Original Article

Evaluation of the Bacterial Contamination of Air and Surfaces in Different Dental Environments

Seyed Hamed Mirhoseini, Mojtaba Bayani[1]

Department of Environmental Health Engineering, School of Health, Arak University of Medical Sciences, Arak, Iran, [1]Department of Periodontics Dentistry, School of Dentistry, Arak University of Medical Sciences, Arak, Iran

Abstract

Aim: In dental clinic environment, dental staff and patients are daily exposed to many types of infectious agents transported by aerosols and droplets, promoting an increased risk of cross infection. The aim of this study was to assess the level of bacterial contamination of air and surfaces in different wards of the educational clinic in Arak University of Medical Sciences. **Materials and Methods:** Samples were obtained from the air and surfaces of five active wards of the dental school clinic. Air sampling was performed actively at ½ and 2 m distances from two random units in each ward. Sampling from surfaces was conducted using a wet sterile swab from the washing sink and handpiece after disinfection. Grown colonies were counted and bacterial phenotyping was based primarily on morphology, Gram-staining, endospore formation, catalase activity, and cytochrome oxidase presence. For statistical analysis, the Kruskal–Wallis test was used at a significance level of $P < 0.05$. **Results:** Bacterial contamination was detected in all of 80 samples taken from the surfaces of different sections. Regarding the total number of colonies growing from surface samples, there was no significant difference between the studied wards ($P > 0.05$). The mean concentration of airborne bacteria in the pediatric ward (488 CFU/m^3) at a distance of 0.5 m and the surgical ward (339 CFU/m^3) at a distance of 2 m had the highest value compared to other wards. In general, there was no statistically significant difference between the total density of airborne bacteria at distances of 0.5 and 2 m ($P > 0.05$). **Conclusion:** Bacterial contamination in the environment of the dentistry clinic increases during the treatment process. The clinic's space, the types of the ward and treatment process, and distance from the unit are among the factors affecting the type and diffusion extent of microbial aerosols.

Keywords: Airborne bacteria, cross-infection, dentistry, surface contamination

Introduction

Infection control in dentistry centers has always been one of the most important concerns in the field. It has been shown that many infectious diseases caused by pathogenic bacteria, viruses, and fungi can be transmitted to individuals in dentistry clinics. People in dentistry clinics are exposed to a variety of infectious agents dispersed by aerosols and droplets during various treatment processes, increasing the risk of infection transmission.[1] These aerosols are small particles that remain suspended in the air for hours before settling on various surfaces. Around 75% of these particles fall within a radius of 2 m from the patient.[2] The human oral cavity acts as a natural habitat and reservoir for a wide variety of microorganisms, so the spread of infection through oral cavity aerosols and secretions is one of the most important concerns in dentistry. Oral secretions are commonly contaminated with mostly aerobic bacteria (*Streptococci* and *Staphylococci*), as well as viruses.[3] During dentistry procedures, high-speed hand pens, ultrasonic scalers, air turbines, and abrasive and polishing tools are used that produce aerosols with active circulation of water along with compressed air.[4] Therefore, it is very likely that these aerosols contain blood-borne bacteria, viruses, and other organisms found in gingival plaques. Bioaerosols greatly increase the risk of infection transmission to different wards of dentistry clinics. Microorganisms may be present in dentistry equipment such as water tubes, and biofilms may colonize on surfaces, so the sterilization process may not be adequately

Access this article online

Quick Response Code:

Website: www.ijehe.org

DOI: 10.4103/ijehe.ijehe_14_21

Address for correspondence: Dr. Seyed Hamed Mirhoseini, Department of Environmental Health Engineering, School of Health, Arak University of Medical Sciences, Arak, Iran.
E-mail: hmirhossaini@gmail.com

How to cite this article: Mirhoseini SH, Bayani M. Evaluation of the bacterial contamination of air and surfaces in different dental environments. Int J Env Health Eng 2022;11:4.

