ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at:www.ijdsir.com

Volume – 8, Issue – 2, March – 2025, Page No. : 104 - 111

Assessment of Microbial Contamination of Aerosols in Speciality Dental Clinics- An Institutional Cross-Sectional Study

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Citation of this Article: Dr Geerthanaa Muthu, "Assessment of Microbial Contamination of Aerosols in Speciality Dental Clinics- An Institutional Cross-Sectional Study", IJDSIR- March – 2025, Volume – 8, Issue – 2, P. No. 104 – 111.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Introduction: This research evaluates the bacterial load in specialized dental clinics to optimize infection control within an institution. It focuses on aerosol transmission, particularly in the 0.5 to 10 μm range, highlighting the risks of cross-contamination in dentistry. The microorganisms present in the dental clinic can lead to cross-infection among dentists, auxiliary staff, and patients.

Aim: To compare and evaluate the bacterial load in the aerosols across different specialty dental clinics of an institution using settle plate method

Material and methods: The present study was conducted over five days in an institution. 105 environmental samples were collected using settle plate method from seven speciality dental clinics at specific time points: 30 minutes before the institution's work hours commenced (Group I), during peak hours of institutional activity (Group II), and 30 minutes after the conclusion of work hours (Group III). After the collection of samples, the blood agar culture medium plates were incubated at 37°C in an incubator for 24 h. The number of colonies was expressed as colonies per media plate. Samples were assessed for growth, colony-forming units (CFU), and morphology. Data were tabulated and statistically analysed for significance

Results: The study conducted over five days analyzed mean CFU values within and between departments across Group I ($p < 0.05$), Group II ($p < 0.001$), and Group III ($p < 0.001$) time points. Significant differences ($p < 0.05$) were observed between departments within each group, indicating varying bacterial loads. Temporal variations in bacterial colonization within the dental clinics were evident across the studied time intervals.

Conclusion: Our study highlights the significant aerosol load and varying levels of bacterial contamination across dental departments, emphasizing the need for rigorous infection control measures, especially during peak clinic hours. The observed decline in aerosol and bacterial contamination levels post-operational activity underscores the effectiveness of cleaning protocols in reducing environmental risks within dental settings.

Keywords: colony-forming units, infection control, microbiota, occupational health, Settle plate method

Introduction

In the dental setting, the term "aerosol," as introduced by Micik and colleagues refers to particles with a diameter less than 50 micrometers. These small particles can remain suspended in the air for an extended period, potentially leading to contamination of surfaces or inhalation into the respiratory system. Among these aerosol particles, those ranging from 0.5 to 10 μm in diameter are of particular concern due to their ability to penetrate and become lodged in the smaller air passages of the lungs, posing a higher risk of disease transmission. [1] In dentistry, infection control is a key concern due to the potential transmission of infections through saliva, blood, direct/indirect contact, and aerosols generated during treatments. Contaminated instruments and equipment also contribute to this risk. Bioaerosols, carrying hazardous microorganisms and toxins, can lead to cross-contamination in dental clinics. Despite their long-known existence, the significance of these aerosols in dentistry has only recently gained attention, especially after the pandemic. Contaminated clinic air may contain particles from saliva, blood, plaque, and dental materials, posing a significant infection risk to clinic staff and a notable occupational health hazard. [2]

While Grenier in 1995 identified a significant increase in bacterial air contamination during dental procedures in both closed dental operatories and multi-chair clinics, it is important to note that this was an early observation. [3] Passage of time has revealed that ongoing research remains crucial as various factors continue to change, leading to variations in aerosol levels and composition within dental facilities. These factors encompass the evolving landscape of dental procedures, the use of diverse equipment, advancements in ventilation and air filtration technologies, modifications in infection control protocols, and the evolving hygiene practices within dental institutions. Additionally, evolving patient demographics and oral health conditions also play a role in shaping the composition of aerosols generated during dental treatments. Consequently, the need for continued research to address these evolving factors remains paramount.

In this study the bacterial load in such aerosols within the specialty dental clinics at a private dental college were evaluated. This study is pivotal in providing invaluable insights into the environmental microbiota within the dental college, thereby contributing to more methods of infection control and enhancing the safety of dental health professionals and patients.

Material and Methods

The study was conducted in various specialty dental clinics at a private dental college in southern Tamil Nadu, India. Specifically, the study encompassed the following departments:

1. Department of Oral Medicine and Radiology
2. Department of Oral Surgery
3. Department of Periodontology
4. Department of Endodontics
5. Department of Prosthodontics
6. Department of Pedodontics
7. Department of Orthodontics

A total of 105 environmental samples were collected using sheep blood agar plates, employing the Settle plate method. Samples were collected at three specific time points: 30 minutes before the institution's work hours commenced (Group 1), during peak hours of institutional activity (Group 2), and 30 minutes after the conclusion of work hours (Group 3).

