EC DENTAL SCIENCE
Review Article

The Importance and Improvement of Indoor Air Quality in Dental Clinics within the context of Covid-19

Guven Y[1]*, Sepet E[2], Sezgin BI2 and Celik EG[3]

[1]*Istanbul Kent University, Faculty of Dentistry, Basic Science Department*

[2]*Istanbul Kent University, Faculty of Dentistry, Department of Pedodontics*

[3]*Istanbul Kent University, Faculty of Dentistry, 2nd Year Student*

***Corresponding Author:** Guven Y, Istanbul Kent University, Faculty of Dentistry, Basic Science Department.

Received: August 25, 2020; **Published:** December 28, 2020

Abstract

As of August 24, 2020, WHO has reported 23 311 719 Covid-19 confirmed cases in 216 countries, areas. The confirmed death toll from these cases is 806 410. New information on the transmission routes of Covid-19 is found every day. While there are no conclusive results on the "airborne transmission" of Covid-19 in indoor transmission, recent research suggests that Covid-19 can be detected in the air and can live for a long time after aerosolization.

Workers at dental clinics are also in the largest risk group exposed to extra aerosols that emerge during treatment.

The purpose of this review is to review the studies on Covid-19, the cause of the pandemic that has been around the world for about six months, and to review the studies on aerosol transmission from the air, which are not much discussed (controversial), and to review the studies on the quality and improvement of office air during dental procedures, which are one of the most important risks for virus transmission.

It is concluded that indoor air quality should be of the highest standard for the health of the dental clinics personal and patients in the waiting room. Air movement should be ensured. To do that; since it is the safest way to provide air quality, airing to dilute the infectious particle concentration in the air should be ensured. If ventilation equipment is to be used, ventilation systems with HEPA filter that distribute negative pressure should be chosen. Personal must not put off their protective equipment before leaving the clinic.

In addition, information on aerosol transmission and protection from transmission of Covid-19 by inhalation should be added by updating the public health guidelines published to prevent the spread of the virus.

Keywords: *İndoor Air; Air Quality; Dental Clinic; Covid 19*

Introduction

The world has faced three coronavirus outbreaks in the past two decades: 1) SARS (SARS-CoV-1) in 2002-2003, 2) MERS (MERS-CoV) in 2012, and 3) Covid-19 (SARS-CoV-2) in 2019-2020.

Despite consecutive outbreaks such as SARS (Severe Acute Respiratory Syndrome), MERS (Middle East Respiratory Syndrome) and Covid-19, our awareness and concern to prevent the transmission of viral and bacterial infections that exist in the air, and about the importance of management of "indoor air quality" unfortunately is not better than the past. However, experience with severe acute respiratory syndrome (SARS) in 2003 revealed the importance of "aerosol" transmission among both healthcare workers and patients. Airborne transmission via aerosol has also been identified for many other human pathogens. Aerosols are suspension of solid or liquid particles in a gas and its particle size is above 0.001 to 100 µm. Aerosols containing pathogens are infectious. Large droplets can become small droplets and then droplet nuclei with evaporation process.

A droplet nuclei is the airborne residue of a potentially infectious aerosol after the liquid portion has evaporated [1].

Droplets formed by breathing, speaking, laughing, singing, coughing and sneezing lead to the formation of a potentially contagious aerosol in infections known to occur in the respiratory tract. These aerosols are likely to be transported to longer-range locations and create potential infection from pathogens [2].

As defined by William F. Wells for the first time in the 1930s, the size range between small and large droplets that move in the air and cause disease transmission, as suggested by the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) in our day, and as stated in other publications, to define the upper limit of the size of small droplets, it is 5 µm or 5 - 10 µm. WHO, CDC and the literature are compatible in using the term aerosol to refer to "breathable particles smaller than 5 - 10 µm that can remain airborne and have short and long range transport capacity". Larger droplets fall to the ground by > 20 µm gravitational effect and are too large to get through the air by inhalation; those in the 10 - 20 µm range either fall to the ground or remain in the air [3-5].

In addition to discussing the importance of droplets smaller than 5-10 µm for aerosol transport, the researchers discuss the importance of size distribution and penetration from the respiratory systems. It has been reported that small droplets in the range of < 5 µm can penetrate the respiratory ways up to the alveolar cavity [2].

Scientific Publications that Record the Importance of Aerosol Transport for Viruses Similar to Covid-19

Transmission via aerosol has been reported to be a well-known and important route of exposure for infectious agents such as influenza and other viruses, including corona-viruses. SARS-CoV-1 viral RNA was found in air samples, and long-distance aerosol transport has been cited as the cause of disease spread in several studies [2].

The authors noted reports showing that viruses such as flu can spread in the air in pandemic situations, and that some agents can be transmitted from atypical large distances due to aerosol formation. It was also reported that the potential for infection depends on the dose of pathogen that the individual receives by inhalation and the role of the immune response, as well as relative humidity, temperature, and other environmental factors necessary to keep airborne viruses alive.

In a study that examine the pathogen emission and transport by respiratory tract in turbulent gas clouds [6], it was shown that pathogen-containing droplets can travel up to 23 - 27 feet, also the droplet size, turbulence, speed of the gas cloud, humidity and temperature were recorded to be important factors for distance. Covid-19 has been shown to stay alive longer in low (< 50%) humid environment.

In a study on aerosol transmission of infectious agents [3], "aerosol transmission" was defined as transmission from one person who is infected with infectious agents that are known to be transmissible via airborne aerosol to another person.

A study has shown that seasonal covids can be spread through normal respiration with more aerosols than droplets [7]. More recent studies on the propagation size of droplets show distances longer than 2 meters (≈6 feet) [6,8,9].The maximum distance recorded in several current studies is 8 meters (≈26 feet) [6,10] and the risk of infection is well beyond the recommended distance.

Droplet sizes

In respiratory diseases, the dynamics of the droplets taken are related to particle size. Those with a size of 10 - 100 µm have been reported to mediate medium-to long-term outbreaks in airborne transmission, while those smaller than 10 µm in diameter have been reported to cause short-term outbreaks with high attack effects. However, population dynamics are determined by pathogen infectivity and host contact rates, among other parameters [11].

There is also no agreement on the identification of the way of transmission by droplet. There is a consensus that particles smaller than 5 μm in diameter are airborne particles, but there are significant differences in the literature when it comes to the classification of the lower size limit of droplets.

Wells [12] determined 100 μm as the separation limit for the droplet path. However, in later studies it has been shown to have a particle diameter of 10 μm to-100 μm and more [13-15]. WHO uses a separation limit of 5 μm to distinguish the transmission routes of aerosols (≥ 5 μm) and droplets (> 5 μm). However, there is a study that even particles more than 10 μm in diameter can remain in the air long enough not to fall [16].

