http://iahsj.kaums.ac.ir/
International Archives of Health Sciences. 2023; 10(3): 130-136
https://doi.org/10.48307/IAHSJ.2023.179403

Research Article Open Access

Assessment of bacterial bioaerosols and particulate matters characteristics in the indoor air of dentistry clinics

Marzieh Akbari [1], **Fatemeh Atoof** [2], **Ali Nazari-Alam** [3], **Zahra Sadat Fatemi Nasab** [3], **Mohammad Bagher Miranzadeh** [4], **Nezam Mirzaei** [*4]

[1] Department of Environmental Health Engineering, Faculty of Health, Kashan University of Medical Sciences, Kashan, Iran
[2] Department of Biostatistics & Epidemiology, Faculty of Health, Kashan University of Medical Sciences, Kashan, Iran
[3] Department of Microbiology, Faculty of Medicine, Kashan University of Medical Sciences, Kashan, Iran
[4] Department of Environmental Health Engineering, Social Determinants of Health (SDH) Research Center, Kashan University of Medical Sciences, Kashan, Iran

[*] **Corresponding author:** Nezam Mirzaei, Department of Environmental Health Engineering, Social Determinants of Health (SDH) Research Center, Kashan University of Medical Sciences, Kashan, Iran. **Email:** nezammirzaei@yahoo.com, miranzadeh_mb@kaums.ac.ir

Received: 10 May 2022 **Revised:** 16 June 2023 **Accepted:** 19 June 2023 **e-Published:** 17 September 2023

Abstract

Objectives: Air pollutants in dentistry offices may cause problems for the health of staff and patients. Accordingly, the present study was performed to the assessment of bacterial bioaerosols and particulate matter (PM) characteristics in the indoor air of dentistry clinics.

Methods: The sampling points were restoration, endodontics, and prosthesis wards. The PM specimens were taken using Grimm Dust Monitor and the microbial specimens were taken using QuickTake 30.

Results: The maximum and minimum PM10 concentration across the different measure wards occurred as 70.31 and 30.32 µg/m3 in the Ketabchi Clinic restoration and its endodontics ward, respectively. The total number of bioaerosols was 2079. Gram-positive *Staphylococcus* spp.(872), Gram-positive *Micrococcus* spp.(706), and Gram-negative *Bacillus* spp.(501) were present in the indoor air. The results showed a significant relationship for PM1 and PM2.5 in each sampling site.

Conclusion: The low PM and bacterial bioaerosols contamination can be due to the coincidence with coronavirus pandemic, as during this period, health and hygienic protocols have been strictly observed.

Keywords: Indoor air quality, Dentistry ward, Particulate matter, Bacteria, Bioaerosol.

Introduction

Air pollution was cause for 6.7 million deaths worldwide in 2016. Around 89% of mortality resulting from air pollution occurs in developing countries, especially Asia.[1] In Iran, most air quality studies are related to open-air environments. Surveying the human activity patterns indicates that a person spends 87% of their time in enclosed buildings on average.[2] Changes in the human lifestyle over time have caused society to live mostly in vertical enclosed buildings. One of the most important pollutants in this area is particulate matter (PM).[3]

The PM that causes air pollution, regardless of the chemical name, are categorized based on their size into total suspended particles (TSPs), PM10 (PM with an aerodynamic diameter smaller than 10 microns) or large particles, PM2.5 (PM with an aerodynamic diameter smaller than 2.5 microns) or fine particles, and PM0.1 (PM with an aerodynamic diameter smaller than 0.1 microns).[4] The World Health Organization has classified air pollution resulting from PM as the most common cause of mortality worldwide in rank 13.[5] Furthermore, long-term exposure to PM leads to a considerable reduction of life expectancy, increased risk of developing cancer, negative effects on the skin, as well as digestive diseases.[4,6,7] PM may contain microorganisms such as bacteria, viruses, and fungi that can be carried up to far distances.[8] PM is involved in special mechanisms, especially the mechanisms of formation and growth of bacteria, and is heavily associated with microbes, as they are a survival medium for microorganisms.[9] In this

regard, 80% of air microorganisms can be carried by PM.[10]

The health-care environments, air pollutants in dentistry clinics such as microbes, suspended particles in the air, gases, and vapors may cause problems for the health and well-being of staff and patients.[11] The human oral cavity functions as a natural pool and habitat for a wide range of microorganisms.[12]

