THE Safer Air PROJECT

Safer shared air

A critical accessibility and inclusion issue

Acknowledgement of Country

The Safer Air Project acknowledges the Traditional Custodians of Country throughout Australia and their connections to land, sea, sky, and community. We pay our respect to their Elders past and present and extend that respect to all Aboriginal and Torres Strait Islander peoples today.

About the Safer Air Project

The Safer Air Project advocates for safer indoor air quality as a critical accessibility and inclusion issue for people living with chronic health conditions, because everyone should be able to breathe safely indoors without risking poor health outcomes. In doing so, we can create healthier, more accessible, and inclusive communities for all.

To learn more visit **saferairproject.com**

Registered charity

The Safer Air Project Ltd is registered with the Australian Charities and Not-for-profits Commission as a health promotion charity.

Our vision

Our vision is to create a world where everyone can breathe safely indoors, ensuring healthy and inclusive environments for all.

Our mission

Our mission is to advocate for the recognition of indoor air quality as a critical accessibility and inclusion issue for individuals living with chronic health conditions. Through community engagement, education, and policy advocacy we strive to raise awareness about the impact of poor indoor air quality on the well-being of high-risk populations.

We are committed to promoting equitable access to clean and healthy indoor environments by empowering communities, advocating for inclusive policies, and collaborating with stakeholders to implement solutions that ensure every person, regardless of health status, can thrive in indoor spaces safely and comfortably.

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Foreword

A little boy walks into his classroom. Instantly his face lights up when he sees his classmates running and playing with a paper airplane. I'll join in, I'll do the same! And then a realisation: he cannot be 'free' like his friends!

A young woman enters the open-plan office where she works. Friendly faces, smiles, and chats before the morning briefing. She enjoys this small community and feels part of it in every way: intellectually and socially. In a moment she will be immersed in the bustle of the morning. And then the reality sets in: 'I cannot do everything like they can.'

The air in the classroom and in the office, as in many Australian public spaces, is polluted. Nobody checks what is in the air; nobody ensures that the amount of fresh air that reaches the space is adequate in relation to the number of people in the space. Nobody knows if the air delivered is indeed 'fresh', or if occupants' respiratory emissions into the space are quickly removed from it. What are these emissions? Everything we emit during the processes of breathing, speaking, and laughing. All of what we emit because we are alive. But the emitted plume also contains microbes from our respiratory tract: viruses and bacteria. Some of them are pathogenic and make people sick or even kill them if inhaled.

The little boy and the young woman are among millions of Australians with chronic health conditions who are more susceptible to infections if they inhale these airborne pathogens. These infections could be extremely threatening to their health, and they cannot afford to get infected. Therefore, when entering the classroom or the office, they cannot feel 'free' like other people. Right now, people with chronic health conditions must protect themselves from others and the risk of infection in our shared indoor spaces, and they must take responsibility for this because no one else does.

Our Australian community prides itself on being inclusive and supportive, and indeed much has been done to make buildings accessible and safer in many ways. But inclusiveness does not extend to support for clean indoor air; thus, those who are most threatened by air pollution and especially airborne pathogens are excluded from enjoying the most basic freedom of the physiological function of breathing.

But it should not be like this. No one should have to worry about breathing air in public spaces. Indoor air pollution affects us all, and we all have the right to clean air indoors, where we spend more than 90% of our time breathing 12 times per minute. All of us – regardless of whether we have a disability or a chronic condition.

Is it possible to guarantee clean indoor air in all public spaces? The science of indoor air is advanced, and we have sophisticated engineering and building design technologies to achieve this goal. What is missing is the will to implement this knowledge and know-how, and the understanding of how important it is for us all.

The Safer Air Project and its leader, Plum Stone, are doing an extraordinary job of fostering an understanding of the critical role of clean air for the health of our communities and working tirelessly to make clean air the norm. I congratulate the Safer Air Project on this noble pursuit and acknowledge it as an important step towards clean indoor air for all Australians.

Distinguished Professor Lidia Morawska
Australian Laureate Fellow
Centre Director for THRIVE, QUT

Founder's foreword

At the start of the pandemic, I was living in the UK with my young family. Before the country went into lockdown, we all became sick, and I lost my sense of taste and smell for two weeks. Ten days after our symptoms began, my three-and-a-half-year-old daughter suffered a prolonged status epilepticus seizure and was hospitalised. It was several hours before she woke up from the medication that eventually stopped the seizure, the longest hours of my life. Over the next fortnight, she continued to be very unwell, with a range of other challenging symptoms and required several additional trips to the hospital.

Unfortunately, by April 2020, I began developing neurological and cardiovascular symptoms that we now know to be symptoms of long COVID, and which sadly persist today. Both my daughter and I were 'previously healthy' and had no known risk factors for serious illness. Yet, we still suffered poor health outcomes from that initial, acute infection. Adding to our family risk, my husband has an auto-immune disease, which means he is severely immunocompromised and, therefore, remains at significantly increased risk from any infection.

As a result of my family's experience and my almost 20-year history working in healthcare policy and advocacy, I have spent the last few years focusing on the solutions to create safer and more inclusive environments for families like mine, because we are not alone in our experience. People living with high-risk conditions like cancer, diabetes, auto-immune diseases, cardiovascular disease, asthma and many more, are not rare and we are not isolated. People living with these conditions are in every workplace, in every school, in every community. 'They' are all of us: our families, our friends, our neighbours, our co-workers, and we should all be safe to breathe without risk of harm.

So, what's the answer? Many viruses are airborne, and transmission is ultimately fuelled by infections occurring in inadequately ventilated buildings with poor indoor air quality. Improving indoor air quality is, therefore, the obvious solution to making our shared indoor air safer for everyone to breathe, because the burden of responsibility for staying safe shouldn't rest on the immunocompromised or high-risk person, especially when that person is a child.

It's time to recognise that people living with high-risk conditions need safe access to public spaces without risking their health due to airborne infections, and to make indoor air safe for everyone to breathe. To do so, we need to set and implement indoor air quality performance standards that effectively lower the risk of infection from airborne pathogens, and the health impacts of other pollutants, to achieve accessible public spaces for everyone. I appreciate your support as we seek to create a world where we can all breathe safely indoors.

Plum Stone
CEO and Founder

Executive summary

In late 2019, a novel coronavirus (SARS-CoV-2) emerged and, within months, the World Health Organization (WHO) declared the pandemic a public health emergency of international concern. In the months that followed, public health measures aimed at reducing the transmission of SARS-CoV-2 also reduced the transmission of other viruses, such as influenza.[1] However, since relaxing public health measures, we have seen a significant increase in the transmission of SARS-CoV-2 and other airborne pathogens, including influenza, measles, respiratory syncytial virus (RSV), pertussis and others.[2,3] Unfortunately, the increased risk of transmission of airborne pathogens is an ongoing problem that disproportionately affects people living with chronic health conditions and other risk factors because they are at significantly increased risk of poor health outcomes from infection.[4]

It is not a small minority of the population who face increased risks from poor health outcomes from airborne infections. While public health messaging has repeatedly focused on 'protecting the vulnerable', it may have led to a skewed perception that people with chronic illnesses are the minority, thus 'othering' people with high-risk conditions.[5] However, according to the Australian Bureau of Statistics, one in two (49.9% or 12.6 million) people have at least one chronic health condition, and women are more likely to have at least one chronic condition than men (52.3% compared to 47.4%).[6] 'They' are all of us.

We spend 90% of our time indoors, and everyone needs safe access to indoor environments without the risk of poor health outcomes from infection by airborne pathogens and other pollutants, especially people living with chronic health conditions. However, there is a widespread lack of recognition that poor indoor air quality (IAQ) reduces accessibility of indoor spaces for people with risk factors for poor health outcomes from airborne infection and other pollutants. As a result of the invisible nature of the problem and the lack of public awareness or public health campaigns to educate the community, many people are unknowingly putting themselves at risk of poor health outcomes. This is a solvable problem.

The importance of IAQ in health has been recognised for some time and was highlighted in the very first chapter of Florence Nightingale's seminal book, *Notes on Nursing*, in 1859.[7] More than 160 years later, the evidence continues to mount, showing that improving IAQ and committing to safer indoor air environments can both substantially reduce the risk of airborne infection[8,9] and lower the risk of poor health outcomes from other conditions such as asthma and allergies.[10,11] In doing so, we can increase the safety and accessibility of indoor environments for everyone, protecting health now and into the future.

> 'The very first canon of nursing... To keep the air he breathes as pure as the external air, without chilling him.'
>
> – Florence Nightingale, Notes on Nursing[7]

To date, advocates for equity, diversity, inclusion, and belonging have focused on accessibility for people of different races, ethnicity, age, gender, religion, sexual orientation, disability, economic status, and other

diverse backgrounds. For example, the Australian Disability Discrimination Act 1992 makes it necessary for every area and facility open to the public to be safely accessible for people with a disability.[12] The Premises Standards define the accessibility features as 'necessary'. Another example is the National Quality Framework, which puts restrictions on the built environment to ensure the health and safety of children in those environments.[13]

Now we need to expand our thinking on accessibility to include people with chronic health conditions that cause invisible disabilities and clinical vulnerabilities. We also need to recognise that people without known risk factors are also at risk of developing health complications from airborne infections and exposure to other pollutants, such as in damp buildings or during vegetation fires, and that these health risks may significantly impact society.[14]

Recognising that many viruses are airborne and transmitted primarily indoors where spaces are inadequately or inappropriately ventilated, and that they cause disproportionate harm to people living with high-risk conditions, underscores the vital need to prioritise accessible IAQ in all public spaces. Improving IAQ will address the risks associated with airborne pathogens and reduce the poor health outcomes that arise from other airborne pollutants. Creating safer indoor air environments can be achieved, and we already have the tools to make safer indoor air in all public spaces a reality.[9] We have identified four priority areas where the urgent implementation of IAQ performance standards is critical to reduce infection risks from airborne pathogens, as well as the health impacts of other airborne pollutants. These priority areas are:

1. **Child education settings** – All children deserve a safe learning environment that minimises the risk of infections from airborne pathogens
2. **Healthcare** – Healthcare environments must protect patients from healthcare-acquired infections, especially those that may worsen pre-existing conditions
3. **Disability, aged-care, and residential care settings** – Residents have the right to a safe living space, free from infection risks
4. **Workplaces** – Employees, particularly in the high-risk sectors above, deserve safe working conditions, including protection from airborne pathogens.

The right to safe access for employees and other users of each of these settings is already covered by existing workplace health and safety standards and regulations,[15] and these rights need to be reconsidered in the context of preventing serious harm that may occur due to airborne infections and exacerbating existing health inequalities.

Improving IAQ for accessibility and reducing the risk of airborne infection in shared indoor environments, with a focus on people living with high-risk conditions, makes indoor air safer and healthier for everyone. Businesses that invest in improving their IAQ can achieve a social return on their investment through increased accessibility and inclusion, and a financial return as they realise other benefits such as improved cognitive functioning, increased productivity, satisfaction and creativity, and reduced sickness costs.[16–18]

Financial benefits of improved IAQ

Total benefits at a 60% case reduction could range between $24bn and

$50bn

over the 2022–2024 period.

The benefit-cost ratio for Australia, based on these preliminary estimates, would range from

1.5 TO 3.1

A preliminary economic analysis, conducted for this report, on the benefits of improved indoor air quality (which is based solely on reduced sickness, through the avoided costs of COVID-19 and long COVID cases that would not occur due to enhanced air quality in public spaces), indicates that a significant return on investment is achievable. The analysis shows that the benefits of improved IAQ in public spaces, assuming a 60% reduction in cases, could range between $24 billion and $50 billion over the 2022–2024 period and achieve a benefit-to-cost ratio (BCR) for Australia of between 1.5 and 3.1. While there is uncertainty around the precise scale of the benefits and costs of improving IAQ in public spaces, there is a high level of confidence that the BCR in Australia exceeds 1.0, meaning the benefits are likely to outweigh the costs. A more detailed study by the Productivity Commission, or a similar agency, is recommended to determine the precise BCR for Australia.

It is time to recognise IAQ as a critical accessibility and inclusion issue for people living with chronic health conditions. The provision of safe air for all should be considered an urgent priority to prevent and control the transmission of infectious diseases and reduce the disproportionate harm they cause to people living with high-risk conditions.

Recommendations

Over the next year, we call on the Government to action six priority recommendations:

1. Acknowledge IAQ as an accessibility issue that must be addressed to deliver the accessibility theme within Australia's Disability Strategy. In addition, note that a lack of access to safe air spaces represents a potential breach of the Disability Discrimination Act 1992
2. Set IAQ performance standards, which effectively lower the risk of poor health outcomes from infection by airborne pathogens and other airborne pollutants, for all public spaces as covered by the Disability Discrimination Act, and update the Premises Standards to include IAQ as an accessibility feature
3. Address the gaps in the implementation and enforcement of existing workplace health and safety laws and ensure that appropriate steps are taken to prevent infection risks from airborne pathogens
4. Prioritise implementation of IAQ performance standards in four key settings
    a. Education (including early years, primary and high schools)
    b. Healthcare (including hospitals, primary health, allied health, pharmacies etc.)
    c. Disability, aged care and other residential settings
    d. Workplaces
5. Recognise that infection prevention and control (IPC) is a shared, whole of community issue, not just a healthcare setting issue, and direct the newly established Australian Centre for Disease Control (CDC) to include IPC in its remit
    a. Direct the Australian CDC to update IPC guidance, for all settings, to include appropriate mitigations for the prevention of transmission of airborne pathogens
6. Direct the Productivity Commission to conduct a benefit-cost analysis for investments required to meet IAQ performance standards in all public spaces

Over the next year, we call on employers to action two priority recommendations:

1. Adopt and demonstrate compliance with IAQ performance standards for all business premises
2. Acknowledge IAQ as an accessibility and inclusion issue and incorporate it into existing equity, diversity, inclusion, and belonging policies

Improving IAQ for accessibility and reducing the risk of airborne infection in shared indoor environments, with a focus on people living with high-risk conditions, makes indoor air safer and healthier for everyone.

Introduction

In late 2019, a novel coronavirus (SARS-CoV-2) emerged and, within months, the World Health Organization (WHO) declared the COVID-19 pandemic as a public health emergency of international concern. In the months that followed, public health measures aimed at reducing the transmission of SARS-CoV-2 also reduced the transmission of other viruses, such as influenza.[1] However, since relaxing public health measures, we have seen a significant increase in the transmission of SARS-CoV-2 and other airborne pathogens, including influenza, measles, respiratory syncytial virus (RSV), pertussis and others.[2,3] Unfortunately, the increased risk of transmission of airborne pathogens is an ongoing problem that disproportionately affects people living with chronic health conditions and other risk factors because they are at significantly increased risk of poor health outcomes from infection.[4]

It is not a small minority of the population who face increased risks from poor health outcomes from airborne infections. While public health messaging has repeatedly focused on 'protecting the vulnerable', it may have led to a skewed perception that people with chronic illnesses are the minority, thus 'othering' people with high-risk conditions.[5] However, according to the Australian Bureau of Statistics, one in two (49.9% or 12.6 million) people have at least one chronic condition, and women are more likely to have at least one chronic condition than men (52.3% compared to 47.4%).[6] Some of the most prevalent chronic health conditions in Australia include cancer, kidney disease, lung disease including chronic obstructive pulmonary disease (COPD), heart, stroke and vascular disease, diabetes, and asthma (see *Figure 1*).[6,19]

Additionally, many people without known risk factors for poor outcomes from viral infection develop post-acute infection syndromes, such as long COVID and myalgic encephalomyelitis (ME).[14,30] Long COVID and ME can affect people of any age (including children and elderly),[31–35] people of different races and ethnicities, sex and gender, and irrespective of baseline health status.[36,37] Therefore, compounding the high levels of people living with pre-existing health conditions with the ongoing transmission of SARS-CoV-2 and other airborne pathogens, more people will become newly vulnerable to poor health outcomes.[36]

It is not a small minority of the population who face increased risks from poor health outcomes from airborne infections.

Even before the COVID-19 pandemic, acute respiratory illnesses were the leading infectious cause of death, responsible for more than 2.74 million deaths globally.[38] The economic cost of these infections has been, and remains, high. For example, Australia's economic burden from lower respiratory infections exceeded $1.6 billion in 2018–19.[39,40] Yet, for several reasons, the risks and our ability to prevent the significant social and economic costs were largely ignored until the pandemic brought them into focus.

