Safe Indoor Air (Ventilation)

Recommendations

Members of the OzSAGE Safe Indoor Air Working Group (in alphabetical order)

Professor Brendan Crabb
Professor Con Doolan
Mrs Kate Cole
Professor Geoff Hanmer (chair of working group)
Professor Guy Marks (member of OzSage Executive)
Dr Andrew Miller
Professor Jason Monty
Distinguished Professor Lidia Morawska (member of OzSage Executive)
Dr Charitha de Silva

<u>Background</u>

VENTILATION is key to our exit strategy. Schools and businesses have immediate needs for better ventilation, and urban design needs to incorporate improved airflow in a post-COVID world. SARS-CoV-2 spreads through the air. The risk of COVID-19 infection is higher in indoor spaces, and it's even higher when those indoor spaces are poorly ventilated. In this context, ventilation means provision of safe, clean indoor air, not to be confused with ventilation (assisted breathing) of patients in ICU.

Respiratory aerosols from breathing and speaking accumulate in indoor spaces, resulting in increasing risk over time. Spending 10 minutes indoors in a poorly ventilated room is less of a risk than spending hours in there. Many studies of cluster outbreaks of COVID-19 point to airborne transmission as the most likely explanation for infections. Poor ventilation (stagnant air) in public buildings, workplace environments, schools, hospitals, and aged care homes contribute to viral spread.

Good ventilation is one of the most effective ways to reduce the risk of COVID-19 infection, in concert with other mitigations, including density limits, the use of PPE and the use of air purifying devices.

<u>Overarching Principles</u>

a. *High risk can be identified with*: The three V's and T (any of these is a red flag, and more than one indicates higher risk):

   Venue: Multiple people indoors, where social distancing is often harder.
   (poor) Ventilation: Staying in one place with limited fresh air.
   Vocalization: Talking, shouting or singing will increase aerosolization of the virus.
   Time: The amount of time spent in the venue in relation to the risk. Less time is better.

b. *Test*: Use a CO_2 meter to check and to monitor ventilation in the space. If it is a public space, consider making the reading visible to the public. Don't guess, test.

b. *Remediate*: Act as required to improve ventilation to the target level of less than 800 ppm. (recommendations are below)

c. *Ameliorate*: If immediate ventilation improvements are impractical, ameliorate conditions using air purifying devices. At a minimum, these should have a HEPA filter and the size of the unit should be matched to the space. Alternatively, relocate activities outside or to a better ventilated venue.

In a pandemic with a novel virus, it is important to be precautionary and to focus on minimising harm.

Naturally Ventilated Buildings – General Principles

a. Open windows and doors where safe to do so, to bring outdoor air inside and to remove contaminated air. Opening multiple windows and doors allow more outdoor air to move into the space.

b. Work to create a cross-breeze by opening windows and doors at opposite ends of the space. Where no cross-breeze exists, consider improving airflow through simple measures such as child-safe fans. Opening both the front and back doors in smaller shops can improve airflow.

c. Where airflow can't be improved, such as in lifts, stairwells and some common spaces, add localised systems such as air purifiers with a HEPA filter that are appropriately sized for the space.

d. Kitchen exhausts in many fast-food shops and restaurants often deliver good ventilation outcomes providing there is a source of fresh air. Many naturally ventilated shops are 'dead'; there is no effective air flow because openings have been blocked with signage or shop fronts have been replaced with fixed windows. These are a concern if occupancy is high.

e. Keeping exhaust fans running in toilets is recommended where the fan motors are suitable for 100 percent duty to prevent contaminated air moving outside bathrooms. A mechanical engineer or electrician can check the fans duty cycle, or you may be able to download the fan specification. *Do not operate fans continuously if they are not rated for this duty.*

f. Many of these ameliorations will increase energy consumption to maintain comfort conditions inside. Long term solutions that improve ventilation while minimising energy consumption should be considered once the pandemic has abated.

g. Common areas to many Class 2 (apartment) buildings are not ventilated. These and common lifts are a high hazard environment and there need to be urgent adaptations to provide ventilation to these spaces, or to provide air purifiers in the meantime.

Examples: Houses and apartments, motels, aged care facilities, child-care centres plus most gyms, schools, shops, pubs, medical centres and restaurants.