Many methods related to dentistry such as removal of caries, periodontal, and dental preparation with prosthesis, plus dental handpieces, air-water (triplex) syringes, and ultrasonic scalers all generate a large volume of splatter and aerosols.[13] Aerosols can remain in the air for a long time and may be inhaled; the microorganisms can also survive until 6 days in the generated aerosols.[14] Although it has been known that environmental factors such as water and air can function as microorganism pools and act as a means of infection transmission, the information related to microbial contamination and PM pollution in the dentistry environment is still sparse.[15,16]

Thus, studying and determining the microorganisms as well as particular matter in the air of such centers would be a valuable index of the health or pollution status of such centers. Considering the recommendations of the American Dentistry Association recommending the necessity of bringing the indoor air quality of wards to the standard limit for preventing and controlling the mentioned damages and to present solutions to enhance the air quality of dentistry clinics of Kashan University of Medical Sciences, the present research has investigated the air status of these centers in terms of microbial as well as PM pollution (PM1, PM2.5, and PM10). The results obtained from this research can be helpful in enhancing the indoor air quality of dentistry clinics by responsible organizations such as the faculty of dentistry as well as health-care units.

Objectives

The present study was performed to the assessment of bacterial bioaerosols and PM characteristics in the indoor air of dentistry clinics.

Methods

This cross-sectional study was performed in dentistry units at Kashan University of Medical Sciences for 6 months. This university has two centers of faculty of dentistry and Ketabchi Clinic. Each ward of the faculty of dentistry has 24 units, and Ketabchi Clinic has single-unit wards. The ventilation system utilized in the faculty is chiller, but in the Ketabchi Clinic, no special ventilation system is used. In the first stage, to measure air PM and perform the total bacterial count, air sampling was performed. The sampling station in this research was the indoor air of the faculty of dentistry and Ketabchi Clinic. To measure the indoor air quality of the dentistry units, out of the eight available wards, we chose three which had the maximum density according to the experiences of dentistry professors.

The sampling points were in restoration, endodontics, and prosthesis wards. The samplings were performed during the morning. PM specimens were taken using Grimm Dust Monitor air sampler (Germany) within 1 h for each sample, while the microbial samples were taken through active method through QuickTake 30 air microbial sampler (Germany) for 15 min.

The total bacterial count, PM count, and PM concentrations were investigated individually. The utilized instruments were calibrated for the sampling. To prevent interference in the treatment process, the air sampling instruments were placed 1.5 m away from the dentistry unit. All devices were placed 1 m above the ground level so that the sitting respiratory region of health-care staff would be simulated.[17] To cover all days of the week and to acquire better results, the microbial and PM specimens were taken within 6 consecutive months, according to the EPA sampling schedule, 30 days, and each day three specimens from the indoor environment of restoration, endodontics, and prosthesis wards of faculty of dentistry and Ketabchi Clinic. Accordingly, all samples were as follows:

2 (Microbial and PM samples) × 2 (number of clinics) × 3 (number of studied wards) × 15 (number of days in six months) =180 (90 microbial samples and 90 PM samples)

After the collection, the microbial samples were transferred to the microbiology laboratory of the faculty of medicine within shorter than 2 h. Once the samples were incubated at 37°C for 18–24 h, the colony count was counted using a colony count device, after which Gram-staining was performed on the colonies. All isolated bacterial agents were tested in terms of appearance, colony morphology, pigment generation, plus biochemical tests including oxidase, catalase, mannitol, coagulase, sensitivity to novobiocin, and bacitracin, while for the Gram-negative ones, complementary diagnostic tests were performed including TSI, urease, IMVIC, and SIM. The PM samples were transferred to the air pollution laboratory of the faculty of health for analysis.

Statistical analysis

The normality of bacterial bioaerosols and PM was investigated and since there was no normality for any of these variables, Kruskal-Wallis or Mann-Whitney test was used to investigate the relationship between microbial variables and particles with the type of section and sampling location. Bonferroni test was also used as a *post hoc* test. To investigate the correlation between two variables, Spearman test was applied. All statistical analyses were performed with SPSS (version 16.0, SPSS Inc, Chicago, IL, USA). A "P-value" less than 0.05 was considered significant.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki. This study was funded by Kashan University of Medical Sciences under grant number 98103. The ethics code of this study was IR.KAUMS.NUHEPM.REC.1398.028.