Tang., *et al*. [1] reported that SARS-CoV-1 particles of 1 - 3 μm diameter remain suspended almost indefinitely, while it takes 17 minutes for 10 μm to fall to the ground, 20 μm takes 4 minutes, and lastly 100 μm takes 10 seconds.

Covid-19 contagiousness

The contagion of COVID-19 has not yet been fully elucidated, but it is thought to be similar to Sars, which spreads through contact, droplets and airborne transmission [17]. Although many experts in China and other countries have experience with SARS-CoV-1, officials still do not accept airborne transmission [18].

The route of transmission accepted by medical authorities to this day is the transmission by droplets and contact.

However, there are some findings pointing to airborne transmission and the number of studies on this subject is increasing every day. Although the certainty of the danger of COVID-19 is known, the dose-response is unknown and exposure routes are investigated [2].

Hand washing and maintaining social distance are key measures recommended by World Health Organization (WHO) to prevent getting infected with Covid-19. However, unfortunately, these measures do not prevent infection caused by the inhalation of small droplets that can travel within meters (up to ten meters) in the air, released by an infected person and carry viral contents.

To this date, there has been a focus on "near-field transmission" as a way of transmission, through coughing and sneezing from infected individuals, and by hand-to-face transmission through contact from surfaces. It has not been focused specifically on aerosols, which are a potentially important route of transmission. Sneezing, breathing and speech in asymptomatic individuals without a common cough symptom cause small aerosol transport [2].

There are studies showing that airborne transmission of virus-laden particles is a route of transmission [1,18]. Due to studies showing that SARS-CoV-1 can be transported and transmitted by air, it has been reported that Covid-19 is also likely to spread via air [2].

Limited sampling results in laboratory environments show that Covid-19 and SARS-COV-1 remain in the air and can travel long distances within the building. In the hospital setting, viral RNA has been detected in the air, in nearby corridors and inside the patient rooms where Covid-19 patients received care [19]. The data suggest that viral aerosol particles are produced by people with COVID-19 disease, even if they are not coughing, and that a significant proportion of the aerosol that is ejected through breathing is indicated to have a diameter of less than 10 μm in all types of activity (e.g. respiration, speech, and coughing).

During the SARS outbreak in 2003, the increase of the risk of infection with SARS-CoV-1 of the residents on the top floor of a building, was associated with the transport of aerosol from an infected person who lives downstairs, which has increased concerns about infiltration of respirable aerosols containing the infectious agent [17].

In addition to the presence of covid-19 viral loads in the lower and upper respiratory tract [20] it has been reported that the airborne persistence of the virus is possible 3 hours after aerosol formation in laboratory settings. A recent laboratory study on the survival of Covid-19 on various surfaces includes data on the aerosol form. It was concluded that the virus can be contagious in aerosols for hours and live on surfaces for days. It was shown that aerosolized Covid-19 was "able to live in aerosols throughout the experiment (three hours)", and that infectious titre decreased about 6-fold during that time frame [21]. It was also stated that the results are similar to those in SARs-CoV-1. In aerosols " half-lives of Covid-19 and SARS-CoV-1 were found to be similar. Their median values were reported to range from about 1.1 to 1.2 hours with 95% reliable interval of 0.64 to 2.64 for Covid-19, and for SARS-CoV-1 it changed between 0.78 to 2.43.

However, there is not enough information available in the sources that directly addresses the transport of Covid-19 via aerosol.

"21st century health threats" letter of the National Academy of Sciences (NAS) committee stated: "Although specific research on Covid-19 is limited, the results of current studies are consistent with the aerosolization of the virus from normal respiration".

The letter answers questions from the Office of Science and Technology Policy regarding the possibility of transmission of the Covid-19 virus through speech in addition to sneezing/cough-induced droplets [22].

After the examination of the samples from indoors from the Prince of Wales Hospital in Hong Kong [23-25], at health facilities in Toronto [26] and on the plane [27] it was demonstrated that airborne transmission is the main transmission route. Other examples of airborne viral infections include the spread of the Norwalk-like virus among school children [28] and infection with influenza A/H5N1 virus among ferrets [29].

The report which examines the evidence and issued by WHO in 2009, states that viral infectious diseases can spread in distances with aerosols in interior spaces, and can result in big infection accumulations in short time. Considering many similarities between the two SARS viruses and the evidence for virus transport in general, the Covid-19 virus is also likely to spread by air [22]. Experts on droplet dynamics and airflow in buildings agree on this [30]. Covid-19 was shown to be in the air in open spaces at the hospital entrance and in front of a store, and it was concluded that asymptomatic individuals in those areas may have contributed to these results [31].

Covid-19 in interior spaces

As the viruses circulating in the air are not easy to detect directly, public health authorities do not focus on airborne transmission of influenza and Corona viruses. However, the fact that there is no simple method to detect the existance of virus in the air does not mean that the viruses are not circulating in the air.Immediately after exhaling, the particle, which is like a feather carrying the expelled viral content, is diluted with air and moved by air flow [18].

In the indoor environment, the concentration of the virus does not increase stably, but it only rises in the airflow if there is sufficient ventilation [32]. Therefore, the airflow from the infected person to detect the presence of the virus requires sampling information and a long sampling time enough to collect sufficient samples of the viruses. Microbiologists collecting viral samples are not normally experts on building flow dynamics, and in practice it seems that current virus detection methods will require a long period of time for their sensitivity [26].

Retrospective modeling studies showed that SARS-CoV-1 was airborne in 2003 [23-27]. Although we still do not have all the necessary data regarding Covid-19, including the characteristics of interior spaces where Covid -19-related infections occur, the analysis of the first Covid-19 model that broke out in China, especially in areas outside of Wuhan, for example, such as Guangdong and Tianjin, revealed many examples of contactless transmission [18]. On the cruise ship, where there were many passengers and thousands of people were infected, most of the infections occurred after careful hand hygiene was applied, direct contact was restricted and passengers were isolated in their cabins. Therefore, it is debated whether the ventilation system that emits the airborne virus is one of the causes of the infection. It was also hypothesized that airborne transmission was partly responsible for a large number of infections during a choir study in which 45 out of 60 choir members were infected [18].

Despite strong evidence and hypothesis, people all around the world seem to believe that only direct contact is to blame for the spreading of the viral infection. When we are faced with a new COVID-19 viral outbreak, all the evidence that is currently available and former experience point out to the fact that an alarming situation may arise.

Possibilities of transmission from asymptomatic individuals

Asymptomatic individuals do not know that they are infected with Covid-19, as they do not cough or sneeze.

