JCHR (2024) 14(1), 43-49

Journal of Chemical Health Risks

jchr.damghan.iau.ir

ORIGINAL ARTICLE

Environmental Survey on Microbial Contamination in Two Public Hospitals in Qazvin

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(Received: 19 April 2020 Accepted: 13 March 2022)

KEYWORDS

Air Pollution;
Indoor;
Fungi;
Cross Infection;
Environmental Pollutants

ABSTRACT: The presence of microorganisms in healthcare settings environments affected the health of patients and staffs. Air and surfaces contaminated with pathogens are important sources of hospital infections. To evaluate environmental microbial contamination in two hospitals of Qazvin, Iran. This descriptive analytical study has been accomplished in 6 wards of two hospitals in winter 2017.Bioaerosols were assayed by a single-stage Anderson impactor, at an airflow rate of 28.3 L min^{-1}, period of 2-5 min into TSA, SDA and MSA medium. Surface samplings were performed by using sterile swabs impregnated with TSB medium. The EU-GMP standard was used as permissible limit. Data has been analyzed by SPSS20 software and parametric statistic tests. The maximum fungal prevalence was related to *Cladosporium* and *yeast*. The ICU ward of the hospital (A) was the most polluted area with 479.3 CFU m^{3-1}. Maximum microbial contamination was observed on ICU food tables (A). Our findings confirm the significant relationship between concentration of microbial air and the surfaces statistically. Surface contamination can be resulted from airborne transmission in hospital; hence, in addition to surface disinfection and decontamination, it is appropriate to purify air by filtration system in order to improve indoor air quality.

INTRODUCTION

Nosocomial infections caused by presented microorganisms in hospitals may infect patients during their hospitalization. Surface and air contamination plays a major role in hospital hygiene problems [1]. Being in contact with contaminated medical furniture, physical facilities, surfaces and air has been reported as indirect transmission pathways of infection [2]. It is estimated that about 20% of hospital infections are caused by environment [3], and 15 to 30 percent of these infections can be prevented by hand hygiene and controlling equipment [4]. Patients were identified as potential sources of aerosols containing organisms: larger particles (<10 µ) released from their mouths and noses, are settled on horizontal surfaces which can be transferred to

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DOI: 10.22034/jchr.2022.1897883.1126

microorganisms; therefore airborne transmission plays a major role in surface microbial contaminations [5, 6].

Improving ventilation system and using HEPA filtration for hospital air purification causes significant declination in microbial surfaces [7]. Near and touched surfaces to the patients or staff are contaminated with pathogens frequently, termed "high-touch surfaces" [8]. Smaller particles settle into Nucleus Droplets (1–5 μ) slowly which might remain airborne for extended period of time, be transferred, and become a source of biological airborne particle formation called "bioaerosols". These particles settle out in the nasopharynx and are more infectious in this form [9]. About 10-20 percent of hospital infections are transmitted by bioaerosols [6]. Although health risks due to biological aerosols have been recognized, but there is no threshold limits allowable [9].

Contaminated air and surface monitoring is carried out to assessment and control infection risks in healthcare centers and can be an effective way to evaluate preventive guidelines, identify the type of microorganisms and sources of contamination; then the management of airborne transportation of nosocomial pathogens must involve strategies for surface and air disinfection [5, 10]. There have been limited studies on the surface-bound microbial contamination and their correlation with bioaerosols; thus, the purpose of this study is to investigate environmental microbial contamination in two public hospitals of Qazvin in 2017.

MATERIALS AND METHODS

This cross-sectional descriptive-analytical study has been conducted in two educational hospitals of Qazvin in winter 2017. Each surgical and intensive care unit of the hospitals included high prevalence of nosocomial infections, and only these units were studied due to budget limitation. Samples were carried out by a single-stage Impactor Anderson by the Quick Take-30 (United Kingdom), at a flow rate of 28.3 L min^{-1} for 5-10 min, a height of 1.5 m above the floor and 1 m distance from the walls and barriers [11]. Trypticase Soy Agar (TSA), Sabouraud Dextrose Agar (SDA) and Mannitol salt agar (MSA) culture medium were used to identify total microbial, fungal and *Staphylococcus aureus*. Surface samples were collected by sterile swabs impregnated with TSB medium [12]. The standard set for finding *S.aureus* to indicate surface hygiene was <1CFU cm^{2-1} CFU m^{3-1} [13]. Colonies were counted After Incubation and were reported according to sampling time and air volume in CFU/m^3 [14]. The identification of fungal species was done through macroscopic, microscopic morphology, and slide culture methods [15]. Selected surfaces were based on the number of hands-on contacts and their distance from patients [8]. Air sampling was fulfilled referring to NIOSH-0800 standard method, required 3 points in each ward and 1 to 3 plate at each sample point [5, 16]. The European Union's GMP (EU GMP) standard was used as the permissible limits Table 1[17].