Results

Across all wards, the mean 1-h concentration of PM10 was higher than PM2.5 and PM1. The maximum and minimum PM10 concentrations across different measured wards were 70.31 and 30.32 µg/m3 in the Restoration Ward of Ketabchi Clinic and the Endodontics Ward of this clinic, respectively. For PM2.5, the maximum concentration occurred in the endodontics ward of the faculty of dentistry as 17.24 µg/m3, and the minimum concentration was found in the Restoration Ward of Ketabchi Clinic as 10.82 µg/m3. The mean comparison of PM concentration in the air of different wards of dentistryclinics of Kashan University of Medical Sciences is presented in Figure 1.

In the air of different wards of dentistry clinics affiliated with Kashan University of Medical Sciences, colonies ofGram-positive *Staphylococcus*, Gram-positive *Micrococcus*, and Gram-negative *bacilli* were observed. The Gram-positive bacteria claimed 76% of cases. The minimum and maximum microbial frequencies were reported to be associated with the prosthesis ward of the Faculty of Dentistry and Endodontics of Ketabchi Clinic as 87 and 478 CFU/m3. The *Staphylococcus* and *Bacilli* colonies were higher in the Restoration Ward of Ketabchi Clinic compared to other wards, but the *Micrococcus* colony was more frequent in the restoration ward of the faculty of dentistry. The fungi were also more frequent in the Restoration Ward of Ketabchi Clinic. Figure 2 displays the frequency of microbial and fungal groups in the air of each ward.

TSP and PM10 were significant in three different wards of endodontics, restoration, and prosthesis. The results indicated that the median TSP was significantly lower in the endodontics ward as compared to restoration (P=0.003) and prosthesis (P<0.001). Further, the median PM10 has been significantly lower in the endodontics ward compared to the restoration (P=0.018) and prosthesis (P=0.039). The results of post hoc test using Bonferroni method showed that there was no significant relationship between *Staphylococcus* spp., *Bacillus* spp., *Micrococcus* spp., and fungi for each individual ward [Table 1].

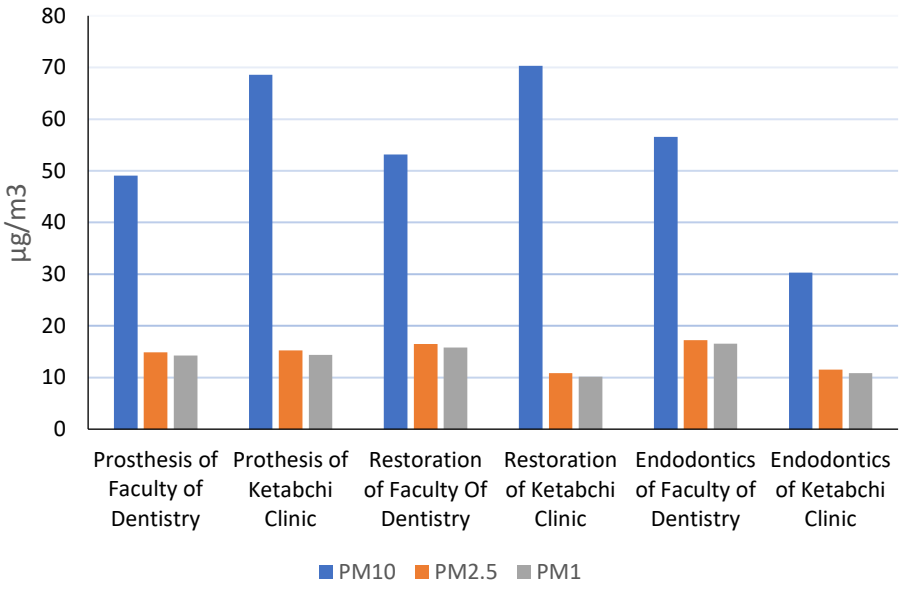

Figure 1. Comparing the mean 1-h concentration of particulate matter (PM_1, $PM_{2.5}$, and PM_{10}) for different wards

