QUESTION TIME BRIEF

Portfolio/s: Education and Youth Affairs

VENTILATION IN SCHOOLS

Talking Points

- Improving air quality in ACT public schools was prioritised ahead of students returning to on campus learning in term 4.
- All learning spaces across the school network have been checked (about 3500) to ensure adequate ventilation.
- Every school has its own **Indoor Air Quality Plan** which lists actions already undertaken by the Directorate (e.g. HVAC systems change) and actions for schools to undertake each day to improve air quality. These Indoor Air Quality Plans can be found on each school's website.
- Ventilation is one component of a multilayered approach that has been implemented to prevent transmission of COVID-19 in schools.
- The routine use of portable HEPA filters and portable carbon dioxide (CO_2) monitors across all ACT schools is not supported at this time, as the evidence for the additional public health benefit of these units over other public health measures and maximising fresh air is currently limited.
- EDU will continue to be guided by ACT Health and AHPPC advice and the evolving evidence on the specific benefit of these devices in addition to other public health measures in a school setting.
- The generosity of school communities is appreciated in offering air purification units or fundraising for them. These units however, are not currently part of EDU's air quality and ventilation plans for ACT public schools.
- In line with expert advice, ventilation is being maximised by opening windows in classrooms, adjusting HVAC systems and turning on exhaust fans in rooms that have them. The message to the community from schools is, *If you would like to make a contribution to your school, please speak with your principal about which types of donations would be most welcome*.
- $0.9 million of priority works committed at 17 November 2021.
- $1.2 million of ventilation works are out for quote/tender at 17 November 2021.

Key Information

- An important part of ACT public schools' return to on campus learning in term 4, 2021 is to ensure that there is proper ventilation in line with Health advice for managing COVID-19.
- It's important to note that ventilation is part of the broader suite of controls to reduce the risk of COVID-19 transmission in school settings including vaccination, physical distancing, good hygiene, cleaning and mask use, and should not be considered in isolation of other mitigation strategies.

- The CHO, AHPPC, World Health Organisation and Safe Work Australia recommend ensuring fresh air ventilation is optimised in all settings, including through adjusting mechanical systems to increase fresh (external) air supply and reduce air recirculation, and use of natural ventilation such as opening windows and doors.
- EDU has developed an Indoor Air Quality (IAQ) framework to assess the IAQ of all public schools commencing with ACT public colleges.
- All public school learning areas have been assessed under the IAQ framework with immediate actions implemented to optimise fresh air flow. There are 3500 learning areas in ACT public schools (including approx. 3000 classrooms).
- Every school has had an IAQ Plan (see example at end of brief) completed under the framework for the return to on-campus learning – this includes a list of actions already undertaken by EDU (including increasing fresh air ventilation via HVAC systems) and actions for schools to undertake each day (including opening windows to promote natural ventilation and turning on exhaust fans). These school actions will be carried out by non-teaching staff like Building Services Officers.
- Site specific IAQ plans were provided to all ACT public colleges on 1 October 2021.
- Site specific IAQ plans were provided to all ACT public schools on 22 October 2021.
- From this work, EDU is confident that fresh air flow can be increased in all public school classrooms to improve ventilation.
- IAQ Plans are being updated to include actions undertaken in term 4.
- Cooler classroom temperatures during cool weather and warmer classroom temperatures during hotter weather are expected to result from increasing fresh air to learning environments.
- Higher energy bills are anticipated to result from the increase in fresh air as a greater volume of air needs to be heated or cooled.
- EDU is investigating technologies to improve air quality in classrooms including modern ventilation systems for toilets and bathrooms and air purification systems and securing the supply of these where appropriate.
- EDU is monitoring air quality in learning spaces to further refine the strategy to provide the best ventilation for ACT public schools including pre-schools.
- Where access to natural ventilation is limited and where mechanical ventilation can not be provided in the short term, germicidal UVC light units are being installed to existing air conditioners. These units are safe and are used to reduce transmission of viruses and bacteria in health settings. The units have been implemented predominantly in preschools.
- Heat Recovery Ventilation (HRV) systems have been purchased to provide a long term energy efficient solution to ventilation of learning environments. These are scheduled to arrive in January 2022. The units are specifically designed for classrooms and control fresh air automaticallying in response to CO_2 levels.

- $2.6 million of additional funding has been allocated to undertake short term actions across the public school portfolio to maximise fresh air in learning spaces in term 4.
- a further $2.6 million of additional funding has been allocated to undertake additional actions to maximise fresh air in learning spaces in term 1 and 2 of 2022.

Background Information

- ACT public schools are very well placed as there has been an extensive program of work underway to improve school ventilation since the 2019-2020 bushfires.
- EDU has been progressively upgrading building controls in 65 schools in order to have better control of the air intake sources for the Heating, Ventilation and Cooling (HVAC) systems.
- Many schools have building controls with CO_2 sensors which provides a proxy for ventilation in a room. CO_2 monitoring will commence once students and staff have fully returned on-site in term 4.
- In 2018, EDU commenced a program of installing CO_2 sensors in schools. To date, more than 326 CO_2 sensors with remote monitoring and management systems have been installed across 40 public schools. Additional CO_2 sensors are being installed at approximately 25 ACT public schools with suitable building control systems over the coming weeks. This will mean 73 per cent (65 of 89) schools will soon have CO_2 sensors to the monitor and manage indoor air quality.
- Not all classrooms are connected to large HVAC systems with CO_2 sensors, however these rooms typically have external natural ventilation and split system air conditioning units so that fresh air can be introduced and air flow maintained.
- Longer term, EDU will look to introduce additional mechanical ventilation in spaces that require it. This may include installation of new building control/management systems with CO_2 sensors that can remotely monitor and control HVAC systems and windows as well as installing supplemental ventilation such as modern exhaust fans in bathrooms and toilets.

Canberra High School Indoor Air Quality Plan	
Background:	As part of the return to on campus learning in Term 4 2021, ACT Health has advised that schools optimise fresh air circulation as one of the controls to reduce the risk of COVID-19 transmission in schools. The risk of COVID-19 transmission is higher in crowded and poorly ventilated spaces where people spend long periods of time together in close proximity. Good ventilation is one part of a suite of controls to minimise transmission in schools, like vaccination, physical distancing, student cohorting, good hygiene, cleaning and mask use. This Plan identifies actions that have been undertaken at your school by the Education Directorate and provides additional measures for the school to undertake to optimise the fresh air ventilation in the school in Term 4.
Health Advice:	The Chief Health Officer, the **Australian Health Protection Principal Committee**, **World Health Organisation** and **Safe Work Australia** all recommend good indoor air quality to reduce the chance of COVID-19 transmission.
Advice:	The ventilation systems at Canberra High School have now been assessed by the Directorate in accordance with the WHO guidance. Fresh air ventilation will be achieved through a mix of natural (opening windows and doors) and mechanical (cooling and ventilation systems). The settings for the Heating, Ventilation and Air Conditioning systems have been reset to achieve good fresh air supply and should not be altered by the school. Increasing the fresh air to classrooms may increase energy costs. Classrooms are also likely to experience lower room temperatures during cooler weather and higher room temperatures in warmer weather. **Learning and teaching spaces with fresh air ventilation from either natural or mechanical systems meet the COVID-19 Health Advice. The school is to prioritise the use of these spaces for indoor teaching and learning along with outdoor spaces**.

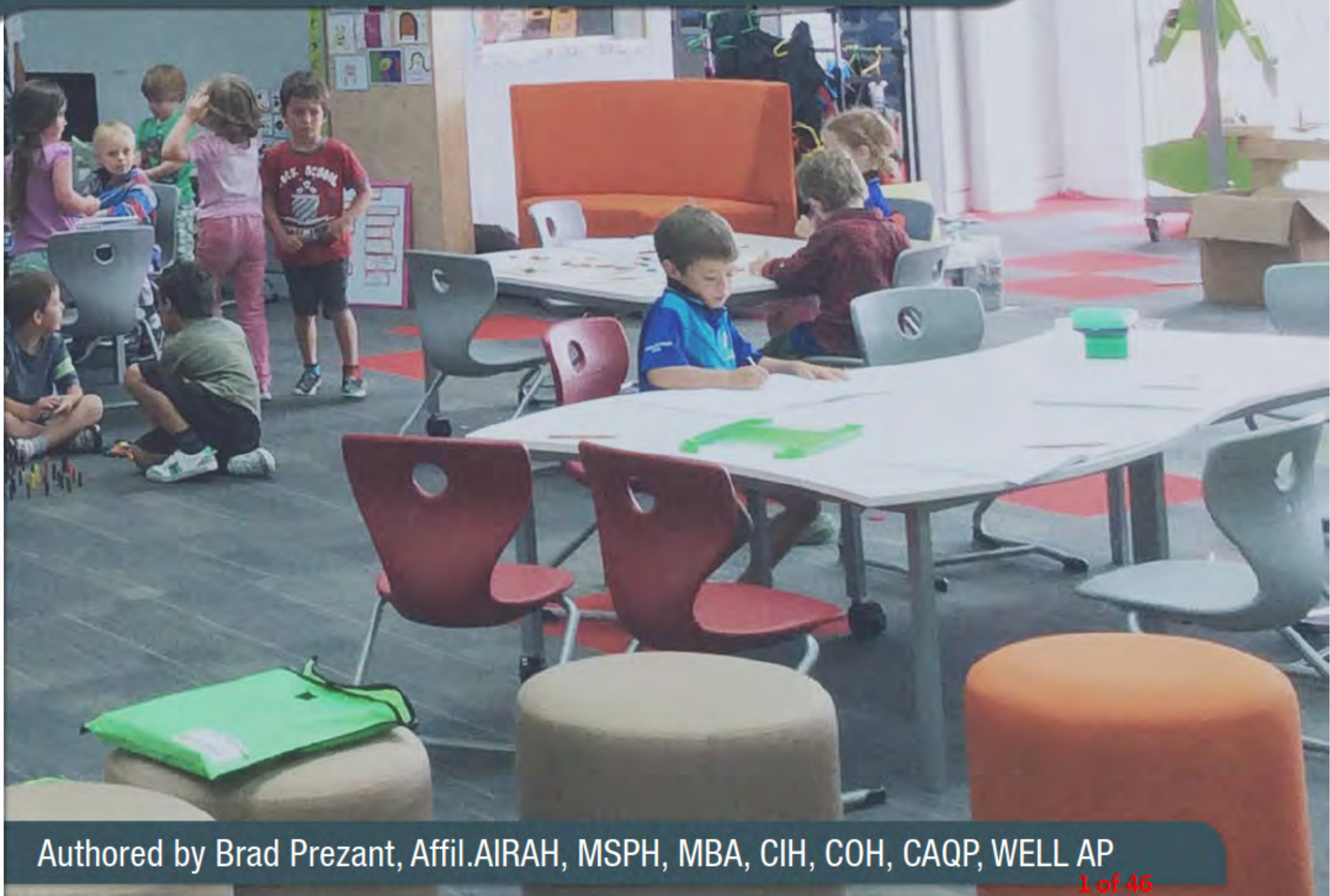
Daily actions to be undertaken by the school in Term 4:	Additional daily measures the school will undertake include: • Opening windows and doors in teaching spaces and other shared spaces of the school to supplement fresh air. Windows above ground level are to be opened only where window restriction is in place to ensure student safety. In line with the National Construction Code, window opening is to be 125mm or less. • Improving air circulation through use of ceiling fans and split system air-conditioning units, only when windows are open. • Ensure bathroom, kitchen and any other exhaust fans are on and operating at full capacity while the school or program is operating and for some time before and after occupancy.
Actions undertaken:	The following actions have been undertaken by the Directorate and its service providers to increase fresh air ventilation in the indoor teaching and learning spaces at the school: • air handling units have been programmed to supply additional fresh air via the mechanical ventilation systems • evaporative cooling in the school will provide full fresh air when operating in either cooling or fan mode. When not in operation, fresh air is to be provided by opening windows • contractors will continue work to audit and enhance the operation of the ventilation systems.
Support or further advice:	For further advice, schools can contact their ICW Network Officer or email ACT.Education@act.gov.au

Cleared as complete and accurate:	17/11/2021	
Cleared for public release by:	Executive Group Manager	
Contact Officer name:	Andrew Parkinson	X54593
Lead Directorate:	Education	
TRIM Ref:	SUB21/7588	

AIRAH

GUIDANCE DOCUMENT FOR PRIMARY AND SECONDARY SCHOOLS

COVID-19 VENTILATION OPTIMISATION



Authored by Brad Prezant, Affil.AIRAH, MSPH, MBA, CIH, COH, CAQP, WELL AP

Contents

Introduction	4
Review and revision	4
Acknowledgements	4
Disclaimer	5
Executive summary	6
Background	7
Informed approach to intervention	8
Existing building characteristics	8
UNDERSTANDING AIRBORNE TRANSMISSION	**9**
Space	10
Concentration in air	11
Dose = Concentration × Time	11
Activity = Source strength which determines airborne concentration	11
How space, time, and activity interact to create infection risk	12
Strategies for minimising exposure and infection risk	13
Existing mitigation measures	14
Layered approach	15
BUILDING VENTILATION SYSTEMS	**16**
Types of systems	17
ACH and flow pattern determine far-field infection risk	19
Introduction of outdoor air can have unintended consequences	20
Provision of outdoor air by design	20
Assessment of ventilation systems	21
Measuring ACH	22

Heat recovery ventilation 24
Indoor particulate monitoring 25
Filtration and filter change schedule 26
Managing temperature and humidity 28
Air cleaning technology 29
Carbon filtration 32
Air disinfection 33
Upper room GUV 34
Other UV-C devices 36
Fumigation 36
Use of internal partitions or other methods to modify airflow 37
Other transmission mechanisms – Surfaces 38
Other transmission mechanisms – Sewage 38
Sunlight 39
Operating schedule 39

BUILDING A STRATEGY FOR YOUR FACILITY 40

Using risk of infection modelling 41
An iterative approach to site assessment 41
Desktop assessment 41
Site assessment 43
Next steps 44

Cover photo: Brad Prezant

Introduction

Schools are re-opening throughout Australia. School administrators and teachers are concerned about the safety of children and staff. There are many more questions about the best way to protect children from COVID-19 infection at school than there are answers.

School administrators are being bombarded by vendors selling a myriad of products, some of which may improve the health of occupants, and some of which may increase the risk of infection. Many of the solutions offered are expensive.

This document, written from an evidence-based public health perspective, is intended to address the many questions that school administrators have been and will be considering in order to provide appropriate guidance for creating a school setting where the focus can be on education, and not the building itself. It is intended as a resource both for schools, and for mechanical engineering designers and maintenance engineers.

Review and revision

Users of this guidance document are encouraged to make known their experience in using it, and to notify AIRAH of any additional information they can provide or to which reference can be made.

Acknowledgements

This COVID-19 Ventilation Optimisation guide is authored by Brad Prezant, Affil.AIRAH, MSPH, MBA, CIH, COH, CAQP, WELL AP Principal Consultant at Prezant Environmental: prezantenvironmental.com.au

AIRAH also acknowledges the review and input of Clive Broadbent, L.AIRAH, Kate Cole, BSc, MEEM, MSc Occupational Hygiene Practice, MAIOH, COH, CF, Brett Fairweather, M.AIRAH, John Penny, M.AIRAH, Adj. Professor Dino L. Pisaniello, FAIOH, FAIHS, FRACI, Dustin J. Poppendick PhD (Environmental Engineer, National Institute of Standards and Technology – NIST USA), Associate Professor Robyn Schofield, and Jeremy Stamkos, M.AIRAH.

Disclaimer

The information or advice contained in this document is intended for use only by persons who have had adequate technical training. The document has been compiled as an aid only and the information or advice should be verified before it is put to use by any person. Reasonable efforts have been taken to ensure that the information or advice is accurate, reliable and accords with current standards as at the date of publication. To the maximum extent permitted by law, the Australian Institute of Refrigeration Air Conditioning and Heating Inc., its officers, employees and agents

(a) disclaim all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs, whether direct, indirect, consequential or special you might incur as a result of the information in this publication being inaccurate or incomplete in any way, and for any reason; and

(b) exclude any warranty, condition, guarantee, description or representation in relation to this publication, whether express or implied.

In all cases, the user should also establish the accuracy, currency and applicability of the information or advice in relation to any specific circumstances and must rely on his or her professional judgement at all times.

Other COVID-19 resources

This document can be found among other resources and frequently asked questions at www.airah.org.au/coronavirus

Last updated November 17, 2021

Executive summary

Space, time, and activity create infection risk indoors. A layered approach to risk reduction is most effective, with social distancing and masks a first step to addressing "near-field" airborne exposures, and ventilation addressing "far-field" exposures.

Classroom ventilation systems range from operable windows, to wall- or ceiling-mounted heat pumps, and include ducted HVAC systems. Unfortunately, most classrooms, as presently designed and operated, do not provide adequate ventilation to minimise these "far-field" airborne exposures.

Ensuring ventilation in classrooms achieves 4 ACH to 6 ACH (air changes per hour), or is as close to that as is feasible, is one important way to minimise COVID-19 transmission indoors. Equally important is understanding the pattern of flow within the space, with cross-ventilation providing the greatest removal efficiency of exhaled air.

A first step for any school is to ensure that the existing ventilation system is performing as originally intended, and if not, returning it to its original operation. This can be accomplished through a tabletop assessment and/or a site assessment.

It is helpful to characterise the existing system's ventilation performance prior to choosing an intervention strategy in order to benchmark existing conditions, and then develop a plan moving forward based on the resources available. Any chosen intervention can then be evaluated against that benchmark as to its predicted or actual effectiveness. Easy-to-use web-based infection risk calculators can help model the infection risk that a particular room presents, once the air exchange is known.

Simple changes in the existing ventilation of the rooms can often be made to achieve infection reduction goals. Additional options for modifying or augmenting the existing ventilation system can also be considered. Some modifications require behavioural changes – occupants are important stakeholders and may need to be included in the assessment and planning.

A variety of technologies are discussed in this document to assist in understanding and choosing the best ones for any particular room or school. There is no one solution; each room and school should consider a variety of approaches in order to select the most effective. Initial capital cost, required maintenance, ongoing energy expense, and other benefits from improved indoor air quality are all part of the equation.

Background

Airborne transmission is now recognised as the dominant pathway for transmitting COVID-19. Recent coverage in the popular media has focused the public's attention on indoor "ventilation" and how it can be assessed and managed to reduce SARS-CoV-2 airborne transmission:

"… many Victorian classrooms – the site for several recent outbreaks – have air quality that is 2 ½ times worse than recommended." [1]

Building stakeholders occupying primary and second schools and childcare centres include employees, students, and parents of students. Each of the groups has recently been bombarded with news accounts similar to these.

Building owners and facility managers are not experts in infection control. Whereas hospitals may have been designed for infection control, childcare facilities and schools have never been designed for this purpose. However, assessing and optimising any building to minimise infection risk is an attainable goal.

This document is intended to identify factors in typical Australian facilities that relate to transmission of COVID-19, in order to form a framework for understanding and choosing appropriate interventions that will:

- Reduce the risk of respiratory infections (including but not limited to COVID-19);
- Optimise resource allocation for maximum benefit;
- Address stakeholder concerns;
- Minimise liability;
- Create a more healthful building environment for occupants beyond avoiding infection.

While the impetus to address these issues may be the current pandemic, there are enormous benefits to be gained from improving school ventilation, which would extend well beyond this present compelling need.[2]

1 Ventilation 'revolution' needed to speed up Australia's path out of lockdown, *The Age*, August 22, 2021.

2 *The Lancet* COVID-19 Commission Task Force, April 2021

Informed approach to intervention

Although Australia spans a wide variety of climate zones and each facility will differ in design and layout, there are a number of common elements such that many considerations will be applicable to a high percentage of buildings used for this purpose.

Each building, however, also has unique aspects of design, operation, maintenance, and use, and the "toolbox" of feasible interventions will need to be intelligently applied for optimal benefit and efficiency. A "layered approach" will typically be required, with several mitigation measures selectively applied to the different buildings based on an understanding of the existing conditions and an analysis of the costs and benefits of the various potential interventions.

A 20-year-old vehicle being brought in for repair might need cleaned spark plugs, a replacement alternator, a head gasket, or just a change in engine timing. Or all of the above. Or just some of the above. There is no simple "one solution fits all" approach likely to represent an efficient use of resources with optimal results for all school buildings.

