ABSTRACT

Introduction: The indoor environment of dental clinics may endanger dental patients and personnel and due to a great variety of air pollutants throughout the usual dental operation. The purpose of the present cross-sectional study was the evaluation of Indoor Air Quality (IAQ) and factors affecting it in a dentistry faculty of Arak University of Medical Sciences.

Material and methods: The IAQ of five dental active wards and the patient waiting room was evaluated. The concentrations of Total Volatile Organic Compounds (TVOC), CO₂, particulate matter, and bioaerosols were measured.

Results: The TVOCs concentration in sampling locations ranged between 817 to 3670 μg/m³ during dental work and exceeded the Leadership in Energy and Environmental Design (LEED) guideline in all sampling locations. The highest values of Particulate Matter (PM) for PM₁₀, PM₂.₅, and PM₁ were observed in the periodontics ward, while the lowest values were observed in the endodontics ward. The PM₁₀ concentrations exceeded the WHO limit in periodontics and pediatric wards. TVOC levels had a significant positive correlation with temperature (r=0.374, p<0.01) and RH (r=0.265, p<0.05). The predominant bacterial genus of the patient waiting area was Bacillus (36%), while the dominant bacterial genus of the other sampling site was Micrococcus spp. Penicillium (35.5%) and Cladosporium (28%) were the predominant fungi detected.

Conclusion: Controlling of airborne particles is to be standardized by the infection control actions of dental clinics and improved ventilation capacity in the air conditioning system was suggested for reducing VOCs and PM concentrations.

Introduction

In recent decades, Indoor Air Quality (IAQ) of health care settings has received growing attention from the researchers, and governments for improving the health, and comfort of patients and health care workers [1]. IAQ in dental settings is of great importance for dentists, patients, and associated personnel whose health are endangered by infectious
microbial aerosols and chemical compounds, and other pollutants [2]. In dental treatment, susceptibility to infected persons and chemical materials could be inevitable. The oral cavity is the main reservoir of infectious bacteria with over 350 different kinds [3]. Dental treatment procedures that use low and high-speed drilling and polishing released microbial aerosols and dental materials into the environment air. Microbial aerosols derived from saliva, blood, gum secretion, dental plaque, and nasal-and throat secretion when is used ultrasonic scaler together with water spray. Aerosolized water droplets diffused from hand-pieces can also be contaminated with microbial biofilm existing in dental waterlines and reservoirs. Aerosol composition is different from case to case, depending on the site and the variety of treatment procedures in the oral cavity [4]. The effects of chronic exposure to airborne particles in dental offices contribute to the risk of development of respiratory cardiovascular diseases, chronic bronchitis reduced, lung function, and even premature death due to respiratory complications [5]. The main transmission route involves inhalation of pathogenic particles that stay suspended in air, settle on surfaces and are re aspirated. Non-living aerosols may release from acrylic, metal, mineral, polymers, and other compounds throughout dental operations and activities. The human health effects of Particulate Matter (PM) are directly related to their size and compositions [2]. PM comprises a great variety of species that differ in chemical composition, number, size (or diameter), surface area, and shape. These characteristics, especially surface area and size, define the expanse and position of deposition in the respiratory tract [6]. On the other hand, many chemical compounds containing resins and solvents are used in dental treatment works, even in regular dental treatment procedures, which could release nitrous oxide, mercury vapor, and Volatile Organic Compounds (VOCs) contaminants in the atmosphere of dental clinics. Depending on dental works, particular VOCs are emitted in dental clinics, including methanol, methyl-methacrylate (MMA), isobutyl-methacrylate, and cyanoacrylate [7]. The source of VOCs in dental offices contributes to the production of bridges, crowns, acrylic dentures, and framework [7]. Other causes for the emission of VOCs can be chemical sterilization approaches in which well-known compounds, including glutaraldehyde, alcohol, and ethylene oxide are used. Acute exposure to such VOCs can cause serious health effects, such as irritation of the eyes, nose, and throat, headaches, dizziness, and nausea. The risk of pulmonary illness, dermatological disease, and allergies may be increased by chronic exposure to such pollutants [5-9]. Above all, high IAQ can defend dental patients and personnel against dangerous airborne substances existing in dental environments. Susceptibility to such substances is considerably more powerful in dental settings compared to other settings, necessitating a high IAQ. The current investigation was aimed at assessing the indoor air quality of different wards in the dentistry faculty of Arak University of medical sciences concerning microbial aerosols, TVOCs, PM, and CO₂ concentration to recognize potential sources and associations between particular dental actions and pollution levels.