Many have described the pandemic as a pandemic of buildings because transmission predominantly occurs indoors, in inadequately or inappropriately ventilated spaces.[41] In finally acknowledging that respiratory illnesses are predominantly spread through the air, we can understand the drivers of transmission and, importantly, how to prevent airborne infections

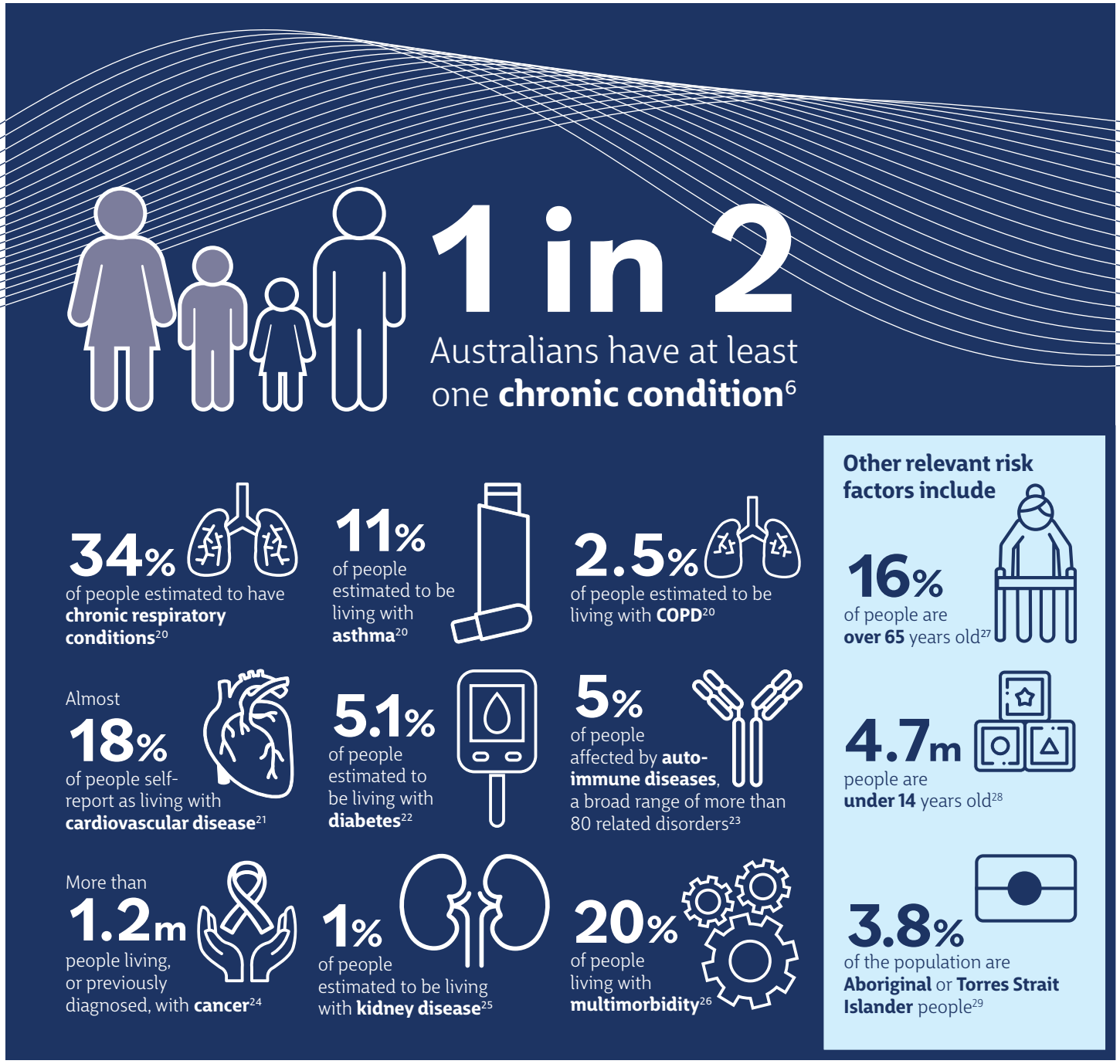

FIGURE 1 'They' are all of us

from occurring by improving indoor air quality (IAQ).[42,43] The pandemic has also shown that we have been paying insufficient attention to the design of buildings and ventilation and filtration systems to achieve healthy indoor environments, including safe workplaces, schools, and public transport.[44] We need this to change, for everyone's benefit.

Improving IAQ and committing to safer indoor air environments can substantially reduce the risk of airborne infection and lower the risk of poor health outcomes for everyone, especially for people living with chronic health conditions and other risk factors. Improving IAQ through ventilation, air filtration and air cleaning will also address other airborne contaminants, such as fine particulate matter ($PM_{2.5}$), that are hazardous to health.[45-47]

Although we may not be able to eliminate respiratory infections by controlling airborne transmission in shared indoor spaces, especially due to the nature of close-range transmission, we can substantially reduce them.[39] In Australia alone, if hospital admissions caused by airborne respiratory viruses could be halved by reducing transmission, it would save hundreds of millions of dollars each year.[39] And it follows that the same measures would reduce hospitalisations for millions of people, saving billions of dollars globally.

This is a solvable problem; it's time to make indoor air safer for everyone to breathe.

The role of indoor air quality in accessibility

For a long time, we have known that people living with chronic health conditions are at increased risk of poor health outcomes from many viral infections. People living with a wide variety of chronic health conditions, including transplants, cystic fibrosis, cancer, auto-immune diseases (such as IgA nephritis and Crohn's disease), the very young, and the elderly have routinely been told by their clinicians to avoid infections. This advice could include things like avoiding public transport, types of careers to avoid, changes to duties at work, forms of childcare to enrol children in – or even considering not having children at all. However, there has been a widespread lack of recognition that poor IAQ increases the risk of airborne pathogen transmission and, in turn, reduces accessibility to indoor spaces for people with risk factors for poor health outcomes from infection and other airborne pollutants.

As a result of the increased risks people living with chronic health conditions face, they need safe access to indoor environments without the risk of poor health outcomes from airborne pathogens or pollutants. By recognising that safe IAQ is critical to protecting the health and safety of people with chronic health conditions, and by choosing to act, we can ensure that the air we share indoors is safer for everyone to breathe.

Equity, diversity, inclusion, and belonging for people with chronic health conditions

Until now, advocates for equity, diversity, inclusion, and belonging (EDIB) have focused on accessibility for people of different ethnicity, age, gender, religion, sexual orientation, disability, and other diverse backgrounds. Yet, despite the high numbers of people living with chronic health conditions, they are rarely considered in diversity and inclusion policies and procedures. At best, people with chronic illnesses may be incorporated under umbrella disability policies, but this is problematic because people with chronic illnesses do not necessarily identify themselves as living with a disability.

The needs of many people living with chronic health conditions go unnoticed due to the often invisible nature of chronic illness. Yet, these people remain at increased risk of exacerbating their illness, or even death, when exposed to unsafe conditions. Meanwhile, the needs of people living with disability to avoid airborne infections through safe IAQ have also not been recognised in policy.

Now it is time to expand our thinking on EDIB to include accessibility for people with chronic health conditions that cause invisible disabilities and clinical risk. We also need to recognise that even people without known risk factors are at risk of developing health complications from airborne infections and other pollutants, such as in damp buildings or during vegetation fires, and that these health risks may significantly impact organisations and society more broadly.[14]

The right to safe and universal access to public spaces

Public places play an important role in communities, and they should be able to accommodate people of all ages and abilities.[48] Around the world, we have laws governing safe and universal access to public spaces for people with disabilities. While the laws that govern safe and universal access to public spaces for people with disabilities vary by country, several key standards for accessibility are commonly

recognised around the world, such as the Americans with Disabilities Act in the US and the European Accessibility Act in the EU.

In Australia, the Disability Discrimination Act 1992 (DDA) makes it unlawful to discriminate against people with disabilities and includes provisions for ensuring accessibility in public spaces and services.[49] The Disability (Access to Premises – Buildings) Standards 2010 also provide detailed requirements for building design and construction of ramps and stairways, accessible entrances and bathrooms, hearing augmentation systems, tactile surfaces and other measures, to ensure that public buildings are accessible for everyone.[50,51]

The DDA states that a person's disability may be temporary or permanent; a physical, intellectual, sensory, neurological, learning, or psychosocial disability; a disease or illness; physical disfigurement; or a medical condition or work-related injury.[51] As such, many chronic health conditions, including temporary illnesses, are already considered a disability under the DDA. If a person's illness falls under this definition, their employer must make reasonable adjustments, including building modifications, to ensure they can continue working.[52]

We can no longer ignore the connection between IAQ in public spaces and the accessibility challenges it presents for people with chronic health conditions and other risk factors; we need to mandate safe IAQ performance standards for all public spaces.[53]

Given the legal provisions that already exist governing universal safe access to public spaces for people with disabilities, including for people living with chronic diseases or invisible disabilities, it is time that the DDA and the Premises Standards are adapted to make indoor air safer for everyone to breathe.

> People living with chronic health conditions need safe access to indoor environments without risk of poor health outcomes from airborne pathogens or pollutants.

PERSONAL PERSPECTIVE

Aaron

Aaron* was a happy, healthy baby, weighing 4.5kg at birth. However, at just five weeks old, he was hospitalised with RSV.

At 11 months, when he started daycare, Aaron developed a persistent cough that became a near-constant presence. We visited the GP multiple times, hoping to find him some relief. When the country went into its first lockdown, Aaron was 18 months old. Within a few weeks, his chronic cough disappeared, and for the first time in months, he was fully well.

As daycare reopened, we returned cautiously. We were not only concerned about Aaron's susceptibility to illness but also his dad's severe immunocompromise, which meant any infections brought home by the kids posed a significant risk to our entire family. While we managed to get the daycare to install air purifiers, they were undersized for the space and number of occupants, and Aaron's cough returned shortly after he rejoined.

By March 2022, his frequent illnesses escalated to multiple middle-of-the-night trips to the hospital with croup. Then, in July 2022, he started developing recurring fevers accompanied by sharp abdominal pains, occurring roughly every three weeks.

In January 2024, Aaron started primary school in NSW, joining his older sister, though we still didn't have answers for his recurring episodes of illness. Although the school was initially hesitant about allowing air purifiers and CO_2 monitors in the classrooms, they acknowledged the risks our family faced and permitted donations of both for our safety and accessibility.

Now, we finally have a diagnosis. He has an inherited auto-inflammatory condition, which explains his susceptibility to infections and recurring episodes of ill-health. Thankfully, we are now able to treat his symptoms more quickly, and although he still experiences flare-ups, he is missing less school.

In NSW, schools have natural ventilation – which means they rely on teachers and other staff remembering to open the windows and doors, and on the ambient conditions not being too hot, too cold, too windy, too smoky, but *just right*. It's tricky to find those days consistently throughout the week, let alone a term, or even throughout the year.

His teachers have been very good and thankfully have

> As a parent of high-risk kids with a high-risk partner, it's exhausting having to continuously advocate for measures that make the school environment safer.

been proactive in ensuring that his classroom is well-ventilated, but many neighbouring classrooms have their windows closed, and the shared facilities such as the hall and music rooms can be hit and miss for windows being open for good ventilation. Obviously, when windows and doors are closed in naturally ventilated classrooms, there is zero ventilation – this is not just an infection risk issue, but also a cognitive functioning and learning issue.

For excursions, it's a completely different challenge. Measuring CO_2 levels can provide a useful proxy for infection risk and ventilation levels and having sent an air quality monitor with his sister during an excursion in 2023, the CO_2 readings on the bus showed just how poor the ventilation can be.

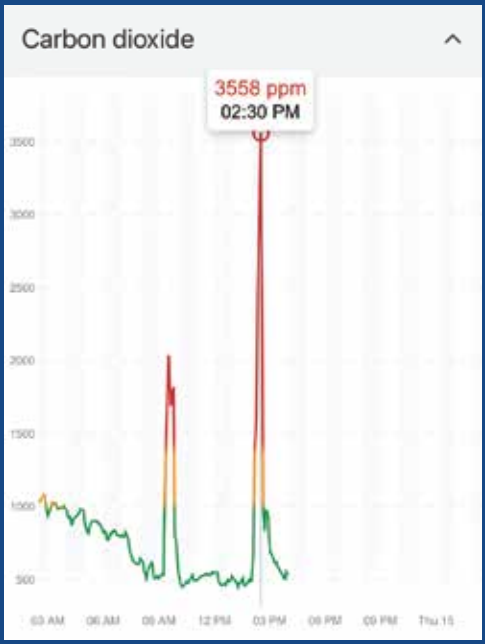

FIGURE 2 CO_2 levels on an excursion bus trip

For context, the concentration of CO_2 outdoors is typically around 420ppm therefore a CO_2 level of 3,560ppm, as on the return bus trip (see *Figure 2*), is equivalent to almost 8% rebreathed air, or 1 in 12 breaths being from someone else's lungs. This is very high and poses a significant infection risk for all children and staff on board, including the bus driver.

Children like Aaron, who have high-risk conditions and/or high-risk families, should be safe to go to school every day, because everyone deserves a safe learning environment. He can't opt out of going to school, and he can't be responsible for the air he breathes and whether it's going to make him sick - that's on us, as parents, as teachers, as grown-ups. As a parent of high-risk kids with a high-risk partner, it's exhausting having to continuously advocate for measures that make the school environment safer. If he had a visible disability, the school would proactively make every effort to ensure the school day, including all activities, were accessible and inclusive. As it is, his invisible risks and the invisible threat are all too easily forgotten and the risk is constant.

Aaron continues to wear a mask indoors in school, and other public places, to protect his health and the health of his family. Unfortunately, this means that he often receives comments from other kids and can feel very lonely and isolated. If we had safer IAQ standards in every classroom, every bus, every hall, etc. it wouldn't just be on him to protect himself. It's hard having to be the only one protecting your health at any age, but especially so when you're in kindy.

**Aaron's name has been changed for this story and a stock photograph included, to protect his identity and privacy. His story has been told by his parents.*

Studies have shown that classrooms equipped with properly designed and maintained mechanical ventilation systems can reduce the relative risk of infection for students by at least 80%.[60]

FOUR PRIORITY AREAS FOR ACTION

1. Children have a right to access a safe learning environment

Many legal frameworks and international agreements enshrine every child's right to a safe learning environment. Internationally, these rights are supported by the United Nations Convention on the Rights of the Child (CRC), domestic laws such as the Education Act 2002 in the United Kingdom, and human rights law. These frameworks collectively ensure that children have access to a safe learning environment that is not harmful to their health.[54]

In Australia, several entities and frameworks work together to ensure that children are safe in education, including the Federal Government, the Australian Human Rights Commission, State and Territory Governments, and schools and education providers. Schools also have a duty of care for students while they are involved in school activities, which extends to situations where students are at the school outside normal school hours or engaging in off-site activities.[55] Additionally, the National Quality Framework puts restrictions on the built environment to ensure the health and safety of children in those premises and includes specific guidelines for ventilation and other safety measures.[13] However, in the absence of standards for safer IAQ, many children with chronic health conditions are at risk of poor health outcomes from viral infections acquired in the classroom.

In addition to the health risks faced by children with pre-existing conditions, many viruses circulating in schools, including SARS-CoV-2, influenza, RSV, measles, and bacteria such as mycoplasma pneumonia, pose a significant risk to all children. With each new wave, the number of people, including children, experiencing reinfections with SARS-CoV-2 increases, adding to the cumulative risk of children developing long COVID, as well as sub-clinical organ damage, type 1 diabetes, and other post-acute sequelae.[56–58] In the United States, COVID-19 is also a leading cause of death in children and adolescents.[59]

Without mandated IAQ performance standards that effectively lower the risk of infection from airborne pathogens and the health impacts of other airborne pollutants in schools, many high-risk children (and the children of high-risk families) are put in the position of having to protect themselves from harm. Studies have shown that classrooms equipped with properly designed and maintained mechanical ventilation systems can reduce the relative risk of infection for students by at least 80%, where ventilation rates exceed $10Ls^{-1}$ $student^{-1}$, compared with a classroom with only natural ventilation.[60] Meanwhile, other studies have shown that the use of portable air purifiers can deliver a 30% reduction in infections in daycare settings[61] (see *We have the tools, now we need indoor air quality performance standards*, p52).

