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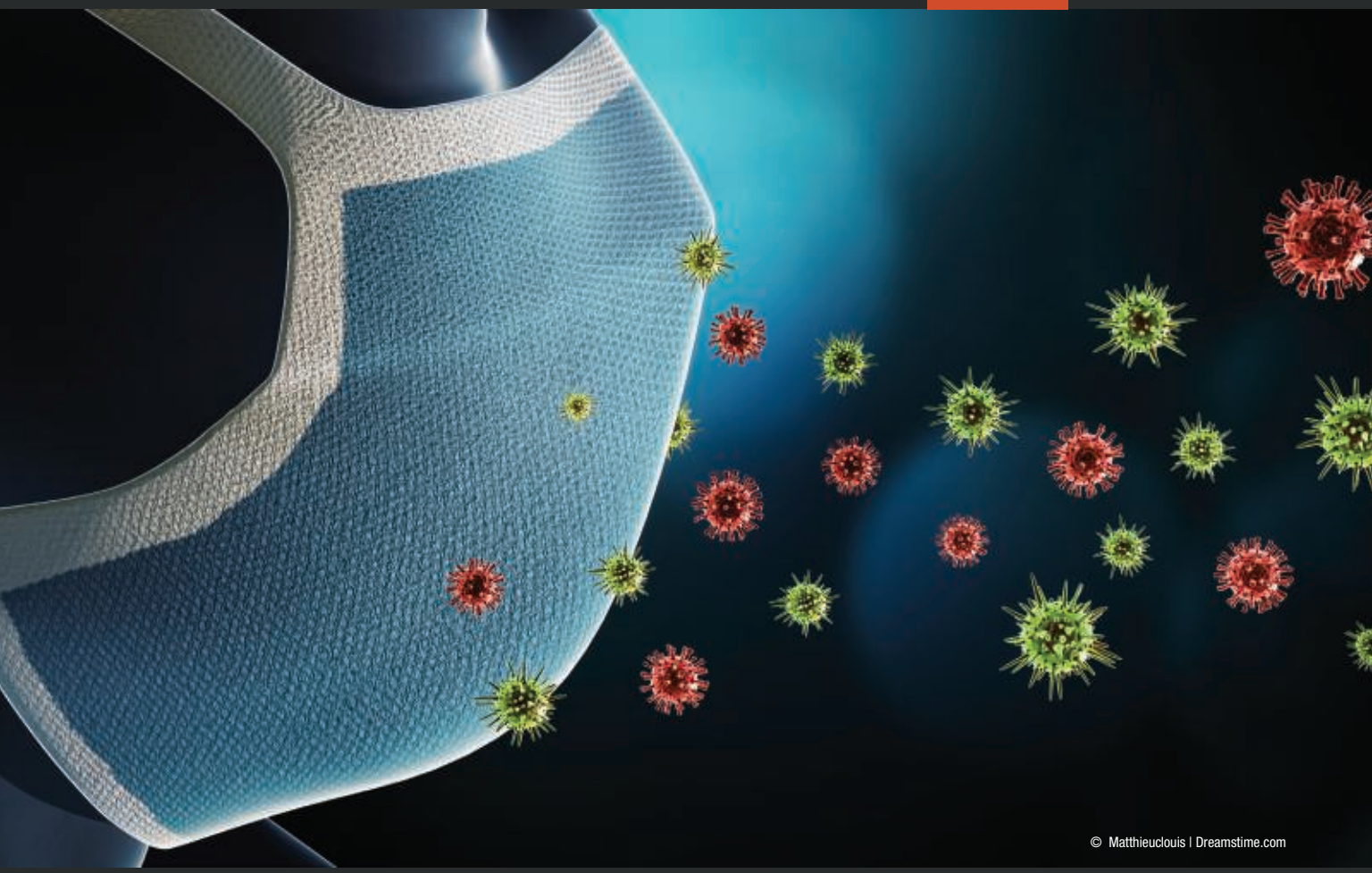

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COVID-19: Part 2— Is there something in the air? Aerosols and infection prevention/control in the dental office

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Abstract

Dental procedures that employ handpieces, lasers, electrosurgery units, ultrasonic scalers, air polishers, prophy angles, hand instruments, and air/water syringes can create bioaerosols and spatter. Ultrasonic scalers and high-speed handpieces produce more airborne contamination than any other instruments in dentistry, but much is still unknown about the nature and infectivity of such aerosols. As dental procedures and technologies have evolved, the incidence of aerosol-creating procedures has increased. Inhalation of airborne particles and aerosols produced during dental procedures may cause adverse respiratory health effects, including high-consequence infectious diseases (HCIDs) spread by airborne routes. While transmission-based precautions may minimize risk to dental health-care providers, the evidence to support the most effective interventions and the guidance for infection control and prevention in regard to airborne disease transmission is rapidly evolving. During the initial pandemic stages, limiting dental practice and minimizing aerosol-generating procedures was critical, but as the current pandemic evolves, it has highlighted our understanding of potential modes of airobone disease transmission in the dental office and effective methods to mitigate such risks. Going forward, dental health-care providers should be aware of invisible risks within their operatories and stay abreast of evolving infection prevention protocols before, during, and after patient care. This course seeks to review up-to-date infection control recommendations and emerging evidence for ongoing infection control when delivering dental care, particularly in relation to the COVID-19 pandemic.