**Materials and methods**

**Sampling sites**

This survey was conducted in the dental school clinic of Arak University of Medical Sciences, Arak, Iran. Air sampling and measurements were carried out in six separate active departments of the clinic, such as pediatric dentistry (PED), periodontics (PER), endodontics (ENDO), prosthesis (PRO), restorative dentistry (RES), and patient waiting room (PWR). Natural ventilation is used for these wards and central air conditioners (HVAC) are employed for heating and cooling.

http://japh.tums.ac.ir
The area of PED, PER, ENDO, PRO, and RES were 50 m², 50 m², 55 m², 90 m², 70 m² and 100 m² respectively. The windows were shut during sampling time. From each ward, two active dental chair units were randomly picked and air samples were collected at the distance of 2 m during the procedure treatment. This study was performed for six months from December 2018 to June 2019. IAQ parameters of sampling locations were measured for 6 h (10 am to 4 pm) per workday. The sample size for each sampling site was five.

The assessed parameters of air quality included airborne bacteria and fungi, three size fractions PM (PM$_{10}$, PM$_{2.5}$, and PM$_{1}$), Total Volatile Organic Compounds (TVOCs), CO$_2$, temperature, and relative humidity. Bacterial and fungal load were evaluated via Andersen one-stage impactors (N6; Andersen Samplers, Atlanta, Georgia) contained 20 ml TSA (tryptic soy agar) culture media for bacteria and MEA (malt extract agar) for fungi at an airflow rate of 28.3 L/min for 5 min. Duplicate samples were incubated at 35°C for 2-3 days for bacteria, and 25°C (room temperature) for 3-5 days, respectively. The number of colony-forming units per volume of air (CFU/m$^3$) was calculated using the positive hole conversion table and sampled air volume. Total bacterial colonies were biochemically identified. The fungal genera were identified by macroscopic observation and morphological analysis [8]. The portable aerosol spectrometer (DustTruk Aerosol Monitor, TSI 8520) was employed for measuring PM$_{1}$, PM$_{2.5}$, and PM$_{10}$. A photoionization detector (PID, First multi-gas/PID detector Firstcheck) was also used to measure TVOC. During sampling, environmental parameters including temperature (°C) and relative humidity (RH %) were also determined using a digital Psychrometer (Kimo instrument, France). During the sampling period, all samples were collected 1.5 m above floor level. The estimation of the number of people in each ward was done based on the logbook records.

### Statistical analysis

The SPSS 20.0 and Kolmogorov-Smirnov trial were used to conduct data analysis and normality was applied upon the usage of parametric and non-parametric analyses. Minimum, maximum, average, and standard deviation values were obtained to describe the indoor concentrations of pollutants. A comparison was made between the mean values of parameters among different wards using the Kruskal-Wallis trial. Also, the relationships between indoor air quality (IAQ) parameters were surveyed using the non-parametric Spearman’s rank correlation approach. P values of less than 0.05 were defined for statistical significance.

