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Investigation of type and density of bacterial bioaerosols in the air of Imam Hossein hospital in Tehran in 2018

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ABSTRACT

Introduction: Hospital microorganisms are the potential sources of infection for patients and staff. Exposure to bioaerosols is relevant to a wide range of health effects, including infectious diseases, acute toxic effects, and allergies.
Materials and methods: In this study, ZTHV02 sampling device was used to evaluate and determine the density of bacterial airborne bioaerosols. The culture medium used in this study was tryptophan agar for bacterial agents to which the antibiotic cyclohexamide was added to prevent fungal growth. Sampling time was 10 min on average. The collected samples were immediately taken to the laboratory and incubated for 48 h. Then the number of colonies was counted and the bacteria were identified. Finally, bacterial density was expressed in CFU/m^3.
Results: The results showed that the mean total density of bacteria measured in Imam Hossein hospital were 16.07 CFU/m^3. The ICU unit of Imam Hossein hospital has the highest bacterial contamination. The most abundant bacteria observed in the air of Imam Hossein hospital were enterococci, Pseudomonas species, coagulase negative staphylococci, Klebsilla species and group D non-enterococcal streptococci, respectively.
Conclusion: Pseudomonas, Klebsiella and Enterococcus species were obtained. The number of bacteria was not significantly related to ambient temperature and humidity, but their number in the evening shift (appointment time) was significantly higher than the morning shift ($p<0.05$). High density of airborne bacteria in the studied hospitals can be considered as an important risk factor for the health of employees and patients.

Introduction

Air is one of the basic and important needs in the life of human, animals and plants, so life is not possible for a moment without it [1, 2]. The importance of indoor air quality is due to the long time that people spend in this environment [3, 4]. Most people are aware of the harmful effects of ambient air pollution on their environment and their health, but they may not have enough information about indoor air pollution, which has significant health effects [5, 6]. In addition, exposure to physicochemical and chemical agents, human may be exposed to biological agents in

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the environment. Exposure to microorganisms in closed environments increases the risk of contracting infectious diseases for sick or sensitive people [7, 8]. Microorganisms are tiny organisms that are invisible to the eye and vary in appearance, function, biochemical characteristics, or genetic mechanisms [9]. Bioaerosols are included dead or living pathogenic or non-pathogenic bacteria, viruses, fungi, molds, high molecular weight allergens, bacterial endotoxin toxins, fungal toxins, pollen and plant fibers [10, 11]. Indoor air may contain a variety of microorganisms such as bacteria, fungi and viruses, some of which can affect human health [12].

Hospitals are enclosed environment so that staff, medical staff, services, patients and visitors are exposed to the inhalation of bioaerosols, and the presence of airborne bioaerosols in high concentrations will pose a serious threat to human health [13]. In addition, the health effects of inhaling bioaerosols on staff and visitors, and nosocomial infections are a global issue [14]. Bioaerosols are very small suspended particles 5µm in size that can remain suspended in the air for a long time. As a result, the risk of airborne infections is very high and being in environment such as hospitals and clinics or enclosed sites has a very high risk [9, 15]. Numerous studies have shown that there is a significant association between nosocomial infections and biological aerosols in the air [16]. Nosocomial infections cause heavy costs to the health systems of countries, especially in developing countries. Research has shown that infectious factors are present in hospital environment and can cause secondary infectious diseases or nosocomial infections. These infections are caused by the patient in contact with germs in a variety of ways, including the respiratory tract [17, 18]. The source and place of spread of microorganisms in the hospital environment may be a sick person or contaminated clothing that is released as a result of activity and dispersed into the air. Ventilation systems as well as cooling and heating systems in hospitals are also the cause of the spread of many pathogens [19]. It should be noted that many microorganisms scattered in the air of hospitals are non-pathogenic microbes that are harmful only to sensitive, weak and sick people, but hospital air can also carry pathogenic microbes [20, 21]. Hence, people can be affected by many pathogenic microorganisms, such as Mycobacterium tuberculosis, which are transmitted from person to person through the air [10]. Therefore, considering that the biological quality of hospital air is important and few studies have been done in this field, the present study was conducted to investigate the type and density of bacteria in the air of Imam Hossein hospital in Tehran.