However, in Australia, many schools are naturally ventilated. While some states in Australia acted to ensure air purifiers were placed in every classroom to protect children from infection when schools returned following the lockdowns,[62] the majority relied solely on natural ventilation or hybrid systems.

The challenge with relying on natural ventilation is that it depends on teachers remembering to open the windows and doors, which may not happen due to noise, the weather being too hot or too cold, or poor outdoor air quality due to bushfire smoke. For example, the SAMHE study in the UK measured ventilation rates in schools and found that the overall mean ventilation rates were well below these rates at $5.3Ls^{-1}$ $person^{-1}$, rising to $6.8Ls^{-1}$ $person^{-1}$ in warmer weather and falling to $3.8Ls^{-1}$ $person^{-1}$ in colder weather.[63] The number exceeding the 1500ppm CO_2

threshold rose to approximately 20% when the daily mean outdoor temperature fell to around 5°C, indicating that thermal comfort will be prioritised over IAQ.[63] Notably, these rates are well below the $10Ls^{-1}$ $student^{-1}$ in the classroom study (see previous page),[60] and significantly below the $20Ls^{-1}$ $student^{-1}$ recommended for classrooms the ASHRAE Standard 241 (ASHRAE 241) for the control of infectious aerosols[64] (see *We have the tools, now we need indoor air quality performance standards*, p52).

The same human challenges also exist for ensuring the proper use of air purifiers, with teachers needing to switch them on, position them properly, and ensure they are running at the right speed, adding to the existing workload. Parent groups and individual families have become responsible for advocating for the use of air purifiers and carbon dioxide (CO_2) monitors on an *ad hoc* basis with varying degrees of success. In the meantime, high-risk children continue to wear respirator masks to protect their health and the health of their families, with limited support and often while experiencing bullying and exclusion.

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The wearing of respirators should be a last resort because people living with chronic health conditions, particularly children, shouldn't be the only ones responsible for protecting their health from unsafe air. It's a huge responsibility for young children to have to wear respirators to protect themselves and their families from poor health outcomes because the air they breathe at school, and in other public spaces, is not safe for their health. In the same way that we wouldn't expect children to have to boil water to make it safe to drink, not just because they could get burnt but because of the burden of responsibility for doing so, we shouldn't expect them to protect themselves from the air they breathe. Yet without mandated IAQ standards in schools (and other public spaces), that's what we've ended up with when it comes to air quality.

We have heard from many teachers and parents that schools are no longer taking steps to prevent the spread of airborne pathogens. Examples include schools allowing teachers and children to come to work while knowingly sick, leading to infection of other staff and students, and refusing to notify families of confirmed cases, preventing high-risk families from making an informed risk assessment. These actions are placing high-risk families in the untenable position of having to balance the need for their children to receive an education with their family's need to protect themselves from potentially catastrophic health outcomes following an infection, which is at odds with the school's duty of care to each child.

It's time to ensure every classroom in Australia is safe for every child. We need to set IAQ performance standards that can reduce the transmission of airborne infections to the lowest practicable level, monitor IAQ in real time and mechanically ventilate schools to ensure classrooms meet these accessible standards consistently.

PERSONAL PERSPECTIVE

Kate for Emily

In March last year, my four-year-old niece Emily was diagnosed with neuroblastoma, a rare and aggressive childhood cancer that started as a single immature cell and quietly grew into a tumour the size of a grapefruit.

Oncologists call neuroblastoma 'a silent monster' because by the time it is found and finally diagnosed, it has usually spread. In the space of a month, Emily's cancer spread to her skull, her spine, her arms and legs, her optical nerve, and her bone marrow. During this time, her only symptom was a sore tummy and an occasional fever.

For this reason, neuroblastoma is also known as 'the kitchen sink' of childhood cancers. Oncologists must throw everything at it: chemotherapy, surgery, high-dose chemotherapy with stem cell rescue, radiation, and immunotherapy. Neuroblastoma has one of the longest, most aggressive, and most toxic treatment protocols of any paediatric cancer.

In fact, one of the chemotherapies that Emily received is so toxic that we had to bathe her every four hours, day and night, so that her skin didn't burn when the toxins left her body.

Like most kids, however, Emily rolled with the punches. Despite the pain she endured, she never complained. The hospital was her new home, and she named her IV pole Bobby. Naturally, Bobby was to blame for the fake spiders that taunted the night nurses, and the super soaker that drenched unsuspecting visitors. After a dressing change or a blood transfusion, Emily coaxed the doctor on call to fetch her a toy from the Bravery Box. As a family, we often joked that she was dancing while cancering because even at her sickest, she would still sing and dance.

There was always hope.

After five rounds of chemo and a high-risk surgery to remove her primary tumour, that hope was amplified. The frontline treatment worked better than expected. Her PET scan revealed she was cancer-free. She had a perfect response to treatment.

However, because of the high chance of relapse – a threat that hangs over every family with neuroblastoma – we had to proceed with a bone marrow transplant. At this point, Emily's immune system would be destroyed past the point of recovery and rebuilt with her own stem cells. The transplant team assured us that Emily was in safe hands. 'Transplant works best when there's no evidence of disease,' they said. 'Emily is in the best position possible.'

For the second time since Emily's diagnosis, we allowed ourselves to feel hope. Cautious hope.

During transplant, while Emily was in protective isolation, she entertained herself by opening a coffee shop – Emily's Unicorn and Rainbow Cafe. There were three menus to choose from: First Dessert, Second Dessert, and Snacks. If there was an item on the menu that Emily didn't feel like making, she would simply say, 'Sorry, we're closed'.

When the high-dose chemotherapy obliterated her immune system, her coffee shop closed for good. At times, the pain was so severe she fainted. Thumbs up and thumbs down became her only way of communicating due to the mucositis in her mouth. Because she couldn't eat or drink, she received a nutritional formula intravenously through a special pump. She suffered greatly, and there was nothing we could do.

Naïvely, we thought the worst was over when Emily's stem cells engrafted, and her neutrophils started to rise. But that's the thing about hope: it conspires against you.

At some point during her transplant, Emily contracted a fungal infection called *Lomentospora prolificans*. The fungus, which has been isolated from hospital soils and plants, occurs in urban environments and is typically found in arid climates. While the infection can affect the immunocompetent, it is especially dangerous for the immunocompromised, particularly those with cancer. When we asked Emily's oncologist how she encountered the fungus, he said, 'She probably breathed it in.'

Two days later, the fungal infection travelled to Emily's brain and caused six mycotic aneurysms. When the first aneurysm ruptured, she was left with permanent brain damage. She lost her movement, her vision, and her complex reasoning. A shunt was implanted in her brain to drain the excess blood and fluid, and she was put on a ventilator to help her breathe.

After a week in the ICU, an infectious disease specialist finally agreed to meet with us. She explained that Emily's best chance was the antifungal regime; however, Emily's particular infection was resistant to most antifungal treatments. In the next breath, she informed us that the most promising drug available, Olorofim, was not an option for Emily because it had not yet been approved for use in children. 'Even if they released the drug,' she said, 'I wouldn't know how to dose her.'

Emily died three days later, with her mum and dad holding her, and our family gathered around her bed. She was wearing her *Bluey* pyjamas and holding her stuffed puppy. Her Make-A-Wish was granted the next day.

One year on, we still have questions. How did Emily contract a fungal infection during her bone marrow transplant? Why did the hospital's infection prevention and control measures fail? Why wasn't Emily safe? Was the airlock system working? Why weren't we told how serious the infection was, so that we could say goodbye to Emily before she had a stroke and was no longer conscious?

The only explanation we've been given is that 'Emily was just very unlucky'.

Luck shouldn't control a child's life. Luck shouldn't determine your health or your happiness or your future. Luck is a gambling term. Why are we rolling the dice with the most vulnerable members of our community – our children?

Like other kids with neuroblastoma, Emily was diagnosed with one of the most devastating cancers. But in the end, it wasn't the cancer that took her life. It was the air she breathed. At least with the cancer, it was a fair fight. With the infection, and with no immune system to fight it, she never had a chance.

Kate Cantrell is a communications advisor at Neuroblastoma Australia and serves on consumer advisory bodies at Redkite and Cancer Council Queensland. She shares Emily's story on Instagram at @all.4.emily

FOUR PRIORITY AREAS FOR ACTION

2. Patients have a right to access healthcare safely

Every person has a right to safe healthcare, governed by a range of laws and regulations internationally. In Australia, the Australian Commission on Safety and Quality in Healthcare (ACSQHC) sets benchmarks for safety and quality in healthcare services and is responsible for the Charter of Healthcare Rights.[65]

The Charter describes seven rights that people and their carers can expect when accessing healthcare. These rights apply to all healthcare providers in Australia (see *Figure 3*). Of the seven rights, a person can expect to have access to care that meets their needs, safe care that meets national standards and makes them feel safe, and treatment with respect and dignity.[65]

My healthcare rights

This is the second edition of the Australian Charter of Healthcare Rights.

I have a right to:

Access

Safety

Respect

Partnership

Information

Privacy

Give feedback

AUSTRALIAN COMMISSION ON SAFETY AND QUALITY IN HEALTH CARE

For more information ask a member of staff or visit safetyandquality.gov.au/your-rights

FIGURE 3 The Australian Charter of Healthcare Rights[65]

Unfortunately, in the absence of the safest possible IAQ standards and appropriate airborne infection prevention and control (IPC) policies, many people with chronic health conditions, and other risk factors like age and disability, do not have these rights fulfilled because of the risk of healthcare-acquired infection (HAI) from airborne pathogens. Data from Victorian hospitals in 2022 show a mortality rate of >10% in patients who acquired COVID-19 while in hospital,[66] while data from NSW show that 14% of all COVID-19 deaths in 2023 were due to infections acquired in healthcare settings.[67] Similarly alarming mortality rates from healthcare-acquired COVID-19 infections have been reported overseas.[68] Because of these increased risks, many people with chronic health conditions are making decisions about whether they *really need* to access healthcare, or not. Indeed, a recent Australian study showed that, because of the increased risks of infection occurring in healthcare settings, many people with chronic health conditions are avoiding going to the doctor or hospital for their own healthcare needs.[5]

The process of assessing the risk of SARS-CoV-2 transmission and other airborne pathogens in healthcare facilities needs an urgent paradigm shift. SARS-CoV-2 is airborne and constantly present in the community, and approximately 60% of infections are the result of presymptomatic transmission.[69] Additionally, it is widely recognised that COVID-19 is frequently asymptomatic,[70] that some infected people have non-respiratory symptoms and that many people are infectious for well beyond the minimum isolation requirements. All hospital patients should be regarded as 'high-risk' given their current medical problems. In many cases, patients are unable to wear respirators due to young or advanced age, confusion, or during surgery, imaging, or other treatments.

> Respiratory protection plays an important role in employee safety in many sectors and should be integrated into healthcare occupational health and safety protocols.

Thus, they rely entirely on the facility to provide a safe environment.

Therefore, in addition to providing the safest possible IAQ standards to reduce the potential for airborne HAIs, it is also necessary to address source control via other measures such as universal respiratory personal protective equipment (PPE), including the use of N95 respirators, testing, and isolation. The use of N95 masking is widely recognised as both source control and PPE control in the risk reduction of airborne pathogens – with source control being the more effective risk reduction measure (i.e. everyone masking versus one-way masking).[71] Education about proper use of PPE and why it's important to wear respirators can help overcome potential resistance to their use.

The current recommendations that leave PPE decisions to individuals fail to acknowledge that one-way masking is insufficient protection: hospital stays involve many moments where masks must be removed (eating, taking medications, treatments, etc) and masking is impractical for infirm, elderly or confused patients. High-risk patients also need to be able to attend healthcare facilities while caring for their family members, as carers themselves.

One Australian study found staff N95 mask use and admission screening testing of patients can reduce hospital-acquired COVID-19 infections and COVID-19 deaths.[72] The same study also found that these two interventions can save the health system potentially hundreds of millions of dollars in the long term, and many thousands of lives.[72]

Meanwhile, another study found masking among healthcare workers can reduce HAI respiratory viral infections by ~60%.[73] The authors also note that it would be a mistake to ignore the SARS-CoV-2 threat and that 'healthcare facilities could reimagine masking policies to protect patients from the full array of nosocomial respiratory viral infections, using masking to protect all patients from all viruses when viral activity is elevated and the most vulnerable patients year-round'.[73]

Respiratory protection plays an important role in employee safety in many sectors and should be integrated into healthcare occupational health and safety protocols. Employee training, education, and mask fit-testing should now be routine to protect patients, visitors, and staff, noting particularly that the provision of a safe work environment is also a basic employee right.

Ultimately, patients shouldn't need to self-advocate for basic airborne infection control procedures; providing a safe healthcare facility is the responsibility of the facility and cannot be transferred to patients. As part of good governance and optimising patient outcomes, healthcare facilities should explicitly prioritise protecting patients from contracting SARS-CoV-2 or any other communicable disease when in their care. Health service organisations accredited to the National Safety and Quality Health Service Standards[74] must comply with the Preventing and Controlling Infections Standard, which requires environmental control measures, such as effective ventilation systems, to be in place to reduce the risk of infection transmission.[75]

Guidance for IPC, including optimising ventilation, should be updated to include mitigations for airborne diseases that:

- appropriately recognise asymptomatic and presymptomatic transmission
- acknowledge that high-risk patients are not confined to clinically high-risk areas, and may be attending as carers
- recognise that airborne transmission occurs through breathing and talking and isn't confined to 'aerosol-generating procedures'
- recognise that even where IAQ is optimised, respiratory protection is required to prevent the risks of near-field transmission occurring.

In addition to updating IPC guidance and improving IAQ in all healthcare facilities, the HAI committee of ACSQHC, which has been responsible for the National Hand Hygiene Initiative for many years, should implement a 'National Airborne Infection Prevention Initiative'. Promoting the prevention of airborne transmission in the same way that the ACSQHC promotes the prevention of other HAIs will help educate and raise awareness among healthcare workers and patients of the risks of airborne transmission and how to prevent it from occurring. It will also ensure that patients are protected from all modes of transmission that cause healthcare-acquired infections.

Additionally, given that infections are transmitted outside of healthcare settings, the newly formed Australian Centre for Disease Control (CDC) must include IPC in its remit. Leaving IPC solely under the remit of ACSQHC ignores the fact that IAQ is a shared, whole of community issue and not just a healthcare setting issue.

PERSONAL PERSPECTIVE

Robyn

I'm an atmospheric chemist and an aerosol scientist. I worked with colleagues from the Royal Melbourne Hospital in late 2020 to characterise the ventilation within a COVID ward. We examined how air cleaners could reduce infectious aerosol loads in a hospital setting – showing that we could reduce aerosols by 99% in five and half minutes within a patient room with two small domestic air cleaners.[76] I also pulled together a website Air Cleaner Guide[77] to help the public and wider community navigate the air cleaning technologies available on the market – and to ensure that people were able to make informed purchasing decisions when it came to cleaning their indoor environments.

It is with this expertise that in March 2023 I sat opposite an unmasked surgeon, in a small, sterile, clinical room, with a dear friend beside me taking immaculate notes, and I was told that I had breast cancer. In this moment, you are suddenly trying to navigate a complex public / private health system for cancer treatment, understand what ER, PR, HER-2 and Ki-67 numbers mean; what tumour grades (as opposed to stages – who knew?) all mean. You don't want to (and most people just don't!) think about the quality of the air you are breathing – you expect it to be safe. This situation is scary, it is emotional, and all you want to have is a treatment team who you can trust to 'get this damn cancer out' of you, and stop it coming back. You want them to be the best in their field, to keep up with the latest science, to be – basically – the superstars who are going to save your life. You want them to be working in a hospital with infection control leaders and boards who equally have patient safety at the centre of their ethos.

I did have a superstar team that looked after me, and when I finished my treatment on Halloween last year, bald, tired, and battered – I can say that I had done everything I could to improve my odds of survivorship. I should qualify this that in Australia: 1 in 7 women get breast cancer, and the survivorship at 5 years is 92% (up from 78% in the early 1990s) – so the odds are in my favour. The surgery gives you about a 75% survivorship, radiotherapy about 15%, and chemotherapy (for my tumour) 6%. It is the chemotherapy that is really playing with the smallest odds, and causing the most impact (3 months I will not get back, my finger and toe-nails lifted off their beds and I'm still coming to terms with my new curls!). While undergoing chemotherapy you need blood tests to check your white blood cell counts, you need to sit for 4–6 hours in a chair receiving the chemotherapy, and you are extremely immunocompromised. All this for a 6% chance of survival over the next 5 years – you certainly don't want to be contracting a respiratory virus like COVID-19 while in hospital, which, as a cancer patient in Victoria, presented a 25.6% all-cause 100-day mortality in 2020 to 8.1% in 2022.[78] A cancer hospital is the one place where you will find vulnerable patients and visitors will do all they can to enhance the outcomes of their loved ones.