Educational objectives

Upon completion of this course, the dental professional should be able to:

- Explain the risk factors and basic properties of aerosols generated during routine dental procedures
- Describe what types of dental procedures result in significant dental aerosol production
- Understand the types of pathogens and resultant illnesses associated with such aerosols
- Differentiate between standard and transmission-based precautions and their utility in the dental office for safe delivery of care
- List infection control and aerosol mitigation techniques that may reduce the risk of cross-contamination to patients and providers

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Introduction

A novel β-coronavirus (SARS-CoV-2), purportedly originating in a seafood market in Wuhan, Hubei province, China, is causing severe and potentially fatal pneumonia (COVID-19) and has demonstrated pandemic spread throughout the globe.[1–3] The World Health Organization (WHO) has stated that modes of transmission include contact, droplet, airborne, and fomite routes. The US Centers for Disease Control and Prevention (CDC) further states that most cases are spread by close person-to-peson interaction within six feet through airborne respiratory particles produced during many common activities including coughing, sneezing, speaking, and even breathing.[4-8] Additionally, while an airborne route of transmission is suspected for SARS-CoV-2, the exact nature and conditions necessary to allow for this kind of transmission are currently unknown. Given these transmission routes, there has been a renewed interest in aerosols in the practice of dentistry and their risk to dental practitioners and dental patients, as well as mitigation strategies for risks associated with reducing viral contamination and infection due to dental procedures.

Currently, dental practitioners, members of the dental team, and their patients are exposed to risks associated with aerosols in the dental office due to the frequency of face-to-face communication, exposure to saliva, blood, and other body fluids, and—indirectly—by the touching of instruments and other surfaces that may serve as fomites (any inanimate object that if contaminated with or exposed to an infectious agent can then transfer that agent to a new host).[9-12] Previous studies have shown that microorganisms in the mouth and respiratory tract can be transported in the aerosols and spatter generated during dental procedures and can contaminate the skin and mucous membranes of the mouth, respiratory passages, and eyes of dental personnel as well as surfaces and materials exposed to such aerosols and droplets.[13–20] As such, dental professionals can play an important role in preventing disease transmission within the dental practice.[13–20] This course seeks to explore potential risks posed by aerosols in the dental office and assess infection control measures that can be implemented during dental practice to block the person-to-person transmission routes through standard, transmission-based, and potentially novel precautions.[21]

Aerosols in the dental office: What are the risks associated with dental procedures?

Airborne transmission of various pathogens, including tuberculosis and measles, has been reported in various health-care and community settings.[22,23] Furthermore, viral transmission of common infections after airborne droplets/particles have settled on surfaces has also been shown.[22,23] Air quality evaluation within dental operatories has revealed the presence of multiple pathogens capable of aerosol transmission, indicating a risk to dental health-care professionals, staff, and patients through these routes of transmission.[24,25] It is currently unclear under which circumstances, if any, SARS-CoV-2 can be transmitted via dental aerosols, and no reported cases of COVID-19 transmission have been traced to the direct provision of dental care. This type of transmission may be dependent upon many factors, including overall viral load in the aerosol/spatter, proximity of dental personnel to an infected patient, type and effectiveness of personal protective equipment (PPE), and host susceptibility.

Airborne droplets: aerosols versus spatter

Aerosols are defined as liquid or solid particles less than 50 micrometers in diameter.[16,17,26,27] Particles of this size are small enough to stay airborne for an extended period before they settle on environmental surfaces or enter the respiratory tract after inhalation.[16,17] Smaller particles of an aerosol (0.5 to 10 µm in diameter) have the potential to enter the lungs and settle within the bronchial passages, reaching as far as the pulmonary alveoli.[16,17] These droplets, due to their capacity to remain in the air, may prompt a shift in infection prevention and control practices employed in the dental office.[26,27]

Spatter describes airborne particles, usually a mixture of air, water, and/or solid substances, larger than 50 µm in diameter, which may be up to several millimeters in diameter and visible to the naked eye.[16,17] These particles have been shown to behave in a ballistic or projectile manner.[16] Thus, these particles or droplets are ejected forcibly from their origin in an arc and travel along a bullet-like trajectory until they contact a surface or fall to the ground due to gravitational forces.[16] Unlike aerosols, these particles are too large and contain too much mass to become suspended in the air and are airborne only briefly.[16,17] Because of this, they demonstrate limited penetration into the respiratory system.[16,17]

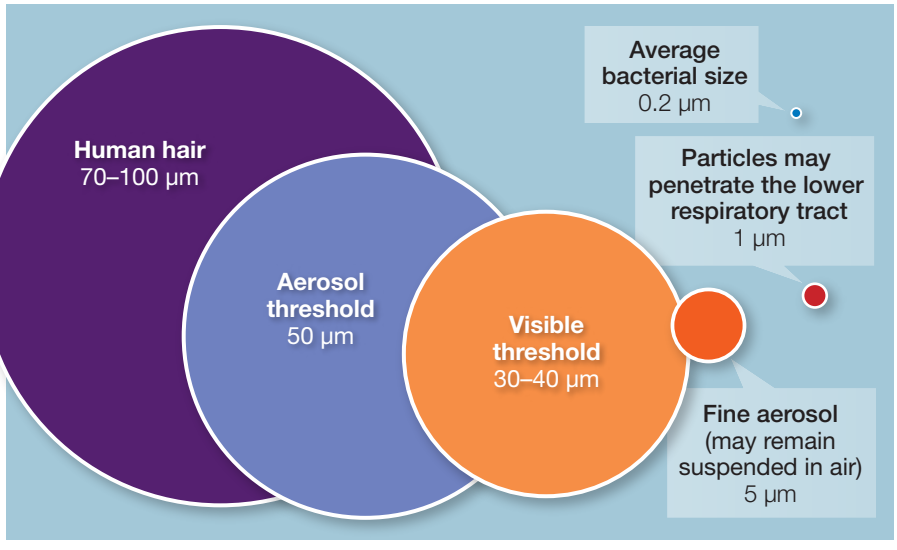

FIGURE 1: Relative sizes of airborne droplets

Figure 1 demonstrates the relative sizes of droplets commonly produced during dental procedures.

