Government of Western Australia
Department of Health

Information on COVID-19 and building ventilation

This document provides information on the relationship between COVID-19 transmission and ventilation and reflects current advice about the SARS-CoV-2 virus in Western Australia. This document is aimed at workplaces, public and commercial buildings. A summary of information for residential homes is available here. A summary of information on air purifiers / cleaners can be found here.

Context

SARS-CoV-2, the virus responsible for COVID-19 infection, and other respiratory viruses can be transmitted through the air, with transmission known to occur in crowded and enclosed spaces, or in areas with poor ventilation and airflow. Airborne respiratory droplets and aerosols containing SARS-CoV-2 are emitted when an infected person breathes or talks, with exertional activities such as coughing, sneezing, singing or physical activity potentially releasing larger numbers of viral particles. These viral particles can be carried several metres away, and in areas with poor ventilation they can remain in the air. Other people in the same indoor space, or who enter the space within a short time can then inhale the viral particles. The probability of inhaling enough virus to cause infection increases with no mask wearing, close proximity to an infected person (e.g. talking face to face), higher numbers of infected people in a room and longer exposure times.

The predominant mode of human to human transmission is via direct and close contact with an infected person and indirectly via contaminated objects and surfaces. It is important that optimising ventilation occurs in combination with other public health measures, including vaccination, social distancing, face masks where recommended, good respiratory and hand hygiene and cleaning and disinfection of surfaces and objects.

Ventilation

Adequate indoor ventilation has a number of health benefits (external link). Ventilation is the process of replacing the indoor air with clean (usually outdoor) air, to control odour, climate, prevent mould growth and reduce levels of contaminants, such as from cooking or heating emissions. Effective ventilation can reduce the concentration of airborne SARS-CoV-2 by either removing or diluting contaminated indoor air that may contain virus exhaled from infected person(s). This will reduce the risk that the virus will be inhaled by other occupants. Optimising air exchange rates, along with air filtration and purification, are increasingly recognised as being important in reducing the airborne transmission of COVID-19 in indoor spaces – particularly in localities where there is community transmission.

Employers have a duty under occupational health and safety laws to eliminate or minimise the risks of COVID-19 in the workplace, so far as is reasonably practicable.

Employers in shared premises and without direct control over HVAC systems may need to discuss ventilation provisions with building owners or facility managers (and other business owners).

The information provided below is intended to supplement, rather than replace, any State or Commonwealth laws, rules and/or regulations that apply.

Further information for workplaces is available from OzSAGE Safe Indoor Air Working Group Creating safe workplaces during the COVID-19 pandemic (external link) and Safe Work Australia COVID-19 Information for workplaces (external link). Links to additional ventilation resources are provided at the end of this document.

Optimising ventilation

Adequate ventilation may be achieved by using natural or mechanical methods used together or separately. Existing ventilation provisions of buildings should first be assessed to optimise the air exchange rate and provide the maximum possible amount of outdoor (clean) air. It is recommended that workplaces and public and commercial buildings have a formal assessment by an occupational hygienist and/or Heating, Ventilation and Air Conditioning (HVAC) professional to assess ventilation and provide advice.

Natural ventilation

Natural ventilation uses natural forces, such as temperature differences between indoor and outdoor air, or wind pressure through open windows or doors, to deliver fresh air into buildings. Outdoor air enters through external openings such as doors and windows. Natural ventilation works best by opening windows or doors on opposite sides of the room or space (and keeping internal doors open) to create cross-ventilation.

Cross-ventilation is far more effective than single-side ventilation. Opening the highest and lowest windows in a space at the same time can also assist ventilation. Ensure windows open easily and are not blocked by window furnishings or furniture.

Mechanical ventilation

Most commercial, government and public buildings will have a Heating, Ventilation and Air-Conditioning (HVAC) system. Depending on their set up, these systems distribute a combination of fresh outdoor air and recirculated indoor air within a building. The minimum amount of outdoor air provided into a space (ventilation rate) should be 10L/s/person, as outlined in the Australian Standard AS 1668.2-2012 Mechanical ventilation in buildings (external link).

It is important to understand if your air-conditioner, or HVAC system, can provide outdoor air.

Some cooling and heating systems, including split-system air conditioners, work by recirculating air, that is they take indoor air and heat or cool it before returning the same air back into the space. However, some ducted and all-in-one window/wall-mounted air conditioners can bring in fresh air. Ducted evaporative air conditioners bring in outdoor air and are required to be used with some natural openings, which allows for good dilution.

To enhance the performance of mechanical ventilation systems:

- ensure that air conditioning and HVAC systems and filters are regularly inspected, maintained and cleaned outlined in the manufacturer recommendations (increased frequency is not required due to COVID-19) – addressing any cleaning and maintenance issues can provide immediate improvements in ventilation

- check if the ventilation rate of the system can be increased by consulting the technical manual and/or a HVAC professional
- prioritise the supply of outdoor air over energy-saving and demand-controlled ventilation controls that reduce air supply based on expected occupancy or climate control
  - limit the level of recirculating air by increasing the percentage of outdoor air supply up to the maximum possible percent of outdoor air, preferably 100%
- run HVAC systems at nominal speed for at least 30 minutes (but ideally 2 hours) before, and at lower speed for at least 2 hours after, building occupancy ("purge cycles")
- if possible, upgrade HVAC systems to a high grade filter (minimum G4 main filter, and higher efficiency F7 or F8 grade filters for recirculated air), ensuring that the air handling unit can handle the additional pressure drop of the new filter
- direct any exhaust outdoors, and ensure outlets are away from windows, air intake systems or areas where people may need to work or congregate
- buildings should comply with applicable regulations and standards such as AS 1668.2-2012 Mechanical ventilation in buildings (external link).