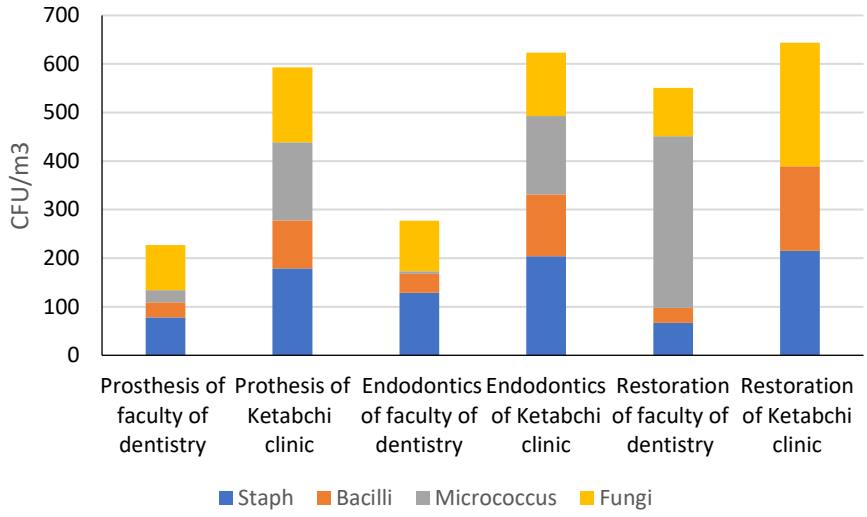

Figure 2. The frequency distribution of microbial and fungal groups in the air of different wards

The results showed a significant relationship for PM1 and PM2.5 in each sampling site. Furthermore, there was colony, *Staphylococcus* spp., *Bacillus* spp., and fungi in the Ketabchi Clinic and faculty of dentistry [Table 2].

The results showed that the median TSP was significantly lower in the Endodontics ward of Ketabchi Clinic compared to endodontics of faculty of dentistry (P = 0.03), prosthesis of faculty of dentistry (P=0.015), restoration of faculty of dentistry (P<0.001), restoration of Ketabchi Clinic (P<0.001), and prosthesis of Ketabchi Clinic (P<0.001). Further, the median PM10 was significantly lower in the Endodontics Ward of Ketabchi Clinic compared to endodontics of faculty of dentistry (P<0.01), restoration of faculty of dentistry (P<0.04), restoration of Ketabchi Clinic (P<0.001), and prosthesis of Ketabchi Clinic (P<0.001). PM2.5 and PM1 were significantly lower in the Restoration ward of Ketabchi Clinic compared to the restoration of faculty of dentistry with significance levels of P=0.03 and P=0.03, respectively. The results showed that the median colony was significantly higher in the Endodontics Ward of Ketabchi Clinic compared to the endodontics of the faculty of dentistry (P=0.015) and prosthesis of the faculty of dentistry (P=0.001). Further, the median colony was significantly larger in the Restoration Ward of Ketabchi Clinic compared to the prosthesis of the faculty of dentistry (P<0.001). In the Prosthesis Ward of Ketabchi Clinic, again the median colony was significantly higher than in the prosthesis ward of the faculty of dentistry (P<0.001).

However, in the endodontics ward of the faculty of dentistry, the median colony has been significantly smaller than in the Prosthesis Ward of Ketabchi Clinic (P<0.001). For *bacillus* spp., again the colony has been significantly smaller in the restoration ward of the faculty of dentistry compared to the Prosthesis Ward of Ketabchi Clinic (P=0.03). On the other hand, in the prosthesis of Ketabchi Clinic, the median *bacillus* spp. has been significantly larger than in the prosthesis ward of the faculty of dentistry (P=0.015). The median fungi were significantly higher in the Restoration Ward of Ketabchi Clinic compared to the prosthesis ward of the faculty of dentistry (P=0.03) and restoration ward of the faculty of dentistry (P=0.04) [Table 3].

To evaluate the interrelationships between the studied variables with each other, Kolmogorov–Smirnov test was applied. Then, Spearman correlation test was employed. Based on the results of this test, no significant relationship was found between the bacteria in the air and PM (P<0.05).