Within the dental office, these airborne droplets, both splatter and aerosols, may present risks to dental practitioners and patients, which may vary based upon the amount and types of droplets produced.[26,27] The type of exposure encountered during dental care and needed PPE may vary based upon the level of aerosols produced. Additionally, droplet contamination of porous and nonporous surfaces after dental treatments is dependent upon the type of procedure and the resultant airborne droplets produced. Because aerosols can remain in the air for a long time and may be transported with air flows for long distances, they are capable of contaminating wide areas within the dental operatory.[26–28] Conversely, spatter particles are generally deposited on surfaces closer to their origin, an estimated 15–120 cm from the source.[29,30] Spatter particles are, therefore, a risk due to their contact with mucous membranes and close surfaces, including dental practitioners and dental assistants.[27,28] In some instances, however, hardy microorganisms may survive within the material in spatter as the droplet evaporates, and these organisms may even become re-airborne as dust particles.[27,28] It is currently unknown which, if either, of these droplet types may represent significant risks within the dental office as the viral bioload of SARS-CoV-2 within these particles and the necessary viral exposure for development of infection are, as of yet, unknown.

Dental procedures and their ability to produce aerosols

Airborne contamination may be due to a variety of procedures commonly performed in dental practice. Microorganisms of salivary, oral, and respiratory sources may be transmitted through spatter and/or aerosols during dental instrumentation.[31] Dental instruments, surfaces within the dental operatory, and dental unit water lines, when improperly sterilized, stored, or cleaned, can serve as a source of organisms within aerosols, and those microbes can be passed from one patient to another and can also serve as a repository for microbiota within aerosols or other airborne contamination.[31] Dental handpieces, ultrasonic scalers, and air-water syringes are all capable of producing aerosols, which are usually a mix of air and water derived from these devices and the patient's saliva.[32] It should also be noted that these aerosols are always accompanied by spatter (table 1).[28]

The oral environment is naturally wet and has a high level of contamination with bacteria and other microorganisms. Dental plaque is a major source of such organisms, containing more than 700 known pathogens,[33] but the mouth also harbors bacteria from elsewhere in the respiratory tract, including the nasopharynx and the lower pulmonary system.[26] Microscopic blood droplets, gingival crevicular fluid, debris from tooth preparation, and dental materials all may be aerosolized during dental procedures and cause threats of disease transmission.[29,30] Any dental procedure that has the potential to aerosolize saliva can cause contamination with microorganisms from these sources.[28–30]

The most intense aerosol and spatter emission has been shown to occur during use of ultrasonic scalers and high-speed handpieces without a rubber dam.[26,28,29] While these procedures are associated with the highest levels of aerosol production, use of low-speed handpieces, air/water syringes, patient coughing, and even the capture of intraoral radiographs have all been shown to create aerosols in the dental setting.[32] It is also important to note that while these procedures may produce large volumes of aerosols, the majority of aerosolized materials likely is not derived from salivary or respiratory sources, but rather the lavage from the instrumentation used. This may result in a dilution of the infectious agents within patient secretions, thus lowering the infectious bioload.[34]

Use of barrier protections, such as a rubber dam, and high-speed evacuation may reduce overall aerosol exposure during such procedures.[26] Additionally, the use of preprocedural mouth rinses has demonstrated a reduction in the overall microbial load detected in aerosols generated during dental procedures.[35] Because of the ability of aerosols to remain suspended in the air for several hours, they may not be able to be completely removed from the environment during commonly used surface decontamination and could cause disease in others through an airborne route of transmission or via fomite transfer, even after the infected person is no longer in the immediate area.[32,36–38] Furthermore, because aerosols may travel significantly farther than spatter, they may contaminate distant surfaces, and certain microorganisms (e.g., SARS-CoV-2) can survive

Dental devices/procedures	Airborne contamination potential	Potential mitigation for droplet/aerosols
Ultrasonic/sonic scalers	Considered to be the greatest source of aerosol contamination in dental practice	High-volume evacuation during powered scaler use reduces airborne contamination by > 95%
Air polishing	Airborne bacterial counts indicate aerosol production nearly as high as with ultrasonic scalers	High-volume evacuation during powered scaler use reduces airborne contamination by > 95%
Air-water syringe	Airborne bacterial counts indicate aerosol production nearly as high as with ultrasonic scalers	High-volume evacuation during powered scaler use reduces airborne contamination by > 95%
Tooth preparation with air turbine handpiece	Minimal airborne contamination if proper placement of a rubber dam is in place	Use of a rubber dam and high-volume evacuation is indicated.
Tooth preparation with air abrasion	Microbial contamination is unknown. Extensive contamination with abrasive particles has been shown.	Use of a rubber dam and high-volume evacuation is indicated.

TABLE 1: Dental devices and procedures known to produce airborne contamination (Adapted from Harrel and Molinari, 2010)[26]

on such environmental surfaces for prolonged periods of time.[32,39] In the case of SARS-CoV-2, the virus may survive on plastic or metal surfaces for up to two or three days. Therefore, dangers could arise from contaminated surfaces, and the potential could exist for inhalational exposure if a prior infectious patient received treatment and the air within the treatment room was not exchanged, filtered, and/or sanitized.

Infectious diseases known or suspected to be associated with aerosols: What influences infectivity?