The blood agar plates were positioned centrally between four dental chairs on a stainless-steel instrument table (with a 6 feet distance between each chair). After an exposure period of 30 to 40 minutes, the blood agar plates were sealed and promptly transported to the department for further processing within 15 minutes. Subsequently, the plates were incubated at 37°C for 24 hours.

Upon completion of the incubation period, the plates were examined for the presence of bacterial growth. If more than 15 colonies were observed, further analysis was conducted. The colony-forming units were quantified, and colony morphology was documented. Gram staining was performed to evaluate organism morphology.

Sampling was conducted over five different days, and the average mean value over these days was calculated for each group within every department. The collected data were tabulated and subjected to statistical analysis to compare the quantitative bacterial load between different groups within each department and across departments. The results of this analysis were then evaluated for significance.

Results

The sampling process extended over five days, with the mean average values calculated for each group within every department as depicted in Table 1. The collected data was tabulated and subsequent statistical analysis was done to compare the quantitative bacterial load both within and across departments.

Analysis of mean CFU (colony-forming units) values between departments within Group-I revealed significant differences ($p < 0.05$). Specifically, Conservative Dentistry & Endodontics exhibited statistically significant variation compared to Pedodontics ($p = 0.025$) and Orthodontics ($p = 0.006$). Prosthodontics also showed significant differences compared to Pedodontics ($p = 0.035$) and Orthodontics ($p = 0.008$), as demonstrated in Table 2.

In Group-II, comparisons of mean CFU values displayed significant differences ($p < 0.05$) across departments. Notably, Oral Medicine differed significantly from other departments ($p = 0.001$), as did Oral Surgery ($p = 0.001$), Conservative Dentistry & Endodontics ($p < 0.001$), Prosthodontics ($p < 0.001$), and Periodontology ($p < 0.001$), as indicated in Table 2.

Similarly, in Group-III, comparisons of mean CFU values demonstrated significant differences ($p < 0.05$) across departments. Oral Medicine ($p = 0.006$), Oral Surgery ($p = 0.001$), Conservative Dentistry & Endodontics ($p < 0.001$), Prosthodontics ($p < 0.001$), and Periodontology ($p < 0.001$) all exhibited statistically significant variation compared to other departments, as detailed in Table 2.

Within the groups, comparisons of mean CFU values indicated significant differences (*$p < 0.05$ for comparisons with Group-I and $p < 0.05$ for comparisons with Group-II), as illustrated in Table 3. The morphology of the colonies and their respective appearance in Gram's stain is depicted in Table 4.

Table 1: Mean CFU values of different groups

Department	Group-I (MEAN±SD)	Group-II (MEAN±SD)	Group-III (MEAN±SD)
Oral medicine	19.00±1.00	38.60±2.07	19.60±1.87
Oral surgery	19.60±1.14	35.40±4.61	24.80±2.56

Conservative dentistry & endodontics	22.40±3.20	83.40±7.26	65.40±1.49
Prosthodontics	22.20±1.92	72.20±6.49	62.60±2.45
Periodontics	18.80±2.16	78.00±8.39	46.20±3.10
Pedodontics	17.40±1.94	46.40±5.59	36.60±2.19
Orthodontics	16.60±0.54	35.80±2.77	26.60±3.19

Table 2: Comparison of mean CFU values between the departments

Department	Group-I (MEAN±SD)	Group-II (MEAN±SD)	Group-III (MEAN±SD)
Oral medicine	19.00±1.00	38.60±2.07	19.60±1.87
Oral surgery	19.60±1.14	35.40±4.61	24.80±2.56
Conservative dentistry & endodontics	22.40±3.20	83.40±7.26[1,2]	65.40±1.49[1,2]
Prosthodontics	22.20±1.92	72.20±6.49[1,2]	62.60±2.45[1,2]
Periodontics	18.80±2.16	78.00±8.39[1,2]	46.20±3.10[1,3,4]
Pedodontics	17.40±1.94[3, 4]	46.40±5.59[3,4,5]	36.60±2.19[1,3,4]
Orthodontics	16.60±0.54[3,4]	35.80±2.77[3,4,5]	26.60±3.19[1,3,4]

Table 3: Comparison of mean CFU values within the groups

Department	Group-I (MEAN±SD)	Group-II (MEAN±SD)	Group-III (MEAN±SD)	p value
Oral medicine	19.00±1.00	38.60±2.07*	19.60±1.87*	0.03
Oral surgery	19.60±1.14	35.40±4.61*	24.80±2.56	0.04
Conservative dentistry & endodontics	22.40±3.20	83.40±7.26*	65.40±1.49*,#	0.001
Prosthodontics	22.20±1.92	72.20±6.49*	62.60±2.45*	0.001
Periodontics	18.80±2.16	78.00±8.39*	46.20±3.10*,#	0.001
Pedodontics	17.40±1.94	46.40±5.59*	36.60±2.19*	0.02
Orthodontics	16.60±0.54	35.80±2.77*	26.60±3.19*	0.03

(*p<0.05 significant compared group-I with other groups, #p<0.05 significant compared group-II with other groups.

