# Briefing

## Options to improve ventilation

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| **Date due to MO:** | 21 March 2024 | **Action required by:** | N/A |
| **Security level:** | IN CONFIDENCE | **Health Report number:** | H2024036633 |
| **To:** | Hon Dr Shane Reti, Minister of Health | | |
| **Consulted:** | Health New Zealand: ☒<br>WorkSafe: ☒<br>Ministry of Business, Innovation and Employment: ☒ | | |

## Contact for telephone discussion

| Name | Position | Telephone |
|---|---|---|
| **Dr Andrew Old** | Deputy Director-General, Public Health Agency \| Te Pou Hauora Tūmatanui | s 9(2)(a) |
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## Minister's office to complete:

| | | |
|---|---|---|
| ☐ Approved | ☐ Decline | ☐ Noted |
| ☐ Needs change | ☐ Seen | ☐ Overtaken by events |
| ☐ See Minister's Notes | ☐ Withdrawn | |

Comment:

# Options to improve ventilation

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| **Security level:** | IN CONFIDENCE | **Date:** | 18 March 2024 |
| **To:** | Hon Dr Shane Reti, Minister of Health | | |

## Purpose of report

1. This briefing responds to a request from your Office following an aide-mémoire on the current COVID-19 response (H2024035351 refers). It provides an overview of work undertaken to date and options to improve ventilation for the purposes of reducing risk of transmission of airborne pathogens. This report also highlights the co-benefits of improved ventilation for other aspects of health and wellbeing. This report discloses all relevant information and implications.

## Summary

2. Evidence on the importance of ventilation in indoor settings is now well established. Benefits of improving ventilation to recommended levels include:
   a. reducing risk of transmission of airborne pathogens
   b. better cognitive function
   c. lower exposure to pollutants associated with other conditions (such as certain cancers and chronic respiratory conditions).
3. Based on reliable available evidence, it appears that many public indoor settings in New Zealand are not well ventilated. With the exception of work to improve ventilation in some hospitals, managed isolation and quarantine (MIQ) hotels, and schools in 2021 and 2022, there has been relatively little work done to improve ventilation from a general public health perspective.
4. Further work on options for enhancing indoor ventilation as a control measure is warranted, particularly in public buildings such as schools, libraries, workplaces, and government facilities. There is also likely opportunity to further reduce the risks of nosocomial airborne infections, including COVID-19, in hospitals.
5. Noting the current fiscal context, this briefing recommends an initial focus on providing improved public information, and engagement with the health and transport sectors. These actions can be undertaken within baseline funding, in the 2024 calendar year.
6. This briefing also outlines a range of other actions, wider in scope, that improve ventilation which would either require additional funding, and/or significant involvement from other agencies. If you are interested in these actions, we can provide a follow-up briefing with further details of feasibility and cost estimates.

## Recommendations

We recommend you:

a) **Note** that multiple New Zealand studies have indicated that ventilation levels in indoor settings are frequently lower than recommended from a public health perspective. **Noted**

b) **Note** that research studies have also shown that it is often possible to improve ventilation in these settings using existing infrastructure without significant additional cost. **Noted**

c) **Note** that government agencies in Australia, the United Kingdom, and the United States provide general public health guidance in relation to recommended ventilation levels, and information on simple practical ways that ventilation can be improved. The Australian Health Protection Principals Committee has recently adopted indoor air quality as a priority for guidance and policy development. **Noted**

d) **Note** that the Ministry of Health plans to undertake the following activities to support improved ventilation (Group A actions): **Noted**

1. update public information on ventilation from a public health perspective, including recommended ventilation levels and simple, practical tips on how to improve ventilation
2. support the Ministry of Education to update guidance to early childhood education (ECE) centres
3. targeted engagement with higher risk settings/sectors, with an initial focus on health and transport sectors.

e) **Indicate** if you would like a further briefing on any of the following potential actions, which would require additional funding and/or significant involvement from other agencies (Group B actions).

4. Investigate the costs and feasibility of working with willing agencies/sectors to collect anonymised data to develop a better sense of the relative risk profiles in different settings. **Yes/No**
5. Investigate the costs and feasibility of commissioning an independent agency to assess the various technologies available in New Zealand, and produce a product guide/review. **Yes/No**
6. Investigate the costs and feasibility of establishing a voluntary standard for ventilation. **Yes/No**
7. Investigate costs and feasibility of providing practical support to higher risk settings – such as settings in the health, transport and education sectors. **Yes/No**
8. Work with relevant regulatory and/or accreditation agencies to understand more about whether it would be feasible to consider

updating and/or including more specific information on ventilation and air purification, and if so, what the process would involve:

a. HealthCERT – in relation to Sector Guidance for Ngā Paerewa Health and Disability Services Standard **Yes/No**

b. The Royal New Zealand College of General Practitioners quality framework – in relation to Foundation and Cornerstone programmes **Yes/No**

c. New Zealand Transport Authority (NZTA) – in relation to the Requirements for urban buses in New Zealand (the 'RUB') **Yes/No**

d. The Ministry of Business, Innovation and Employment – in relation to updating the New Zealand standard "Ventilation for Acceptable Indoor Air Quality" (4303:1990) (note this would only affect new builds and is not retrospective in application). **Yes/No**



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Date: 14/03/24

Hon Dr Shane Reti

**Minister of Health**

Date:

# Options to improve ventilation

## Background

7. On 13 February 2024, you received an aide-mémoire on the current response to COVID-19 [H2024035351]. The aide-mémoire noted: "*Evidence on the importance of ventilation in indoor settings is now well established. Further work on options for enhancing indoor ventilation as a control measure is warranted, particularly in public buildings such as schools, libraries, workplaces and government facilities*".

8. Your Office requested further information on what the further work could involve, along with a copy of the briefing on ventilation provided to the Minister for COVID-19 Response in December 2022 (H2022015972). This briefing (including the December 2022 briefing attached as Appendix 1) responds to that request.

### Why is ventilation and/or air purification important from a public health perspective?

*Many common pathogens are transmitted primarily via the air*

9. It is now well understood that many common pathogens are transmitted primarily via the air, and that most infections from these pathogens occur in indoor settings. Pathogens primarily transmitted via the air include:

    a. rubeola (measles)

    b. SARS-CoV-2 (the virus that leads to COVID-19 infection)

    c. respiratory syncytial virus (RSV)

    d. rhinovirus (common cold)

    e. seasonal influenza viruses

    f. varicella (chickenpox)

    g. coxsackievirus (the most common cause of hand, foot, and mouth disease [HFMD])

10. Less common pathogens that are also primarily transmitted via the air include Middle East Respiratory Syndrome (MERS) and *mycobacterium tuberculosis* (TB).

*How does ventilation and/or air filtration reduce risk of transmission?*

11. Indoor settings with adequate ventilation and/or air purification limit the risk that pathogens will be transmitted from a person who is infectious to others present in that setting.

12. The interventions and the ways of measuring the adequacy of the ventilation depend on the type of ventilation:

    a. **natural ventilation** – involves bringing fresh outdoor air into an indoor space, via openings such as windows, doors, or air vents. Interventions involve opening windows or doors to ensure that indoor air is replaced with fresh outdoor air at an appropriate rate. Natural ventilation is typically reliant on the person or people in charge of that setting taking action, whether that be opening and closing windows.

b. **mechanical ventilation (for example, via a centralised heating, ventilation and air conditioning (HVAC) system or an individual local air conditioning unit)** – mechanical ventilation replaces or dilutes indoor air with outside air using mechanical equipment. Most HVAC systems also have a filter (HEPA or Minimum Efficiency Reporting Value [MERV]), which filter contaminants including pathogens. Interventions involve ensuring the mechanical system is regularly serviced, that filters are upgraded where possible, increasing the proportion of outdoor air where possible, and ensuring that the system is appropriate for the nature of the setting.

13. **Air purification** can be used to support ventilation. The two primary methods of air purification are filtration, to remove pathogens, or methods of sterilisation by inactivating the pathogens. Portable air cleaners (PACs) with high efficiency particulate air (HEPA) filters clean the air within the room of impurities. Air purifiers are most useful in spaces which are not mechanically or naturally ventilated and are used intermittently, or where existing ventilation is insufficient. Ultra-violet light can be used to inactivate viruses and bacteria without removing them from the air.

*What level of ventilation is recommended in naturally ventilated settings?*

14. The level of carbon dioxide ($CO_2$) in a naturally ventilated indoor setting is a reliable proxy measure for the adequacy of ventilation. When people breathe, they exhale $CO_2$, and the level of $CO_2$ in the room will increase. In a poorly ventilated room, $CO_2$ will remain in the room for longer, building up to higher levels.

15. Outdoor air currently has a $CO_2$ level of approximately 420 parts per million (ppm). In indoor settings, it is generally recommended that $CO_2$ levels of 800 ppm or below indicate that a setting is adequately ventilated. The United States Centers for Disease Control (CDC) recommends that "readings above 800 ppm suggest that you may need to bring more fresh, outdoor air into the space".[1] The Health and Safety Executive (HSE) in the United Kingdom (UK) recommends 1,000 ppm as acceptable, with levels consistently higher than 1,500 ppm indicating poor ventilation.[2] The New Zealand Ministry of Education (MoE) has advised schools that 800 ppm is considered well-ventilated, and recommends schools take action if $CO_2$ levels stay above 800 ppm for an hour or more.[3]

*What level of ventilation is recommended in mechanically ventilated settings?*

16. The CDC recommends aiming for at least 5 air changes per hour (ACH), and upgrading to MERV-13 filters (filters have ratings from 1-20, with higher numbers indicating that the filter can block a greater percentage of airborne particles).[4]

17. The UK HSE's Approved Code of Practice recommends that "the fresh-air supply rate should not normally fall below 5 to 8 litres per second, per person (L/s/person ). A value of 10 litres per second per person is recommended in many guides as a suitable value for most commercial buildings".[5]

*The risk profile of a setting is dependent on factors relating to the occupants, the setting itself, and the broader community*

18. The overall risk profile of an indoor public setting or workplace is a combination of factors associated with the occupants (number, vulnerability, activity), the setting itself

(physical factors, ventilation adequacy, and other control measures in use), and the broader community (pathogens circulating, community prevalence, other control measures in use). Appendix 2 contains further details of the components of each of these factors.

19. As an example, health care settings can be at particularly high risk during periods of high prevalence of sickness in the community due to airborne pathogens, as the occupants are often more vulnerable than people in other settings. In this context, adequate ventilation in combination with other control measures such as mask use, and use of negative pressure rooms are vital. Health New Zealand - Te Whatu Ora (Health NZ) expects to have data on hospital-acquired infections due to COVID-19 in the coming month. In September 2023, the Australasian Health Infrastructure Alliance released a guide for Pandemic Preparedness, which includes ventilation standards.[6] The guide stipulates that the planning principles should be considered for both new build and refurbishment work.

20. Individuals often have very limited control over ventilation in the public indoor settings and workplaces, and are reliant on those in control of the setting (employees and/or persons conducting a business or undertaking [PCBUs]) to ensure that the ventilation is adequate. As with other public health issues, a multi-level approach is required: helping and enabling individuals to do what they can to reduce risk, but also supporting systemic change.

*What are the costs and benefits of improving ventilation?*

21. For indoor settings with either natural or mechanical ventilation, it is generally possible to improve ventilation by using simple measures without making structural changes to those systems.

22. The cost/benefit profile of improvements to ventilation will vary depending on multiple factors, specific to each situation. Examples of factors include:

    a. the risk profile of that setting (occupants, setting, broader community – see paragraph 18 and appendix 2)

    b. the cost of making the improvement

    c. the relative gain by making the improvement.