Mechanically Ventilated Buildings – General Principles

a. Increase the proportion of outdoor air provided into enclosed spaces. Do this through speaking with an appropriately qualified mechanical engineer and configuring the system to maximise the outdoor air intake that the Heating, Ventilation and Air Conditioning (HVAC) system can safely accommodate, without negatively impacting on key factors, including the reduction of indoor humidity. (low humidity appears to be associated with an increased risk of transmission.)

b. Consult with a mechanical engineer to disable demand-control ventilation systems so that air supply is not reduced by temperature or occupancy.

c. Consult with a mechanical engineer to increase the total airflow being supplied to maximise the air changes per hour (ACH) that the HVAC system can deliver.

d. Consult with a mechanical engineer to improve air filtration in HVAC systems to the maximum amount possible given the design of the system.

e. Ensure that mechanical ventilation systems are inspected and maintained regularly to ensure they are working as per their design. As part of this, work to understand locations of low or poor ventilation. In those locations, reduce occupancy and/or use additional measures such as localised portable HEPA air purifiers.

f. Where HVAC systems can't be improved due to design constraints, or in lifts, stairs and unventilated common spaces, add localised systems such as portable HEPA air purifiers that are appropriately sized for the space.

g. Many of these ameliorations will increase energy consumption. Long term solutions that improve ventilation while minimising energy consumption should be considered once the pandemic has abated.

Examples: Hospitals, cbd hotel quarantine, hotels, office buildings, supermarkets and shopping centres, clubs, airports, university teaching spaces, theatres, cinemas and auditoriums, some schools, medical centres, shops, pubs, gyms and restaurants.

<u>Warnings:</u>

a. Do not open windows or doors to improve air quality in buildings with mechanical ventilation systems unless checked with a mechanical engineer.
b. Do not operate fans outside their designed duty cycle to avoid the risk of overheating fan motors.

Buildings with wall-mounted air-conditioning systems – General Principles

Wall-mounted air-conditioning systems (split systems) without fresh-air intake will simply recirculate contaminated air. These systems need to be supplemented with an outdoor air supply (or portable air-cleaning devices). Therefore, work to bring outdoor air inside by opening windows and doors or via a mechanical fresh air system.

Always consult with a mechanical engineer when reconfiguring mechanical ventilation systems.

Differential Pressure

Using the difference in air pressure to move air from one space to another is an effective way of controlling and containing the spread of contaminated air. This is most effectively applied where confirmed or suspected COVID-19 persons are already within a confined space. Examples include healthcare and purpose designed quarantine facilities.

HVAC systems are not normally designed to achieve differential pressure and if they are, these systems need to be carefully monitored to ensure they are working properly.

Maintaining differential pressure in a room relies on a steady-state environment to be effective. If windows or doors are opened into areas that are designed to be at negative pressure, then the pressure differential can be lost and contaminated air inside the space can move outside that space. For this reason, existing buildings used for hotel quarantine must not be fitted with openable windows or balcony doors.

Ventilation Hoods for COVID patients in healthcare

These transparent polymer hoods, pioneered in the Victorian Health system and developed by Professor Jason Monty and Dr Forbes McGain are proven to reduce the transmission of SARS-CoV-2 in patient care settings. These hoods can achieve an Air Change Rate of 100 per hour, providing high quality air to patients while minimising risk to Health Care Workers (HCW) and other patients.

Carbon Dioxide Monitoring

CO_2 monitors can help assess whether there is good ventilation or poor ventilation. Measuring carbon dioxide (CO_2) is a useful and practicable surrogate indicator to assess the relative infection risk of COVID-19 indoors. Humans exhale CO_2 in addition to aerosols, which will contain SARS-CoV-2 virions if a person is infected with COVID-19. As the number of people inside a space increase, CO_2 will increase to varying degrees, depending on the ventilation effectiveness and the volume of the space.

Concentrations of CO_2 will gradually increase over time if insufficient outdoor air is delivered into the space. If persons are in poorly ventilated spaces for a prolonged time, regardless of physical distancing, then the risk of infection will increase.

There are some limitations to the use of CO_2 monitoring, because it is not representative of risk related to non-airborne transmission pathways. It doesn’t account for re-circulated air that has undergone filtration and it doesn’t consider other control measures, such as the use of masks as source control, nor the use of respiratory protection, nor contributions of CO_2 from other sources. Notwithstanding, if the limitations are well understood, a precautionary approach supports the use of CO_2 monitoring as a useful and relatively low-cost tool to make real-time assessments of relative infection risk, which should lead to improvements being made to improve ventilation in indoor spaces.

Outside in the open air, the ambient concentration of CO_2 is approximately 400 ppm. Humans will exhale CO_2 at approximately 8 Litres per minute, depending on the level of physical exertion.

Measurements should be taken at multiple locations within a room or space and repeated periodically during the time the room or space is occupied. A building wide system with central reporting and monitoring is desirable in all spaces with high occupancy, including healthcare, schools, aged-care and critical workplaces.