### Results and discussion

The mean and standard deviation of indoor air parameters from the six locations of the dental office are displayed in Table 1. The mean values of CO$_2$ concentration in sampling wards ranged from 775 ppm to 1180 ppm with the minimum value in PER and the maximum value in PED and exceeded the recommended limit (1,000 ppm) of the ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers) for indoor environments [9]. The difference between the mean concentrations of CO$_2$ in the sampling wards was statistically significant (p<0.001). The RH and temperature variations in the sampling location were statistically significant (p<0.05). The PWA (background level) and PER recorded the highest mean temperature (25.2±1.3) and RH (42.4±2.3) during the measurement, respectively. The mean TVOCs concentrations in all sampling departments during working hours were above the Leadership in Energy and Environmental Design (LEED) recommended limit of 500 µg/m$^3$ for the indoor air environment [10] (Table 1). The highest mean level occurred in the PRO (2737±936 µg/m$^3$), while the minimum level was found in the PWR. The
mean TVOCs level in six sampling wards was statistically significant (p<0.005). The highest values of PM$_{10}$, PM$_{2.5}$ and PM$_1$ were observed in PER, while minimum values were observed in the Endo (Table 1). According to the Kruskal-Wallis trial, no significant variations were observed in PM (PM$_{10}$, PM$_{2.5}$, and PM$_1$) concentrations between different sampling wards (P=0.406). The maximum value of PM$_{10}$ concentration was 119µg/m$^3$, while that for PM$_{2.5}$ and PM$_1$ were 59µg/m$^3$ and 47µg/m$^3$, respectively. However, none of the concentrations of PM$_{10}$ values exceeded the limit of 50 µg/m$^3$ recommended by World Health Organization (WHO) [11]. The PM$_{2.5}$ concentrations exceeded the WHO limit of 25 µg/m$^3$ in two sampling wards (PER and PED).

Table 1. Mean (SD) concentrations of air quality variables in the different sampling departments of the dental school clinic (n=180)

| Exposure          | (n=30)     | (n=30)     | (n=30)     | (n=36)     | (n=30)     | Ground level (n=30) | limit |
|-------------------|------------|------------|------------|------------|------------|---------------------|-------|
| TVOCs, µg/m$^3$   | 1998 (439) | 1840 (404) | 2370 (759) | 2243 (649) | 2737 (936) | 1300 (283)          | $^a$500 |
| CO$_2$, ppm       | 775 (56)   | 952 (85)   | 790 (63)   | 1180 (92)  | 650 (48)   | 935 (89)            | $^b$1000 |
| PM$_1$, µg/m$^3$  | 25 (7)     | 23 (6)     | 19 (5)     | 24 (7)     | 19 (6)     | 16 (4)              | -     |
| PM$_{2.5}$, µg/m$^3$ | 28 (8) | 24 (7)     | 20 (5)     | 27 (9)     | 20 (7)     | 10 (5)              | $^c$25 |
| PM$_{10}$, µg/m$^3$ | 48 (16) | 30 (14)    | 22 (11)    | 46 (13)    | 22 (9)     | 19 (6)              | $^d$50  |
| Bacteria, CFU/m$^3$ | 338       | 248        | 153        | 332        | 203        | 118                 | $^d$500 |
| Fungi, CFU/m$^3$  | 198        | 125        | 67         | 82         | 46         | 28                  | -     |
| T °C              | 24.8 (0.8) | 25.4 (1.1) | 23.7 (2.1) | 22.8 (0.6) | 24.2 (1.4) | 25.2 (1.3)          | 20-24 |
| RH %              | 42.4 (2.3) | 34.7 (3.1) | 36.5 (1.9) | 31.8 (1.4) | 30.5 (2.9) | 41.2 (1.7)          | 30-60 |