Scientists from the Centers for Disease Control and Prevention (CDC) and the National Institute of Health (NIH) in the United States have discussed transmission from asymptomatic people and stated that coughing and sneezing may not be the only important way to spread the active virus [2].

Case reports on infection were published in studies which show that normal breathing and speech in asymptomatic individuals produce small droplets in a size that can be carried by aerosol [2]. While experimental data that record aerosolized covid-19 particles that remain in the air for hours is limited, there is some data that they can be transported over distances, including outside of rooms and inside buildings. Supporting the importance of aerosol transmission of infectious diseases, these data show that urgent attention should be paid to the importance of the effects of aerosols on public health.

Researchers in China have indicated that asymptomatic COVID-19 transmission is a possibility after studying five family members who become symptomatic after contacting with an asymptomatic family member who visitied them from Wuhan [33].

Zou., *et al*. [34] identified viral loads with featureless CT scans in an asymptomatic patient, similar to those without symptoms.

Wei., *et al*. [35] reported possible "pre-semptomatic transmission" in seven case groups after investigating all 243 COVID-19 cases reported in Singapore between January 23 and March 16. In addition, the researchers assessed that a large proportion (79%) of transmission cases in China were from untested individuals, possibly because a large proportion of them were asymptomatic [36].

Case reports that show the transmission of virus to others from Covid-19 infected asymptomatic individuals with normal breathing, speech, etc. mainly report the role of small droplets of < 1 µm size in aerosol transport [2].

A limited number of empirical data that detect aerosolized Covid-19 and SARS-CoV-1 particles suspended in the air for hours indicate that they are transported over long distances, including outside of rooms and inside buildings [2].

In a study, which was conducted at a hospital in Wuhan, the surface and aerosol distribution of covid-19 in various parts of the intensive care unit and in general ward sections of the hospital were measured. The findings confirm that exposure to covid-19 aerosol poses a risk [37]. The researchers suggested that the distance could not be determined precisely because of the limitation of the amount of live virus and its infectious dose in the transmission samples, but it could be 4 metres (13 ft).

Numerous literature reports that aerosol droplets are dominant in normal individuals during normal breathing and speech and occasionally while coughing [38-41]. There is also consensus among studies that with normal breathing and speech, most of the size that causes spread (80 - 90%) is through droplets that are in the <1 µm range [41]. In short, these observations and similar observations have gained increasing acceptance in the daily public press, and it is argued among medical staff that transmission from asymptomatic individuals is an important transmission route [18,30,42].

Dentistry-Covid-19

Since dentists are exposed to saliva, blood and aerosol / droplets in most dental treatment procedures, they are professionals who face the greatest risk for coronavirus within different study categories [43-46].

There are many dental procedures such as restorative dentistry, root canal treatment, ultrasonic scaling, curettage, periodontal dental surgery, prosthetic dentistry, orthodontic treatment, dental implant surgery and surgical removal of third molars. The use of high-speed rotating instruments or ultrasonic scalers can produce aerosols. Microbial aerosols can also be emitted during dental procedures. These aerosols are liquid or solid molecules that are suspended in the air and contain bacteria, virus, fungi, saliva, and blood. Aerosols produced during dental procedures not only reduce indoor air quality, but are sources of infection that may pose a threat to the health of dental personnel [47-49].

Investigation of pollution in dental clinics is focused on methods of reducing the contamination of the air and various infectious diseases (tuberculosis, hepatitis, upper respiratory tract infections, and other viral or bacterial diseases) that emerge as a result of contamination during dental treatment procedures [50-53].

For this purpose, contamination levels of air, water and surfaces before, during and after dental treatments were analyzed [54-56]. Bacterial aerosol pollution levels were compared between different positions in different dental treatment environments and in the same dental clinics [57,58].

Intensive aerosol production and persistence during dental treatments expose dentists to the risk of inhaling small particles and droplets that are reported to potentially carry microorganisms such as bacteria and viruses [59]. For this reason, it is very important to protect both the health of the patients and the staff from the virus by creating a safer working environment [60].

Due to the rapidly developing pandemic, in terms of dental transmission of Covid-19, data on clinical experience in dentistry is scarce. There are studies that confirm Covid-19 transmission can occur through inhalation of aerosols/droplets from infected individuals during dental procedures or through direct contact with mucous membranes, oral fluids, contaminated instruments and surfaces [61-63]. In these studies that are mostly from China, the risks associated with dental practice and recommended infection management protocols for dentists have been identified [44-46]. The study conducted in 2020 by Meng., *et al*. reported data on clinical activities To., *et al*. [64] proposed that saliva from infected individuals is a Covid-19 reservoir, therefore aerosol-producing procedures should be reduced.

Covid-19 has been reported to be able to stay alive for up to 3 hours in aerosol and have a fairly long half-life of about 1.1 to 1.2 hours [21], suggesting that the production of aerosols and droplets during routine dental procedures will have a significant impact on the contagion of the virus [65].

In a study conducted by Xu., *et al*. [46[] the infectious risk of oral cavity was assessed, and data revealing the ACE2 host cell receptor for Covid-19 was present in mucus, was obtained.

Helmis., *et al*. [65] studied the air quality parameters and the aerosol distribution in 6 different branches of dentistry (pediatric dentistry, craniofacial, periodontology, general dentistry, equipment disinfecting room and patient waiting area). The highest atmospheric concentrations (PM10, PM2.5 and PM1) is located in the department of periodontology, while the lowest concentrations occurred in the patient waiting area. The highest rate of airborne bacteria was found in the patient waiting room. (1299.25 CFU m- 3, It was reported that 94% of these bacteria were gram-positive bacteria, and most of them (25%) were found in the pediatric clinic, least of them were found in the equipment disinfection room (9%), and the major pathogens were identified as *micrococcus luteus* and *Bacillus cereus* (Liu., *et al*, 2017).

Indoor air quality in dental clinics

Air quality in dental clinics must comply with the following ISO standards:

- ISO 14644-1: Clean Room standards (2015): classification of air cleanliness by particle concentration
- ISO/DIS 14644-1.2 (2018): specifications for observing air purity with nano-scale particle (ultrafine) concentration

According to these standards, the maximum number of particles with a size of ≥ 1 μm that can be found in clean room air is 8320/m^3, while the maximum number of particles with a size of ≥ 5 μm is 293/m^3. This corresponds to class 1000 according to FED STD 209E [66].

The importance of air quality in dental clinics

In dental clinics, indoor air is 5 times dirtier than outdoor air. The air of the clinic is full of pollutants such as bacteria, viruses and chemicals like mercury and disinfectants. These chemicals can pose a serious threat to the health of staff and patients.

It is important to maintain good air quality to protect dental staff and patients from many harmful airborne pollutants.