> Disappointingly and fundamentally, we won't see a change in the management of the air even in our most vulnerable spaces without indoor air quality standards.

It was to my dismay that, as I was undergoing radiotherapy, masking mandates were lifted in our 'world-leading' cancer hospital. This prompted me to write to the board and management of the hospital. If you visit now you won't see many staff, volunteers, doctors or visitors wearing masks. It is hard to find a quality mask (they're still there – hidden and tokenistic). Disappointingly and fundamentally, we won't see a change in the management of the air even in our most vulnerable spaces without indoor air quality standards.

The science is clear,[79] the health economics is clear,[72] but the public health messaging and environmental health policies that make clean indoor air a reality are not where they need to be to protect us all.

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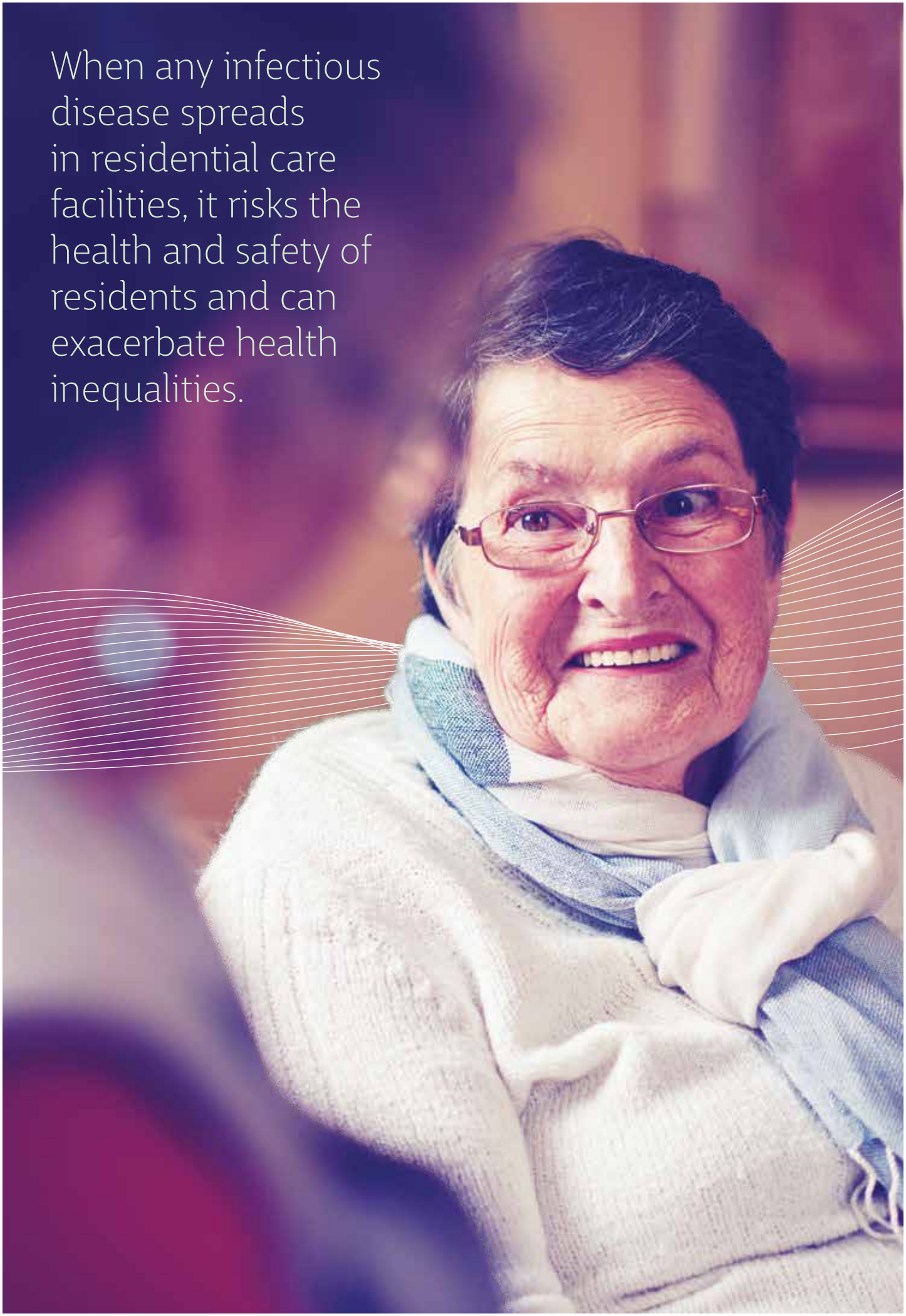


When any infectious disease spreads in residential care facilities, it risks the health and safety of residents and can exacerbate health inequalities.

3. People in living residential care facilities have a right to access safe living environments

As with healthcare settings, preventing the transmission of airborne infections in residential care facilities is fundamental to ensuring safe and accessible living environments for all. Residential care facilities are designed to offer supportive and secure environments for people who are living with disabilities, people who are elderly and people with other high-risk conditions, including frailty, immunocompromise, or living with comorbidities. High rates of comorbidities amongst the elderly increase the risk of mortality,[9] and therefore must offer additional prevention and control measures to keep residents safe from harm.

Residential settings cover a wide variety of facilities, including prisons, where the consequences of an outbreak would be devastating. People in prison are at great risk of poor health outcomes from infection, with almost one-third of people entering prison having at least one chronic health condition, like asthma, cancer, cardiovascular disease, diabetes, or living with a disability.[80]

In addition to the increased risks of the people living in residential care facilities, these facilities are environments where the rapid spread of airborne pathogens can occur.[9,81,82] For example, an Australian study found the risk of SARS-CoV-2 infection within Australian aged care homes was 27% higher than compared with the general population.[83]

> An Australian study found the risk of SARS-CoV-2 infection within Australian aged care homes was 27% higher than compared with the general population.[83]

New guidelines for IPC for Australian residential aged care facilities were published in August 2024. The guidelines note that 'effective infection prevention and control is central to providing high-quality aged care for all older people and a safe working environment for those that work in aged care settings'.[84]

However, as one of the guidelines' authors noted, the new guidelines were developed with the intention of providing a risk-based approach that balances the social and emotional needs of those in aged care, while attempting to lower the risk of infection for all, but 'remaining practical'.[85]

Balancing the social and emotional needs of residents with effective IPC and the need to protect highly vulnerable residents from poor health outcomes and death, has many challenges. When any infectious disease spreads in residential care facilities, it risks the health and safety of residents and can exacerbate health inequalities.

It is necessary to implement active IAQ controls to effectively mitigate all airborne infection transmission to the lowest practicable level, such as proper ventilation systems and IAQ monitoring, air purification, and routine screening of staff, residents and visitors, to deliver equitable access to a safe living environment for all residents.

PERSONAL PERSPECTIVE

Lyn for her dad

Dad grew up on the land, staying active throughout his life, with an enduring love for sports. He avidly supported the Broncos (NRL) and enjoyed watching the State of Origin. Despite his Parkinson's diagnosis, Dad maintained a determined and optimistic outlook on life. He had a remarkable memory and excelled at trivia, winning the trivia competitions at his aged care facility.

Dad volunteered for many years with the local Rural Fire Brigade, responding to fires and accidents. He was extremely proud of receiving both The National Medal for Service and the QFRS Diligent and Ethical Service Medal for his dedication. Dad was deeply religious, praying every day and following Jesus' teachings on not judging others. He was humble, kind, diplomatic, and young at heart. His playful spirit, intelligence, loyalty, and love for his family and community made him a beloved figure among everyone who knew him. His attention to detail was notable – even insisting on combing his hair before meals or photos, even if he was only in the background.

Dad was 73 when he moved into a residential aged care facility in early 2020, just before the pandemic started. In December 2021, I raised concerns regarding the facility's approach to protecting residents from the pandemic, as the planned onsite vaccination clinic was not conducted, and guardians were not advised of this. An outbreak followed in January 2022 without the vaccination clinic being held. Nearly all residents in the wing, including Dad, were infected with COVID-19.

Dad was so severely ill that end-of-life medications were prepared. While residents were eventually quarantined, the precautions taken were inadequate. When I took the risk to visit Dad because of his deteriorating health during the outbreak, I found the door to his room wide open, with no signage on the door about the infectious resident, the need for respiratory PPE, and the resident's continued communal dining for days. It was not surprising when infections continued to occur, which sadly resulted in the deaths of two residents.

Unfortunately, the facility had poor ventilation, with CO_2 levels reaching unsafe levels (over 1000ppm). This was only reduced when we ran the bathroom exhaust fan, which interfered with communication. Advocacy for air purifiers was met with resistance and we personally provided then, and even after installation, staff would often turn them off despite clear signage.

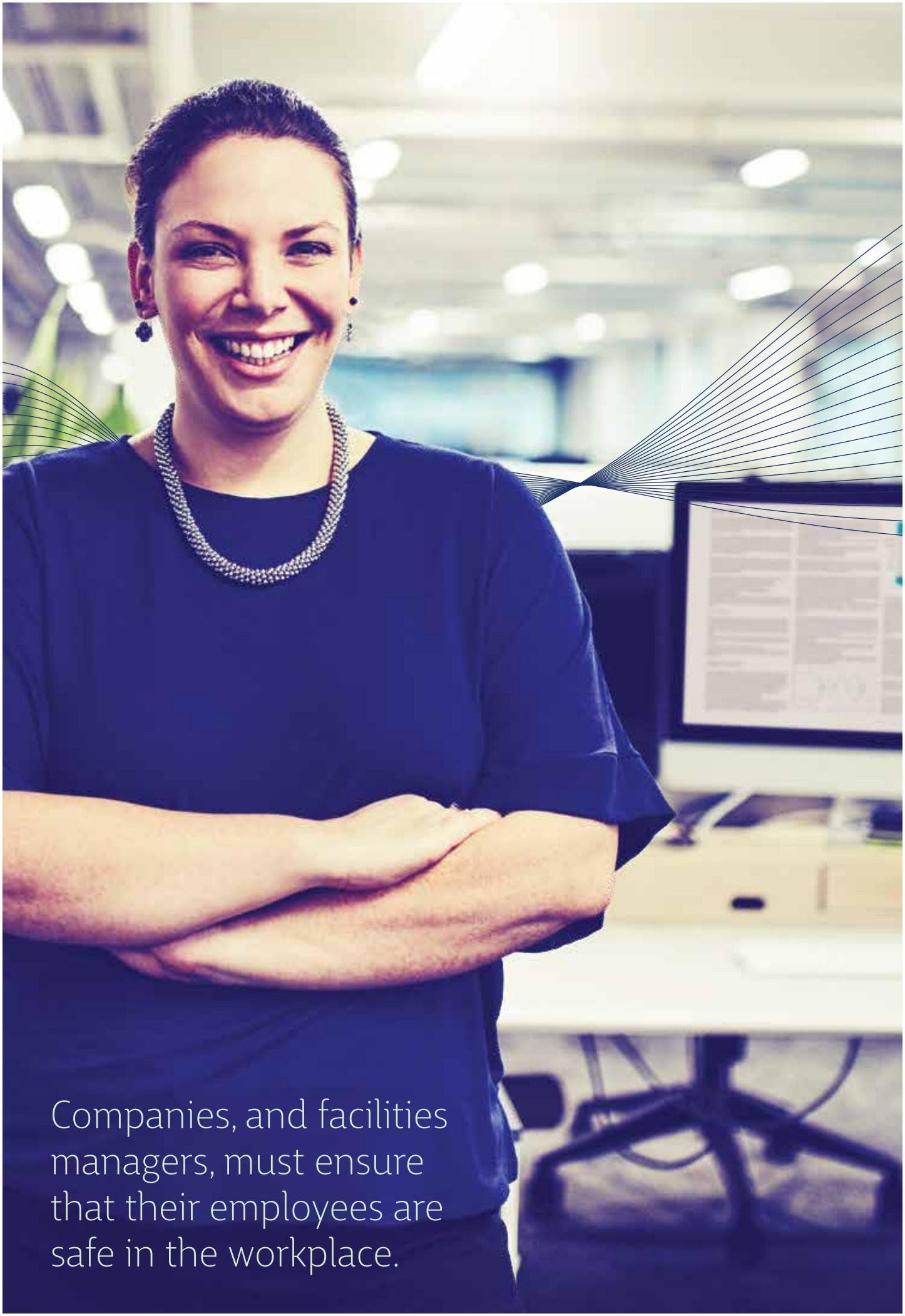
After that outbreak, I continued to raise concerns over infection control, but despite repeated outbreaks, the facility refused to enforce consistent mask-wearing, even in high-risk areas. 'Staff morale' was prioritised over residents' safety, with masks being removed during times of rising community transmission. This led to further resident infections, even as community COVID-19 cases surged in Queensland and changes that should have been implemented never came.

It was extremely disappointing to see the refusal to put simple airborne infection control measures in place, such as N95 respirators, to reduce the risk to residents despite this risk being clearly demonstrated. There are other ways to boost staff morale and address any potential communication issues without jeopardising the health and safety of residents. COVID-19 can lead to a devastating death, and those who survive often do not return to their previous level of health, with substantial evidence of long-term impacts.

My efforts to advocate for better safety protocols, including improved ventilation, air filtration and masking, were met with dismissal from regulators and the facility itself. The ongoing lack of proper precautions made it impossible for me, as an immunocompromised person, to visit my dad safely. The situation created considerable frustration and tension within my family as we watched the facility's repeated outbreaks without substantial improvement.

Knowing the increased risks of infection for people with Parkinson's, my dad didn't want to catch COVID-19 or any other virus, but the facility made it clear that it was his choice to be isolated as a result of that decision. I feel that the new guidelines are discriminatory toward those who wish to avoid COVID-19, as they allow close contacts to mingle with others while offering no safe options for those trying to avoid infection (who have isolated). There was no way to opt out – close contacts and residents 5 days post-testing positive (no clearance needed) were prioritised to mix freely (resulting in lengthy outbreaks – often 4–8 weeks due to ongoing transmission), disregarding the rights of others who did not want to be exposed.

It was such an impossible situation. I am devastated that I couldn't visit Dad as much as I wanted to in his final months and wish that we could go back and put measures in place to properly protect everyone in aged care. Improving indoor air quality and reducing the risk of transmission through the proper application of airborne infection control measures could have made such a huge difference for everyone in the facility, and still could.



Companies, and facilities managers, must ensure that their employees are safe in the workplace.

FOUR PRIORITY AREAS FOR ACTION

4. Employees have a right to access safe working conditions

Workplace health and safety (WHS) laws vary significantly around the world, but there are some common frameworks and standards that influence a country's WHS regulations. In Australia, WHS laws are governed by a combination of national regulations, the Work Health and Safety Act 2011 and the Work Health and Safety Regulations 2011,[86] and State and Territory specific legislation. There are also national guidelines, provided by Safe Work Australia,[87] and State and Territory specific guidelines.

Traditionally, the WHS Act and Regulations have focused on mitigating physical hazards, ensuring that employees work in environments free from risks such as machinery accidents, hazardous chemicals, etc. For ventilation, Regulation 40 requires the duty holder (e.g. employer, building owner), to so far as reasonably practicable provide ventilation that enables workers to work without risk to health and safety, but it's very general. However, the pandemic has exposed the critical gap in these regulations – that is, the need to address the risk of infection from airborne pathogens, particularly for people who are at increased risk of poor outcomes from infection. Extending WHS laws to include protections against the transmission of infectious diseases is fundamental to the right of workers to a safe working environment and, given people work in all public spaces, should apply universally.

