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Determining the Concentration of Particulate Matters and Microbiological Quality of Indoor Air in Intensive Care Units of Kashan Hospital, Iran

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ABSTRACT

Introduction: Maintaining hospital air quality is very important, especially in intensive care units (ICUs), where patients undergo invasive procedures. Therefore, the present study was conducted with the aim of determining the relationship between particulate matters (PMs) and bioaerosols in pediatric ICU (PICU), neonatal ICU (NICU), and ICU open heart (ICU OH) of Shahid Beheshti Hospital in Kashan.

Materials and Methods: This cross-sectional study was conducted for six consecutive months, i.e., autumn and winter of 2021. PM samples were taken using a Grimm Dust Monitor and microbial samples were taken using a Quick Take 30 sampler. Kolmogorov-Smirnov test was used for analysis and then ANOVA and LSD were used for further tests.

Results: The maximum and minimum PM_{10} concentrations in the PICU and ICU OH were 59.19 and 9.71 µg/m^3, respectively; and the maximum and minimum $PM_{2.5}$ concentrations were 20.23 µg/m^3 in the NICU and 4.69 µg/m^3 in PICU. The mean PM concentration and the number of bacterial and fungal colonies were consistent with the WHO and EPA guidelines. Gram-positive *Staphylococcus* were the most abundant bacteria (90.96%). The most abundant fungi were *Aspergillus* (54.23%), *Penicillium* (15.64%), and *Cladosperium* (12.17%) species. There was also no significant relationship between PMs and bioaerosols.

Conclusion: The mean concentrations of PMs and bioaerosols match with the guidelines, which can be attributed to more observance of health protocols and restrictions on the movement of people into ICUs due to the COVID-19 outbreak.

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Introduction

The gradual change in human lifestyle has caused people to spend an average of 87% of their day in indoor environments. One of the most important pollutants in this area is particulate matters (PMs) [1, 2]. The World Health Organization (WHO) has ranked PM-induced air pollution as the 13th most common cause of death in the world [3]. PMs include harmful suspended pollutants in the air and are important components of the air, which

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are divided into total suspended particulate (TSP), PM_{10}, $PM_{2.5}$, and PM_1 according to their size regardless of the chemical name [4]. Epidemiological studies have shown the relationship between indoor air pollution and its effects, i.e. mortality in all age groups, from infants to the elderly [5]. Exposure to air pollution early in life can lead to impaired lung function, increased risk of respiratory diseases, and a higher likelihood of premature death. Evidence suggests that these effects persist into adulthood and later in life, justifying the growing global concern about exposure to air pollution during this period of life [6-8]. Hospital PMs lead to the spread of microorganisms, and respiratory tract infection is strongly affected by these aerosols [9]. These particles may contain microorganisms such as bacteria, viruses, and fungi that can be transported over long distances. A total of 80% of air microorganisms can be carried by PMs [10, 11]. Airborne microorganisms are the main source of air pollution in indoor environments of hospitals, whose concentrations are closely related to medical activities, type and number of patients, method and number of cleaning repetitions, weather conditions, ventilation rate, and building design [12, 13]. One of the most important factors known to cause healthcare-acquired infections (HAIs) is the air in the patient's room [14, 15], especially for critically ill and immunodeficient patients who undergo many invasive procedures in intensive care units (ICUs) [16]. Most critically ill patients are admitted to the ICU. Critically ill infants and children are cared for separately in pediatric ICUs (PICU) and neonatal ICUs (NICU) [17]. The WHO has reported the highest prevalence of HAIs in ICUs and orthopedic wards [18]. Studies have shown a significant relationship between HAIs and bioaerosols in the air [19, 20], and that HAIs occur in ICUs 5-10 times more frequently than in normal wards [21]. Infectious and non-infectious diseases caused by inhalation of different bioaerosols depend on the biological characteristics, chemical composition, and number of inhaled microorganisms [22]. It is necessary to improve routine infection control methods used in ICUs in order to minimize HAIs [23]. Therefore, the present study aims to determine PMs Concentrations and the amount of bacterial and fungal pollutions in indoor air of NICU, PICU, and ICU open heart (ICU OH) of Shahid Beheshti Hospital, Kashan.