Materials and methods

This descriptive study was performed in Imam Hossein hospital in Tehran in 2018. In this study, different parts of teaching hospitals were examined for the presence of bacterial bioaerosols. The sampling site included all wards of the hospital including inpatient rooms, nursing stations, operating rooms, intensive care units, clinics and Paraclinical units. 90 samples were taken in the morning shift and 15 samples in the afternoon shifts during the patients' visit and the crowded wards. The air sampling method was long-term in which 10 min of hospital air was sampled. Air sampling was performed in 3 L/min flow that using the Anderson (ZTHV) single-stage sampler, which operates on a direct collision basis [22]. At every sampling, temperature and relative humidity were measured by a Wet Bulb Globe Temperature (WBGT), (MK427JY model), hygrometer. Sampling pump flow was calibrated before sampling using a (De-fender) digital calibrator.

For sampling, the sampling device was installed at a height of 120 cm from the ground and at a distance of more than 1m from the walls and obstacles [23]. For every 10 samples taken from the hospital environment, a control sample was taken from the laboratory environment equipped with a ventilator. The culture medium used in this study included

Tryptic Soy Agar with 0.5 g of cycloheximide antibiotic made by SERVA USA as an antifungal that was made in the laboratory by maintaining completely sterile conditions and kept upside down in the refrigerator until use [16]. Sterile conditions had to be provided for the samples at each sampling. Therefore, before the culture medium was placed inside the sampler, the cassette was disinfected using 70% ethanol alcohol and dried to remove any initial contamination. After sampling, the plates were sealed with paraffin to reduce the error caused by secondary contamination [9]. After sampling, the plates were placed upside down in the transport box and transferred to the laboratory and incubator at 37 ° C. After 48 h, the media were examined and the colonies formed on them were counted. Finally they were reported in terms of flow rate and sampling time in CFU/m^3. For differential detection of bacteria by methods such as gram staining, and biochemical detection methods including catalase, oxidase, coagulase tests, Deoxyribonuclease (DNase) test, bile scoliosis hydrolysis, urease, citrate test, antibiotic resistance of novobiocin and bacitracin, optochin, consumption Sugars and other differential tests were used [5].

During sampling, information of each sample including the type of culture medium, time and place of sampling, sampling duration, type of ventilation, number of staff in each ward, number of hospitalized patients, temperature and relative humidity were collected. To evaluate the normal distribution of variables from Kolmogorov-Smirnov test, difference in bacterial density from t-test and comparison of bacterial density between different wards of the hospital from one-way analysis of variance and to compare bacterial density at appointment and normal time from Wilcoxon test was used. Also Pearson correlation coefficient test was used to investigate the relationship between temperature and humidity and bacterial density. Data analysis was performed using SPSS [20]. Finally, the results of the colony count were compared with the standard provided by the US Environmental Protection Agency (US EPA), (500 CFU/m^3).

Results and discussion

In this study, a total of 60 samples were prepared from Imam Hossein hospital and the density of bioaerosols was reported based on CFU/m^3. Table1 shows the average total density of bacterial bioaerosols in the air of different sections. Mean and standard deviation of temperature and relative humidity in Imam Hossein hospital were 26.42±3.14 °C and 61.78±8.14%. The density of bacterial contamination in sampling sites in the hospital is shown in Fig. 1.

