Dental Research Journal

Review Article

Redefining aerosol in dentistry during COVID-19 pandemic

Kanupriya Rathore[1], Harshvardhan Singh Rathore[2], Pranshu Singh[3], Pravin Kumar[1]

[1]Department of Dentistry, All India Institute of Medical Sciences, Jodhpur, [2]Department of Radio Diagnosis, Dr SN Medical College, Jodhpur, Rajasthan, [3]Department of Psychiatry, Postgraduate Institute of Medical Education and Research, Chandigarh, India

ABSTRACT

The corona virus malady 2019 (COVID-19) pandemic has rekindled the well established argument regarding the role of dental aerosol in transference of severe acute respiratory syndrome corona virus 2 (SARS-CoV-2). Aerosols and droplets are generated amid innumerable dental procedures. With the commencement of the COVID-19 pandemic droplet, a review of the infection/disease control strategies for aerosols is required. We do not know where this pandemic is directed. We do not have conclusive evidence for an optimal management strategy. Every day brings in varying information, so recognizing the hazard created by aerosols will help diminish the probability of infection transfer at the time of dental procedures. Hence, the author assessed the evidence-based medical and dental literature in relation to "aerosol' that documented the source of transmission of aerosol through various potential routes, addressed the risk potential to patients and the dental team, and assessed the additional measures that might minimize the viral transmission if regularly adopted. In this article, the author evaluated and compiled dental guidelines by various countries and various health-care associations in context to aerosol-generating procedures and has made recommendations for the restriction of dental aerosols and splatter in routine dental practice.

Key Words: Aerosols, COVID-19 virus, dentistry, severe acute respiratory syndrome coronavirus-2

Received: 26-May-2021
Revised: 19-Jul-2021
Accepted: 17-Oct-2021
Published: 18-Jul-2022

Address for correspondence:
Dr. Kanupriya Rathore, Department of Dentistry, All India Institute of Medical Sciences, Jodhpur, Rajasthan, India.
E-mail: rathorekanu@gmail.com

INTRODUCTION

It has been stated that the mouth is a Petri dish and the cavity of the mouth is home to mutliplex, potent, and diversified microbiologic compilations in the human body. Current studies propose that up to 1000 bacterial species exist in the oral cavity, occupying several diverse microbial niches, for example saliva, teeth, gingival sulcus, hard and soft palate, tongue, cheek, lip, and attached gingival.[1,2] By now, over 700 microbial species have been detected in saliva, many of which are associated with oral and systemic infections.[3] Since saliva can host many distinct viruses including severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), the transmission risk of viruses through saliva is inevitable in a dental office. The WHO has asserted that the pandemic virus of SARS-CoV-2 could have a profound repercussion on dentistry as it predominantly transmits through droplets and aerosols.[4] Aerosols can be defined as "suspensions of liquid and/or solid particles in the air generated by coughing, sneezing, or any other act that expels oral fluids into the air."[5] Dental procedures can provoke generation of the cross-infection, droplets, aerosols, and spills that are contaminated

Access this article online

Website: www.drj.ir
www.drjjournal.net
www.ncbi.nlm.nih.gov/pmc/journals/1480

How to cite this article: Rathore K, Rathore HS, Singh P, Kumar P. Redefining aerosol in dentistry during COVID-19 pandemic. Dent Res J 2022;19:53.

with saliva, which may specifically infect uncovered skin/conjunctiva/mucosa, or be breathed in by the professional, causing potential cross-contamination. In addition, saliva-infected aerosols and droplets can also contaminate inanimate areas in the dental operatory which too may lead to nosocomial infection.[6] Dentists are at a high occupational risk of infection; therefore, we have to be proactively vigilant and pursue rigorous infection control protocol. We suspect getting to be another SARS-CoV-2 casualty, being an asymptomatic spreader, and tainting members of our family. Therefore, this review focuses on highlighting the potential sources and factors correlated with the transmission of aerosols, types of pathogens they can harbor, primary properties of aerosols generated during routine human activity and everyday dental procedures, its hazardous effects, and the different techniques to manage aerosol and to decrease the risk of cross-infection to patients and health-care workers.

MATERIALS AND METHODS

Literature research

The electronic research was carried out by searching the PubMed and Advanced Search (Basic Search) catalog to search evidence-based clinical trials related to aerosol-generating dental procedures and strategies adopted to prevent aerosol. A Google search was conjointly been undertaken to seek out different recommendations for dental practice and dental guidelines in context to aerosol generating procedures throughout COVID-19 pandemic. The electronic research was complemented with a hand search of the following websites: "Irish Dental Association, American Dental Association, Australian Dental Association, Swiss Dental Association, The Royal Dutch Dental Association, Scottish Dental Clinical Effectiveness Programme, Centers for Disease Control and Prevention, Biosafety Working Group of the São Paulo Regional Dentistry Council, Royal College of Dental Surgeons of Ontario, Chinese Stomatological Association, Croatian Chamber of Dental Medicine, Dental Council of India, Irish Dental Association, Myanmar Dental Association, Norway Dental Health Service – FHI, Philippine Dental Association Science Committee, The Polish Dental Association, Spanish National Dentistry Council."

