall or the obstacles). In both methods, the above process was performed in the outer space air as well [18]. An air analyzer device (BABUC/A) was used in order to investigate the relationship between fungal colonies and air emissions. Concentrations of pollutant gases (O_3, NO_2, NO, CO) and factors such as relative humidity (%) and temperature (°C) of hospitals were measured, and their correlation with fungal colonies was studied using SPSS 19 in the active method. Identification of Fungal Colonies grown on plates was studied in mycology laboratory and were identified using macroscopic and microscopic methods.

RESULTS AND DISCUSSION

Mean and standard deviation for fungi of all three hospitals and wards are listed in Tables 1 and 2.

These results have been obtained using active and passive methods. Results of the active method in hospital No. 1 show that the highest and lowest fungal concentration levels have been observed in the surgical ICU with a mean of 178.53 CFU/m^3 and the General ICU with a concentration of 94.84 CFU/m^3, respectively. In the passive method, the highest and lowest concentration levels were observed in the open air and women burn wards respectively, with means of1808.37 CFU/m^2/h and 883.94 CFU/m^2/h. In hospital No. 2 the highest and lowest concentration levels were observed in the operating room and NICU with means of 152 CFU/m^3 and 101.35 CFU/m^3, respectively. Moreover, the highest and lowest concentration levels in hospital No. 2 were related to the open air and the transmission room with means of 1309.79 CFU/m^2/h and 829.07 CFU/m^2/h, respectively, in the passive method. In hospital No. 3, CS ICU and operating rooms had the highest and lowest concentrations in the

Table 1. Concentrations of fungi collected CFU/m^3 in indoor and outdoor whit active method in different units of the hospitals during a period of research

Different Ward of Hospitals (Sampling Site)	Hospital No. 1		Hospital No. 2		Hospital No. 3	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Women Burn	110.65	101.29	-	-	-	-
Men burn	119.95	122.48	-	-	-	-
Post ICU	-	-	-	-	132.97	94.11
General ICU	94.84	65.89	-	-	-	-
Neurology ICU	131.11	127.85	-	-	-	-
Surgery ICU	178.53	207.20	-	-	-	-
Delivery Room	-	-	113.27	69.85	-	-
Surgery Room 1	115.30	110.86	160.11	99.62	70.76	43.27
Surgery Room 2	138.54	105.39	-	-	-	-
NICU	-	-	101.35	112.64	133.48	143.43
Oncology	167.37	137.78	-	-	-	-
CS ICU	-	-	-	-	162.72	110.58
Burn ICU	130.73	121.08	-	-	-	-
Outdoor	144.13	117.23	152.49	89.16	153.10	162.19

Table 2. Concentrations of fungi collected CFU/m^2 in indoor and outdoor whit passive method in different units of the hospitals during a period of research

Different Ward of Hospitals (Sampling Site)	Hospital No. 1		Hospital No. 2		Hospital No. 3	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Women Burn	883.94	735.11	-	-	-	-
Men burn	971.37	916.88	-	-	-	-
Post ICU	-	-	-	-	904.63	688.38
General ICU	1099.87	824.59	-	-	-	-
Neurology ICU	1106.6	1049.58	-	-	-	-
Surgery ICU	1193.38	1014.34	-	-	-	-
Delivery Room	-	-	958.17	829.07	-	-
Surgery Room 1	1052.61	717.69	910.92	854.58	824.17	548.22
Surgery Room 2	1133.66	861.36	-	-	-	-
NICU	-	-	998.64	841.32	946.91	680.23
Oncology	1160.79	734.58	-	-	-	-
CS ICU	-	-	-	-	1194.32	1280.64
Burn ICU	910.94	952.63	-	-	-	-
Outdoor	1808.37	1087.76	1727.39	1309.79	2031.03	1596.29

active method with means of CFU/m^3 162.72 and 70.76 CFU/m^3, respectively, and the highest and lowest concentrations in the passive method were related to the open air and the operating room with means concentration levels of 2031.03 CFU/m^2/h and 824.17 CFU/m^2/h, respectively.