Table 1. Recommended limits for microbial contamination.

Grade	Bioaerosols concentration (CFU/m^3)	Surfaces samples (CFU/Plate)
A	<1	<1
B	10	5
C	100	50
D	200	100

The results of the experiments were analyzed by SPSS vs. 20.0 software and descriptive statistics, including means and standard deviations (SD). As the data were normally distributed, the comparison between microbial concentration of air and surfaces in different wards of hospitals were investigated by analysis of variance (ANOVA). To assess the correlation between the results obtained from air and surfaces Pearson's correlation test were used. The significance level was set at $p<0.05$.

RESULTS

A total of 250 samples were collected from both hospitals. The Maximum prevalence of fungal species was *Cladosporium* spp. and *yeast* Figure 1. As shown in, maximum total and fungal contamination was observed on ICU food tables in hospital (A) and bed sheets of women's surgery ward (A). The highest rate of *S. aureus* prevalence was recorded on bed sheets of female surgical ward (B). According to the Figure 2, the average of the

total fungal bioaerosols was 260.3 CFU m^{3-1} and 39.8 CFU m^{3-1}, and hospital ICU (A) with 479.3 CFU/m^3 and 77 CFU m^{3-1} contained the highest level of airborne microbes. Based on the EU GMP standard, microbial contaminations were observed in most air and surface samples of unacceptable areas. ANOVA test showed significant differences in mean density of bioaerosols and contamination surfaces ($p=0.03$, $p<0.0001$). Pearson's correlation revealed a significant relationship between the concentration of bioaerosols and the contamination of surfaces ($p<0.05$) [The average air fungal contamination of this study was 39.8 CFU m3-1, which was close to the results of Mehrasbi et al. (40.57 CFU m3-1) [28]. In this regard, the quality of air in the hospitals was better than the recent studies have been conducted in Nigeria and Egypt [21, 29].

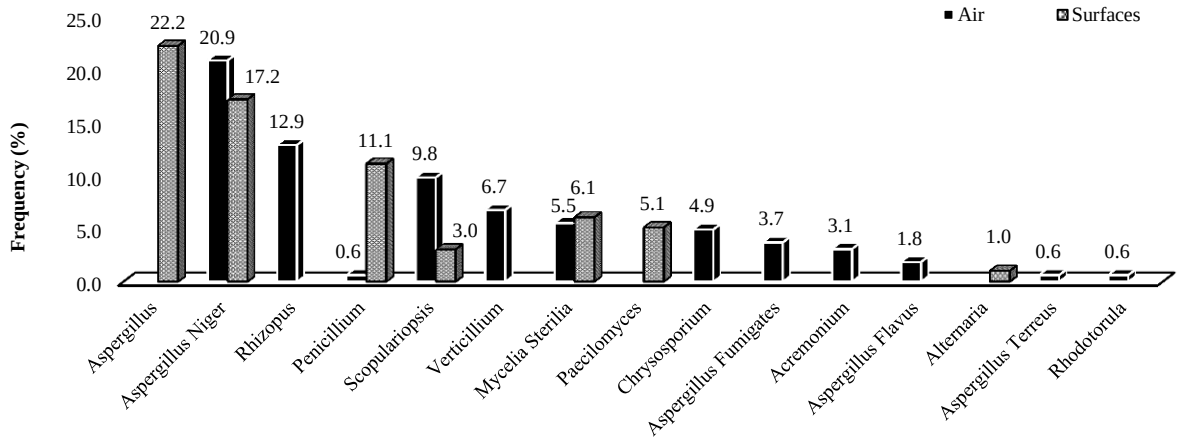

Figure 1. Frequency of fungal species in air and surfaces samples.

DISCUSSION

The prevalence of bacterial and fungal bioaerosols was 81.1% and 83.2%, which is lower than the results of Bauer et al. study (98.9%) [18]. Fungal and bacterial contamination of internal surfaces in the range of 89.8% and 97.6% is higher than previous researches results [19, 20].

Table 2. Mean of surface microbial contamination: total, fungal (CFU/plate) and *S. aureus* count (CFU cm^{2-1}).

