Introduction

This document is provided for information and is not guidance. It aims to provide a summary of information on ventilation to mitigate the risk of COVID-19 transmission, with a focus on advice and information that has relevance for dental facilities. The information has been compiled from several key publicly available documents developed by other organisations and expert groups, including the Scientific Advisory Group for Emergencies (SAGE) Environmental and Modelling group (EMG) and NHS National Services for Scotland (NSS). This resource was developed with input from expert members of the SDCEP Aerosol Generating Procedures Working Group, and end-users.

While this summary document might not fully address all aspects of queries on ventilation, it reflects the currently available information. The key sources are listed at the end of the document and have not been formally appraised for this summary. Direct quotes are shown in italics. For an understanding of the basis for the information and advice, and any underpinning evidence, users are advised to consult the original sources.

1. Why is ventilation important?

The SAGE EMG explains that “the virus that causes COVID-19 is spread through very small aerosols and droplets released in exhaled breath. There is evidence to show that in some cases these aerosols can be carried more than 2m in the air and could cause infection if they are inhaled” (1).

“Increasing ventilation rate and reducing exposure time are key mitigation measures to control the far-field transmission of SARS-CoV-2 by small aerosols between people who share the same indoor space. The measure is not likely to have significant impacts on close range transmission by droplets and aerosols (within 1-2m) or transmission via contact with surfaces” (2).

Aerosols are also produced by a range of dental procedures (Aerosol Generating Procedures, AGPs) which have been categorised according to their likelihood of producing small particles (<5 μm) (3). Although the risk of COVID-19 transmission from a dental AGP is unclear, the greatest implications are for the next patient entering the treatment room, who unlike dental staff wearing appropriate personal protective equipment (PPE), will not be able to wear any face-covering during treatment. The post-AGP fallow time is intended to reduce the potential risk to subsequent occupants of the room by allowing for aerosol dispersion. This is primarily achieved by dilution through air changes and consequently ventilation is the main determinant of fallow time (3). AGPs should not be carried out in rooms that have no mechanical or natural ventilation.

[1]

Adequate ventilation is an important measure to mitigate the risk of COVID-19 transmission not only in clinical areas but also in all occupied spaces throughout the dental practice, including the reception area, waiting rooms, staff areas and toilets.

The SAGE EMG notes that “ventilation is also important for human health beyond COVID-19. Studies have shown that good ventilation is associated with improved health, better concentration, higher levels of satisfaction with an environment, lower rates of absence from schools and work, better quality of sleep and reduced exposure to a wide range of air pollutants” (1). Good ventilation will also help combat other known and emerging airborne pathogens.

2. What is the difference between ventilation, air cleaners, extraoral suction and air conditioning?

The SAGE EMG defines ventilation as “the process of bringing in fresh air from outside and removing indoor air, which may contain pollutants including virus particles” (1).

SDCEP describes air cleaners as “devices that use technologies such as high efficiency particulate air (HEPA) filtration, germicidal ultraviolet (GUV) light and ionisation, alone or in combination, to remove or inactivate airborne particles” (3). Air cleaners do not provide fresh air so are not a source of ventilation. While some may in principle be able to achieve the same effect as ventilation with regard to reducing aerosol levels of SARS-CoV-2 virus or other microbial contaminants, they will not reduce the concentrations of all air pollutants. See Section 8 for more information on air cleaners.

Extraoral suction devices are types of local exhaust ventilation (LEV)[2] and typically use a capture hood or funnel placed near the source of aerosol (i.e. near the patient’s mouth), connected via tubing or ducting to an air cleaning component (e.g. HEPA filtration) and an extract fan. While the aim of in-room air cleaners is to reduce airborne contamination throughout the room, LEV systems are designed to remove contamination at the source. Like air cleaners, standalone extraoral suction devices do not provide outside air ventilation. Air cleaners and extraoral suction devices are sometimes also referred to as air purifiers, air scrubbers, air filtration units, portable extraction systems or similar.

According to the SAGE EMG, “Air conditioning refers to changing the temperature and humidity of the air, usually cooling the air when it is too hot for people to be comfortable. Air conditioning is sometimes connected to the ventilation system, but many rooms have a stand-alone air conditioner which just recirculates the room air. Recirculating air conditioners may pose a risk if they are operated in a room which has a very low outdoor flow rate – the air conditioner can make occupants feel comfortable, but masks the poor air quality and can allow any virus to build up in the air. A number of studies have linked transmission to recirculating air conditioners, with the high velocities created by these units potentially allowing larger viral aerosols to remain airborne over longer distances” (1).

3. What types of building ventilation are used in dental surgeries?

Buildings are ventilated using natural ventilation, mechanical ventilation or a combination of both (sometimes referred to as hybrid ventilation).

