

COVID 19 Air Spread Infections: Role of Aerosols in Dentistry and a Basic Cure in this Pandemic

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Abstract: The detection of SARS-CoV-2 RNA in aerosols but failure to isolate viable (infectious) virus are commonly reported, there is substantial controversy whether severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) can be transmitted through aerosols. This conundrum occurs because common air samplers can inactivate virions through their harsh collection processes. We sought to resolve the question whether viable SARS-CoV-2 can occur in aerosols using VIVAS air samplers that operate on a gentle water vapor condensation principle. During the rapid rise in COVID-19 illnesses and deaths globally, and notwithstanding recommended precautions, questions are voiced about routes of transmission for this pandemic disease. Inhaling small airborne droplets is probable as a third route of infection, in addition to more widely recognized transmission via larger respiratory droplets and direct contact with infected people or contaminated surfaces.

Keywords: SARS-CoV-2, aerosols, infectious, COVID-19.

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INTRODUCTION

Coronavirus disease 2019 (COVID-19) was first reported in Wuhan, China, in December 2019 [1].

The disease is caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and asseverated to be transmitted from human-to-human by multiple means through droplets, aerosols, and fomites [2]. COVID-19 infection occur as, severe acute respiratory illness, with fever, cough, myalgia, are common symptoms at the onset of illness.

Infectious agents may spread from their natural reservoir to a susceptible host in different pathways. There are various classifications reported in the literature for modes of transmission of different infectious agents [3]. Has presented a classification for virus transmission, including human-human transmission, airborne transmission, and other means of transmission such as endogenous infection, common vehicle, and vector spread. However, many respiratory viruses are believed to transmit over multiple routes, of which droplet and aerosol transmission paths become

paramount, but their significance in transmitting the disease remains unclear [4]. In general, infected people spread viral particles whenever they talk, breathe, cough, or sneeze. Such viral particles are known to be encapsulated in globs of mucus, saliva, and water, and the fate/behavior of globs in the environment depends on the size of the globs.

Respiratory particles may often be distinguished to be droplets or aerosols based on the particle size and specifically in terms of the aerodynamic diameter. One could dispute that, unlike larger droplets, aerosols may pose a greater risk of the spread of the COVID-19 disease among many susceptible hosts positioned far from the point of origin.

Control of COVID-19 sources in closed spaces

To avoid the direct transmission of SARS-CoV-2 and subsequent potential airborne transmission in closed spaces in which people are present for significant durations, it is essential that the guidance is followed, which are outlined in documents such as ECDC's guidance for discharge and ending of isolation of people with COVID-19 [5]. These include that

COVID-19-positive people, people with COVID-19-related symptoms and people in quarantine must not stay in closed spaces together with other people.

In the enclosed spaces of vehicles, it is also essential to adhere to the guidance as outlined in guidance documents from ECDC in collaboration with other relevant EU agencies:

- COVID-19 Rail Protocol: Recommendations for safe resumption of railway services in Europe, 21 July 2020 [6];
- COVID-19 Aviation Health Safety Protocol: Guidance for the management of airline passengers in relation to the COVID-19 pandemic, issue 2, 1 July 2020 [7];
- EU guidance for cruise ship operations, 27 July 2020 [8].

Engineering controls in mechanically ventilated and naturally ventilated closed spaces

Building administrators should review, maintain (including the upgrade of filters where appropriate), particularly in relation to the cleaning and changing of filters [9]. There is no benefit or need for additional maintenance cycles in connection with COVID-19.

The minimum number of air exchanges per hour, in accordance with the applicable building regulations, should be ensured at all times. Increasing the number of air exchanges per hour will reduce the risk of transmission in closed spaces. This may be achieved by natural or mechanical ventilation, depending on the setting [10-14].

Specific recommendations for natural ventilation through opening windows and doors should be developed on an individual basis, taking into account the characteristics of the room (volume, size and function of openings, occupancy rates), the activities taking place in the room, the climatic and weather conditions, as well as energy conservation and the comfort of the users. Advice on these topics can be found in the documents referenced in this guidance [9, 13, 14].

When it is not possible to measure the ventilation rate, measuring carbon dioxide air levels can be considered, especially in naturally ventilated rooms, as a surrogate of the sufficiency of ventilation. Technical guidelines recommend that the carbon dioxide concentration is kept below 800 to 1 000 ppm to ensure sufficient ventilation [9].

Energy-saving settings, such as demand-controlled ventilation in central HVAC systems controlled by a timer or CO₂ detectors, should be assessed for their possible impact on risks of transmission. Consideration should also be given to

extending the operating times of HVAC systems before and after the regular period [9, 15].