Table 1. Description of PM_1, $PM_{2.5}$, PM_{10}, TSP and Colony, *Staphylococcus* spp., *Bacillus* spp., *Micrococcus* spp., fungi for each ward

Variable		Ward			Total	P-Value
		Endodontics	Restoration	Prothesis		
Particulate matter	TSP	64.52 (44.41,107.75)	113.27 (86.59, 155.95)	115.62 (77.27, 170.33)	103.98 (62.44, 143.02)	<0.001
	PM_{10}	36.71 (23.33, 60.27)	61.13 (35.70, 79.07)	56.12 (35.49, 79.94)	56.48 (32.83, 73.91)	0.009

	$PM_{2.5}$	13.01 (6.44, 17.93)	13.47 (9.45, 18.05)	14.41 (10.55, 17.67)	13.71 (10.03, 17.67)	0.886
	PM_1	12.44 (6.16, 17.11)	12.78 (9.05, 17.37)	13.57 (9.78, 16.93)	13 (9.49, 16.93)	0.931
Bacterial Bioaerosols	**Colony**	18 (10,30.75)	15 (7.25, 34.25)	17 (5,27)	17 (8,30)	0.731
	***Staphylococcus* spp.**	8 (0,15)	15 (5,25)	5 (0,15)	6.5 (0,15)	0.566
	***Bacillus* spp.**	5 (0,5)	8 (3,13)	5 (0,5.75)	5 (0,5.75)	0.979
	***Micrococcus* spp.**	0 (0,0)	0 (0,0)	0 (0,0)	0 (0,0)	0.818
	Fungi	8 (5,10)	10 (3,18.5)	5 (3,10.75)	6.5 (3,13)	0.261

Table 2. Description of PM_1, $PM_{2.5}$, PM_{10}, TSP and Colony, *Staphylococcus* spp., *bacillus* spp., *micrococcus* spp., fungi for each sampling site

Variable		**Sampling Site**		**Total**	**P-Value**
		Ketabchi Clinic	**Faculty of Dentistry**		
Particulate matter	**TSP**	108.30(53.09, 148.22)	101.65(71.17, 138.33)	103.98(62.44, 143.02)	0.968
	PM_{10}	57.99(31.06, 78.57)	55.34(33.32, 71.54)	56.48(32.83, 73.91)	0.675
	$PM_{2.5}$	12.94(8.76, 15.55)	15.73(10.23, 20.12)	13.71(10.03, 17.67)	0.039
	PM_1	12.29(8.23, 14.48)	15.29(9.74, 19.39)	13(9.49, 16.93)	0.032
Bacterial Bioaerosols	**Colony**	23(14.5,35.5)	10(3,18)	17(8,30)	<0.001
	Staphylococcus spp.	8(0,25)	3(0,13)	6.5(0,15)	0.008
	Bacillus spp.	5(5,10)	0(0,5)	5(0,5.75)	<0.001
	Micrococcus spp.	0(0,0)	0(0,0)	0(0,0)	0.306
	Fungi	8(5,18)	5(3,10)	6.5(3,13)	0.003

Table 3. Description of PM_1, $PM_{2.5}$, PM_{10}, TSP and Colony, *Staphylococcus* spp., *bacillus* spp., *micrococcus* spp., fungi for each ward and for both in total

Variable	**Particulate matter**				**Bacterial Bioaerosols**				
Sampling Site	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**PM_1**	**Colony**	***Staphylococcus* spp.**	***Bacillus* spp.**	***Micrococcus* spp.**	**Fungi**
Endodontics of Faculty of Dentistry	103.83 (82.47, 121.11)	57.88 (50.82, 70.64)	16.43 (10.71, 22.00)	15.74 (10.41, 21.15)	11 (8,18)	10 (0,13)	3 (0,5)	0 (0,0)	8 (3,10)
Endodontics of Ketabchi Clinic	48.26 (43.22, 63.72)	30.90 (20.81, 34.23)	11.22 (6.25, 15.44)	10.49 (5.90, 14.58)	30 (13,43)	8 (0,25)	5 (5,10)	0 (0,8)	8 (5,10)
Restoration of Faculty of Dentistry	103.98 (73.97, 144.58)	56.63 (29.99, 75.63)	17.04 (10.38, 20.43)	15.85 (10.00, 19.97)	8 (3,18)	0 (0,13)	0 (0,5)	0 (0,5)	5 (3,10)
Restoration of Ketabchi Clinic	121.81 (86.59, 158.85)	69.60 (57.63, 86.70)	10.08 (8.091, 13.85)	9.50 (7.61, 13.23)	18 (13,38)	8 (5,25)	8 (0,13)	0 (0,0)	18 (5,25)
Prosthesis of Faculty of Dentistry	82.02 (65.36, 168.23)	39.78 (32.83, 55.91)	11.80 (7.65, 17.62)	11.20 (7.27, 16.81)	5 (3,10)	3 (0,5)	0 (0,5)	0 (0,0)	5 (3,10)
Prothesis of Ketabchi Clinic	140.19 (111.52, 173.78)	68.63 (56.33, 79.99)	14.62(12.94, 17.82)	13.70 (12.29, 17.30)	23 (18,33)	13 (0,20)	5 (5,8)	0 (0,13)	8 (3,18)
Total	103.98 (62.44,143.0)	56.48 (32.83,73.9)	13.71 (10.03,17.6)	13 (9.49,16.9)	17 (8,30)	6.5 (0,15)	5 (0,5.75)	0 (0,0)	6.5 (3,13)
P value	<0.001	<0.001	0.022	0.022	<0.001	0.070	<0.001	0.042	0.015