Materials and Methods

Description of sampling sites and strategies

In this cross-sectional study, air samples were taken in six consecutive months during the autumn and winter of 2021 from PICU, NICU, and ICU OH of Shahid Beheshti Educational-Therapeutic Hospital, Kashan. The specifications of each ward are given in Table 1. In order to obtain a comprehensive sample, random sampling was used. Each ward was divided into 15 parts according to its area, and sampling was carried out randomly in one of these parts. Sampling was carried out at a standard breathing height (120 cm) and with a distance of more than 1 meter from walls and obstacles [24]. Each PM was sampled using Grimm dust monitor (MINI-LAS, Germany); a calibrated air sampling device for one hour, and microbial sampling was also performed using a Quick Take 30 (SKC, USA) air sample pump with a flow rate of 28.3 L/min for 15 minutes in Blood Agar culture medium. In order to cover all days of the week and obtain better results from microbial and PMs samples, sampling was carried out according to the standard sampling schedule (EPA 2021) for 15 days in the autumn and winter of 2021, and the total number of PMs and microbial samples reached to 90. These measurements included the concentration of PMs, the number and species of bacteria and fungi [16, 25].

Table 1: Characteristics of the Kashan Shahid Beheshti hospital wards

Hospital wards	Area (m^2)	No. of Beds	Ventilation system	Sampling locations
PICU*	400	9	Exhaust fan	Between Patient Bed, Nurse Station Doorway, Pavilion, Isolate Room
ICU OH**	500	5	Exhaust fan	
NICU***	600	32	Exhaust fan and Natural ventilation	

* Pediatric intensive care unit
** Intensive care unit open heart
*** Neonatal intensive care unit

Detection of bacteria and fungi

The plates containing the samples obtained from the hospital environment were transferred to the Microbiology Laboratory of Kashan University of Medical Sciences immediately to investigate bacterial and fungal colonies. For this purpose, Blood Agar plates containing samples were incubated for 24 hours at 37 °C [26]. Then, bacterial and fungal colonies were counted with the colony counter (CFU/m^3), and then Gram's staining was carried out. This was followed by oxidase, catalase and DNase tests, then Novobiocin disc and special media such as Mannitol salt agar (MSA) were used for additional investigation and bacterial identification [27]. To identify fungal colonies, first the colonies formed on the plates were counted visually and their number was reported as CFU/m^3. To perform differential diagnosis, the colony appearance on the plate was first observed. Then, the fungal species were identified by direct slide preparation and ultrastructural observation [28].

Data analysis

Sampling was done randomly. The data, including one-hour and 24-hour concentrations of TSP, PM_{10}, $PM_{2.5}$, and PM_1, the number and species of bacteria and fungi, concentrations of PMs and bioaerosols based on WHO and EPA guidelines were collected and then analyzed by SPSS ver.16 software. Next, mean and standard deviation were used to describe the quantitative data, and the number and percentage were used for the qualitative variables to draw necessary tables and graphs. Finally, Kolmogorov-Smirnov test and ANOVA were used for analysis and LSD was used for subsequent tests. The significance level was assigned as 0.05 in this study. Also, Pearson and Spearman tests were performed to calculate correlation coefficients. In addition, the data were described using descriptive statistics such as central and dispersion indices in the case of quantitative variables, and determination of absolute and relative frequency in the case of qualitative variables, followed by drawing necessary tables and graphs. In order to measure the relationship between variables, Kolmogorov-Smirnov test was used to determine whether the data are normally distributed. ANOVA and LSD post hoc tests were used for inter-group comparison. Also, Pearson and Spearman tests were performed to calculate correlation coefficients.

Ethical issues

This study was authorized by Kashan University of Medical Sciences ethics committee IR.KAUMS.NUHEPM.REC.1399.063.

Results

Forty-five samples were taken from PICU, NICU, and ICU OH of Shahid Beheshti Hospital in Kashan (n = 15 samples per ward). Results of comparing the one-hour mean concentration of PMs in the indoor air of the above-mentioned wards of Shahid Beheshti Hospital of Kashan are presented in Figure 1. In all wards, the one-hour mean of PM_{10} was higher than $PM_{2.5}$ and PM_1. The maximum and minimum one-hour PM_{10} concentrations were obtained in PICU (60.88 μg/m^3) and ICU OH (47.10 μg/m^3). The maximum and minimum one-hour $PM_{2.5}$ concentrations were 28.52 and 21.53 μg/m^3 in the NICU and PICU, respectively. Also, the maximum and minimum one-hour PM_1 concentrations were 27.61 and 20.54 μg/m^3 in the NICU and PICU, respectively. The

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highest and lowest one-hour mean concentration of TSP were observed in PICU (120.73 μg/m^3) and ICU OH (76.75 μg/m^3), respectively. The results showed no significant difference between the PM_1, $PM_{2.5}$, PM_{10} and TSP mean concentrations in each ward (Table 2).

