Submission No 63

INQUIRY INTO CLEAN INDOOR AIR

Organisation: OutbreakSafe

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Portfolio Committee No. 2 – Health
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1. Introduction

1.1 About OutbreakSafe

OutbreakSafe Pty Ltd is an Australian biotechnology company founded in 2022 and headquartered in Victoria. The company's work focuses on technologies and approaches for monitoring airborne infectious disease risk in indoor environments. This work relates to broader international efforts to explore environmental surveillance approaches for indoor airborne infection risk.

The company draws on multidisciplinary expertise spanning epidemiology, infectious disease, engineering, and healthcare operations.

The company's work is focused on improving understanding and management of indoor airborne infection risk.

1.2 Purpose of this submission

OutbreakSafe welcomes the opportunity to contribute to the Portfolio Committee No. 2 – Health inquiry into clean indoor air in New South Wales.

This submission draws upon: contemporary scientific literature on airborne transmission and indoor air quality (IAQ); analysis across major Australian and international IAQ reports; findings from the *Safer Shared Air* report (2024); the *State of Indoor Air in Australia* report (2025); the Australian Academy of Science – *Indoor Air Quality* report (2024), the *Impact of Indoor Air Quality on Transmission of Airborne Viral Diseases* report (2024); IWBI's *Investing in Health Pays Back (2024–2025)*; and applied modelling and deployment insights, where consistent with published evidence.

Our goal is to provide evidence-informed, practical recommendations that strengthen NSW's approach to clean indoor air, infectious-disease resilience, worker safety, and whole-of-system preparedness. Of note, not all buildings require the same level of intervention; preparedness measures should be proportionate to risk, occupancy, and function.

1.3 Terms of reference addressed

From the Inquiry's Terms of Reference, this submission addresses the following elements:

1. (b) Indoor Air Quality Standards and Monitoring.

   (c) Solutions to improve indoor air quality, including:

   (i) building design;

   (ii) retrofitted measures; and

(iii) emerging technologies.

(d) Implications for pandemic preparedness.

(e) Other related matters.

2. Executive Summary

2.1 Key messages

Australia's indoor air quality monitoring framework remains incomplete, with current practice relying on proxy indicators such as carbon dioxide and particulate matter that cannot detect airborne pathogens or directly measure infection risk [1–4].

Current building design standards do not yet systematically incorporate infection-risk-focused approaches, including performance-based verification of clean-air delivery, airflow modelling to identify stagnation and distribution issues, or routine integration of digital indoor air quality monitoring infrastructure, meaning infection risk is not consistently addressed at either the design or operational stage [1,3,7,10].

High-impact retrofit measures—such as ventilation optimisation, high-efficiency filtration and ultraviolet germicidal irradiation (UV-C)—have been shown in real-world field studies and systematic evidence syntheses to substantially reduce aerosolised viral and bacterial loads in occupied indoor environments, particularly when applied in high-risk settings [3,4,9,14–16].

Pandemic preparedness is increasingly understood to require indoor early-warning and surveillance approaches, with buildings moving beyond passive compliance toward more active management of airborne infection risk and operational readiness during infectious disease events [1,3–5,7,8,11,12].

Clean indoor air is increasingly recognised as essential public-health infrastructure, and NSW has an opportunity to demonstrate national leadership through the adoption of performance-based standards, strengthened monitoring frameworks, structured evaluation of emerging indoor air quality technologies, and integration of these measures within broader public-health and pandemic preparedness frameworks [1,3–5,7,10–12].

2.2 Summary of recommendations

Recommendation 1: Establish a NSW Monitoring Framework Including Pathogen Detection

Current indoor air quality indicators rely on proxy measures and cannot detect airborne infectious particles. NSW should prepare standards and regulatory pathways capable of incorporating biological monitoring once such technologies are sufficiently mature, independently validated, and appropriate for regulatory use.

Recommendation 2: Update Building Design Standards to Incorporate Infection Risk

Modern building design standards should incorporate infection-risk considerations, including airflow modelling, performance-based verification of clean-air delivery, and digital readiness for continuous monitoring, so that infection risk is addressed systematically at both design and operational stages.

Recommendation 3: Prioritise High-Impact Retrofits in High-Risk Sectors

High-impact retrofit measures, including ventilation optimisation, HEPA or MERV-13+ filtration, and ultraviolet germicidal irradiation (UV-C), should be prioritised for deployment in healthcare, aged care, schools, and public buildings, based on assessed infection risk, building characteristics, and available evidence of effectiveness.

Recommendation 4: Support Evaluation of Emerging Pathogen-Detection Technologies

International agencies identify the importance of continued research and evaluation of airborne pathogen-detection technologies. NSW should support independently validated pilot deployments in priority sectors to assess technical performance, feasibility, and integration with existing building and public-health systems.

Recommendation 5: Integrate Pathogen Monitoring into Pandemic Preparedness Frameworks

Where appropriate, airborne surveillance capabilities, including real-time or near-real-time monitoring, should be integrated into emergency management, workplace health and safety, and public-health preparedness frameworks to support earlier detection and proportionate response during infectious disease events.

Recommendation 6: Enable an "Infection Mode" for Building Operations During Outbreaks

NSW should enable an operational "infection mode" capability for critical facilities, allowing buildings to activate enhanced ventilation, filtration, and disinfection measures when indoor air quality indicators or validated detection signals indicate elevated infection risk.