Received: 03-07-2021, **Accepted:** 12-09-2021, **Published:** 29-11-2022

effective in eradicating these bacteria in dentistry clinics. In the biofilms obtained from the surgical ward of dentistry clinics, various bacterial species such as *Pseudomonas aeruginosa*, *P. cepacia*, *Legionella pneumophila*, and *Mycobacterium chelonae* have been detected. Studies have shown that the total concentration of bacterial aerosols has a direct correlation with working duration (hours) in the surgical ward of dentistry clinics.[5,6]

The educational-therapeutic departments of dentistry faculties provide favorable conditions for the growth and transmission of microorganisms due to high people density, lack of ventilation, and inappropriate structural environment. Due to constant contact with contaminated oral secretions and blood of patients, preventing the transmission of infections through the aerosols and secretions dispersed in the environment is one of the main priorities in dentistry clinics. Pathogenic diseases such as influenza, measles, scarlet fever, diphtheria, cough, tonsillitis, acute respiratory cold, tuberculosis, and smallpox are transmitted from a patient to a healthy person through the air contaminated with small infectious droplets of mucus and saliva during coughing, sneezing, or talking.[6] On the other hand, a healthy person carrying *Staphylococcus aureus* in the nose, on the skin, or on clothes can directly and indirectly transmit the infection.[6] Moreover, these microorganisms are becoming more resistant every day, threatening the health of people more seriously, due to the emergence of mutated strains and incorrect use of disinfectants (inappropriate concentrations), and excessive prescription of antibiotics.[7] To promote infection control, it is important to periodically screen the air and surfaces of dentistry clinics, which can help identify and correct the weaknesses of infection control strategies in each department. In this regard, the purpose of this study was to assess bacterial contamination of air and surfaces in different departments of the dentistry educational clinic of the Dentistry Faculty of Arak University of Medical Sciences.

Materials and Methods

This descriptive cross-sectional study was performed in the educational clinic of the Dentistry Faculty of Arak University of Medical Sciences. This study was conducted for 6 months from December 2018 to June 2019. Sampling from the air and surfaces was performed in five active sections of the clinic, including oral and maxillofacial surgery, endodontics, reconstructive surgery, pediatrics, and prosthetic laboratory. Air sampling was performed actively using a single Anderson sampler (SKC, the UK) from 1.5 m above the ground level (Q = 28.3 l/min) for 5 min. The samples were cultured on the Tryptic Soy Agar plate containing nystatin to facilitate bacterial colonization and prevent the growth of fungi.[7,8] From each section, two active units were randomly selected using a table of random numbers. Air sampling was performed in 0.5 m and 2-m radius of the unit during the last 10 min of treatment. The sampling was performed in the same way once a week for 4 consecutive weeks. Therapeutic procedures lasting more than 20 min were included in the study. Considering five wards, two units per ward, the sampling distances of 0.5 m and 2 m from each unit, and finally four repetitions, a total of 80 samples were collected. Before each sampling and placing into a plate containing the culture medium, the sampling device was sterilized using a piece of cotton impregnated with 70% alcohol. Sampling from surfaces (handpiece and handwashing sink) in each department was randomly performed using a sterile wet swab. The samples were then cultured linearly on agar extract medium. All surfaces were disinfected before the onset of the treatment process. After sampling, the plates containing the bacterial culture media were transferred to the laboratory. Bacterial cultures were incubated at 35°C for 5 days. At the end of the incubation period, colonies were identified and enumerated. Considering that each sample was cultured in duplicate, the average number of the colonies counted in two plates was reported as the number of airborne bacteria. The bacteria were identified using biochemical methods based on Bergey's guidelines. Bacterial phenotyping was based primarily on morphology, Gram-staining, endospore formation, catalase activity (catalase test), and cytochrome oxidase presence (oxidase test).[2]

Statistical analysis was performed in SPSS software version 20 (SPSS Inc., Chicago, IL, USA). The results were reported using descriptive statistics (mean and standard deviation). Regarding the nonnormal distribution of the data, the nonparametric test of Kruskal–Wallis was used to compare variables between different groups at the significance level of $P < 0.05$.

Results

The frequency of surface microbial contamination

Overall, out of 80 samples obtained from surfaces (washing sink and handpiece) in different dentistry sections at the end of the treatment process, all resulted in the growth of microorganisms as shown in Table 1.

There was no significant difference comparing the total number of colonies grown from the samples obtained from surfaces in different sections ($P > 0.05$). Of the total species identified, 52.6% were Gram-positive cocci, 13.6% Gram-positive bacilli, 19.2% Gram-negative cocci, and 14.6% Gram-negative bacilli. The most common genera included *Staphylococcus, Streptococcus, Micrococcus, Bacillus, Pseudomonas, Enterobacter*, and *Clostridium*.