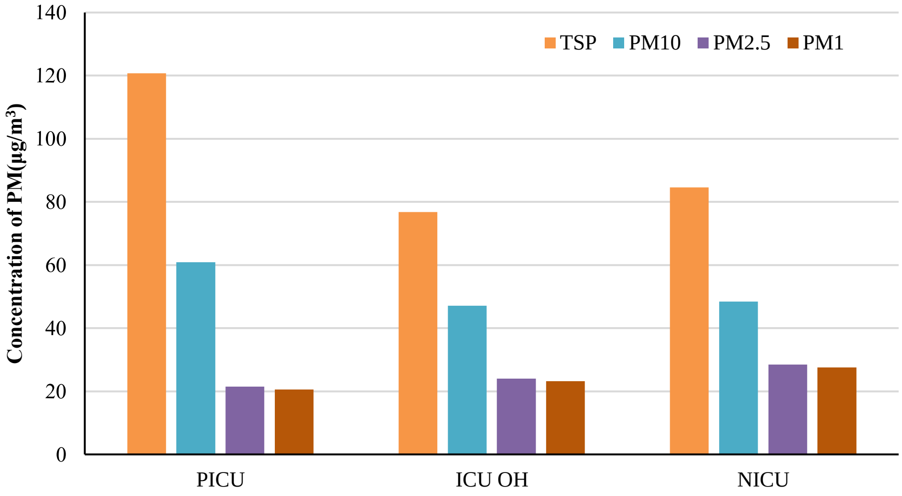

Figure 1: Comparison of one-hour mean concentration of PMs (TSP, PM_{10}, $PM_{2.5}$, PM_1) in different wards of Shahid Beheshti Hospital, Kashan, Iran.

Table 2: Statistical indicators of PMs and bioaerosols in different wards of Shahid Beheshti Hospital, Kashan (Mean ± SD)

variable	Unit	Ward PICU	Ward ICU OH	Ward NICU	P-Value
TSP	μg/m^3	120.73 ± 81.97	76.75 ± 23.38	84.59 ± 36.73	0.068
PM_{10}	μg/m^3	60.88 ± 31.19	47.10 ± 15.60	48.47 ± 9.08	0.149
$PM_{2.5}$	μg/m^3	21.53 ± 6.89	24.04 ± 8.45	28.52 ± 9.08	0.072
PM_1	μg/m^3	20.54 ± 6.63	23.25 ± 8.14	27.61 ± 8.66	0.056
Bacteria	CFU/m^3	30.20 ± 25.32	24.00 ± 7.80	42.47 ± 18.20	0.029
Fungi	CFU/m^3	25.47 ± 22.25	19.27 ± 17.49	12.80 ± 5.96	0.128

To compare PMs with the guideline, one-hour concentration of PMs was converted to 24-hour concentration using a conversion factor (0.4) [29]. The maximum and minimum microbial abundance belonged to NICU and ICU OH, respectively. Similarly, the highest and lowest fungal abundance were obtained from PICU and NICU wards, respectively (Table 3). Figure 2 also shows the mean concentration of bioaerosols for each ward.

As shown in Table 4, the results of statistical tests did not show any relationship between PMs and bacterial and fungal bioaerosols in the PICU, NICU, and ICU OH (P > 0.05).

Table 3: Statistical indicators of 24-hour concentration of PM and bioaerosols in different wards of Shahid Beheshti Hospital, Kashan