23. However, in general terms, improvements to ventilation in poorly ventilated settings are associated with a number of benefits, including:

    a. reduced level of sickness-related absence, for example:

        i. a UK study involving 10 schools that were provided with HEPA air purifiers in all classrooms found that absences due to COVID-19 decreased by 20%[7]

        ii. a study involving 409 traditional and 25 portable classrooms from 22 schools in the United States found that 45% of classrooms had short-term $CO_2$ concentrations above 1000 ppm, which was associated with a 10-20% increase in student absence[8]

        iii. a study based on 162 primary school classrooms in California, across 2 years, demonstrated an increase in ventilation by 1 L/s/person resulted in a 1.6% reduction in illness-related absences[9]

iv. a study involving 144 classrooms with mechanical ventilation in 31 schools in the United States, over a 2-year period, found a significant association between annual illness-related absence rates and classroom ventilation rates; each 1L/s/person increase in ventilation rate was associated with a decrease of 5.59 days with absences per year (0.15% increase in annual daily attendance rate)[10]

v. the Royal College of Engineers in the United Kingdom reported that the cost of seasonal disease costs the country £8 billion a year, but that improved ventilation could minimise transmission, reduce the number of people infected, save lives, and reduce the societal impact[11]

b. improved cognition – for example:

i. a study involving 70 primary school classrooms in the United States found a statistically significant association between ventilation rates and standardised test scores for mathematics[12].

24. High $CO_2$ and low natural ventilation have been associated with increased levels of pathogens in the air, for example:

a. a study of 241 indoor air samples from 21 community settings in Belgium for common pathogens found on average 3.9 pathogens per sample, and 85% of samples tested positive for at least one pathogen; high $CO_2$ and low natural ventilation were independent risk factors for detection[13].

25. Where it is not possible to ventilate (or sufficiently and reliably ventilate) an indoor space with fresh air, use of mechanical ventilation and/or HEPA air purifiers can have the added benefit of reducing the level of pollutants in the air.

26. Investing in good ventilation and/or air filtration can also help to prepare for future outbreaks and/or pandemics, as several of the pathogens most likely to lead to outbreaks or pandemics are largely transmitted via the air.

## What is known about the adequacy of ventilation in public indoor settings in New Zealand?

*Available data suggests that many public indoor spaces in New Zealand have poorer ventilation than recommended*

27. Multiple studies in a range of public indoor settings in New Zealand have indicated that ventilation in indoor settings is frequently lower than recommended:

a. a 2019 PhD thesis study of early childhood education centres in Auckland found that mean $CO_2$ levels in 75% of sleep rooms monitored exceeded the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) and Ministry of Education guidelines[14]

b. a winter 2022 study of 6 early childhood education (ECE) centres in Taranaki in June and July 2022 found high levels of $CO_2$ (over 1,500ppm) in 4 out of the 6 centres; 2 out of the 4 sleep rooms with high $CO_2$ levels did not have windows able to be opened but the remaining rooms either had windows or sliding doors that could be opened[15]

c. in late 2021, MoE established a Ventilation Technical Advisory Group, with air quality, engineering, and architectural experts from universities, crown research institutes, and government agencies. MoE commissioned a number of studies surveying both ventilation levels and effects of various interventions to improve ventilation in schools, and early childhood education centres.[16] The initial study (which did not involve any intervention) found that 31% of observed teaching periods had poor ventilation (sustained $CO_2$ levels above 1500 ppm), but that the likelihood of high levels was greatly reduced when windows and/or doors were open[17]

d. in 2022, the University of Auckland found high levels of $CO_2$ on buses compared to other publicly used indoor environments, and highlighted concerns about increased risk of viral transmission[18]

e. in 2023, Greater Wellington Regional Council (GWRC) commissioned 2 studies considering on-board bus air quality:

   i. an initial pilot study by Air Matters Ltd tracked $CO_2$ levels on Metlink buses and found that sustained elevated levels of $CO_2$ (above 1500 ppm) were found on 22% of monitored trips (ie bus runs, not passenger trips). $CO_2$ levels were particularly elevated when passenger levels were high, and on the upper deck of double decker buses. The study noted that there is "no national policy or regulation for acceptable $CO_2$ levels for public transport environment and no ventilation specifications in the 'Requirements for Urban Buses'. Public health advice is required to determine whether measured $CO_2$ levels pose a risk to passenger health."[19]

   ii. the second study by the National Institute of Water and Atmospheric Research (NIWA) looked at the impact of changing ventilation on a double-decker bus, in response to the findings of the pilot study. This study compared results in the full recirculation and fresh air mode (10% intake), and found that the maximum total number of passengers was a strong predictor of maximum $CO_2$ levels on both decks in both modes. Introducing fresh air reduced $CO_2$ levels during the bus journey by approximately 60% compared to the recirculation mode. The authors noted that not all buses currently in use have the ability to modify the level of fresh air intake.[20]

28. In summary, many of the ECE centres, schools, and bus settings studied had poor ventilation (sustained levels above 1500 ppm) for a significant proportion of occupied periods. However, for at least a proportion of settings, the risk was able to be significantly reduced using existing infrastructure, without significant additional cost. This action was reliant on the individual in charge of that setting (teachers and bus drivers) being aware of the risk, the mitigation, and being practically able to implement it.

*On the domestic side, there has been significant work in recent years to improve ventilation in rental properties*

29. There has been significant work done to improve the extent to which rental housing is able to be ventilated, in an effort to reduce mould, dampness, and associated health effects for people living in rental properties. Specifically, the Healthy Homes ventilation standard, which became a requirement in 2021, requires that all habitable rooms in a rental property must have at least one window, door, or skylight which opens to the

outside and can be fixed in the open position; and that all kitchens and bathrooms must either have an extractor fan that vents air to the outside or a continuous mechanical ventilation that meets certain criteria.

*However, relatively limited work has been undertaken to date to improve ventilation in public indoor spaces from a public health perspective in New Zealand*

30. However, compared to other jurisdictions, relatively little work has been undertaken to date to improve ventilation in **public settings**. The 3 areas that have had the most experience to date in using ventilation to reduce risk of transmission are:

    a. education (state and integrated schools) – in 2022, MoE distributed more than 12,500 portable $CO_2$ monitors and 13,000 portable air cleaners to state and state-integrated schools to support them with good ventilation, as part of the COVID-19 response. These devices were provided at no cost to the schools

    b. MIQ hotels – a substantial programme of modification of almost every MIQ hotel was required to bring them up to current standards

    c. some public hospitals received funding for ventilation improvements, as part of the COVID-19 response.

31. In December 2022, the Ministry of Health provided a briefing on options to improve ventilation to the Minister for COVID-19 Response. Further action following this work was paused following changes to funding available for the COVID-19 response.

32. In May 2023, Greater Wellington Regional Council (GWRC) wrote to the Ministry of Health requesting public health advice on recommended $CO_2$ levels on buses, attaching a copy of a study they had commissioned on $CO_2$ levels on Metlink buses at different times and under different conditions (referred to in paragraph 27(e)). The Ministry of Health responded that an update to the guidance on the website was planned by the end of the year, however this has work has been delayed.

33. In the latter part of 2023, MoE approached the Ministry of Health, seeking input on guidance to early childhood education centres in relation to ventilation. This response is also on hold until the guidance on the website is able to be updated.

34. At the end of March 2024, the Ministry of Health expects to receive the final report of a study led by NIWA which aims to understand how risk of COVID-19 infection in buildings occupied by particularly vulnerable people (young children and the elderly) can be reduced by implementing low-cost options to improve ventilation. The study focused on Māori and Pacific Island communities, including medical centres, churches, various community hubs and youth centres, along with a longer term case study involving a marae. One of the study outputs is "reproducible guidance and processes to improve ventilation for all sectors of New Zealand society".[21] This guidance will be used to update public information regarding ventilation on the Ministry of Health and Health Ed websites.

35. New Zealand does not currently have detailed guidance or specification of recommended ventilation levels from a public health perspective. Appendix 3 provides examples of guidance from other jurisdictions and international agencies in relation to ventilation.

## What are the roles and interests of other government agencies in relation to ventilation?

36. Table 1 below outlines the nature of other government agencies roles and interests in relation to ventilation.

*Table 1: Agency interests and levers in relation to ventilation*

| **Nature of interest** | **Levers** |
|---|---|
| Ministry of Business, Innovation and Employment (MBIE) | |
| As steward for the built environment regulatory system, MBIE has an interest from the perspective that ventilation contributes to the structural integrity, performance over time, and efficiency of the built environment.<br><br>MBIE also has a role in ensuring that regulation on businesses is proportionate. | • Building Regulations 1992, clause G4 - which applies to new buildings, states that spaces in buildings are to provide adequate ventilation consistent with their maximum occupancy and intended use. Buildings must comply with regulations at the time they are consented, there is no obligation to maintain compliance if regulations are updated.<br>• Acceptable Solutions and Verification Methods[22]<br>• New Zealand Standard Ventilation for acceptable indoor air quality. NZS 4303: 1990.[23]<br>• Annual Building Warrant of Fitness - confirms that the owner has met the legal requirements to maintain, inspect, and report on the building's specified systems (as at time of consent).[24] |
| WorkSafe | |
| WorkSafe has an interest in ventilation where it relates to workplace health and safety. | • Health and Safety at Work Act 2015 – section 36 outlines the primary duty of care.[25]<br>• Health and Safety at Work (General Risk and Workplace Management) Regulations 2016 – clause 10 requires that PCBUs must ensure, so far as is reasonably practicable, that there is suitable and sufficient ventilation to enable workers to carry out work without risks to health and safety.[26]<br>• Workplace Exposure Standards (WES) – provide guidelines for health risk management however these are not applicable to the general public. They are aimed at healthy working adults so set different levels of 'acceptable' exposure than for the general public e.g. via NZS 4303:1990. The recommended time-weighted average for healthy adult workers for $CO_2$ is 5,000ppm or 9,000mg/m3. The short-term exposure limit is 30,000ppm, or 54mg/m3.[27]<br>• It should be noted that the Building Regulations 1992, clause G4/NM1 cite the Workplace Exposure Standards 2019 as a method of verifying 'air purity'. However, in addition to these Standards not being applicable to the general public as explained above, they are updated by WorkSafe annually, so the 2019 version is out of date.[28] |
| Ministry of Education (MoE) | |
| MoE provides guidance to schools in relation to ventilation, air purification, and $CO_2$ monitoring. | • Indoor Air Quality and Thermal Comfort Guidelines[29]<br>• Guidance to schools in relation to $CO_2$ levels.[30] |

37. Other government agencies with significant operational activities involving members of the public also have a role in relation to ventilation: Ministry of Justice, Department of Corrections, Oranga Tamariki, New Zealand Customs Service, New Zealand Police, and the Ministry of Social Development.

38. Several of these agencies were interviewed as part of the process of developing the December 2022 briefing on ventilation. Agencies were generally aware of the issue and benefits of ventilation, and had taken steps to improve it in the settings they were responsible for. That is, settings where the State (a) legally requires that certain people be present in a particular setting (such as prisons, courts, and schools) and (b) owned the property. However, most agencies reported challenges in knowing what level of ventilation and/or air purification was sufficient, and had practical challenges in both identifying suitable solutions and implementing those solutions.

### What is the view of the business sector towards ventilation?

39. Based on interviews conducted as part of the process of developing the earlier briefing on ventilation in late 2022, interviewees from the private sector had mixed views and interests in improving ventilation. While some interviewees had no interest in improving ventilation, others were aware of the potential benefits (and/or risk), but unsure of what to do in a practical sense, and unclear what ventilation levels would be sufficient for their setting.

40. Interviewees from the private sector involved in the health sector (broadly defined) or highly regulated sectors appeared to be more knowledgeable and willing to improve ventilation than those from other sectors. However, similar to interviewees from the public sector – many were unsure what level of ventilation was adequate, and how to improve it (specifically navigating the range of available technology). Some were concerned that if they monitored ventilation and found it to be inadequate, they would be required to improve it, at what they thought could be significant cost.