Several types of bacteria and viruses have demonstrated airborne person-to-person transmission. Microorganisms transmitted by aerosols can cause diseases such as influenza (influenza viruses types A and B), the common cold (rhinoviruses and other viruses), tuberculosis (*Mycobacterium tuberculosis*), Legionnaires' disease (*Legionella pneumophila*), severe acute respiratory syndrome (SARS, SARS-CoV-1), and early data suggest COVID-19 (SARS-CoV-2) may also be transmitted in such a manner (table 2).[9,21,40–43]

For many of these microorganisms, their transmissibility in aerosols is dependent upon a myriad of factors. The overall microbial load within secretions may be variable based upon the disease course and the particular bacteria/virus.[7–9,21] This variability can influence the likelihood of exposure in aerosol. Additionally, the reproduction number (R_0) differs significantly between microorganisms.[44] The R_0 is the number of cases, on average, an infectious patient will cause during their infectious period. The R_0 is often described as either "basic" (reproduction in a wholly susceptible population) or "effective" (dependent upon the population's current susceptibility). In other words, in real-world modeling, R_0 is influenced by vaccination rates, previous infection rates, cross-immunity from similar diseases, population behaviors (e.g., social distancing), and the novelty of a pathogen.[44] Lastly, the likelihood of transmission is also influenced by the susceptibility of the host and, in certain instances, this may be related to overall health status, genetic influences, immunocompetence, vaccination/infection history, and previous exposure to similar diseases.[45,46]

While continued discussion about the immediate threat of COVID-19 infection in the dental office exists, there are additional concerns about lung damage subsequent to such an infection, even one with mild and/or subclinical symptoms, and the long-term effects of aerosol exposure on dental personnel. For example, a temporal association between occupational exposure to contaminated dental unit water line (DUWL) output water with aerobic bacterial counts of more than 200 colony-forming units (CFU)/ml at 37° C and the subsequent development of asthma has been demonstrated in a subgroup of dentists who were followed longitudinally after entering dental training.[47] Occupational exposure in dentistry has also be associated with an increased risk of other pulmonary diseases, including idiopathic pulmonary fibrosis (IPF), although causation has not been established.[48] Given the potential for long-lasting risks to dental personnel, care should be paid to establishing safety protocols that allow for the greatest mitigation of occupational risk.

Disease	Causitive microbe	Method of transmission
Pneumonic plague	*Yersinia pestis*	Most transmission was through an insect vector (flea), but also person-to-person via bacterial inhalation
Tuberculosis	*Mycobacterium tuberculosis*	Droplet nuclei expelled fron an infected patient by coughing
Influenza	Influeza virus types A and B	May be associated with coughing but more likely with direct patient contact
Legionnaires' disease	*Legionella pneumophila*	Aerosolization has been associated with HVAC systems and hot tub spas, which have been linked to outbreaks
Severe acute respiratory syndrome (SARS)	SARS-CoV-1	Spread by aerosolized droplets, through fomite transfer, and by direct contact
COVID-19	SARS-CoV-2	Spread by aerosolized droplets, through fomite transfer, and by direct contact

TABLE 2: Diseases known to be spread by droplets or aerosols (Adapted from Harrel and Molinari, 2010)[26]

Standard and transmission-based precautions: best practices for dental professionals

In 1985, the Centers for Disease Control (now the US CDC) introduced the concept that all blood and body fluids that might be contaminated with blood should be treated as infectious.[49] Infection control precautions were introduced largely because of the human immunodeficiency virus (HIV) epidemic and have been updated in the intervening years. Such precautions have been sequentially titled "universal" and now "standard" precautions, and they are designed to prevent transmission of HIV, hepatitis B virus (HBV), hepatitis C virus (HCV), and other blood-borne diseases.[50,51] Additionally, the Occupational Safety and Health Administration (OSHA) bases its blood-borne pathogens standard on the concept of standard precautions.[52]

Standard precautions

Generally, standard precautions are the minimum infection prevention practices that apply to all patient care, regardless of suspected or confirmed infection status of the patient, in any setting where health care is delivered. These practices are designed to both protect dental health-care providers and prevent practitioners from spreading infections to patients. Current recommendations for standard precautions in the dental office include:[53]

- Proper hand hygiene
- Use of appropriate personal protective equipment (e.g., gloves, masks, eyewear, disposable gowns, etc.)
- Respiratory hygiene/cough etiquette
- Sharps safety and other engineering and work practice controls
- Safe injection practices (e.g., aseptic technique for parenteral medications and sharps management)

- Sterile instruments and devices for use in patient care
- Clean and disinfected environmental surfaces utilizing approved disinfection techniques

While standard precautions alone cannot prevent all disease transmission, they represent minimal standards to be applied to all patients, even those who report low risk and/or appear asymptomatic. They may be supplemented with transmission-based precautions.

Transmission-based precautions

In some circumstances, patients may have a documented infection or may be suspected of having an infection with specified highly transmissible pathogens for which standard precautions cannot completely eliminate risks associated with airborne or droplet transmission or transmission by contact with skin or contaminated surfaces. A second tier of precautions, referred to as transmission-based precautions, is commonly employed in these cases to prevent or mitigate the risk of disease transmission. There are three categories of transmission-based precautions: airborne, droplet, and contact.[54-56]

Typically, dental settings are not be designed to carry out all of the transmission-based precautions (e.g., airborne precautions for patients with suspected tuberculosis, measles, or chickenpox) that are recommended for hospital and other ambulatory care settings.[53] Patients, however, do not usually seek routine dental outpatient care when acutely ill with diseases requiring transmission-based precautions. SARS-CoV-2 in its presymptomatic phase may be an exception to such recommendations and require dental health-care providers to develop and carry out systems for early detection and management of potentially infectious patients at initial points of entry to the dental setting. It should be noted that early data from Singapore suggest that transmission associated with presymptomatic carriers accounted for approximately 6.4% of locally acquired cases,[57] and rates of COVID-19 in health-care providers in the US and worldwide are noted to be significantly lower than those of the broader community.[58,59]