Table 4: Morphology of the colonies and their respective appearance in Gram's stain

Morphology of the colonies	Appearance in Gram's stain
Small yellow colony	Gram negative cocci
Big white colony	Gram positive bacilli
Small white colony	Gram positive cocci

Figure 1: Comparison of mean CFU values between the departments of Group II

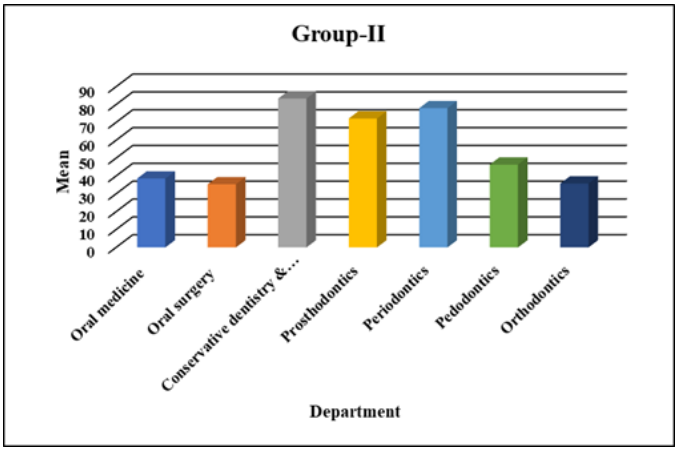
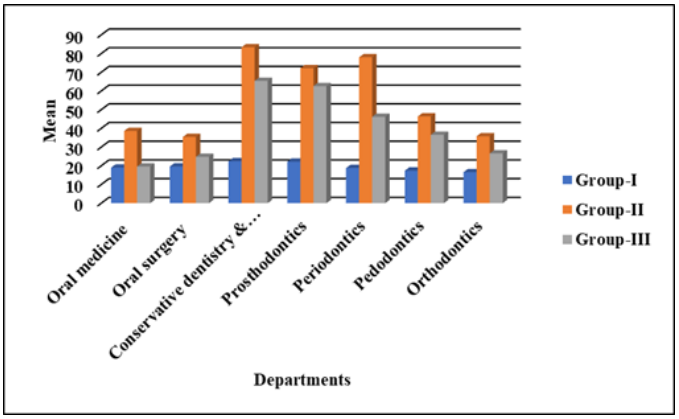


Figure 2: Comparison of mean CFU values within the groups



Discussion

The creation of aerosols and splatter in dentistry poses a significant health risk. Aerosols generated during dental procedures carry microorganisms that can cause infections among both dental professionals and patients. The human oral cavity houses more than 700 species of bacteria and other infectious microbes, including viruses and fungi, which can be released into the air through aerosol-generating procedures (AGPs). This airborne transmission of pathogens can contribute to respiratory health issues and facilitate the bidirectional spread of diseases. Given the proximity between patients and dentists during procedures in a dental setting, the risk of respiratory infections in this environment is notably heightened. [4] Few studies show no increased risk of respiratory diseases among dental students but have not included studies on dental staff, possibly overlooking relevant research. [5,6]

In areas where dental procedures involving aerosol-generating equipment are performed, there has been a significant increase in airborne bacteria, as noted by Sawhney in 2015. [7] The General Dental Council (GDC) in the UK classifies specific dental procedures as Aerosol Generating Procedures (AGPs). These include the use of high-speed handpieces for restorative procedures, ultrasonic scalers, high-pressure air syringes, tooth polishing, air-driven surgical handpieces, air abrasion, tooth drainage, definitive crown or bridge cementation, surgical tooth extraction, and implant placement (FGDP 2020; GDC 2020; WHO 2020d).[8-10] Additionally, certain non-AGPs like intraoral radiography can induce gag reflexes, potentially leading to coughing or sneezing and the creation of aerosols. [11]

Based on the results of the present study, the higher mean CFU values observed in the departments of Conservative Dentistry & Endodontics and Prosthodontics suggest a potentially higher aerosol load in these clinical areas compared to others. The significant differences in CFU values indicate varying levels of bacterial contamination among departments, with Conservative Dentistry & Endodontics and Prosthodontics standing out notably. Furthermore, the increase in CFU values from Group I to Group-II across all departments highlights a rise in bacterial load during peak hours of institutional activity, likely due to increased aerosol generation from dental procedures. This trend underscores the importance of infection control measures and aerosol management protocols during busy clinic hours. Conversely, the decline in CFU values observed in Group III following the conclusion of

work hours suggests a reduction in aerosol and bacterial contamination levels post-operational activity. This decline signifies the effectiveness of cleaning procedures or reduced aerosol-generating activities after clinic hours, contributing to a lower risk of environmental contamination and potential infection spread during non-operational periods.