Discussion

Bacterial aerosols in dentistry can move as long as 100 cm horizontally. Further, bacterial aerosols can remain in the air for more than 20 min posttreatment.[18] The average number of *Bacillus* spp. in the present study was smaller than the mean reported by Kedjarune *et al.*[19] In the study by Al Maghlouth *et al.*, as with the present study, *Staphylococcus* spp. and *Micrococcus* spp. were observed, but *Bacillus* spp. was not reported. Furthermore, in this study, *Staphylococcus* spp. was the dominant one, which is in line with the present research.[20] The bacteria of the air in dentistry according to Zemouri *et al.*'s study included three colonies observed in the present study, i.e., *Staphylococcus* spp., *Micrococcus* spp., and *Bacillus* spp.[21] In the study by Soltanian *et al.*, the greatest microbial contamination was observed in the periodontics ward.[22] In the study by Lasemi *et al.*, the contamination level of the morphology ward was larger than other wards.[23] In the research by Malakootian *et al.,* the contamination level of the endodontics ward was higher than in other wards.[24] However, in the present study, the highest microbial contamination was found in the endodontics ward of Ketabchi Clinic.

Dentistry involves the use of dentistry tools such as turbine burs, drills, ultrasonic scalers, as well as abrasion and air polisher units, which generate aerosols.[16] In our study, PM10 was higher in the Restoration Ward of the Ketabchi Clinic compared to other wards, which can be due to the extensive use of various dentistry instruments. Hobson *et al.* concluded that the use of different methods in dentistry causes initial elevation of PM10, and 30 s following initiation of the course of treatment, the generation of dental aerosols becomes constant.[25] Furthermore, unsuitable ventilation and nonuse of high-volume suction can also be effective. Nulty *et al.* showed that an external high-volume extraction device could reduce the number of aerosol particles during dentistry operations.[26] Bates *et al.* concluded that the use of high-volume suction was effective in keeping the aerosol levels low and could improve the working environment for patients and dentists.

Further, ventilation has a considerably positive influence on aerosol distribution.[27] In the present study, the median PM2.5 in the prosthesis ward of the faculty of dentistry and clinic was 11.80 and 14.62 μg/m3, respectively, which have been far lower than the values in Arsal *et al.* study.[28] In the study of Liu *et al.*, the highest PM1, PM2.5, and PM10 concentrations were observed in the periodontal ward, and the minimum in the patient waiting area.[17] However, in the present study, the highest PM10 concentration was found in the Restoration Ward of Ketabchi Clinic, and the maximum PM2.5 and PM1 in the endodontics ward of the faculty of dentistry.

Conclusions

The results indicated there was no significant relationship between the bacteria in the air and PM. The Endodontics Ward of Ketabchi Clinic has the maximum number of bacteria, while the Restoration Ward of this clinic contained the maximum number of fungi. The mean PM10 concentration in the Restoration Ward of Ketabchi Clinic and the mean concentrations of PM2.5 and PM1 were higher in the endodontics ward of the faculty of dentistry compared to other wards. The low PM and bacterial bioaerosols contamination can be due to the coincidence with coronavirus pandemic, as during this period, health and hygienic protocols have been strictly observed and the number of patients has been limited.

Acknowledgment

This study was funded by Kashan University of Medical Sciences under grant number 98103. The Ethics code of this study was IR.KAUMS.NUHEPM.REC.1398.028.

Competing interests

The authors declare that they have no competing interests.