Table 1: The frequency and percentage of bacteria isolates obtained from surfaces in each dentistry section after the treatment process

Sampling location	Washing sink, *n* (%)	Handpiece, *n* (%)	Total, *n* (%)
Restorative	49 (12.2)	35 (8.9)	84 (20.8)
Pediatric	51 (12.6)	44 (10.8)	95 (23.6)
Surgery	53 (13.2)	46 (11.4)	99 (24.6)
Prosthesis	22 (5.4)	32 (7.8)	54 (13.4)
Endodontic	36 (8.9)	35 (8.7)	71 (17.6)
Total	211 (52.3)	192 (47.6)	403 (100)

The frequency of air microbial contamination

Table 2 shows the average density of airborne bacteria in different sections assessed. The results showed that the highest densities were related to the pediatric section with an average bacterial density of 488 CFU/m^3 at a distance of 0.5 m and the surgery section with an average density of 339 CFU/m^3 at a distance of 2 m [Table 2]. The average density of airborne bacteria in the pediatric, restorative, and endodontic sections was significantly higher at the distance of 0.5 m compared to 2 m from the unit ($P < 0.05$). However, there was no statistically significant difference in the overall mean bacterial density comparing 0.5 m and 2 m distances ($P > 0.05$).

The analysis of bacterial aerosols in the air of different wards of the clinic showed that 38%, 22%, 20%, and 20% of the colonies were *Micrococcus*, *Bacillus*, *Streptococcus*, and *Staphylococcus*, respectively. Table 3 shows the most common identified species in each section.

Discussion

Controlling environmentally transmitted infections has always been a major concern in dentistry clinics. The spread of pathogenic microorganisms in these centers can occur through direct contact with patients or biological fluids and indirect contact with contaminated air, environment, materials, and medical equipment and devices. Bacterial aerosols and the droplets produced during the treatment procedure in different wards of the dentistry clinic are the sources of disease transmission to health staff and patients. The surfaces of the high-speed rotating tools such as turbines used in dentistry are sources for transmitting oral cavity aerosols.[9,10]

The results of this study showed that the surface of the sink and handpiece in all sections had a high rate of microbial contamination, with the highest rate being related to the surgery and pediatric departments. *Staphylococcus* and *Streptococcus*, two genera of Gram-positive cocci, were the most frequently detected bacteria, which were in accordance with the studies conducted by Khorakian *et al.* in the Dentistry Faculty of Mashhad University of Medical Sciences[11] and Rautemaa *et al.* in Helsinki, Finland.[12] In an assessment on bacterial contamination in the restorative and periodontics wards of the Dentistry Faculty of Shahid Beheshti University of Medical Sciences, Valian *et al.* reported that the contamination rate of the back of seats was significantly higher than that of light turn on/off keys and handles of trays.[13] Furthermore, contamination rate was higher in the periodontics than in the restorative ward.[13] Pasquarella *et al.* in a study assessed environmental contamination in Italian dentistry clinics observed large changes in the rate of microbial contamination of surfaces in different clinics and at different times. They also reported that the contamination rate of trays and light turn on/off keys was significantly higher than other surfaces.[14]

In a study by Smith and Smith who assessed the contamination of handpiece surfaces, it was revealed that microbial contamination still remained in the outer and inner surfaces of the handpiece even after disinfection, with a higher microbial load on the outer compared to the inner surface of the handpiece. Out of 40 turbines studied, the mean CFU of 200 was detected for each turbine, and the most common isolates included oral *Streptococcus*, *Pseudomonas*, and *S. aureus*.[15] The species isolated in the present study were similar to that isolated in a number of prior studies.[11-13] Most of the identified species belong to the human normal flora and are considered nonpathogenic; nevertheless, when the immune system is weakened, they can result in various diseases. In the study of Valian *et al.,* the highest rate of contamination was related to Staphylococcus on the surface of tabure in the prosthetic department. Furthermore, a high level of contamination with this bacterium was observed on the head back in the pediatric and periodontics wards, as well as the light handle in the orthodontic ward.[13] In a study conducted by Kurita *et al.* on the risk of transmission of methicillin-resistant *Staphylococcus aureus* (MRSA) through surfaces during dental surgery, MRSA infection was detected in eight of 140 patients, whose antibiograms showed that the isolated species were the same as those isolated from different surfaces during the procedure.[16] This observation suggested the occurrence of cross-infection through surfaces, which was in line with our results. Although *S. aureus* belongs to the normal flora of the

Table 2: Mean and standard deviation of airborne bacteria density (CFU/m^3) in each ward at 0.5 and 2 m distances from the unit