For example, in addition to the high-risk settings discussed in previous sections, public transport should be considered another priority setting for improving IAQ standards, for reducing airborne pathogen transmission and exposure to other airborne pollutants for workers and the public. Ventilation in public transport, particularly buses, can be extremely poor,[88] with CO_2 levels frequently exceeding safe limits for cognition,[89] and increasing the risk of airborne disease transmission.[90] Even before the pandemic, the occupational risks for people working in the public transport sector as a result of poor IAQ were known, with research showing that workers' exposure to bioaerosols was a significant risk.[90] However, the risk of transmission and therefore the occupational risks for public transport workers can be reduced by increasing ventilation rates into vehicles.[88,91]

Workers spend a significant portion of their lives at work, and their health and safety should be safeguarded by comprehensive legal standards that

> Workers spend a significant portion of their lives at work, and their health and safety should be safeguarded by comprehensive legal standards that address both traditional and emerging risks.

address both traditional and emerging risks. Under existing workplace health and safety laws, businesses must do everything reasonably practicable to ensure the health and safety of workers and others.[92] Just as laws have evolved to address new safety challenges in physical environments, they must now evolve to include the risks associated with airborne diseases.

Companies, and facilities managers, must ensure that their employees are safe in the workplace, and need to recognise their responsibilities with respect to IAQ and health. Reducing infections in the workplace isn't just necessary from a health perspective; infections can lead to significant economic consequences, including increased sick leave, reduced productivity, and higher healthcare costs. By incorporating infection control measures into workplace safety regulations, employers can minimise these disruptions and contribute to a more resilient economy.

To effectively address the risk of airborne pathogens, workplace safety laws should include:

- IAQ performance standards that effectively lower the risk of infection from airborne pathogens for accessibility
- guidelines for the use of PPE, such as respirator masks, especially in high-risk environments (see *Patients have a right to safe healthcare*, p23)
- systems, policies and data for monitoring and reporting health conditions related to airborne infections to ensure timely responses and interventions.

It's time to address the gaps in our existing WHS laws and ensure that appropriate steps are taken to address infection risks from airborne pathogens as a necessary progression in protecting workers, especially those who are at increased risk from infection. By adapting legal standards to the current realities of increased airborne infection, we protect individual employee health, help prevent businesses from being disrupted, and secure economic stability.

PERSONAL PERSPECTIVE

Phil

Growing up with the inherited lung disease cystic fibrosis in the 1980s, I wasn't concerned about airborne viruses. I mean, my doctors didn't expect me to live beyond my 30s, and that aside, like many kids I was focused on shorter-term things. My doctors would have been proven right if it weren't for the incredible gift of a double-lung transplant when I was 22. However, despite a rapid and successful recovery, I still lived with the knowledge that my extended life was likely temporary. After all, my older brother had tragically died just 1 year after his own double-lung transplant, the year before I received my own! I knew many others like him. But, thankfully I lived, and lived, and I continued growing up. One year turned into 2, 2 into 5, then 10, 20 and now, 28 years post-transplant, my life has proven itself anything but temporary. I've built a rewarding and enriching career. I'm raising two amazing children alongside an inspiring and hardworking woman I'm privileged to call my wife. I'm 50 years old. I now dare to make long-term plans.

If I'm to see these long-term plans come to fruition, now I really do need to exercise a healthy degree of caution about airborne viruses. Still on medication that suppresses my immune system to protect my transplanted lungs, I'm far more susceptible than the average person to contracting an illness if I'm exposed. On top of this, my now not-so-new lungs are unfortunately scarred from many battles with viral, bacterial and even fungal infections over the last 28 years, meaning that respiratory viruses are more challenging than ever; I get sicker, and

recovery takes more effort and time. Right now, of all the airborne viruses I could be exposed to, none are more challenging than COVID. I've caught it only once so far, and I was lucky: it was a mild case, no doubt helped by being able to start antivirals the same day I tested positive. But my doctors caution me that this doesn't predict how my body will respond if it happens again. The statistics are pretty confronting – I'm still at much, much higher risk of getting very sick and dying from COVID than the average person, even though I didn't get sick the first time, and I've had multiple booster vaccines. So really, it's a gamble. The thing is, I don't want to gamble with my life every time I walk into a crowded room. I shouldn't have to, especially not when there are things we can do that will make it safer for me, and for the many like me facing similar challenges.

As a society, we already recognise the importance, and value, of supporting people whose health or physical limitations impact their lives. We pay our Medicare levies so that everyone has access to quality healthcare when they need it. We support the NDIS so people with disabilities can improve their quality of life, including returning to work. We enact legislation to prevent discrimination on the basis of health status or physical disability. We build ramps, elevators and escalators so people who have difficulty climbing stairs or accessing public transport can enjoy public spaces. We implement and adopt policies about nut-free foods so that kids with allergies can learn, play, and eat safely at school. We've proven time and time again that we care enough to improve our systems so that people experiencing disadvantage can live fuller lives.

Now we need to improve our policies, our procedures and our practice around the prevention of airborne virus transmission indoors. Not just for people like me, but for everyone who would rather not catch the flu or COVID at work, at a party, in hospital or at a restaurant.

If I'm to see these long-term plans come to fruition, now I really do need to exercise a healthy degree of caution about airborne viruses.

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‘While there is a cost in the short term, the social and economic benefits to public health, wellbeing and productivity will likely far outweigh the investment in cost to achieve clean indoor air.’

– Distinguished Professor Lidia Morawska, QUT News[100]

The additional benefits of investing in safer indoor air

Improving IAQ for accessibility and reducing the risk of airborne infection in shared indoor environments, with a focus on people living with high-risk conditions, makes indoor air safer and healthier for everyone. Businesses that invest in improving their IAQ can achieve a social return on their investment through increased accessibility and inclusion. They can also gain a financial return as they realise other benefits such as improved cognitive functioning, increased productivity, and reduced costs.[16,17]

IAQ monitoring, for example, can have many benefits including improving employee satisfaction, creativity, safety and presence, increasing productivity, and optimising health and climate goals.[18,41] Many studies have shown that workers or students in well-ventilated buildings are healthier and more productive than those in poorly ventilated buildings.[93-95] For instance, testing of office workers in the US at different ventilation rates has shown that better ventilation improves cognitive performance.[89] It also found significant declines in cognitive scores when CO_2 concentrations were increased to levels common in indoor spaces (about 950ppm). Meanwhile, another US study found that school students were more attentive and calmer in well-ventilated classrooms.[96]

The health benefits associated with enhanced ventilation rates far exceed the per-person energy costs relative to salary costs.[97] The improved work performance associated with better ventilation has been estimated to produce a $6,500 (USD) increase in worker productivity, with only an increase in energy cost of $40 (USD) per person, per year, and as low as $1 if energy-efficient systems are used.[97] Other research has estimated that improving air quality at work in the US in 1997 would have saved $6–19 billion from fewer respiratory diseases, $1–4 billion from fewer allergies and asthma, $10–20 billion from fewer sick building syndromes, and $12–125 billion from better productivity.[98] Other research found similar savings.[99]

> Businesses that invest in improving their IAQ, can achieve a social return on their investment through increased accessibility and inclusion.

Environmental impacts from additional energy required to handle greater volumes of air in our mechanical systems, or where natural ventilation is increased, can be mitigated at regional, building, and individual-level scales. This can be achieved through the transition to renewable energy sources, the adoption of energy-efficient systems and ventilation strategies, and the promotion of other sustainable policies.[97]

INVESTING IN A HEALTHIER AND MORE PRODUCTIVE FUTURE

Improving accessibility for people with chronic health conditions

Recognising the health and productivity gains achievable, many global companies are already investing in improving their IAQ, including Amazon and JP Morgan Chase.[101]

In addition to the financial and environmental return on investment that companies are realising, there is also a social return on investment that is yet to be realised – that of the increased accessibility and inclusion created for employees and customers with high-risk conditions.

Most organisations desire inclusion, and many already participate in membership programs to strengthen their commitments to be accessible and inclusive employers and service providers.

Therefore, organisations must understand that IAQ is a critical accessibility and inclusion issue, ensure their IAQ is accessible, and address the inclusion of their high-risk employees and customers through existing EDIB pathways.

'Amazon is using an algorithm my company developed called HEAAL, which stands for Health-Optimized, Excellent, Action, Alert, Limit. When a measure of air quality is at "Action" level it's not immediately dangerous and should be looked at by facilities within the month. At "Alert" level, the situation should be evaluated within two weeks. "Limit" means you are potentially endangering worker health, so the issue should be escalated to an environmental health and safety team and acted on within a day or two.'

– Associate Professor Joe Allen, Harvard Business Review[41]

PERSONAL PERSPECTIVE

Lewis

From my late teens, I began to understand that good health can be temporary or even impossible for many people. I had asthma as a child, and although I maintained a healthy lifestyle as a young adult – staying active, eating well, and getting enough sleep – I learned that these behaviours aren't always enough to prevent illness. In my late teens, I developed bronchitis, and in my early 20s, I became seriously ill with pneumonia. After first hearing that COVID was a respiratory illness, I knew I needed to take precautions due to my asthma.

The health problems I developed in my early 20s worsened over time. I'd had pelvic pain for years and finally was diagnosed with endometriosis in 2021. Not long after, I began feeling faint. I would often feel dizzy, have a racing heart rate and struggle to concentrate after standing up for hours during my patisserie training classes. My symptoms were worse when the kitchen was hot, especially in summer. My doctor at the time said my blood pressure was fine after I reported how I often felt dizzy if I stood up too quickly. However, a second opinion led me to a cardiologist, who diagnosed me with postural orthostatic tachycardia syndrome (POTS) in 2022.

I initially assumed most people understood that anyone, regardless of age, could develop chronic conditions. However, the pandemic highlighted that many see illness as something that can be avoided if people living with disabilities only tried harder. I had thought that there was a better understanding of chronic illness and disability within the queer community. My generation of queer people heard all the time about the importance of safe sex and STI prevention. Older queer people knew from the HIV/AIDS crisis that public health responses can often come too late, yet many queer people trusted the government and queer health organisations that COVID wasn't a problem for them.

I was disappointed to see that many queer spaces began to stop encouraging masking from 2022 onwards. I used to attend markets regularly and shows for the queer community but stopped after hearing that someone else in the venue tested positive for COVID the next day.

As masks have become less common, so too has the broader understanding that diseases spread from person to person, or that some people are at significantly increased risks of poor outcomes from infection. Without isolation requirements, it's clear that public spaces often contain people who may be contagious for any airborne disease, which puts people like me at increased risk of being infected.

There seems to be a lack of understanding about how our health is connected to the health of others and

> There seems to be a lack of understanding about how our health is connected to the health of others and our environment.

our environment. Yet we recognise that one person's actions, like drunk driving or smoking indoors, can harm others and have legislation to prevent those harms from happening to each other. Similarly, when someone infected with a virus goes to an indoor event without taking precautions, they risk spreading illness to others. Even while wearing a properly fitted respirator, there is still a risk of being infected by someone who doesn't know they're contagious.

Since the pandemic began, I've tested positive for COVID three times. Yet, I'm often perceived as unusual for trying to protect myself from a preventable illness that causes me great harm.

I've had many encounters where people question why I'm wearing a mask. For example, a pharmacist assistant was confused about why I had one on, assuming I was sick. I was actually wearing it to stay healthy. At a recent event, where masks were required for participants, someone driving by yelled at us, equating the masks with hiding our identities. The masks made us visibly different, and I was glad I wasn't the only person standing out.

Each infection has left me bedridden for about a week, followed by several more weeks of recovery. After my latest infection, my recovery took even longer, with my POTS becoming more severe. Simple tasks, like standing or sitting up, made me light-headed, and I was unable to work for four weeks due to extreme fatigue. Only after two months was I well enough to resume my regular activities, like going to the gym. Avoiding infection is really important to me to prevent a deterioration in my health.

In late 2022, I started working at a bakery but soon realised it wasn't a safe environment for me. One of my coworkers came to work while sick with COVID. My boss, aware of my health conditions, didn't inform me, and I felt my well-being was disregarded. As a result, I left the hospitality industry in early 2023 and transitioned to working from home.

As a transgender person, I'm aware of the increased risk of developing long COVID.[102] I've been encouraged to see that some queer event organisers are taking steps to protect attendees by providing masks and using air purifiers. When I attended Le Freak's show at Fringe, I was impressed to see nearly all of the audience was wearing masks. I'm attending two more shows where these precautions are in place, allowing me to enjoy public events without compromising my health. Regardless of someone's vulnerability to illness, no one should have to choose between protecting their health and participating in public life.

There is a significant and growing burden of disease caused by long COVID and ME.

Investing in preventing post-acute infection syndromes

COVID-19 is not the first airborne virus to cause a post-acute infection syndrome. ME, which has been described in medical literature for hundreds of years, is also predominantly caused by viruses such as influenza, Epstein–Barr virus (glandular fever) or Ross River fever.[30]

There is a significant and growing burden of disease caused by long COVID and ME. While estimates vary, many studies have shown that at least 10% of COVID infections may lead to the development of long COVID.[103-105] Long COVID shares many symptoms and biological abnormalities with ME, with up to 45% of those with long COVID meeting the diagnostic criteria for ME after six months.[106] This adds significantly to the existing number of people in Australia already living with ME, which research estimates to be 0.4–1% of the population: up to 250,000 Australians.[107]

Long COVID represents the constellation of post-acute and long-term health effects caused by SARS-CoV-2 infection; it is a complex, multisystem disorder that can affect nearly every organ system and can be severely disabling.[36] The disease burden spans from mild symptoms to profound disability, the scale making this a huge, new healthcare challenge.[103]

> 'The oncoming burden of long COVID faced by patients, health-care providers, governments and economies is so large as to be unfathomable.'
>
> – Professor Danny Altmann, *et al.*, *Nature Reviews Immunology*[103]

In 2022, long COVID cost the Australian economy almost

$10bn

in labour and other factors.

The cumulative global incidence of long COVID is estimated to be around 400 million individuals,[103] and to have an annual economic impact of approximately $1 trillion—equivalent to about 1% of the global economy.[36] One study, published in August 2024, demonstrated that long COVID cost the Australian economy almost A$10 billion in 2022 alone.[14,108] The authors noted that 'widespread SARS-CoV-2 infections in Australia mean that even a small proportion of infected people developing long COVID-related illness and disability could have important population health and economic effects'.[14] This is in addition to the estimated $10–14.5 billion ME costs the Australian economy annually.[109,110]

In addition to the costs of post-acute infection syndromes, such as long COVID and ME, there are significant direct and indirect socioeconomic costs associated with airborne disease transmission.[9] Even in the absence of post-acute infection there are other impacts on the workforce, including reduced productivity (related to increased sick leave and presenteeism), declines in employee engagement, sick leave costs and others.[9] It follows, therefore, that reducing transmission through improved IAQ can prevent these costs occurring and deliver significant benefits to organisations and societies that prioritise safer indoor air environments.

PERSONAL PERSPECTIVE

Tracey

In January 2022, I contracted the Delta variant of COVID-19. I was confined to bed for a fortnight. During February and March, I slowly recovered, managing to resume work and beginning to exercise again. However, one day I experienced debilitating chest pain, nausea and dizziness. A series of tests could find nothing wrong. But I continued to suffer an overwhelming sense of fatigue. Even the simplest task – for example, cutting up vegetables for dinner – would lead to several days of bed rest.

Over the subsequent months, these unusual symptoms worsened. During the night, I'd wake up with an 'electric shock' feeling in my foot, which turned out to be small fibre neuropathy. I found it difficult to stand for any longer than a few minutes, without extreme tachycardia. My histamine symptoms were through the roof; each day it felt like I was coming down with the flu.

Twice, I was raced to hospital due to crippling vertigo. I simply couldn't move my head without the world spinning on its axis. Eventually, I had to buy a wheelchair, as I couldn't get from bed to the ensuite toilet without fainting or falling. I was unable to leave the house, except for medical appointments.

My digestive system began to falter. It would switch wildly between constipation and diarrhoea. Ultimately, I restricted my diet to steamed vegetables and tiny portions of raw or quickly cooked protein, as this is all my body could handle.

The worst aspect was the 'post-exertional malaise' after any kind of activity: physical, emotional or cognitive. While writing my latest book, I was only able to concentrate for 20–30 minutes each day, before lying in a darkened room for hours to recover.

In the middle of 2022, I was admitted to the long COVID clinic at St Vincent's hospital. I'm grateful to the doctors at St Vincent's who contributed towards a diagnosis and treatment. Still, it took until early 2024 for me to (almost) fully recover.

It's impossible to overestimate the impact on someone's life, their family and community, and the Australian economy, from this devastating illness. During these two years, I was only able to work sporadically, while lying in bed with the computer on my stomach. While grateful for Medicare and private health insurance, I was only too aware of the burden this mysterious illness was putting on the health system.