PER: periodontics department, RES: restorative department, ENDO: endodontics department, PED: pediatric department, PRO: prosthesis department, T: temperature, RH: relative humidity

a USGBC, LEED v4. Building Design and Construction Guide [10]
b ASHRAE, Standard 62.1-2016 for the Ventilation for Acceptable Indoor Air Quality[9]
c World Health Organization (WHO) [11]

http://japh.tums.ac.ir
TVOCs were positively correlated with temperature significantly ($r=0.374$, $p<0.01$) and RH ($r=0.265$, $p<0.05$) (Table 2). Also, airborne bacteria were positively correlated with PM$_{2.5}$ ($r=0.301$, $p<0.05$) and PM$_{10}$ ($r=0.243$, $p<0.05$). However, airborne fungi had significant positive correlation with CO$_2$ ($r=0.429$, $p<0.05$), temperature ($r=0.345$, $p<0.05$) and RH ($r=0.224$, $p<0.05$).

Table 2. Spearman rank correlation coefficients for indoor air quality parameters

|          | TVOCs | PM$_{10}$ | PM$_{2.5}$ | PM$_1$ | CO$_2$ | T    | RH     | Bacteria | Fungi     |
|----------|-------|-----------|------------|--------|--------|-------|--------|----------|-----------|
| TVOCs    | 1     |           |            |        |        |       |        |          |           |
| PM$_{10}$| 0.065 | 1         |            |        |        |       |        |          |           |
| PM$_{2.5}$| 0.078 | 0.927**  | 1          |        |        |       |        |          |           |
| PM$_1$   | 0.102 | 0.876**  | 0.904**    | 1      |        |       |        |          |           |
| CO$_2$   | 0.016 | 0.023     | 0.017      | 0.011  | 1      |       |        |          |           |
| T        | 0.374* | 0.011    | 0.006      | 0.003  | -0.056 | 1      |        |          |           |
| RH       | 0.265* | 0.017    | 0.008      | 0.004  | -0.223 | -0.305*| 1      |          |           |
| Bacteria | 0.033 | 0.218     | 0.301*     | 0.243* | 0.147  | -0.153| 0.132  | 1        |           |
| Fungi    | 0.021 | 0.114     | 0.156      | 0.189  | 0.429* | 0.345*| 0.224* | 0.109    | 1         |

T: temperature, RH: relative humidity
The results revealed that all the recognized bacterial genera in the present survey were gram-positive (Table 3). The dominant bacterial genera in sampling sites were *Micrococcus* (37.6%), *Bacillus* (24.5%), *Staphylococcus* (21.3%), and *Streptococcus* (16.6%). The predominant bacterial genus of the PWA was *Bacillus* (36% of the total detected bacteria), while the dominant bacterial genus of the other sampling site was *Micrococcus* spp. Based on the findings of our investigation, the dominant fungal genera were *Penicillium* (35.5%), *Cladosporium* (28%), and *Aspergillus* (13.5%) (Table 3).

Table 3. Contributions of Bacterial and fungal genera in the six dental wards

|               | PED | PER | ENDO | PRO | RES | PWA |
|---------------|-----|-----|------|-----|-----|-----|
| **Bacteria genus** |     |     |      |     |     |     |
| *Micrococcus luteus* | 18  | 10  | 14   | ND  | 20  | ND  |
| *Micrococcus roseus* | 10  | 6   | 4    | 8   | ND  | ND  |
| *Micrococcus spp* | 10  | 23  | 16   | 35  | 17  | 34  |
| *Bacillus* | 28  | 13  | 23   | 16  | 31  | 36  |
| *Streptococcus spp* | 14  | 11  | 28   | 21  | 25  | ND  |
| *Staphylococcus aureus* | 5   | 8   | 3    | 1   | ND  | 6   |
| *Staphylococcus epidermidis* | 9   | 13  | 12   | 7   | 7   | ND  |
| *Staphylococcus saprophyticus* | 6   | 16  | ND   | 12  | ND  | 22  |
| **Fungi genus** |     |     |      |     |     |     |
| *Penicillium* | 41  | 32  | 26   | 33  | 39  | 42  |
| *Cladosporium* | 16  | 21  | 40   | 30  | 23  | 31  |
| *Aspergillus* | 19  | 22  | ND   | 12  | 28  | ND  |
| *Rhizopus* | 9   | 14  | 16   | ND  | 6   | 7   |
| *Alternaria* | 2   | 5   | ND   | 22  | ND  | 14  |
| Others | 13  | 6   | 18   | 13  | 6   | 6   |