In routine dental treatments, many chemical compounds may emerge that may be harmful to those exposed to these contaminants. These pollutants can be caused by dental equipment, such as high-speed rotating tools. Dentists are liable to provide safe working conditions for employees and to keep patients healthy. Volatile organic compound sensors should be used to detect substances with adverse health effects including liver and kidney damage and cancer, such as formaldehyde and ketone [67].

Solutions to increase indoor air quality in dentistry clinics

Temporary solutions

Use of disinfectants on surfaces. (It can be time consuming, costly and harmful):

Cleaning products, that contain bleach, emit chlorine-containing compounds such as hypochlorous acid (HOCl) and chlorine gas (Cl_2), which can accumulate at relatively high levels in poorly ventilated indoor environments. These gases can react with other chemicals commonly found in homes, such as limonene, an orange or lemon-scented compound added to many personal care products, cleaners and room sprays. Also, the interior lighting or sunlight from windows can split HOCL and CI_2 into a hydroxyl radical and chlorine atom, which can react with other compounds to form air particles called secondary organic aerosols, and these pollutants may cause respiratory problems and other adverse health effects.

Instead of using hypochlorous acid as a spray in the disinfection of room air, it is preferred to let in fresh air and disinfect with filters and UV that hold viruses. Although there have been studies on the use of hypochlorous acid in wound disinfection and mouthwash since the 2000s, the doses used should not be in a level that is irritating for the skin and especially eyes (non-irritating dose for eyes: 0.013% HOCl, non-irritating dose for the skin: 0.01, 0.03, and 0.1%, without any toxic effect in animal experiments in 28 days: 0.01, 0.03, and 0.1%).

It is reported that it has never been used as a pharmaceutical drug in the treatment of infection because of its chemical structure and there are not enough convincing toxicity studies [68-70].

Long-term preventive solutions

Air filters, Slow-release active chemicals (titanium dioxide, TiO_2), UV-C light and Negative ions: Dental clinics have many different options for cleaning the indoor air.

When choosing a solution, it is important to consider these selection criteria:

Filtration system-the first and most prominent one. Filters are of great importance in eliminating viral and bacterial pathogens that can be present in the air after being released from infected living beings. Especially in order to protect indoor ventilation equipment and maintain healthy indoor air quality, filters capable of handling large amounts of air are installed in buildings' heating and air conditioning (HVAC) systems. One important issue revealed by the Covid-19 pandemic is whether the filters of the central ventilation systems in healthcare institutions transmit the viruses. Central ventilation may be harmful in terms of cross contamination to occur. These ventilation filters, which are used in hospitals and have different types, are important in determining the types and concentrations of virus aerosols in the environment [67,71].

The most important question here is whether respiratory system filters can prevent virus particles from an infected patient from entering the respiratory system and passing through the ventilator into the air and prevent airborne virus spread [72] If these filtering devices cannot contain the virus and protect health workers, there is a great risk. Therefore, filters which are previously known to hold various bacteria, viruses (Mycobacterium tuberculosis, Staphylococcus aureus, hepatitis C virus, HIV, influenza A virus, H1N1, corona virus) and pathogenic proteins should be used. Such filters are hydrophobic mechanical filters that have a very high efficiency rate of bacterial and viral retention in the air (≥ 99,999%) and it have been reported that they have the same retention efficiency for liquid-borne bacterial and viral contamination [73,74].

Filtration efficiency of mechanical filters tends to increase over time as the substances held on the filter form a layer ("filter shell layer"), which has been reported to gradually increase particle retention [72,74].

The filters used in dental clinics should be able to remove all air pollutants effectively and efficiently. In addition to killing bacteria and viruses by using UV-C light, an effective filter system should be able to remove dust, volatile organic compounds, mold, bacteria and odor.

Air purifiers used in dental clinics should have specific characteristics [75]:

- The air flow capacity of the filter system-Air flow rate ($1ft^3/min=0.028\ m^3/min$) that the system can use must be considered, and to provide the necessary efficiency, the dentist office should be ventilated at least once in 30 minutes.
- Sound level of the filter system: The sound that air creates when passing through an air cleaner should not be disturbing. A good air cleaner should be able to provide a large air flow capacity at a volume level of 50 dB (decibel). A silent dishwasher produces approximately 50 dB of sound and human speech produces 60 dB of sound.
- Air reenergization-It has been reported that reenargization of indoor air can help people maintain high levels of cognitive function. Ion generators are thought to re-energize the interior air. It is thought that breathing reenergized air can increase oxygen flow to the brain and increase alertness, reduce lethargy and result in more mental energy.

Humidity level

Other important factors are temperature, relative humidity, the effect of ventilation on droplet propagation and there have been only a few studies [76].

Relative humidity has been shown to play an important role in the evaporation of droplets and the distances at which droplets can travel to. As relative humidity increases, it has been reported that the degree of droplet propagation decreases [77,78], but due to the buoyant force of the cloud formed by breathing, it has been found that the distance that the cloud pushing the droplets can reach horizontally increases with the increase in relative humidity [79]. For droplets smaller than 20 μm in diameter, the local air flow area caused by body temperature is an important factor in determining the extent of contagion because the droplets can be lifted upwards into the respiratory region [80]. Studies have also shown that, depending on the flow direction and the air flow pattern, the long-range of increased ventilation can effectively reduce the risk of airborne transmission [81].

Especially, differences in temperature and humidity affect how determined and contagious viruses are. Some data suggest that cold and dry weather may contribute to flu transmission in winter [82,83].

Dry air affects viral transmission in 2 ways. Firstly, when cold and dry air enters the interior and warms up, the relative humidity in the interior drops by about 20%. This kind of drop in moisture makes it easier for viral particles in the air to move. Secondly, the hair-like organelles on cells in the body's airways, that are called cilia, can't do their job in dry weather conditions, either, and they can't expel viral particles.

One study found that mice in an environment with 10% relative humidity impaired the clearance of the influenza virus compared to mice in a 50% relative humidity environment, and it was shown that exposure of mice to dry air impaired epithelial cell repair in the lung after influenza virus infection. Furthermore, several studies conducted with mice have shown that the immune response to viruses is less stronger in drier conditions. For example, one study found that rodents in environments with 10 - 20% relative humidity "succumb to influenza virus infection faster than those at 50% relative humidity" and reported that the ideal humidity could be 40 - 60% [2,80].

However, it has been reported that very humid outdoor air can also increase viral spread. For example, in the tropics, airborne droplets that contain the virus have been found on interior surfaces where the virus can remain alive for longer. It has been reported that many houses and buildings in such areas are poorly ventilated and the benefits of high humidity are reduced as people often live in close proximity [82,84].