Natural ventilation refers to passive air flow through openings including windows, doors, windows vents and external wall vents, air bricks or grilles. Windows and doors are usually the main sources of natural ventilation, but levels are dependent on the extent and frequency of opening and weather conditions. For a given opening, higher ventilation rates are possible when there is a large difference in temperature between indoors and outdoors (winter) and under higher wind speeds. Thermal comfort is a potential issue, particularly during winter. Natural ventilation is likely to be variable, even within an individual surgery and the air change rate can be difficult to measure reliably due to the influence of external weather conditions. This variability can also create changeable pressure differences inside the building, with rooms potentially under negative or positive pressure depending on the external wind conditions.

Mechanical ventilation uses window, wall or ducted fans and grilles to extract and/or supply air. Extraction systems extract room air outside, creating negative pressure in the room which draws air in via external vents or from other rooms via gaps under doors etc. Supply systems deliver fresh air into the room, pushing the existing air out through positive pressure and thus encouraging the dilution and mixing of room air. Some systems combine both air supply and extraction. This allows the pressure within the room to be adjusted to minimise the movement of air between spaces, for example, from the treatment room to the reception area. Consideration of the direction of airflow due to pressure differences is important, particularly when implementing any changes to ventilation systems. Systems should be designed to reduce the likelihood that air moves from the treatment room to other spaces within the dental practice.

Mechanical ventilation will provide a more consistent air change rate than natural ventilation, although actual measured air exchange rates may diverge from specification rates if the system is not well designed or maintained. It is important that users understand how to operate the ventilation system correctly and that it is maintained according to manufacturer/installer instructions and is turned on. More detailed information on different types of ventilation is provided in Appendix 1 of the NSS SBAR (4) and in guidance

from professional building engineering organisations.[3,4]
The presence of powered fans in windows or external walls, and/or grilles and vents (and sometimes
ducts) on the ceiling or high on the walls would suggest that a dental surgery has a mechanical ventilation
system. If the room only has openable windows and no other signs of ventilation, then it is most likely
naturally ventilated (1). A room with a fan and an opening window has both mechanical and natural
ventilation. If unclear about the type of ventilation, it would be advisable to consult a ventilation engineer
(e.g. a member of the Chartered Institution of Building Services Engineers (CIBSE), Building Engineering
Services Association (BESA) or another appropriate professional body).

4. What are the requirements for ventilation in dental settings?

As explained in the SDCEP Mitigation of Aerosol Generating Procedures in Dentistry review (3): "UK
building regulations recommend whole building ventilation to be 10 l/s/person[5] and current healthcare
guidance for new buildings and major refurbishments[6,7] specifies that a treatment room should have at least
10 air changes per hour (ACH). This is also stipulated for a dental treatment room in Scottish Health Planning
Note 36 (Part 2 NHS Dental Services in Scotland).[8] Therefore, all dental care providers are strongly
encouraged to investigate dental surgery ventilation and the modifications that may be necessary to meet
the requirements of current UK healthcare guidance and legislation. A revised version of HTM 03-01 is
expected to be published in 2021. However, this is unlikely to impose additional specific requirements for
primary dental care settings.

5. What is the air change rate in my surgery?

The ventilation rate for a room can be described in terms of the number of air changes per hour (ACH).
With every air change the new air mixes with the room air, diluting contaminants exponentially. Assuming
perfect mixing and no other mechanisms of contaminant removal, the level of any contaminants in the air
will be reduced by 63% with each air change.
For mechanical ventilation, calculating the ACH can be straightforward if the air flow rate delivered by the
ventilation system and the room volume are known (ACH = the air flow rate in volume per hour divided by
the volume of the room). The theoretical air flow rate might be specified in manufacturer/ installation
records for the ventilation system. Otherwise, an assessment of the flow rate may have to be carried out
by a ventilation engineer.
Air change rates from natural ventilation in a dental surgery will vary, being affected by atmospheric

conditions and user interactions with windows and doors, and may be difficult to estimate or measure reliably. NSS (4) suggest a pragmatic approach of assigning a rate of 1 ACH for any room ventilated using open windows, which has also been incorporated into the practical guide provided by FGDP(UK)/CGDent.[9]

A method for estimating natural ventilation flow rates for spaces with one window (single sided) and more than one window (cross-flow) is also provided in the WHO roadmap on ventilation.[10]

The SAGE EMG suggests that "in some spaces it is possible to use carbon dioxide (CO_2) meters to estimate the effectiveness of the ventilation and a CO_2 meter can be used to identify spaces where ventilation is poor, but they are less effective at showing good ventilation". However, they also caution that "estimating ventilation using CO_2 meters needs to be done with care as it is possible to get false or inaccurate readings" and that "measurement is much more reliable in spaces where there are higher numbers of people". More information is provided by the SAGE EMG in source (2). Use of CO_2 meters in dental surgeries where there are only a small number of people present may still give a useful indicator of poor ventilation, but should be treated with caution. Particle counters are not likely to be a reliable method of estimating ventilation as there are multiple particle sources in the environment, particularly when a room is naturally ventilated.

6. How does the ACH relate to post-AGP fallow time?

The fallow time is the time allowed for aerosol dispersion after a dental AGP has been carried out. Since this is primarily achieved by dilution through air changes, the ACH rate is a key determinant of the recommended fallow time (3).