Sampling location	The number of samples	The number of units	Bacterial density (0.5 m)	Bacterial density (2 m)
Restorative	16	4	271±87	247±89
Pediatric	16	5	448±102	337±88
Surgery	16	4	283±64	338±95
Prosthesis	16	5	187±68	203±73
Endodontic	16	4	200±64	153±52

Table 3: The frequency of different species of airborne bacteria in different wards of the dentistry clinic

Sampling location	*Bacillus*	*Staphylococcus*	*Micrococcus*	*Streptococcus*
Surgery	13	37	39	11
Pediatric	28	20	38	14
Restorative	31	7	37	25
Prosthesis	16	20	43	21
Endodontic	23	15	34	28

human body, it can lead to dangerous skin diseases if it changes to pathogenic strains, or the immune system is weakened.

In this study, the rate of airborne bacterial contamination was determined in various sections of the educational dentistry clinic during different therapeutic processes at two different distances (0.5 m and 2 m) from units. Our results showed a similar concentration of airborne bacteria in different sections of the clinic as compared with other studies. However, it is noteworthy that comparing the concentration of airborne bacteria between different studies is problematic and somewhat inapplicable since microbial aerosols in a dentistry clinic can be affected by various factors such as the type and location of air sampling, as well as environmental factors. Using a standard air sampling method and taking similar samples from the same distances from units can provide an opportunity for making a credible comparison. Our results showed that the concentration of airborne bacteria in the pediatric section was significantly higher than other sampling sections. This can be probably due to the type of treatments performed in this department, as well as the higher number of people, dentists, and staff in this section. Previous studies have reported that, depending on the department and the type of the treatment process, the concentration and composition of bioaerosols vary among patients.[10,17] Previous findings have also shown that the highest concentration and dispersion of aerosols occur when ultrasonic scalers and high-speed handpieces are utilized.[18]

In a study by Malakootian *et al.,* 89% of the air samples of dentistry clinics in Yazd had microbial contamination.[19] In the recent study, the rate of contamination was significantly associated with the number of patients, the space of offices and clinics, the type of application, and work and nonwork shifts, but not with the number of units.[19]

The concentration of airborne bacteria at a distance of 0.5 m from the unit in the pediatric, restorative, and endodontic wards was significantly higher compared with a distance of 2 m from the unit. In parallel, Manarte-Monteiro *et al*. showed that the number of bacteria in the air at a distance of 0.5 m was significantly higher than that of 2 m when root canal treatments were delivered.[2] In contrast to the present results, Rautemaa *et al.* reported that bacterial density was found to be higher in the more remote (>1.5 m) sampling points, believing that the rapid rotation of the tool would cause the bacteria to disperse faster and to a longer distance.[12] Chiramana *et al.* observed that the maximum aerosol dispersion occurs at a distance of 0.6 m from the patient and at all angles while all-angle aerosol dispersion is negligible at a distance of 1.8 m.[20] A study on the risk of contamination of dentists' faces through the aerosols dispersed due to the movements of high-speed handpieces during treatment reported that aerosols most commonly contaminated eyes and nose surroundings.[21]

We also noticed that Gram-positive cocci were the predominant species, which was in agreement with previous studies in which *Micrococcus*, *Bacillus*, *Streptococcus*, and *Staphylococcus* species were the most common bacteria isolated from the air of dentistry clinics.[1,2,17] *Micrococcus* and *Staphylococcus* have a human source, and *Streptococcus*, as a part of the flora of human skin, respiratory system, and gastrointestinal tract, is the most important cause of infections in immunocompromised patients. In the study of Lasemi *et al*. in 2010, *Staphylococci* were found to be present in the air of all the educational departments of the dentistry unit of Islamic Azad University, and the ratio of pathogenic bacteria such as hemolytic *Streptococcus* and *S. aureus* was higher in the surgery room than in other wards.[22]

Conclusion

The results of this research showed that the number of bacteria in the dentistry clinic environment increased during the treatment process, emphasizing on the need for managing the potential risk of infection transmission to physicians, dentistry staff, and patients through contaminated surfaces and air in dentistry clinics. The clinic's space, the types of the ward and treatment process, and distance from the unit are among the factors affecting the type and diffusion extent of microbial aerosols. Upgrading the dentistry clinic's ventilation system and periodic microbial screening of surfaces and indoor air in different departments under the supervision of an Infection Control Committee will effectively prevent infection transmission in these clinics.