Ward	Statistical indicators	TSP (µg/m^3)	PM_1 (µg/m^3)	$PM_{2.5}$ (µg/m^3)	PM_{10} (µg/m^3)	Bacterial colony (CFU/m^3)	Fungal colony (CFU/m^3)
PICU	Mean	48.29	8.21	8.61	24.35	30.20	25.47
	SD	32.79	2.65	2.76	12.48	25.32	22.25
	Max	128.31	13.47	14.06	59.19	94.00	85.00
	Min	16.91	4.46	4.69	9.73	5.00	5.00
	Median	38.02	7.82	8.19	22.42	19.00	17.00
ICUOH	Mean	30.70	9.30	9.62	18.84	23.67	19.27
	SD	9.36	3.26	3.38	6.24	7.82	17.50
	Max	49.83	16.01	16.50	31.89	38.00	59.00
	Min	14.47	5.52	5.66	9.71	7.00	3.00
	Median	29.82	8.21	8.51	17.09	24.00	12.00
NICU	Mean	33.84	11.05	11.41	19.39	42.47	12.80
	SD	14.69	3.46	3.63	3.63	18.21	5.9
	Max	78.75	19.35	20.23	26.13	73.00	28.00
	Min	21.23	6.98	7.27	15.08	17.00	5.00
	Median	30.00	9.43	9.64	18.71	17.00	5.00
WHO guideline (24-hour)		-	-	25	50	100	50
EPA guideline (24-hour)		260	-	35	150	-	-

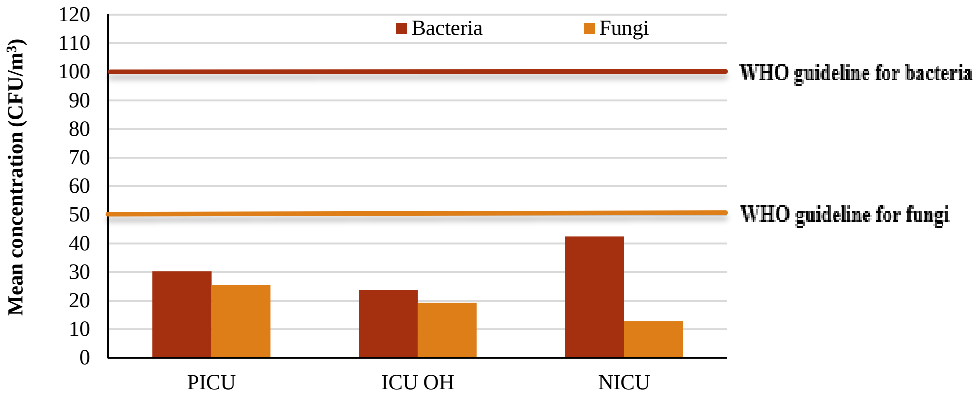

Figure 2: The mean concentration of bacterial and fungal colonies in each ward of Shahid Beheshti Hospital, Kashan, Iran.

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Table 4: Values of the correlation coefficients of bioaerosols in the air and the concentration of PMs according to Pearson and Spearman test

Variable	Bacteria		Fungi	
	Coefficient	Sig.(P-value)	Coefficient	Sig.(P-value)
TSP	0.078*	0.610	0.119*	0.436
PM_{10}	-0.071**	0.644	0.218*	0.151
$PM_{2.5}$	0.010**	0.950	0.148*	0.333
PM_1	0.018**	0.907	0.139*	0.361

* Spearman test
** Pearson test

Table 5 shows that four bacterial Species were identified in the studied wards; *Staphylococcus* was the most abundant (90.96%), followed by *Bacillus* (8.02%), *Acinetobacter* (0.82%), and *Diphtheroid* (0.2%).

The fungal species of *Aspergillus, Fusarium, Phoma, Penicillium, Geotrichum, Cladosporium, Alternaria, Mucor, Scopulariopsis, Trichoderma,* and *Candida colonies* were observed in indoor air of PICU, ICU OH, and NICU of Shahid Beheshti Hospital in Kashan. Generally, *Aspergillus* was the most abundant (54.23%), followed by *Penicillium* (15.64%) and *Cladosporium* (12.17%). *Scopulariopsis* was also the least abundant (0.58%). The highest fungal abundancy was observed in PICU, and 44.27% of all species of fungi and the highest diversity of fungi were reported in ICU OH. The least fungal abundance (22.25%) was also observed in NICU. Figure 3 shows the percentage of fungal Species for each ward separately.