Direct air flow should be diverted away from groups of individuals to avoid the dispersion of SARS-CoV-2 from infected persons and transmission to other persons. For example, in supermarkets, cashiers and customers have different levels of mobility and durations of occupancy. As a general principle, mechanical ventilation should be arranged so that it minimises the direction of sustained air flow towards stationary persons.

Building administrators should, with the assistance of their technical/maintenance teams, explore options to avoid the use of air recirculation as much as possible [9]. They should consider reviewing their procedures for the use of recirculation in HVAC systems based on information provided by the manufacturer or, if unavailable, seeking advice from the manufacturer.

It is not recommended to change heating set points, cooling set points and possible humidification set points of HVAC systems as a measure to reduce potential SARS-CoV-2 transmission [9, 13].

The use of stand-alone air cleaning devices equipped with an HEPA filter or a filter with comparable efficiency level can be considered, especially in spaces in which optimal ventilation is impossible. Such 'room air cleaners', however, usually only cover small areas and need to be placed close to the people occupying the room [9]. UVGI devices, either in the ducts of HVAC systems or placed sufficiently high in rooms, can also be considered, but they should be shielded from direct vision due to the risk of causing cataracts. Stand-alone air cleaning devices and UVGI devices can have a role in settings where central HVAC systems are not capable of increasing the air exchange or reducing the recirculation of air.

The technical specifications regarding the logistical arrangement of closed spaces, including the physical placement of HVAC systems, need to be informed by scientific evidence and technical expertise, so as to minimise the risk of transmission of SARS-CoV-2. These specifications also need to take into account the expected number of users, the different types of user, and the users' activity.

Administrative controls

As a general principle, it is recommended to limit the maximum number of people in closed spaces (e.g. office buildings, schools, universities, shops, buildings for leisure activities) and the maximum duration of stay in them, to reduce the risk of transmission of SARS-CoV-2 [16].

Other non-pharmaceutical measures include continued teleworking/e-learning, as outlined in, for example, ECDC's guidelines for the implementation of non-pharmaceutical interventions against COVID-19 [7].

Personal protective behaviour

Even the best COVID-19-related adaptations of HVAC systems and engineering measures for naturally ventilated spaces are jeopardised in the absence of personal protective behaviour to reduce potential direct SARS-CoV-2 transmission. Personal preventive measures with proven evidence of reducing the risk of SARS-CoV-2 transmission should therefore be emphasised [7]. Organisers and administrators responsible for gatherings and critical infrastructure settings should provide guidance material to participants and personnel regarding the application of personal preventive measures, including:

- Physical distancing;
- Meticulous hand hygiene;
- Respiratory etiquette;

The appropriate use of face masks and areas where physical distancing cannot be maintained due to structural or functional impediments.

The application of the above guidance should be in accordance with national and local regulations (e.g. building regulations, health and safety regulations) and appropriate to local climatic conditions.

Avoid Air Recirculation

The recirculation of air is a measure for saving energy, but care must be taken, as it can transport airborne contaminants (including infectious viruses) from one space and distribute them to other spaces connected to the same system, potentially increasing the risk of airborne infection in areas that otherwise would not have been contaminated. This concern has been noted previously in regard to the possible recirculation of biological agents during terrorist attacks that have investigated the effectiveness of eliminating recirculation (e.g. providing 100% outside air to spaces and exhausting all of it) as a countermeasure following an indoor release of the agent [17]. A study modelling the risk of airborne influenza transmission in passenger cars provided also a case against air recirculation in such situations [18].

Particulate filters and disinfection equipment in recirculated air streams can reduce this risk, but they need to be purposely designed to control risk of airborne infection and need regular service to maintain their effectiveness. Many systems are designed for filters that are intended to remove larger particles that may affect the functioning of equipment and that are not effective at removing small, sub micrometre or micrometre size particles associated with adverse health effects. Filter ratings by test methods, such as ASHRAE

Standard 52.2 [19] that give an indication of performance as a function of particle size should be utilized in choosing appropriate filters.

Following the above considerations, during an epidemic, including the current COVID-19 pandemic, air should not be recirculated as far as practically possible, to avoid the dissemination of virus-laden particles throughout the indoor environment. For central air handling units at a building level or serving multiple zones, recirculation should be avoided, and the system operated on 100% outdoor air (OA) if possible. Disabling recirculation can be achieved by closing the recirculation dampers and opening outdoor air dampers. In systems where it is not possible, one should try to maximize the OA-level and apply filtering or ultraviolet germicidal irradiation to remove or deactivate potential viral contamination from the recirculated air. In many health care settings, air recirculation is, in most cases not allowed at all, though though recirculation is commonly used in non-hospital settings for improving energy efficiency. At a room (decentral) level, secondary air circulation systems may be installed. One needs to assure that any of such systems also provides ventilation with outdoor air (e.g., induction units). If this is the case, such a system should not be switched off. Other systems, which do not have this feature (e.g., split air-conditioning units) should if possible be turned off, to avoid potential transfer of virus through air flows between people. When such a system is needed for cooling then additional ventilation with outdoor air should be secured by regular/ periodic ventilation through, e.g., window opening.