Ward	Type of contamination	Nurse's station	Food tables	Bed railing	Keyboard	Mouse	Bedding	Pillow	Hallway corridors	Serum holder
		Mean(SD)								
Women's surgery(A)	Total	41.2(1.4)	58.2(25.6)	39.5(2.1)	32.5(2.1)	11(4.2)	84.3(4.8)	46(29.6)	70(2.8)	4.2(4.2)
	Fungal	28.6(9.2)	48.4(4.9)	15(4.2)	7(1.4)	5(1.4)	63.9(25.4)	22.6(17.8)	28.5(9.2)	45(4.2)
	S. Aureus	0	0.02	0.08	0	0	0	0	0.06	0
Men's surgery(A)	Total	37.3(2.7)	32.7(5)	80.7(3.8)	33(0.3)	11(0.7)	94.4(19.7)	39.5(2.1)	59(0.4)	22(0.1)
	Fungal	8.3(2.5)	11(1.4)	27.1(0.7)	7(0.1)	4.5(4.9)	28.1(0)	10(2.8)	28(0.2)	5(0.2)
	S. Aureus	0.02	0.04	0.06	0	0	0	0	0	0.02
ICU(A)	Total	26.5(4.9)	157.6(89.4)	85.7(9.4)	29.5(2.1)	25(4.2)	86.5(7.8)	81(8.5)	42.2(28.4)	46(5.6)
	Fungal	11.5(2.1)	58.1(14.3)	40.6(3.7)	17(1.4)	6(2.1)	39(1.4)	37(2.1)	23.5(2.1)	24(1.4)
	S. Aureus	0.02	0.02	0.02	0	0	0	0	0	0
Women's surgery(B)	Total	29.5(2.1)	42.4(5.1)	38.5(3.5)	35.1(18.5)	25(4.2)	37.1(1.3)	81(7.5)	40(27.2)	36(0.3)
	Fungal	8.5(0.7)	12.3(3.2)	17(1.4)	16(12.8)	6.5(2.1)	8.5(2.1)	37(2.1)	15(15.5)	5(0.6)
	S. Aureus	0	0	0	0	0	0.14	0	0	0
Men's surgery(B)	Total	29(2.8)	39.7(2.1)	29(4.2)	24.5(3.5)	13.5(3.5)	64(32.5)	30(2.8)	18(4.2)	30(1.4)
	Fungal	10.5(2.1)	17(6.7)	9.5(2.1)	9.5(6.4)	1(1.4)	18.5(13.4)	13.5(2.1)	9(2.8)	9(1.4)
	S. Aureus	0	0	0	0	0	0.02	0	0	0
ICU(B)	Total	17.5(2.1)	26(7)	23(7.1)	15.3(13.6)	23(2.8)	76(15.5)	68.5(3.5)	31.5(2.2)	24.5(4.9)
	Fungal	6.5(2.1)	10(1.1)	5.5(0.7)	5.7(5.5)	12(2.8)	19(2.8)	25.5(4.9)	9(1.4)	6.5(2.1)
	S. Aureus	0	0	0	0	0	0.02	0	0	0

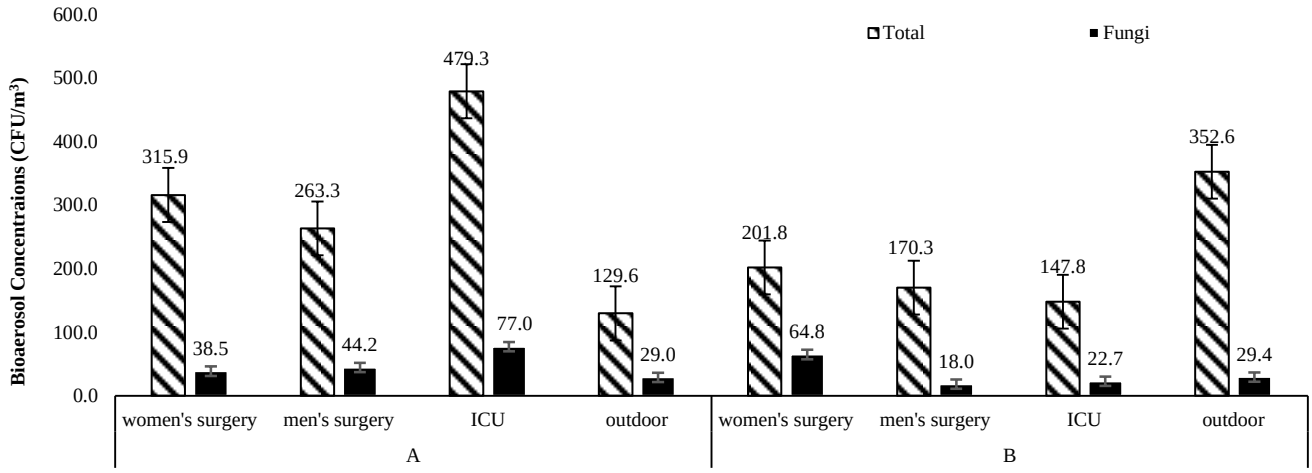

Figure 2. Mean of total and fungal bioaerosols (CFU m^{3-1}) based on ward hospital.