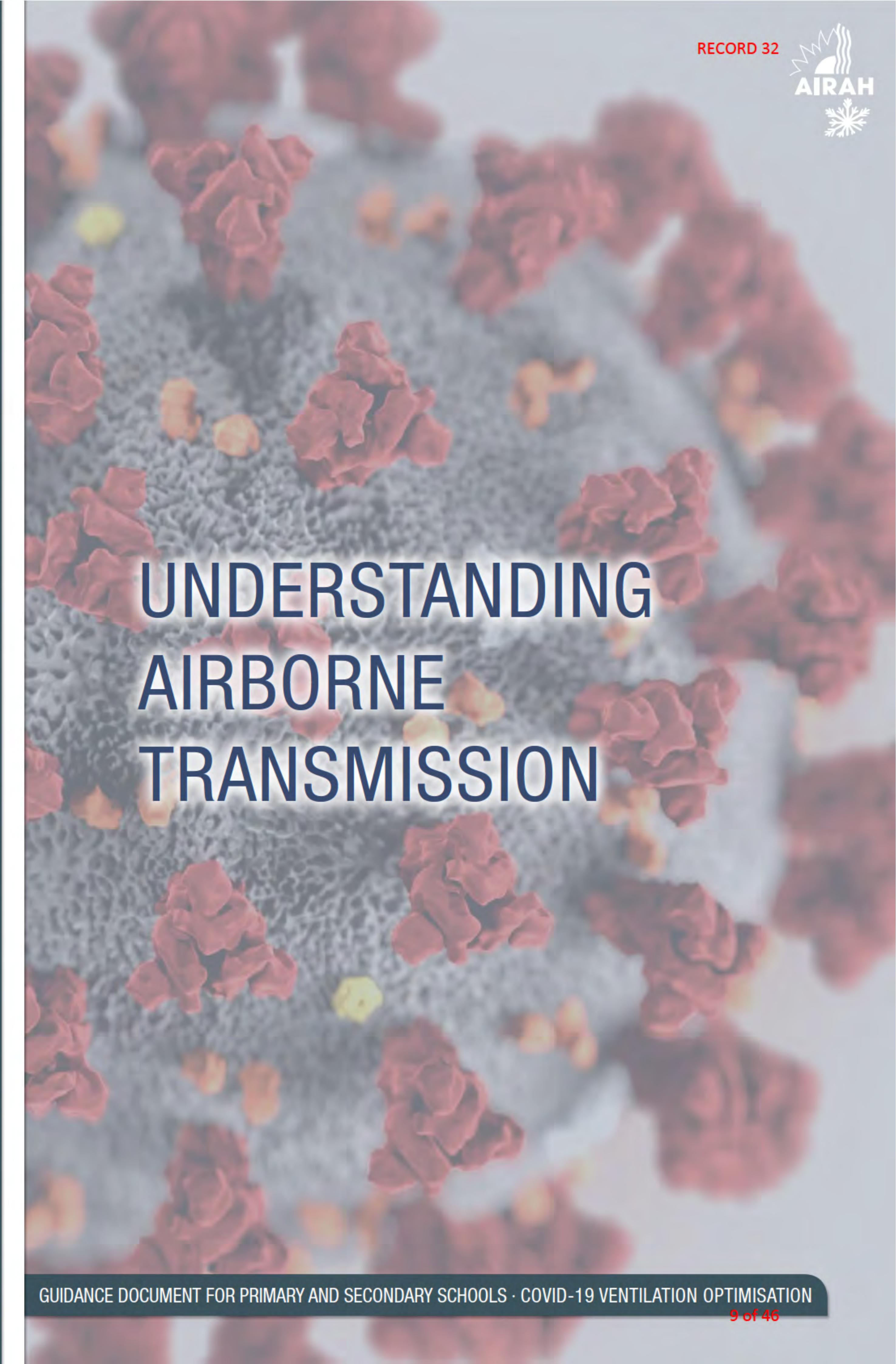
Existing building characteristics

Many newer buildings are slab-on-grade structures, while older buildings may be on stumps or of similar construction with a traditional beam and bearer support structure.

Many modern schools are heated and/or cooled with wall-mounted or ceiling-mounted split system refrigerant-based "heat pumps/air conditioners", with evaporators indoors and condensers (in cooling mode) located outdoors. Older schools may have unit ventilators along perimeter walls; such a system often includes at least a small percentage of outdoor air intake. Central ducted HVAC systems are also commonly used for larger schools.

Each ventilation, heating, and cooling design presents challenge and opportunity for providing ventilation and minimising infection.

Toilets, sinks, and/or showers, when incorporated, require by code that there be ceiling exhaust in the design. These can influence airflow.



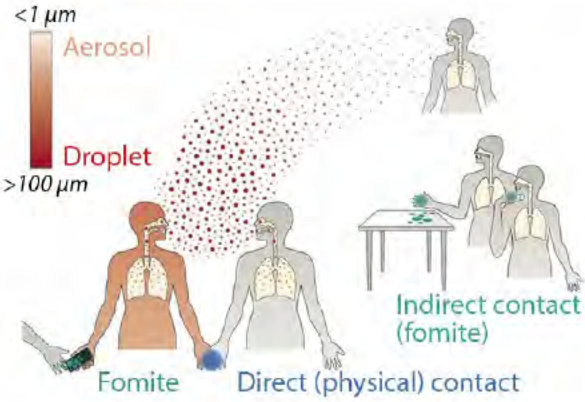
UNDERSTANDING AIRBORNE TRANSMISSION

Space

There are three airborne transmission "scenarios of interest". One is when people are within 1.5 metres of each other, or "near-field". Near-field includes direct touching, deposition of large droplets on the skin or eyes from talking, sneezing, or coughing, and the inhalation of immediately exhaled air from a person close by.

A second transmission mechanism that took 18 months to be fully recognised, particularly in Australia, with many consequential infections, such as hotel quarantine escapes. This "far-field" transmission scenario is particularly important with the delta variant, and likely explains many infections. "Far-field" is more than 1.5 metres, and is similar to cigarettte smoke diffusing thoughout a room. A third transmission mechanism is when air moves from room to room within the same building or even between buildings. This is less common but exists.

Ultimately, risk is a function of how close one is to the source of infection. Research suggests that being close to the person exhaling, in their "near field" of within 1.5 metres, or farther away but directly in line with a cough or sneeze, can result in exposures to infective material five times higher than if you are in the "far-field".[3]



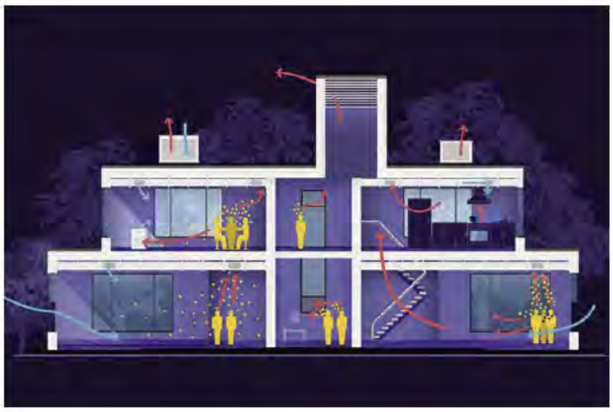


Image: Brad Prezant © Prezant Environmental

3 Table 7.3, *Assessment of Risks of SARS-CoV-2 Transmission During Air Travel and Non-Pharmaceutical Interventions to Reduce Risk, Phase Two Report: Curb-to-Curb Travel Through Airports* (Faculty and Scientists at the Harvard T.H. Chan School of Public Health), https://cdn1.sph.harvard.edu/wp-content/uploads/sites/2443/2021/02/Harvard-APHI-Phase-Two-Report.pdf

Concentration in air

Close to the source, for "near-field" exposures, the concentration of exhaled infective material in the air is highest. After being diluted and mixed with the surrounding room air the concentration decreases – but the potential for infection is still present. The small exhaled particles hang around in the air and gently follow room air currents, mixing and diluting within the room air, behaving similarly to the way smoke would behave. Just as one might smell smoke anywhere in a large room if a smoker is present, one is exposed to infective material anywhere in the room once an infected person is present, exhaling, and this mixing occurs. This is what is meant by "far-field". When air moves from room to room, dilution of infective material may or may not occur, such that simply being separated by a wall may or may not be protective.

Dose = Concentration × Time

For each of these scenarios of interest, a critical factor is time of exposure. While the exact mechanisms of transmission are not fully understood, based on current knowledge it is predicted that longer exposures to low concentration of airborne infective material are the equivalent of higher exposures for shorter periods of time. Thus the risk of infection for a susceptible person is the product of airborne concentration and time spent breathing that air.

Activity = Source strength, which determines airborne concentration

Activity determines the strength of emission by an infected person, with higher activity (breathing) levels or higher vocalisations (such as occur with shouting or singing) related to higher emissions. Higher emissions result in higher airborne concentrations. Activity also affects breathing rate in a susceptible person, and therefore impacts dose, as a person breathing twice as hard due to a higher activity level will cycle two times more infective material into their lungs and have double the dose. It is for this reason that numerous outbreaks of COVID-19 occurred in gyms where both infected and susceptible persons are at high activity levels for moderate periods of time.

How space, time, and activity interact to create infection risk

When an infected person enters an indoor space, their normal breathing expels both large and small particles of respiratory fluid containing infective SARS-CoV-2 virus. The large particles settle out due to gravity, but the small particles shrink in size as they dehydrate and remain airborne for a long period of time, sometimes hours, carried on room air currents throughout the space. These particles likely remain infectious for an extended period, and as small particles, have the potential to enter the deepest portions of the lungs and cause infection.

Over many minutes and hours of exhalation, these particles accumulate within the space, and an increase in concentration of infective material spread throughout the room occurs, assuming the person continues to be present and exhaling. There is wide variation among different persons in the amount of exhaled particles.

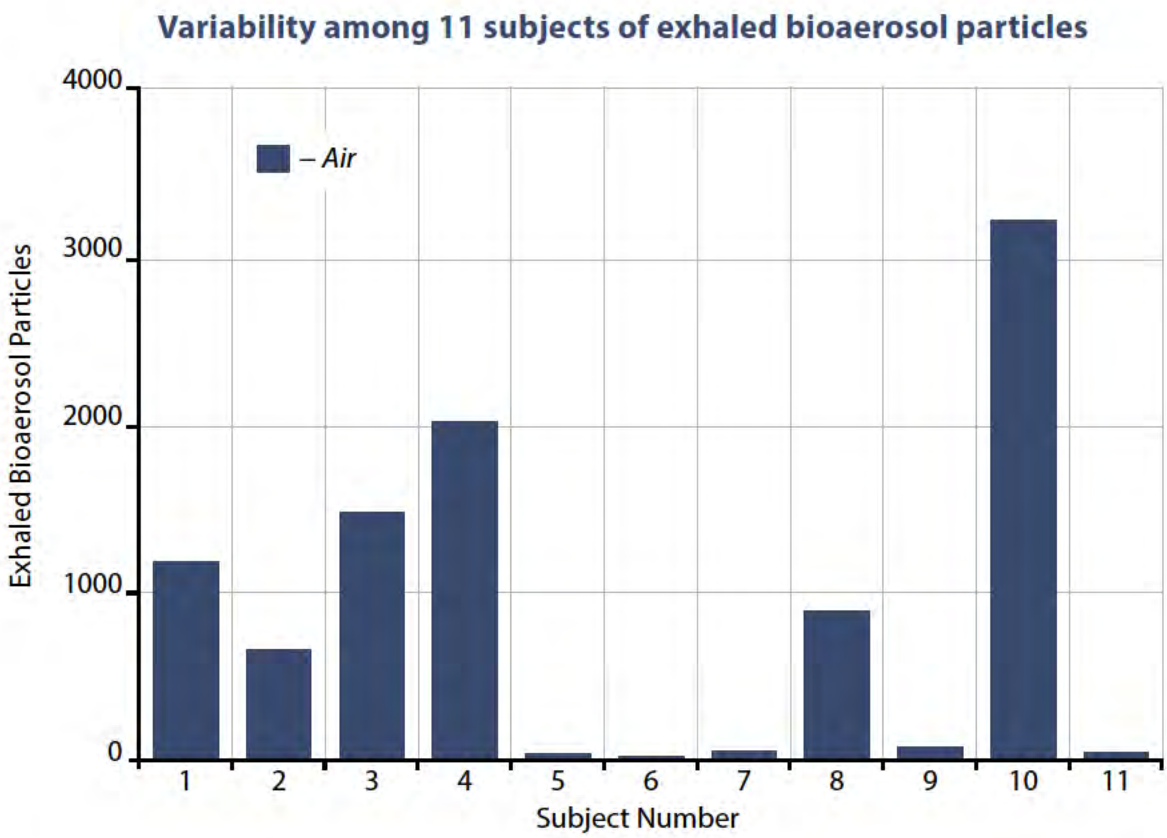


Chart: Edwards DA, Man JC, Brand P, Katstra JP, Sommerer K, Stone HA, Nardell E, Scheuch G. Inhaling to mitigate exhaled bioaerosols. Proc Natl Acad Sci U S A. 2004 Dec 14;101(50):17383-8. doi: 10.1073/pnas.0408159101. Epub 2004 Dec 6. PMID: 15583121; PMCID: PMC536048.

Dilution of room air, and a reduction in concentration of these particles will occur from air entering the space, either through infiltration through the building envelope, operable windows or doors, or an active HVAC system capable of bringing in outdoor air and mixing it into the delivered air.

Based on how many air changes per hour (ACH) are occurring in a room, assuming the infected person continues their occupancy (doesn't leave and keeps exhaling), buildup in concentration of airborne infective particles can increase for many hours, taking as long as 6 hours to reach a maximum value if ACH are low, i.e., at 0.5 ACH.

With higher ventilation rates, for example, 3 ACH, this maximum value will be reached in 1 hour, and the ultimate maximum concentration reached would be lower than if there is less air exchange (lower ACH) of infective particles.

If the infected person leaves the room, the decrease in airborne concentration can also take a long time, with continued exposure for anyone present. The decrease is quicker with more air changes, and slower with fewer air changes.

Given two rooms with an infected person present and equal air exchange, if the room is very large in volume (length x width, times ceiling height), the exhaled infective material will reach a lower maximum concentration than if the room is very small in volume, because the same amount of exhaled material is divided between a larger volume. A small room concentrates the infected material in a smaller area, with higher concentrations reached. In general, therefore, higher ceilings are protective.

If a susceptible person is present in the room the entire time, sharing the air with the infected person but always more than 1.5 metres away, this susceptible person is exposed to infective material for the duration of time both persons occupy the room. If they both leave, and a new susceptible person immediately enters, this person as well will be exposed, as the concentration of infective material will remain airborne, decreasing slowly with time, as a function of the ventilation rate in ACH.

Strategies for minimising exposure and infection risk

All strategies for mitigating exposure and infection risk will utilise the principles outlined above, and all interventions potentially considered should be able to be assessed as to how they are impacted by these criteria.

Existing mitigation measures

Occupancy restrictions, social distancing, and mask wearing are critical public health elements in minimising the public health impact of SARS-CoV-2, and have been extensively recommended throughout Australia. Each of these can impact both "near-field" and "far-field" exposures:

- Restricting occupancy reduces the likelihood of a randomly infected person to be present simply because there are fewer people. Restricting occupancy also reduces the number of persons who could potentially be infected if an infected person is present (one person infecting 1, 2, 3, 4, or more susceptible persons). But when one infected person is present, the risk of any individual present becoming infected is the same whether there is only one person in the room with the infected person or many persons in the room with the infected person.
- Minimising indoor time is extremely effective, as "far-field" transmission outdoors in wind and sunlight has not been documented. Transmission outdoors is only likely to occur in the "near field", with two persons facing and close to one another, or in dense crowds. Holding classes outdoors in favourable weather when feasible, or taking multiple breaks outdoors during the day, is a highly effective mitigation measure.
- Social distancing both indoors and outdoors reduces near-field exposures and ultimately dose, and is extremely effective in minimising transmission.
- Mask wearing is also extremely important as it reduces both the exhalation of infective material by approximately 30%[4] (and up to 99% depending on the type of mask worn), and reduces the inhalation of infective material by approximately 30% (and up to 99% depending on the type of mask worn). The ultimate dose is therefore reduced by the product of the two, such that with 30% efficiency masks (70% penetration), the inhalation of infectious particles is $0.7 \times 0.7 = 0.49$, or one-half of the exposure if neither person were wearing a mask.

4 Jin Pan et al. *Inward and outward effectiveness of cloth masks, a surgical mask, and a face shield*, (2020)

Layered approach

All mitigation measures – social distancing, mask-wearing, and minimising contact time should be implemented when feasible, with ventilation providing an additional layer of mitigation. This has been described as the "swiss cheese" approach, with each layer providing additional protection:

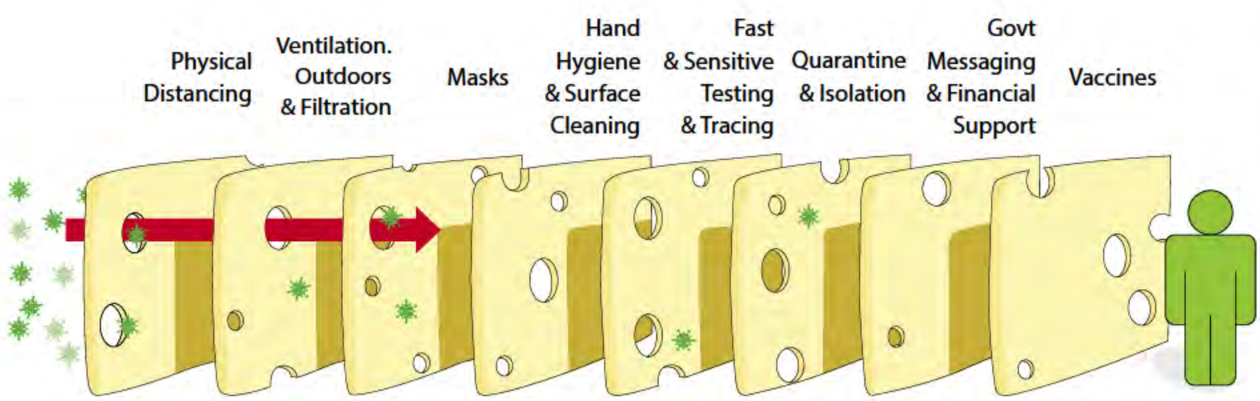
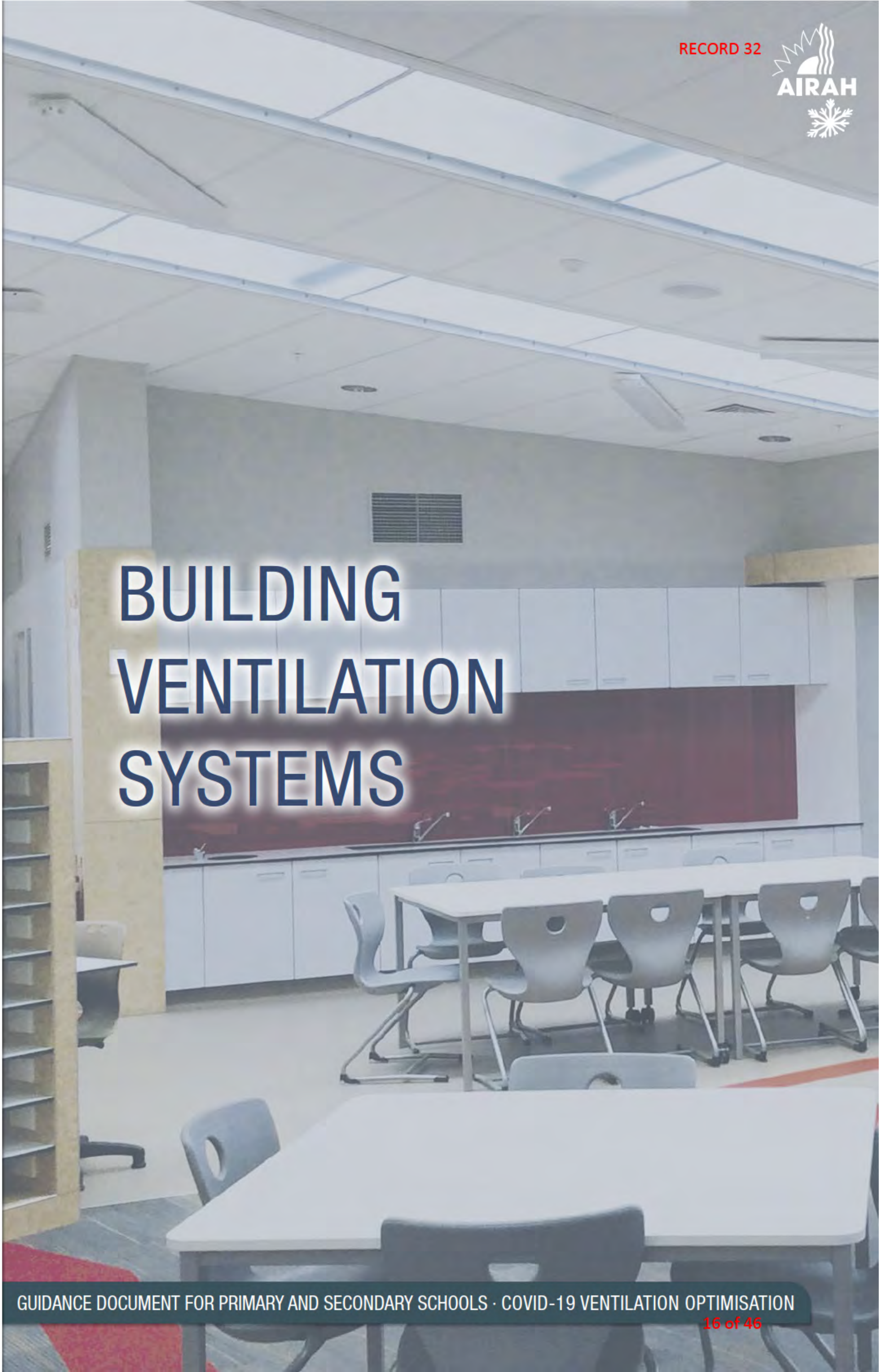


Image: Brad Prezant © Prezant Environmental. Adapted from Ian Mackay, *Virology Down Under*, virologydownunder.com



BUILDING VENTILATION SYSTEMS

Types of systems

Building ventilation systems range from very simple, i.e., operable windows but no mechanical equipment, to very complex with mechanical heating, cooling, and ventilation (HVAC) systems and accompanying sensors capable of both delivering and assessing quantity, composition, and delivery rates of a mixture of both building return and outdoor filtered and conditioned air.