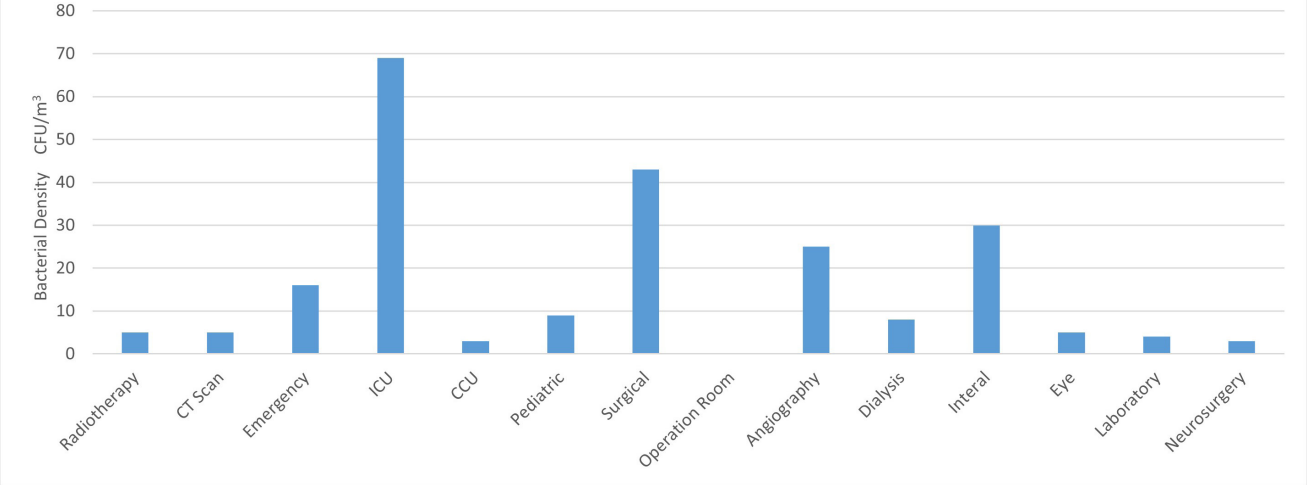

Fig. 1. The density of bacterial contamination in sampling sites

Table 1. The average total density of bacterial bioaerosols in the air of different sections

Sampling site	Number of samples	Statistical index	Number of colonies (CFU/m^3)	Temperature (°C)	Humidity (%)
Imam Hossein Hospital	90	Max	69	29.4	80.5
		Min	0	21.7	47.15
		Average	16.07	26.42	61.78
		standard deviation	9.7	3.6	10.2

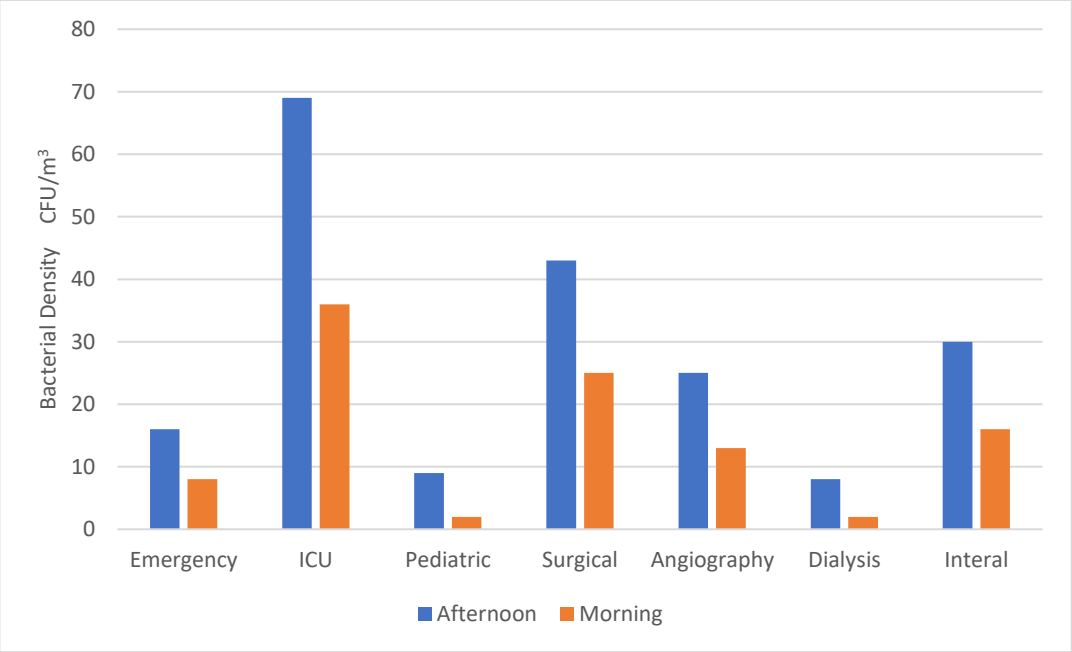

Fig. 2. The results of sampling from different wards in the morning and evening shifts

ICU units with a density of 69 CFU/m^3 have the highest bacterial contamination and angiography (operating room) with a density of zero CFU/m^3 have the lowest bacterial contamination. The results of sampling from different wards of the hospital in the morning and evening shifts (simultaneously with the visiting time) are shown in Fig. 2. As can be seen and expected, the bacterial contamination rate during the visit is higher than the morning shift. Fig. 3 shows the abundance of bacteria observed in the air of Imam Hossein hospital. Where in Enterococcus (29/7%), Pseudomonas (21/1%), Coagulase Negative Staphylococci (16/2%) and Klebsiella species (11.8%) were the most common, respectively.