PER: periodontics department, RES: restorative department, ENDO: endodontics department, PED: pediatric department, PRO: prosthesis department

http://japh.tums.ac.ir
Indoor air pollution of dental offices with volatile organic compounds (VOCs), different organic and inorganic chemicals, fine particulates, and airborne microorganisms can affect the health of dentists, dental workers, and patients. Based on the results, the concentration of total fungal and bacterial aerosols increased considerably through dental therapy. Furthermore, the concentrations of TVOCs, CO$_2$, and PM in the indoor air of the dentistry clinic were risky since particular materials were used for dental procedures, cleaning processes, and also there were a large number of personnel in the room. In this study, the TVOCs levels of the sampling locations exceeded the LEED exposure limit, and the highest TVOCs level was recorded in the PRO (2737 µg/m$^3$). Resins and solvents are the main sources of VOCs in PRO, which are used more than other departments. The volatile compounds such as methyl methacrylate, methanol, and isobutyl-methacrylate are the main ingredients of these materials. Also, relatively high concentrations of TVOCs were recorded in ENDO and PED wards. Endodontic therapy (saving the tooth when the pulp and/or periradicular tissues are damaged) uses endodontic substances. The mentioned materials are commonly applied for disinfecting (irrigants and intracanal medicaments) and filling the pulp in root canal treatment. In PED, pediatric dentists also use volatile composite resin, particularly more highly filled resins and bonding agents for anterior restorative care. Inhalation of low concentrations of this compound for a short period of time may irritate the throat, eyes, and skin. However, chronic exposure may have a negative impact on the skin, liver, and central nervous system [12]. According to the obtained results, even the background concentration of TVOCs in PWA has higher values than the recommended limits. These increases are attributed to the application of detergent solutions for daily disinfecting and cleaning of work surfaces. In the study of IAQ in the Dentistry Faculty of Athens University, the use of acrylic and Kalocryl® known to source high levels of TVOCs (2000-5500 µg/m$^3$) in the indoor environment of the dental clinic offices. Also, higher background levels than the indoor air limits have been attributed to the use of disinfectants and cleaners at the beginning and the end of the shifts [13]. Similarly in some investigations, increased levels of VOCs concentrations were reported throughout business hours in dental clinics and exceeded occupational standards and guidelines [5, 7, 14]. However, a number of studies reported that VOC compounds in the environment of dentistry were below limits recommended by [15, 16]. The CO$_2$ levels in the PED ward had greater values in comparison to other dentistry wards owing to the higher quantity of dental staff, active dentists, and patients combined with inadequate ventilation conditions. The indoor CO$_2$ level has been proposed as a key factor for the transmission of airborne viruses and a potential proxy for indicating the infection risk of respiratory diseases in the dental clinic [17]. The infection risk of transmission through re-inhaled air can be obtained by comparing the indoor concentration of CO$_2$ with its background concentration [18]. In agreement with past studies, our data showed that the dental treatment procedure plays a major role in increasing the concentration of aerosols [2, 19, 20]. In periodontics, treatment activities such as scaling and root planning, regenerative procedures (reversing lost tissue and bone), and root surface debridement (removing damaged tissue) may produce high PM concentrations compared to other dentistry wards. However, some factors, such as increasing the number of patients, treatment staff, and students affect the concentration of suspended particles in dental educational clinics. On
the other hand, some past studies reported that although higher concentrations of bioaerosol were generated through scaling, other aerosol levels reverted to baseline after 10–30 min [20]. Some researchers showed that using an adequate suction system and saliva standard ejectors can significantly reduce \( \text{PM}_{10} \). However, lower efficiency was observed in the aspiration of \( \text{PM}_1 \) particles during dental procedures [20]. Furthermore, \( \text{PM}_{2.5} \) and \( \text{PM}_1 \) concentrations are related to bacteria levels. Accordingly, the using standard saliva ejectors with increasing ventilation efficiency can effectively lead to spreading decrease of bioaerosols in the dental environment. In this study, the gram-positive bacteria were dominant and mainly source from human respiratory system, patient moth, and skin. Several studies have shown that the fungal species of Cladosporium and Penicillium generally occur in indoor environments and are found to be an important risk for dental staffs [19, 21]. Nevertheless, their presence in the outdoor environment could result in their migration into rooms.