Image: Brad Prezant © Prezant Environmental


Image: www.apave.fr/actualite/groupes-froids-comment-etre-en-conformite?hcb=1

Also included in building ventilation systems are those components not intended to heat or cool, such as toilet or kitchen exhausts, or passive or wind-driven roof vents that supplement the natural thermal stack effect and move air upwards and out of the structure.


Image: Brad Prezant © Prezant Environmental

Building ventilation systems determine the ACH within the indoor space by exhausting indoor air to the outdoors and replacing it with air from the outdoors. Higher exhaust and intake rates created by fans and dedicated exhaust/intake ducting create higher ACH.

Building ventilation systems impact "far-field" exposures by controlling the time it takes to reach maximum airborne concentration of infective material being exhaled by an infected person, and the magnitude of concentration of infective material in the air. They have little impact on "near-field" exposures; other mitigation measures are required to address these exposures.

At one extreme, building ventilation systems can create a pattern of flow that is linear, such as what exists in a clean room or operating room, with air moving only in one direction, passing clean air over contaminated zones and then exhausting that contaminated air.

At the other extreme, building ventilation systems can create a pattern of flow described as complete mixing, or turbulent mixing, with dilution of generated contaminants (including infective particles) spread throughout the room somewhat uniformly, such as what might exist in a room with an operating overhead fan. While this may be ideal for creating temperature uniformity, for infection control it has the potential to expose everyone in the room to exhaled viruses.

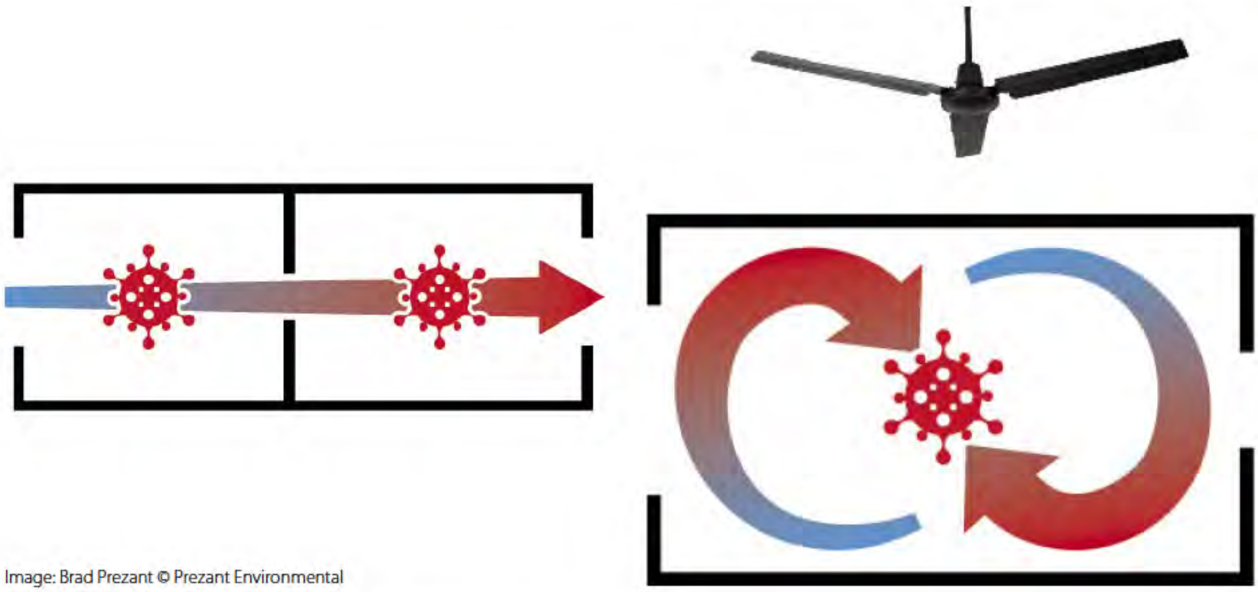


Image: Brad Prezant © Prezant Environmental

Unit ventilators or ceiling or wall-mounted refrigerant-based evaporators, i.e., "heat pumps", or "split systems" might recirculate air in a consistent pattern in one portion of the room, creating "hot spots" of recirculation in that part of the room relative to other portions of the room. These systems should be audited to ensure that the present discharge configuration is not creating high air velocities that enhance "unfiltered" distribution of airflows from one person to another.

Ceiling or wall-mounted refrigerant-based evaporators also have the potential to create stratification when in heating mode. During heating season, warm air from the evaporators will tend to hug the ceiling due to the physical principle of hot air rising, and resist mixing with the cooler air near the floor that has "sunk" from perimeter walls and window glazing. The air lower in the room becomes a stagnant zone, and infective material will concentrate at higher levels in that stagnant zone than if there were more turbulent mixing, thereby increasing the risk of infection in the lower "stagnant" region.

Heat pumps/refrigerant-based split systems do not exhaust air from the space or bring in outdoor air, thus they do not "ventilate", they only recirculate with thermostat-driven heating or cooling. Other components must be relied upon to ventilate these spaces, including natural ventilation.

ACH and flow pattern determine far-field infection risk

Both the overall air exchange measured in ACH, and the pattern of flow define the exposure potential and infection risk. Higher ACH reduce shared air and therefore infection risk, and flows which direct potentially contaminated exhaled air towards the exhaust rather than mix it into room air reduce exposure to shared air and infection risk.

Hospitals adjust air exchange to be in the range of 6 ACH to 12 ACH for infection control purposes. These values are not always practical to achieve in public buildings; some public health authorities have suggested 4-6 ACH,[5] without undesirable airflow characteristics. This could be achieved through a mix of outdoor air introduction and particle removal within the room. The two are additive, such that if the outdoor air ventilation is accommodating 2 ACH, and localised particle removal achieves 2 ACH to 4 ACH, a total of 4 ACH to 6 ACH will be reached.

All buildings have a pattern of flow that can be determined and assessed independently of the ACH. These patterns can possibly be optimised or manipulated in some manner to minimise infection risk, as shown below:

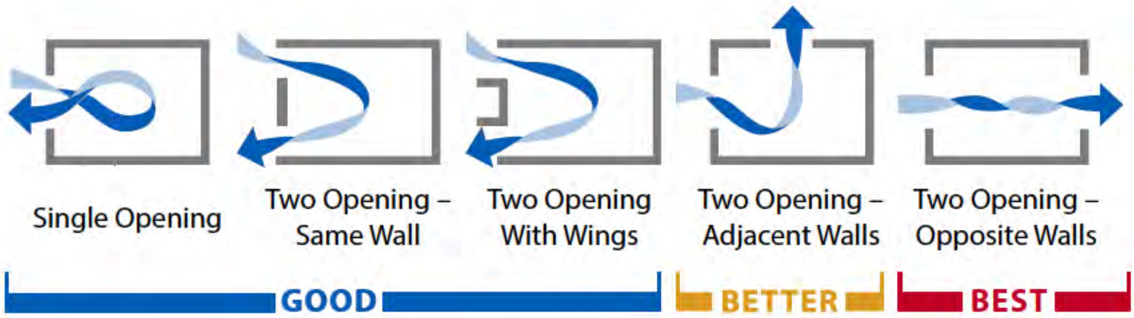


Image: Adapted by Brad Prezant from schools.fohealth.org

For a building with operable windows, 4 ACH to 6 ACH may be achieved under the correct conditions with windows and/or doors open. With windows closed this level of air change will not be approached, and a reasonable estimate absent specific building knowledge is that air changes in schools and childcare centres may be around 1 ACH, and possibly significantly lower. This can vary significantly with wind and temperature differences.

5 *5-step guide to checking ventilation rates in classrooms*, Joseph Allen, Jack Spengler, Emily Jones, Jose Cedeno-Laurent, Harvard Healthy Buildings program, www.ForHealth.org

For a mechanically ventilated building, a fixed amount of ACH may be designed into the system, or the HVAC system may automatically adjust the ACH based on outdoor air conditions and thermostat settings. For these systems, the minimisation of energy use while still maintaining thermal comfort may be the sole criterion determining the ACH.

Introduction of outdoor air can have unintended consequences

For either a building with operable windows or mechanical ventilation, adjusting the system to deliver the 4 ACH to 6 ACH might be ideal for minimising infection risk, but it is critically important to understand that the building as a whole may not have been designed to manage the additional moisture introduced by a large quantity of outdoor air entering. The building may or may not be able to accommodate the introduction of this moisture without causing potentially grievous damage to the building components. It is therefore imperative that prior to modifying the ACH, consideration be given to the impact of this moisture within this larger context of building performance. Introduction of outdoor air may also impact energy costs.

While it is generally advantageous to ventilate at the greatest possible number of ACH for infection control, that assumption presupposes that the outdoor air is of good quality. If a building is located in a particularly polluted location, such as immediately adjacent to a highway, or outdoor air is compromised by excessive fine particulate due to frequent controlled burns and bushfires, increasing the amount of outdoor air may not be at all desirable, or may at least be considered as a trade-off.

Provision of outdoor air by design

Classrooms in general are required to introduce outdoor air by design, either through natural ventilation or mechanical ventilation.

On initial construction, building codes will define the required outdoor air ventilation to be designed into an active HVAC system, in litres per second per person, and differ for the type of occupancy based upon *AS 1668.2–2012 The use of ventilation and air conditioning in buildings Part 2: Mechanical ventilation in buildings*. For classrooms the appropriate value is 12 L/second/person.

There is no information on carbon dioxide in the Australian standard, though in New Zealand, a benchmark of 1,000ppm CO_2 is set, and in the U.S., 700ppm above ambient, or around 1,125ppm CO_2.

AS 1668.4–2012 The use of Ventilation and air conditioning in buildings Part 4: Natural ventilation of Buildings will be applicable in the absence of a built-up HVAC type system, and may represent the large majority of facilities. The provisions for natural ventilation define the percentage area of openable windows and doors as a function of floor surface area as an alternative to provide mechanical outdoor air ventilation. Wind-driven roof-mounted aluminium ventilators present on the roof may be integrated into the design considerations for natural ventilation, as they will augment the natural stack effect of the building and move air upwards and outwards. Of course, their functionality in practice is somewhat dependent on wind speed and building-specific factors.

Assessment of ventilation systems

Toilets are required by building codes to have exhaust but these may be linked to lighting operation, presence detection, or controlled by a clock, and may not be operating at all times. For infection control purposes, these exhausts should operate on a continuous basis so as to ventilate the toilet area and also to increase overall ventilation in the building.

As part of a recommendation for an initial audit of the existing ventilation control systems to verify intended design, installation and operation, simple tests can be done to demonstrate that the toilet exhausts are functioning, as shown below:

Images: Brad Prezant © Prezant Environmental

On the left, is a small vane anemometer that can be used to estimate the actual flow and compare with design specifications. On the right is the even simpler "toilet tissue test" that doesn't require a calibrated instrument but would at least identify exhausts that are present, and either very poorly functioning or not functioning at all.

Toilets may have both mechanical exhaust ventilation and operable windows. Opening the windows in toilets could be counter-productive, as it would disrupt the exhaust flow and potentially direct contaminated aerosolised toilet air inward to other occupied areas (see section below on additional transmission mechanisms). For this reason, they should be kept closed unless airflows are assessed. Passive exhaust ventilation in toilets may not always function as intended, that is air could flow inward in reverse direction to the intended outward flow. Consideration to incorporating active fan ventilation in such systems would benefit infection control.

Kitchen exhaust systems may be set to operate continuously to contribute to increased ventilation and ACH in the building, and thereby enhance infection control.

It is highly unlikely that naturally ventilated buildings are delivering either 10–12L/s/person of outdoor ventilation air or keeping CO_2 levels below those cited above, excepting when a high percentage of openable doors and windows are open.

When windows and doors are closed in naturally ventilated buildings, the ACH achieved may be between 0.5 ACH and 1.0 ACH, or lower, depending on the construction details, the frequency of door opening and closing, the functionality of toilet and any other building exhausts, and the degree of infiltration through the building envelope.

When windows and doors are open, air exchange rates are often unpredictable and highly variable, from 2.0 ACH to 20-plus ACH, influenced by outdoor wind conditions as well as the area, configuration, and location of the openings.

Measuring ACH

Ventilation, in ACH, can be estimated for buildings with active mechanical systems by inferring from the design drawings (engineering estimates), or measuring the actual as-built, installed and maintained airflows (commissioning and/or re-commissioning).

Tracer gases are the most accurate method to provide a realistic, in-use measure of ACH. Blower door tests can also be a less precise, but useful estimate of ACH.

For buildings with openable windows, ventilation ACH can also be estimated using exhaled carbon dioxide (CO_2), as infiltration through windows or doors cannot be directly measured using instrumentation as one might do for diffusers and outdoor air intakes in buildings with mechanical HVAC systems.

There are important caveats to using carbon dioxide because CO_2 values measure both ventilation and occupancy, and we only want to measure ventilation – the values obtained can therefore be misleading.

When using CO_2 in either naturally ventilated or mechanically ventilated buildings to estimate ACH, ***there must be the typical maximum numbers of occupants present for several hours prior to measuring CO_2***.

Alternatively, CO_2 can be artificially increased in an unoccupied building using dry ice or compressed gas to build up a concentration of several thousand ppm, and the curve from the tracer decay analysed to determine the air changes per hour.

Inappropriate interpretation of CO_2 levels can falsely indicate the room is better ventilated than it actually is.

This error is particularly common when a single measurement is taken, rather than using continuous reading instruments tracked over time. In particular, if CO_2 were measured as part of a short (1–2 hour) audit of a room or building, and the room is not a typical "full" occupancy, it is very possible that a misleading value for CO_2 might be obtained.

High CO_2 measured values indoors, however, typically do indicate that the space is poorly ventilated and that condition is identified by the use of CO_2. In Australia, the NCC (National Construction Code) IAQ Verification Method (originally designed as an indicator for body odour) recommends a maximum concentration of CO_2 of 850ppm averaged over 8 hours, which represents 400–450ppm greater than outdoor air. This is defined as an adequately ventilated building from an occupant "odour amenity" point of view, not an infection control point of view. A recent 2020 AIRAH publication recommends an orange light indicator at 800ppm and a red light indicator at 1,000ppm "in order to promote as much ventilation as possible."[6]

850ppm CO_2 is probably a reasonable level of CO_2 to aspire to in an educational setting. Many if not most schools in Australia likely do not have sufficient ventilation.

For buildings depending on natural ventilation (openable windows, doors, and/or sliders), opening these continuously either partially or wholly, intermittently on schedule, or after occupancy and prior to re-occupancy, may create thermal discomfort but can contribute significantly to reducing airborne infection risk. Doing this when outdoor conditions are mild would of course be highly effective without thermal consequence, and cracking the windows even during adverse outdoor air temperature periods may minimally impact thermal comfort.

Periodic opening of doors and windows requires behavioural modification by staff, and may be difficult to achieve. CO_2 monitors in classrooms could demonstrate the impact of the operable

6 *AIRAH Guidance for School Buildings COVID19*, https://www.airah.org.au/Content_Files/Resources/2020_AIRAH_COVID-19_Guidance_for_School_Buildings.pdf

windows in reducing CO_2 and indicate when the outdoor air has completely refreshed the indoor air, i.e., when the concentration of CO_2 indoors approximates the concentration outdoors. Doors and windows would remain open no longer than necessary using this approach. Additionally, occupants would gain a perception of control of infection risk, which could increase satisfaction and reduce anxiety regarding the building and the risk of infection.

One should anticipate an energy cost penalty if the mechanical systems had to re-heat or re-cool the outdoor air.

Heat recovery ventilation

Heat recovery ventilation (HRV) can be a useful strategy for increasing air exchange (in ACH) with minimal energy penalty. HRVs bring in outdoor air and remove room air, transferring the heat (or cool) from the exhaust air to the incoming air with high efficiency. This effectively dilutes contaminants present indoors, including infectious particles generated by occupants as well as volatile organic compounds associated with building materials, people, or activities.

This provides an advantage over portable particle air cleaners, as the overall air quality will be improved, provided outdoor air is of high quality.

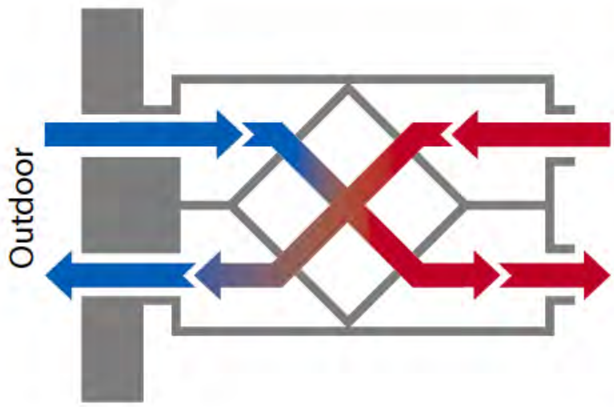


Image: Brad Prezant © Prezant Environmental

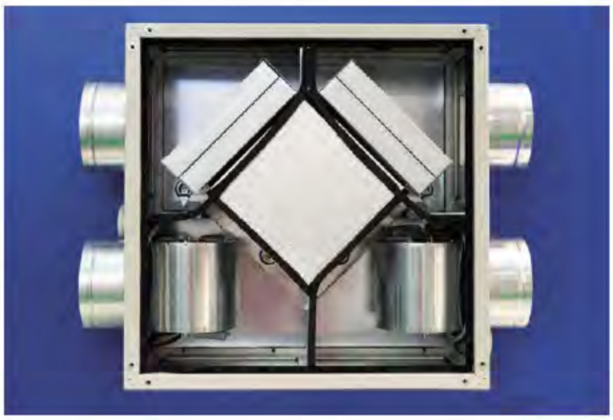


Image: www.ny-engineers.com/blog/ventilation-efficiency-measures

Heat recovery ventilators introduce outdoor moisture, and as discussed elsewhere, introduction of moisture could impact overall building integrity. This needs professional assessment prior to implementation. HRVs can be combined with dehumidification in certain climates – this can be a very desirable strategy for creating comfortable and healthful indoor environments and is gaining in popularity, particularly when existing systems do not effectively dehumidify.

Many HRV systems are ducted, requiring complex installation including provision of electrical service to the HRV fan location, and will therefore incur considerable initial cost. Maintenance of HRVs is important to prevent build-up of dusts and/ or moisture within the units, which could lead to problems of mould growth.