Three search strings were run in PubMed from inception to April 01, 2021. Search terms were combined in the search strategy using Boolean operators [Supplementary 1]. In PubMed, the following strings were combined: ([aerosols {Mesh} OR aerosol OR aerosols OR bioaerosol OR bio-aerosol OR "bio aerosol" OR bio-aerosols OR "bio aerosols"] OR ["Aerosol generating procedures"]) AND (COVID-19).

Study Selection

Eligibility assessment of the studies was performed independently in an unblinded standardized manner by three investigators (KR, HR, and PS). After initial search and duplicate removal, titles of the identified studies were reviewed for relevance to the review question. Further, the abstracts and full texts of the eligible studies were evaluated independently and the articles addressing review questions specifically were selected for the review. If any disagreements between reviewers occured regarding the inclusion of studies they were resolved by consensus and discussion with the fourth reviewer (PK).

SOURCE OF AEROSOL GENERATION

Aerosols generated during routine activities

During this COVID-19 pandemic, all of us have remained incredibly focused on aerosol-generating procedures (AGPs), but it is crucial to recognize that aerosols are additionally generated via routine human activities (e.g., respiration).[7] Papineni and Rosenthal have revealed that around 90% of the particles produced by human expiration are <1 µm.[8] Table 1 shows the outcome of an experiment performed by Duguid,[9-10] who concluded that 95% particles were lesser than 100 µm, and the greater number were between 4 and 8 µm. The majority of small droplets emerge from the front of the mouth and a few, from the nose or from the throat.

Aerosol-generating procedures in dentistry

AGPs can be defined as "any medical or patient care procedure that results in the production of airborne particles (aerosols)"[11] Table 2.[12-19] According to a review, use of high-speed handpieces and 3-in-1 syringes account for 56% of the AGPs, powered (sonic/ultrasonic) scalers for 43%, slow-speed handpieces for 29%, and surgical handpieces account for 22% AGPs.[17] In spite of the fact that the aerosols do not have a dominant role in the transference of SARS-CoV-2 in the usual everyday functions, the status is dissimilar within the dental operatory. This is because many dental devices need a water splash to cool the operating tip and to restrict heat generation.

Table 1: The number of droplets produced throughout human expiration and the region of their origin

Activity	Number of droplets generated (range)	Region of origin
Respiratiory function (for 5 min)	0-few	Nose
Single normal nasal expiration	Few–few hundred	
Laughing (for 1 min)	0-few	Facial region
Counting feebly (1-100)	Few–few dozen	
Counting aloud	Few dozen–few hundred	Oral
A single cough with open mouth	0–few hundred	Oral
A single cough with closed mouth	Few hundred–many thousand	Oral
Single sneeze	Few hundred thousand-few million Few–few thousand	Oral Nasal and facial region

Table 2: Aerosol generating dental procedures and methods to minimize contamination

Dental procedure	Cause of aerosol production	Methods to minimize aerosol
Ultrasonic and sonic scalers	The cavitation effect of an ultrasonic scaler, utilized in combination with controlled water spray during scaling produces countless airborne particles derived from blood, saliva, tooth debris, dental plaque, and calculus. The incorporation of blood products within the aerosol is more during root planning	High-volume suction Antiseptic mouthwashes
Air polishing	After the scaling procedure, air polishing is done to smoothen up the tooth surface. It is done by a device that releases pressurized air to remove all the debris and plaque, which generates aerosols in high numbers near the operatory site	High-volume suction Antiseptic mouthwashes
Air/water syringe	The water released from this device comes through a waterline that is connected to the dental chair which is a hub for many microorganisms which can easily enter oral cavity. Also, the compressed air with water can generate aerosols	Regularly sterilize this syringe since it gets placed in multiple oral cavities, decontamination of DUWLs
Air turbine handpiece/air rotor	After combining with body fluids such as saliva and blood in the mouth, water coolant could generate bioaerosols	use mouthwash, rubber dam, high-speed evacuation, decontaminate DUWLs
Orthodontic procedures	Aerosols are generated by the use of water spray during enamel etching and also during the removal of composite following completion of fixed orthodontic appliance treatment	Minimize use of water-spray syringe, use antiseptic mouthwash, nonetching mediated bonding, biomimetic bonding agents (eliminate use of rotary instruments), carbide tungsten bur