The results presented in Table 1 showed that in active method, the mean number of fungal colonies in surgical intensive care unit (ICU) was 178.53207.20± CFU/m^3 which was maximum among the hospital wards. The minimum contamination was observed in general ICU. Also, the mean number of fungi in the outdoor air was more than that in the indoor air of most of the wards of hospital 1. The presence of fungal spores in the indoor air may be originated from contact with the outdoor air. It was conducted a study by Abdollahi et al., on air microbes of Imam Khomeini Hospital, Tehran, and reported the maximum fungal contamination (760 CFU/m^3) in the ICU [11]. Table 2 illustrates the number of fungal colony per cubic meter of air in various wards of hospital 1 using the passive method. The maximum and minimum fungal contaminations were observed in women's burn ward and the outdoor environment, respectively. In this method, the mean number of fungi in the outdoor air was more than that in the indoor air of different wards in hospital 1. It can be said that indoor contamination can originate from outdoor contamination. According to the results shown in Table 1, using active method to count the mean fungal number in hospital 2 (CFU/m^3), the maximum contamination was observed in the operating room, which was160.11 ± 99.62 CFU/m^3. The minimum mean was observed in the NICU of hospital 2. Furthermore, the results obtained from the passive method demonstrated that outdoor environment and operating room had the maximum and minimum fungal contaminations, respectively. The level of fungal contamination in the outdoor environment was higher than that of all the other wards, except the operating room. The results of fungal colony number in CFU/m^3 in various wards of hospital 3 using active and passive methods revealed that, in the active method, the mean of fungal colony in CS ICU was 162.72 ± 110.58 CFU/m^3, which was higher than that in other wards. The minimum fungal contamination was observed in the operating room. In the passive method, the maximum mean of fungal colonies was observed in the outdoor environment (2031.03 ± 1596.29 CFU/m^3) and the minimum mean was in the operating room (824.17 ± 548.22 CFU/m^3). In the active method, fungal contamination in the outdoor environment of most wards was higher, except for CS ICU. However, in the passive method, the outdoor contamination was higher than all the other studied wards. Low number of microorganisms in operating rooms is often due to higher hygienic standards of this ward than the others [12]. A study was conducted on the air of Genova Hospital and reported the minimum fungal contamination in the operating room (12 ± 14 CFU/m^3) [4]. Investigating the relationship between temperature (˚C) and relative humidity (%) with the number of fungal colonies in CFU/m^3 in various wards of hospitals 1, 2, and 3 revealed no significant relationship between them, which may be due to the point that the temperature and humidity rates of this study were not extensive. Studying the relationship of gases and fungal colonies (CFU/m^3) in different wards of hospitals 1, 2, and 3 demonstrated no relationship between the density of gases and fungal colonies ($P > 0.05$). Many researchers reported no indoor sources of SO_2 and O_3, which mostly came from outside [13]. Some other researcher considered air quality of urban hospitals and showed that the concentration of nitrogen dioxide (NO_2) and ozone (O_3) emissions inside the hospitals was higher at the beginning of the week than the weekend, which could be because of heavy traffic jam around the hospitals. In our study, the same pattern could be observed, particularly in hospital 1, which was located near the main road [14].Table 3 shows the frequency of the fungi isolated from the hospital air, which included Cladosporium, Penicillium and Alternaria, Aspergillus, Rhizopus, Mucor, Fusarium, Aureobasidium pullulans, Chrysosporium, and so on. From among the isolated Aspergillus, A. flavus, and A. niger had maximum frequency. Aspergillus terreus and A. fumigatus were of minimum frequency. The maximum percentage of fungi existing in the outdoor air of the studied hospitals was the same as that in the indoor air of the wards. In the present work as well as some other studies, A. flavus as the predominant pathogen in hospital environments has substituted A. fumigatus [15]. Due to the generation of aflatoxin mycotoxins and causing respiratory infections, isolating A. flavus is of high medical importance [16]. It was showed by Azimi et al. that the most common isolated fungi in Shariati Hospital, Tehran, included Penicillium (70%), Aspergillus (14%), Cladosporium (12%), Alternaria (2%), and other fungi (2%) (8). Many researchers investigated the air in a hospital in Nigeria and indicated that the most common fungus species were Penicillium and Aspergillus [17].

CONCLUSIONS

Fungal contamination rate in current study was higher than other studies, which could be due to sampling in difference seasons, sampling methods, detection methods, age of hospital buildings, inappropriate air conditioning, ineffective aseptic technique, differences in weather and geographical conditions, hygienic behavior of staff and doctors, lack of proper training for cleaners, presence of animals like cats and pigeons, and existence of trees in hospitals.

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COMPETING INTERESTS

The authors hereby declare that in conducting this study, they had no competing interests.

AUTHOR'S CONTRIBUTIONS

All the authors contributed and participated equally in the collection, analysis, and interpretation of the data in this study. All authors critically reviewed, refined, and approved the manuscript.

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ETHICAL CONSIDERATIONS

The authors certify that all data collected during the study is presented in this manuscript, and no data from the study has been or will be published separately.

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