The lipid-enveloped virus such as Covid-19 has been observed to have a half-life of about 3 hours at about 80% relative humidity, and stay alive longer at low (< 50%) relative [2].

It has been scientifically proven that the optimum humidity level in internal environments, including dental clinics, should be 40-60% (2,80).

What can be done to improve indoor air quality?

Recommended Technologies According to the Directives of Environmental Protection Agency (EPA-USA):

(H.E.P.A) Filters that are evaluated according to merv (Minimum Efficiency Reporting Value) scale

It has been proven for decades that HEPA filters (high-efficiency particulate) control the effectiveness and contagion of airborne particles and organisms such as viruses and bacteria. The efficiency of HEPA filters is measured with MPPs (most penetrating particle size), MPPs range from 0.1 to 0.2 micrometers [85]. Bacteria and viruses are usually smaller than this, but they attach themselves to larger particles. HEPA filters do not actively kill living organisms, but capture and keep them in the filter's matrix [86]. It cleans 99.97% of all particles in the air which are in the size of 0.3 μm and bigger. Particulate pathogens (viruses, bacteria, and infectious organisms) contain allergens and carcinogens [87].

Antiseptic UV lights (UV-C)

UV-C light emits a germ-killing ray at a wavelength between 200 - 300 nm. This reacts with DNA and permanently changes the structure and molecular bonds of microbiological pollutants such as bacteria, viruses, germs, mildew and mould [88]. It has been scientifically proven that ultraviolet germicidal lamps (UVC) which work at the right intensity at 253.7 nanometers, can effectively prevent cross contamination of airborne diseases such as Aspergillus Niger, Legionella, ARS, Bacillus Anthracis, Acarus, factors that cause allergies and sinusitis, tuberculosis (TB), and H1N1.

Magnetized air filtration (Electrostatic Filters)

Electrostatic air precipitators capture electrically charged particles with electrostatic attraction. They draw the air from the ionization section where the particles receive an electric charge. Charged particles then accumulate on a flat plate called the collector that is conversely charged [89]. Electrostatic charged nanofiber filters have been reported to be excellent in capturing COVID-19 [90].

Bi-polar ionization (Germicidal Medical Lamp)

- Air ion generators or ionizers disperse negatively charged ions (anions) into the air, similar to electronic air purifiers but without a collection plate.
- These ions cling to airborne particles, making them heavier and allowing them to fall faster to the ground away from the nasal respiratory region.
- Negatively charged oxygen molecules act as hydroxyl radicals, neutralizing odors and destroying the DNA of pathogens and allergens.
- Studies show that anions can refresh indoor air, reduce fatigue and stress, alleviate depression, strengthen the collagen, functions of autonomic nerves and the immune system [91-93].

Photo-Catalytic Oxidation (Nano TiO_2)

Nano titanium dioxide (TiO2) converts biological and gaseous pollutants into harmless products through a process called photocatalytic oxidation (PCO).

When applied as a coating and exposed to ultraviolet or ambient lighting, Nano-TiO2 produces hydroxyl radicals and super-oxide ions that will neutralize biological and gas pollutants in indoor air [94,95].

Conclusion and Recommendations

Recommendations for the prevention of airborne contagion

Transmission of airborne diseases can be restricted in three ways:

- To control the source of infection by quarantine and the use of isolation facilities
- Controlling the transmission routes in the air using negative pressure ventilation systems
- Sliding doors instead of hinged doors and the improvement of seals around doors and windows; and protecting susceptible individuals from the exposure to virus which is transmitted through contact with both aerosol and infection by using personal protective equipment (PPE) [1].

Transmission of pathogens over long distances is directed by air flows driven by pressure differences which is produced by ventilation systems, open windows and doors, movement of humans, or temperature differences. Due to the connection between airflow and droplet dynamics in indoor spaces in buildings, all precautions regarding indoor air must be taken to ensure there is no contamination by air [18].

Recommendations on the contagion of Covid-19

As evidence emerges on the mechanisms of transmission through scientific studies on Covid-19, which has a significant contagion effect in indoor environments, studies on aerosols, which are important for public health safety, also increase [2].

However, as of now, no country or authority has reported any conclusive results regarding the "airborne spread" of COVID-19 in their arrangements for the Covid-19 transmission in the interior spaces. The latest information from China and the United States about the presence of viruses in the air is very different from each other, in some studies there is no mention of airborne transmission, while there are some which accept the possibility of this transmission. According to the results of a limited number of studies, it is very important that the authorities acknowledge the fact that the virus is airborne and recommend that the droplets loaded with the Covid-19 virus be removed from the indoor air through ventilation and that adequate control measures be implemented to prevent further spread [18]. As more detailed information is obtained, longer-term protective strategies will be developed to prevent contagion (transmission) and incidence of Covid-19 [2]. Researchers report that if the air transmission route is not taken seriously during the outbreak, it will be too late when the pandemic is over and retrospective data shows the importance of airborne transmission, also measures taken now will better prepare communities for the next outbreak disaster. The fact that the time lost means more infection and more loss of life should not be forgotten [18].

The public health guidelines issued to prevent the continued spread of the virus should be updated, adding information on aerosol transmission and protection from Covid-19 by inhalation route. While the evidence on the role of aerosols in the transmission of viruses in people with Covid-19 is known more extensive research which states the importance of aerosol transmission and investigates the virus duration of survival and the distances it can travel in the air, its concentration, the effects of temperature and humidity and the dose values in various particle sizes which can reach the respiratory system, is needed [2].

Improving indoor air quality

Ventilating rooms

The main determinant of contamination is airing the room with fresh air, which serves to dilute the concentration of infectious matter particles in the air [95].

It has been reported that the airing of rooms can lower levels of fine particles. Emission rates for fine and coarse particles were found to be almost equal, also coarse particles were found to be prone to deposition on internal surfaces [65].

The corona virus, despite its low concentration, affects the lungs due to high levels of exposure and inhaling large amounts of the infected air. Higher air flows in these areas will have a dilutive effect depending on important factors such as wind speed, humidity and temperature during exercising outdoors [2].

In spite of this, aerosols formed due to Covid-19, their concentrations in the air, its life span, the distance it can travel to, and its role in large indoor places where people gather such as mosques and churches, and outdoor areas such as stadiums need to be investigated.

The potential of aerosol contamination of buildings, rooms and surfaces should be investigated.

The role that human activities play in aerosols which have the potential to transmit Covid-19 in both indoor and outdoor areas must be determined. Necessary measures to prevent exposure via respiration to indoor aerosols of 5 µm or smaller in size, should be investigated [2].