Filters in building ventilation systems

Filtration can be installed as part of a building mechanical ventilation system or as stand-alone (portable) units. Filtration can be used to help mitigate the risk of indoor transmission of COVID-19 by reducing the airborne concentration of SARS-CoV-2.

Air filters within building ventilation systems can help remove particles from introduced outside and/or recirculated supply air. Building ventilation systems should be upgraded to the highest efficiency filter that does not adversely impact the performance of the HVAC system; a system needs to produce enough power to compensate for high pressure drops to move air through a filter, and special filter frames may be required. It is important not to add an air filter to a system for which it is not designed, as this can cause significant damage. If the filter does not fit properly it will not function effectively due to insufficient sealing.

To date, there is no clear evidence of COVID-19 transmission occurring via recirculation of air through a building air handling unit. High-efficiency particulate air (HEPA) filters can effectively remove SARS-CoV-2 and other particles from recirculated air, but not all HVAC systems are compatible with HEPA filters. If possible, upgrading to F7 or F8 grade filters, that have reasonable capture for virus-laden particles, is recommended where supply air is recirculated. Further guidance should be sought from a HVAC professional or other appropriately qualified expert, and further details about filter grade is available at Comparative Guide to Norms for the Classification of Air Filters (external link).

As a precaution, appropriate personal protective equipment (disposable gloves and mask) should be worn when handling filters with any discarded filters, gloves and masks disposed of in a sealed bag.

Improving air flow and mixing

Adjunct measures, such as standing, ceiling and exhaust fans or fan settings on air conditioners, can be used to supplement existing natural and mechanical ventilation systems and direct air flow.

Air motion or mixing of air within a room can be assisted by using fans. For example, placing fans in a room to blow air in the direction that it is naturally moving to assist cross ventilation in a naturally ventilated home or placing a fan at a window, facing out, to pull / exhaust air out of a room.

Airflow from fans should be directed away from people to avoid placing them in the path of air that might be carrying viral particles from any infected individuals.

Ventilation can also be improved by operating exhaust fans in bathrooms, kitchens, and toilets whenever in use, or continuously if possible. Window or roof mounted exhaust vents and fans can also provide exhaust ventilation.

Temperature and humidity

HVAC systems are designed to control indoor temperature and humidity. Temperature and humidity can affect the stability and/or transmissibility of airborne infectious agents such as SARS-CoV-2. Although seasonal variation in transmission of COVID-19 is not well defined, other respiratory viruses (including other coronaviruses) have demonstrated increased transmission in cooler and less humid months, and decreased transmission in warmer and more humid months.

Evidence to date shows that SARS-CoV-2 is more stable at lower temperatures. However, coronaviruses are generally quite resistant to environmental changes, and are only susceptible at temperatures and humidity that are not attainable or acceptable indoors. Therefore, HVAC systems should still be set to provide acceptable indoor thermal conditions of around 20-25°C and 40-60% relative humidity.

Carbon dioxide monitors

Carbon dioxide is **not** a direct measure of exposure to COVID-19. Carbon dioxide monitors are increasingly being used as a way of assessing ventilation and therefore as a proxy indicator of risk of exposure to COVID-19 infection because carbon dioxide exhaled by people builds up in a space that is not adequately ventilated for the number of people using the space.

Carbon dioxide monitoring is a low cost and practical option providing a real-time assessment of how well-ventilated a room is at any one time, taking into account the occupancy level and activities happening in the space. It can be used to indicate when actions need to be taken, such as improving ventilation, minimising high exertion activities, or reducing occupancy level. The usefulness of real-time carbon dioxide monitors is limited in less populated settings with only a few occupants (such as a private residence), but may be useful in settings such as workplaces, gyms, or public and commercial buildings, especially where peak occupancy and activity level varies. An occupational hygienist and/or HVAC professional should be consulted if carbon dioxide monitoring is being considered.

The ambient concentration of carbon dioxide outside in the open air is around 400 parts per million (ppm). The National Construction Code (external link) mandates carbon dioxide levels of less than 850ppm inside a building averaged over eight hours, but this is an adequately ventilated building from an occupant “odour amenity” point-of view, not for infection control purposes. There is no single level at which an indoor setting is deemed to be “safe” from the airborne transmission of COVID-19, as this also depends on other factors such as activity levels of occupants and the number of infected and susceptible individuals. Instead, carbon dioxide measurements can provide information about relative risk within an indoor space – that is, if the carbon dioxide level remains near background, then the risk of COVID-19 transmission is likely to be kept relatively low.