Table 5: Prevalence of different bacterial Species in PICU, HCU OH, and NICU of Shahid Beheshti Hospital, Kashan

Type	Species	PICU		ICU OH		NICU		Total	
		Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Gram positive	*Staphylococcus*	420	92.72	303	79.53	615	96.55	1338	90.96
	Bacillus	33	7.28	63	16.54	22	3.45	118	8.02
	Diphtheroid	-	-	3	0.78	-	-	3	0.2
Gram negative	*Acinetobacter*	-	-	12	3.15	-	-	12	0.82
Total		453	100	381	100	637	100	1471	100

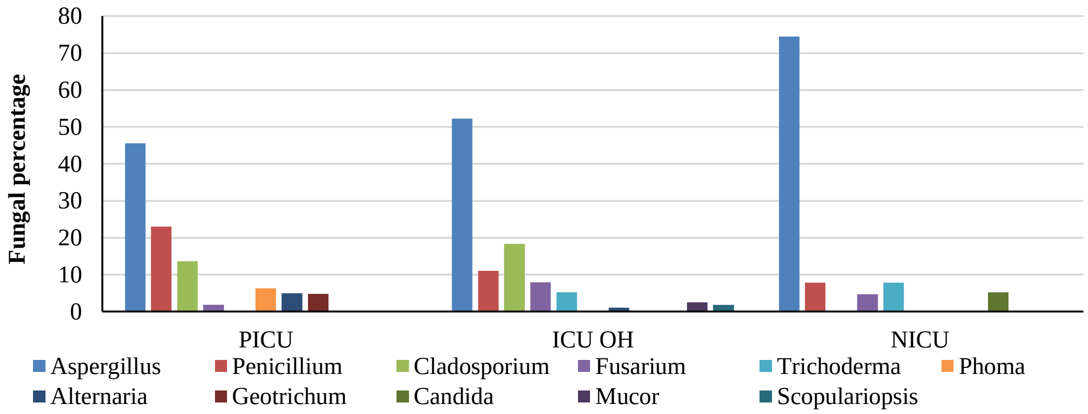

Figure 3: Abundance of fungal species percentages in each ward of Shahid Beheshti Hospital, Kashan, Iran.

Discussion

The present study was carried out in PICU, NICU, and ICU OH during six months, while adhering to calibration and sterilization requirements. The number and Species of bacteria, fungi and also the concentrations of PMs were also determined.

The results showed that the 24-hour concentration of PMs in all three wards was lower than the WHO and EPA guidelines. The maximum PM_{10} concentration was detected in all wards. The highest and lowest concentrations of PM_1 and $PM_{2.5}$ were observed in NICU and PICU, respectively. The result of a study in the United States (2016) indicated that movable walls between patient beds in PICU may help to some extent to reduce PM transfer [30]. This result can also be applied to the present study, since among the three studied wards, only PICU had separate rooms for each patient, and the $PM_{2.5}$ and PM_1 concentrations was less than the other two wards. In a study, Dehghani et al. reported that the lowest PM_{10} and $PM_{2.5}$ levels were related to ICU OH and an operating room in Shiraz[17], and in the present study, the lowest PM_{10} concentration level was observed in ICU OH (18.84 μg/m^3). In a study in

Taiwan, Tang et al. stated that the mean PM_{10} concentration in ICUs was 14 μg/m^3, which is lower than the guideline and is consistent with the present study. Gaidajis and Angelakoglou (2014) also obtained a mean PM_{10} concentration of 59 μg/m^3 in Greece and showed that the mean was lower than previous research studies in ICUs [31]. In a study in the United States (2016), Licina et al. measured PM_{10} concentrations in NICU over a year. The results of this study showed that PM_{10} concentration was generally low and did not exceed 5 μg/m^3. The researchers attributed this favorable result to the efficient PM filtration and construction in compliance with effective health guidelines [30].

The maximum TSP, PM_{10} concentrations, and fungal colonies were also observed in PICU, which can be attributed to the frequency of PICU cleaning and suctioning the patients' respiratory tracts. The concentrations of PM_{10}, $PM_{2.5}$, and PM_1 increase due to activities such as nebulizers, suction, and cleaning the environment and surfaces, especially when patient admissions are at their highest, seasonal viruses are at their peak, and central air conditioning system is used. The infected parents, guardians, visitors and hospital staff also increase the risk of hospital infections by contributing to the increase in the PM concentration [16, 32-34].

WHO has declared that the maximum acceptable levels of hospital bacterial and fungal bioaerosols is 100 and 50 CFU/m^3, respectively [35]. The present study showed that bacterial and fungal pollution levels in all wards were consistent with the WHO guideline. In a study by Rezaei et al., in a hospital in Tehran, it was reported that the number of bacterial colonies was higher than the standard level in 14% of cases, which is not consistent with the results of the present study [22]. However, Valedeyni et al., in a study in two hospitals in Ardabil, showed that the mean total bacterial concentration was lower than the standard level, which is consistent with the results of the present study [36].