Conclusion

This study provides data concerning the levels of IAQ parameters in an educational dentistry clinic. Based on the findings from this study, dental activities and procedures in the different dental wards may increase TVOCs and PM concentrations. The dental clinic personnel are exposed to elevated levels of TVOCs, airborne bacteria throughout dental cleaning procedures. The results revealed significant correlations between TVOCs with indoor temperature and relative humidity, as well as bacteria concentrations and PM (\( \text{PM}_{2.5} \) and \( \text{PM}_1 \)). Maximum values of PM concentrations were observed throughout scaling and root planning in periodontics. The quality of indoor air of educational dental clinics requires special attention and long-term surveillance for the health protection of patients, dental students, and treatment staff. The indoor particles are to be assessed and compared with the standard level by the infection control procedures of dental clinics. The presence of opportunistic microorganisms (Staphylococcus spp. and Streptococcus spp.) is significant. Also, fungi can be useful indicators of indoor air quality. Furthermore, since Aspergillus species may lead to nosocomial infections and allergies, their presence in the indoor environment of dental clinics may be a hazardous. Therefore, controlling airborne particles is to be standardized by infection control actions of dental clinics. Important sources of emissions of indoor air pollutants and the development of appropriate control techniques should be identified.

Financial supports

This study was funded by Arak University of Medical Sciences, Arak, Iran, and the grant number 3441.

Competing interests

The authors declare they have no actual or potential competing interests.

Acknowledgements

The authors wish to extend their thanks to dentists and staff of the Faculty of Dentistry, Arak University of Medical Sciences.

Ethical considerations

“Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc) have been completely ob-served by the authors.” This study was approved by the Ethical Committee of Arak University of Medical Sciences with code: IR.ARAKMU. REC.1398.010

http://japh.tums.ac.ir
References

1. Cincinelli A, Martellini T. Indoor air quality and health. International Journal of Environmental Research and Public Health. 2017;14(11):1286. https://doi.org/10.3390/ijerph14111286.

2. Cocârţă DM, Prodana M, Demetrescu I, Lungu PEM, Didilescu AC. Indoor Air Pollution with Fine Particles and Implications for Workers’ Health in Dental Offices: A Brief Review. Sustainability. 2021;13(2):599. https://doi.org/10.3390/su13020599.

3. Szymanska J. Dental bioaerosol as an occupational hazard in a dentist’s workplace. Annals of Agricultural and Environmental Medicine. 2007;14(2).

4. Mirhoseini SH, Koolivand A, Bayani M, Sarlak H, Moradzadeh R, Ghamari F, Sheykhan A. Quantitative and qualitative assessment of microbial aerosols in different indoor environments of a dental school clinic. Aerobiologia. 2021 Jun;37(2):217-24. https://doi.org/10.1007/s10453-020-09679-z

5. Helmis CG, Tzoutzas J, Flokas HA, Halios CH, Assimakopoulos VD, Stathopoulou OI, Panis V, Apostolatou M. Emissions of total volatile organic compounds and indoor environment assessment in dental clinics in Athens, Greece. International dental journal. 2008 Oct;58(5):269-78.