Room airing can be provided mechanically with ventilation systems that can distribute negative pressure. Such systems require special expertise for design and are expensive to install and maintain [95]. Instead of these systems, natural ventilation just by opening windows, can provide higher rates of air change at a little cost or for free, but it depends on climate. The system providing natural ventilation should be developed within the existing infrastructure [95].

Measures to improve indoor air have been reported to include increasing ventilation rate, using airing- natural ventilation, avoiding air circulation, preventing another person from being in direct airflow, and minimizing the number of people sharing the same environment [81].

In buildings that may have natural ventilation, it is necessary to maximize it. As the number of people increases, viruses show a certain stability in internal environments due to possible accumulations of virus-carrying droplets. Therefore, it is routine to attach importance to provide adequate ventilation in hospitals. Personal protective equipment, especially masks and breathing masks, are recommended where fresh air is not sufficient [7,96]. The National Health Commission of the People's Republic of China has published a series of prevention and control guidelines with the aim of supervision of the prevention and control of the outbreak, and as of March 12, 2020, the rules have been updated six times [18].

Recommendations For Dental Clinics

Necessary Steps to Clean the Air in Clinics [60,97]:

- The safest way is airing (even in mechanically ventilated buildings).
- If ventilation is to be used:

Air purification systems can play a role in significantly reducing infectious bio-aerosols. In a dental clinic setting, the most practical and useful solution is the use of independent air filter systems that clean dirty indoor air by constantly pulling out and emptying clean filtered air from the room. Filters should prevent cross contamination and cross infection.

Although reducing Aerosol production is one of the preventive measures against Covid-19 infection, it is recommended that the indoor air is renewed frequently during and after dental treatment by opening windows in the patient's room or using mechanical ventilation.

- Ventilation should be operated at least 2 hours before the use of the clinic and 2 hours after the use of the clinic it should be switched to low speed.
- Ventilation should not be turned off at night and at weekends, but the system should be kept operating at a lower speed.
- Opening windows should be avoided in toilets to ensure proper ventilation direction.
- Toilets should be washed with a closed lid.
- While there isn't any evidence that anyone has fallen ill with COVID-19 due to exposure to wastewater, the fact that the virus that cause COVID-19 exists in untreated waste water, increases the importance of hygiene measures.
- Indoor air circulation units must be transferred to 100% outdoor air.

- Heat recovery equipment should be examined to ensure leaks are under control.
- The fan coils must be closed or the fans must be operated continuously switched on.
- Heating, cooling and possible humidification setting points should not be changed.
- Ventilation duct cleaning should not be planned during this time.
- Central outdoor air should be replaced and air filters removed according to the maintenance program.
- Regular filter replacement and maintenance work, including respiratory protection should be done with protective measures.
- Since the virus tends to stay in airborne particles, it is recommended not to remove personal protective equipment before leaving the contaminated area.

Acknowledgements

Authors would like to thank Ipek Sayrak (Institutional Translator) for her assistance in editing this manuscript.

Bibliography

1. Tang JW., *et al*. "Factors involved in the aerosol transmission of infection and control of ventilation in healthcare premises". *Journal of Hospital Infection* 64.2 (2006): 100-114.
2. Anderson Elizabeth L., *et al*. "Consideration of the Aerosol Transmission for COVID-19 and Public Health". *Risk Analysis* (2020).
3. Tellier Raymond., *et al*. "Recognition of aerosol transmission of infectious agents: a commentary". *BMC infectious diseases* 19.1 (2019): 101.
4. Centers for Disease Control and Prevention. "Guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings". (2007).
5. World Health Organization. "Infection prevention and control of epidemic-and pandemic-prone acute respiratory infections in health care". *World Health Organization* (2014).
6. Bourouiba Lydia. "Turbulent gas clouds and respiratory pathogen emissions: potential implications for reducing transmission of COVID-19". *Jama* 323.18 (2020): 1837-1838.
7. Leung Nancy HL., *et al*. "Respiratory virus shedding in exhaled breath and efficacy of face masks". *Nature medicine* 26.5 (2020): 676-680.
8. Parienta Dror., *et al*. "Theoretical analysis of the motion and evaporation of exhaled respiratory droplets of mixed composition". *Journal of aerosol science* 42.1 (2011): 1-10.
9. Lee Jinho., *et al*. "Quantity, size distribution, and characteristics of cough-generated aerosol produced by patients with an upper respiratory tract infection". *Aerosol and Air Quality Research* 19.4 (2018): 840-853.

10. Bourouiba Lydia. "A sneeze". *New England Journal of Medicine* 375.8 (2016): e15.

11. Stilianakis Nikolaos I and Yannis Drossinos. "Dynamics of infectious disease transmission by inhalable respiratory droplets". *Journal of the Royal Society Interface* 7.50 (2010): 1355-1366.

12. Wells William F. "On Air-Borne Infection: Study Ii. Droplets And Droplet Nuclei". *American journal of Epidemiology* 20.3 (1934): 611-618.

13. Zhu Shengwei., *et al.* "Study on transport characteristics of saliva droplets produced by coughing in a calm indoor environment". *Building and environment* 41.12 (2006): 1691-1702.

14. Xie X., *et al*. "How far droplets can move in indoor environments–revisiting the Wells evaporation–falling curve". *Indoor air* 17.3 (2007): 211-225.

15. Liu Li., *et al*. "Evaporation and dispersion of respiratory droplets from coughing". *Indoor Air* 27.1 (2017): 179-190.

16. Hinds William C. "Aerosol technology: properties, behavior, and measurement of airborne particles". *John Wiley and Sons* (1999).

17. Yu Ignatius TS., *et al*. "Evidence of airborne transmission of the severe acute respiratory syndrome virus". *New England Journal of Medicine* 350.17 (2004): 1731-1739.

18. Morawska Lidia and Junji Cao. "Airborne transmission of SARS-CoV-2: The world should face the reality". *Environment International* (2020): 105730.

19. Santarpia Joshua L., *et al*. "Transmission potential of SARS-CoV-2 in viral shedding observed at the University of Nebraska Medical Center". *MedRxIV* (2020).

20. Wölfel Roman., *et al*. "Virological assessment of hospitalized patients with COVID-2019". *Nature* 581.7809 (2020): 465-469.

21. Van Doremalen Neeltje., *et al*. "Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1". *New England Journal of Medicine* 382.16 (2020): 1564-1567.

22. Fineberg HV and National Research Council. "Rapid expert consultation on the possibility of bioaerosol spread of SARS-CoV-2 for the COVID-19 pandemic (April 1, 2020)". *The National Academies Press NRC. The National Academies Press, National Research Council, Washington, DC* (2020).

23. Li Y., *et al*. "Role of air distribution in SARS transmission during the largest nosocomial outbreak in Hong Kong". *Indoor air* 15.2 (2005): 83-95.