Indoor particulate monitoring

Particulate monitoring, including size-selective particulate monitoring, can easily be accomplished using portable instrumentation. But because such monitoring is not specific to respiratory aerosols, and respiratory aerosols represent only a small fraction of total particulate of all sizes that might be airborne, any infectious signal is overwhelmed.

Past experience in child care and school settings is that the relatively high density of occupation combined with the active nature of kids, creates ongoing disruption of the settled dusts within an activity room. This dust consists of outdoor soil and outdoor biological material, but also will be enriched with products used indoors as part of the learning experience such as art materials. Various contaminants are brought indoors by the kids on their clothing and shoes, such as pet hair and other allergens.

Images: Brad Prezant © Prezant Environmental

Particulate monitoring may serve as a surrogate measure of air removal and replacement in a before/after type of scenario when operating an air cleaning device or turning "on" ventilation that removes room air and introduces outdoor air, and could be useful to determine the effectiveness of the device or ventilation. Particulate monitoring might also be useful to check functionality of a HEPA-type air cleaner on a periodic basis, as these units can fail due to breakdown of the seal between the unit and the filtration device and cease to remove fine particulate, or malfunction and allow leakage in some other manner.

Filtration and filter change schedule

For an HVAC system that cycles occupied space return air through an HVAC unit containing a filter, higher filtration efficiency will remove a greater proportion of fine particulate associated with disease transmission. All filtration systems remove a percentage of particles, so even lower efficiency filtration provides some removal of fine particulate associated with infectious aerosols.

Ideally, to achieve a high degree of removal efficiency, MERV-13 rated filters would be in place in such systems, but many systems have not been designed for the pressure drop associated with higher efficiency filtration, and original system design criteria may have specified filters with lower capture efficiency. While HEPA systems remove up to 99.97% of all particles, lesser-rated filters can have high removal efficiencies, exceeding 90%.

Frames to support filters may not provide sufficient support or clearance for higher efficiency filters. Prior to upgrading filtration from the original manufacturer specified efficiency or type, an engineering assessment should be undertaken to ensure that other aspects of system operation are not adversely impacted, particularly a reduction in total flow from the additional resistance associated with higher efficiency filters.

Images: Brad Prezant © Prezant Environmental

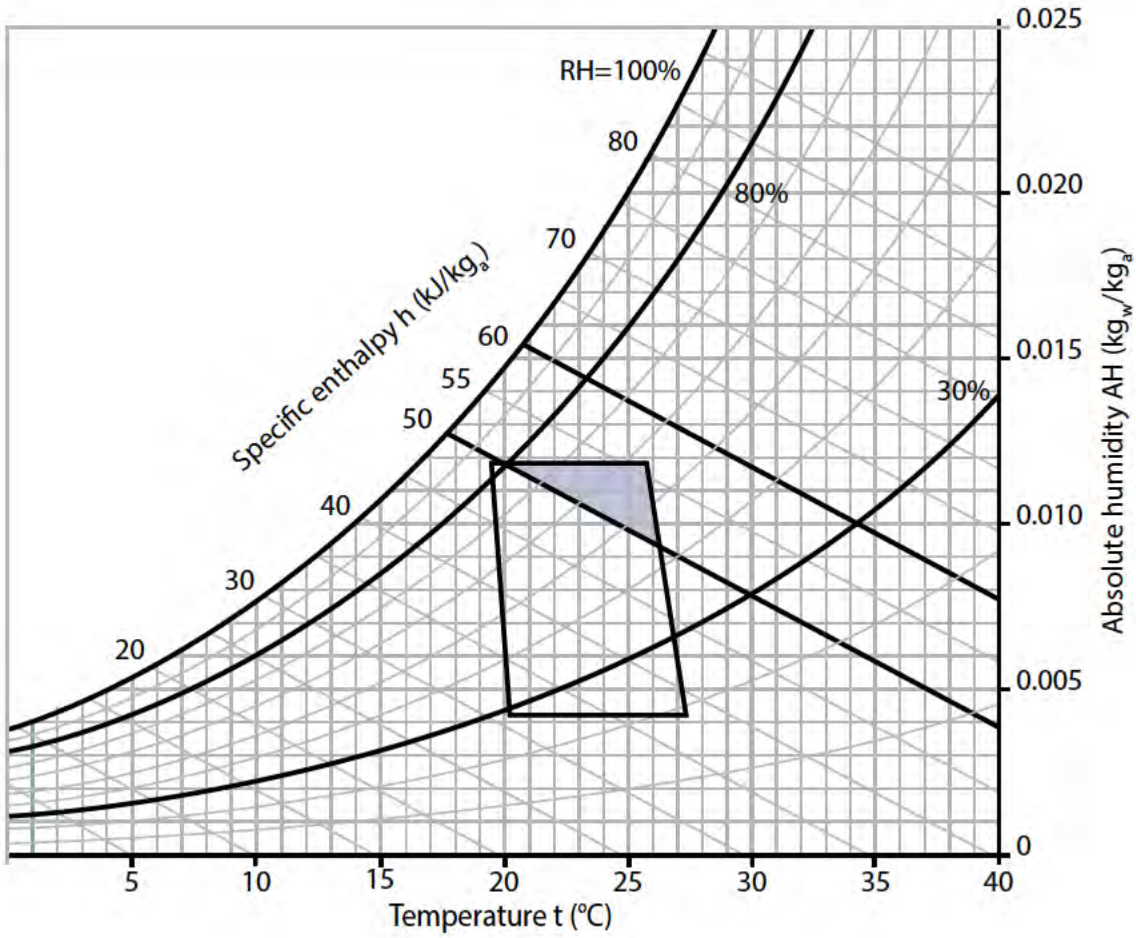
It is desireable to ensure that filters are present, properly in place, and not overloaded or clogged so they are functioning as intended. There is no value, however, in increasing the existing scheduled interval for replacing outdoor air filters, as this additional expense will not create additional value in infection control. For filters on internal fans such as those on wall or ceiling-mounted split systems evaporators, there is no evidence to suggest that impacted particles will be shed from these filters during use, so similarly, the existing replacement interval should be followed to ensure proper airflow unimpeded by pressure drop resulting from an overloaded filter. The scheduled replacement interval should therefore not be advanced for the purposes of infection control.

When changing out filters, particularly if there is reason to suspect that an infected person may have been present in the space, precautions including gloves and respiratory protection, and gentle handling as the filter is placed in an enclosed sealed bag would be appropriate for the safety of maintenance personnel.

Managing temperature and humidity

There is some information suggesting that SARS-CoV-2 survives poorly and inactivates faster in warmer and more humid environments. The drawing below indicates in the grey shaded area where these unfavourable conditions of survival fall within thermal comfort recommendations (the larger rectangle represents the comfort zone).

This SARS-CoV-2 "quicker deactivation" zone that is still within the range of thermal comfort is approximately 21–26°C, with humidity levels of 45% RH to 80% RH (the grey coloured triangle below).



In more tropical climatic zones, maintaining a high temperature and humidity might be feasible, but it would be difficult in cooler climatic zones to maintain levels in excess of 50% RH, absent humidification. These high levels of humidity would not be recommended due to consequential moisture management issues.

Quantitatively, it is difficult to estimate the contribution that maintaining these values would contribute to reducing infection risk, and how much better 26°C and 80% RH would be than 21°C and 45% RH, or any values in between, but this could be considered as one element of a comprehensive approach. Minimally, openable windows on cool dry days can be regulated such that indoor temperatures do not drop to the (undesirable) lower left corner of the comfort zone pictured above, 20°C and 30% RH, the cool and dry corner of the comfort zone.

Air cleaning technology

The particles of condensed respiratory fluids that contain the infective SARS-CoV-2, flu virus, and/or other pathogens are within the size range that can be filtered by pleated paper filters. High efficiency particle-arresting (HEPA) filters will effectively remove 99% + of these particles and consequently reduce the airborne concentration and infection risk.

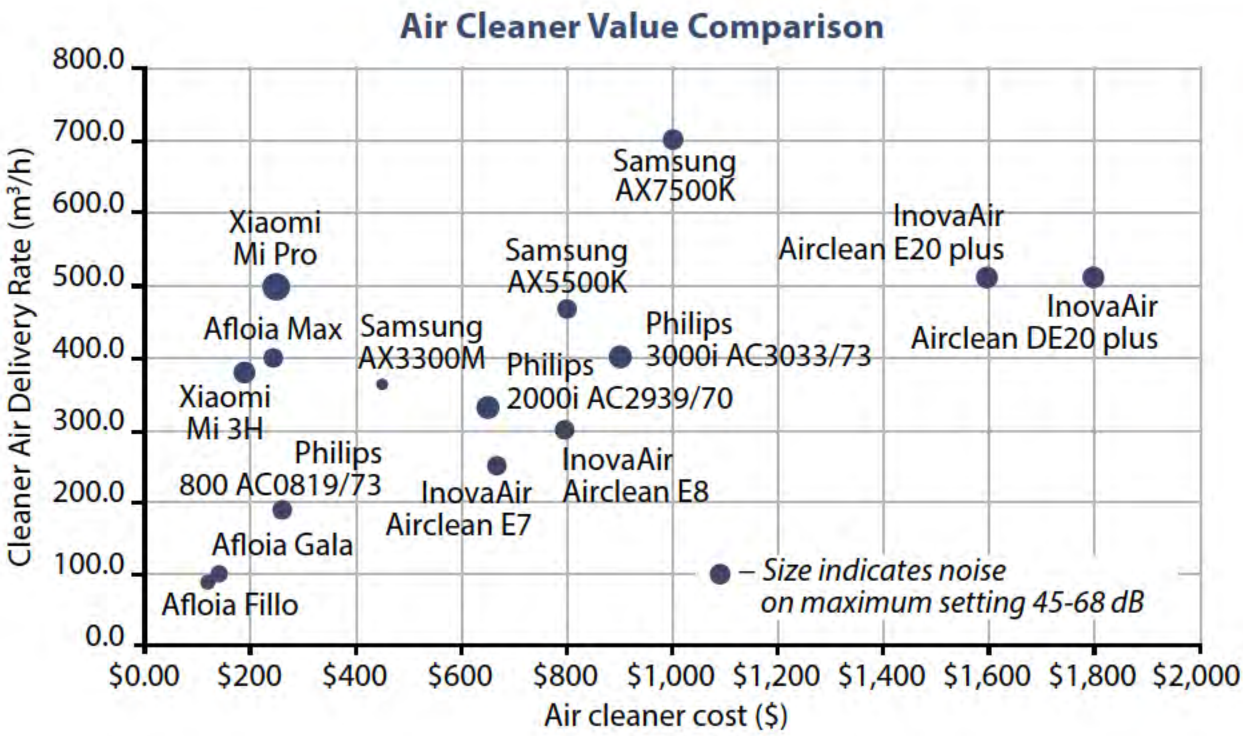
Put simply, they work quite effectively to reduce infection risk, but do not provide the same additional benefits that increasing the ACH by exhausting room air and introducing outdoor air provide, as they do not remove the gases and vapours present in the air.

Absent their ability to remove gases and vapours, however, and specific to removing respiratory aerosol carrying SARS-CoV-2, air filtration and outdoor air ventilation are complementary and can be manipulated to have an additive effect in reducing exposure to infective particles. If it is not feasible to improve ventilation, air cleaning technology can achieve the same goal of reduced infection risk. If air cleaning is not feasible, ventilation can be improved. Improve both and the infection risk reduction benefits are increased in an additive manner.

HEPA filters can be incorporated into an existing HVAC system when the equipment permits (which is not typically the case), or such systems can be modified to accept higher efficiency filtration than what they were originally equipped with (not always feasible, but often possible), or HEPA filtration can be accomplished via stand-alone ceiling-mounted or portable devices.

All HEPA devices will load with particulate as their hours of operation increase. The volume of air passing through will decrease with the added resistance resulting from loading. Filtration efficiency, however, will remain the same or improve with use. It is not advantageous to replace filters on an accelerated schedule, but it is important to replace them when they become "loaded" with use and the resistance increases to the point where volumetric flow is reduced. Pre-filters can prolong the life of HEPA filters.

An important criterion when considering air filtration devices is noise. If the unit is noisy, it will be turned off. Choosing a product based upon its volumetric throughput with minimal noise is therefore essential. Fortunately, there are resources that suggest the sweet spot for both capacity (Clean Air Delivery Rate or CADR) and noise. Below is a chart produced by researchers at the University of Melbourne indicating some air cleaners commercially available in Australia, the CADR, cost, and the noise on maximum setting as a function of the size of the dot:[7]



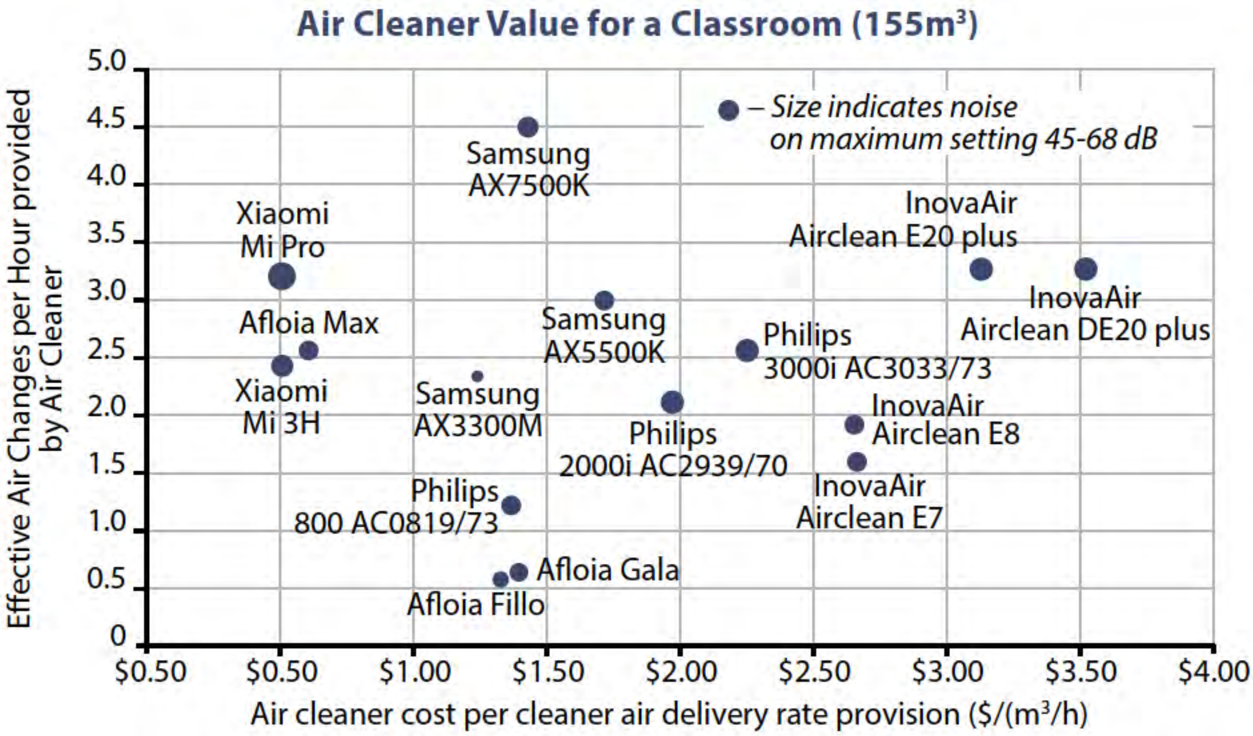
Source: https://sgeas.unimelb.edu.au/engage/guide-to-air-cleaner-purchasing

Recent research suggests that many portable air cleaners recirculate the cleaned air back through the intakes, reducing their efficiency. This may reduce the CADR by as much as 25%.[8]

7 Accessed at https://sgeas.unimelb.edu.au/engage/guide-to-air-cleaner-purchasing

8 *Viruses have arrived in society, Correct design and evaluation of mobile air cleaners to prevent false safety* (draft paper), Fahmi Yigit, November 2021.

For use in a room of 155m³, or a footprint of 65m², with a 2.4 metre ceiling, the following ACH can be achieved by the products illustrated above:



Source: https://sgeas.unimelb.edu.au/engage/guide-to-air-cleaner-purchasing

Multiple portable air cleaners might be required to reach the intended air change per hour goal.

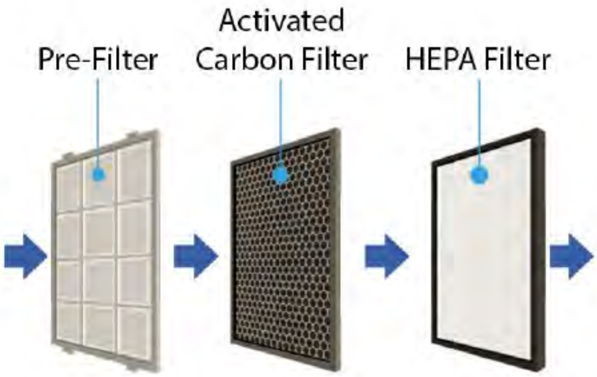
For planning and budgeting, if portable air cleaners were to be utilised throughout a school, one could compare alternative scenarios for both initial and ongoing costs for these units with comparable initial and ongoing costs to achieve higher ACH through the existing or a modified HVAC system.

Placement of air cleaners can be optimised to minimise far-field transmission. As a general guide, the air cleaner should be placed as close as possible to the source of emissions. If the students are clustered in one area, it would be far more effective to place all of the air cleaners in their immediate vicinity or "downwind" from the group if the patterns of flow are discernible, rather than distributing them in a static manner, for example, in each corner of the room. This would be true even if the students dispersed to other parts of the room after gathering, as the air cleaners located close to the source will reduce the ambient level of infective particulate everywhere. This approach would suggest an easy method of moving them, which, given they are trailing a power lead that could create a trip hazard, may not be easy to achieve. If they are to be located "permanently" in the room, at least a preliminary analysis of airflows can be assessed such that they aren't placed directly adjacent to an openable window or another source of fresh air, but likely to be close to a source of exhaled air.

Another reasonable option for the use of air cleaners would be in occupied separate offices and/or reception areas, where a single air cleaner would create 4 ACH to 6 ACH due to the smaller room footprint. This would reduce the exposures of the admin person working in these locations.

Carbon filtration

Carbon filtration is not a practical or desirable filtration technology for infection control. Carbon filtration selectively removes some but not all non-polar dissolved chemicals in the air, but has no impact on small respirable particles that can enter the lung and carry infection.



Images: Brad Prezant © Prezant Environmental

Most portable devices using carbon filtration have a small amount of active surface area carbon filtration, which quickly becomes saturated with humidity and/or absorbed contaminants, rendering the devices ineffective and requiring rapid replacement of the media, creating unnecessary expense with no benefit. They may also slightly increase the pressure drop within any fan-driven system, and are therefore detrimental to ideal functioning of the air delivery system by reducing overall volume throughput.

If portable air filtration systems are utilised that contain both HEPA filters and activated carbon filters, it is recommended that the activated carbon filters either be removed (if that would not adversely impact operation), or not replaced when they reach saturation and/or the end of their service life, provided that does not impact airflow.

Air disinfection

Ozonation, photochemical oxidation (PCO), and ionisation technologies (positive, negative, and bipolar) have all been suggested as air cleaning technologies to deactivate SARS-CoV-2 and reduce airborne transmission of COVID-19. A typical product using these technologies would be a free-standing device, though systems intended to be incorporated into HVAC systems exist. Many of these technologies have not been independently and/or verifiably demonstrated to be effective as deployed in a typical room volume, despite manufacturer claims to the contrary.[9]

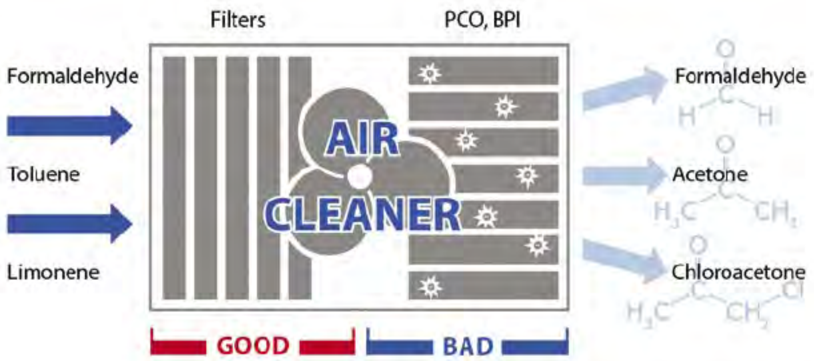


Image: Brad Prezant © Prezant Environmental – based on Ye 2021 & Chen 2005

These technologies are based on chemical or light energies that are non-selective – they oxidise both the target organisms (with the goal of de-activating them) but also oxidise any airborne volatile and semi-volatile chemicals dissolved in the air at low concentrations. Some of these airborne volatile and semi-volatile chemicals are from outdoor air as pollutants, but most are generated indoors from building materials, furnishings, clothing, occupants, and classroom items such as water-based markers, paper, or other art supplies. Breakdown products resulting from the oxidation of these compounds from disinfection technologies can be more irritating than the original chemicals, or in other ways adversely impact human health.