## What are the opportunities to improve ventilation in 2024?

*This report outlines a different set of options and way forward to the December 2022 briefing*

41. The December 2022 briefing on ventilation reflected the context and an assessment of opportunities at that point in time. Further work on ventilation did not occur partly due to a change in the funding context for COVID-19. The options included in this briefing reflect the current context of prudent fiscal management and a need to focus effort where the potential return will be greatest.

42. An additional feature of the current context is that officials from both MBIE and WorkSafe have indicated that further work on ventilation for public health is not a priority for their agency at this point in time. However, it is important to note that the nature of these agencies' interests in ventilation and ability to support improvement is different to health. While MBIE is the steward of the building regulatory system, the agency's ability to influence or enforce is largely limited to new builds. WorkSafe has noted that from their perspective industrial air quality and extraction ventilation that removes contaminants rather than dilutes the air (like natural or general ventilation) is more likely to be a priority than indoor air quality or insufficient general ventilation.

*Where would effort to improve be best targeted?*

43. Further work on options for enhancing indoor ventilation as a control measure is warranted, particularly in public buildings such as schools, libraries, workplaces, and government facilities.

44. There remains a lot of 'low hanging fruit' for ventilation improvement, in that there is currently:

    a. limited public information or awareness on the health benefits of improving ventilation, or the risks associated with poor ventilation

    b. potential to improve ventilation in many settings for no or minimal additional cost

    c. willingness and interest from some sectors (and individuals within others) in improving ventilation.

45. Given the relatively low level of public awareness and knowledge about why ventilation is important and how to improve it, an initial focus on improving public information is recommended. As has been demonstrated in other jurisdictions in recent years, it is possible to provide this type of information in a way that does not necessarily confer an obligation on those responsible for public indoor settings and workplaces. This is a key consideration given the context outlined in paragraph 41.

46. Options for improvement are outlined in table 2, and have been divided into 2 groups:

    a. Group A: actions that can occur within baseline funding, and are likely able to be progressed by the Ministry

    b. Group B: actions that would require funding and/or significant involvement from other agencies over a longer time period.

*Table 2: Options for improving ventilation and/or air purification*

| | |
|---|---|
| **Group A:**<br>**Actions that can occur within baseline funding** | 1. **Update public information** – update Ministry of Health and Health Ed website guidance relating to ventilation with more practical information to help people to know what level of ventilation and/or air purification is recommended, along with simple practical tips on how to achieve it. |
| | 2. Following the guidance update, **support the Ministry of Education to update guidance for ECEs** in relation to ventilation (the Ministry of Education approached the Ministry of Health seeking assistance to do this in the latter part of 2023, following an internal report that identified it as a gap). |
| | 3. Undertake **targeted engagement with higher risk settings/sectors (with an initial focus on the health and education sectors)** - to talk through the guidance and to understand more about the barriers they face to implementing the guidance (for example: primary care, hospitals, aged and disability-related residential care facilities, schools, ECE centres). |
| **Group B:**<br>**Actions that would require:**<br>• **funding and/or**<br>• **significant involvement from other agencies** | 4. Investigate the costs and feasibility of working with willing agencies/sectors to collect anonymised data to **develop a better sense of the relative risk profiles** in different settings. |
| | 5. **Assist people who want to improve ventilation and/or air purification to navigate the technology options** - investigate the costs and feasibility of commissioning an independent agency (such as Consumer or NIWA) to assess the various technologies available in New Zealand, and produce a product guide/review to help those wishing to invest to have greater certainty regarding the appropriateness and reliability of available products. |
| | 6. Investigate the costs and feasibility of establishing a **voluntary standard** (for example, certification that a setting has [good ventilation and/or air filtration] of [X for X% of the time] that people are present in the setting', self-audit, |

| | |
|---|---|
| | gold/silver/bronze levels). This would assist those settings with good ventilation and/or air purification to communicate this information to occupants/customers. |
| | 7. Provide **practical support to higher risk settings** - investigate the costs and feasibility of funding assessments/$CO_2$ monitors/air purifiers in specified higher risk settings (for example, settings in the health, transport and education sectors) ensuring appropriate guidelines are used i.e. guidelines for the public on e.g. $CO_2$ and particulates, not guidelines for workers (Workplace Exposure Standards). |
| | Work with relevant **regulatory and/or accreditation agencies to understand more about the whether it would be feasible to consider updating and/or including more specific information on ventilation and air purification, and if so, what the process would involve:**<br>8. HealthCERT – in relation to Sector Guidance for Ngā Paerewa Health and Disability Services Standard.[31]<br>9. The Royal New Zealand College of General Practitioners quality framework – in relation to Foundation and Cornerstone programmes.[32]<br>10. New Zealand Transport Authority (NZTA) – in relation to the Requirements for urban buses in New Zealand (the 'RUB').[33]<br>11. The Ministry of Business, Innovation and Employment – in relation to updating the New Zealand standard "Ventilation for Acceptable Indoor Air Quality" (4303:1990) please note this would only apply to new builds and is not retrospective in application).[34] |

## Improving ventilation in settings with mechanical ventilation would have the added benefit of improving indoor air quality

47. Exposure to indoor air quality is important as people spend most of their time in a variety of indoor environments, including home, workplace, school, and commuting. This is often the environment where vulnerable population groups (eg sick and older people) spend the majority of their time. While their exposure to air pollutants is indoors, the source of the pollutants are generated from both indoors and outdoors.

48. Indoor sources of pollution include heating and cooking appliances, open fires, insulation materials, furniture, fabrics and furnishings, glues, cleaning products, other consumer products, and various biological sources – for example, house dust mites, fungi, and bacteria[35].

49. There are challenges around identifying burden of disease within the indoor environment due to the range of individual exposures to a variety of sources.

50. The 2021 World Health Organization (WHO) Air Quality Guidelines was published to provide guidance on particulate matter (PM2.5 and PM10), nitrogen dioxide, ozone, sulphur dioxide, and carbon monoxide. The guidelines are applicable to both outdoor and indoor environments. In addition, there still exists the 2010 WHO Guidelines for Indoor Air Quality: Selected Pollutants. This guideline was developed to provide protection opportunities for public health from risks due to chemical pollutants commonly found in indoor air[36].

51. Australia (enHealth[37]) is finalising their strategic plan which identifies indoor air quality as a high priority topic. Among other strategic indoor air quality projects they are looking to:

a. developing a national evidence base for indoor air quality

b. providing national guidance on air quality and health

c. linking air quality to climate change and health work.

## Equity

52. A key benefit of ventilation is its potential use as a mechanism to enhance equity. This occurs in 2 distinct ways:

    a. ventilation generally occurs in the background and is not reliant on individual behaviour, or access to information or other resources. This means that people who are at higher risk of severe disease do not have to rely on the behaviour of others to ensure their own safety in everyday settings.

    b. Improvements to ventilation are a systemic mechanism for primary prevention – that is, it reduces the risk of people getting infected in the first place. This is important, given the acknowledged differential exposure to risk relating to sociodemographic factors.

## Next steps

53. The Ministry of Health plans to carry out the actions outlined in Group A in the 2024 calendar year.

54. Following your feedback on whether you would like further information on the costs and feasibility of any of the actions in Group B, we will provide a further briefing to you. The timing of this is dependent on the nature of the actions selected for further investigation.

**ENDS.**

## Appendix 1: Options to improve ventilation as a systemic way to manage COVID-19, 13 December 2022 (H2022015972)

[see attached file]

## Appendix 2: Risk profile components

| | Risk components | Possible factors to consider |
|---|---|---|
| People | **Occupant factors** | • number of people in a setting<br>• vulnerability of people in a setting (eg. risk increases if sick and/or frail elderly people present) |
| | **Use factors** | • the nature of the activity being undertaken (risk increases if activity involves higher levels of aerosol formation)<br>• time period that people typically spend in the setting (risk increases with longer dwell times) |
| Setting | **Physical factors** | • the volume of indoor space in the setting<br>• the layout (risk higher in confined spaces than larger spaces) |
| | **Ventilation adequacy** | Settings where ventilation is largely or solely natural:<br>• level of natural ventilation<br>• reliability of natural ventilation<br>• $CO_2$ levels provide a proxy for the composite risk arising from physical and use factors |
| | | Settings where ventilation is mechanical:<br>• type of mechanical ventilation system<br>• type of filter<br>• appropriate maintenance and servicing of system<br>• the appropriateness of the mechanical system for the physical space and use (generally assessed in the number of air changes per hour) |
| | **Other control measures in use** | • for example: guidance or requirements in relation to mask use |
| Community | **Pathogens** | • type of pathogens in circulation<br>• likelihood that infection will have health impacts<br>• nature of health impacts (extent, and whether acute and/or chronic) |
| | **Community prevalence** | • employee sick leave rates |
| | **Other control measures in use in the community** | • for example: vaccination levels, mask use, and case isolation |

# Appendix 3: Examples of ventilation guidance

## New Zealand: Ministry of Education[1]

### *Carbon Dioxide ($CO_2$) monitoring*

*Monitoring CO2 levels is one way to quickly assess whether a space is well ventilated when it is occupied. Elevated CO2 levels for a sustained period of time (e.g. over an hour or more) indicate that fresh air isn't flowing into a space quickly enough to meet the needs of the space's occupants.*

*A space under 800ppm is considered well-ventilated and when levels start to climb above this level, associated risk of airborne transmission of illnesses such as COVID-19 also begins to rise. We advise schools to take action to improve ventilation if CO2 levels stay above 800ppm for an hour or more. More detail about these actions is provided in the table below.*

| Sustained CO2 levels | Actions to consider |
|---|---|
| Green<br>Under 800ppm | Your space is well ventilated for its current number of occupants and their level of activity, continue with the current approach. |
| Green<br>800-1250ppm | Open windows more if this can be done while maintaining comfortable indoor temperatures. Consider lowering the level of activity, briefly vacating the room and/or purging and refreshing the air in the space (a "reboot"). |
| Amber<br>1251-2000ppm | Take further action to introduce more fresh air, for example:<br>• Open all windows and doors as much as possible, and whenever it is practical to do so while maintaining comfortable indoor temperatures.<br>• Reboot the room by fully opening all windows and doors for a short time (e.g. 5-10 minutes), preferably while vacating the room, to purge and refresh the air in the space.<br>• Reduce the level of vigorous activity performed in the room or lower the total occupancy.<br>• Consider using other protective measures such as face coverings and increased physical distancing. |
| Red<br>Over 2000ppm | If you have followed the above advice and still have persistent CO2 levels over 2,000ppm for a sustained period of time (e.g. over the course of an hour), or have very frequent CO2 peak levels exceeding 2,000ppm, please contact your Ministry property advisor.<br><br>In addition, instigate at least four refresh breaks through the school day where you reboot the room with all windows and doors open for a few minutes, and preferably with the room unoccupied. |



[1] https://temahau.govt.nz/covid-19/advice-schools-and-kura/ventilation-schools/assessing-ventilation

## USA: Centers for Disease Control and Prevention (CDC)[2]

### *Basic strategies*

1. *Maintain regularly as recommended by the manufacturer.*

2. *Change filters in your system regularly, according to the manufacturer's instructions.*

3. *Ensure filters fit properly in the filter rack, so as little air as possible gets around the filters.*

### *Enhanced strategies*

1. ***Aim for 5** - Aim to deliver 5 or more air changes per hour (ACH) of clean air to rooms in your building. This will help reduce the number of viral particles in the air. You may need to use a combination of ventilation (air supply, filtration, and air treatment) strategies to reach this target.*

2. ***Upgrade filters** - Use filters rated MERV-13 or higher, when possible. Using higher-rated filters in your heating or air conditioning system can remove more germs in the air than lower-rated filters.*

3. ***Turn your HVAC system "ON"** - Set your ventilation system to circulate more air when people are in the building. You can do this by setting the thermostat's fan control to the "ON" position instead of "AUTO." This will make the fan operate continuously but can increase fan energy use, so limit use to when needed.*

4. ***Add fresh air** - Bring more clean outdoor air into spaces by opening windows and doors and using exhaust fans. Even small openings can help.*