Other aerosol-generating dental procedures: Preparation of intra-coronal cavities, Crown preparations, Reducing high points new restorations, Removal of old restorations, Any procedure that requires acid etching followed by rinsing and drying, Endodontic therapy. DUWLs: Dental unit waterlines

The water, when combined with compressed air, is used as a coolant, and spraying generates aerosols that become infected with microbes from mouth.[18] A water sprayer is also utilized to lavage the operating site to increase the operator's vision.[12] A COVID-positive patient bears several viruses in his saliva and on tongue.[19] If aerosols generated procedures are performed on these individuals, they are likely to transfer the virus to the dentist.[20] The mean level of bioaerosols generated depends on the procedures; greater levels of aerosol are produced during cavity preparation (24–105 CFU/m^3) and for ultrasonic scaling (42–71 CFU/m^3), and lower levels for extraction (9–66 CFU/m^3) and for clinical examination of oral cavity (24–62 CFU/m^3).[21] Most studies have reached the conclusion that bioaerosols return to baseline 2 h after the dental procedure.[22] The sites displaying the greatest microbial contamination due to splatter and aerosol are masks of the operator and assistant, a unit lamp, areas close to spittoons, and mobile instruments. A dental surgeon operates from about ≤60 cm from the patient's mouth. Recent research shows that the greatest amount of microbial contamination in the dental operatory takes place not beyond 1 m from the mouth, through both aerosols and splashes.[23]

MODES OF TRANSMISSION OF AEROSOL

Direct and indirect contact

Cross-transmission of the pathogen [Table 3] in dental setups via direct contact can occur through hands, improperly sterilized instruments, or needle stick mishaps.[24] The prime contagion route includes inhalation of those pathogens that remain suspended in environment and later descend upon surfaces.[25] This happens because even after the treatment is completed, aerosols hover within the dental clinic air, with

Table 3: Pathogenic microorganisms in a dental clinic sorted by their prime transference route[24]

Transference through direct contact		Transference through blood-blood contact		Transference through dental unit water and aerosols	
Viruses	**Bacteria**	**Viruses**	**Bacteria**	**Viruses**	**Bacteria**
Herpes simplex virus types 1/2	*Staphylococcus aureus*	Hepatitis viruses (HBV, HCV, HDV)	*Neisseria gonorrhoeae*	Cytomegalovirus	*Streptococcus pyogenes*
Norovirus	*Escherichia coli*	HIV	*Treponema pallidum*	Measles virus	*Mycobacterium tuberculosis*
Coxsackievirus				Mumps virus	*Legionella pneumophila*
				Respiratory viruses (influenza, rhinovirus, adenovirus)	*Pseudomonas aeruginosa*
				Rubella virus	

HBV: Hepatitis B virus, HCV: Hepatitis C virus, HDV: Hepatitis D virus, HIV: Human immunodeficiency virus

heavier and bigger particulates descending sooner.[20] Settling occurs in almost all areas, after which these can possibly act as a medium for transference of the SARS-CoV-2 virus via indirect contact. Researches prove that the viable virus was still present on plastic surfaces even after 72 h for up to 7 days.[26] Recent research has revealed that the COVID causing coronavirus can persist on some surfaces for up to 9 days.[27] Indirect transmission is through a fomite, "an object that has been in contact with an infected person and can thus spread the infection to another person." Irrespective of the route of transference, the minimum dose of SARS-CoV-2 dose that can be contagious has not yet been confirmed. Hence, regardless of the level of infection, all areas that are potentially aerosol contaminated or touched by patients must be considered as a potential source of infection [Figure 1].

Blood contact

The greatest incidents of transmission in clinic happen if microbes are transferred directly from blood (e.g., of the patient) to blood (e.g., of the dental health-care personal). These mishaps occur throughout the medical fraternity, but dental surgeons are comparatively at a greater risk. The possibility of transference of blood-borne pathogens is consequently an occupational health hazard, as dental health-care personal regularly handle sharp equipments and needles and many times, they work under indirect vision, hence injuring their fingers.[28]

Airborne route

Airborne transference is distinct from droplet transference because it indicates the existence of microorganisms in droplet nuclei, which are commonly recognized as particles <5 µm in diameter. These particles can hover in environment for a prolonged time and may transmit to other individuals over distances more than 1 m [Figure 1]. Three probable sources of airborne infection amid dental procedure are saliva and respiratory sources, dental instrumentation, and from the treatment site.[29]

Dental unit waterlines

The water from dental unit waterlines (DUWLs) is utilized amid procedures to cool the operating unit; this is required for a safe dental procedure. At the same time, this coolant could be a potential source of transference of virulent microbe. Water in the DUWLs can be contaminated from water coming back from the patients' side into the DUWLs as well as from the microbes from the incoming water.[30]

Shortly after the first use of the DUWLs, a multispecies biofilm develops within the inner surface of the waterlines.[31] The various factors responsible for adherence and flourishment of biofilms are damp environment of the DUWLs at room temperature and the used fabrics of the DUWLs. Both dental health workers and patients are risked of infected water from the DUWLs directly or indirectly (through aerosols, generated via dental handpiece).[32]

RISKS OF COVID-19 TRANSMISSION IN DENTAL HEALTH CARE

The transference of SARSCoV-2 primarily happens via aerosol and droplets. SARSCoV-2 can stay in aerosol for up to 3 h and has a comparatively longer half-life of almost 1.1–1.2 h.[26] Meng *et al.*[33] revealed the incidence of nine COVID-19 cases amid 169 dental professionals, emphasizing the significant hazard of contagion to professionals.