Given the novel nature of SARS-CoV-2 and the high level of uncertainty surrounding the risks of transmission in the dental office, current guidance is interim and likely to change as data emerge. It is assumed that infected individuals may be asymptomatic and/or presymptomatic, but the viral loads and transmissibility of the virus from asymptomatic individuals is poorly characterized. As such, until more definitive recommendations are developed, it is recommended that the CDC's precautions regarding infection prevention and control in dental offices be used on an empiric basis and protocols reviewed and updated often.[60]

Strategies to mitigate airborne disease transmission risk in the dental office

Given the present uncertainty about viral transmission in dental offices, current infection control protocols and routine PPE used for dental procedures may not be adequate and cannot be relied upon until further data are available. Based upon emerging evidence regarding SARS-CoV-2 and previous investigations studying other coronaviruses, spread is thought to occur mostly person-to-person via respiratory droplets among close contacts. Close contact can occur while delivering patient care and is currently defined by the CDC as: 1) being within approximately six feet (two meters) of a patient with COVID-19 for a prolonged period of time (30 minutes) or 2) having direct contact with infectious secretions from a patient with COVID-19. Infectious secretions may include sputum, saliva, serum, blood, and respiratory droplets.[60]

CDC and American Dental Association interim recommendations updated on June 17, 2020, for infection prevention and control include:[60–62]

- Dental health-care providers (DHCPs) and patients should stay at home if experiencing COVID-19 symptoms and seek medical care as recommended based upon symptoms and health-care provider assessment.
- Use of face coverings by patients and maintenance of social distancing in non-clinical areas and when not engaged in active receipt of patient care.
- Assess and triage patients using teledentistry prior to an in-person dental visit and upon arrival in the dental office. Assess the nature of the patient's dental needs, underlying systemic health and risk factors, and any symptoms related to COVID-19. Patients with confirmed or suspected COVID-19 should be referred to contact the hospital emergency department to determine the optimal patient care options, even for dental emergencies.
- DHCPs should assess the likelihood of aerosol production during care and consider mitigation strategies, including: 1) reducing aerosol bioload, 2) barriers and PPE that reduce droplet deposition and aspiration for dental health-care providers, and 3) reduction of aerosol droplets in room air.
- If the needed procedure is unlikely to produce aerosols, DHCPs can use routine PPE and the procedure is considered low risk.
- If aerosols are likely to be produced, the following recommendations should be employed:
  - Use of four-handed dentistry, high-velocity evacuation suction, and dental dams to reduce and/or minimize droplet splatter and aerosols.
  - Consider the use of HEPA air filtration in treatment areas to reduce aerosol concentrations in the room.
  - Be sure to account for cleaning time of surfaces in patient areas between patient visits.
  - Utilize appropriate PPE, including surgical and/or respirator masks and eye protection, and consider PPE supply optimization strategies.
- Practice how to properly don, use, and doff PPE in a manner to prevent self-contamination.
- Perform hand hygiene with alcohol-based hand rub before and after all patient contact, contact with potentially infectious material and before putting on and upon removal of PPE, including gloves. Use soap and water if hands are visibly soiled.
- Clean and disinfect clinical surfaces with approved disinfection protocols and utilizing disinfectants from EPA-approved emerging viral pathogens claims (List N).[59]
- Screen all DHCPs at the beginning of their

shifts for fever and respiratory symptoms. Document shortness of breath, new or change in cough, and sore throat. If a DHCP is ill, have him/her put on a face mask and leave the workplace.

Interim special precautions for high-aerosol procedures (known or suspected COVID-19 cases)

If emergency dental care is medically necessary for a patient who has, or is suspected of having COVID-19, airborne precautions including the following:[60,61]

- DHCP in the room should wear an N95 or higher-level respirator, eye protection, gloves, and a gown.
- The number of health-care providers present during the procedure should be limited to only those essential for patient care and procedure support. All other individuals should avoid contact within six feet of the patient.
- Procedures should ideally take place in an airborne infection isolation room (AIIR).
- Clean and disinfect procedure room surfaces promptly using approved protocols and disinfectants identified by the Environmental Protection Agency as effective against SARS-CoV-2.[62]

Dental treatment should be provided in a hospital or other facility that can treat the patient using the appropriate precautions.

Emerging evidence regarding infection control updates in dental practice

As science and our understanding of the SARS-CoV-2 virus evolves and the pandemic subsides, it is likely that we may find ourselves in an endemic situation in which lower levels of this virus or similar pathogens exist in the global population, demonstrating periodic or even seasonal spikes in infection. In this scenario, it will also be imperative that we develop more targeted methods to interrupt the chain of infection. There are several strategies that are currently promising for use in practical application in the dental office.

1. Vaccination development and widespread implementation for health-care providers and individuals in the population. Effective inoculation techniques that are well accepted in society would be ideal to reduce disease spread and have the potential to eliminate disease as has been seen with other formerly endemic diseases such as polio and smallpox.
2. Point-of-care rapid screening tests to identify both asymptomatic carriers and those who may carry immunity to COVID-19 via adequate antibody titers may allow improved risk reduction for dental practitioners and dental patients seeking dental care.
3. Identification of practical, lower-cost disinfection protocols against SARS-CoV-2 to be implemented in dental practice. These could include the use of UV radiation, hydrogen peroxide vapor, and/or other novel techniques.
4. Improved barriers, particularly for dental procedures that produce high levels of aerosols. Currently, hospitals have implemented the use of impermeable barriers during delivery of high-risk treatments, such as intubations and otolaryngeal procedures, for COVID-19 positive or suspected cases. Given that rubber dam use can significantly reduce aerosols, it is conceivable that additional barriers may have efficacy to reduce aerosol spread and mitigate both direct and indirect transmission risks.
5. Improved respirators/masks with additional filtration. While surgical masks are appropriate for droplet protection, the use of additional filtration may be imperative given the increased risks from aerosols. While current N95 respirators are not widely available and/or used during dental procedures, improved designs and supply chain availability may improve the ease of use in dental settings.
6. Use of effective preprocedural mouth rinses to decrease viral load in oral secretions, particularly for patients who require aerosol-producing procedures. Such mouth rinses could include povidone iodine, hydrogen peroxide, and/or hypochlorite. *In vivo* investigations on the efficacy of preprocedural mouth rinses in symptomatic and asymptomatic patients will provide guidance to quantify the achievable levels of viral load reduction and the maintenance of such reduction over acceptable time frames to accomplish dental procedures in a clinical setting.
7. Enhanced air filtration systems and/or, in some cases, installation of negative pressure environments to provide specialized care to high-risk patients may be warranted.