5. ***Use air cleaners** - Air cleaners (also known as air purifiers) filter air with high-efficiency filters that remove germs from the air. Choose one that's the right size for your space.*

6. ***Install UV air treatment systems** - UV air treatment systems can kill germs in the air. They can also provide a high level of effective air changes per hour while using little energy.*

7. ***Use portable carbon dioxide (CO2) monitors** - A portable $CO_2$ monitor can help you determine how stale or fresh the air is in rooms. Readings above 800 parts per million (ppm) suggest that you may need to bring more fresh, outdoor air into the space.*



[2] https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/improving-ventilation-in-buildings.html

## Australia: SafeWork Australia, Improving ventilation in indoor workplaces: COVID-19[3]

***Assessing the quality of indoor ventilation***

*General information on assessing the quality of indoor ventilation and minimum ventilation rates in the context of COVID-19, can be found in the World Health Organization Roadmap to improve and ensure good indoor ventilation in the context of COVID-19 (the WHO Roadmap). The WHO Roadmap defines the key questions to consider when assessing whether indoor ventilation is adequate. It outlines steps to reach recommended ventilation rates through both natural and mechanical ventilation to reduce the risks of COVID-19. Section 6.2 of the WHO Roadmap provides a helpful flow chart outlining these steps and strategies. The British Occupational Hygiene Society has also published a ventilation tool with helpful guidance for workplaces.*

*Many businesses have complex indoor spaces and/or complex ventilation systems which may make assessment of indoor ventilation and airflow difficult. In these cases, building owners and/or facilities managers or other businesses should consult with a mechanical or ventilation engineer and an occupational hygienist to assess the quality of indoor ventilation and get advice on maintaining or improving ventilation to minimise the risks of COVID-19. These experts may also advise on minimum ventilation rates per person and maximum building occupancy.*

***Monitoring the quality of indoor ventilation***

*Although carbon dioxide (CO2) levels are not a direct measure of possible exposure to the COVID-19 virus, checking levels using a CO2 monitor may help identify poorly ventilated areas. However, CO2 levels will depend on the occupancy density and do not measure the effectiveness of other infection prevention and control measures put in place.*

*According to the UK Health and Safety Executive, a consistent indoor air concentration of less than 800 parts per million (ppm) CO2 is likely to indicate that a space is well ventilated.*

*When CO2 concentration measurements average between 800-1500ppm over the occupied period this is an indicator to take action to improve indoor ventilation. An average of 1500ppm CO2 concentration over the occupied period in a space is likely an indicator of poor ventilation. You should particularly take action to improve ventilation where CO2 readings are consistently higher than 1500ppm. However, where there is continuous talking or singing, or high levels of physical activity (such as dancing, playing sport or exercising), a higher level of ventilation may be required to keep CO2 levels below 800ppm, given the higher risks of transmission.*

*Measurements of CO2 should be taken at different times with different occupancies to get a better indication of how the ventilation system is working under different conditions. There are some situations where CO2 monitors may be less informative, such as areas that rely on air cleaning units, or large, open spaces with high ceilings (e.g. warehouses), or areas with very limited occupation density (e.g. large office areas with one or two occupants). There are many different types of CO2 monitors available and you should consult a ventilation engineer or occupational hygienist about whether CO2 monitoring is required, and which type is best for your circumstances.*

***Measures to improve indoor ventilation***

*This section provides general information about improving indoor ventilation through natural and mechanical ventilation. Improving ventilation using a combination of natural and mechanical ventilation is also possible, using the strategies outlined below. Further information can be found in the WHO Roadmap. You may need to consult with a mechanical or ventilation engineer, your building owner and/or facilities manager to adjust your systems to help minimise the risks of COVID-19.*

***Natural ventilation (passive air flow)***

*Many buildings do not have mechanical ventilation systems. In these cases, improving ventilation will require you to consider passive air flow. You can consider ways to improve natural ventilation in your workplace such as opening windows, doors (but not fire doors), air vents and roof turrets/whirlybirds,*

[3] https://covid19.swa.gov.au/doc/improving-ventilation-indoor-workplaces-covid-19

*where possible. Do not open windows and doors if doing so poses a security risk, safety risk (such as a risk of falling), or other health risk, such as triggering asthma or other respiratory diseases when pollen counts are high or bush fire smoke is present outside (refer to guidance on Managing the risks from air pollution: Advice for PCBUs for more information about air pollutants). If improvement to indoor air quality is needed in these situations, consider alternatives such as filtration (outlined in Table 2 in the section on Mechanical Ventilation below).*

*You should also consider whether objects such as furniture, pillars and screens prevent the flow of air and cause stale air to accumulate in parts of the workplace, noting that screens may be useful to protect workers. As mentioned above, using a CO2 monitor may help assess whether there is a need to improve air quality.*

*Where possible, you can open windows on opposite sides of the room to increase airflow through cross ventilation (air entering through one window, crossing the room and exiting via another window). When the room is occupied, the thermal comfort (heat and cold) of workers needs to be taken into consideration.*

*You should consider still days and areas where airflow improvement is difficult (such as stairwells or elevators). Ceiling and portable fans can also be used to improve natural ventilation, but you should take care to ensure the air is not directly blowing from one person to another and that fresh air is available. Refer to Table 2 for more information about using mechanical ventilation options such as exhaust fans and air cleaners to improve indoor air quality.*

*Where possible, you should continue to leave doors and windows open even when the room is unoccupied to air the room.*

*Table 1 lists some ways you can improve natural ventilation in the workplace.*

***Table 1: Measures to improve natural ventilation (adapted from the United States Centers for Disease Control and Prevention Ventilation in Buildings).***

| | |
|---|---|
| *Increase the introduction of outdoor air* | *Opening windows and doors, where possible and when weather conditions allow, to increase outdoor air flow. Do not open windows and doors if doing so poses a safety or health risk (e.g., risk of falling, triggering asthma or hay fever symptoms, exposure to extreme temperatures or bushfire smoke and outdoor noise pollution) to occupants in the building.* |
| *Use portable fans to increase the effectiveness of open windows* | *To achieve this, fan placement is important and will vary based on room configuration. Avoid placing fans in a way that could potentially cause contaminated air to flow directly from one person to another. This is particularly important in indoor environments where people are exercising and breathing heavily, such as in gyms.* |

***Mechanical ventilation***

*Mechanical ventilation is the active process of supplying air to or removing air from an indoor space by powered air movement components.*

*Ventilation can be improved by adjusting mechanical ventilation systems such as HVAC systems. Building mechanical ventilation systems can be complex and adjustments should be made by people familiar with the operation of your building's systems. You may need to consult with a mechanical or ventilation engineer, your building owner and/or facilities manager to adjust your systems to help minimise the risks of COVID-19.*

*For HVAC systems, it is preferable to maximise fresh air supply and not recirculate air. If you have exhaust fans in restrooms, kitchens and other facilities, check they are functional and operating continuously and at full capacity. Operating them when the space is not occupied will also improve overall ventilation.*

*Kitchen exhausts in many fast-food shops and restaurants often deliver good ventilation outcomes providing there is a source of fresh air. To prevent contaminated air moving outside bathrooms, keep exhaust fans running in toilets provided the fan motors are suitable to be operated continuously. A mechanical engineer or electrician can check the fan motor's capacity to operate continuously, or you may be able to download the fan specification. Do not operate fans continuously if they are not rated for this.*

*Exhausted air should be directed outdoors and away from windows and air intake systems of your building and that of any surrounding buildings. Your building owner and/or facilities manager can assist you with checking and adjusting air flow at your workplace.*

*Air purifiers or cleaners such as those fitted with high-efficiency particulate air (HEPA) filters can lower the concentration of airborne contaminants (including viruses) in the air and are useful additions in areas with poor ventilation. It is important to consider the filtration capacity required and to place in a location that does not interfere with existing HVAC airflow. Air purifiers or cleaners should be operated and maintained in accordance with the manufacturer's instructions. Businesses should consider consulting an occupational hygienist to assist in determining appropriate placement of these devices within the room to ensure maximum benefit is achieved.*

*HVAC systems must always be maintained by a qualified mechanical or ventilation engineer in accordance with the manufacturer's instructions to ensure ongoing compliance with building regulations, including during the COVID-19 pandemic.*

*If you do not directly control or manage the HVAC unit or system, you will need to liaise with the building owner and/or facilities manager to ensure the system is regularly inspected and maintained. Before you allow your workers to resume work after a period of shutdown, you should confirm with the building owner and/or facilities manager that the correct start-up procedures and control settings have been followed.*

*It is important that you do not open windows or doors to improve air quality in buildings with mechanical ventilation systems unless checked by a mechanical engineer. You should not operate fans outside their designed operation to avoid the risk of overheating fan motors.*

*See our webpage on HVAC Systems for more details on maintenance.*

*Table 2 lists some ways you can improve mechanical ventilation in the workplace.*

***Table 2: Measures to improve mechanical ventilation (adapted from the United States Centers for Disease Control and Prevention Ventilation in Buildings).***

| | |
|---|---|
| *HVAC systems* | *Consider opening outdoor air dampers beyond minimum settings to reduce or eliminate HVAC air recirculation and increase the introduction of outdoor air. In mild weather, this will not affect thermal comfort or humidity. However, this may be difficult to do in cold, hot, or humid weather, and as systems differ may require consultation with a mechanical or ventilation engineer regarding your individual HVAC system.*<br><br>*Rebalance or adjust HVAC systems to increase total airflow to occupied spaces, where possible.*<br><br>*Consider running the HVAC system at maximum outside airflow for 2 hours before and after the building is occupied. You may need to consult a ventilation engineer regarding your individual HVAC system.*<br><br>*Turn off any demand-controlled ventilation (DCV) controls that reduce air supply based on occupancy or temperature during occupied hours.*<br><br>*In buildings where the HVAC fan operation can be controlled at the thermostat, set the fan to the "on" position instead of "auto," which will operate the fan continuously, even when heating or air-conditioning is not required.* |
| *Improve central air filtration* | *HVAC filters that only filter outdoor air do not need to be upgraded.*<br><br>*Increase indoor air filtration to as high as possible without significantly reducing design airflow. Increased filtration efficiency (the fraction of particles removed from air passing through the filter) is especially helpful when enhanced outdoor air delivery options are limited.*<br><br>*Inspect filter housing and racks to ensure appropriate filter fit and minimise air that flows around, instead of through, the filter.*<br><br>*Make sure air filters are maintained in accordance with the manufacturer's instructions and replaced at the end of their service life.* |

| | |
|---|---|
| *Use and maintain window, restroom and kitchen exhaust fans* | *Use a window exhaust fan, placed safely and securely in a window, to exhaust room air to the outdoors. This will help draw outdoor air into the room via other open windows and doors without generating strong room air currents. Similar results can be achieved in larger facilities using other fan systems, such as gable fans and roof ventilators.*<br><br>*Ensure restroom exhaust fans are functional and operating at full capacity. Operating them even when the specific space is not occupied will increase overall ventilation.*<br><br>*Inspect and maintain exhaust ventilation systems in areas such as kitchens, cooking areas. Operate these systems any time these spaces are occupied. Operating them for a few hours even when the specific space is not occupied will increase overall ventilation. However, it is important to ensure that fans are not operated outside of their designed cycle time to avoid the risk of overheating the fan motors.* |
| *Air purifiers or cleaners with HEPA filters* | *Use of air purifiers or cleaners with HEPA filters can reduce the concentration of COVID-19 virus in the air, if it is present.*<br><br>*Use only HEPA filters. Air cleaners that use other types of filters are less efficient than those with HEPA filters at reducing the concentration of COVID-19 virus in the air.*<br><br>*Choose an air purifier or cleaner that is appropriate for the size of the room it is placed in.*<br>*Placement of air cleaners or purifiers is important to improve airflow and quality and businesses may want to consult an occupational hygienist.*<br><br>*Air cleaners and purifiers should be maintained as per manufacturer's instructions.* |