Saliva as a source of aerosol transmission

WHO has claimed that the novel coronavirus (2019-nCoV) transmits principally through saliva droplets or discharge from the nose.[4] SARS-CoV-2 has the three different courses to show in saliva. It might enter the oral cavity through the lower and upper respiratory tract; SARS-CoV-2 within the blood may infiltrate the oral cavity through the gingival crevicular fluid; the salivary gland can be infected by this virus, with the particle discharge into the saliva via salivary ducts.[34] As SARS-CoV-2 can be identified in saliva,[19] the hazard of transference of viruses that cause respiratory diseases via saliva cannot be overlooked within the dental setup; hence, the transference-based protections ought to be taken within the dental operatory.[33] COVID-19-positive patients without any symptoms may show up for the emergency in dental clinics. These patients are assumed to have infected saliva and are confirmed sources of contamination. Also, the nasolacrimal duct is associated with the conjunctival mucosa and the upper respiratory tract, and they share ACE2 on their cell membranes,[35] this endangers the dentist to the possibility of contamination through direct exposure of conjunctiva to splatter/droplets from patients amid the various dental procedures.

ACE2 is the prime host cell receptor of SARS-CoV-2 and plays an integral part in the access of virus into the cell.[36] The research laboratory results prove that angiotensin-converting enzyme-2 is expressed highly on oral mucosa epithelial cells, advocating that the mouth is at more risk for SARS-CoV-2 infection.[37]

Role of particle size in transmission

Aerosols are assorted mostly depending on their particle size [Table 4][25,38,39]: Spatter is more than 50 µm, droplet is <50 µm, and a droplet nucleus is <10 µm. In dental environments, 90% of the aerosols generated are usually <5 µm[40] There is continuing

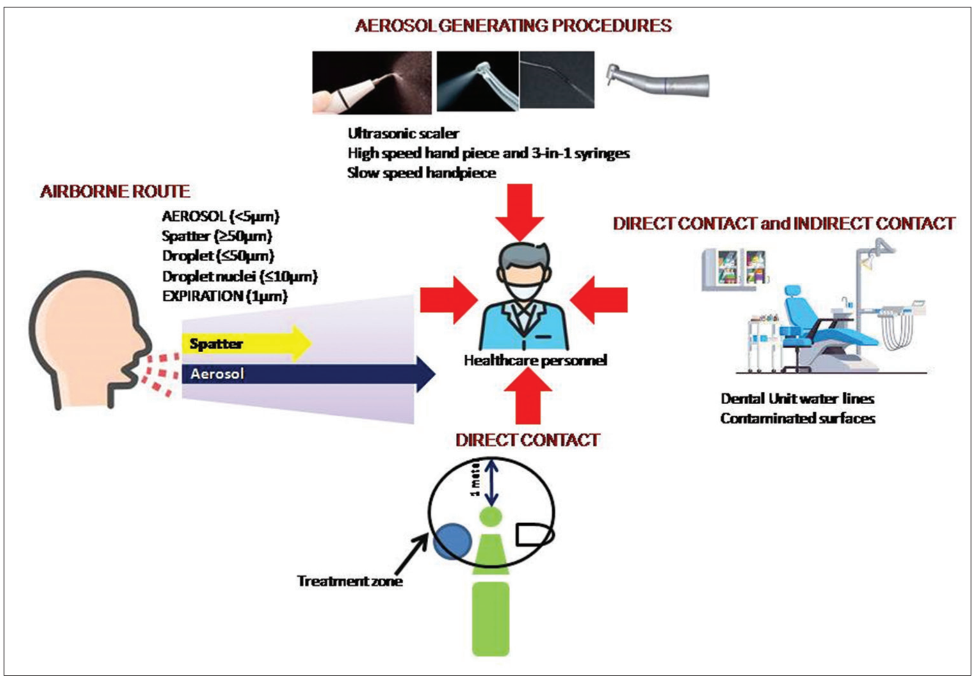


Figure 1: Modes aerosol transmission in dental clinics.