SDCEP proposed a pragmatic scheme for the application of discrete fallow times on completion of a dental procedure likely to produce small aerosol particles (3) which has been incorporated into national infection prevention and control guidance.[11] The suggested benchmark fallow times in the scheme are determined by the range of air change rates that the ACH for a given dental surgery falls into. Dental surgeries with the highest ACH rates benefit from the shortest suggested fallow times.

7. How can I improve the ventilation in my surgery?

The SAGE EMG ventilation report (2) provides a summary of options for improving ventilation, with consideration of effectiveness, advantages and disadvantages, including thermal comfort, energy use, noise and relative cost (see Table 1 in the SAGE EMG ventilation report). While some of the options, such as increased use of natural ventilation provision and temporary purge ventilation/airing may be relatively

easy to carry out in dental premises, others such as installation of new ventilation systems will require
specialist advice and services and have significant cost implications.
Note, as stated in the SAGE EMG ventilation report (2), that "portable fans, ceiling mounted fans or
recirculating air conditioners will assist air circulation, but will not add to the air change rate or the amount
of outdoor air coming into the space"
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The SAGE EMG advises that "measures to improve ventilation will be dependent on the particular setting and
it is not possible to give a "one size fits all" solution, or a simple rule that everyone can follow" (2). They also
advise that "any changes to ventilation must consider other negative consequences including financial,
energy use, noise, security and health and wellbeing impacts from thermal discomfort and exposure to
pollutants" (2).
Practical tips relating to thermal comfort when increasing natural ventilation, that might be applicable in
some dental premises, are provided by the SAGE EMG:
"More ventilation will be provided with larger openings and, if available, use of opening windows at opposite
sides of the building. It is recognised that providing maximum ventilation by opening all windows fully when
outdoor air temperatures are low will be difficult or unacceptable. However, occupants might also note that
the rate of supply of air increases with larger temperature difference between the inside and outside, so that
windows do not need to be opened as much in colder weather to achieve the same flow rates" (2).
"If windows have openings at both high and low levels (such as sash windows) using just the top opening can
be helpful in colder weather because incoming cold air will mix with warm room air and help temper cold
draughts" (1).

8. Will an air cleaner help?

The SAGE EMG position on air cleaners is:
"Air cleaning devices are not a substitute for ventilation, and should never be used as a reason to reduce
ventilation; all occupied spaces must have some background ventilation to be suitable for human habitation
and to comply with building and workplace regulations" (5).
However, they also acknowledge that air cleaners "may be suitable for spaces where there is insufficient
ventilation and the ventilation can't be improved. There is currently very little evidence that air cleaners are
an effective control to prevent COVID-19, however the principles of air cleaning suggests that they may be
useful in some cases" (1).
The SAGE EMG also advises that: "Air cleaners that are based on filtration (with a HEPA filter) are likely to be

most effective, and those that include ultra-violet lamps (UV-C at 254nm wavelength) may also work. It is a good idea to avoid any devices that produce ozone or other chemicals as these may be a respiratory irritant.
It is also important to consider how much air the device can clean; a small device in a large room will have very little effect. Noise is also an important consideration, particularly for larger devices with a higher fan speed" (1). Different air cleaning technologies are compared in Annex 1 of the SAGE EMG paper on air cleaning devices (5).

The SAGE EMG paper (5) also suggests the potential application of air cleaners for the scenario of aerosol generating procedures in dentistry and healthcare settings, with the following points noted:
"High flow rate portable enclosed devices positioned to remove aerosol generation close to the source.
Appropriate in poorly ventilated dental surgeries/treatment rooms, but not likely to be beneficial in spaces with high ventilation rates such as operating theatres."
Assessing the effectiveness of an air cleaning device in a given setting can be difficult, as indicated by the SAGE EMG:
"Effectiveness of air cleaning devices depends on multiple parameters including the underlying technology, the design of the device, the in-room location of the device, the environment that it is used in and the maintenance of the device. The performance of most devices is based on data measured in idealised controlled environments, and is likely to be different and often lower in a real-world setting. Caution should be used when considering idealised performance data stated by a manufacturer" (5).
The NSS SBAR (4) provides a worked example for estimating the equivalent air change rate (ACH) provided by an air cleaner, using the manufacturer's reported clean air delivery rate for the device and the room size. The SBAR advises assuming an efficiency of 50% to take into consideration the recirculation of clean air directly back into the device rather than contributing efficiently to dilution throughout the room. The estimated equivalent ACH provided by the air cleaner can be added to that provided by the natural or mechanical ventilation to give an overall ACH rate for the room (4).
Annex 2 of the SAGE EMG report (5) includes principles for the safety and maintenance of air cleaning devices that users might find useful.
Local exhaust ventilation (LEV) systems, such as extraoral suction devices, aim to remove airborne contaminants at source. The effectiveness of these devices is unclear at present and neither NSS (4) nor the SAGE EMG (5) make specific recommendations relating to them.

If considering air cleaners or LEVs, it is preferable to have performance ratings that have been determined through independent testing by professional bodies or through published, high quality research rather than manufacturer's claims alone.