Acknowledgments

The authors wish to extend their thanks to the school officials for their assistance during the study. This article was obtained from a research proposal approved by the Research Ethics Committee of Arak University of Medical Sciences (code IR.ARAKMU.REC.1398.010).

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. 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.
2. Manarte-Monteiro P, Carvalho A, Pina C, Oliveira H, Manso MC. Air quality assessment during dental practice: Aerosols bacterial counts in an universitary clinic. Rev Port Estomatol Med Dent Cir Maxilofac 2013;54:2-7.
3. Vilarinho Oliveira AM, de Alencar RM, Santos Porto JC, Fontenele Ramos IR, Noleto IS, Santos TC, *et al.* Analysis of fungi in aerosols dispersed by high speed pens in dental clinics from Teresina, Piaui, Brazil. Environ Monit Assess 2018;190:56.
4. Mirhoseini SH, Koolivand A, Bayani M, et al. Quantitative and qualitative assessment of microbial aerosols in different indoor environments of a dental school clinic. Aerobiologia 2021;37:217-24.
5. Kadaifciler DG, Cotuk A. Microbial contamination of dental unit waterlines and effect on quality of indoor air. Environ Monit Assess 2014;186:3431-44.
6. Zemouri C, de Soet H, Crielaard W, Laheij A. A scoping review on bio-aerosols in healthcare and the dental environment. PLoS One 2017;12:e0178007.
7. Mirhoseini SH, Nikaeen M, Shamsizadeh Z, Aali R. Prevalence and

molecular identification of antibiotic resistant airborne bacteria at intensive care units. Koomesh 2018;20:772-8.
8. Mirhoseini SH, Dehdashti FA, Mohammadi S. A comparative evaluation of bioaerosol emission and particle matter concentration in urban primary schools. Int J Env Health Eng 2020;9:21.
9. Chuang CY, Cheng HC, Yang S, Fang W, Hung PC, Chuang SY. Investigation of the spreading characteristics of bacterial aerosol contamination during dental scaling treatment. J Dent Sci 2014;9:294-6.
10. Choi JO, Choi YJ, Nam SH. Study on the prevention of cross-infection by aerosols during scaling. Biomed Res 2018;29:3479-82.
11. Khorakian F, Movahed T, Ghazvini K, Karbasi S, Tabrizi Nouri S, Bahramian L, *et al*. Evaluation of frequency of microbial contamination in clinical setting surface in dental school of Mashhad university of medical sciences. J Mashhad Dent Sch 2017;41:209-18.
12. Rautemaa R, Nordberg A, Wuolijoki-Saaristo K, Meurman JH. Bacterial aerosols in dental practice – A potential hospital infection problem? J Hosp Infect 2006;64:76-81.
13. Valian A, Shahbazi R, Farshidnia S, Tabatabaee F. Evaluation of the bacterial contamination of dental units in restorative and peridontics departments of dental school of shahid beheshti university of medical sciences. J Mashhad Dent Sch 2014;37:345-56.
14. 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. Sci Total Environ 2010;408:4045-51.
15. Smith G, Smith A. Microbial contamination of used dental handpieces. Am J Infec Control 2014;42:1019-21.
16. Kurita H, Kurashina K, Honda T. Nosocomial transmission of methicillin-resistant *Staphylococcus aureus* via the surfaces of the dental operatory. Br Dent J 2006;201:297-300.
17. Kimmerle H, Wiedmann-Al-Ahmad M, Pelz K, Wittmer A, Hellwig E, Al-Ahmad A. Airborne microbes in different dental environments in comparison to a public area. Arch Oral Biol 2012;57:689-96.
18. Szymańska J. Dental bioaerosol as an occupational hazard in a dentist's workplace. Ann Agric Environ Med 2007;14:203-7.
19. Malakootian M, Molazadeh P, Eskandarizadh A. Microbial and fungal contamination of air at dental clinics and dental offices in kerman. Tooloebehdasht Yazd 2015;13:13-24.
20. Chiramana S, Bindu OS, Kadiyala KK, Prakash M, Prasad TD, Chaitanya SK. Evaluation of minimum required safe distance between two consecutive dental chairs for optimal asepsis. J Orofac Res 2013;3:12-5.
21. Nejatidanesh F, Khosravi Z, Goroohi H, Badrian H, Savabi O. Risk of contamination of different areas of dentist's face during dental practices. Int J Prev Med 2013;4:611.
22. 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. J Res Dent Sci 2011;7:7-11.