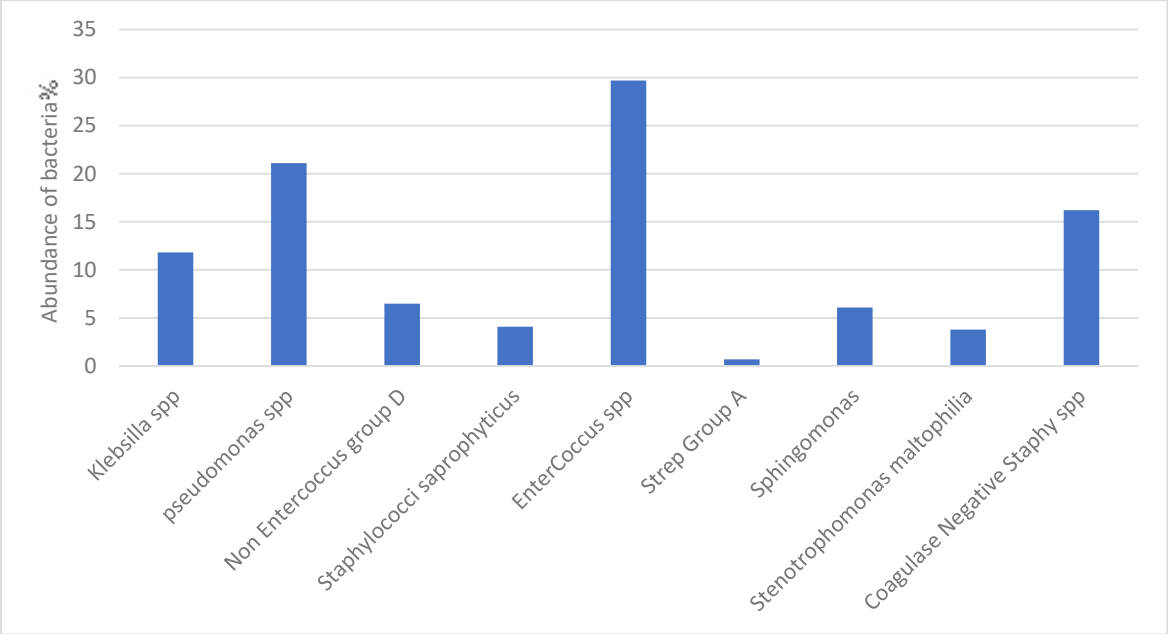

Fig. 3. The abundance of bacteria observed in the air of Imam Hossein hospital

The results of this study were performed for 3 months in two shifts in the morning and afternoon, observing the standard conditions of calibration and sterilize, in which a total of 9 types of bacteria were isolated from Imam Hossein hospital. Based on the results, the most abundant bacteria detected in hospital air were Enterococcus, Pseudomonas, Staphylococcus coagulase negative and Klebsiella species, respectively. Among these microorganisms, Staphylococcus coagulase is a type of gram-positive cocci. The high concentration of gram-positive cocci in the air may be due to the lower sensitivity of these bacteria to ambient pressure or heat [24]. Although staphylococcus coagulase is not highly toxic, it is an important cause of infection in high-risk groups. Staphylococci are highly resistant to drought and harsh conditions, and this feature facilitates their life in the environment, food multiplication and contagion [25]. Enterococci are also resistant to harsh bacteria so they can survive in the air. In a face study in Sari hospitals, gram-positive cocci were observed in almost all wards [26].

The results of similar research in Poland showed that the largest number of microorganisms in the air of the hospital were gram-positive cocci, which accounted for 30-45% of the total microbes in the air [27]. In another study, the highest prevalence of identified microorganisms were Escherichia coli, Pseudomonas, Klebsiella, Staphylococcus aureus, Staphylococcus aureus negative. Staphylococcus aureus was obtained [28].