It's impossible to overestimate the impact on someone's life, their family and community, and the Australian economy, from this devastating illness [long COVID].

To this day, I don't know how I contracted the virus. My vaccinations were all up-to-date, and I wore a mask where possible. However, in December 2021, I socialised in three venues with family as part of Christmas celebrations. None of them were ventilated. Of course we were social distancing, but we had no control over the safety of the air in these places. This is what sparked my passion for the clean air movement.

Every human has a right to breathe clean air. It's shocking to think of the number of people living with long COVID and its related conditions, because of the lack of understanding, regulation, and legislation around ventilation and air filtration.

This is a fixable problem that would be life-changing – indeed, life-saving – for millions of people.

Cost-benefit analysis – the economic imperative for investing in safer IAQ

BY PROFESSOR QUENTIN GRAFTON, ASSOCIATE PROFESSOR LONG CHU AND PROFESSOR TOM KOMPAS

Poor IAQ is a hidden cost to people and business through the transmission of illnesses and reduced productivity. As such, in addition to increasing accessibility and inclusion, there are two main types of benefits from improving IAQ – reduced sickness and improved focus.[111]

The following analysis of the benefits of improved IAQ are based solely on reduced sickness, through the avoided costs of COVID-19 and long COVID cases that would not occur due to enhanced air quality in public spaces. Our estimates, derived from 2022 data and findings in the *Medical Journal of Australia*, focus exclusively on reductions in labour supply, meaning they underestimate avoided costs, as they do not account for the impact on non-working individuals.[14] Further, 'reduction in labour supply' does not include the costs of reduced quality of life, losses due to caring responsibilities, or increased healthcare utilisation.

In 2022, long COVID cost the Australian economy almost $10 billion due to declining labour supply and reduction in other production factors.[14] New estimates for 2022, which include both COVID and long COVID, indicate a 1.9% reduction in labour supply, equating to a $20 billion loss in labour value-added alone, or roughly a $39 billion reduction in gross domestic product (GDP), assuming a proportional decrease in other factors (*Pers. comm Grafton, Chu and Kompas October 2024*). This figure includes the effects of both typical COVID-19 cases (with recovery within a week) and long COVID cases.

Benefits

While there is considerable uncertainty regarding the scale in the reduction in COVID cases from improving IAQ, we assume a range from 30% (a lower estimate accounting for infections in private spaces) to 90% (the best-case scenario with highly effective filtration). Our most likely estimate is a 60% reduction in cases.

Consequently, the benefits of improved IAQ in public spaces, even at the lowest reduction in labour supply, amount to $12 billion. At the highest estimate, benefits could reach $25 billion, assuming a 60% reduction in cases. These are annual estimates for 2022 alone; future-year benefits would likely increase due to avoided costs of repeated infections, which may increase the prevalence of long COVID.[112] Conversely, future-year costs would likely decrease due to operating and maintenance costs being lower than initial investment.

Estimating costs involves assessing air filtration, installation, and operating expenses, along with the number of public buildings in Australia.

The benefits of improved indoor air quality in public spaces, even at the lowest reduction in labour supply, amount to $12 billion. At the highest estimate, benefits could reach $25 billion.

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The benefits of improved indoor air quality in public spaces, even at the lowest reduction in labour supply, amount to

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New estimates for 2022, which include both COVID and long COVID, indicate a

1.9%

reduction in labour supply.

Total benefits at a 60% case reduction could range between $24bn and

$50bn

over the 2022–2024 period.

This equates to a $20bn loss in labour value-added alone, or roughly a

$39bn

reduction in GDP.

The benefit-cost ratio for Australia, based on these preliminary estimates, would range from

1.5 TO 3.1

Drawing from the recently published report, *Time to clear the air: the economic benefits of improving New Zealand's indoor air quality*, which estimates a cost of NZ$125 million for upgrades with an additional NZ$10 million per year in operating costs, we scale this to Australia's economy (about seven times larger than New Zealand's).[111] This suggests a capital cost of approximately $875 million and annual operating costs of $70 million. The New Zealand analysis is based on upgrading classrooms and office buildings, as this is where the current standards and levels of compliance are relatively low and where the potential benefits are greatest.[111]

Alternatively, if we assume an average filtration unit cost of $5,000 per public building, and considering Australia has around 1.4 million apartment dwellings and potentially 1 million public buildings, we arrive at a capital cost of roughly $12 billion, with annual operating costs of $1.2 billion (assuming 10% of the capital cost).

Benefit-cost ratio

The benefit-cost ratio (BCR) depends on assumptions about the benefits (avoided costs) and costs of filtration. Based on ongoing excess deaths (lower in 2024 than in 2022),[113] we can reasonably assume avoided costs for at least three years, not just 2022.

Even if costs are halved in 2024, which may not be the case due to the cumulative risk of long COVID increasing with repeated reinfections, total benefits at a 60% case reduction could range between $24 billion and $50 billion over the 2022–2024 period.

For costs, assuming filtration units were installed in 2022 and operating costs incurred through 2024, the total would be approximately $16 billion.

Thus, the BCR for Australia, based on these preliminary estimates, would range from 1.5 to 3.1 (assuming the higher cost estimates). By comparison, the New Zealand report's BCR was between 3.4 and 4.6.[111]

In conclusion, while there is uncertainty around the benefits and costs of improving IAQ in public spaces, there is a high level of confidence that the BCR in Australia exceeds 1.0 – meaning the benefits are likely to outweigh the costs. A more detailed study by the Productivity Commission, or a similar agency, is recommended to determine the precise BCR for Australia. The preliminary analysis, along with New Zealand's findings, strongly supports the need for such a study. However, we note that given access to safer indoor air is a critical accessibility and inclusion issue for people living with chronic health conditions, implementing this report's other recommendations should not be delayed pending the Productivity Commission's findings.

PERSONAL PERSPECTIVE

Daniel

As a kid, I loved music. So in 2013, when the opportunity came to audition for *The X Factor* in Sydney, I was super excited. At the time I was 14 years old and it really felt like all my dreams were starting to come true. I made it through the auditions and went on to *The X Factor* Bootcamp, making it to the top 30 under-25 boys.

After I left school, I followed my childhood dreams and began working in the music industry. As a 17-year-old, working in artist development, life was fast paced and exciting. Every day was different – it often involved long days, late nights, and attending events, live shows and industry parties.

Sadly, in May 2023 my life turned upside down. I had spent the previous year recovering from post-COVID vaccine complications, which were resolving, when I was subsequently infected with COVID. Since then, I have not been able to work at all, and now I often struggle to leave home. My symptoms include devastating fatigue, struggles with my cognition and focus, chest pain and fluctuating blood pressure. Like many others who are now living with long COVID, I have also been diagnosed with POTS, a condition that causes my heart to race and intense dizziness when standing up.

Over the last year, I have racked up thousands of dollars in bills from hospital visits, medical tests, specialist appointments and medications (many of which are not on the PBS), trying to find treatments that can help me get better.

Compounding the financial stress, I haven't been able to work in the industry I love so much because I'm too ill to work. I might have one or two good days where I gaslight myself into thinking that I could go back to work, and I'll be looking at a job – and then the next day I'll be completely bedridden again.

Recently, I went for a meeting with a disability employment provider as part of my obligations with JobSeeker, and they questioned why I was wearing a respirator mask. They said it would be much harder for me to get a job while wearing a mask, even though I need to keep myself safe to protect my health from the risk of reinfection. I'm unsure how to navigate a return to work safely when I'm able to do so in the absence of safe indoor air, if I'm also not allowed to protect myself.

Even accessing healthcare safely has been a struggle. Not long after my May 2023 infection, I was hospitalised because my post-COVID POTS was so extreme I could barely stand up. As I waited for treatment on the ward, I was in a shared room with another patient who had respiratory symptoms, but who refused to conduct a rapid antigen test, on doctor's orders, because they didn't want to be isolated. As a result, I spent a stressful night in a shared room with a patient whose behaviour put my health at increased risk, and there was nothing I could do about it.

I wish people understood the isolation that people like me have experienced since developing long COVID. It is extremely challenging watching the world go on, watching everyone continue to chase their dreams and tick off important milestones, while my life is on pause. I would not wish long COVID upon my worst enemy.

Having to rely so much on a parent at the age of 26 is also a very humbling experience, that's put a lot of strain on the relationship with my mum.

We have to find a way to help people who already have long COVID to be safe from the risks of reinfection, and to prevent more people from having the same experience. That means making our shared air safer for us all to breathe and being welcoming and understanding of people who need to protect themselves by wearing masks.

> They said it would be much harder for me to get a job while wearing a respirator, even though I need to keep myself safe to protect my health from the risk of reinfection.

We have the tools, now we need indoor air quality performance standards

Creating safe indoor air environments can be achieved through the implementation of a variety of tools and technologies. In August 2024, Australia's Chief Scientist published a report, 'The impact of Indoor Air Quality on the transmission of airborne viral diseases in public buildings: a systematic review of evidence', on behalf of the Prime Minister's National Science and Technology Council.

The Chief Scientist's report noted that there are four broad categories of IAQ strategies that have the potential to reduce the transmission of airborne diseases in public buildings, including:

1. Installation of air cleaning technologies – HEPA filters
2. Use of air disinfection technologies – Ultraviolet-C (UVC) lights, also known as germicidal UV or UVGI, which can be generated using lights emitting short wavelength radiation (180–280nm)
3. Dilution of contaminated air with cleaner air – through natural and mechanical ventilation
4. Control of contaminated air dispersion.[9]

By combining multiple approaches that include air filtration, UVC lights and ventilation, we can tailor IAQ solutions to meet the requirements of a wide variety of indoor spaces.

The Chief Scientist's report also noted that there are four methods for monitoring IAQ to support reducing airborne disease transmission, including:

1. Direct air sampling for pathogens
2. Measurement of background ventilation rates
3. Monitoring CO_2
4. Monitoring particulate matter concentrations.[9]

With our knowledge of how IAQ impacts the transmission of airborne pathogens and their impact on health and health inequalities, it is necessary that we effectively use the available tools to ensure that everyone can breathe more safely indoors. In addition to the use of the above technologies, we also need to use the knowledge we have to educate the public and raise awareness of IAQ and its role in our health. By monitoring and displaying live data on IAQ, we can make the invisible visible and help raise awareness of the role of IAQ in our health.

Unfortunately, as noted by Morawska *et al.*, there is no single national government authority with responsibility for IAQ in most countries, and this is also the case in Australia.[39] Where relevant legislation does exist, responsibilities are spread between different organisations in individual States and Territories. For example, the State or Territory Department of Education is responsible for IAQ in schools, and

> With our knowledge of how IAQ impacts the transmission of airborne pathogens, and their impact on health and health inequalities, it is necessary that we effectively use the available tools to ensure that everyone can breathe more safely indoors.

similarly the State or Territory Department of Health is responsible for IAQ in healthcare facilities.[39] Compounding this, there are currently no performance standards for indoor air, only design and operation standards, which are frequently not met during construction. Buildings are often not commissioned prior to final instatement and occupation, meaning that design objectives are not met.[18]

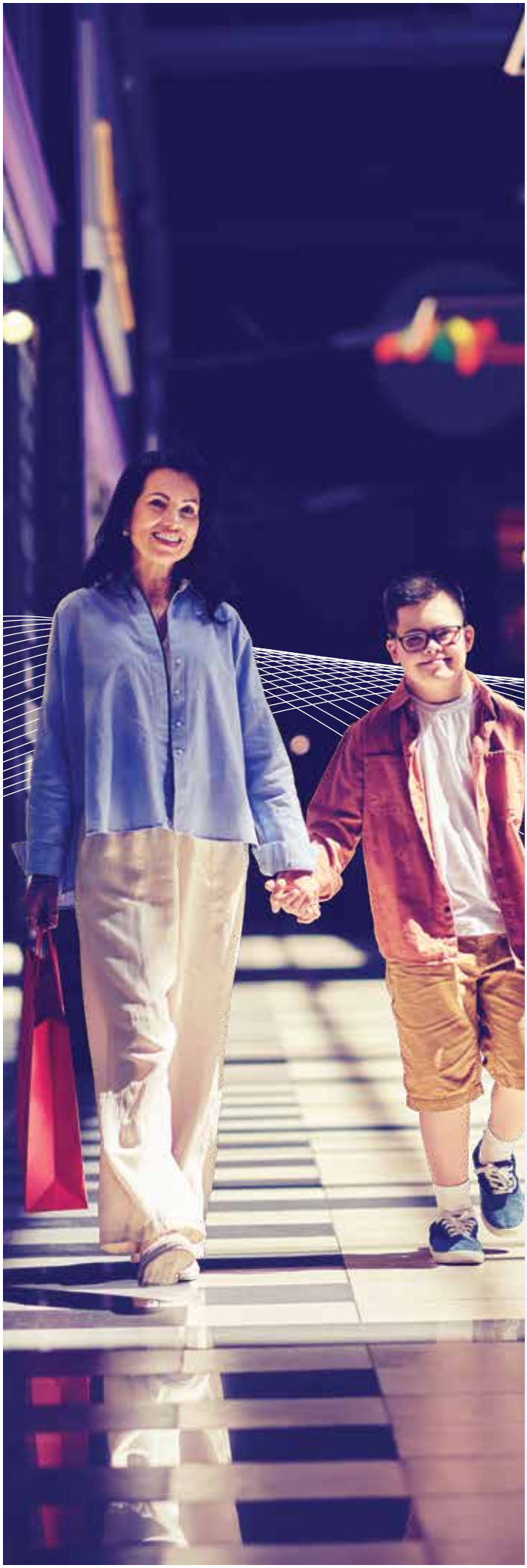
Since the start of the pandemic, many organisations have provided guidelines for improving IAQ to reduce the transmission of airborne pathogens. In late 2022, the White House hosted the first 'Summit on Indoor Air Quality' and subsequently asked ASHRAE, a global society advancing human well-being through sustainable technology for the built environment, to develop a 'national pathogen control' standard.

In June 2023, the ASHRAE Standard 241 (ASHRAE 241) for the control of infectious aerosols was published.[64] The purpose of ASHRAE 241 was to establish design and operation standards for minimum ventilation requirements aimed at reducing the risk of disease transmission through exposure to infectious aerosols in new buildings, existing buildings and major renovations.[114] ASHRAE 241 provides a practical approach to achieve equivalent clean air flow rates that apply to buildings when running in 'infection risk management mode'.

However, ASHRAE 241 compliance does not apply to the ongoing performance of the ventilation systems. At any given time, there may be occupants who have a significantly increased risk of poor health outcomes from any airborne infection, so, arguably, infection risk management mode or an appropriate metric should always apply to ensure accessibility for everyone.

IAQ design standards focus on the planning and engineering aspects of indoor environments, while IAQ operation standards cover the day-to-day management and functioning of indoor spaces. As with the ASHRAE standards in the US, in Australia, several key standards and guidelines cover the design and operation of IAQ in various settings, including the Australian Standard (AS) 1668 series,[115] the National Construction Code,[116] the Australian Building Code Board,[117] and Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) Guidelines. Australian design and operation standards are yet to be updated to prevent and control airborne pathogens.

Design standards are necessary to ensure buildings are designed to provide desired IAQ and operational standards are necessary to ensure proper functioning i.e., ventilation control, maintenance protocols and occupant behaviour, but they only set a baseline.



For a competitive market like corporate real estate, voluntary healthy building certifications (such as the WELL Building Standard,[118] Fitwel,[119] and others) play an important role in demonstrating industry best practice. It's time to establish a national data repository that supports ongoing analysis, enables benchmarking and demonstrates best practice. Organisations seeking to comply with standards should be required to share their data for the repository on an ongoing basis.

In May 2024, the International WELL Building Institute (IWBI), launched the International Healthy Building Accord which included a commitment to achieving 'Health Equity'. Noting that,

> 'Advancing health equity through better buildings helps everyone feel welcome, seen and heard. Multiple studies show that employees in diverse and inclusive workplaces are more likely to innovate, enjoy their jobs, work harder, and ultimately stay with their employers for longer. By adopting inclusive design strategies, equitable access to healthy spaces and research-based design strategies we can reduce health disparities and ensure the advantages of healthy buildings reach our most vulnerable and marginalised populations.' [120]

Now we need to establish IAQ performance standards, to measure the actual IAQ against established benchmarks that effectively lower the risk of poor health outcomes from airborne pathogens and other pollutants, at all times, in all public spaces. There are many reasons why, even if buildings are designed and operated according to the relevant standards, IAQ is still not as desired. This may be because a building's occupancy density is exceeded, there is a fault in the system, or the space is not being used according to its intended purpose, and without IAQ performance standards, these faults may not be detected promptly. It's time to consider demonstration of compliance with IAQ performance standards in real time as important, not just as a one-off exercise when it is built and/or in response to an issue. In Australia, we have precedents we can build on, such as NABERS and the energy disclosure, and can apply the same approach for IAQ.