Abbreviations

Particulate matter: PM.

Authors' contributions

All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

Funding

None.

Availability of data and materials

The data used in this study are available from the corresponding author on request.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. This study was funded by Kashan University of Medical Sciences under grant number 98103. The ethics code of this study was IR.KAUMS.NUHEPM.REC.1398.028.

Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

References

1. Song J, Lu M, Lu J, Chao L, An Z, Liu Y, et al. Acute effect of ambient air pollution on hospitalization in patients with hypertension: A time-series study in Shijiazhuang, China. Ecotoxicology and environmental safety. 2019;170:286-92. doi:10.1016/j.ecoenv.2018.11.125 PMid:30530180
2. Mohammadyan M, Keyvani S, Bahrami A, Yetilmezsoy K, Heibati B, Pollitt KJG. Assessment of indoor air pollution exposure in urban hospital microenvironments. Air Quality, Atmosphere & Health. 2019;12(2):151-9. doi:10.1007/s11869-018-0637-6
3. Halek F. Vertical Profile of Particulate Matter Concentrations in Indoor Air (Case Study: Karaj, Iran). Particulate Science and Technology. 2015;33(6):617-20. doi:10.1080/02726351.2015.1016641
4. Park S-Y, Byun E, Lee J, Kim S, Kim H. Air Pollution, Autophagy, and Skin Aging: Impact of Particulate Matter (PM10) on Human Dermal Fibroblasts. International journal of molecular sciences. 2018;19(9):2727. doi:10.3390/ijms19092727 PMid:30213068 PMCid:PMC6163910
5. Zhu X, Qiu H, Wang L, Duan Z, Yu H, Deng R, et al. Risks of hospital admissions from a spectrum of causes associated with particulate matter pollution. Science of The Total Environment. 2019;656:90-100. doi:10.1016/j.scitotenv.2018.11.240 PMid:30502738
6. Mutlu EA, Comba IY, Cho T, Engen PA, Yazıcı C, Soberanes S, et al. Inhalational exposure to particulate matter air pollution alters the composition of the gut microbiome. Environmental pollution. 2018;240:817-30. doi:10.1016/j.envpol.2018.04.130 PMid:29783199 PMCid:PMC6400491
7. Losacco C, Perillo A. Particulate matter air pollution and respiratory impact on humans and animals. Environmental Science and Pollution Research. 2018;25(34):33901-10. doi:10.1007/s11356-018-3344-9 PMid:30284710
8. González-Delgado A, Shukla MK, DuBois DW, Flores-Márgez JP, Hernández Escamilla JA, Olivas E. Microbial and size characterization of airborne particulate matter collected on sticky tapes along US-Mexico border. Journal of Environmental Sciences. 2017;53:207-16. doi:10.1016/j.jes.2015.10.037 PMid:28372745
9. Sun Y, Xu S, Zheng D, Li J, Tian H, Wang Y. Effects of haze pollution on microbial community changes and correlation with chemical components in atmospheric particulate matter. Science of The Total Environment. 2018;637-638:507-16. doi:10.1016/j.scitotenv.2018.04.203 PMid:29754085
10. Haas D, Galler H, Luxner J, Zarfel G, Buzina W, Friedl H, et al. The concentrations of culturable microorganisms in relation to particulate matter in urban air. Atmospheric Environment. 2013;65:215-22. doi:10.1016/j.atmosenv.2012.10.031
11. Hong YJ, Huang YC, Lee IL, Chiang CM, Lin C, Jeng HA. Assessment of volatile organic compounds and particulate matter in a dental clinic and health risks to clinic personnel. Journal of environmental science and health Part A, Toxic/hazardous substances & environmental engineering. 2015;50(12):1205-14. doi:10.1080/10934529.2015.1055129 PMid:26301846
12. Adhikari A, Kurella S, Banerjee P, Mitra A. Aerosolized bacteria and microbial activity in dental clinics during cleaning procedures. J Aerosol Sci. 2017;114:209-18. doi:10.1016/j.jaerosci.2017.09.019