Further research is necessary to fully evaluate the practicality and efficacy of such novel infection prevention and control procedures in dental practice.

Clinical recommendations

In summary, available evidence suggests the following:

1. Aerosols are generated by all individuals during many routine activities, including speaking, eating, and breathing.
2. Aerosols are also created during many dental procedures, particularly those that use powered scalers, dental handpieces, air polishers, and the air-water syringe. The nature of these aerosols, the aerodynamics of aerosols in the dental office, and the pathologic bioloads of those produced during various dental procedures are not well-defined.
3. The bioload in aerosols correlates with disease severity for respiratory diseases, but the overall viral bioload of SARS-CoV-2 in airborne droplets produced in the dental office and its capability to cause fulminant disease is currently unknown.
4. Several methods are effective in mitigating the production of dental aerosols and in reducing bioload. Chief among these are the use of high-volume evacuators, air flow and filtration optimization, and pre-procedural mouth rinsing, but effectiveness may vary based upon implementation within dental practices.
5. Similarly, several barrier techniques are effective in protecting the occupants of the dental operatory from direct and indirect aerosol exposure. These include commonly used PPE such as surgical masks/respirators, face shields, fluid impermeable gowns, and gloves.
6. No evidence exists to suggest that dental health-care professionals are at a

higher risk of airborne viral disease transmission than the general population, and emerging evidence suggests that the risk may be lower during the delivery of dental care than in other health-care settings.

7. Nonclinical areas within the dental office and/or community exposure of dental personnel may pose a significant risk within the dental office and adherence to public health guidelines is critical to limit spread of airborne illness.

Summary

The global pandemic caused by the SARS-CoV-2 has highlighted the risk of airborne disease transmission, particularly in the dental office. There is established evidence of airborne transmssion via droplets and/or aerosols from infected individuals during person-to-person contact. Given the high incidence of droplet and aerosol production during dental procedures and the close contact dental health-care providers have when delivering care, advanced methods to reduce the risks to dental health-care providers and their patients have been proposed as current best practices. Because this situation is rapidly evolving, dental health-care providers are urged to continue close monitoring of emerging science and advisory statements from governmental and other agencies regarding best practices. Care should be taken by dental health-care providers to utilize enhanced infection control protocols in addition to standard precautions when delivering care to patients. Dental care is is an essential health-care service and the ability to safely deliver dental health-care services is critical for patients, providers, the dental team, and the public as a whole.

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QUESTIONS

1. The person-to-person transmission routes for COVID-19 of concern in dental practice include all of the following except:
   A. Direct transmission through airborne particles produced by a cough or sneeze
   B. Direct transmission through airborne particles produced by dental procedures
   C. Contact transmission after touching contaminated surfaces and then touching oral, nasal, and eye mucous membranes
   D. Fecal transmission

2. A fomite is described as:
   A. Microbial particles capable of causing infection
   B. An infected individual who is capable of transmitting disease
   C. Porous or nonporous surfaces or objects that can become contaminated and facilitate viral transfer
   D. An airborne droplet that can be inhaled and cause disease

3. Transmission of SARS-CoV-2 via dental aerosols has been shown in a clinical setting. Aerosol transmission of SARS-CoV-2 may be dependent upon many factors including overall viral load in the aerosol/spatter, proximity of dental personnel to an infected patient, type and effectiveness of PPE, and host susceptibility, among others.
   A. Both statements are true.
   B. The first statement is true; the second statement is false.
   C. The first statement is false; the second statement is true.
   D. Both statements are false.

4. Aerosols are defined as liquid or solid particles less than 50 micrometers in diameter. Particles of this size are small enough to stay airborne for an extended period, but can only travel limited distances (less than 120 cm).
   A. Both statements are true.
   B. The first statement is true; the second statement is false.
   C. The first statement is false; the second statement is true.
   D. Both statements are false.

5. Smaller particles of an aerosol, those of ___ in diameter, have the potential to enter the lungs and settle within the bronchial passages, reaching as far as the pulmonary alveoli, and are thought to convey the highest level of risk of infection transmission in the dental office.
   A. 0.5–10 µm
   B. 25–50 µm
   C. 100–250 µm
   D. > 250 µm

6. All of the following are true about spatter droplets, except:
   A. Spatter particles are usually a mixture of air, water, and/or solid substance and are larger than 50 µm in diameter.
   B. They may become suspended in the air for long periods of time.
   C. Spatter particles follow a ballistic pattern and travel in an arc after they are emitted until they contact a surface or fall to the ground.
   D. They may be visible to the naked eye.