## Victoria, Australia: Ventilation[4]

***How to improve ventilation at home or in the workplace***

*There are simple steps you can take to ventilate your home and prevent COVID-19 virus aerosols from accumulating inside.*

*To ventilate your home or workplace, you should:*

1. *Let fresh air in.*
2. *Improve airflow.*
3. *Filter the air.*

### *1. Let fresh air in*

*Bringing outdoor air into your home is the simplest way to ventilate your home. If it is safe, open doors and windows to bring outdoor air in.*

*Natural ventilation is especially effective when air can flow across indoor spaces, so try to open doors, windows, and vents on opposite sides of a room or corridor.*

*While it is better to open windows as wide as possible, even having a window open slightly can help.*

*Remember to leave internal doors open in hallways and corridors.*

***During colder months***

*There is an increased risk of COVID-19 spreading in the cooler months because windows and doors tend to be closed and people gather indoors.*

*You should still try to open windows where practical, even if only for 10 minutes each hour or when a room is empty.*

*Your comfort and safety should remain your priority.*

### *2. Improve airflow*

*You can use existing heating and cooling systems to help circulate air in your home and prevent COVID-19 aerosols from accumulating. It is best to use options that circulate fresh air into the room.*

***Split system air conditioners***

*Split system air conditioners circulate air in a room but do not bring in fresh air. Most home air conditioners are split system. If you have a split system, keep it on, but keep a window, vent or door open too to bring in fresh air. Use the 'on' mode rather than 'auto' mode for best results.*

***Evaporative cooling and ducted systems***

*Some older evaporative cooling systems and ducted systems bring in air from outside. Some windows or doors need to be left open for these systems to circulate fresh air effectively.*

*Run evaporative coolers or ducted systems once or twice a day in 'fan-only' mode to flush rooms with fresh outside air.*

*Heating and cooling systems need to be serviced regularly to make sure they are running effectively.*

*If you are using a ducted system or air conditioner, change the filter regularly according to the manufacturer's instructions.*

[4] https://www.coronavirus.vic.gov.au/ventilation

*Some buildings have commercial ventilation systems that require specialist knowledge to operate. Building owners should get advice on how to increase fresh air circulation and filtration in these systems.*

***Fans***

*Fans can be used in addition to other methods to reduce the build-up of COVID-19 aerosols, especially in areas with poor airflow.*

*Fans circulate air in a room but do not provide fresh air. Fans work best when used alongside open windows, vents, or doors to bring in fresh air.*

*Turn ceiling fans on a low setting or use a pedestal fan in 'swing' mode to help air circulate.*

*Place pedestal fans near an open window, if possible, but point them away from people so they do not blow air directly onto others.*

## *3. Filter the air*

*Portable air cleaners (filtration units, scrubbers, or purifiers) use filters to remove aerosol particles and other contaminants and release clean air.*

*Air cleaners are useful when existing heating and cooling systems do not bring fresh air into a space.*

*Put air cleaners in places where there is the least ventilation, away from windows, vents, fans, and grilles. Place the unit so the air intake is clear of obstructions.*

*Always choose the highest flow setting (when noise levels allow) and, if possible, keep the unit on for at least two hours after a room has been used. Check manufacturer instructions to make sure your air cleaner is big enough for the size of the room.*

***What if you can't change ventilation in an indoor space?***

*If you can't change ventilation in your indoor space, consider reducing risk by:*

- *moving any gatherings with more people to an outdoor location*
- *reducing the number of people in an indoor space at any one time*
- *reducing the length of time people spend indoors together*
- *avoiding peak activity times and places where people gather indoors*
- *wearing a well-fitted face mask when indoors*
- *optimising ventilation by periodically opening a window (for example, every 10 minutes at every hour if the weather is too cold or supervision is needed near an open window).*

***A carbon dioxide monitor***

*A personal carbon dioxide (CO2) monitor is a small portable device that measures the amount of carbon dioxide that people have breathed out into a room or space.*

*CO2 monitors can help you decide if a room that appears low risk might carry a higher risk. These include spaces that have few people or low activity, such as some offices or libraries. A high CO2 reading suggests the ventilation is poor.*

*CO2 monitors are not useful where there are a lot of activity and people moving over short periods of time, such busy cafés, or gyms. These are already higher risk environments.*

*There are limitations to their use. CO2 monitors don't measure the COVID-19 virus in the air and don't account for the effect of filtration or masks.*

*You can buy CO2 monitors at some stores and online. Use according to the manufacturer's instructions.*

*Businesses may consider CO2 monitors to identify ventilation dead zones or use other monitoring systems. These other systems may be complex and require specialist advice.*

***More information for workplaces***

*Good ventilation is essential to keep workers, customers and the public safe. Workplaces with crowded or high-traffic areas can carry a higher risk of COVID-19 transmission.*

*For general information and guidance to help workplaces incorporate ventilation into their COVIDSafe Plan, see Ventilation in the workplace.*

*Different types of businesses need different types of ventilation strategies and have differing requirements. To learn more about ventilation in your business, see:*

- *Small Business Ventilation Guide*
- *Guide | Improve ventilation*
- *Ventilation principles and strategies to reduce transmission of COVID-19 in community and workplace settings*

**Victoria, Australia: Ventilation principles and strategies to reduce transmission of COVID-19 in community and workplace settings v3 (June 2023) (excerpt)[5]**

### *4.1 Air changes per hour (ACH)*

*Air change per hour refers to the rate at which clean air is moved through a space within an hour. Evidence suggests that air change rates of 4-5 are good, 6 are better and >6 are best.*

*Aim for 5 or more air changes per hour (ACH) of clean air to help reduce the number of viral particles in the air. This can be achieved through any combination of mechanical ventilation, natural ventilation, or devices that augment existing ventilation systems.*

*The 5 ACH target provides a guide to air change levels likely to be helpful in reducing infectious particles. The optimum number of ACH remains uncertain.*

*For guidance on calculating ACH, refer to Centres for Disease Control and Prevention (CDC) May 2023 Ventilation in Buildings | CDC <https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html>.*

*Large volume spaces with very few occupants (e.g., a warehouse) may not require 5 ACH and spaces with high occupancy or higher-risk occupants may need higher than 5 ACH.*

*While ACH levels higher than 5 (e.g., those used in negative pressure isolation rooms in hospitals) may reduce infectious aerosols further, the potential benefits of increased ventilation should be balanced with the additional upfront costs, periodic maintenance, comfort level, and energy costs that will be incurred.*



[5] https://www.coronavirus.vic.gov.au/sites/default/files/2023-06/ventilation-principles-and-strategies-to-reduce-transmission-of-covid-19-in-community-and-workpaces.docx

## UK: Health and Safety Executive (HSE), Improving ventilation in the workplace (excerpt)[6]

### *1. Overview*

*Employers must make sure there is adequate ventilation in enclosed areas of their workplace.*

*Ventilation is the process of bringing in fresh air from outside and removing indoor air, which may:*

- *be stale*
- *be hot and humid because of work machinery and processes*
- *contain pollutants and other impurities*

*This guidance will help you and your workers:*

- *assess your workplace to identify poorly ventilated areas*
- *decide on the actions you can take to improve ventilation*

*It does not cover the removal of harmful substances from the air such as welding fumes and dust generated by processes. For help with this, go to our guidance on:*

- *the Control of Substances Hazardous to Health Regulations (COSHH)*
- *local exhaust ventilation*

*The guidance aims to help businesses comply with their duty to provide sufficient fresh air under health and safety law rather than reducing the spread of infectious diseases.*

#### *Why ventilation is important*

*Not only is it the law to provide sufficient fresh air, but studies have shown that good ventilation is associated with:*

- *improved health*
- *better concentration*
- *higher levels of satisfaction with an environment*
- *lower rates of absence from work*
- *better quality of sleep*
- *reduced exposure to a wide range of air pollutants*

#### *Methods of ventilation*

*The method of ventilation will depend on the building and you will need to decide which options work best for your workplace.*

*Natural ventilation relies on doors, windows and other openings such as trickle vents, air bricks or grilles to provide air.*

*Mechanical ventilation uses fans to move air into and out of rooms. In small spaces and buildings these may be in the room, but larger buildings may use a network of ducts and fans to blow clean air into rooms and/or extract the stale air.*

*Many buildings have a mixture of natural and mechanical ventilation, with either (or both) systems in different spaces.*



[6] https://www.hse.gov.uk/ventilation/overview.htm

***What the law says***

*Under regulation 6 of the Workplace Health, Safety and Welfare Regulations, employers must 'ensure that every enclosed workplace is ventilated by a sufficient quantity of fresh or purified air'.*

## *2. Assessing the risk of poor ventilation*

*As part of your legal duty to provide sufficient fresh air, your workplace risk assessment should identify poorly ventilated work areas:*

- *look for areas where there is no natural ventilation (open windows, doors, or vents) or mechanical ventilation (fans or ducts bringing air in from outside)*
- *identify areas that feel stuffy or smell bad*
- *consider using a CO2 monitor to identify poor ventilation*

*It may help to list areas in your workplace or use floor plans to record how areas are ventilated. Remember to include changing rooms and areas used for breaks, such as canteens.*

***Understanding when to take action***

*The ventilation rate*

*The ventilation rate refers to the volume of air that is provided to a room over a period of time. What is necessary for adequate general ventilation will depend on several factors such as the amount of floor space per occupant, and the work activity.*

*HSE's Approved Code of Practice and guidance (PDF) states that 'The fresh-air supply rate should not normally fall below 5 to 8 litres per second, per occupant.' A value of 10 litres per second per person is recommended in some building guides as a suitable value for most commercial buildings. In some workplaces, like draughty workshops, it is obvious there is enough air. In other, more enclosed settings, it can be difficult to estimate the flow rate of air in a space, particularly for natural ventilation, but a useful way to do it when you think you may have a problem is by using CO2 monitors.*

*Complex ventilation systems*

*If your workplace has/requires a complex ventilation system, for example due to having multiple floors, more detailed guidance is available from the Chartered Institution of Building Services Engineers (CIBSE).*

*You may need a ventilation engineer to provide expert advice on the best system for your workplace.*

*Desk or ceiling fans*

*You should not rely purely on desk or ceiling fans in poorly ventilated areas. They won't improve fresh air.*

*Local exhaust ventilation*

*You may use local exhaust ventilation (LEV) to control risks from workplace hazards such as dust or welding fumes. If an LEV system discharges the air outside, it will also improve general ventilation in the area.*

*Talk with your workers*

*Talking with your workers will help you assess the risk and put in effective measures to improve ventilation.*

*Questions to ask them*

- *How do we bring fresh air (ventilation) into our workplace?*
  - *Think about natural ventilation through windows, doors and vents you can open fully or partially*
  - *If we use mechanical ventilation, is it set correctly and do we maintain it?*

- *How can we improve ventilation?*
    - *Think about areas that feel stuffy or smell bad – open windows, air vents and doors (not fire doors)*
    - *If we have recirculating systems, do we bring in some fresh air?*
    - *Are temperatures in the workplace comfortable?*

*Discussing the outcome of your risk assessment and the measures identified will also help them understand how they can play their part in improving ventilation at work.*

## *3. How to improve ventilation*

*Practical ways to improve your ventilation include:*

- *increasing natural ventilation by opening doors, windows and vents*
- *ensuring that mechanical systems which recirculate air, including air-conditioning systems, have been designed with fresh air inlets and that they are kept open to avoid the air becoming unhealthy*

*You may need a combination of natural and mechanical ventilation.*

### *How to improve natural ventilation*

*You can improve natural ventilation by fully or partly opening windows, air vents and doors. But do not prop fire doors open.*

*You should be able to open any windows and keep vents or trickle vents open that let in fresh air. If any windows have been painted shut, they should be reopened. If they cannot be opened, ventilation in that area will be less effective.*