Microbial pollution of different hospital wards, including ICUs, is one of the important factors underlying the transmission of hospital infections. The result of a study in Singapore (2003) shows that patients are the main sources of bacterial transmission [37]. In this study, the maximum number of bacterial colonies was related to NICU (Table 4), which could be due to the high traffic of patients and staff and the long hospital stay. Also, in this ward, the mean $PM_{2.5}$ (11.41 μg/m^3) and PM_1 (11.05 μg/m^3) concentrations in NICU were higher than in other wards, which can be due to the high number of open doors and windows and the high traffic of personnel and parents.

In the current study, the dominant bacterial and fungal species were *Staphylococcus epidermidis* (90.96%) and *Aspergillus* (54.23%); followed by *Bacillus* (8.02%) in the bacterial group and *Penicillium* (15.64%) and *Cladosporium* (12.17%) in the fungal group. The abundance of Gram-positive bacteria was 99.18%, which 90.96% of them were Gram-positive *Staphylococcus* and 8.22% were *Diphtheroid* and other Gram-positive *Bacillus*. Gram-negative bacteria accounted for only 0.82% of all bacteria, which included Gram-negative *Bacillus*. In a study, Sandra Caboverde et al. investigated the abundance of Gram-positive *cocci* in Portugal in two seasons, summer and winter. They found that *Staphylococcus* and *Micrococcus* were the most abundant bacterial species with frequencies of 51% and 37%, and *Penicillium* and *Aspergillus* were the most abundant fungal species with frequencies of 41% and 24%, respectively. The higher abundance of Cocci is due to their presence in dust and the lack of basic and correct cleaning and disinfection [38]; which is consistent with the current study in terms of diversity of microorganisms. Rafiei et al. also reported that the most abundant bacterial and fungal species in two hospitals of Tehran were *Staphylococcus epidermidis* and *Aspergillus*, which is consistent with this study [39]. A study in China also demonstrated that *Staphylococcus epidermidis* was the dominant bacterial species (51%) [40]. *Staphylococcus* are not virulent species, but they are important causes of infection in high-risk groups. The high concentration of these Gram-positive *cocci* can be due to their lower sensitivity to environmental heat or pressure. This species is resistant to drought and harsh conditions, which in turn has made it easier for them to live, multiply, and spread. They are often found in indoor air of hospitals of Iran located in a semi-arid region [41, 42]. Some studies have referred to *Staphylococcus* as an indicator of indoor bacterial pollution [43]. In the study of Hasanvand et al. in Khorramshahr, the most abundant bacteria were Gram-positive *cocci* and *Bacillus*. Since the dry climate can cause the death of bacteria, and the sensitivity of Gram-negative bacteria is higher than Gram-positive bacteria, the higher percentage of Gram-positive bacteria in this study can be attributed to the dry climate. This result can also be observed in the present study [44]. The results of a similar research in Poland also showed that the largest number of microorganisms in hospital air are Gram-positive *cocci*, comprising 30-45% of cases [45]. The results of the study by Zazouli et al. in two educational hospitals of Mazandaran showed that *Escherichia coli*, as a Gram-negative bacterium, was the most abundant bacterial species, which is not consistent with the present study [46]. In another study in ICUs of two hospitals, AlvesSimoes et al. showed that most of the detected fungal species included *Aspergillus*, *Penicillium*, and *Cladosporium*, and their concentrations were higher than the standard level [47], which is not in line with the current study. The results of other studies are provided in Table 6.

In this study, the bacterial load in NICU (43.3%) was higher than the other two wards. According to our observations, natural ventilation such as opening the door and windows was used in addition to the central ventilation (exhaust fan) of the hospital in NICU. The results of a study on the effect of ventilation systems on the concentration of bioaerosols showed higher bioaerosol concentrations in hospital areas with natural ventilation compared to areas with conventional mechanical ventilation systems, which is consistent with the results of the present study [48]. Moreover, patients' companions and personnel commuted to this ward more frequently than the other two wards. TSP, PM_{10} and bacterial load were lower in ICU OH, where the number of patients was much less and companions commuted less frequently, compared to other two wards. The results of studies in Singapore show that the higher the population and density of people, the higher the abundance of indoor bacteria [37]. Masoudinejad et al. also reported in a study in Tehran that the colony count at high-traffic sampling stations was higher than other sampling stations [49]. Other studies referred to ward traffic and overcrowding, the type of services, and the type of hospitalized patients as reasons for the increase in the density of microorganisms in some hospitals [50, 51]. In the study by Johi et al., they concluded that the location of the hospital, ventilation, and the number of staff and patients are effective on the concentration of bioaerosols [52].