6. Bazzazpour S, Rahmatinia M, Mohebbi SR, Hadei M, Shahsavani A, Hopke PK, Houshmand B, Raeisi A, Jafari AJ, Yarahmadi M, Farhadi M. The detection of SARS-CoV-2 RNA in indoor air of dental clinics during the COVID-19 pandemic. Environmental Science and Pollution Research. 2021 Aug 3:1-9.

7. Hong Y-J, Huang Y-C, Lee I-L, Chiang C-M, 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. 2015; 50(12):1205–14. https://doi.org/10.1080/10934529.2015.1055129

8. Mirhoseini SH, Didehdar M, Akbari M, Moradzadeh R, Jamshidi R, Torabi S. Indoor exposure to airborne bacteria and fungi in sensitive wards of an academic pediatric hospital. Aerobiologia. 2020;1–8. https://doi.org/10.1007/s10453-020-09624-0

9. ASHRAE. Standard 62.1-2016 for the Ventilation for Acceptable Indoor Air Quality. 2016.

10. D. LEED v4 for Building Design and Construction. U.S. Green Building Council: Washington, DC, USA. 2019.

11. WHO Air quality guidelines: global update 2005: particulate matter, ozone, nitrogen dioxide, and sulfur dioxide. World Health Organization. 2006.

12. Vu LM. Pilot study assessment of indoor air quality in two dental settings: Particulate matter and volatile organic compounds. Dissertation, University of Texas School of Public Health 2011.

13. Helmis CG, Tzoutzas J, Flokas HA, Halios CH, Assimakopoulos VD, Stathopoulou OI, Panis V, Apostolatou M, Sgouros G, Adam E. Indoor air quality in a dentistry clinic. Science of the Total Environment. 2007 May 15;377(2-3):349-65. https://doi.org/10.1016/j.scitotenv.2007.01.100

14. 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. Environmental Monitoring and Assessment. 2017;189(11):571. https://doi.org/10.1007/s10661-017-6265-z.

15. Godwin CC, Batterman SA, Sahni SP, Peng C-Y. Indoor environment quality in dental clinics: potential concerns from particulate matter. American Journal of Dentistry. 2003;16(4):260–6.
16. Santarsiero A, Fuselli S, De Blasio G, De Felice M, Nazzicone M, Ortolani E. Dentistry setting and related environment: a preliminary study. Annali di igiene: medicina preventiva e di comunita 2007;19(6):541–50.

17. Zemouri C, Awad SF, Volgenant CMC, Crielaard W, Laheij A, De Soet JJ. Modeling of the transmission of coronaviruses, measles virus, influenza virus, Mycobacterium tuberculosis, and Legionella pneumophila in dental clinics. Journal of dental research. 2020;99(10):1192–8. https://doi.org/10.1177/0022034520940288

18. Peng Z, Jimenez J. Exhaled CO$_2$ as a COVID-19 infection risk proxy for different indoor environments and activities. Environmental Science & Technology Letters. 2021;8,5:392–397. https://doi.org/10.1021/acs.estlett.1c00183.

19. Polednik B. Aerosol and bioaerosol particles in a dental office. Environmental Research. 2014; 134:405–9. https://doi.org/10.1016/j.envres.2014.06.027

20. Rexhepi I, Mangifesta R, Santilli M, Guri S, Di Carlo P, D’Addazio G, Caputi S, Sinjari B. Effects of natural ventilation and saliva standard ejectors during the COVID-19 pandemic: A quantitative analysis of aerosol produced during dental procedures. International Journal of Environmental Research and Public Health. 2021 Jan;18(14):7472. https://doi.org/10.3390/ijerph18147472

21. Kadaifciler DG, Cotuk A. Microbial contamination of dental unit waterlines and effect on quality of indoor air. Environmental Monitoring and Assessment. 2014;186(6):3431–44. https://doi.org/10.1007/s10661-014-3628-6.

http://japh.tums.ac.ir