*Airing rooms*

*If ventilation is poor, airing rooms can improve it as a temporary measure while awaiting longer-term changes. Opening all the doors and windows as fully as possible maximises ventilation in a room.*

*If it's too cold for the people in the room you can do this when they leave for a break. Even 10 minutes an hour can help increase the amount of fresh air, depending on the size of the room.*

### *How to improve mechanical ventilation*

*Mechanical ventilation brings fresh air into a building from outside using ducts and fans. Providing it is working correctly, it has the advantage of providing fresh air consistently. However, it may be more costly, requires energy to operate the system and needs to be properly maintained.*

*It's important to make sure that clean outdoor air is actually supplied, rather than assuming outdoor air is clean. If you expect the air coming in to be heavily contaminated with particulates such as heavy traffic or smoke, then it should be filtered.*

*You should speak to the people who manage the day-to-day operations of your workplace's mechanical ventilation systems to:*

- *understand how they operate*
- *make sure they're supplying fresh air into an area and how much*
- *make sure they're maintained in line with manufacturers' instructions*

*You may need a ventilation engineer to check your system is providing adequate ventilation.*

### *Use of recirculated air*

*Air to be recirculated should be adequately filtered to remove particulates and should have fresh air added to it before being reintroduced into the workplace.*

*HSE's Approved Code of Practice states 'In the case of mechanical ventilation systems which recirculate air, including air-conditioning systems, recirculated air should be adequately filtered to*

*remove impurities. To avoid air becoming unhealthy, purified air should have some fresh air added to it before being recirculated. Systems should therefore be designed with fresh-air inlets, which should be kept open.'*

***If your ventilation is still poor***

*If your ventilation is still inadequate, for example if CO2 readings remain above recommended levels or the room continues to feel stuffy, you could consider:*

- *changing how workspaces are used, for example restricting the length of time people spend in them or the number of people using them at a single time*
- *installing a mechanical ventilation system (upon advice from a ventilation engineer), if there is no mechanical ventilation already or if the existing system does not provide fresh or purified air*

*Find out more*

*Examples of improving ventilation.*

## *5. Using CO2 monitors*

*Carbon dioxide (CO2) monitors can help you identify poor ventilation so you can improve it.*

- *How monitors can help identify poor ventilation*
- *Types of monitor*
- *How to use a monitor*
- *Where to place them*
- *How to get accurate measurements*
- *Understanding the numbers and when to take action*
- *Deciding if a space is suitable for monitors*

*How monitors can help identify poor ventilation*

*The priority for your risk assessment is to identify areas of your workplace that are usually occupied and poorly ventilated.*

*People breathe out CO2. If there is a build-up of CO2 in an area it can indicate that ventilation needs improving.*

*There is separate guidance for businesses to help them assess the risk from CO2 as a hazardous substance.*

*Types of monitor*

*The most appropriate portable devices to use in the workplace are non-dispersive infrared (NDIR) CO2 monitors.*

*How to use a monitor*

*Before using the monitor, read the manufacturer's instructions so you understand how to use it correctly.*

*Where to place them*

*CO2 levels vary within an indoor space.*

*Place them at head height and keep them away from:*

- *windows*
- *doors*
- *air supply openings*

*Position the monitors over 50cm away from people as their exhaled breath contains CO2. If your monitor is too close it may give a misleadingly high reading.*

*Try out several locations to find the most representative position for the monitor in the space. In larger spaces more than one sampling location will usually be required.*

*How to get accurate measurements*

- *Follow the manufacturer's instructions, including those on calibrating your monitor*
- *Single or 'snapshot' readings can be misleading. Take several measurements throughout the day, when the room is occupied, to represent changes in activities, the number of people using it and ventilation rates*
- *As weather changes you may need to repeat monitoring due to differences in natural ventilation, for example from different windspeeds or people opening and closing windows or doors to prevent draughts*
- *Record CO2 readings, number of occupants and the type of ventilation you're using at the time. This information will help you decide if an area is poorly ventilated*

## *Understanding the numbers and when to take action*

### *The ventilation rate*

*The ventilation rate refers to the volume of air that is provided to a room over a period of time and is often stated in building guidance as ' recommended values'.*

*HSE's Approved Code of Practice states that 'The fresh-air supply rate should not normally fall below 5 to 8 litres per second, per person (l/s/p). A value of 10 litres per second per person is recommended in many guides as a suitable value for most commercial buildings.'*

*CO2 monitors are a useful way to estimate airflow rates. The amount of CO2 in the air is measured in parts per million (ppm). 1000ppm is equivalent to about 10 litres per second, per person.*

*CO2 levels consistently higher than 1500ppm in an occupied room indicate poor ventilation and you should take action to improve it.*

*Remember that CO2 measurements are only a broad guide to ventilation rather than demonstrating 'safe levels'*

*Deciding if a space is suitable for CO2 monitors*

*CO2 monitors will only be effective in certain workspaces. They are not suitable in areas with air cleaning units because these remove contaminants from the air but do not remove CO2 or improve ventilation.*

*Monitors are also not suitable in areas that contain processes that produce CO2. They are of limited use in:*

- *areas with not many people in them, including fitting rooms or large offices with one or two occupants or if the numbers of people are inconsistent*
- *large, open spaces with higher ceilings such as production halls or warehouses, where you can't be sure the air is fully mixed and CO2 monitors may be less representative*

*The following examples of different workspaces will help you consider whether a CO2 monitor is appropriate for you.*

***Small spaces (up to 50 square metres)***

- *Monitors can be used for spaces when the same number of people use the space for over an hour, such as small offices and meeting rooms*
- *They are unlikely to give reliable measurements where the overall number of people changes over short amounts of time, for example in changing rooms and small retail premises*

***Mid-sized work spaces (50-320 square metres)***

- *Monitors can be used for spaces when a consistent number of people use them for over an hour, such as larger office and meeting rooms, classrooms, restaurants/bars and some retail spaces*
- *They can be used for spaces where the overall number of people changes over short amounts of time, for example some retail settings. Treat results carefully as CO2 levels may be affected by these changes*

***Large spaces (over 320 square metres)***

- *Monitors can be used when a consistent number of people use the space for a longer period of time, for example indoor concert venues, large places of worship and airport concourses*
- *You may require multiple monitors to get meaningful measurements*
- *Where the overall number of people changes over short amounts of time, for example in rail concourses and shopping centres, they are unlikely to give reliable measurements*

*These examples are based on recommendations in a paper by the Scientific Advisory Group for Emergencies (SAGE) on using CO2 monitors in managing ventilation and reducing COVID transmission but remain valid for general ventilation management.*

**UK: Workplace health, safety and welfare. Workplace (Health, Safety and Welfare) Regulations 1992. Approved Code of Practice and guidance[7]**

## Regulation 6 Ventilation

**Regulation 6**

*(1) Effective and suitable provision shall be made to ensure that every enclosed workplace is ventilated by a sufficient quantity of fresh or purified air.*

*(2) Any plant used for the purpose of complying with paragraph (1) shall include an effective device to give visible or audible warning of any failure of the plant where necessary for reasons of health or safety.*

*(3)* [Regulation 6(3) was revoked by Health and Safety (Miscellaneous Amendments) Regulations 2002 (SI 2002/2174) regulation 6(e).]

**ACOP 6**

**47 Enclosed workplaces should be sufficiently well ventilated so that stale air, and air which is hot or humid because of the processes or equipment in the workplace, is replaced at a reasonable rate.**

**48 The air which is introduced should, as far as possible, be free of any impurity which is likely to be offensive or cause ill health. Air which is taken from the outside can normally be considered to be 'fresh'. However, air inlets for ventilation systems should not be sited where they may draw in contaminated air (for example close to a flue, an exhaust ventilation system outlet, or an area in which vehicles manoeuvre). Where necessary, the inlet air should be filtered to remove particulates.**

**49 In many cases, windows or other openings will provide sufficient ventilation in some or all parts of the workplace. Where necessary, mechanical ventilation systems should be provided for parts or all of the workplace.**

**50 Workers should not be exposed to uncomfortable draughts. In the case of mechanical ventilation systems, it may be necessary to control the direction or velocity of air flow. Workstations should be re-sited or screened if necessary.**

**51 In the case of mechanical ventilation systems which recirculate air, including air-conditioning systems, recirculated air should be adequately filtered to remove impurities. To avoid air becoming unhealthy, purified air should have some fresh air added to it before being recirculated. Systems should therefore be designed with fresh-air inlets, which should be kept open.**

**52 Mechanical ventilation systems (including air-conditioning systems) should be regularly and adequately cleaned. They should also be properly tested and maintained to ensure that they are kept clean and free from anything which may contaminate the air.**



[7] https://www.hse.gov.uk/pubns/books/l24.htm

**ACOP 6**

**53 The requirement of regulation 6(2) for a device to give warning of breakdowns applies only 'where necessary for reasons of health or safety'. It will apply to 'dilution ventilation' systems used to reduce concentrations of dust or fumes in the atmosphere, and to any other situation where a breakdown in the ventilation system would be likely to result in harm to workers.**

**Guidance 6**

54 Regulation 6 covers general workplace ventilation, not local exhaust ventilation, for controlling employees' exposure to asbestos, lead, ionising radiations or other substances hazardous to health. There are other health and safety Regulations and Approved Codes of Practice on the control of such substances.[19-23] More detailed guidance on ventilation is available from HSE's website (www.hse.gov.uk/toolbox/harmful/ventilation.htm) and CIBSE (www.cibse.org/).

55 It may not always be possible to remove smells coming in from outside, but reasonable steps should be taken to minimise them. Where livestock is kept, smells may be unavoidable, but they should be controlled by good ventilation and regular cleaning.

56 Where a close, humid atmosphere is necessary, for example in mushroom growing, workers should be allowed adequate breaks in a well-ventilated place.

57 The fresh-air supply rate should not normally fall below 5 to 8 litres per second, per occupant. When establishing a fresh-air supply rate, consider the following factors:

- the floor area per person;
- the processes and equipment involved;
- whether the work is strenuous.

58 Some ventilation systems are water based. Any water system where water is used or stored, and where there is a means of creating and transmitting water droplets that may be inhaled, can create a foreseeable risk of exposure to legionella. Guidance on the necessary measures to prevent or adequately control this risk is available on the HSE website (www.hse.gov.uk/legionnaires/), in the relevant ACOP[24] and also from CIBSE[25].

59 An enclosed workplace is not necessarily a 'confined space'. Confined spaces are workplaces that are wholly or largely enclosed and where there is a specific risk of serious injury from fire, explosion, noxious gases or fumes, lack of oxygen, high temperature or asphyxiation from drowning in water or by a free-flowing solid. Work should not be done in such places where it can be avoided. If work must be done, additional risk assessment will be needed to comply with the Confined Spaces Regulations 1997 (www.hse.gov.uk/confinedspace/).

**The Lancet COVID-19 Commission, Safe Work, Safe School, and Safe Travel Task Force, "The first four healthy building strategies every building should pursue to reduce risk from COVID-19 (8 July 2022)"[8]**

# Key Strategies

## 1. COMMISSION OR RECOMMISSION BUILDING SYSTEMS

Commissioning is the process of verifying that building systems are operating as designed. The goal is to ensure that existing buildings are operating as designed and to determine what additional enhancements are needed. Recommissioning is the process of commissioning a building again, after it has previously been commissioned. Ideally buildings should be recommissioned every 3-5 years.[15,16]

- **Benefits related to reducing the risk of COVID-19 and other infectious disease transmission:** Commissioning can ensure building heating, ventilation, and air conditioning (HVAC) equipment is performing as intended. For example, common HVAC deficiencies that can be corrected by commissioning include imbalanced airflow, HVAC schedule mismatch with occupied hours, damper malfunction, and system controls malfunction.[17,18]
- **Benefits beyond disease transmission:** Commissioning leads to cost savings, energy savings, improved occupant thermal comfort, improved indoor air quality, and extended equipment life.[19] In a recent study involving 1,482 buildings, median energy savings due to commissioning in existing buildings was 6.4%.[17]
- **Feasibility:** Although there are up-front costs to commissioning (e.g., median cost in 985 projects in existing buildings was $0.26 per square foot), commissioning saves money over the long term, with a median payback time of 1.7 years for 656 commissioning projects in existing buildings.[17]

## 2. MAXIMIZE OUTDOOR AIR

Outdoor air ventilation can be mechanical (e.g., HVAC system) or natural (e.g., open windows). Buildings are typically designed to comply with guidance that specifies minimum outdoor air ventilation rates based on the building type, floor area, and occupancy (e.g., ASHRAE 62.1-2019[20]). These minimum ventilation rates, however, are not sufficient to mitigate airborne infectious disease transmission indoors. Higher ventilation rates of 10 L/s per person[21] and 4-6 air changes per hour[22] have been proposed to reduce the risk of airborne infectious disease transmission indoors.