Air Cleaning and Disinfection Devices May Be Beneficial

In environments where it is difficult to improve ventilation, the addition of local air cleaning or disinfection devices, such as germicidal particle-free air produced by the air cleaner [20].

Kujundzic *et al.*, [21] reported air cleaners were similarly effective against removing both airborne bacterial and fungal spores from the air at clean air delivery rates of between 26 and 980 m³/h corresponding to effective cleaning of between 5 and 189 m³ room volumes respectively. However, these systems are of little benefit against person-to-person transmission when installed in the supply air of once-through systems that do not re-circulate air within the space or building.



Airborne Spread

The airborne spread of SARS-Cov (severe acute respiratory syndrome coronavirus) is well-reported in many literatures. Dental procedures produce aerosols and droplets that are contaminated with virus [22]. Thus, droplet and aerosol transmission of 2019-nCoV are the most important concerns in dental clinics and hospitals, because it is hard to avoid the generation of large amounts of aerosol and droplet mixed with patient's saliva and even blood during dental practice [23]. In addition to the infected patient's cough and breathing, dental devices such as high-speed dental handpiece uses high-speed gas to drive the turbine to rotate at high speed and work with running water. When dental devices work in the patient's oral cavity, a large amount of aerosol and droplets mixed with the patient's saliva or even blood will be generated. Particles of droplets and aerosols are small enough to stay airborne for an extended period before they settle on environmental surfaces or enter the respiratory tract. Thus, the 2019-nCoV has the potential to spread through droplets and aerosols from infected individuals in dental clinics and hospitals.

Contact Spread

A dental professional's frequent direct or indirect contact with human fluids, patient materials, and contaminated dental instruments or environmental surfaces makes a possible route to the spread of viruses [23]. Dental professionals and other patients have likely contact of conjunctival, nasal, or oral mucosa with droplets and aerosols containing microorganisms generated from an infected individual and propelled a short distance by coughing and talking without a mask. Effective infection control strategies are needed to prevent the spread of 2019-nCoV through these contact routines.

SUMMARY

Since December 2019, the newly discovered coronavirus (2019- nCov) has caused the outbreak of pneumonia in Wuhan and throughout China. 2019-nCov enters host cells through human cell receptor ACE2, the same with SARS-CoV, but with higher binding affinity [24]. The rapidly increasing number of

cases and evidence of human-to-human transmission suggested that the virus was more contagious than SARS-CoV and MERS-CoV.

By mid-February 2020, a large number of infections of medical staff have been reported [25], and the specific reasons for the failure of protection need to be further investigated. Although clinics such as stomatology have been closed during the epidemic, a large number of emergency patients still go to the dental clinics and hospitals for treatment. We have summarized the possible transmission routes of 2019-nCov in stomatology, such as the airborne spread, contact spread, and contaminated surface spread. We also reviewed several detailed practical strategies to block virus transmission to provide a reference for preventing the transmission of 2019-nCov during dental diagnosis and treatment, including patient evaluation, hand hygiene, personal protective measures for the dental professionals, mouthrinse before dental procedures, rubber dam isolation, anti-retraction handpiece, disinfection of the clinic settings, and management of medical waste.

CONCLUSIONS

Until full life time, a effective pharmacological treatments or vaccines are available to reduce the effective reproductive number to less than 1.0 and stop the ongoing COVID-19 pandemic, enhanced ventilation may be a key element in limiting the spread of the SARS-CoV-2 virus. These are the key ventilation-associated recommendations:

1. To remind and highlight to building managers and hospital administrators and infection control teams that engineering controls are effective to control and reduce the risks of airborne infection – and SARS-CoV-2 has the potential and is likely to be causing some infections by this route.
2. To increase the existing ventilation rates (outdoor air change rate) and enhance ventilation effectiveness - using existing systems.
3. To eliminate any air-recirculation within the ventilation system so as to just supply fresh (outdoor) air.
4. To supplement existing ventilation with portable air cleaners (with mechanical filtration systems to capture the airborne micro- droplets), where there are areas of known air stagnation (which are not well-ventilated with the existing system), or isolate high patient exhaled airborne viral loads (e.g. on COVID-19 cohort patient bays or wards). Adequate replacement of the filters in the air cleaners and their maintenance is crucial. And use of surgical mask or N95 mask in your day to day life style and sanitization.

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