Table 4: Difference between aerosol and splatter

Aerosols	Splatters
Size – particles less than 50 µm in diameter	Size – airborne particles more than 50 µm in size
Cannot be seen with naked eyes	Seen with naked eyes
Particles of this size are small enough to stay in the air for a long time even after the completion of the dental procedure	Particles of this size are ejected forcibly from the operating site and arc in a trajectory similar to that of a bullet until they contact a surface. Splatter evaporates, leaving smaller particles called droplet nuclei
The aerosol particle of size ranging between 0.5 and 10 µm in diameter can easily enter and lodge in the smaller tracts of the lungs	As these particles are too large to become suspended in the air and are airborne only briefly, shows limited penetration into the respiratory system
Carried in air currents for great distances	Unaffected by air currents, travel in ballistic manner
Subsizes – particulate matter 2.5 µm – reach alvelous Particulate matter 10 µm reach higher respiratory tree	No subsizes, grossly contaminate surfaces such as the skin, hair, clothing, and operatory
Possible mode of transmission – inhalation	Possible mode of transmission – direct contact or from dust

Table 5: Summary of aerosol-generating procedures[17]

Country	AGP details	PPE	Procedural mitigation	Environmental mitigation
Country-Ireland Source-Irish Dental Association Updated on May 15, 2020	Not reported	Face mask - FFP2, Fit test required, eye protection, disposable apron, surgical cap/hat, and shoe covers not recommended	Mouthwash not recommended, rubber dam, high-volume suction	Dentaloperatory cleaning immediately after AGP is not required unless a patient has known or suspected COVID-19
Country-Australia Source-Australian Dental Association	High-speed handpieces, 3-in-1 syringe, powered scalers, lasers	Face mask - Level 2/3 surgical mask or P2/N95 respirator, fit test required, Protective eyewear, Face shields in conjunction with surgical mask, Surgical gown, Disposable apron	Rubber dam – High-level evacuation, preprocedural mouthwash 1% hydrogen peroxide	A negative pressure room, Social distancing in the waiting room. Keep minimum items in dental clinic
Country-Canada Source-Royal College of Dental Surgeons of Ontario Updated on May 31, 2020	High-speed, low-speed, other rotary handpieces, powered scalers, 3-in-1 syringes	Face mask – Level 2 or 3 surgical mask or N95 respirator, Fit-test required, eye protection OR face shield, protective gown	Must avoid AGPs, use lowest aerosol-generating options if necessary. Mouthwash - 1% - 1.5% hydrogen peroxide or 1% povidone-iodine (60 s), rubber dam, high-volume suction	The operatory must be left empty (with the door closed) to permit the clearance and/or settling of aerosols
Country-Kenya Source-Ministry of Health, Director of Healthcare Services, Oral Health Service Published on March 24, 2020	3-in-1 syringe	Double gloving, face masks – N95 for hospital staff, face shield, disposable apron, waterproof footwear	Rubber dam, high-volume suction	Not reported
Country-India Source-Dental Council of India Published on July 05, 2020	Not reported	Face mask – three layered surgical mask and N95 respirator, Goggles/face visor, disposable apron, head caps, shoe covers	Mouthwash - preoperative 1% hydrogen peroxide, use-rubber dams. High-volume saliva ejectors, high-volume suction, do not use a spittoon	General ventilation – Fumigation is done daily at end of the day in clinical or high contact areas; biweekly in nonclinical or low contact areas
Country - Malta Source-Office for the Deputy Prime Minister. Ministry for Health Published on Jun-20	High- and slow-speed handpieces, powered scalers, 3-in-1 syringes, gagging/retching due to intra-oral radiography or an infected patient coughing	Face mask – if N95 or other respirators isot available, use both surgical mask and full face shield Goggles/ full face visor surgical cap/ hat disposable apron shoes or disposable shoe covers should be worn	Mouthwash-Pretreatment rinsing with1% H_2O_2, 0.2% Povidone or a combination of Chlorhexidine (0.5%-0.12%) + CPC (0.01%-1%), Rubber dam, high-volume suction	Keep windows open during procedure if no other means of General ventilation Ensure proper ventilation. Windows should be closed if there is an air purification system. Use of upper-room UV irradiation should be considered as an adjunct to higher general ventilation
Country - USA Source-ADA Updated on September 06, 2020	Not reported	Face mask - surgical face mask, N95 or KN95, fit test required, goggles/face visor, surgical gown, surgical cap/ hat, shoe covers	Rubber dam, high-volume suction, use hand scaling instead of ultrasonic scaling	Not reported
Country-USA Source-CDC Updated on June 17, 2020	Avoid use of dental handpieces, 3-in-1 syringe, powered scalers	Face mask - N95 or, powered air-purifying or elastomeric respirators, Fit test, Goggles, protective eyewear, full face shield Gown/protective clothing	Mouthwash, Rubber dam, High-volume suction, Avoid AGPs	Systems that provide air movement in a clean-to-less clean flow direction are better, HEPA air filtration unit, use upper-room ultraviolet germicidal irradiation as an adjunct