- **Benefits related to reducing the risk of COVID-19 and other infectious disease transmission:** Increased outdoor air ventilation can dilute or displace airborne particles including those carrying viruses, resulting in lower (or no) inhaled viral doses for susceptible individuals in an indoor space.[23] Higher ventilation rates are associated with reduced sick leave and airborne infectious disease transmission.[24,19]
- **Benefits beyond disease transmission:** Higher ventilation rates are associated with improved cognitive function, work performance, and academic performance; reduced reports of building-related symptoms and illness; healthcare cost savings; reduced asthma; and reduced absenteeism.[25,26,27]
- **Feasibility:** Increasing outdoor airflow may increase building energy usage and may not be possible to achieve while maintaining occupant thermal comfort on very hot and very cold days. However, in many buildings on most days of the year, it is possible to modify HVAC controls to increase ventilation.[23] Appropriate professionals, such as HVAC engineers, can determine how best to modify HVAC controls and what additional HVAC modifications may be possible to increase outdoor airflow to a building.



[8] https://covid19commission.org/s/HPH-18706_LancetLessons_HealthyBuildings_HighRes-2.pdf

## 3. UPGRADE AIR FILTERS TO MINIMUM EFFICIENCY REPORTING VALUE (MERV) 13

HVAC systems often have air filters to remove airborne particles from outdoor air that is brought indoors and from air that is recirculated within the building.

- **Benefits related to reducing the risk of COVID-19 and other infectious disease transmission:** Upgrading filters on recirculated air to those with ratings of MERV 13 or higher will reduce the transport of airborne particles while systems are operating, which may help reduce airborne infectious disease transmission within rooms and between rooms.
- **Benefits beyond disease transmission:** Enhanced filtration can reduce indoor concentrations of airborne particles of either indoor origin (e.g., cooking, cleaning or vacuuming, frequent use of printers) or outdoor origin (e.g., vehicle traffic, wildfires, desert dust storms). Exposure to fine particulate matter is associated with reduced cognitive function and reduced respiratory and cardiovascular health.[26,27,28,29,30,31,32,33,34,35,36,37]
- **Feasibility:** Filter upgrades may not be possible for all HVAC systems; HVAC professionals should be consulted before filter changes are made in a building. Annual material, labor, and fan energy costs associated with the use of MERV 13 filtration in a hypothetical 500 $m^2$ office are estimated to be $156.[38]

## 4. SUPPLEMENT WITH PORTABLE AIR CLEANERS, WHERE NEEDED

Free-standing, plug-in portable air cleaners with high efficiency particulate air (HEPA) filters capture airborne particles in rooms where they are deployed, when sized correctly.[39]

- **Benefits related to reducing the risk of COVID-19 and other infectious disease transmission:** Properly sized portable air cleaners with HEPA filters can reduce in-room concentrations of airborne particles, including those carrying viral material.
- **Benefits beyond disease transmission:** Portable air cleaners can reduce indoor concentrations of any airborne particles and reduce the risk of harmful particle-induced impacts on neurological/cognitive, respiratory, and cardiovascular health.
- **Feasibility:** Portable air cleaners are cost-effective, flexible solutions to reduce the risk of airborne infectious disease transmission in spaces where other ventilation and filtration modifications are impossible, or where building occupants seek additional reassurance about air quality.[40]

**This is not intended to be a full and complete list of all building-related strategies organizations should pursue.** Rather, these are strategies that can be implemented quickly in nearly all buildings, are feasible, do not require substantial or expensive investments in most cases, and would lead to significant benefits in terms of risk reduction at the individual, building, and societal level. Further, each recommendation contributes to an effective COVID-19 risk reduction strategy while simultaneously providing other long-term health benefits beyond the current pandemic. As a result, we recommend that these actions be considered for acknowledgment and recognition as part of the Administration's new Clean Air in Buildings Challenge.

## The Lancet COVID-19 Commission, Safe Work, Safe School, and Safe Travel Task Force, Proposed Non-infectious Air Delivery Rates (NADR) for Reducing Exposure to Airborne Respiratory Infectious Diseases (18 November 2022)[9]

*Severe acute respiratory syndrome coronavirus 2 (SARSCoV-2) and other respiratory pathogens are effectively transmitted through the inhalation exposure route indoors, mostly in places with inadequate ventilation and filtration. Current building standards, however, promote bare-minimum ventilation and filtration targets that do not protect against infectious disease transmission. There is urgency in setting new minimum standards that can help reduce respiratory disease risk indoors and promote better health overall. Yet, to date, leading organizations have not established clear health-based targets for use outside of healthcare settings. There also remains significant confusion regarding which metric to use (volumetric flow rate of air per volume of the room, per person, or per floor area). The important scientific debates about metrics and targets must continue. However, while there is debate about the "best" metric to use, and there is debate about the specific targets for each, there is no debate that the current targets are too low.*

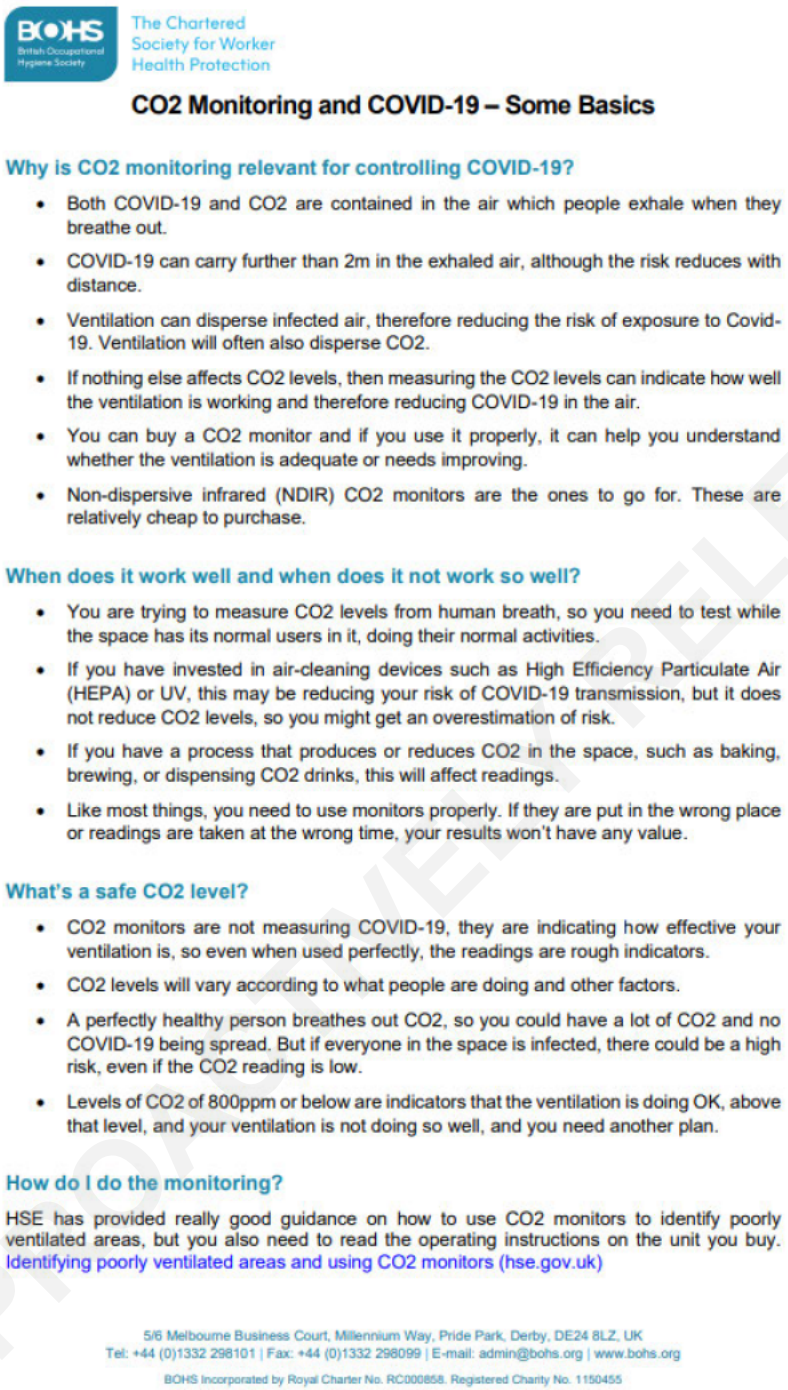
*To advance this conversation around health-based ventilation targets for airborne respiratory pathogens, the Lancet COVID-19 Commission Task Force on Safe Work, Safe School, and Safe Travel reviewed the scientific evidence around ventilation and disease transmission for SARS-CoV-2 and other airborne pathogens. We found that when we look at the totality of evidence – and despite differences across studies, experts, and metrics – there is coalescence around ventilation targets above current minimums. Based on this assessment, the Task Force proposes the following Non-infectious Air Delivery Rates (NADR) for Reducing Exposure to Airborne Respiratory Infectious Diseases, which are feasible and achievable right now with existing and widely available approaches and technologies. Note that these proposed NADRs are not intended to replace existing targets for healthcare or residential settings.*

**Proposed Non-infectious Air Delivery Rates (NADR) for Reducing Exposure to Airborne Respiratory Diseases; The Lancet COVID-19 Commission Task Force on Safe School, Safe Work, and Safe Travel**

| | Volumetric flow rate per volume | Volumetric flow rate per person | | Volumetric flow rate per floor area | |
|---|---|---|---|---|---|
| | ACHe | cfm/person | L/s/person | cfm/ft$^2$ | L/s/m$^2$ |
| Good | 4 | 21 | 10 | 0.75 + ASHRAE minimum outdoor air ventilation | 3.8 + ASHRAE minimum outdoor air ventilation |
| Better | 6 | 30 | 14 | 1.0 + ASHRAE minimum outdoor air ventilation | 5.1 + ASHRAE minimum outdoor air ventilation |
| Best | >6 | >30 | >14 | >1.0 + ASHRAE minimum outdoor air ventilation | >5.1 + ASHRAE minimum outdoor air ventilation |

[9] https://covid19commission.org/s/Lancet-Covid-Commission-TF-Report-Nov-2022.pdf

## British Occupational Hygiene Society[10]



The Chartered Society for Worker Health Protection

### CO2 Monitoring and COVID-19 – Some Basics

**Why is CO2 monitoring relevant for controlling COVID-19?**

- Both COVID-19 and CO2 are contained in the air which people exhale when they breathe out.
- COVID-19 can carry further than 2m in the exhaled air, although the risk reduces with distance.
- Ventilation can disperse infected air, therefore reducing the risk of exposure to Covid-19. Ventilation will often also disperse CO2.
- If nothing else affects CO2 levels, then measuring the CO2 levels can indicate how well the ventilation is working and therefore reducing COVID-19 in the air.
- You can buy a CO2 monitor and if you use it properly, it can help you understand whether the ventilation is adequate or needs improving.
- Non-dispersive infrared (NDIR) CO2 monitors are the ones to go for. These are relatively cheap to purchase.