The most microbial contamination was observed on ICU surfaces (A). Also the maximum total load and fungal bioaerosols were in the ICU (A), practically the same as the results in Osman et al. study [21]. The high microbial parts was formed mainly due to the long-stay patients in hospital and the accumulation of contamination, as well as the lack of principle hygiene observations such as changing clothes and wearing scrubs in the ward [22]. Given that patients who stay in ICU require extended treatments and intensive care, they are at higher risk of being exposed to bioaerosol contamination and these sort of infections [23]. In hospital (B), the highest concentration of bioaerosols was observed in female surgical ward. Similar studies show that the most microbial contamination part of hospital is surgical unit due to various factors such as commuting, insufficient ventilation, and improper floor cleaning [24-26].

Staphylococcus aureus has been considered as the standard to estimate the cleanliness of surfaces [13]; In present study the count of *S. aureus* in all surface samples was <1CFU cm^{2-1}. On the contrary, White et al. extracted *S. aureus* from surfaces such as sink and floor, therefore levels of contamination exceeded the standard [27].

The average air fungal contamination of this study was 39.8 CFU m^{3-1}, which was close to the results of Mehrasbi et al. (40.57 CFU m^{3-1}) [28]. In this regard, the quality of air in the hospitals was better than the recent studies have been conducted in Nigeria and Egypt [21, 29].

Table 3. Relationship between bioaerosols concentrations and surfaces contaminations.

			Bioaerosol concentration	
			Total	**Fungal**
Surface contamination	Total	R^2	0.43	0.30
		p value	0.001*	0.002*
	Fungal	R^2	0.35	0.26
		p value	0.009	0.04*

* Statistical significant was set at p<0.05

The two predominant fungal genera in the air were *Cladosporium* spp. and *Aspergillus* spp. and on surface samples those were *Aspergillus* spp. and *yeast*. The role of air in diffusion of *Aspergillus* spp. in hospital environment was proved [30, 31]. Kelkar believed that surgical site infections might be caused by fungal spores entering from outdoors and their settlement on open wounds [32]. With respect to the concentration ratio of indoor/outdoor bioaerosols (1>I/O) in hospital (B), ambient air was more polluted than indoor air. It is necessary to focus on proper air purification and closing doors and windows. The identified fungi were able to form spores which caused to protect these species against environmental changes; therefore the dominance of this kind of genus and specie was related to their metabolic potential which preserved their distribution and survival

under adverse environmental conditions such as lack of food or high temperature [33]. This kind of fungus and its other genus might cause a variety of diseases such as infection, allergy, irritation, and toxicosis [34]. Furthermore, fungal contamination on indoor surfaces not detected in airborne samples might be a source of potential colonization as well [35].

Compared to the EU GMP standard, 62.5% of total bioaerosol concentration was higher than category D (undesirable), and 100% fungal density was in grade C (medium). Microbial contamination of the surfaces in 71.4% of the total samples and in 61.1% of the fungal samples were in grade C. In a similar study conducted by Massoudinejad et al., gram-negative bacterial contamination at A and B zone, and density of gram-positive species were often classified as C [36]. Also, the results of another study in a Qazvin private hospital show that 50% of the bioaerosols concentration were classified as D [37].

The results indicate a significant relationship between microbial contamination of surfaces and air. Another study has reported significantly that the concentration of bioaerosols are diminished after cleaning the environment and equipment [38]. Huang et al. has found a positive correlation between microbial air density and surfaces in the ICU ward [14]. Earlier investigations also declared the efficiency air filtration on microbial density at surfaces [1, 39]. Panagopoulou et al. has observed a positive correlation between the microbial contamination on indoor surfaces, air, and ventilation canals, which was an agreement with the results of the present study [40].

One of the limitations of this study was the lack of measurement of bioaerosols in size distribution. Future researches into the utility of portable particle counters or other impactors (like Andersen 8-stage) able to measure particles in different diameters. Another potential limitation is counting of culturable microorganisms that limited to evaluate the degree of contamination based only on quantitative exposure assessment. Due to budget constraints, bacterial species and other wards of hospitals had not been investigated.

The characteristics of the relationship between air and surface microbial contaminations were well understood. We have obtained demonstrating that only surface disinfection could not be adequate for decline microbial bar environment rather because of bioaerosols settling down hospital surfaces we need more attention to improve air microbial quality.

CONCLUSIONS

The interpretation of the results of this study can still lead to underestimation of the fungal and bacterial contamination of two hospitals in Qazvin in comparison with previous studies. Also if there is microbial contamination in different wards of the hospital, the surfaces contamination will be possible; therefore, as well as disinfection of hospital equipment, it is necessary to improve the indoor air quality using various air purification methods. Moreover, further investigations should be carried out in the field of airborne biocontamination in hospitals.

Financial support and sponsorship

This research was supported by the Qazvin University of Medical Science, grant number: 14002791.

Conflict of Interest

None declared.

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