The relationship between PMs and bacterial and fungal bioaerosols was evaluated in the present study. The results showed no significant relationship between the above-mentioned variables (P-value > 0.05). Nikpey et al. carried out a study in a hospitals of Qazvin. The results of the correlation test showed no significant relationship between $PM_{2.5}$ and microbial pollution [53]. Also, Li and Hou in China showed no significant relationship between PMs and bioaerosols [54], which is consistent with the present study. Lack of a correlation between PMs and bioaerosols could be attributed to the change of indoor environment conditions, including the number of people, frequency of disinfection and cleaning surfaces, ventilation conditions such as opening doors and windows, and types of occupational tasks. Basiri et al., in a study in Khorramabad, reported that there is a significant relationship between PMs and the abundance of fungal bioaerosols, which is due to the increase in PMs concentration by increasing air temperature and, as a result, increasing fungal bioaerosols [55]. Lack of a correlation between PMs and bioaerosols in the present study could be due to the study time (autumn and winter), since according to previous studies, season, meteorological parameters, geographical features, and physical and chemical changes in the air can affect this correlation.

Table 6: PMs and bioaerosols concentrations in other studies

Author (year)	Country	PMs	Bacterial aerosols concentration	Dominant bacteria	Fungal aerosols concentration	Dominant Fungi	References
Tavakoli et al. (2021)	Iran	$PM_{2.5}$, PM_{10} were at an acceptable level	-	-	-	-	56
Maleki et al. (2018)	Iran	-	16.07	Enterococcus	-	-	45
Morgado-Gamero et al. (2019)	Colombia	-	110.13	Staphylococcus	-	-	57
Chung et al. (2015)	Taiwan	PM_1, $PM_{2.5}$, PM_{10} were below the indoor air quality standard	131.9	Micrococcus	36.7	Aspergillus	16
Montazeri et al. (2020)	Iran	-	73.5	Staphylococcus	71	Penicillium	28
Cabo Verde et al. (2015)	Portugal	-	374	Staphylococcus	16.5	Aspergillus	38
Demirel et al. (2017)	Turkey	-	-	-	47.5	Penicillium	58
Maji et al. (2013)	India	-					59
Nasiri et al. (2020)	Iran	-	57.44	Staphylococcus	16.13	Penicillium	42
Li et al. (2003)	China	There were weak relationships among particle concentration (PMs 0.1, 0.2, 0.3, 0.5, 1, and 5 µm) and bioaerosols.	88	-	4	-	54

- This variable was not investigated in the study.

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Conclusion

The diversity and density of bioaerosols in indoor air of hospitals can be considered as an indicator to determine whether they are polluted with or free from hospital infections. The results of the present study showed no significant relationship between bacteria and fungi with PMs. Such a lack of correlation can be attributed to the change in the conditions of indoor environments, including the number of people, the frequency of disinfection and cleaning surfaces, ventilation conditions such as opening doors and windows, and all kinds of occupational tasks of each season. NICU and PICU had the highest bacterial and fungal colony count, respectively. The mean concentrations of PM_1 and $PM_{2.5}$ in NICU and the mean concentrations of PM_{10} and TSP in PICU were higher than in other wards. PM-induced pollution was within the guideline range of the WHO and EPA, which can be due to the reduction in people's traffic and much greater compliance with health protocols due to the spread of the coronavirus and UV disinfection. Also, the mean level of bioaerosol was consistent with the WHO guideline for hospital environments. The air-borne pathogenic microorganisms are a dangerous health-related issue and one of the problems that cause irreparable damage to medical centers. If the microbial pollution of the hospital indoor air is ignored, the recovery process of the patients will be disrupted, and the disease will progress and the hospitalization time will be prolonged with the spread of various infections. Due to the Covid-19-related restrictions applied in the hospital at the time of the present study, it is suggested to investigate this relationship in all wards of the hospital in order to achieve more accurate results.

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Conflict of interest

The authors declare that there is no conflict of interest.

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