For restaurants, bars and shops, the provision of public information on CO_2 levels should be considered.

Action limits should be applied as per below:

1. Below 800 ppm - indicates a low relative risk of infection.
2. Between 800 ppm to 1,500 ppm - indicates a moderate relative risk of infection. Improvements should be made where practicable to increase the provision of fresh air into the indoor space.
3. Above 1,500 ppm - 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.
4. Around 600 ppm or below is best practice.

Vehicles

Shared vehicles including cars, trucks, vans, taxis and public transport are not currently subject to effective regulation of ventilation levels. National standards should be developed and implemented. Monitoring of ventilation levels and performance should be the responsibility of operators.

No vehicle transporting SCOVID or COVID patients should be operated without the fresh air intake being set to maximum. Drivers should consider lowering windows slightly where this is possible, particularly where this will encourage air to exit the vehicle at the rear. Passengers and drivers should never sit next to each other if possible, or if this is unavoidable, a minimum of fit-tested P2/N95 respiratory protection should be used.

Do not set the ventilation system to recirculate.

Short and Long-term Strategies

A key barrier to implementing ventilation strategies relates to confusion about the need to separate short-term from long-term strategies. It is recognised that there are many constraints regarding the practicality of implementing expensive large-scale ventilation modifications in the short term. Long-term strategies best implemented during design phase of new infrastructure projects or to coincide with the replacement of mechanical equipment or an interior fitout.

In contrast, there are many cost-effective short-term measures that can be practically applied to mitigate COVID infection risk focused on ventilation.

Most buildings are Deemed-to-Satisfy (DTS) naturally ventilated under the National Construction Code. Most schools, aged care facilities, small shops, restaurants, general practices, dental surgeries and so on have no mechanical systems that can be upgraded. The key here is operating manually controlled ventilation openings (mostly windows) to the extent necessary to improve ventilation to achieve target CO_2 levels internally.

Hospitals are a special case; they are mostly but not all mechanically ventilated and the systems are complex. Pulling down a ceiling to upgrade the mechanical system above it may not be practical in an operating hospital, especially now. Working out whether filtration can be improved and fresh air increased without replacing components other than the filter assemblies in plant rooms is a recommended first step.

Improvement of ventilation in the built environment should be made a priority for the Australian Building Control Board (ABCB) by the Building Ministers Forum (BMF). The Regulatory Impact Statement (RIS) should consider costs and societal benefits of improved ventilation, including improved health and improvements in cognition, particularly for children in school.

The Australian Government should consider the financial support of improved ventilation through both direct budget spending and loan schemes. A benefit/cost analysis of improving ventilation across the built environment may show that benefits outweigh costs.

Air cleaners/Air purifiers

Local air cleaning (portable HEPA filters) can be an effective form of source control. This is because the air purifiers can set up a very localised air flow around them and stop infectious particles getting far from the room they were expelled in. Ventilation hoods in ICUs are proven to work and clinical settings including GP's and Dentists should consider air purifiers unless their ventilation is excellent.

In lifts, stairwells, corridors and other common spaces in buildings that have no ventilation, air purifiers are a practical option until building codes are changed to require them to be ventilated.

Operating many air purifiers in an institutional setting is complex because the operation of each unit can only be assessed locally. Devices with the capacity to be networked would be useful, but portable devices with this function are not yet generally available.

The priority in any space other than those spaces with SCOVID or COVID patients is to improve ventilation and only to introduce air purifiers if this is not possible.

Australia must set and introduce national performance standards for air cleaners and compliance should be monitored by the ACCC or another suitable body.

Re-opening Schools in High Caseload Settings

NSW is currently experiencing the highest daily infection numbers of any Australian state at any time during the pandemic. Already, over 100 schools in NSW are infection sites and the number continues to grow, therefore focussing on ventilation in schools is of utmost importance.

As approximately 5M children under 16 are unvaccinated, it is likely that this will lead to high rates of infection amongst school age children as it has in the UK, the US and Israel. All these countries have much higher rates of vaccination amongst their adult population than Australia and as a result, children in Australia will be more likely to be infected by adults or to infect them. Until vaccination is extended to young children, the 5M under 16's in Australia will be the single largest reservoir of infection, significantly outnumbering the 4M adults who will be unvaccinated at the 80 percent target adopted by the National Cabinet.

For schools to open with any degree of safety, it will be vital to consider ventilation, capacity limits, the type of activities to be allowed and the time spent together indoors. The use of outdoor facilities should be encouraged as much as possible.

Departments of Education and private providers should immediately embark on a process of measuring ventilation levels at every school and acting where required, in accordance with the recommendations contained in this document.