ADA: American Dental Association, CDC: Centers for Disease Control and Prevention, AGP: Aerosol-generating procedures, COVID-19: Coronavirus disease-2019, UV: Ultraviolet, CPC: Cetylpyridinium chloride, HEPA: High efficiency particulate air

debate about how to segregate them, the World Health Organization[41] defines that "the particles of more than 5 μm as droplets, and those <5 μm as aerosols or droplet nuclei." Particles of sizes between 0.5 and 10 μm have the highest potentiality to enter the lungs and respiratory tract, acquiring the probability to spread the infection.[42] Segregating aerosols by their basic size is relevant in relationship to their dispersion patterns. Outcomes from some research have exhibited that aerosols from microbes such as SARS-CoV-2 can migrate >6 feet.[43]

METHODS OF REDUCING AEROSOL

As per the present epidemiological research, 2019-nCoV has greater transmissivity as compared to SARS-CoV and MERS-CoV.[44] Hence, modification of standard safety measure disease control regime focused on 2019-nCoV is indispensable amid this flare-up [Table 2]. Various dental AGPs as defined in international dental guidelines and the mitigation procedures suggested by them are tabulated in Table 5.

CONCLUSION

A direct co-relationship between bioaerosols generated during dental procedures and the transference of highly contagious infections not only to the dental professionals but additionally to patients has been confirmed. The probability of SARS-CoV-2 spreading through aerosols even in the absence of aerosol-generating procedures has also been supported by some studies.

Recommendations

The COVID-19 pandemic has had a startling effect on clinical practice. There is a huge gap in our knowledge regarding the role of aerosol in the spreading of COVID-19 and to prevent its transmission. Indeed, it is the appropriate time for dental surgeons to update themselves and be dynamic members of health-care organizations dealing with the pandemic. It is indispensable that in the current scenario, the necessary salience should be given to dental procedures that the WHO labeled as emergencies. This would be a suitable step in an attempt to abridge any transference of COVID-19. Dentists who treat amid the coronavirus pandemic should assume "every" person is potentially infected and mandatorily follows universal infection control protocol, as discussed in the current article.

Financial support and sponsorship

Nil.

Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

REFERENCES

1. Dewhirst FE, Chen T, Izard J, Paster BJ, Tanner AC, Yu WH, *et al.* The human oral microbiome. J Bacteriol 2010;192:5002-17.
2. Jenkinson HF. Beyond the oral microbiome. Environ Microbiol 2011;13:3077-87.
3. Li Y, Ren B, Peng X, Hu T, Li J, Gong T, *et al.* Saliva is a non-negligible factor in the spread of COVID-19. Mol Oral Microbiol 2020;35:141-5.
4. Coronavirus. WHO; 2020a. Available from: https://www.who.int/health-topics/coronavirus#tab=tab_1. [Last acessed on 2021 May 17].
5. King TB, Muzzin KB, Berry CW, Anders LM. The effectiveness of an aerosol reduction device for ultrasonic scalers. J Periodontol 1997;68:45-9.
6. Peng X, Xu X, Li Y, Cheng L, Zhou X, Ren B. Transmission routes of 2019-nCoV and controls in dental practice. Int J Oral Sci 2020;12:9.
7. Asadi S, Wexler AS, Cappa CD, Barreda S, Bouvier NM, Ristenpart WD. Aerosol emission and superemission during human speech increase with voice loudness. Sci Rep 2019;9:2348.
8. Papineni RS, Rosenthal FS. The size distribution of droplets in the exhaled breath of healthy human subjects. J Aerosol Med 1997;10:105-16.
9. Morawska L. Droplet fate in indoor environments, or can we prevent the spread of infection? Indoor Air 2006;16:335-47.
10. Duguid JP. The numbers and the sites of origin of the droplets expelled during expiratory activities. Edinb Med J 1945;52:385-401.
11. Resuming General Dental Services Following COVID-19 Shutdown. SDCEP; 2020. Available from: http://www.sdcep.org.uk/wp-content/uploads/2020/06/SDCEP-Resuming-General-Dental-Services-Following-COVID-19-Shutdown-Update-120620.pdf. [Last accessed on 2021 May 17].
12. Farah RI. Effect of cooling water temperature on the temperature changes in pulp chamber and at handpiece head during high-speed tooth preparation. Restor Dent Endod 2019;44:e3.
13. Grenier D. Quantitative analysis of bacterial aerosols in two different dental clinic environments. Appl Environ Microbiol 1995;61:3165-8.
14. Al Maghlouth A, Al Yousef Y, Al Bagieh N. Qualitative and quantitative analysis of bacterial aerosols. J Contemp Dent Pract 2004;5:91-100.
15. Leggat PA, Kedjarune U. Bacterial aerosols in the dental clinic: A review. Int Dent J 2001;51:39-44.
16. Eliades T, Koletsi D. Minimizing the aerosol-generating procedures in orthodontics in the era of a pandemic: Current evidence on the reduction of hazardous effects for the treatment team and patients. Am J Orthod Dentofacial Orthop 2020;158:330-42.
17. Clarkson J, Ramsay C, Richards D, Robertson C, Aceves-Martins M. CoDER Working Group; 2020. Aerosol Generating Procedures and their Mitigation in International Dental Guidance Documents – A Rapid Review. Available from: https://oralhealth.cochrane.org/sites/oralhealth.cochrane.org/files/public/uploads/rapid_review_of_agps_in_international_dental_guidance_documents.pdf. [Last accessed on 2021 May 17].
18. 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.
19. To KK, Tsang OT, Yip CC, Chan KH, Wu TC, Chan JM, *et al.* Consistent detection of 2019 novel coronavirus in saliva. Clin Infect Dis 2020;71:841-3.
20. Bennett AM, Fulford MR, Walker JT, Bradshaw DJ, Martin MV,