7. Unlike aerosols, spatter particles are too large and contain too much mass to become suspended in the air and are airborne only briefly, so they demonstrate ___ penetration into the respiratory system.
   A. No
   B. Limited
   C. Extensive
   D. Continuous

8. While aerosols can remain airborne and travel long distances within dental treatment areas, spatter particles are generally deposited on surfaces closer to their origin, an estimated ___ cm from the droplet source.
   A. 1–5
   B. 6–12
   C. 15–120
   D. 50–250

9. The highest levels of aerosol and spatter emission has been shown to occur with the use of:
   A. Ultrasonic scalers
   B. Intraoral radiograph capture
   C. High-speed handpiece use with a rubber dam
   D. Low-speed handpiece

10. Dental aerosols are ___ accompanied by spatter.
    A. Never
    B. Occasionally
    C. Frequently
    D. Always

11. All of the following have been shown to reduce microbial-containing aerosol generation in the dental operatory during aerosol-producing procedures, except:
    A. Use of barriers on surfaces within the dental operatory
    B. Use of a rubber dam
    C. Properly positioned high-speed evacuation
    D. Preprocedural mouth rinses

12. SARS-CoV-2 may remain suspended in the air once aerosolized:
    A. For up to one minute
    B. For up to five minutes
    C. For several hours
    D. Indefinitely

13. SARS-CoV-2 may survive on hard plastic or metal surfaces for up to:
    A. 6 hours
    B. 12 hours
    C. 24 hours
    D. 2–3 days

14. All of the following diseases have been associated with transmission via aerosols except:
    A. Influenza (Influenza viruses types A and B)
    B. Tuberculosis (*Mycobacterium tuberculosis*)
    C. Human immunodeficiency virus (HIV)
    D. Legionnaires' disease (*Legionella pneumophila*)

15. In response to the HIV epidemic, the Centers for Disease Control (now the Centers for Disease Control and Prevention [CDC]) introduced the concept that all blood and body fluids that might be contaminated with blood should be treated as infectious. What year was this advice introduced?
    A. 1979
    B. 1982
    C. 1985
    D. 1991

16. Standard precautions (formerly "universal precautions") are designed to reduce exposure to blood-borne pathogens and include all of the following except:
    A. Hand hygiene
    B. Performing aerosol-generating procedures in an airborne infection isolation room (AIIR)
    C. Proper use of personal protective equipment (PPE)
    D. Handling contaminated materials or equipment in order to prevent cross-contamination

17. Standard precautions represent minimal standards to be applied to all patients, even those who report low risks and/or appear asymptomatic. They may be supplemented with transmission-based precautions.
    A. Both statements are true.
    B. The first statement is true; the second statement is false.
    C. The first statement is false; the second statement is true.
    D. Both statements are false.

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QUESTIONS

18. Standard precautions apply to all patient care delivered in the following settings:
    A. Hospital settings
    B. Outpatient clinical settings
    C. Any setting where health care is delivered
    D. A and B only

19. Transmission-based precautions include all of the following categories except:
    A. Airborne
    B. Droplet
    C. Contact
    D. Distance

20. SARS-CoV-2 poses a unique situation when delivering dental care in that it likely requires additional transmission-based precautions that many dental outpatient clinics may not be equipped to deliver. But, unlike other diseases, like measles, patients may be able to spread SARS-CoV-2 during the asymptomatic phase and may require dental health-care providers to develop and carry out systems for early detection and management of potentially infectious patients at initial points of entry to the dental setting.
    A. Both statements are true.
    B. The first statement is true; the second statement is false.
    C. The first statement is false; the second statement is true.
    D. Both statements are false.

21. Much of the current infection control protocols in place in dental offices and the PPE used for dental procedures are designed to protect dental health-care providers from ___ pathogens.
    A. Airborne
    B. Blood-borne
    C. A and B
    D. None of the above

22. The CDC states that close contact with a patient infected with SARS-CoV-2 conveys significant risk for development of COVID-19. The CDC defines "close contact" as: 1) being within approximately 6 feet (2 meters) of a patient with COVID-19 for a prolonged period of time (30 minutes) or 2) having direct contact with infectious secretions from a patient with COVID-19.
    A. Both statements are true.
    B. The first statement is true; the second statement is false.
    C. The first statement is false; the second statement is true.
    D. Both statements are false.

23. The CDC recommends that health-care workers take precautions to avoid direct contact with infectious secretions from patients who are known to be COVID-19 positive or suspected to be COVID-19 positive. All of the following are considered infectious secretions except:
    A. Sputum
    B. Saliva
    C. Blood
    D. Sweat

24. CDC advice for the treatment of patients who are known to be COVID-19 positive or suspected to be COVID-19 positive are:
    A. Assess and triage these patients with acute respiratory symptoms and risk factors for COVID-19 to minimize chances of exposure, including placing a facemask on the patient and placing them in an examination room with the door closed.
    B. Use standard and transmission-based precautions when caring for patients with confirmed or possible COVID-19.
    C. Perform hand hygiene with alcohol-based hand rub before and after all patient contact, contact with potentially infectious material, and before putting on and upon removal of PPE, including gloves. Use soap and water if hands are visibly soiled.
    D. All of the above

25. The American Dental Association suggests the use of ___ to perform initial assessments for patients to determine 1) the likelihood of previous exposure to SARS-CoV-2 and 2) the nature of any dental emergency prior to performing any in-person procedures.
    A. In office questionnaires and temperature screening
    B. Teledentistry interview
    C. An isolated treatment room
    D. Any of the above

26. Current CDC guidance suggests that procedures that produce high levels of aerosols, in particular those that demonstrate exposure to infectious secretions or are likely to induce coughing, should be avoided, if possible. If such procedures must be performed, the CDC suggests use of an N95 or greater respirator and other appropriate PPE.
    A. Both statements are true.
    B. The first statement is true; the second statement is false.
    C. The first statement is false; the second statement is true.
    D. Both statements are false.