24. Xiao Shenglan., *et al*. "Role of fomites in SARS transmission during the largest hospital outbreak in Hong Kong". *PloS one* 12.7 (2017): e0181558.

25. Yu Ignatius TS., *et al*. "Temporal-spatial analysis of severe acute respiratory syndrome among hospital inpatients". *Clinical Infectious Diseases* 40.9 (2005): 1237-1243.

26. Booth Timothy F., *et al*. "Detection of airborne severe acute respiratory syndrome (SARS) coronavirus and environmental contamination in SARS outbreak units". *The Journal of infectious diseases* 191.9 (2005): 1472-1477.

27. Olsen Sonja J., *et al*. "Transmission of the severe acute respiratory syndrome on aircraft". *New England Journal of Medicine* 349.25 (2003): 2416-2422.

28. Marks PJ., *et al*. "A school outbreak of Norwalk-like virus: evidence for airborne transmission". *Epidemiology and Infection* 131.1 (2003): 727-736.

29. Herfst Sander., *et al*. "Airborne transmission of influenza A/H5N1 virus between ferrets". *science* 336.6088 (2012): 1534-1541.

30. Lewis Dyani. "Is the coronavirus airborne? Experts can't agree". *Nature* 580.7802 (2020): 175.

31. Liu Yuan., *et al*. "Aerodynamic analysis of SARS-CoV-2 in two Wuhan hospitals". *Nature* 582.7813 (2020): 557-560.

32. Morawska Lidia. "Droplet fate in indoor environments, or can we prevent the spread of infection?". *Proceedings of Indoor Air 2005: the 10th International Conference on Indoor Air Quality and Climate. Springer* (2005).

33. Bai Yan., *et al*. "Presumed asymptomatic carrier transmission of COVID-19". *Jama* 323.14 (2020): 1406-1407.

34. Zou Lirong., *et al*. "SARS-CoV-2 viral load in upper respiratory specimens of infected patients". *New England Journal of Medicine* 382.12 (2020): 1177-1179.

35. Wei Wycliffe E., *et al*. "Presymptomatic Transmission of SARS-CoV-2-Singapore, January 23–March 16, 2020". *Morbidity and Mortality Weekly Report* 69.14 (2020): 411.

36. Li Ruiyun., *et al*. "Substantial undocumented infection facilitates the rapid dissemination of novel coronavirus (SARS-CoV-2)". *Science* 368.6490 (2020): 489-493.

37. Guo Zhen-Dong., *et al*. "Aerosol and surface distribution of severe acute respiratory syndrome coronavirus 2 in hospital wards, Wuhan, China, 2020". *Emerg Infect Dis* 26.7 (2020): 10-3201.

38. Fabian Patricia., *et al*. "Origin of exhaled breath particles from healthy and human rhinovirus-infected subjects". *Journal of aerosol medicine and pulmonary drug delivery* 24.3 (2011): 137-147.

39. Johnson Graham Richard and Lidia Morawska. "The mechanism of breath aerosol formation". *Journal of Aerosol Medicine and Pulmonary Drug Delivery* 22.3 (2009): 229-237.

40. Johnson GR., *et al*. "Modality of human expired aerosol size distributions". *Journal of Aerosol Science* 42.12 (2011): 839-851.

41. Morawska LJGR., *et al*. "Size distribution and sites of origin of droplets expelled from the human respiratory tract during expiratory activities". *Journal of Aerosol Science* 40.3 (2009): 256-269.

42. Asadi Sima., *et al*. "The coronavirus pandemic and aerosols: Does COVID-19 transmit via expiratory particles?". (2020): 635-638.

43. Li ZY and LY Meng. "Prevention and control of novel coronavirus infection in department of stomatology". *Zhonghua kou qiang yi xue za zhi= Zhonghua kouqiang yixue zazhi= Chinese journal of stomatology* 55.4 (2020): 217-222.

44. Meng L., *et al*. "Coronavirus disease 2019 (COVID-19): emerging and future challenges for dental and oral medicine". *Journal of Dental Research* 99.5 (2020): 481-487.

45. Peng Xian., *et al*. "Transmission routes of 2019-nCoV and controls in dental practice". *International Journal of Oral Science* 12.1 (2020): 1-6.

46. Xu Hao., *et al*. "High expression of ACE2 receptor of 2019-nCoV on the epithelial cells of oral mucosa". *International journal of oral science* 12.1 (2020): 1-5.

47. Szymanska Jolanta. "Dental bioaerosol as an occupational hazard in a dentist's workplace". *Annals of Agricultural and Environmental Medicine* 14.2 (2007).

48. Bennett AM., *et al*. "Microbial aerosols in general dental practice". *British dental journal* 189.12 (2000): 664-667.

49. Leggat Peter A., *et al.* "Occupational health problems in modern dentistry: a review". *Industrial health* 45.5 (2007): 611-621.

50. Miller RL and RE Micik. "Air pollution and its control in the dental office". *Dental Clinics of North America* 22.3 (1978): 453-476.

51. Littner MM., *et al*. "Occupational hazards in the dental office and their control. I. Measures for controlling infections". *Quintessence international, dental digest* 14.1 (1983): 67-69.

52. Kohn WG., *et al*. "and Centers for Disease Control and Prevention (CDC)". Guidelines for infection control in dental health-care settings-2003". *MMWR Recomm. Rep*. 52.RR-17 (2003).

53. Harrel Stephen K and John Molinari. "Aerosols and splatter in dentistry: a brief review of the literature and infection control implications". *The Journal of the American Dental Association* 135.4 (2004): 429-437.

54. Cellini L., *et al*. "Quantitative microbial monitoring in a dental office". *Public Health* 115.4 (2001): 301-305.

55. Monarca S., *et al*. "Environmental monitoring of infective risks in Italian dental offices". *Minerva stomatologica* 51.7-8 (2002): 319.

56. Liguori G., *et al*. "Microbial environmental monitoring in the dental surgery room". *Annali di igiene: medicina preventiva e di comunita 15*.2 (2003): 123-133.

57. Grenier Daniel. "Quantitative analysis of bacterial aerosols in two different dental clinic environments". *Applied and environmental microbiology* 61.8 (1995): 3165-3168.

58. Kedjarune Ureporn, *et al*. "Bacterial aerosols in the dental clinic: effect of time, position and type of treatment". *International dental journal* 50.2 (2000): 103-107.

59. Zemouri Charifa., *et al*. "A scoping review on bio-aerosols in healthcare and the dental environment". *PloS one* 12.5 (2017): e0178007.

60. Izzetti R., *et al*. "COVID-19 transmission in dental practice: brief review of preventive measures in Italy". *Journal of Dental Research* (2020): 0022034520920580.