Some disinfection technologies produce ozone, either intentionally or as a by-product. Ozone very effectively rips apart both pathogens as well as everything chemical in the air. Even at low levels of generation, this would augment typical outdoor ozone levels infiltrating indoors. For ionisation systems, the ions produced are proportional to the amount of ozone generated, thus more effective air cleaners may generate more ozone.

9 *Open Letter to address the use of Electronic Air Cleaning Equipment in Buildings*, Dr Marwa Zaatari and Dr Marcel Harmon, https://medium.com/open-letter-to-address-the-use-of-electronic-air/no-to-ionizers-plasma-uvpco-bc1570b2fb9b

All ozone is bad in occupied spaces, even low levels of infiltrating outdoor ozone. Ozone is an EPA-recognised air pollutant in all jurisdictions, with adverse effects on human health. Increasing ozone levels indoors via an introduced technology is not protective of human health, and generation of even minute quantities should be avoided.

Upper room GUV

One exception as regards disinfection technology is upper room GUV (germicidal ultra-violet radiation). It uses shortwave UV-C spectrum wavelength (usually 254nm) to penetrate the cell wall (for bacteria), disrupt DNA or RNA (for viruses), and inactivate micro-organisms (for both bacteria and viruses). This technology has been deployed in hospitals for many years, and while its effectiveness for SARS-CoV-2 has not been demonstrated, initial studies suggest it is effective, with 71% to 100% efficiency in some studies.[10] With any UV radiation, the intensity of irradiance and the time the air spends being irradiated are important to reach critical levels necessary to inactivate any micro-organism. Any system employing such technology needs to demonstrate that these factors are aligned to achieve the intended goal.

Image: https://www.alfaauv.com/blog/the-use-of-upper-room-uvgi-system-for-air-disinfection-during-covid-19-pandemic/

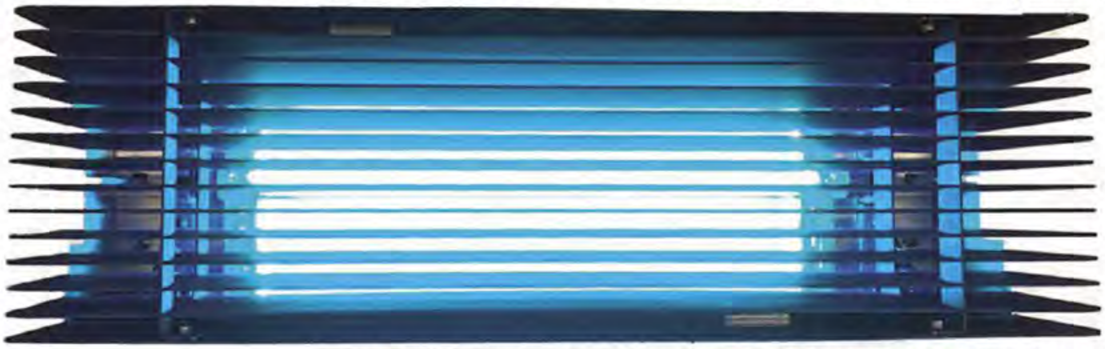


Image: https://uvresources.com/powerful-upper-room-germicidal-uv-c-fixture-kills-airborne-viruses-and-bacteria/

10 Berry, G., et. all, A review of methods to reduce the probability of the airborne spread of COVID-19 in ventilation systems and enclosed spaces *Environmental Research* 203(2022)11765

As typically deployed, upper room GUV is limited to the ceiling portion of the room, and impacts far-field airborne pathogens as they move via normal air currents through the upper portion of the room. A system typically contains reflectors that direct the light upwards and prevent exposure to occupants below. Upper room GUV would only be applicable in a reasonably high-ceilinged room where the irradiation is directed away from occupants, as the UV-C creates significant safety concerns for the skin and particularly for the cornea of the eye.

Professional installation and commissioning of upper room GUV systems including purpose-built fixtures with minimal reflection below, and measurement of irradiance in occupied areas is required, as certain ceilings can reflect UV. Supplemental mechanical air mixing such as low velocity ceiling fans is sometimes utilised to move air vertically in order to permit air to spend as much time as possible in the irradiated zone (germicidal effectiveness is a function of intensity of irradiance and time).

In poorly ventilated spaces, upper room GUV might be extremely effective in reducing far-field (but not near-field) exposure to viable SARS-CoV-2, as viruses are easier to kill than other pathogens as they have no cell wall. Upper room GUV has been shown to be quite effective in reducing transmission of airborne tuberculosis (TB) by up to 80% in studies (TB is likely harder to kill than SARS-CoV-2).

When utilised, cleaning of air that is the equivalent of 6 ACH to 12 ACH of air exchange can be achieved by properly designed systems. Annual re-lamping, maintaining lamp surfaces with periodic cleaning, and dedicated specialised fixture costs as part of the initial investment make this a significant investment, but with a service life of 15 years, upper room GUV is likely to be more cost effective than mechanical ventilation or room air cleaners to achieve the same infection control goals as increased ACH. It should be noted that upper room GUV doesn't have the ancillary benefits that filtration or ventilation have at removing other particles and gases. There is little data on formation of chemical species from UV-C as utilised in upper room GUV at present, and this is of some concern.

Some new promising research suggests that UV radiation in the 222nm band may be ideal for inactivation of SARS-CoV-2. This is a band with minimal penetration into human skin, and a better alternative to 254nm UV.

Unlike other mitigation measures, upper room GUV is quite visible to occupants, and may have psychological benefits to stakeholders that other non-visible mitigation measures cannot provide.

Other UV-C devices

Upper room GUV is a better choice than placement of uVGI inside ventilation ducting, as the air is passing through the irradiated zone quickly inside a duct, whereas it passes slowly in upper room GUV. With UV lamps within ducting, a long linear path of irradiance must therefore compensate for the short exposure time; efficiency of deactivation is greater in upper room GUV due to longer contact time.

UV-C decontamination in healthcare settings of surfaces using portable trolleys emitting high levels of UV-C in unoccupied rooms has been deployed, but would not be recommended for surface disinfection or airborne disinfection outside of hospitals.

Use of other wavelengths of UV (200nm – 222nm) that might be effective in inactivating SARS-CoV-2 with fewer risks to human health are being explored, but lack validation at present, and are therefore not a current option to consider. Some of these technologies, however, show promise.

UV-C irradiation of cooling coils to minimise growth with bacteria and fungi has been successfully utilised and is a recommended component of WELL Building guidance for new building construction. This technology is unlikely to impact airborne concentration of infective virus as the time of exposure as the air passing through the coils is very small, and not likely to reach critical values necessary to deactivate the virus.

Fumigation

Fumigation or fogging, such as with hydrogen peroxide vapour or using other chlorine-based systems, is not recommended because it creates significant safety risks.

It is only effective on surfaces, and the primary route of transmission is airborne. Also, fumigation creates chemical by-products that can be a concern.

Its use should only be considered following known presence of an infected person in the space, and then only with experienced guidance in an unoccupied building.

Use of internal partitions or other methods to modify airflow

Various devices intended to reduce near-field exposures have been suggested and/or implemented in school environments. As one example, millions of dollars have been spent on plastic barriers in school districts throughout the U.S.

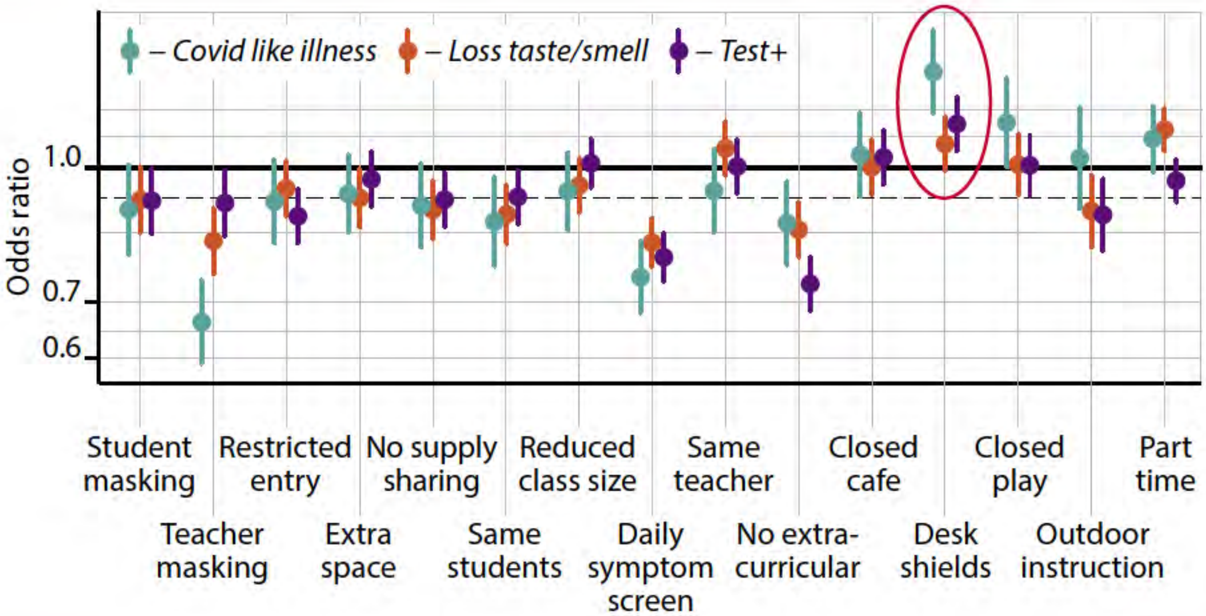


Image based on https://www.mdpi.com/2071-1050/13/12/6875/pdf

A recent study examined various school interventions, including the use of plastic barriers such as desk shields.[11] Plastic barrier desk shields were the only intervention noted to increase risk, not decrease risk. This was hypothesised to be due to a decrease in the effectiveness of ventilation efficiency.

Such an approach is not recommended without detailed engineering and/or occupational hygiene analysis of the likely effectiveness.

11 Lessler J. et al., Household COVID-19 risk and in-person schooling; *Science* 10.1126/science.abh2939 (2021).

Other transmission mechanisms – Surfaces

At the beginning of the pandemic, significant resources were invested in cleaning surfaces. Particularly for outdoor surfaces, normal sunlight UV will rapidly degrade SARS-CoV-2. Indoors, several research studies have suggested that touching surfaces is a minor means of transmitting COVID-19, and that resources devoted to repeated cleaning might be more productively used to reduce airborne transmission.

Some materials can inhibit survival of viruses such as SARS-CoV-2, including copper surfaces, and some cleaning products claim to leave a residue with antimicrobial properties.

If an infected child is sharing an indoor space with other susceptible persons, particularly in a child care setting, for several hours, it is unclear how shared touching of surfaces absent a microbial surface can be effectively prevented. The evidence base to justify enhanced cleaning to prevent infection is weak – normal cleaning is sufficient. "Deep cleaning" of all surfaces – as was done before the accumulation of evidence suggesting a minor role of touching as a transmission mechanism – is likely neither necessary nor cost-effective.

Other transmission mechanisms – Sewage

In 2003, SARS-CoV-1 is suspected to have been transmitted via faecal contact, either faecal-oral or potentially from aerosolisation resulting from flushing of toilets. Stool samples have been shown to contain SARS-CoV-2 virus, and the potential for transmission via this route should be considered.

Aerosolisation from toilets is best controlled by flushing toilets with a closed lid. This is best accomplished by mechanical means, as depending on behavioural controls is unreliable. Ensure that intended toilet exhaust ventilation is present and operating according to its intended volumetric flow. Of additional concern is the potential for dried-out drains and U-traps in floors causing aerosol transmission through the sewage system. This is best addressed through maintenance procedures that specify an appropriate interval for watering traps, typically at least every three weeks, according to REHVA (Federation of European Heating, Ventilation and Air Conditioning Associations).

Sunlight

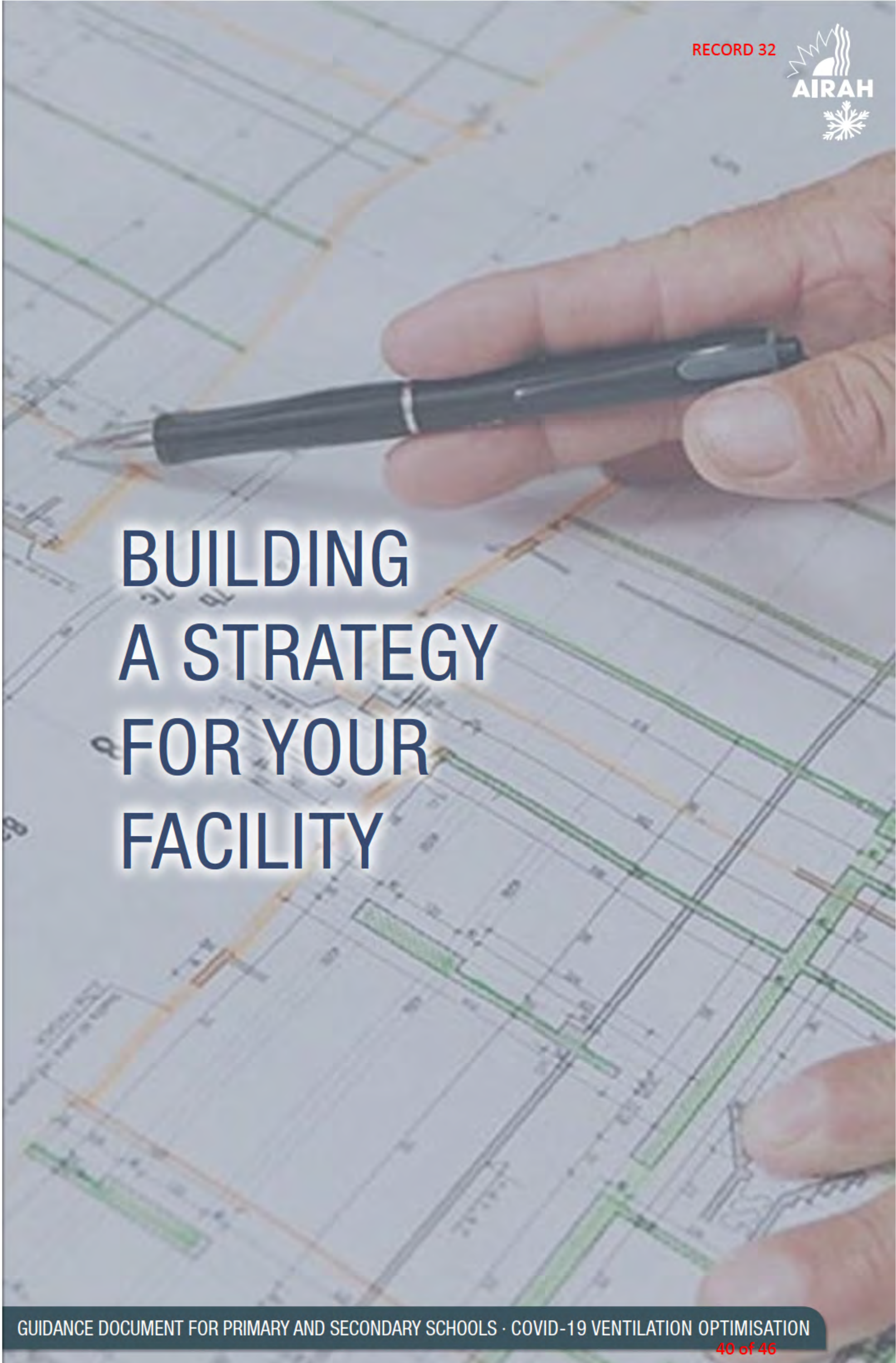
SARS-CoV-2 decays rapidly in sunlight, and the outdoors provides rapid dissipation of exhaled air. Moving activities outdoors in good weather can dramatically lower airborne exposure and risk of transmission.

To the extent surfaces could transmit COVID-19, SARS-CoV-2 will deactivate rapidly on sun-bathed surfaces.

While the class is outside, ventilate, turn portable air cleaners to maximum setting, operate exhaust fans, and do anything else that can maximise air exchange during this period. Ideally, all infective material could be removed during these unoccupied periods, such that when the class returns, there is no residual infective material present.

Operating schedule

Most ventilation systems shut off at the end of the day, and during weekends. Natural infiltration will achieve sufficient air exchanges over an 8-hour period that no additional operation of the ventilation system should be required to reduce any airborne contagion to less than 1% of its previous maximum concentration. If a shorter time period exists between the end of occupancy and the beginning of re-occupancy, flushing of the building would be appropriate to achieve several air changes prior to re-occupancy, with consequent reduction of airborne particulate.



BUILDING A STRATEGY FOR YOUR FACILITY

Using risk of infection modelling

It is useful to have a tool to understand the existing risk of infection present in any given building. This serves two purposes. First, it gives a baseline for any building such that the toolbox of interventions can be assessed, and when this assessment is repeated after the interventions, the effectiveness of the effort can be measured and its cost/benefit and cost-effectiveness determined.

Second, it enables the buildings/rooms to be rank ordered in terms of infection risk present and, assuming not all locations will be simultaneously addressed, permit those in greatest need of improvement to be prioritised.

There are a number of infection risk models that incorporate building characteristics, ventilation design, time of occupancy, and activity to determine the risk of transmission of SARS-CoV-2 (expressed as a % risk of infection for an occupant). Most of these models consider only far-field exposure – the Harvard model considers both near-field and far-field.[12] They can also incorporate and determine the reduction of risk obtained with the use of air cleaning technologies, such as upper room GUV or portable air cleaners, and in the case of the latter, determine the appropriate capacity and number of units required to achieve a defined goal.

From these models, a risk of infection can be quantitatively assessed both prior to intervention and following intervention. This can assist in determining the likely benefits and justify associated expense.

An iterative approach to site assessment

Desktop assessment

An iterative approach begins with a "desktop" assessment of the structure and function of the existing building configuration and intended design for ventilation. From this assessment, conducted off-site, the operation and capabilities of the system can at least be inferred, as can be described in the cases below.

12 https://covid-19.forhealth.org/covid-19-transmission-calculator/

A building with a roof-mounted "cupola" (thermal chimney) may provide an opportunity to exhaust air from this central roof location, creating an airflow pattern through doors and windows in the perimeter walls toward the centre of the building. While that may not have been the original design, this modification may achieve a better pattern of flow for minimising shared exhaled air and reduce infection potential.

A building with an opposing shed-style roof with clerestory windows along the ridgeline might be able to be modified to exhaust air and provide both greater ventilation and more linear flow within the classrooms. Such an interior ceiling would present a much greater volume of air in the rooms, which will result in lower concentrations of airborne infective particulate assuming uniform mixing throughout the full height of the space.

Smaller volume rooms may provide additional challenge but could be amendable to either ceiling-mounted air cleaning or upper room GUV. Larger rectangular rooms with large ratios of width to length and depending on natural ventilation might have a potential to create a linear flow from one end to the other via fan assistance in openable windows.

Many buildings have been modified from their original heating, ventilating and/or air conditioning design, either intentionally or unintentionally. Returning the system to its original functionality could be the lowest-hanging fruit to accomplish the intended goals with minimum effort.

A small minority of schools have a built-up HVAC system (a central system with central fan and distribution ducts). For these systems, the controls logic, also referred to as the building management system (BMS) provides a powerful tool to manage many factors that could influence the amount and distribution of air. Very often the operational and ventilation strategy can be understood, and changes made to the operating characteristics of this system, via internet remote access. In this manner, one could understand and potentially optimise for air exchange without changing out any equipment or even being on-site. Other types of systems may require a site visit.

Demand control ventilation varies total supply airflow based on occupancy in order to save energy when rooms are minimally, or not at all occupied. Because these systems reduce the volume of air delivered to save energy during these low occupancy periods, the overall air exchange (ACH) in the room is reduced during these low occupancy periods. Unfortunately, the risk of infection is therefore increased for anyone who happens to be in the room when these systems modulate down the volume of delivered air. This is because exhaled air from the infected person accumulates to a higher concentration during reduced supply volume periods, and therefore the exposure to a susceptible person in the room increases, and the risk of infection for that person then increases.