13. Han P, Li H, Walsh LJ, Ivanovski S. Splatters and Aerosols Contamination in Dental Aerosol Generating Procedures. 2021;11(4):1914. doi:10.3390/app11041914
14. Rao RM, Shenoy N, Shetty V. Determination of efficacy of pre-procedural mouth rinsing in reducing aerosol contamination produced by ultrasonic scalers. Journal of Health and Allied Sciences NU. 2015;05(03):052-6. doi:10.1055/s-0040-1703913
15. Cocârţă DM, Prodana M, Demetrescu I, Lungu PE, Didilescu AC. Indoor Air Pollution with Fine Particles and Implications for Workers' Health in Dental Offices: A Brief Review. Sustainability. 2021;13(2):599. doi:10.3390/su13020599
16. Pasquarella C, Veronesi L, Castiglia P, Liguori G, Montagna MT, Napoli C, et al. Italian multicentre study on microbial environmental contamination in dental clinics: a pilot study. Science of The Total Environment. 2010;408(19):4045-51. doi:10.1016/j.scitotenv.2010.05.010 PMid:20547411
17. Liu M-H, Tung T-H, Chung F-F, Chuang L-C, Wan G-H. High total volatile organic compounds pollution in a hospital dental department. Environ Monit Assess. 2017;189(11):571. doi:10.1007/s10661-017-6265-z PMid:29044438 PMCid:PMC5691115
18. Chuang C-Y, Cheng H-C, Yang S, Fang W, Hung P-C, Chuang S-Y. Investigation of the spreading characteristics of bacterial aerosol contamination during dental scaling treatment. Journal of Dental Sciences. 2014;9(3):294-6. doi:10.1016/j.jds.2014.06.002
19. Kedjarune U, Kukiattrakoon B, Yapong B, Chowanadisai S, Leggat P. Bacterial aerosols in the dental clinic: effect of time, position and type of treatment. International dental journal. 2000;50(2):103-7. doi:10.1002/j.1875-595X.2000.tb00807.x PMid:10945190
20. Al Maghlouth A, Al Yousef Y, Al Bagieh N. Qualitative and quantitative analysis of bacterial aerosols. The journal of contemporary dental practice. 2004;5(4):91-100. doi:10.5005/jcdp-5-4-91 PMid:15558094
21. Zemouri C, Volgenant CMC, Buijs MJ, Crielaard W, Rosema NAM, Brandt BW, et al. Dental aerosols: microbial composition and spatial distribution. J Oral Microbiol. 2020;12(1):1762040. doi:10.1080/20002297.2020.1762040 PMid:32537096 PMCid:PMC7269059
22. Soltanian M, Torabi S, Mohajeri P, Najafi F. Density of Airborne Bacterial Species in Dentistry Units in Urban Health Centers, Kermanshah, Iran. J Mazand Univ Med Sci. 2017;27(152):132-42.
23. Lasemi E, Fayaz F, Navi F, Gharnizadeh K, Ahmadi B. Evaluation of Microbial aerosols in Dental departments of Islamic Azad University, Dental Branch, Tehran in 2009. Res-Dent-Sci. 2011;7(4):11-7.
24. Malakootian M, Molazadeh P, Eskandarizadh A. Microbial and Fungal Contamination of Air at Dental Clinics and Dental Offices in Kerman. Tolooe Behdasht. 2015;13(5):13-24.
25. Hobson RS, Pabary SB, Alamani K, Badminton K. Aerosols created by dental procedures in a primary care setting. 2020; 08.27.20183087. doi:10.1101/2020.08.27.20183087
26. Nulty A, Lefkaditis C, Zachrisson P, Van Tonder Q, Yar R. A clinical study measuring dental aerosols with and without a high-volume extraction device. British Dental Journal. 2020. doi:10.1038/s41415-020-2274-3 PMCid:PMC7658616
27. Bates AJ, Bates DR. Analysing air particle quantity in a dental primary care setting. 2020.08.12.20173450. doi:10.1101/2020.08.12.20173450
28. Arsal S, Pekey B, Pekey H. Assessment of occupational exposure to fine particulate matter in dental prosthesis laboratories in Kocaeli, Turkey. Environ Monit Assess. 2020;192. doi:10.1007/s10661-020-08620-8 PMid:33006063

How to Cite this Article:
Akbari M, Atoof F, Nazari-Alam A, Nasab ZS, Miranzadeh MB, Mirzaei N. Assessment of bacterial bioaerosols and particulate matters characteristics in the indoor air of dentistry clinics. Int Arch Health Sci 2023;10(3):130-136. doi: 10.48307/IAHSJ.2023.179403