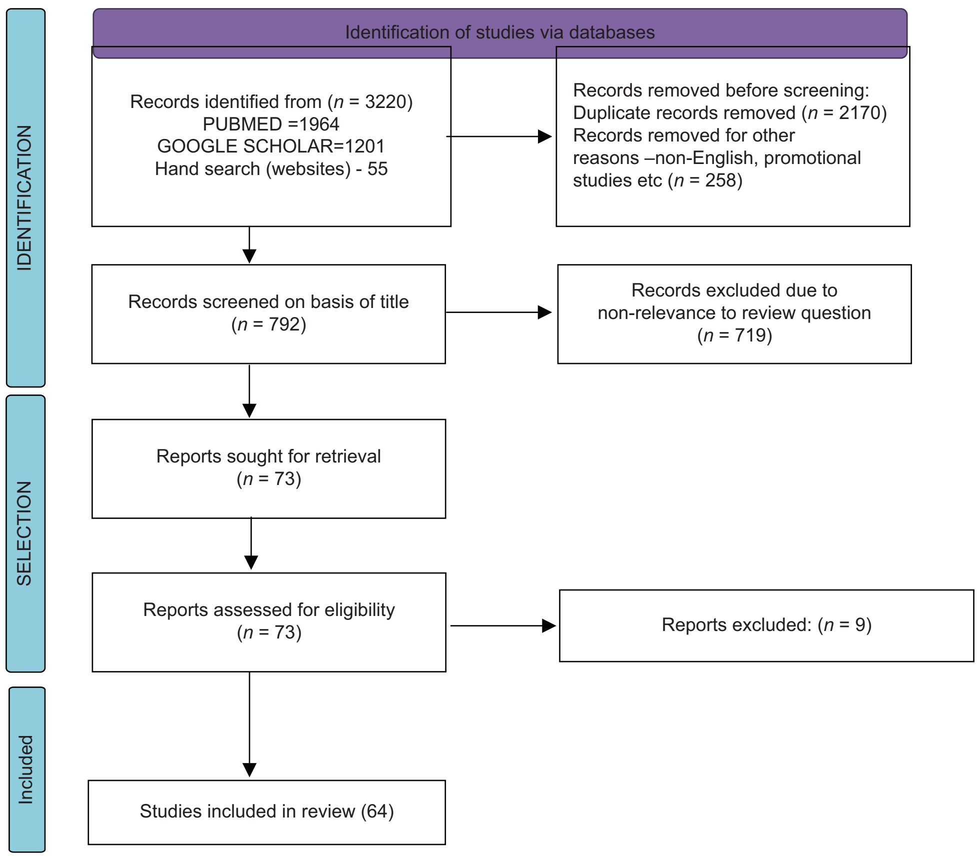
Marsh PD. Microbial aerosols in general dental practice. Br Dent J 2000;189:664-7.
21. Hallier C, Williams DW, Potts AJ, Lewis MA. A pilot study of bioaerosol reduction using an air cleaning system during dental procedures. Br Dent J 2010;209:E14.
22. Dutil S, Meriaux A, de Latremoille MC, Lazure L, Barbeau J, Duchaine C. Measurement of airborne bacteria and endotoxin generated during dental cleaning. J Occup Environ Hyg 2009;6:121-30.
23. Zemouri C, Volgenant CM, Buijs MJ, Crielaard W, Rosema NA, Brandt BW, *et al.* Dental aerosols: Microbial composition and spatial distribution. J Oral Microbiol 2020;12:1762040.
24. Volgenant CM, de Soet JJ. Cross-transmission in the dental office: Does this make you ill? Curr Oral Health Rep 2018;5:221-8.
25. Raghunath N, Iyer M, Shreeshyla HS, Nitin P. Aerosols in dental practice-A neglected infectious vector. BMRJ 2016;14:1-8.
26. van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, *et al.* Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. N Engl J Med 2020;382:1564-7.
27. Kampf G, Todt D, Pfaender S, Steinmann E. Persistence of corona viruses on inanimate surfaces and their inactivation with biocidal agents. J Hosp Infect 2020;104:246-51.
28. Pervaiz M, Gilbert R, Ali N. The prevalence and underreporting of needlestick injuries among dental healthcare workers in Pakistan: A systematic review. Int J Dent 2018;2018:9609038.
29. Pippin DJ, Verderame RA, Weber KK. Efficacy of face masks in preventing inhalation of airborne contaminants. J Oral Maxillofac Surg 1987;45:319-23.
30. Lewis DL, Arens M, Appleton SS, Nakashima K, Ryu J, Boe RK, *et al.* Cross-contamination potential with dental equipment. Lancet 1992;340:1252-4.
31. Barbeau J, Tanguay R, Faucher E, Avezard C, Trudel L, Côté L, *et al.* Multiparametric analysis of waterline contamination in dental units. Appl Environ Microbiol 1996;62:3954-9.
32. Coleman DC, O'Donnell MJ, Shore AC, Russell RJ. Biofilm problems in dental unit water systems and its practical control. J Appl Microbiol 2009;106:1424-37.
33. Meng L, Hua F, Bian Z. Coronavirus disease 2019 (COVID-19): Emerging and future challenges for dental and oral medicine. J Dent Res 2020;99:481-7.
34. Sabino-Silva R, Jardim AC, Siqueira WL. Corona virus COVID-19 impacts to dentistry and potential salivary diagnosis. Clin Oral Investig 2020;24:1619-21.