The results of this study showed that the mean total density of airborne bacteria in Imam Hossein hospital was 16.07 CFU/m^3. High crowds and traffic in the area is one of the important factors affecting the density of bacterial contamination. Due to the fact that Imam Hossein hospital is one of the educational and large hospitals in the city, this place is considered a busy place and consequently can be a reason for the high density of bacterial bioaerosols. This finding is consistent with a study conducted in hospitals in Damghan city [9].

The results of this study showed that the total density of bacterial agents in Imam Hossein hospital was 375 CFU/m^3. Also, a comparison of the total density of bacterial bioaerosols with the US Environmental Protection Agency standard (500 CFU/m^3) showed that the total density of bacterial bioaerosols was lower than recommended. According to studies conducted in other hospitals in Tehran, the number of colonies forming in the air in 86% of cases was

less than the standard (500 CFU/m^3) , which is consistent with the study [5].

The number of bacteria in the air can be a function of factors such as population density, ventilation, sanitary conditions of the building and its occupants. Due to the fact that the mentioned hospital is one of the large and specialized hospitals in the city, so the volume of referrals to it is higher than other hospitals, and this can be one of the reasons for the high density of bacterial bioaerosols. Also, the results of studies have shown that the total number of bacteria in the indoor air is more than the ambient air and the high number of bacteria can be a function of factors such as building conditions, type of patients and length of hospitalization, high traffic and Rooms weak ventilation can increase the density of bacterial bioaerosols in the hospital compared to the standard [29]. Compared to the studied wards of the hospital, the Intensive Care Unit (ICU) ward with a density of 69CFU/m^3 has the highest amount of infection while the operating room with a density of zero CFU/m^3 has the lowest bacterial contamination. These findings are consistent with a study conducted in Valiasr hospital in Tehran in 2009 and found that the intensive care unit has the most fungal and microbial contamination [25]. Due to the fact that central ventilation is used for ICU air conditioning, but the existing system at the time of sampling may not have the appropriate operational and executive standard, and therefore should be checked for more detailed information of the existing system in terms of ventilation system design principles. In the angiography section (operating room), the density of bacterial bioaerosols was the lowest, which could be due to the high level of health standards in this area compared to other hospital facilities and also the use of proper ventilation system during the sampling. Similar to a report conducted in Shiraz hospitals, which showed that the least pollution is related to the operating room [23]. There was no significant difference between the densities of bacteria in the air of hospital wards ($P>0.05$). Also, no significant relationship was found between the percentage of humidity and the temperature of the sampling environment with the bacterial concentration.

Wilcoxon test was used to evaluate the number of colonies isolated from the samples taken in the morning and afternoon shifts. The results showed that the density of bacteria in the morning shift was significantly lower than the concentration of airborne bacteria in the evening shift. The results obtained in both morning and afternoon sampling showed that the number of colonies isolated from the samples taken in the afternoon in all wards was significantly higher than the density of colonies observed in the samples taken in the morning. Since Imam Hossein hospital is an educational and large hospital in Tehran, the number of visitors is high and this increase may be due to the movement of people and as a result of the spread of more microbial pollution in the air of the hospital in the afternoon (visit time). The results of this study showed that the density of bacterial infection after surgery is higher than when surgery was not performed. The hospital operating room should be free of biological aerosols due to sterilization. The presence of bioaerosols in the operating room may be due to inefficiency of the ventilation system, sterilization or due to the presence of individuals and patients during surgery [30].

Conclusion

According to the results obtained in this study, the total density of bacterial bioaerosols is lower than the proposed standard. The high number of bacteria in the hospital can be related to the presence of patients, their activities and inadequate ventilation. Therefore, in order to reduce the number of bioaerosols and improve the air quality of the hospital, it is recommended that measures such as installing filters in the air entering the hospital wards, preventing the windows from being opened for natural ventilation, as well as regular disinfection of the hospital. The amount of air pollution in the hospital at the time of visiting patients is much more than the normal working time of the hospital. Therefore, due to the close relationship between the number of clients and the pollution load, preventing the movement of irresponsible people outside of

visiting hours will play an important role in reducing the pollution load. Due to the identification of high concentrations of bacteria in the respiratory air of some parts, compliance with safety and health standards by all people, as well as the necessary care in choosing the disinfectant and disinfection is a necessity.

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Competing interests

The authors declare that there are no conflicts of interest.

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Ethical considerations

The authors declare that ethical issues (including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed.

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