61. Liu Li., *et al*. "Epithelial cells lining salivary gland ducts are early target cells of severe acute respiratory syndrome coronavirus infection in the upper respiratory tracts of rhesus macaques". *Journal of virology* 85.8 (2011): 4025-4030.

62. Chen Jieliang. "Pathogenicity and transmissibility of 2019-nCoV—a quick overview and comparison with other emerging viruses". *Microbes and infection* (2020).

63. Kampf Günter., *et al*. "Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents". *Journal of Hospital Infection* 104.3 (2020): 246-251.

64. To Kelvin Kai-Wang., *et al*. "Consistent detection of 2019 novel coronavirus in saliva". *Clinical Infectious Diseases* (2020).

65. Helmis CG., *et al*. "Indoor air quality in a dentistry clinic". *Science of the Total Environment* 377.2-3 (2007): 349-365.

66. Federal Standarts 209E- The last revision (FS 209E). Airborne Particulate Cleanliness Classes in Clean Rooms and Clean Zones was published on 11 Sept 1992.In: The Space Environment: Implications for Spacecraft Design - Revised and Expanded Revision. Alan C. Tribble Princeton University Press. New Jersey, USA (2003).

67. Setti Leonardo., *et al*. "Airborne transmission route of COVID-19: why 2 meters/6 feet of inter-personal distance could not Be enough". (2020): 2932.

68. American Chemical Society. "Cleaning with bleach could create indoor air pollutants". (2019).

69. Wang L., *et al*. "Hypochlorous acid as a potential wound care agent: part I. Stabilized hypochlorous acid: a component of the inorganic armamentarium of innate immunity". *Journal of burns and wounds* 6 (2007).

70. Nowell Lisa H and Jürg Hoigné. "Photolysis of aqueous chlorine at sunlight and ultraviolet wavelengths-I. Degradation rates". *Water Research* 26.5 (1992): 593-598.

71. Goyal Sagar M., *et al*. "Detection of viruses in used ventilation filters from two large public buildings". *American journal of infection control* 39.7 (2011): e30-e38.

72. Heuer Jan F., *et al*. "Can breathing circuit filters help prevent the spread of influenza A (H1N1) virus from intubated patients?". *GMS hygiene and infection control* 8.1 (2013).

73. Ye Qing., *et al*. "Haze is a risk factor contributing to the rapid spread of respiratory syncytial virus in children". *Environmental Science and Pollution Research* 23.20 (2016): 20178-20185.

74. Chen Gongbo., *et al*. "Is short-term exposure to ambient fine particles associated with measles incidence in China? A multi-city study". *Environmental research* 156 (2017): 306-311.

75. Barrett Andrew and John M McMahon. "Protecting dental staff from the most hazardous job in America". *Dental Economics*.

76. Bahl Prateek., *et al*. "Airborne or droplet precautions for health workers treating COVID-19?". *The Journal of infectious diseases* (2020).

77. Wei Jianjian and Yuguo Li. "Enhanced spread of expiratory droplets by turbulence in a cough jet". *Building and Environment* 93 (2015): 86-96.

78. Liu Ming-Hui., *et al*. "High total volatile organic compounds pollution in a hospital dental department". *Environmental monitoring and assessment* 189.11 (2017): 571.

79. Bourouiba Lydia., *et al.* "Violent expiratory events: on coughing and sneezing". *Journal of Fluid Mechanics* 745 (2014): 537-563.

80. Yan Yihuan., *et al.* "Thermal effect of human body on cough droplets evaporation and dispersion in an enclosed space". *Building and Environment* 148 (2019): 96-106.

81. Qian Hua and Xiaohong Zheng. "Ventilation control for airborne transmission of human exhaled bio-aerosols in buildings". *Journal of thoracic disease* 10.19 (2018): S2295.

82. Moriyama Miyu., *et al.* "Seasonality of respiratory viral infections". *Annual review of virology* 7 (2020).

83. Dee Scott A., *et al*. "Further evaluation of alternative air-filtration systems for reducing the transmission of porcine reproductive and respiratory syndrome virus by aerosol". *Canadian Journal of Veterinary Research* 70.3 (2006): 168.

84. Sandoiu A. "How humidity may affect COVID-19 outcome Medical News Today –Newsletter- COVID-19: Latest news and resources". *Fact checked by Catherine Carver, MPH* (2020).

85. Leung Wallace Woon Fong and Qiangqiang Sun. "Electrostatic charged nanofiber filter for filtering *airborne novel coronavirus (COVID-19) and nano-aerosols". Separation* and Purification Technology (2020): 116886.

86. Farr Camfil. "ASHRAE testing for HVAC air filtration: A review of standards 52.1-1992 and 52.2-1999". *Technical Services Bulletin* (2013).

87. Hagbom Marie., *et al*. "Ionizing air affects influenza virus infectivity and prevents airborne-transmission". *Scientific reports* 5 (2015): 11431.

88. Panov Vladimir and Tsvetelina Borisova-Papancheva. "Application of ultraviolet light (UV) in dental medicine". *MedInform* 2 (2015): 194-200.

89. Baumann K. "Transmission Precautions for Dental Aerosols". *J Multidisciplinary Care Decisions in Dentistry* 30.12 (2018): 32-35.

90. Escombe A Roderick., *et al*. "Natural ventilation for the prevention of airborne contagion*". PLoS Med* 4.2 (2007): e68.

91. Jiang Shu-Ye., *et al.* "Negative air ions and their effects on human health and air quality improvement". *International journal of molecular sciences* 19.10 (2018): 2966.

92. Meschke Sl., *et al*. "The effect of surface charge, negative and bipolar ionization on the deposition of airborne bacteria". *Journal of applied microbiology* 106.4 (2009): 1133-1139.

93. Liga Michael V., *et al*. "Virus inactivation by silver doped titanium dioxide nanoparticles for drinking water treatment". *Water research* 45.2 (2011): 535-544.

94. Foster Howard A., *et al*. "Photocatalytic disinfection using titanium dioxide: spectrum and mechanism of antimicrobial activity". *Applied microbiology and biotechnology* 90.6 (2011): 1847-1868.

95. Escombe A Roderick., *et al*. "Improving natural ventilation in hospital waiting and consulting rooms to reduce nosocomial tuberculosis transmission risk in a low resource setting". *BMC infectious diseases* 19.1 (2019): 88.

96. Huang Wei and Lidia Morawska. "Face masks could raise pollution risks". (2019): 29-30.

97. REHVA: Federation of European Heating, Ventilation and Air Conditioning Association COVID-19 guidance document (2020).

Volume 20 Issue 1 January 2021