35. Liu Z, Sun CB. Conjunctiva is not a preferred gateway of entry for SARS-CoV-2 to infect respiratory tract. J Med Virol 2020;92:1410-2.
36. Zhou P, Yang XL, Wang XG, Hu B, Zhang L, Zhang W, *et al.* A pneumonia outbreak associated with a new coronavirus of probable bat origin. Nature 2020;579:270-3.
37. Xu H, Zhong L, Deng J, Peng J, Dan H, Zeng X, *et al.* High expression of ACE2 receptor of 2019-nCoV on the epithelial cells of oral mucosa. Int J Oral Sci 2020;12:8.
38. Hinds WC. Aerosol Technology: Properties, Behavior, and Measurement of Airborne Particles. New York: Wiley; 1982. p. 6-8.
39. Cottone JA, Terezhalmy GT, Molinari JA. Practical Infection Control in Dentistry. Baltimore: Williams & Wilkins; 1996. p. 139-40.
40. James R, Mani A. Dental aerosols: A silent hazard in dentistry! Int J Sci Res 2016;5:1761-3.
41. Infection Prevention and Control of Epidemic and Pandemic Prone Acute Respiratory Infections in Healthcare – WHO Guidelines. World Health Organization; 2014. Available from: https://www.who.int/csr/bioriskreduction/infection_control/publication/en/. [Last accessed on 2021 May 20].
42. Singh A, Shiva Manjunath RG, Singla D, Bhattacharya HS, Sarkar A, Chandra N. Aerosol, a health hazard during ultrasonic scaling: A clinico-microbiological study. Indian J Dent Res 2016;27:160-2.
43. Kutter JS, Spronken MI, Fraaij PL, Fouchier RA, Herfst S. Transmission routes of respiratory viruses among humans. Curr Opin Virol 2018;28:142-51.
44. Chen J. Pathogenicity and transmissibility of 2019-nCoV-A quick overview and comparison with other emerging viruses. Microbes Infect 2020;22:69-71.

SUPPLEMENTARY FILE

Supplementary 1: Information sources and search strategy

Three search strings were run in PubMed from inception to April 01, 2021. In PubMed the following strings were combined: ((”aerosols”[MeSH Terms] OR (“aerosol s”[All Fields] OR “aerosolization”[All Fields] OR (“bioaerosol”[All Fields] OR “bioaerosols”[All Fields]) OR “Aerosol generating procedures”[All Fields]) AND (“covid 19”[All Fields] OR “covid 19”[MeSH Terms] OR “sars cov 2”[All Fields] OR “sars cov 2”[MeSH Terms] OR “severe acute respiratory syndrome coronavirus 2”[All Fields] OR “ncov”[All Fields] OR “2019 ncov”[All Fields] OR ((“coronavirus”[MeSH Terms] OR “coronavirus”[All Fields] OR “cov”[All Fields]).

PRISMA flow chart



Flow diagram of literature searches according to the PRISMA statement.