The findings from the present study align with the concerns highlighted by Harrel and Molinari (2004) regarding the transmission risks associated with dental aerosols. While complete elimination of this risk is challenging, they advocated for practical and cost-effective precautions. These include the use of universal barrier precautions, preprocedural rinses, rubber dams when feasible, and high-volume evacuation (HVE) for all procedures. Employing these precautions could significantly minimize the risk of aerosolized infection spread. [1]

The findings from the present study align with the study conducted by Seyed Hamed Mirhoseini and colleagues (2021). Both studies highlight the departments of Conservative Dentistry & Endodontics and Prosthodontics as areas with potentially higher aerosol loads, suggesting an increased risk of environmental contamination and infection transmission compared to other clinical areas. Mirhoseini et al. specifically identified pediatric and periodontics wards as having the highest counts of airborne bacteria and fungi, underscoring the varied sources of microbial aerosols originating from patients, treatment procedures, and human activity. The significant increase in bacterial and fungal aerosol levels observed closer to the dental chair during treatment procedures underscores the localized impact of dental activities on airborne microorganisms. [12] In a similar study by Manish Jain and colleagues (2020) found that colony counts increased during and after dental work sessions, with the highest increase in the department of periodontology. S. epidermidis was the most prevalent bacterium, followed by micrococcus, diphtheroid, fungi, and S. aureus. This study highlights the elevated aerosol levels during and after dental procedures, increasing the potential for infectious agent transmission in clinical environments. [2]

In their review, Ilona G Johnson and colleagues (2021) focused on the impact of the SARS-CoV-2 virus on routine dentistry, especially periodontal care. The review included 50 studies on procedures like ultrasonic scaling, air polishing, prophylaxis, and hand scaling. Contamination was found in all procedures, even with suction, with higher power settings leading to more contamination. The contamination varied in location, affecting the operator, patient, and assistant. It was generally low to medium-quality evidence but highlighted the need for infection control, thorough cleaning around patients, and appropriate personal protective equipment, particularly respiratory, facial, and body protection. [13] In contrast, our study focuses on comparing bacterial load across different departments and periods within dental clinics, revealing higher CFU values in specific clinical areas during peak operational hours. However, the findings of both studies collectively emphasize the need for comprehensive infection control protocols and heightened awareness of aerosol management strategies in dental settings to ensure the safety and protection of dental personnel and patients alike.

Implementing strategies to minimize aerosol production in dental settings is crucial for preventing disease transmission. Various approaches can be employed to achieve this goal. For instance, using antimicrobial mouthwash before procedures can help decontaminate the oral cavity, while placing rubber dams around treated

teeth can prevent aerosols from escaping. Additionally, using high-volume suction devices can effectively remove aerosols from the treatment area, and maintaining good general ventilation, such as by keeping windows open, can reduce aerosol concentration in the air. Furthermore, air decontamination methods like ultraviolet light sterilization can be utilized. These interventions can be used individually or in combination to enhance effectiveness. Research studies have examined the impact of these interventions on disease transmission, considering factors such as cost, acceptability by patients and dentists, and ease of implementation. [14]

The present study's limitations arise from variable factors that could not be predetermined due to their dependence on the inpatient flow on the participant day and nature of the treatment procedure being done. These factors should be carefully considered as they could influence the bacterial load during the specific time. To mitigate this bias, samples were collected on five different days, and the average values were calculated. The variable factors include the number of walk-in dental staff in the area, number and nature of treatment procedures performed.

Conclusion

The present study underscores the critical need for robust infection control measures in dental clinics, particularly during peak operational hours when aerosol generation is heightened. Departments like Conservative Dentistry & Endodontics and Prosthodontics exhibit higher aerosol loads, emphasizing targeted interventions in these areas. Implementing strategies to minimize aerosol production, such as using rubber dams and high-volume suction devices, can mitigate the risk of environmental contamination and disease transmission in dental settings. Continued research and adoption of effective interventions are imperative to safeguard the health of both dental professionals and patients amidst the ongoing challenges posed by aerosol-generated pathogens.

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