If a demand control system were operated at full capacity, regardless of occupancy, we would be maximising airflow and minimising infection, whether there is one susceptible person present or many susceptible persons present. The system should therefore be operated at maximum flow at all times: demand control ventilation is not ideal for infection control.

Site assessment

A site assessment can range from a simple walk-through with verification of the presence of intended design elements to a more thorough assessment of function, including simple or more complex measurements.

It is not unusual in a commercial building to have "structure but a lack of function", i.e., the HVAC equipment is present but it is not operating as intended. When this is the case, the site assessment audit may permit systems to be returned to the intended design condition, which can often be an excellent first start.

If the target ACH or other health-based targets of the school have been articulated, simple modifications determined to be achievable from the site assessment may be implemented with minimal time and expense.

Building occupants are important stakeholders and involving them in the process can be an important component of the site assessment. These include occupant perceptions of indoor air quality, temperature, lack of ventilation. When occupants understand which zone is covered by what thermostat, or gain control of windows or similar, actual or perceived air quality issues can be resolved.

All potential interventions can be modelled using the "risk of infection" models described above, with existing conditions identified, and possible interventions quantitatively estimated, yielding reasonable expectations for what can be achieved by a suite of interventions, along with the expected costs associated with each potential benefit.

Most importantly, the site assessment provides the school with a logical decision-making approach to evaluate, compare, prioritise, and implement interventions effectively as is economically feasible given the school's specific requirements and resources.

Next steps

Following either a desktop assessment conducted remotely, and/or a more intensive site assessment and investigation, existing conditions can be identified and a plan to further assess the ventilation of the system may then be considered.

The site assessment provides the school with the starting point for ventilation modifications: a benchmark to assess the impact of any changes that might be accomplished. With the proposed target criteria defined, such as 4–6 ACH, a logical decision-making approach to evaluate, compare, prioritise, and implement interventions can then be formed. This plan can determine if the best way to achieve the goal is via modification of the existing system, augmentation with portable air cleaners or other localised air cleaning technology, or a combination of the two approaches.

As one approach, a carbon dioxide (CO_2) monitor could be located in each room, or representative rooms, tracking levels of CO_2 over a 2- to 4-week period during normal operation, combined with a log of the occupancy loads during each daytime period (see discussion of interpreting CO_2 levels, above, as this data can require specialised expertise to interpret correctly).

Select CO_2 monitors upload the measured CO_2 levels to the internet, where they can be stored and remotely accessed.

A CO_2 monitor that continuously uploads data to a web portal, where it can be inspected and analyzed for trends. When combined with an understanding of the design of the ventilation system, this can assist in understanding air exchange. It also allows an expert to look at the data from afar, saving time and costs associated with site visits.

Image: John Penny.

Following assessment of these buildings, it may not be necessary to keep a CO_2 monitor present full-time in any given room, unless it is being used by the staff as described above to inform ventilation. This would permit the monitors to be moved from room to room, or for a multi-building campus, from building to building and reduce the capital costs associated with acquisition of the monitors. When they are being used, they can be deployed, but if they are not providing useful information to staff, they can be relocated.

A centralised monitoring and reporting system can be implemented for storing long-term measurement history from monitors throughout the school. Some of these CO_2 systems also can be integrated with the BMS if a more sophisticated HVAC system is present, and the values of CO_2 are used to change the operating conditions to maximise ventilation when CO_2 levels in excess of a given value are identified.

For any school, measurement of air changes per hour can be conducted in classrooms or other spaces using a tracer gas, such as SF6 or, if the building is unoccupied, CO_2.

Once the ACH are calculated for a room, with the room dimensions of height, length, and width, infection risk modelling can be conducted to determine the percentage likelihood of infection for any given time period using web-based infection risk calculators.

This likelihood of infection can be compared with the percentage likelihood of infection of a "typical" classroom of $81m^2$, with a ceiling height of 3 metres, and the recommended air change rate of 5 ACH (this works out to a risk of infection of between 0.4% and 2.0% for a student sitting at rest using the web-based risk models such as published by the University of Colorado or QUT).

Because the volume of a room has a very strong effect on the risk of infection, high ceilings are quite protective, and a large gymnasium or multipurpose room, for example, with only 1 ACH, will provide a lower risk of infection than a typical classroom with 5 ACH.

Using this approach, the numerous spaces in a school of different ceiling heights and ventilation rates can be ranked ordered by degree of risk of infection, and priorities determined for use and/or for intervention.

DATA DRIVEN HEALTH

Real-Time Air Quality Monitoring

AETMOS

"IF IT CAN'T BE MEASURED, IT CAN'T BE IMPROVED."

AETMOS

WE APPROACH BUILDING UPGRADES WITH INTEGRITY, PUTTING OUR CLIENTS IN TOUCH WITH THE BEST PRODUCTS AND SOLUTIONS FOR THEIR GOALS.

USING DATA, WE WILL HELP YOU MAKE INFORMED DECISIONS TO AVOID THE PITFALLS OF USING PROPRIETARY TECHNOLOGY.

AND FUTURE PAIN POINTS THAT ARISE FROM LACK OF SUPPORT, FLEXIBILITY, PRODUCT SCALABILITY, VALUE FOR MONEY AND TECHNOLOGY DEAD-ENDS.

- AETMOS TEAM

DATA DRIVEN HEALTH

Real-Time Air Quality Monitoring

VENTILATION

Monitoring CO2 levels in the environment to ensure sufficient fresh air is being delivered into the space - and limiting risk of covid spread.

COMFORT

We are what we breath.
Track the optimal comfort conditions needed to increase occupant air comfort and cognitive performance.

FILTRATION

Real-time monitoring of particulate matter capable of transmitting viruses as well as measuring filter performance.

AETMOS

DATA DRIVEN HEALTH

Real-Time Air Quality Monitoring

https://www.theatlantic.com/health/archive/2021/09/coronavirus-pandemic-ventilation-rethinking-air/620000/

AETMOS

VENTILATION

Monitoring CO2 levels in the environment to ensure sufficient fresh air is being delivered into the space - and limiting risk of covid spread.

AIR CHANGES PER HOUR

Targeting 4 to 6 air changes per hour within the built environment significantly reduces risk of covid-19 and other viruses spread through aerosol.

INCREASING OUTSIDE AIR SUPPLY

Increasing air changes per hour is achieved by increasing the supply of fresh air into the conditioned space. Either through existing HVAC equipment like Air Handling Units or by the installation of Heat Reclaim Ventilation Units.

DATA DRIVEN HEALTH

Real-Time Air Quality Monitoring

https://www.hsph.harvard.edu/news/press-releases/office-air-quality-may-affect-employees-cognition-productivity/

https://www.researchgate.net/publication/327268841_The_impact_of_exposure_to_air_pollution_on_cognitive_performance

COMFORT

We are what we breath.
Track the optimal comfort conditions needed to increase occupant air comfort and cognitive performance.
This is accomplished via monitoring of temperature , relative humidity and CO2 levels within the air.

COGNITIVE PERFORMANCE

Improve cognitive performance of building occupants by up to 299%.
Implement gains of almost $2000 per worker, per year due to increased performance.

REDUCED SICK DAYS

On average, building with good air quality can halve the amount of sick days taken by their occupants .

AETMOS

DATA DRIVEN HEALTH

Real-Time Air Quality Monitoring

https://airfiltration.mann-hummel.com/fileadmin/user_upload/air_knowledge/Filtration_Standards/ISO16890/ISO_Guide/ISO_16890_a_guide_to_the_new_air_filtration_standard_EN.PDF

AETMOS

FILTRATION

Real-time monitoring of particulate matter capable of transmitting viruses as well as measuring filter performance.

LEVERAGING ISO 16890

Measuring ambient air quality being used for fresh air supply within the building allows for simple calculation of the filtration required to achieve this standard. Unlocking better air quality for building occupants and a safer working environment - without the need for expensive engineering costs.

INDOOR VS OUTDOOR

Simultaneous real-time monitoring of PM10 and PM2.5 levels in outdoor and indoor air provides insight to filtration performance. Resulting in real-time filtration arrestance rates.
This data then becomes your valuable 'proof of concept' evidence.

DATA DRIVEN HEALTH

AETMOS

Real-Time Air Quality Monitoring

ROADMAP

INSTALL

Every building is different. Before air quality improvements can be made a baseline must be established.

Capturing longitudinal data from as many points throughout the building as possible is imperative to developing a solid baseline and gaining insight into how your building performs.

Real-time monitoring devices can be integrated into existing BMCS; vastly increasing overall sensor points and allowing for better HVAC control.

Inclusion of a single ambient air monitor for your building unlocks real-time building filtration scoring.

ANALYSE

Leveraging the real-time data being captured by devices each day, analysis and diagnostics can be performed in real-time.

New capabilities include alerts for areas of the building that are performing outside of Australian Standards and allows immediate action to be taken by management to eliminate the risk to occupants.

Establish new filtration targets and calculate the new filters needed with ISO 16890

Engineer increased ventilation required to deliver a safe and healthy environment.

IMPROVE

FItout new filtration and measure effectiveness to prove performance evidence.

Increase fresh air supply to achieve 4-6 air changes per hour via new or existing HVAC equipment.

Measure the improvements to indoor air quality throughout the building using historically captured longitudinal data vs post improvement data.

Continue to monitor air quality and provide alerts for areas with poor performance, optimal cognitive parameters and Australian Standards such as 1668.1.

DATA DRIVEN HEALTH

Real-Time Air Quality Monitoring

WHAT WE WILL MONITOR

AIR POLLUTANTS:

✓ CARBON DIOXIDE – CO2
✓ AIRBORNE PARTICLES – PM1, PM2.5, PM10
✓ VOLATILE COMPOUNDS – TVOC
✓ FORMALDEHYDE – CH2O
☐ [OPTION] OZONE – O3
☐ [OPTION] CARBON MONOXIDE – CO

ENVIRONMENTAL COMFORT:

✓ TEMPERATURE
✓ RELATIVE HUMIDITY
✓ ATMOSPHERIC PRESSURE
✓ AMBIENT LIGHT INTENSITY
☐ [OPTION] BACKGROUND NOISE LEVEL
☐ [OPTION] AMBIENT LIGHT COLOR TEMPERATURE

BUILDING OCCUPANCY:

☐ [OPTION] RF SCANNING

AETMOS

DATA DRIVEN HEALTH

Real-Time Air Quality Monitoring

HOW WE INTEGRATE

Integration with BMS and HVAC

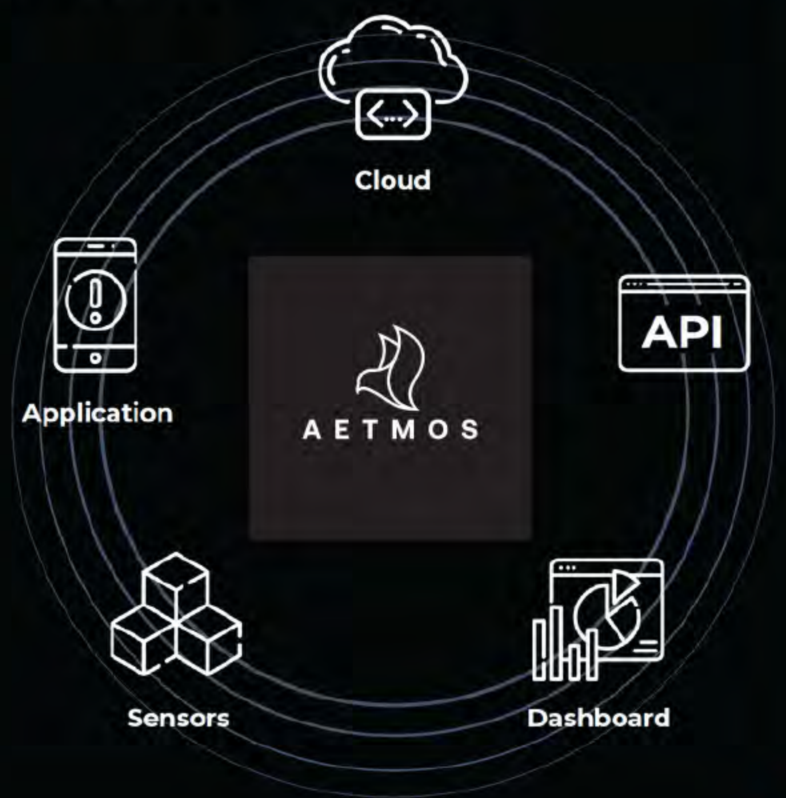
Connectivity and API enable seamless integration with the existing Building Management System (BMS) or direct connection with Heating, Ventilation, and Air Conditioning (HVAC).

Default Interfaces:

✓ Wi-Fi 802.11 b/g/n, 2.4GHz
✓ Bluetooth 4.1
✓ USB-A
✓ RS-485

Optional interfaces:

☐ Ethernet
☐ BACnet
☐ Modbus
☐ LTE (4G)
☐ NB-IoT
☐ HVAC system wiring



DATA DRIVEN HEALTH

Real-Time Air Quality Monitoring

WHAT WE USE TO MONITOR AIR QUALITY

SE-200 SENSEDGE MINI:
✓ WELL STANDARD COMPLIANT
✓ EASILY REPLICABLE SENSOR MODULES
✓ FREE DASHBOARD AND SMART PHONE APP
✓ BACNET,MODBUS, API

SE-100 SENSEDGE:
✓ WELL STANDARD COMPLIANT
✓ EASILY REPLICABLE SENSOR MODULES
✓ FREE DASHBOARD AND SMART PHONE APP
✓ BACNET,MODBUS, API

ATMOCUBE:
✓ FITTED WITH BEST SENSORS ON THE MARKET
✓ HIGHLY CUSTOMISABLE LOOKS
✓ SCALABLE
✓ DASHBOARD AND SMART PHONE APP
✓ MODBUS, API

NUBO:
✓ AMBIENT AIR MONITOR
✓ CURRENTLY BEING TRIALLED BY ACT GOV
✓ DEVELOPED BY SENSIRION
✓ FREE DASHBOARD AND SMART PHONE APP
✓ PV SOLAR POWERED

AETMOS

kaiterra

Breathe Smart with the Sensedge

The air quality monitor made for smart, healthy, and energy-saving buildings.

We breathe more than 15,000 liters of air every single day. Optimizing indoor air can have measurable benefits and help people and businesses thrive.

Wellness **Productivity** **Energy Saving** **Profits**

Your Healthy Building Starts Here

The Sensedge is tested and certified by the RESET standard for accuracy, and fully compliant with the WELL v2 building standard for performance.

Trusted by

The Air Monitoring Solution for Your Needs

$PM_{2.5}$ | TVOC | CO_2 | Temperature | Humidity

Customizable Modules

The Sensedge is equipped with modular sensors which can be custom-made to fit your project's monitoring needs:

HCHO | CO | O_3 | NO_x | SO_x

and more!

Accurate Monitoring, No Calibration Needed

With easily replaceable sensor modules, there is absolutely no need to recalibrate your Sensedge. Simply replace the sensors in seconds for continuous and accurate monitoring with little to no maintenance.

vs

Kaiterra Sensedge		Conventional Monitors
✓ Sensor Replacement	**Calibration Method**	Off-site Calibration ✗
✓ Anyone	**Expertise Required**	Trained Technicians ✗
✓ < $200	**Calibration Cost**	$1,000+ ✗
✓ < 1 Minute	**Time Spent**	Weeks to Months ✗

Manage Your Air with the Kaiterra Dashboard and App

Use the Kaiterra Dashboard to monitor and manage your devices in one portal, and use the Kaiterra app to stay on top of your air even on the go.

Monitor and manage multiple devices

View real-time data and trends

Identify sources of pollution

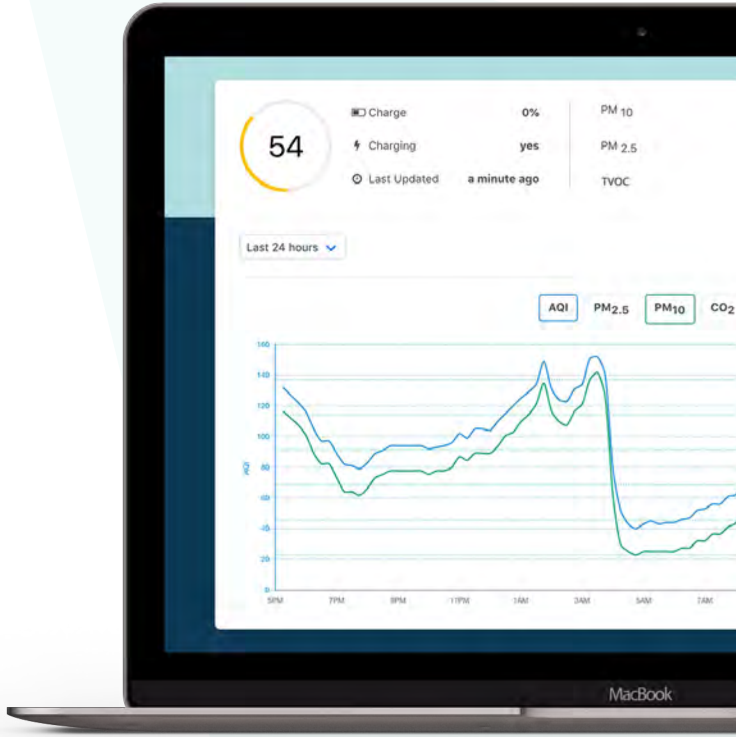
Compare readings across devices

Receive notifications

Export historical data

Create Certified Performance Reports

The Sensedge collects minute-by-minute readings and is directly exportable in formats recognized and supported by the WELL, RESET and LEED standards.



Secure, Flexible, Connected

Using end-to-end SSL/TLS encryption, the Sensedge provides maximum security for data transfer.

The Sensedge supports Wi-Fi and ethernet for connectivity, as well as various network configurations, including company proxy servers, hidden SSIDs, and captive portals. Both Static IP and DHCP options are available.

Wi-Fi

Ethernet

API

Modbus

Cloud and Local MQTT

BACnet

Powerful Automation and Control

Maximize the performance of your filtration and HVAC systems with flexible connectivity options. Seamlessly integrate to your building's automation control system through our open API, BACnet, and more.

Simple Installation

The Sensedge is easily mounted onto any wall with just three screws. Power on and access your air quality data within minutes.

Product Features

Customizable Modules

Wi-Fi Connection

Ethernet Socket

8GB On-Board Memory

Data Buffer

Micro-SD Card

5200mAh Battery

7" Full Color Touchscreen

Multiple Languages

Made for Healthy Buildings Worldwide

IWBI Headquarters (WELL Platinum)
New York

DARWIN Smart Home
Melbourne

Perkins Eastman
New York

Milliken Showroom
San Francisco

Delos Living (WELL Platinum)
New York

MANN+HUMMEL Asia Pacific Headquarters
Singapore

M. Moser
New York, Hong Kong & Shanghai

MANN+HUMMEL Headquarters
Ludwigsburg

Product Specifications

	Sensor Type	Measuring Range	Sensor Output Resolution	Accuracy
Particulate Matter 2.5 ($PM_{2.5}$)	Laser Particle Sensor (Light Scattering)	1 - 1000 μg/m^3	1 μg/m^3	±10 % (<30 μg/m^3: ±3 μg/m^3)
Total Volatile Organic Compounds (TVOCs)	Metal Oxide Semiconductor Sensor (MOS)	0 - 60000 ppb	1 ppb	±15 %
Carbon Dioxide (CO_2)	Non-Dispersive Infrared Detector (NDIR)	400 - 10000 ppm (full range) 400 - 2000 ppm (range with high accuracy)	1 ppm	±3 % ±50 ppm
Temperature	Digital Sensor	-20 - 100 ℃	0.1 ℃	±1 ℃
Relative Humidity	Digital Sensor	0 - 99 %RH	1 %RH	±5 %RH

Dimensions	Length: 184 mm (7.2 in) Width: 146 mm (5.7 in) Height: 48 mm (1.9 in)
Weight	Unit Weight: 800 g (1.76 lbs)
Connectivity & Intergration	Wi-Fi Connection 2.4 GHz 802.11 b/g/n Ethernet Bacnet / Modbus * * For Modbus connection, an external adapter is required
Operational Environment	Operational Temperature: 0 - 50 °C Operational Humidity: 5 to 95 %RH, non-condensing
Data Storage & Logging	Log Interval: 1 minute, 1 hour, 1 day Data Push Interval: 1 minute * Onboard Memory: 8 GB (>50,000,000 data points) * Customizable upon requests

Power Consumption	Input: DC - 5 V 1.8 A Operating: 10 W
Battery	Capacity & Voltage: 5200 mAh @ 4.2 V Usage Time: 8 hours
Warranty & Durability	Standard Warranty: 1 year * Expected Lifespan: 5 to 7 years * Extended warranty available
Certifications	Environmental: ROHS, REACH, WEEE Customer: FCC (US), CE (Europe) Electronic safety: SRRC (China), RESET
Accessories	Drywall anchors & screws USB cable Power adapter * * Regional variants available

kaiterra

www.kaiterra.com info@kaiterra.com
Beijing • Crans Montana • Hong Kong • New Delhi • Vancouver

From: Matthews, David
To: EDU, EGMBSG
Subject: FW: FOR CLEARANCE: FILE2021/5443 - DG CORRO: COVID-19 measures in schools - Jodie Griffiths-Cook (Children and Young People Commissioner)
Date: Tuesday, 23 November 2021 8:53:45 AM
Attachments: image001.png
image003.png
GOVERNMENT & STAKEHOLDER RELATIONS - Partnerships & Collaboration - DG CORRO ~ Cook (Children and Young People Commissioner).tr5
FOR ACTION FILE20215443 - DG CORRO COVID-19 measures in schools - Jodie Griffiths-Cook (Children and Young People Commissioner).msg
20211108-DG Education correspondence from CYPC.PDF
FILE20215443 DG LETTER COVID-19 measures & HEPA filters in schools Griffiths-Cook.DOTX
Importance: High

OFFICIAL

Approved, with thanks.