In March 2024, 40 international experts, led by QUT's Distinguished Professor Lidia Morawska, published a blueprint for mandating national IAQ performance standards for public spaces.[53,100] The authors noted that despite decades of research and advocacy, most countries do not have legislated IAQ performance standards. They recommended proposed parameter levels for monitoring CO_2, $PM_{2.5}$, carbon monoxide (CO), and ventilation rates, noting that the actual values can be lowered, or increased, by jurisdiction.[53]

If we wait for an airborne pathogen to be declared an epidemic, or pandemic, before switching the operation of building ventilation systems to infection risk management mode, we are reacting too late to contain the threat and to protect those at greatest risk.

We do not take a sample of our drinking water at the tap after we have swallowed the water to show it was safe to drink. Similarly, we should not have to measure air quality in a way that tells us we have been exposed to unsafe air. As in the case of the water treatment plant, we need to have regulations, monitoring and compliance of our built environment systems that will reliably provide safe air to all occupants, at all times. We do not know the vulnerability of people entering our buildings, nor those with whom they are in close contact.

Effective prevention and control of airborne pathogens requires a proactive approach. For specifically managing infection risk, we don't yet have the sensing technology to measure the level of pathogens in the air. Until we do, all we have are measures for improving IAQ through CO_2, $PM_{2.5}$ and ventilation rates as described by Morawska *et al.* in March 2024, which are aligned with airborne infection risk mitigation. In the absence of pathogen sensing technology, the best we can do is to aim to effectively reduce infection risk by increasing pathogen removal rates through increasing ventilation rates, filtration, and disinfection. We can measure the rate of the potential removal, which is usually expressed as an equivalent clean air rate, and set performance standards based on these proxies.

We need Australian IAQ design, operation, and performance standards that account for potential epidemic risk, at all times. These IAQ standards must be set for the effective reduction of the transmission of airborne pathogens with the known, most contagious, pathogen in mind. Current modelling suggests airborne infection risk to be greatest for SARS-CoV-2 (Delta and later variants) and that it requires increased ventilation rates, above $14 L s^{-1}$ $person^{-1}$ coupled with air disinfection and filtration technology, to reduce transmission risk.[39]

We do not take a sample of our drinking water at the tap after we have swallowed the water to show it was safe to drink. Similarly, we should not have to measure air quality in a way that tells us we have been exposed to unsafe air.

It's time to make indoor air safer for everyone to breathe

The pandemic has driven the acknowledgement that many infectious diseases are airborne (albeit belatedly) and that we need to breathe clean air to minimise the risk of infection in our shared indoor spaces. This is particularly important for people who face increased risks of poor health outcomes from airborne infections. There are lessons to be learned from the ongoing pandemic that should be implemented now.[8] Acting on this hard-earned knowledge would help prevent further harm from existing variants of SARS-CoV-2, protect against future SARS-CoV-2 variants, and protect against new and emerging threats from airborne pathogens with epidemic, or pandemic, potential.

Recognising that many viruses are airborne and transmitted primarily indoors where air is inadequately, or inappropriately, ventilated – and that they cause disproportionate harm to people living with high-risk conditions – underscores the vital need to prioritise creating safe and accessible IAQ in all public spaces.

As the Morawska *et al.* blueprint for IAQ performance standards demonstrates, consensus has already been reached; it's time to mandate IAQ performance standards for all public buildings. To ensure accessibility for everyone, regardless of health status, IAQ performance standards that effectively lower the risk of poor health outcomes from infection by airborne pathogens and other airborne pollutants should be established and applied to all public indoor spaces with urgency.

We can ensure everyone can breathe safely indoors through existing legislative frameworks. In acknowledging IAQ as an accessibility issue, we must act to address it through safe IAQ performance standards if we are to fully deliver the accessibility theme within Australia's Disability Strategy, and the principles of WHS legislation.[121] IAQ performance standards should apply to all public spaces as covered by the Disability Discrimination Act, and the Premises Standards should be updated to include IAQ as an accessibility feature.

The implementation of targets and standards for buildings as they impact IAQ should be considered an urgent priority to prevent and control the transmission of infectious diseases and reduce the disproportionate harm they cause to people living with high-risk conditions.

In doing so, we can make indoor spaces safer, healthier and more accessible for everyone, and create a world where everyone can breathe safely indoors.

> ‘It’s not just reasonable to expect (clean indoor air), I’d say it’s our fundamental right.’
>
> – Distinguished Professor Lidia Morawska[122]

Recommendations

Over the next year, we call on the Government to action six priority recommendations:

1. Acknowledge IAQ as an accessibility issue that must be addressed to deliver the accessibility theme within Australia’s Disability Strategy. In addition, note that a lack of access to safe air spaces represents a potential breach of the Disability Discrimination Act 1992
2. Set IAQ performance standards, which effectively lower the risk of poor health outcomes from infection by airborne pathogens and other airborne pollutants, for all public spaces as covered by the Disability Discrimination Act, and update the Premises Standards to include IAQ as an accessibility feature
3. Address the gaps in the implementation and enforcement of existing workplace health and safety laws and ensure that appropriate steps are taken to prevent infection risks from airborne pathogens
4. Prioritise implementation of IAQ performance standards in four key settings
    a. Education (including early years, primary and high schools)
    b. Healthcare (including hospitals, primary health, allied health, pharmacies etc.)
    c. Disability, aged care and other residential settings
    d. Workplaces
5. Recognise that IPC is a shared, whole of community issue, not just a healthcare setting issue, and direct the newly established Australian CDC to include IPC in its remit
    a. Direct the Australian CDC to update IPC guidance, for all settings, to include appropriate mitigations for the prevention of transmission of airborne pathogens
6. Direct the Productivity Commission to conduct a benefit-cost analysis for investments required to meet IAQ performance standards in all public spaces

Over the next year, we call on employers to action two priority recommendations:

1. Adopt and demonstrate compliance with IAQ performance standards for all business premises
2. Acknowledge IAQ as an accessibility and inclusion issue and incorporate it into existing equity, diversity, inclusion, and belonging policies

References

1. O'Neill GK, Taylor J, Kok J, et al. Circulation of influenza and other respiratory viruses during the COVID-19 pandemic in Australia and New Zealand, 2020–2021. *West Pac Surveill Response J WPSAR* 2023; 14: 1–9.
2. Feinmann J. Analysis reveals global post-covid surge in infectious diseases. *BMJ* 2024; 385: q1348.
3. World Health Organization Western Pacific Region. Measles and rubella, https://www.who.int/westernpacific/health-topics/measles (2024, accessed 18 September 2024).
4. U.S. Centers for Disease Control and Prevention. Underlying Conditions and the Higher Risk for Severe COVID-19. *COVID-19*, https://www.cdc.gov/covid/hcp/clinical-care/underlying-conditions.html (2024, accessed 21 August 2024).
5. Soh S-E, Ayton D, Bevins A, et al. Attitudes and Behaviours Regarding COVID-19 Mitigation Strategies in Australians With an Underlying Health Condition: A Cross-Sectional Study. *Health Expect* 2024; 27: e70025.
6. Australian Bureau of Statistics. Health conditions prevalence, 2022, https://www.abs.gov.au/statistics/health/health-conditions-and-risks/health-conditions-prevalence/latest-release (2023, accessed 9 April 2024).
7. Nightingale F. *Notes on Nursing: What it is, and what it is not*. Harrison London, 1860.
8. Morawska L, Li Y, Salthammer T. Lessons from the COVID-19 pandemic for ventilation and indoor air quality. *Science* 2024; 385(6707):396-401.
9. National Science and Technology Council. The impact of indoor air quality on the transmission of airborne viral diseases in public buildings, https://www.chiefscientist.gov.au/sites/default/files/2024-08/Indoor%20Air%20Quality%20Report%202024.pdf (2024, accessed 12 August 2024).
10. Robertson NM, Qiu A, Raju S, et al. Cleaning Indoor Air- What Works for Respiratory Health: An Updated Literature Review and Recommendations. *J Allergy Clin Immunol*; 0. Epub ahead of print 21 August 2024. DOI: 10.1016/j.jaci.2024.08.011.
11. Asthma Australia. Homes, Health and Asthma in Australia, https://asthma.org.au/wp-content/uploads/2022/11/AA2022_Housing-Survey-Report_full_v4.pdf (2023, accessed 18 September 2024).
12. Australian Government. Federal Register of Legislation - Disability Discrimination Act 1992, https://www.legislation.gov.au/C2004A04426/latest/text (2023, accessed 3 October 2024).
13. The Australian Children's Education & Care Quality Authority. Quality Area 3: Physical environment, https://www.acecqa.gov.au/national-quality-framework/guide-nqf/section-4-operational-requirements/quality-area-3-physical-environment (2023, accessed 3 October 2024).
14. Costantino V, Grafton Q, Kompas T, et al. The public health and economic burden of long COVID in Australia, 2022–24: a modelling study. *Med J Aust* 2024; 221: 217–223.
15. Safe Work Australia. Model WHS laws, https://www.safeworkaustralia.gov.au/law-and-regulation/model-whs-laws (2024, accessed 27 September 2024).
16. Haverinen-Shaughnessy U, Moschandreas DJ, Shaughnessy RJ. Association between substandard classroom ventilation rates and students' academic achievement. *Indoor Air* 2011; 21: 121–131.
17. Chan WR, Parthasarathy S, Fisk WJ, et al. Estimated effect of ventilation and filtration on chronic health risks in U.S. offices, schools, and retail stores. *Indoor Air* 2016; 26: 331–343.
18. Marzban S, Candido C, Avazpour B, et al. The potential of high-performance workplaces for boosting worker productivity, health, and creativity: A comparison between WELL and non-WELL certified environments. *Build Environ* 2023; 243: 110708.
19. Australian Bureau of Statistics. Long-term health conditions, https://www.abs.gov.au/articles/long-term-health-conditions (2022, accessed 19 August 2024).
20. Australian Institute of Health and Welfare. Chronic respiratory conditions, Summary, https://www.aihw.gov.au/reports/chronic-respiratory-conditions/chronic-respiratory-conditions/contents/summary (2024, accessed 12 September 2024).
21. Heart Foundation. Key statistics: Cardiovascular disease, https://www.heartfoundation.org.au/your-heart/evidence-and-statistics/key-stats-cardiovascular-disease (2024, accessed 12 September 2024).
22. Australian Institute of Health and Welfare. Diabetes: Australian facts, Summary, https://www.aihw.gov.au/reports/diabetes/diabetes/contents/summary (2024, accessed 2 October 2024).
23. Australasian Society of Clinical Immunology and Allergy. Autoimmune Diseases, https://www.allergy.org.au/patients/fast-facts/autoimmune-diseases (2023, accessed 12 September 2024).
24. Australian Institute of Health and Welfare. Cancer, https://www.aihw.gov.au/reports/australias-health/cancer (2024, accessed 11 September 2024).
25. Australian Bureau of Statistics. Kidney disease, 2022, https://www.abs.gov.au/statistics/health/health-conditions-and-risks/kidney-disease/latest-release (2023, accessed 2 October 2024).
26. Australian Institute of Health and Welfare. Australia's health 2024: data insights: The ongoing challenge of chronic conditions in Australia, https://www.aihw.gov.au/reports/australias-health/chronic-conditions-challenge (2024, accessed 11 September 2024).
27. Australian Institute of Health and Welfare. Older Australians, Demographic profile, https://www.aihw.gov.au/reports/older-people/older-australians/contents/demographic-profile (2024, accessed 12 September 2024).
28. Australian Institute of Health and Welfare. Australia's children, Australian children and their families, https://www.aihw.gov.au/reports/children-youth/australias-children/contents/background/australian-children-and-their-families (2022, accessed 12 September 2024).

29. Australian Bureau of Statistics. Estimates of Aboriginal and Torres Strait Islander Australians, 30 June 2021, https://www.abs.gov.au/statistics/people/aboriginal-and-torres-strait-islander-peoples/estimates-aboriginal-and-torres-strait-islander-australians/latest-release (2023, accessed 12 September 2024).
30. Choutka J, Jansari V, Hornig M, et al. Unexplained post-acute infection syndromes. *Nat Med* 2022; 28: 911–923.
31. Zimmermann P, Pittet LF, Curtis N. How Common is Long COVID in Children and Adolescents? *Pediatr Infect Dis J* 2021; 40: e482.
32. Rao S, Gross RS, Mohandas S, et al. Postacute Sequelae of SARS-CoV-2 in Children. *Pediatrics* 2024; 153: e2023062570.
33. Gurdasani D, Akrami A, Bradley VC, et al. Long COVID in children. *Lancet Child Adolesc Health* 2022; 6: e2.
34. Mansell V, Dykgraaf SH, Kidd M, et al. Long COVID and older people. *Lancet Healthy Longev* 2022; 3: e849–e854.
35. Fung KW, Baye F, Baik SH, et al. Prevalence and characteristics of long COVID in elderly patients: An observational cohort study of over 2 million adults in the US. *PLOS Med* 2023; 20: e1004194.
36. Al-Aly Z, Davis H, McCorkell L, et al. Long COVID science, research and policy. *Nat Med* 2024; 1–17.
37. Xie Y, Bowe B, Al-Aly Z. Burdens of post-acute sequelae of COVID-19 by severity of acute infection, demographics and health status. *Nat Commun* 2021; 12: 6571.
38. Troeger C, Forouzanfar M, Rao PC, et al. Estimates of the global, regional, and national morbidity, mortality, and aetiologies of lower respiratory tract infections in 195 countries: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet Infect Dis* 2017; 17: 1133–1161.
39. Morawska L, Marks GB, Monty J. Healthy indoor air is our fundamental need: the time to act is now. *Med J Aust*; 217, https://www.mja.com.au/journal/2022/217/11/healthy-indoor-air-our-fundamental-need-time-act-now (2022, accessed 8 April 2024).
40. Australian Institute of Health and Welfare. Health expenditure Australia 2018-19, https://www.aihw.gov.au/reports/health-welfare-expenditure/health-expenditure-australia-2018-19/contents/data-visualisation (2020, accessed 22 August 2014).
41. Allen JG. It's Time for Companies to Monitor Workplace Air Quality. *Harvard Business Review*, 2023, https://hbr.org/2023/11/its-time-for-companies-to-monitor-workplace-air-quality (2023, accessed 27 August 2024).
42. Morawska L, Allen J, Bahnfleth W, et al. A paradigm shift to combat indoor respiratory infection. *Science* 2021; 372: 689–691.
43. Morawska L, Bahnfleth W, Bluyssen PM, et al. Coronavirus Disease 2019 and Airborne Transmission: Science Rejected, Lives Lost. Can Society Do Better? *Clin Infect Dis* 2023; 76: 1854–1859.
44. Sachs JD, Karim SSA, Aknin L, et al. *The Lancet* Commission on lessons for the future from the COVID-19 pandemic. The Lancet 2022; 400: 1224–1280.
45. World Health Organization. WHO global air quality guidelines: particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide, https://www.who.int/publications/i/item/9789240034228 (2021, accessed 17 September 2024).
46. AHSRAE. Position Document on Filtration and Air Cleaning, https://www.ashrae.org/file%20library/about/position%20documents/pd_filtration-and-air-cleaning_2024.pdf (2024, accessed 26 August 2024).
47. Li C, Bai L, He Z, et al. The effect of air purifiers on the reduction in indoor $PM_{2.5}$ concentrations and population health improvement. *Sustain Cities* Soc 2021; 75: 103298.
48. Pineda VS. What is Inclusive and Accessible Public Space? *J Public Space* 2022; 7: 5–8.
49. Australian Human Rights Commission. D.D.A. guide: The ins and outs of access, https://humanrights.gov.au/our-work/disability-rights/dda-guide-ins-and-outs-access (2024, accessed 25 August 2024).
50. Department of Industry Science and Resources. Premises Standards, https://www.industry.gov.au/building-and-construction/premises-standards (2024, accessed 25 August 2024).
51. Australian Human Rights Commission. Access for all: Improving accessibility for consumers with disability, https://humanrights.gov.au/our-work/employers/access-all-improving-accessibility-consumers-disability (2016, accessed 25 August 2024).
52. NSW Department of Customer Service. Your rights at work, https://www.nsw.gov.au/health/serious-illness-and-injury/if-you-have-a-chronic-illness/managing-your-illness-while-working/your-rights-at-work (2021, accessed 25 August 2024).
53. Morawska L, Allen J, Bahnfleth W, et al. Mandating indoor air quality for public buildings. *Science* 2024; 383: 1418–1420.
54. Javidan P. False divisions and dubious equivalencies, https://www.manchesterhive.com/display/9781526170149/9781526170149.00009.xml (2024, accessed 24 August 2024).
55. NSW Department of Education. Student health and wellbeing, https://education.nsw.gov.au/policy-library/policies/pd-2004-0034.html (2024, accessed 3 October 2024).
56. Long Covid Kids. Dr Rae Duncan on Children, COVID-19, Clean Air & Prevention, Online Briefing with Dr David Nabarro, https://www.youtube.com/watch?app=desktop&v=k0mojFpAU00 (2022, accessed 26 August 2024).
57. Sabatino J, Di Chiara C, Di Candia A, et al. Mid- and Long-Term Atrio-Ventricular Functional Changes in Children after Recovery from COVID-19. *J Clin Med* 2022; 12: 186.
58. Rahmati M, Keshvari M, Mirnasuri S, et al. The global impact of COVID-19 pandemic on the incidence of pediatric new-onset type 1 diabetes and ketoacidosis: A systematic review and meta-analysis. *J Med Virol* 2022; 94: 5112–5127.