In practice, most sources suggest a target carbon dioxide level of around 500-600ppm indoors, with levels below 700-850ppm indicating a low relative risk of infection, and levels above this requiring action – for example, see OzSAGE Safe Indoor Air (Ventilation) Recommendations (external link) which recommend carbon dioxide action limits for restaurants, bars and shops.

Carbon dioxide level	Action
Below 800ppm	Indicates a low relative risk of infection; ~600ppm or below is best practice
800 to 1500ppm	Indicates a moderate relative risk of infection; improvements should be made where practicable to increase the provision of fresh air into the indoor space
Above 1500ppm	Indicates a high relative risk of infection; immediate improvements must be made to increase the provision of fresh air into the indoor space or air filters must be operational – if this is not possible, the space should be evacuated

Although general guidance on carbon dioxide monitoring is available, there are many types of carbon dioxide monitors that may be purchased, and it is important to also read the operating instructions on the particular unit that is used. The most appropriate portable devices to use are non-dispersive infrared (NDIR) carbon dioxide monitors which can be purchased for less than a few hundred dollars per unit.

When using a carbon dioxide monitor it is important to:

1. Check the monitor against background outdoor air levels (~400ppm) to ensure that it is working correctly. Note that monitors need to be calibrated and may be affected by other factors such as humidity.
2. Use the monitor while a space is occupied by its normal users performing their normal activities. A typical maximum number of occupants should be present for several hours prior to taking a measurement.
3. Position the monitor at head height and away from windows, doors, or air supply openings – and at least 50-100cm away from people to avoid misleading readings.
4. Place the monitor in different locations within an occupied space, as different parts of a room will give different measurements. Larger areas may need multiple units.
5. Periodically check the monitor or use a monitor with a logging function so levels can be monitored over the period of occupancy.
6. Note that monitors do not account for recirculated filtered air, so are not as useful when HEPA air filters are being used to clean air, as these remove contaminants such as SARS-CoV-2 but not carbon dioxide.
7. Remember that other limitations to carbon dioxide monitoring exist: it is not representative of risk related to short range transmission, that is people in close proximity; it does not consider other measures such as masks as source controls; and the contribution of carbon dioxide from other sources is not taken into account.

For further information about carbon dioxide monitoring, see:

- National Collaborating Centre for Environmental Health Indoor CO2 Sensors for COVID-19 Risk Mitigation: Current Guidance and Limitations (external link)
- COVID-19 Indoor Safety Guideline calculator (external link) uses a theoretical model to calculate easily interpretable safe exposure times and occupancy levels for a range of settings (including classrooms, offices and restaurants), based on a range of adjustable parameters.

Ultraviolet germicidal irradiation (UVGI)

Ultraviolet germicidal irradiation, or UVGI, is the use of ultraviolet-C (UVC) energy to kill viral, bacterial, and fungal organisms. Ultraviolet germicidal irradiation systems may be used within existing air ducts or overhead room devices to disinfect the air. Stand-alone UVC lamps or air purifiers are available but installation within an air duct or overhead devices is safer to prevent people being exposed to UVC.

Inactivation of SARS-CoV-2 requires direct exposure to UVC, but this direct UVC exposure can also cause burns and injuries to the skin and eyes. Additionally, some UVC lamps generate ozone that may act as a respiratory irritant. If used, it is essential that the UVGI design is site specific and safely installed with an ongoing safe system of work implemented to prevent exposure to UVC. Further information about UVGI is available from UVGI disinfection technology (external link).

Further information

Studies have consistently demonstrated that combined interventions are most effective in mitigating the risk of COVID-19 transmission. For further information about COVID-19 refer to https://www.healthywa.wa.gov.au/Articles/A_E/Coronavirus.

Additional external general resources about COVID-19 and ventilation are listed below. It should be noted that not all advice applies to the Australian setting.

- World Health Organization (WHO) Roadmap to improve and ensure good indoor ventilation in the context of COVID-19 (external link) and Coronavirus disease (COVID-19): Ventilation and air conditioning (external link)
- OzSAGE Safe Indoor Air Working Group Safe Indoor Air (Ventilation) Recommendations, Creating safe workplaces during the COVID-19 pandemic (external link), and Protecting children from COVID-19 and making schools and childcare safer (external link)
- Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) COVID-19 resources page (external link)
- Safe Work Australia COVID-19 Information for workplaces (external link)
- Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA) COVID-19 Guidance Directory (external link) and Post-COVID Ventilation (external link)
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) COVID-19 Core Recommendations for Reducing Airborne Infectious Aerosol Exposure (external link)
- Centers for Disease Control and Prevention (CDC) Improving Ventilation in Your Home (external link) and Ventilation in Buildings (external link)

- Environmental Protection Agency (EPA) Indoor Air and Coronavirus (COVID-19) (external link) and Ventilation and Coronavirus (COVID-19) (external link)
- Chartered Institution of Building Services Engineers (CIBSE) Emerging from lockdown (external link) documents
- Optimising ventilation for infection prevention and control in healthcare settings

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This document can be made available in alternative formats on request for a person with disability.

health.wa.gov.au