27. All of the following are currently recommended by the CDC when performing aerosol-producing procedures on COVID-19 positive or suspected patients except:
    A. Limiting the number of health-care providers to those that are essential for the procedure
    B. Utilizing a surgical mask for all procedures that produce aerosol
    C. Performance of aerosol-generating procedures in an airborne infection isolation room (AIIR), where available
    D. Clean and disinfect procedure room surfaces promptly using approved protocols and disinfectants identified by the Environmental Protection Agency as effective against SARS-CoV-2 (EPA List N)

28. Emerging strategies to augment infection control measures in dental practice to combat the COVID-19 pandemic include:
    A. Widespread vaccination
    B. Novel disinfection technologies
    C. Improved barriers, particularly for aerosol-producing procedures
    D. All of the above

29. The ability to identify individuals who may be infected and asymptomatic as well as recovered individuals is currently not widely available. Point-of-care rapid screening tests to identify both asymptomatic carriers and those who may carry immunity to COVID-19 via adequate antibody titers are currently available to allow such screening of patients in a dental office.
    A. Both statements are true.
    B. The first statement is true; the second statement is false.
    C. The first statement is false; the second statement is true.
    D. Both statements are false.

30. Future research avenues focusing on quantification of the efficacy of emerging mitigation strategies will allow for assessment of the risk-benefit analysis for such treatments. As science evolves, the best practices for delivery of dental care in dental practices will continue to evolve.
    A. Both statements are true.
    B. The first statement is true; the second statement is false.
    C. The first statement is false; the second statement is true.
    D. Both statements are false.

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ANSWER SHEET

COVID-19: Part 2—Is there something in the air? Aerosols and infection prevention/control in the dental office

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Educational Objectives

1. Explain the risk factors and basic properties of aerosols generated during routine dental procedures
2. Describe what types of dental procedures result in significant dental aerosol production
3. Understand the types of pathogens and resultant illnesses associated with such aerosols
4. Differentiate between standard and transmission-based precautions and their utility in the dental office for safe delivery of care
5. List infection control and aerosol mitigation techniques that may reduce the risk of cross-contamination to patients and providers

Course Evaluation

1. Were the individual course objectives met?

   Objective #1: Yes No Objective #3: Yes No Objective #5: Yes No

   Objective #2: Yes No Objective #4: Yes No

Please evaluate this course by responding to the following statements, using a scale of Excellent = 5 to Poor = 0.

2. To what extent were the course objectives accomplished overall? 5 4 3 2 1 0
3. Please rate your personal mastery of the course objectives. 5 4 3 2 1 0
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6. Please rate the author's effectiveness. 5 4 3 2 1 0
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8. Please rate the usefulness and clinical applicability of this course. 5 4 3 2 1 0
9. Please rate the usefulness of the references. 5 4 3 2 1 0
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12. If any of the continuing education questions were unclear or ambiguous, please list them.

    _____

13. Was there any subject matter you found confusing? Please describe.

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14. How long did it take you to complete this course?

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    _____

    _____

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10.	Ⓐ	Ⓑ	Ⓒ	Ⓓ		25.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
11.	Ⓐ	Ⓑ	Ⓒ	Ⓓ		26.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
12.	Ⓐ	Ⓑ	Ⓒ	Ⓓ		27.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
13.	Ⓐ	Ⓑ	Ⓒ	Ⓓ		28.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
14.	Ⓐ	Ⓑ	Ⓒ	Ⓓ		29.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
15.	Ⓐ	Ⓑ	Ⓒ	Ⓓ		30.	Ⓐ	Ⓑ	Ⓒ	Ⓓ

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EXAM INSTRUCTIONS
All questions have only one answer. If mailed or faxed, grading of this examination is done manually. Participants will receive confirmation of passing by receipt of a Verification of Participation form. The form will be mailed within two weeks after receipt of an examination.

COURSE EVALUATION AND FEEDBACK
We encourage participant feedback. Complete the evaluation above and e-mail additional feedback to Aileen Gunter (agunter@endeavorb2b.com) and Laura Winfield (lwinfield@endeavorb2b.com).

COURSE CREDITS AND COST
All participants scoring 70% or higher on the examination will receive a verification form for three (3) continuing education (CE) credits. Participants are urged to contact their state dental boards for CE requirements. The cost for courses ranges from $20 to $110.

PROVIDER INFORMATION
Endeavor Business Media is an ADA CERP–recognized provider. ADA CERP is a service of the American Dental Association to assist dental professionals in identifying quality providers of continuing dental education. ADA CERP neither approves nor endorses individual courses or instructors, nor does it imply acceptance of credit hours by boards of dentistry. Concerns about a CE provider may be directed to the provider or to ADA CERP at ada.org/gotocerp.

Endeavor Business Media is designated as an approved PACE program provider by the Academy of General Dentistry. The formal continuing dental education programs of this program provider are accepted by the AGD for fellowship, mastership, and membership maintenance credit. Approval does not imply acceptance by a state or provincial board of dentistry or AGD endorsement. The current term of approval extends from 11/1/2019 to 10/31/2022. Provider ID# 320452. AGD code: 148.

Dental Board of California: Provider RP5933. Course registration number CA code: 03-5933-20001. Expires 7/31/2022. "This course meets the Dental Board of California's requirements for three (3) units of continuing education."

Endeavor Business Media is designated as an approved provider by the American Academy of Dental Hygiene Inc. #AADHPNW (January 1, 2019–December 31, 2020). Approval does not imply acceptance by a state or provincial board of dentistry. Licensee should maintain this document in the event of an audit.

RECORD KEEPING
Endeavor Business Media maintains records of your successful completion of any exam for a minimum of six years. Please contact our offices for a copy of your CE credits report. This report, which will list all credits earned to date, will be generated and mailed to you within five business days of receipt.

CANCELLATION AND REFUND POLICY
Participants who are not 100% satisfied can request a refund by contacting Endeavor Business Media in writing.

IMAGE AUTHENTICITY
The images in this educational activity have not been altered.

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