**When does it work well and when does it not work so well?**

- You are trying to measure CO2 levels from human breath, so you need to test while the space has its normal users in it, doing their normal activities.
- If you have invested in air-cleaning devices such as High Efficiency Particulate Air (HEPA) or UV, this may be reducing your risk of COVID-19 transmission, but it does not reduce CO2 levels, so you might get an overestimation of risk.
- If you have a process that produces or reduces CO2 in the space, such as baking, brewing, or dispensing CO2 drinks, this will affect readings.
- Like most things, you need to use monitors properly. If they are put in the wrong place or readings are taken at the wrong time, your results won't have any value.

**What's a safe CO2 level?**

- CO2 monitors are not measuring COVID-19, they are indicating how effective your ventilation is, so even when used perfectly, the readings are rough indicators.
- CO2 levels will vary according to what people are doing and other factors.
- A perfectly healthy person breathes out CO2, so you could have a lot of CO2 and no COVID-19 being spread. But if everyone in the space is infected, there could be a high risk, even if the CO2 reading is low.
- Levels of CO2 of 800ppm or below are indicators that the ventilation is doing OK, above that level, and your ventilation is not doing so well, and you need another plan.

**How do I do the monitoring?**

HSE has provided really good guidance on how to use CO2 monitors to identify poorly ventilated areas, but you also need to read the operating instructions on the unit you buy. Identifying poorly ventilated areas and using CO2 monitors (hse.gov.uk)

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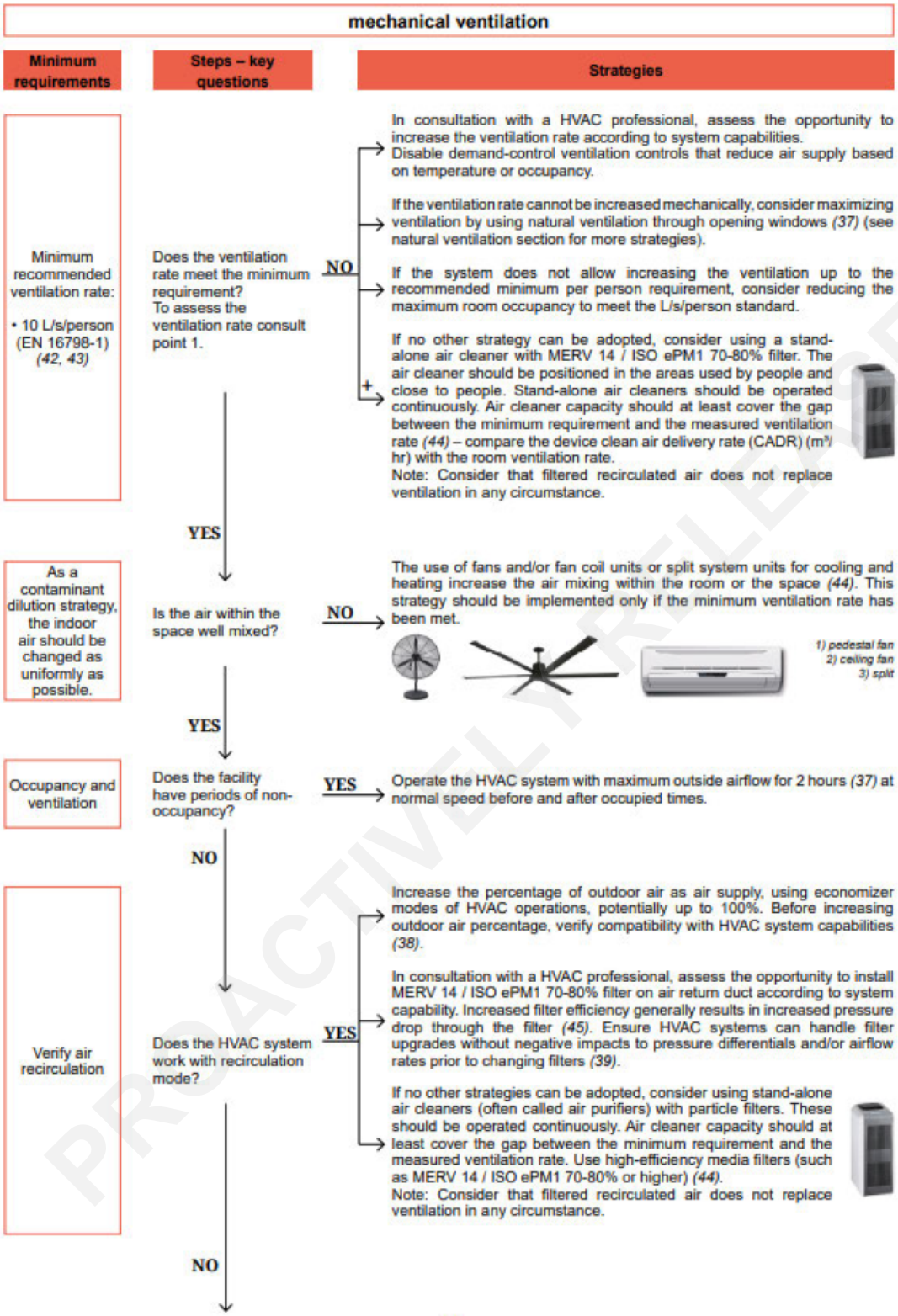
BOHS Incorporated by Royal Charter No. RC000858. Registered Charity No. 1150455



See also: COVID-19 and Ventilation Frequently Asked Questions[11]

[10] https://www.bohs.org/app/uploads/2021/09/CO2-Monitoring-and-Covid-19-Some-Basics.pdf
[11] https://www.bohs.org/app/uploads/2021/07/COVID-19-and-Ventilation-FAQs-v2.pdf

## World Health Organisation (WHO)[12]




[12] **Roadmap to improve and ensure good indoor ventilation in the context of COVID-19** (*Non-residential settings with mechanical ventilation)* https://www.who.int/publications/i/item/9789240021280

Verify heat recovery unit

Is the HVAC system designed with heat recovery?

YES

- Virus particle transmission via heat recovery devices is not an issue when a HVAC system is equipped with a twin-coil "run around loop" heat exchanger that guarantees air separation between the return and supply side *(40)*.
- Virus particle transmission via heat recovery devices is not an issue when a HVAC system is equipped with cross-flow air-to-air heat exchangers, if the heat exchanger is not compromised.
- For rotary heat exchangers, fitted with purging sectors and properly maintained seals, leakage rates are very low, and cross contamination is a minimal risk.
- If critical leaks (>3%) are detected in the heat recovery device, in consultation with a HVAC professional, assess the opportunity to install MERV 14 / ISO ePM1 70-80% filter according to system capability. Increased filter efficiency generally results in increased pressure drop through the filter. Ensure HVAC systems can handle filter upgrades without negative impacts to pressure differentials and/or airflow rates prior to changing filters *(39)*.
- If critical leaks (>3%) are detected in the heat recovery sections and the system does not allow MERV 14 / ISO ePM1 70-80% filter installation or the highest compatible with the filter rack, pressure adjustment *(37)* (higher pressure on supply air side than exhaust air side), deactivation or by-pass of the heat exchanger could be adopted *(41)*.

NO

HVAC system should be operated continuously when people are in the building and should be regularly inspected, maintained and cleaned

Is the HVAC system regularly inspected, maintained, cleaned and operated, including filter cleaning and replacement?

NO

- HVAC systems should be regularly inspected, maintained and cleaned according to the manufacturer's recommendations. Contact a HVAC professional, manufacturer or a specialized company to verify that the system complies with the manufacturer's maintenance requirements.
- Clean or replace the air filter according to the manufacturer's recommendations.

YES

Heating and air conditioning with recirculating units should be assessed, maintained and cleaned

Conditioning and heating is performed by non-ducted (with indoor air recirculation) convectors such as split or fan coil units.

YES

- In collaboration with a HVAC professional, if the device is equipped with filters, consider replacing existing air filters with MERV 14 / ISO ePM1 70-80% filter or the highest compatible with the filter rack. Make sure the units can overcome the additional pressure drop of the new filters.
  Note: Consider that non-ducted recirculating units do not replace ventilation in any circumstance.
- Air-conditioning and heating units performed by split system and fan coil units should be periodically cleaned and maintained. Filters should also be periodically cleaned or changed.
  Note: Consider that non-ducted recirculating units do not replace ventilation in any circumstance.

NO

Air should be exhausted directly to the outside away from air-intake vents, people and animals *(34)*

Is the exhausted air correctly managed?

NO

- If the system does not allow air filter installation, consider fencing the area nearby the exhausted outlet, keeping people or animals at a distance at least of 4 m. The air intake should be at least at 2 m if air outlet is above and 4 m if air outlet is below (EN 16798) from the exhaust.
- In consultation with a HVAC professional, assess the opportunity to install MERV 14 / ISO ePM1 70-80% filter according to system capability.

YES

END

## Heating and ventilating your rental home (Tenancy Services, New Zealand)

Landlords should make sure their rental home can be well heated and ventilated. Tenants are responsible for ventilating the home during their tenancy.

### Heating your rental home

Currently landlords must provide a form of heating in any living room under the Housing Improvement Regulations 1947. Some councils may provide information on approved forms of heating. If they don't, the Tenancy Tribunal may consider an inexpensive plug in heater (or similar) to be enough. However this type of heater will most likely not meet the healthy homes standards.

Heating is one of the healthy homes standards.

To meet the heating standard landlords must provide one or more fixed heaters that can directly heat the main living room. The heater(s) must be acceptable types and must meet the minimum heating capacity required for your main living room.

Use the compliance timeframes decision tool to find out when your property needs to comply with the healthy homes standards

Healthy homes standards

Heating standard

### Keeping the home ventilated

Good ventilation reduces the amount of moisture in your home. This helps keep tenants healthy and also makes the home easier to heat.

Ventilation is also one of the healthy homes standards.

Ventilation standard

If you're a landlord, you might also want to think about:

- a dryer that vents to the outside
- a central ventilation system that sources air from the outside

Tenants should open doors and windows regularly to let fresh air in, even in winter.

Opening windows when cooking or showering, gets rid of excess moisture in your rental home. Keeping the bathroom door closed during and after showering can help prevent steam from spreading further.

Poor heating and ventilation can lead to mould growth and dampness.

Mould and dampness

### Maintaining heaters and ventilation systems

Landlords are responsible for maintaining any heaters and ventilation systems. Although landlords are responsible for maintenance, tenants are required to keep the rental property reasonably clean and tidy, and this includes any heat pumps or heaters installed for the healthy homes heating standard or supplied as part of the rental property.

Where it is accessible and easy to do so, a tenant must clean a device and its filters to a reasonable standard as well as keeping gardens or lawns clear of external units. It is best practice for landlords to show tenants how to clean and keep clean any accessible filters or units when doing the first inspection of the property.

Where any technical knowledge or any specific tools are required, or the filters are not easily accessible, the landlord is generally required to maintain the device, including cleaning. This comes under their obligation to keep heater(s) in good working order.

For usable fireplaces, the landlord will need to keep the chimney safe. They are also responsible for regular chimney cleaning, as this requires technical knowledge and specific tools. Regularly cleaning of the chimney may also be required for insurance purposes.

Under the healthy homes standards, landlords will need to close up open fireplaces or block the chimney unless the tenant asks in writing for it to remain usable and the landlord agrees.

Draught stopping standard

## Benefits for tenants and landlords

When a home is warm and dry, tenants are less likely to suffer health problems caused by cold and damp. This includes respiratory illnesses like asthma and more serious diseases like rheumatic fever.

Avoidable illnesses can result in unplanned medical bills and time off work. These extra costs can increase the risk of missed rent payments. Tenants are also likely to stay longer if their home is warm and cheap to heat.

A well-insulated home that has energy-efficient heating and appliances is easier to market and can attract a higher rent.

EECA Energywise's buying and renting checklist can help show you how warm and comfortable the home is.

# References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