Dave Matthews
EGM BSG

From: Martinez, Catherine <Catherine.Martinez@act.gov.au> **On Behalf Of** EDU, EGMBSG
Sent: Monday, 22 November 2021 5:07 PM
To: Matthews, David <David.Matthews@act.gov.au>
Cc: EDU, EGMBSG <EGMBSG.EDU@act.gov.au>
Subject: FW: FOR CLEARANCE: FILE2021/5443 - DG CORRO: COVID-19 measures in schools - Jodie Griffiths-Cook (Children and Young People Commissioner)
Importance: High

OFFICIAL

OFFICIAL

Good afternoon David

Please find attached DG response to letter attached for your clearance.

DUE to DG tomorrow 23 November.

Regards
Catherine

From: Stewart, Ell <Ell.Stewart@act.gov.au> **On Behalf Of** ICW EBM Office
Sent: Thursday, 18 November 2021 5:11 PM
To: EDU, EGMBSG <EGMBSG.EDU@act.gov.au>
Cc: ICW EBM Office <ICWEBMOffice@act.gov.au>

Subject: FW: FOR CLEARANCE: FILE2021/5443 - DG CORRO: COVID-19 measures in schools - Jodie Griffiths-Cook (Children and Young People Commissioner)

OFFICIAL

Good afternoon

Letter in TRIM for clearance please:

Date due to EGM	19 November 2021
Date Due to DG	23 November 2021

Thank you, Ell

From: Parkinson, Andrew <Andrew.Parkinson@act.gov.au>
Sent: Thursday, 18 November 2021 5:07 PM
To: ICW EBM Office <ICWEBMOffice@act.gov.au>
Subject: Fw: FOR CLEARANCE BY FRI: FILE2021/5443 - DG CORRO: COVID-19 measures in schools - Jodie Griffiths-Cook (Children and Young People Commissioner)

OFFICIAL

thanks Ell, I edited out the paragraph s about UVC and HRF in trim

cleared to EGM

Andrew Parkinson | Executive Branch Manager

Infrastructure & Capital Works | Education Directorate | **ACT Government**

Phone 02 6205 4593 | **Mobile 0478 301 085**

220 London Circuit, Civic | www.act.gov.au

Dhawura nguna, dhawura Ngunnawal

From: Stewart, Ell <Ell.Stewart@act.gov.au> on behalf of ICW EBM Office <ICWEBMOffice@act.gov.au>
Sent: Thursday, 18 November 2021 16:49
To: Parkinson, Andrew <Andrew.Parkinson@act.gov.au>
Cc: ICW EBM Office <ICWEBMOffice@act.gov.au>; Mitchell, BethL <BethL.Mitchell@act.gov.au>;

Ryan, JohnW <JohnW.Ryan@act.gov.au>
Subject: FOR CLEARANCE BY FRI: FILE2021/5443 - DG CORRO: COVID-19 measures in schools - Jodie Griffiths-Cook (Children and Young People Commissioner)

Andrew, as Beth is [redacted], I've drafted the DG letter (attached and in TRIM) – for your clearance please and due to EGMBS by Fri 19 Nov

Thanks, Ell

From: Stewart, Ell **On Behalf Of** ICW EBM Office
Sent: Tuesday, 9 November 2021 4:18 PM
To: Mitchell, BethL <BethL.Mitchell@act.gov.au>
Cc: ICW EBM Office <ICWEBMOffice@act.gov.au>; Parkinson, Andrew <Andrew.Parkinson@act.gov.au>; Ryan, JohnW <JohnW.Ryan@act.gov.au>
Subject: FW: FOR ACTION: FILE2021/5443 - DG CORRO: COVID-19 measures in schools - Jodie Griffiths-Cook (Children and Young People Commissioner)
Importance: High

OFFICIAL

Good afternoon Beth

Could you please provide a DG response for this one (regarding COVID mitigation measures and the use of HEPA filters in schools-letter attached) for EBM clearance by 12PM THU 18 NOV, on the template in TRIM

Many thanks, Ell

From: Wraith, Clementine <Clementine.Wraith@act.gov.au> **On Behalf Of** EDUMCR
Sent: Tuesday, 9 November 2021 3:07 PM
To: ICW EBM Office <ICWEBMOffice@act.gov.au>
Cc: EDU, EGMBSG <EGMBSG.EDU@act.gov.au>; DGEDUoffice <DGEDUoffice@act.gov.au>; EDUMCR <EDUMCR@act.gov.au>
Subject: FOR ACTION: FILE2021/5443 - DG CORRO: COVID-19 measures in schools - Jodie Griffiths-Cook (Children and Young People Commissioner)

OFFICIAL

Good afternoon,

Please action on the attached reference. Please review the below table to provide the appropriate response type and note the due dates.

Title/Question	DG CORRO: COVID-19 measures in schools - Jodie Griffiths-Cook (Children and Young People Commissioner)
Action	Prepare a response to Ms Griffiths-Cook
Responsibility	ICW

Response type	DG
TRIM	FILE2021/5443
Date due to EGM	19 November 2021
Date Due to DG	23 November 2021
Clearance	Please refer to the Executive Clearance Protocol document for appropriate clearance levels/drop copy requirements: here
Comment	Please contact edumcr@act.gov.au if you have any questions.

Please let me know if you have any queries.

Kind regards,
Clementine

From: Flaherty, Hannah <Hannah.Flaherty@act.gov.au> **On Behalf Of** DGEDUoffice
Sent: Monday, 8 November 2021 5:07 PM
To: EDUMCR <EDUMCR@act.gov.au>
Subject: FOR ACTION: CYPC correspondence re COVID-19 measures in schools

OFFICIAL

Hi team

Please TRIM the attached to ICW for a response to be drafted to Ms Griffiths-Cook

Thanks so much

Hannah Flaherty | Executive Support Officer to Katy Haire, Director-General, Education Directorate
Phone: 02 620 59156 | Mobile: 0466 244 210

The Education Directorate acknowledges the Ngunnawal Peoples as the Traditional Custodians of the ACT and region upon which we live and work.

From: Griffiths-Cook, Jodie <Jodie.Griffiths-Cook@act.gov.au>
Sent: Monday, 8 November 2021 3:57 PM
To: DGEDUoffice <DGEDUoffice@act.gov.au>
Cc: DGACTHealth <DGACTHealth@act.gov.au>; JACS ACTkids <JACSACTkids@act.gov.au>
Subject: CYPC correspondence re COVID-19 measures in schools

Yuma

(Hello – in Ngunnawal language*)*

Please find attached correspondence to Ms Katy Haire. Please note that this is separate correspondence to that which was sent earlier today.

Warm regards,

Jodie Griffiths-Cook

Public Advocate and Children and Young People Commissioner
Pronouns: she/her/hers – ***#diversitygoeswith ...everything I do***

ACT Human Rights Commission
Level 1, 5 Constitution Avenue
Canberra City ACT 2601
Phone: 02 6205 2222

I acknowledge the traditional custodians of this great land, whose cultures and customs have nurtured and continue to nurture the land, and pay my respects to Elders past, present and emerging.

CHILDREN & YOUNG PEOPLE COMMISSIONER
ACT Human Rights Commission

8 November 2021

Ms Katy Haire
Director-General
Education Directorate
Via email to: DGEDUOffice@act.gov.au
Cc: DGACTHealth@act.gov.au

Dear Katy,

COVID-19 measures in schools

In my capacity as ACT Children and Young People Commissioner, representations have been made to me via both email and social media about the adequacy of measures that have been put in place to mitigate against COVID outbreaks in schools, and particularly in primary schools.

Through my own reading of the information on the Education Directorate website, [redacted], I am aware that all schools are responsible for developing and implementing plans that serve to both mitigate against and respond to the potential for COVID outbreaks. These plans have already been implemented in a number of schools and I recognise that it is still early days in terms of assessing whether such plans are sufficiently adequate. I am also aware that other measures such as improving ventilation, CO2 monitoring, environmental modifications and keeping year-level cohorts separate, are similarly part of the broader strategy being implemented by the Education Directorate.

Having said that, a specific issue that has been raised with me, and which was the subject of some local media in recent weeks, is the ACT Government's decision not to pursue the use of air purifying devices such as HEPA filters in classrooms.

The evidence that has been presented to me about the efficacy of such devices in other jurisdictions is quite compelling, so I am interested to understand the rationale behind the ACT Government's current position in respect of their use. To this end, any information you could provide about this and, in particular the details of any risk assessment that has been undertaken, would be appreciated.

I recognise and appreciate the Education Directorate's commitment to ensuring safe environments for our children and young people and trust you will continue to give due regard to the range of options that might assist in achieving this goal.

I look forward to your response however should you require further information, please do not hesitate to contact me on 02 6205 2222.

Kind Regards,

[redacted]

Jodie Griffiths-Cook
Public Advocate and Children and Young People Commissioner
ACT Human Rights Commission

ACT Government
Education

Ms Jodie Griffiths-Cook
Public Advocate and
Children and Young People Commissioner
Jodie.griffiths-cook@act.gov.au

Dear Ms Griffiths-Cook

Thank you for your letter of 8 November 2021 about COVID-19 mitigation measures in ACT public schools.

The Education Directorate is committed to the safety and well-being of students and staff and is taking a cautious approach to limit the spread of COVID-19 to keeping the community safe. The Education Directorate's priority to implement the safe return to on-campus learning and improving air quality in ACT public schools was prioritised ahead of students returning in term 4.

As you are aware, ventilation is one component of a multilayered approach that has been implemented to reduce the risk of COVID-19 transmission in school settings, including vaccination, physical distancing, good hygiene, cleaning and mask use. The ACT Government has committed $5.2 million to improved Indoor Air Quality in ACT public schools as part of the ACT Government's COVID-19 Pathway Forward. Every school also has its own Indoor Air Quality Plan which lists actions already undertaken by the Education Directorate (e.g. HVAC systems change) and actions for schools to undertake each day to improve air quality. These Indoor Air Quality Plans can be found on each school's website.

The Education Directorate continues to be guided by ACT Health, the ACT Chief Health Officer and the Australian Health Protection Principal Committee advice and the evolving evidence on the specific benefit of air purifying devices in addition to other public health measures in a school setting. The ACT Chief Health Officer's Health Guidelines for Schools and Early Childhood Education and Care (Including OSHC) Term 4 2021 are available at https://www.covid19.act.gov.au and further information on the ACT Public School arrangements for Term 4 is available at the Education Directorate website at https://www.education.act.gov.au/public-school-life/covid-school-arrangements.

Thank you for raising this important issue with me and I assure you that the Education Directorate has an ongoing commitment in considering all options to support the safety and well-being of students in ACT public schools in these extraordinary times.

Katy Haire
Director-General

November 2021

From: Pilicic, Courtney on behalf of EDU, EGMBSG
To: EDUCOVID
Cc: EDU, EGMBSG
Subject: CLEARED: BSG Input - EDU Sit Rep 88 - Term 4 03122021
Date: Friday, 3 December 2021 10:49:00 AM
Attachments: EDU Sit Rep 88 - Term 4 03122021 (1).docx

OFFICIAL

Good morning COVID team,

Please see attached input from BSG, cleared by EGMBSG David Matthews.

Kind regards,
Courtney

From: Matthews, David <David.Matthews@act.gov.au>
Sent: Friday, 3 December 2021 10:25 AM
To: EDU, EGMBSG <EGMBSG.EDU@act.gov.au>
Subject: FW: FOR URGENT CLEARANCE: BSG Input - EDU Sit Rep 88 - Term 4 03122021

OFFICIAL

Approved, with thanks.

Dave Matthews
EGM BSG

From: Pilicic, Courtney <Courtney.Pilicic@act.gov.au> **On Behalf Of** EDU, EGMBSG
Sent: Friday, 3 December 2021 8:50 AM
To: Matthews, David <David.Matthews@act.gov.au>
Cc: EDU, EGMBSG <EGMBSG.EDU@act.gov.au>
Subject: FOR URGENT CLEARANCE: BSG Input - EDU Sit Rep 88 - Term 4 03122021

OFFICIAL

Good morning David,

Please see attached for your clearance the BSG input into this week's COVID Situation Report.

The following sections have been updated by the relevant areas and cleared by the EBMS:

- Mandatory Vaccination Implementation (Alex)
- School Ventilation (Andrew)
- Information and Communication (Paul)

- COVID-19 Costs (Thao)

Due to EDUCOVID by 11:00am.

Kind regards,
Courtney

Education Directorate
COVID SIT REP

Sit Rep No. #88	**Week:** 29 November to 3 December 2021
Incident: Ongoing COVID Response inc. Scenario 2 event management	**Location:** Whole of ACT
Operating position: Term 4 2021 – All years returned to on campus learning	
COVID Response Lead: Jane Simmons	

<All items in Yellow are from SIT REP 87 – 26 November>

Hot Issues

- [redacted]
- [redacted]

Priority updates continue from **Page 2.**

Priority Updates

The updates below focus on the priorities that the Directorate is focusing on as part of our ongoing COVID-19 response.

Priority Stream	Update
[redacted]	
School Ventilation	• ICW are working to deliver priority works across all schools to support improvements to ventilation identified in the indoor air quality plans (IAQP) issued to all schools at the beginning of Term 4 2021. Priority works include: • making windows operable • installing CO2 sensors to monitor indoor air quality and manage airflows where mechanical systems are available • updating toilet extraction fans

	• installing germicidal UV-C lights in existing air-conditioning systems where outdoor air movement into classrooms is limited only. The system selected is used by Health to assist in reducing the transmission of viruses and bacteria. • longer term planning is underway to assess requirements for ventilation in the coming winter • as works are finalised at each school site, the school will receive and updated IAQP. • Of the additional $2.6m in funding provided to support improved ventilation, the current status is: • $**1.19 million** of priority works are in contract at 2 December 2021. • a further $**1.67 million** of ventilation works are out for quote/tender at 2 December 2021.

COVID Coordination Lead approval: Peter Steele
COVID Response Lead approval: Jane Simmons

From: Matthews, David
To: EDU, EGMBSG
Subject: FW: FOR CLEARANCE: REQUEST FOR DOT POINTS - DG Meeting with P&C - Item 9 - School Ventilation and Preparation for Summer
Date: Tuesday, 7 December 2021 9:10:38 AM
Attachments: Papers.tr5
Item 9. School Ventilation and Preparation for Summer.DOCX
Importance: High

OFFICIAL

Approved, with thanks.

Dave Matthews
EGM BSG

From: Martinez, Catherine <Catherine.Martinez@act.gov.au> **On Behalf Of** EDU, EGMBSG
Sent: Monday, 6 December 2021 3:32 PM
To: Matthews, David <David.Matthews@act.gov.au>
Cc: EDU, EGMBSG <EGMBSG.EDU@act.gov.au>
Subject: FW: FOR CLEARANCE: REQUEST FOR DOT POINTS - DG Meeting with P&C - Item 9 - School Ventilation and Preparation for Summer
Importance: High

OFFICIAL

OFFICIAL

Good afternoon David

Please find attached dot points on School Ventilation and Preparation for Summer for your clearance.

DUE to MCR COB tomorrow 7 December.

Regards
Catherine

From: Stewart, Ell <Ell.Stewart@act.gov.au> **On Behalf Of** ICW EBM Office
Sent: Monday, 6 December 2021 2:13 PM
To: EDU, EGMBSG <EGMBSG.EDU@act.gov.au>
Cc: ICW EBM Office <ICWEBMOffice@act.gov.au>
Subject: FOR CLEARANCE: REQUEST FOR DOT POINTS - DUE MON 10AM DG Meeting with P&C

Importance: High

OFFICIAL

OFFICIAL

Good afternoon

Updated ***Item 9. School Ventilation and Preparation for Summer*** dot points for ACTP&C meeting are in TRIM for clearance please

Apologies for the delay

Thanks, Ell

From: Parkinson, Andrew <Andrew.Parkinson@act.gov.au>
Sent: Monday, 6 December 2021 2:10 PM
To: ICW EBM Office <ICWEBMOffice@act.gov.au>
Subject: Fw: URGENT: REQUEST FOR DOT POINTS - DUE MON 10AM DG Meeting with P&C

OFFICIAL

cleared to EGM

Andrew Parkinson | Executive Branch Manager

Infrastructure & Capital Works | Education Directorate | **ACT Government**

Phone 02 6205 4593 | **Mobile 0478 301 085**

220 London Circuit, Civic | www.act.gov.au

Dhawura nguna, dhawura Ngunnawal

From: Mitchell, BethL <BethL.Mitchell@act.gov.au>
Sent: Monday, 6 December 2021 11:43
To: ICW EBM Office <ICWEBMOffice@act.gov.au>
Cc: Parkinson, Andrew <Andrew.Parkinson@act.gov.au>
Subject: RE: URGENT: REQUEST FOR DOT POINTS - DUE MON 10AM DG Meeting with P&C

OFFICIAL

Ready for review

Beth Mitchell | Director – Asset Strategies, Sustainability and Environment

Phone: +61 2 6207 8364 | Fax: +61 2 6205 9333 |Email: bethl.mitchell@act.gov.au
Infrastructure and Capital Works | Education| ACT Government
Level 4 220 London Circuit | GPO Box 158 Canberra ACT 2601 | www.det.act.gov.au

---

From: EDU, MCR Secretariat <EducationSecretariat@act.gov.au>
Sent: Friday, 3 December 2021 9:15 AM
To: ICW EBM Office <ICWEBMOffice@act.gov.au>
Cc: EDU, EGMBSG <EGMBSG.EDU@act.gov.au>
Subject: REQUEST FOR DOT POINTS - DG Meeting with P&C

OFFICIAL

Good morning

Please see the below request for dot points. Template is available in the attached TRIM container. Apologies for the short turn around.

REQUEST FROM MCR	
TRIM Number	FILE2021/129
Title/Question	School Ventilation
Action Required / Response Type	**Dot Points**
Responsibility	ICW
Clearance level required	**EGM BSG**
Critical Date and Reason	**10 December – Meeting Date**
Date Due to EGM/DDG SPR/DDG	Midday 6 December 2021
Date Due to MCR (for quality assurance check)	COB 7 December 2021.
Further information provided	Plans and procedures for School ventilation and potential problems in summer from heat and smoke. Need for clear and timely advice to parents on what measures will be taken.