59. Flaxman S, Whittaker C, Semenova E, et al. Assessment of COVID-19 as the Underlying Cause of Death Among Children and Young People Aged 0 to 19 Years in the US. *JAMA Netw Open* 2023; 6: e2253590.

60. Buonanno G, Ricolfi L, Morawska L, et al. Increasing ventilation reduces SARS-CoV-2 airborne transmission in schools: A retrospective cohort study in Italy's Marche region. *Front Public Health* 2022; 10: 1087087.

61. Vartiainen VA, Hela J, Luoto A, et al. The effect of room air cleaners on infection control in day care centres. *Indoor Environ* 2024; 1: 100007.

62. Victoria Department of Education. School Operations - Ventilation and Air Purification: Policy, https://www2.education.vic.gov.au/pal/ventilation-air-purification/policy (2024, accessed 27 August 2024).

63. Wood SGA, Handy AEE, Roberts K, et al. Assessing classroom ventilation rates using CO_2 data from a nationwide study of UK schools and identifying school-wide correlation factors. *Dev Built Environ* 2024; 19: 100520.

64. Gold J. New ASHRAE Indoor Air Quality Standard Offers Reduced Virus Transmission Risk. *Forbes*, https://www.forbes.com/sites/jamiegold/2023/10/17/new-ashrae-indoor-air-quality-standard-offers-reduced-virus-transmission-risk/ (2023, accessed 1 March 2024).

65. Australian Commission on Safety and Quality in Health Care. Australian Charter of Healthcare Rights, https://www.safetyandquality.gov.au/our-work/partnering-consumers/australian-charter-healthcare-rights (2024, accessed 25 August 2024).

66. Gleeson H. Hundreds of patients died after catching COVID in hospital, and experts say their deaths were preventable. *ABC News*, https://www.abc.net.au/news/2024-05-06/hundreds-died-catching-covid-victoria-hospitals-testing-masking/103784896 (2024, accessed 26 August 2024).

67. Gleeson H. Thousands caught COVID in NSW hospitals last year, hundreds died, new data shows. *ABC News*, https://www.abc.net.au/news/2024-10-14/thousands-patients-caught-covid-nsw-hospitals-2023-data-shows/104448862 (2024, accessed 15 October 2024).

68. Helanne H, Forsblom E, Kainulainen K, et al. Incidence and outcome of hospital-acquired COVID-19 infections in secondary and tertiary care hospitals in the era of COVID-19 vaccinations. *Antimicrob Steward Healthc Epidemiol* 2023; 3: e216.

69. Zhang L, Zhang Z, Pei S, et al. Quantifying the presymptomatic transmission of COVID-19 in the USA. *Math Biosci Eng* 2024; 21: 861–883.

70. Shang W, Kang L, Cao G, et al. Percentage of Asymptomatic Infections among SARS-CoV-2 Omicron Variant-Positive Individuals: A Systematic Review and Meta-Analysis. *Vaccines* 2022; 10: 1049.

71. European Centre for Disease Prevention and Control. Considerations for the use of face masks in the community in the context of the SARS-CoV-2 Omicron variant of concern, https://www.ecdc.europa.eu/en/publications-data/using-face-masks-community-reducing-covid-19-transmission (2022, accessed 25 August 2024).

72. McAndrew F, Abeysuriya RG, Sacks-Davis R, et al. Admission screening testing of patients and staff N95 masks are cost-effective in reducing COVID-19 hospital acquired infections. *J Hosp Infect*; 0. Epub ahead of print 15 July 2024. DOI: 10.1016/j.jhin.2024.06.015.

73. Klompas M, Baker MA, Rhee C, et al. Strategic Masking to Protect Patients from All Respiratory Viral Infections. *N Engl J Med* 2023; 389: 4–6.

74. Australian Commission on Safety and Quality in Health Care. National Safety and Quality Health Service Standards (second edition), https://www.safetyandquality.gov.au/publications-and-resources/resource-library/national-safety-and-quality-health-service-standards-second-edition (2021, accessed 23 September 2024).

75. Australian Commission on Safety and Quality in Health Care. Action 3.08, https://www.safetyandquality.gov.au/standards/nsqhs-standards/preventing-and-controlling-infections-standard/infection-prevention-and-control-systems/action-308 (2024, accessed 23 September 2024).

76. Buising KL, Schofield R, Irving L, et al. Use of portable air cleaners to reduce aerosol transmission on a hospital coronavirus disease 2019 (COVID-19) ward. *Infect Control Hosp Epidemiol* 2022; 43: 987–992.

77. Dorey N. Guide to air cleaners. *School of Geography, Earth and Atmospheric Sciences*, https://sgeas.unimelb.edu.au/engage/air-cleaner-guide (2024, accessed 2 October 2024).

78. Hall VG, Sim BZ, Lim C, et al. COVID-19 infection among patients with cancer in Australia from 2020 to 2022: a national multicentre cohort study. *Lancet Reg Health – West Pac*; 38. Epub ahead of print 1 September 2023. DOI: 10.1016/j.lanwpc.2023.100824.

79. Greenhalgh T, MacIntyre CR, Baker MG, et al. Masks and respirators for prevention of respiratory infections: a state of the science review | Clinical Microbiology Reviews. *Clin Microbiol Rev*; 37: e00124-23.

80. Human Rights Law Centre. Explainer: Prisons and covid19. *Human Rights Law Centre*, https://www.hrlc.org.au/prisons-and-covid19 (2020, accessed 20 September 2024).

81. Lansbury LE, Brown CS, Nguyen-Van-Tam JS. Influenza in long-term care facilities. *Influenza Other Respir Viruses* 2017; 11: 356–366.

82. Falgione J, Snyder GM, Cannon C, et al. Assessing COVID-19 Transmission Risk: Roommate and Unit Mate Exposures at an Inpatient Behavioral Health Facility. *Am J Infect Control*; 0. Epub ahead of print 13 September 2024. DOI: 10.1016/j.ajic.2024.09.003.

83. Quigley A, Stone H, Nguyen PY, et al. COVID-19 outbreaks in aged-care facilities in Australia. *Influenza Other Respir Viruses* 2022; 16: 429–437.

84. Australian Commission on Safety and Quality in Health Care. Infection prevention and control in aged care, https://www.safetyandquality.gov.au/our-work/infection-prevention-and-control/infection-prevention-and-control-aged-care (2024, accessed 27 August 2024).
85. Prof Peter Collignon [@CollignonPeter]. These are the just realesed (sic) Aged Care Infection Prevention and Control Guide. I was fortunate to be the co-chair of the expert group writing these. The intent is to help guide a risk based approach that balances the social and emotional needs of those in aged care, while attempting to lower risk of infection for all, but being practical. *X, formerly Twitter*, https://x.com/CollignonPeter/status/1825798585092550696 (2024, accessed 30 August 2024).
86. Australian Government. Work Health and Safety Act 2011, https://www.legislation.gov.au/C2011A00137/2018-07-01 (2018, accessed 27 August 2024).
87. Safe Work Australia. Welcome, https://www.safeworkaustralia.gov.au/ (2024, accessed 27 August 2024).
88. Querol X, Alastuey A, Moreno N, et al. How can ventilation be improved on public transportation buses? Insights from CO_2 measurements. *Environ Res* 2022; 205: 112451.
89. Allen JG, MacNaughton P, Satish U, et al. Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers: A Controlled Exposure Study of Green and Conventional Office Environments. *Environ Health Perspect* 2016; 124: 805–812.
90. Nowakowicz-Dębek B, Pawlak H, Wlazło Ł, et al. Evaluating bioaerosol exposure among bus drivers in the public transport sector. *J Occup Environ Hyg* 2017; 14: D169–D172.
91. Kumar P, Omidvarborna H, Tiwari A, et al. The nexus between in-car aerosol concentrations, ventilation and the risk of respiratory infection. *Environ Int* 2021; 157: 106814.
92. SafeWork NSW. Managing hazards and risks, https://www.safework.nsw.gov.au/legal-obligations/employer-business-obligations/managing-hazards-and-risks (2018, accessed 22 August 2024).
93. Allen JG, MacNaughton P, Laurent JGC, et al. Green Buildings and Health. *Curr Environ Health Rep* 2015; 2: 250–258.
94. Daisey JM, Angell WJ, Apte MG. Indoor air quality, ventilation and health symptoms in schools: an analysis of existing information. *Indoor Air* 2003; 13: 53–64.
95. Fan Y, Cao X, Zhang J, et al. Short-term exposure to indoor carbon dioxide and cognitive task performance: A systematic review and meta-analysis. *Build Environ* 2023; 237: 110331.
96. Coley DA, Greeves R, Saxby BK. The Effect of Low Ventilation Rates on the Cognitive Function of a Primary School Class. *Int J Vent* 2007; 6: 107–112.
97. MacNaughton P, Pegues J, Satish U, et al. Economic, Environmental and Health Implications of Enhanced Ventilation in Office Buildings. *Int J Environ Res Public Health* 2015; 12: 14709–14722.
98. Fisk WJ, Rosenfeld AH. Estimates of Improved Productivity and Health from Better Indoor Environments. *Indoor Air* 1997; 7: 158–172.
99. Mendell MJ, Fisk WJ, Kreiss K, et al. Improving the Health of Workers in Indoor Environments: Priority Research Needs for a National Occupational Research Agenda. *Am J Public Health* 2002; 92: 1430–1440.
100. Queensland University of Technology. Blueprint for mandating indoor air quality for public buildings in form of standards. *QUT*, https://www.qut.edu.au/news?id=193657 (accessed 27 August 2024).
101. 60 Minutes. Indoor air systems crucial to curbing spread of viruses, aerosol researchers say, https://www.youtube.com/watch?v=WxEssOeEsVk (2023, accessed 27 August 2024).
102. Trans Health Research. Why Are Trans People at Higher Risk of Long COVID? *Trans Research*, https://www.transresearch.org.au/post/long-covid (2023, accessed 2 October 2024).
103. Altmann DM, Whettlock EM, Liu S, et al. The immunology of long COVID. *Nat Rev Immunol* 2023; 23: 618–634.
104. World Health Organization Europe. Post COVID-19 condition (Long COVID), https://www.who.int/europe/news-room/fact-sheets/item/post-covid-19-condition (accessed 30 August 2024).
105. Davis HE, McCorkell L, Vogel JM, et al. Long COVID: major findings, mechanisms and recommendations. *Nat Rev Microbiol* 2023; 21: 133–146.
106. Kedor C, Freitag H, Meyer-Arndt L, et al. A prospective observational study of post-COVID-19 chronic fatigue syndrome following the first pandemic wave in Germany and biomarkers associated with symptom severity. *Nat Commun*; 13. Epub ahead of print 2022. DOI: 10.1038/s41467-022-32507-6.
107. Lorusso L, Mikhaylova SV, Capelli E, et al. Immunological aspects of chronic fatigue syndrome. *Autoimmun Rev* 2009; 8: 287–291.
108. MacIntyre CR, Chu L, Grafton Q, et al. Long COVID cost the Australian economy almost $10 billion in 2022 – new research. *The Conversation*, http://theconversation.com/long-covid-cost-the-australian-economy-almost-10-billion-in-2022-new-research-236948 (2024, accessed 30 August 2024).
109. Zhao T, Cox IA, Ahmad H, et al. The economic burden of myalgic encephalomyelitis/chronic fatigue syndrome in Australia. *Aust Health Rev* 2023; 47: 707–715.
110. Close S, Marshall-Gradisnik S, Byrnes J, et al. The Economic Impacts of Myalgic Encephalomyelitis/Chronic Fatigue Syndrome in an Australian Cohort. *Front Public Health* 2020; 8: 420.
111. Facilities Management Association New Zealand. Time to clear the air: The economic benefits of improving New Zealand's indoor air quality, https://www.fmanz.org/wp-content/uploads/2024/09/FINAL-20240917-IAQ-Report-FMANZ.pdf (2024, accessed 4 October 2024).

112. Bowe B, Xie Y, Al-Aly Z. Acute and postacute sequelae associated with SARS-CoV-2 reinfection. *Nat Med* 2022; 28: 2398–2405.
113. Australian Bureau of Statistics. Causes of Death, Australia, 2023, https://www.abs.gov.au/statistics/health/causes-death/causes-death-australia/latest-release (2024, accessed 11 October 2024).
114. ASHRAE. ASHRAE Standard 241, Control of Infectious Aerosols, https://www.ashrae.org/technical-resources/bookstore/ashrae-standard-241-control-of-infectious-aerosols (2023, accessed 27 August 2024).
115. Standards Australia Store. AS 1668.2:2024 The use of ventilation and air conditioning in buildings, Part 2: Mechanical ventilation in buildings, https://store.standards.org.au/product/as-1668-2-2024 (2024, accessed 21 September 2024).
116. National Construction Code. NCC 2016 Volume Two, Section 2 Performance Provisions, Part 2.4 Health and Amenity (Verification Methods), https://ncc.abcb.gov.au/editions/2016/ncc-2016-volume-two/section-2-performance-provisions/part-24-health-and-amenity (2016, accessed 24 September 2024).
117. Australian Building Codes Board. National Construction Code, Handbook: Indoor air quality, https://www.abcb.gov.au/sites/default/files/resources/2022/Handbook-indoor-air-quality.pdf (2021, accessed 11 October 2024).
118. International WELL Building Institute. Homepage, https://www.wellcertified.com/home (2024, accessed 30 September 2024).
119. Fitwel. Homepage, https://www.fitwel.org (2024, accessed 30 September 2024).
120. International WELL Building Institute. International Healthy Building Accord, https://resources.wellcertified.com/articles/international-healthy-building-accord-sign (2024, accessed 30 September 2024).
121. Australian Government, Department of Social Services. Disability and Australia's Disability Strategy 2021–2031, https://www.dss.gov.au/disability-and-australias-disability-strategy-2021-2031 (2023, accessed 3 September 2024).
122. The ReSisters. Ep 96 Convo with Prof Lidia Morawska, https://www.youtube.com/watch?v=njMSMOUxfGA (2024, accessed 21 September 2024).

Glossary

ACSQHC	Australian Commission on Safety and Quality in Health Care
COPD	Chronic obstructive pulmonary disease
CO	Carbon monoxide
CO_2	Carbon dioxide
CRC	United Nations Convention on the Rights of the Child
DDA	Disability Discrimination Act 1992
EDIB	Equity, diversity, inclusion, and belonging
HAI	Healthcare-acquired infection
IPC	Infection prevention and control
IAQ	Indoor air quality
Ls^{-1} $person^{-1}$	Litres per second per person
Ls^{-1} $student^{-1}$	Litres per second per student
ME	Myalgic encephalomyelitis
POTS	Postural orthostatic tachycardia syndrome
$PM_{2.5}$	Fine particulate matter
PPE	Personal protective equipment
RSV	Respiratory syncytial virus
WHS	Workplace health and safety

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