Kind Regards
Caitlin

Caitlin McGarvey | Assistant Director, Corporate Reporting and Stakeholder Engagement

Ministerial and Corporate Reporting | Communications, Engagement and Government Support
Ph: 6205 2360 | Education Directorate | Level 4, 220 London Circuit, Canberra City| GPO Box 158 Canberra ACT 2601

Director General meeting with ACT P&C
10 December 2021

School Ventilation and Preparation for Summer

Dot points:

- The CHO, AHPPC, World Health Organisation and Safe Work Australia recommend ensuring fresh air ventilation is optimised in all settings, including through adjusting mechanical systems to increase fresh (external) air supply and reduce air recirculation, and use of natural ventilation such as opening windows and doors.
- All schools have an Indoor Air Quality (IAQ) Plan. The Plans are being updated to include actions undertaken in term 4. As works are completed, the updated Plan will be provided to schools.
- Immediate activities undertaken to improve indoor air quality included: ensuring that windows were openable, programming mechanical controls to provide additional outdoor air and to purge air buildings overnight and ensuring that extraction fans in toilets were turned on each day.
- Additional actions to improve mechanical ventilation at school sites have been scoped, these target delivery of thermal comfort in addition to ventilation during extreme temperature days in summer and winter.
- ACT public schools are very well placed as there has been an extensive program of work underway to improve school ventilation since the 2019-2020 bushfires.
- In 2018, EDU began progressively upgrading building controls in 65 schools to provide improved and remote control of the air intake sources for the Heating, Ventilation and Cooling (HVAC) systems. Upgrades included CO_2 sensors which provide a proxy for ventilation in a room allow outdoor air to be introduced automatically to maximise indoor air quality.
- To date, more than 326 CO_2 sensors with remote monitoring and management systems have been installed across 40 public schools. As part of school IAQ Plans, additional CO_2 sensors are being installed over the summer break at approximately 25 ACT public schools with suitable building control systems. This will mean 73 per cent (65 of 89) schools will soon have CO_2 sensors to monitor and manage indoor air quality.
- The routine use of portable HEPA filters and portable carbon dioxide (CO_2) monitors across all ACT schools is not supported at this time, as the evidence for the additional public health benefit of these units over other public health measures and maximising fresh air is currently limited.
- EDU will continue to be guided by ACT Health and AHPPC advice and the evolving evidence on the specific benefit of these devices in addition to other public health measures in a school setting.
- $2.6 million of additional funding has been allocated to undertake short term actions across the public school portfolio to maximise fresh air in learning spaces in term 4.
- A further $2.6 million of additional funding has been allocated to undertake additional actions to maximise fresh air in learning spaces in term 1 and 2 of 2022.
- EDU is investigating technologies to improve air quality in classrooms including modern ventilation systems for toilets and bathrooms and technologies used to provide outdoor air in highly energy efficient buildings and securing the supply of these where appropriate.

- Heat Recovery Ventilation (HRV) systems have been purchased to provide a long-term energy efficient solution to ventilation of learning environments. These are scheduled to arrive in January 2022. The units are specifically designed for classrooms and control fresh air in response to CO_2 levels. The systems also recover heat from internal air during winter and transfer it to cold incoming air to reduce heating costs. In summer they remove the heat from incoming air and transfer it to the outside.
- Where access to natural ventilation is limited and where mechanical ventilation cannot be provided in the short term, germicidal UV-C light units are being installed to existing air conditioners. These units are safe and are used to reduce transmission of viruses and bacteria in health settings. The units have been implemented predominantly in preschools where outdoor air is only provided by windows and after school care facilities with low access to outdoor air.

Background:

- An important part of ACT public schools' return to on campus learning in term 4, 2021 was to ensure that there is proper ventilation in line with Health advice for managing COVID-19.
- It's important to note that ventilation is part of the broader suite of controls to reduce the risk of COVID-19 transmission in school settings including vaccination, physical distancing, good hygiene, cleaning and mask use, and should not be considered in isolation of other mitigation strategies.
- All learning spaces across the school network have been checked (about 3500) to ensure adequate ventilation.
- EDU has developed an Indoor Air Quality (IAQ) framework to assess the IAQ of all public schools commencing with ACT public colleges.
- All public school learning areas have been assessed under the IAQ framework with immediate actions implemented to optimise fresh air flow. There are 3500 learning areas in ACT public schools (including approx. 3000 classrooms).
- Every school has had an **Indoor Air Quality Plan** completed under the framework which lists actions already undertaken by the Directorate (e.g. HVAC systems change) and actions for schools to undertake each day to improve air quality. These school actions will be carried out by non-teaching staff like Building Services Officers. These Indoor Air Quality Plans can be found on each school's website.
- Site specific IAQ plans were provided to all ACT public colleges on 1 October 2021.
- Site specific IAQ plans were provided to all ACT public schools on 22 October 2021.
- Cooler classroom temperatures during cool weather and warmer classroom temperatures during hotter weather are expected to result from increasing fresh air to learning environments.
- Higher energy bills are anticipated to result from the increase in fresh air as a greater volume of air needs to be heated or cooled.

From:	Matthews, David
To:	EDU, EGMBSG
Subject:	FW: FOR CLEARANCE: SUB21/7885 - Air quality in ACT schools - [redacted]
Date:	Friday, 10 December 2021 9:10:07 AM
Attachments:	Air quality in ACT schools - [redacted] COVID For Allocation Contact my Minister - Correspondence [redacted] SUB217885 Air quality in schools [redacted]

OFFICIAL

Approved, with thanks.

Dave Matthews
EGM BSG

From: Martinez, Catherine <Catherine.Martinez@act.gov.au> **On Behalf Of** EDU, EGMBSG
Sent: Wednesday, 8 December 2021 2:48 PM
To: Matthews, David <David.Matthews@act.gov.au>
Cc: EDU, EGMBSG <EGMBSG.EDU@act.gov.au>
Subject: FW: FOR CLEARANCE: SUB21/7885 - Air quality in ACT schools - [redacted]

OFFICIAL

OFFICIAL

Good morning David

Please find attached response letter to email attached for your clearance.

DUE to MO 10 December.

Regards
Catherine

From: Stewart, Ell <Ell.Stewart@act.gov.au> **On Behalf Of** ICW EBM Office
Sent: Tuesday, 7 December 2021 1:16 PM
To: EDU, EGMBSG <EGMBSG.EDU@act.gov.au>
Cc: ICW EBM Office <ICWEBMOffice@act.gov.au>
Subject: FOR CLEARANCE: SUB21/7885 - Air quality in ACT schools - [redacted]

OFFICIAL

OFFICIAL

Good afternoon

Letter in TRIM for clearance please:

Date due to EGM	9 December 2021
Date Due to MO	10 December 2021

Thank you, Ell

From: Parkinson, Andrew <Andrew.Parkinson@act.gov.au>
Sent: Monday, 6 December 2021 3:39 PM
To: ICW EBM Office <ICWEBMOffice@act.gov.au>
Subject: Fw: FOR ACTION: SUB21/7885 - Air quality in ACT schools - [redacted]

OFFICIAL

cleared to EGM

Andrew Parkinson | Executive Branch Manager

Infrastructure & Capital Works | Education Directorate | **ACT Government**

Phone 02 6205 4593 | **Mobile 0478 301 085**

220 London Circuit, Civic | www.act.gov.au

Dhawura nguna, dhawura Ngunnawal

From: Mitchell, BethL <BethL.Mitchell@act.gov.au>
Sent: Monday, 6 December 2021 14:23
To: ICW EBM Office <ICWEBMOffice@act.gov.au>
Cc: Parkinson, Andrew <Andrew.Parkinson@act.gov.au>; Ryan, JohnW <JohnW.Ryan@act.gov.au>; Flint, Katrina <Katrina.Flint@act.gov.au>
Subject: RE: FOR ACTION: SUB21/7885 - Air quality in ACT schools [redacted]

OFFICIAL

Hi,

This one is in Trim and ready for review.

Cheers

Beth Mitchell | Director – Asset Strategies, Sustainability and Environment

Phone: +61 2 6207 8364 | Fax: +61 2 6205 9333 |Email: bethl.mitchell@act.gov.au
Infrastructure and Capital Works | Education| ACT Government
Level 4 220 London Circuit | GPO Box 158 Canberra ACT 2601 | www.det.act.gov.au

---

From: Stewart, Ell <Ell.Stewart@act.gov.au> **On Behalf Of** ICW EBM Office
Sent: Monday, 29 November 2021 11:18 AM
To: Mitchell, BethL <BethL.Mitchell@act.gov.au>
Cc: ICW EBM Office <ICWEBMOffice@act.gov.au>; Parkinson, Andrew <Andrew.Parkinson@act.gov.au>; Ryan, JohnW <JohnW.Ryan@act.gov.au>; Flint, Katrina <Katrina.Flint@act.gov.au>
Subject: FW: FOR ACTION: SUB21/7885 - Air quality in ACT schools -

OFFICIAL

Hi Beth, could you provide a response for EBM clearance by 12PM WED 8 DEC on the template in TRIM please

Thanks, Ell

From: Wraith, Clementine <Clementine.Wraith@act.gov.au> **On Behalf Of** EDUMCR
Sent: Friday, 26 November 2021 1:42 PM
To: ICW EBM Office <ICWEBMOffice@act.gov.au>
Cc: EDU, EGMBSG <EGMBSG.EDU@act.gov.au>; EDUMCR <EDUMCR@act.gov.au>
Subject: FOR ACTION: SUB21/7885 - Air quality in ACT schools

OFFICIAL

Good afternoon,

Please action on the attached reference. Please review the below table to provide the appropriate response type and note the due dates.

Title/Question	Air quality in ACT schools -
Action	Prepare a response to
Responsibility	ICW
Response type	Ministerial
TRIM	SUB21/7885
Date due to EGM	9 December 2021
Date Due to	10 December 2021

MO	
Clearance	Please refer to the Executive Clearance Protocol document for appropriate clearance levels/drop copy requirements: here
Comment	Please contact edumcr@act.gov.au if you have any questions.

Please let me know if you have any queries.

Kind regards,
Clementine

From: Metherell, Skye <Skye.Metherell@act.gov.au> **On Behalf Of** Education DLO
Sent: Friday, 26 November 2021 9:30 AM
To: EDUMCR <EDUMCR@act.gov.au>
Subject: COVID For Allocation: Contact my Minister - Correspondence: [redacted]

Hi Clem,

Can this please be allocated to ICW for Ministerial Response?

Due to Mo 10.12.2021

Thanks,
Skye

From: BERRY <BERRY@act.gov.au>
Sent: Friday, 26 November 2021 9:26 AM
To: Education DLO <EDUDLO@act.gov.au>
Cc: Hobbs, Rebecca <Rebecca.Hobbs@act.gov.au>
Subject: FW: Contact my Minister - Correspondence: [redacted]

Hi Skye,

Please see below/ attached correspondence related to Education. For appropriate action please.

Thank you,
Harini

From: minister@act.gov.au <minister@act.gov.au>
Sent: Thursday, 25 November 2021 5:58 PM
To: BERRY <BERRY@act.gov.au>
Subject: Contact my Minister - Correspondence: [redacted]

CAUTION: This email originated from outside of the ACT Government. Do not click links or open attachments unless you recognise the sender and know the content is safe.

Coat of Arms

Yvette Berry, MLA

The following correspondence has been submitted via the Contact my Minister website.

The constituent has indicated that they would like a response to their correspondence.

Indoor air quality audit at ACT schools

Dear Minister, could you please refer to the news article below regarding air ventilation, specifically in Schools. Every ACT School should be audited for air quality and adjustments made to improve the quality and safety of the air our children learn in. These improvements are not just for the Covid period but beyond and into the future. It appears that short term measures can be made for low cost to improve quality, and then more long term planning can take place for future measures. https://www.abc.net.au/news/health/2021-09-11/covid-transmission-co2-carbon-dioxide-monitor-ventilation-school/100444884 We want to be assured that our children are learning in a safe environment. [redacted] I appreciate your attention to this issue.
Regards, [redacted]

Correspondence Reference [redacted]

Submission date: [redacted]

Contact Information

[redacted]

Yvette Berry MLA
Deputy Chief Minister
Minister for Early Childhood Development
Minister for Education and Youth Affairs
Minister for Housing and Suburban Development
Minister for Women
Minister for the Prevention of Domestic and Family Violence
Minister for Sport and Recreation

Member for Ginninderra

[redacted]

Dear [redacted]

Thank you for your ~~enquiry~~ correspondence of [redacted] in relation to air ventilation in schools specifically regarding work being undertaking to improve indoor air quality at [redacted] and your question regarding CO_2 monitoring of school classrooms.

The ACT Government is committed to enhancing management of classroom air quality as a key strategy in providing healthy learning and teaching environments. While the current focus of indoor air quality is on COVID-19 ventilation requirements, ACT public schools commenced a program to progressively upgrade control systems and equip schools with CO_2 sensors to manage air quality and energy efficiency in 2018.

[redacted] are both equipped with CO_2 sensors connected to the mechanical ventilation systems at the schools. The systems at each site are programmed to bring in fresh air two hours prior to students arriving and continue providing fresh air throughout the day, and for an additional two hours after staff leave for the day. The CO_2 sensors at the schools manage outdoor air intake to keep CO_2 levels in classrooms below 800 parts per million, providing the ideal conditions for learning and for reducing the transmission of airborne illness.

ACT Legislative Assembly London Circuit, GPO Box 1020, Canberra ACT 2601
+61 2 6205 0233 berry@act.gov.au
@YvetteSBerry YvetteSBerry Yvette_berry_mla

I note that ventilation is part of the broader suite of strategies encouraged by the ACT Government to reduce the risk of COVID-19 transmission in school settings including vaccination, physical distancing, good hygiene, cleaning and mask use.

Thank you for raising this issue with me and it is great to see communities and parents getting behind the strategies being undertaken to keep students in school and learning.

Yours sincerely

Yvette Berry MLA
Minister for Education and Youth Affairs

Yapp, Phillip

From: Yapp, Phillip
Sent: Thursday, 20 January 2022 10:48 AM
To: [redacted]
Cc: quotes@canberraaircon.com.au; Mitchell, BethL; Flint, Katrina; Kidman, Fiona; Graham, Cathy
Subject: IAQ 21-22/226 - SterileZone fans - RE: Quote no. 20351
Attachments: IAQ-PO-All School SterileZone UVC Purifiers.pdf; IAQ - General_Terms_and_Conditions_for_Purchase_Orders.pdf

H [redacted]

Please find attached purchase order for SterileZone fans as per Quote 20351. As discussed this will be purchased directly through Education, not ACTPG.

Cheers
Phil

Phil Yapp | Assistant Director – Asset Strategies, Sustainability and Environment

Phone: +61 2 6207 9190 | M: 0435 655 176 | Email: phillip.yapp@act.gov.au
Infrastructure and Capital Works | Education | ACT Government
Level 4 220 London Circuit | GPO Box 158 Canberra ACT 2601 | www.det.act.gov.au

---

From: [redacted]
Sent: Wednesday, 19 January 2022 12:24 PM
To: Yapp, Phillip <Phillip.Yapp@act.gov.au>
Cc: quotes@canberraaircon.com.au; [redacted]
Subject: Quote no. 20351

Dear Phil,

Please find attached Quote no. 20351

If you cannot read attached file/s, please reply to this email.

Thank you.

Kind Regards,

Canberra Air Conditioning Services Pty Ltd
[redacted]

Thank you,
[redacted]
Ph: [redacted] | www: www.canberraaircon.com.au

CANBERRA
AIR CONDITIONING
SERVICES

ACT Government
Education

Purchase Order

Date:	20/01/2022
Purchase Order No:	IAQ 21-22/226

Requesting Section Buyer: Phil Yapp

Vender Supplier Name: **Canberra Air Conditioning Services Pty Ltd**
Address: 5/15-21 Beaconsfield St, Fyshwick ACT 2609

Contact Name: [redacted] Contact Number: [redacted]

Ship to Location (if applicable) or work site: HBCTL, Fremantle Dr, Stirling ACT 2611

Short description of goods/services: Supply 14x Sterile Zone portable UV-C units

Price	Fixed	☒	Variable	☐	Quotes Attached Yes	☒	No	☐	Delivery Required by	/ /
Freight	FIS	☒	FOB	☐	Confirming Order Yes	☐	No	☐		

Line No	Description	Qty	Unit	Unit Price	Total
1	Administration Fee	1		[redacted]	
2	SterileZone Air Purifiers	14			
3	Freight	14			
	GST 10%				2,118.64
			TOTAL		**23,305.04**

Requesting Officer: Phil Yapp	Signature: [redacted]
Contact No: 0435 655 176	Date: 20/01/2022

Delivery Address: ACT Education Directorate – Level 4, 220 London Cct. Email: phillip.yapp@act.gov.au

Line No	Account Flex field	Line No	Account Flex field	Line No	Account Flex field

Name and Title of Approving Officer:	Signature [redacted]
Beth Mitchell – Director Asset Strategies and Sustainability	
(Signatory confirms holding delegation to expend funds)	Date: 20/1/2022

This purchase order is to be read in conjunction with the "General Terms and Conditions for Purchase Orders (Goods and/or Services)" attached.

General Terms and Conditions for Purchase Orders (Goods and/or Services)

1. Provision of Supplies

1.1 The Supplier must provide the goods and/or services specified in the Purchase Order (**Supplies**) according to the provisions of the Purchase Order and these terms and conditions (collectively, **Contract**) and to a high standard of care, skill and diligence.

1.2 Supplies that are goods must be new and unused, free from any security interest, defects in materials and workmanship, of acceptable quality and must conform to any specifications and descriptions set out in the Purchase Order.

1.3 If the Supplies contain hazardous substances, the Supplier must provide material safety data sheets for those hazardous substances.

2. Price of Supplies

2.1 Except if otherwise stated in the Purchase Order, the price for the Supplies is:

(a) payable within 30 days of receipt by the Territory of an Invoice;

(b) inclusive of GST and all other taxes, duties and charges; and

(c) inclusive of all disbursements, including out of pocket expenses incurred by the Supplier.

2.2 An Invoice may be issued by the Supplier upon the satisfactory completion of each milestone set out in the Purchase Order, or if no milestones are specified, on the satisfactory completion of all services and acceptance of all goods comprising the Supplies.

3. Delivery and Acceptance

3.1 Supplies that are goods must be delivered at the times and places detailed in the Purchase Order, in good order and condition and marked with the relevant Purchase Order Number and full delivery point details. Delivery will be free into store unless otherwise specified in the Contract.

3.2 The Territory may reject Supplies supplied incorrectly, damaged, in excess of or less than specified quantities or otherwise found not to be in accordance with the Purchase Order.

3.3 If the Territory rejects any Supplies, the Supplier must, at no cost to the Territory and within any timeframe specified by the Territory, remove the Supplies (in the case of goods) and:

(a) replace any rejected Supplies that are goods; and

(b) re-perform any rejected Supplies that are services; or

(c) refund any payment for the rejected Supplies.

3.4 If the Territory does not reject the Supplies within 14 days of receiving the Supplies, the Territory is taken to have accepted the Supplies.

4. Title and Risk

Risk of loss and damage and title in Supplies that are goods passes to the Territory on its acceptance of those goods.

5. Warranty

For Supplies that are goods, the Supplier must:

(a) during any warranty period specified in the Purchase Order, at no cost to the Territory, correct all defects in the Supplies by way of repair, replacement or such other means acceptable to the Territory; and

(b) ensure, to the extent practicable and permitted by law, that the Territory receives the benefit of any warranty given by a third party with respect to any goods,

however, this does not in any way relieve the Supplier of any obligation or warranty by it under the Contract and the Supplier is liable for all costs incidental to the discharge of any warranty under the Contract.

6. Insurance

The Supplier must effect and maintain for the Purchase Order term any insurances specified in the Purchase Order.

7. Indemnity

The Supplier indemnifies the Territory, its employees and agents against all liability in respect of all claims, costs and expenses in relation to all loss, damage, injury or death to persons or property caused by the Supplier, in connection with the provision of the Supplies, except to the extent that the Territory caused the relevant loss, damage or injury.

8. Cancellation

The Territory may cancel the Purchase Order in part or whole, at any time by notice to the Supplier, if the Supplier:

(a) enters, or in the Territory's absolute opinion, is likely to enter, into any form of external administration or makes any arrangement with its creditors or takes advantage of any statute for the relief of insolvent debtors;

(b) fails to provide the Supplies within, or to meet any other, timeframes or milestones specified in this Contract; or

(c) is otherwise in breach of a provision of this Contract, where that breach:

(i) if capable of being remedied, is not remedied within the period specified in a notice by the Territory, or

(ii) is not capable of being remedied.

9. Assignment and Subcontracting

The Supplier must not assign or subcontract any of its rights or obligations under this Contract without the prior written consent of the Territory.

10. Applicable Law

The laws of the Australian Capital Territory apply to this Contract.

11. Variation

This Contract may be varied only by the written agreement of the parties prior to the expiration of the Contract.

12. Entire Agreement

The Contract constitutes the entire agreement of the parties in relation to the provision of the Supplies and all other agreements, warranties and representations are excluded.