3. Term of Reference – detailed response re 1 (b) Indoor Air Quality Standards and Monitoring

3.1 Current standards and guidelines

Australian and NSW indoor air quality (IAQ) monitoring practices rely primarily on proxy indicators, such as CO_2 concentration, particulate matter, and ventilation estimates, rather than direct measurement of airborne infectious aerosols. Current Australian standards and guidance materials focus predominantly on general indoor pollutants (including CO_2, particulates and volatile organic compounds) and are not designed to directly address airborne infectious disease risk. Major national and international reviews consistently

identify the absence of nationally consistent IAQ standards, the lack of requirements for biological monitoring, and the need for stronger, health-aligned frameworks capable of addressing airborne transmission in real-world indoor environments [1-4,10,12].

3.2 Limitation of current monitoring approached

The *Indoor Air Quality Report 2024* and related national reviews describe several commonly used approaches to indoor air monitoring, including direct pathogen sampling, ventilation measurement, CO_2 monitoring and particulate matter monitoring, and identify important limitations:

- None of these methods directly measure infection risk [1,4].
- Airborne pathogens are typically present at very low concentrations, making reliable sampling technically challenging and often requiring large air volumes and extended sampling durations [1,2,15].
- CO_2 monitoring functions as a proxy for ventilation adequacy but does not account for filtration, pathogen inactivation, or spatial variability in airflow within rooms [4,6,10].
- Particulate matter measurements are highly confounded by non-respiratory sources and do not distinguish infectious from non-infectious aerosols [1,4,14].

Collectively, these limitations demonstrate that reliance on proxy indicators alone is insufficient for understanding or managing airborne infection risk in indoor environments [1,3,4].

3.3 The gap in biological monitoring

Airborne pathogen monitoring is not currently standardised or embedded within Australian IAQ regulatory frameworks:

- There is no formal legislative or standards-based requirement for biological air sampling or pathogen detection in buildings [1,2,3,10].
- International evidence reviews report variability in detection outcomes depending on sampling method, airflow conditions, sampling duration and analytical technique [12,14,15].
- In the absence of biological monitoring, decision-makers lack the ability to directly assess whether infectious aerosols are present in indoor environments [1,4].

This gap limits the capacity of existing IAQ frameworks to support informed risk management during respiratory infectious disease events [1,3,4].

3.4 Emerging need for real-time pathogen detection

International policy and research initiatives increasingly recognise the potential role of direct pathogen detection and environmental surveillance in strengthening pandemic preparedness:

- The European Commission Joint Research Centre identifies environmental surveillance and early-detection technologies as emerging tools for suppressing indoor pathogen transmission [12].
- In the United States, the ARPA-H BREATHE program is funding research and development into advanced indoor air monitoring and early-warning approaches, including pathogen detection and integration with building systems [11].

These initiatives signal a growing international focus on developing and evaluating real-time or near-real-time approaches to airborne pathogen detection as a complement to existing proxy-based IAQ monitoring [1,11,12].

4. Term of Reference – detailed response re 1(c): Solutions to improve indoor air quality

Improving indoor air quality in a manner that meaningfully reduces airborne infectious disease risk is widely understood to require a layered, systems-based approach, rather than reliance on any single intervention. National and international reviews consistently find that the greatest reductions in airborne transmission risk are achieved when building design, retrofit measures and emerging technologies are implemented as complementary components of a coherent indoor air quality strategy, rather than as isolated actions [1,3–5,14].

4.1 Building design

Building design plays a foundational role in shaping indoor air quality and airborne infection risk across the life of a facility. Current Australian building standards primarily address thermal comfort, energy efficiency, and minimum ventilation rates, but do not explicitly incorporate infection-risk management as a primary design objective [1,3,4,10].

A key limitation of traditional design approaches is their reliance on nominal ventilation metrics, such as air changes per hour. While useful for compliance and benchmarking, these metrics do not describe how air and aerosols actually move within occupied spaces. As a result, buildings may meet minimum standards while still exhibiting stagnation zones, airflow short-circuiting, or uneven distribution, leading to areas of elevated airborne infection risk [1,3,4,14].

More performance-oriented design approaches are supported by airflow and contaminant-dispersion analysis, including the application of computational fluid dynamics (CFD) in complex or higher-risk environments. CFD is an established engineering tool, particularly in healthcare and other high-risk settings, used to simulate airflow patterns, aerosol

transport, and contaminant behaviour under representative operating conditions. This allows assessment of ventilation effectiveness beyond nominal design parameters [1,7,12].

When applied appropriately, airflow and dispersion modelling can support improved indoor air outcomes by enabling:

- Identification of areas where airflow patterns may allow airborne contaminants to persist, supporting targeted mitigation [1,3,4];
- Optimisation of air supply and return locations to improve effective dilution and removal of aerosols [1,4,7];
- Examination of potential occupant-to-occupant aerosol pathways in high-density or poorly ventilated spaces [1,4,12];
- Consideration of ventilation performance under different operational scenarios, including periods of elevated infection risk [5,7,12];
- Evaluation of design and retrofit options prior to implementation, reducing reliance on post-occupancy adjustments [1,12].

In addition to airflow analysis, contemporary building design approaches increasingly emphasise:

- Ventilation performance as an outcome, assessed through measures of effective clean-air delivery rather than nominal system capacity alone [4,7,10];
- Operational flexibility, enabling buildings to adjust ventilation and air-treatment strategies during periods of elevated infection risk [5,7,8];
- Digital readiness, including infrastructure that supports monitoring, system integration, and future adoption of emerging technologies as standards and guidance evolve [1,10,11].

Embedding infection-risk considerations and performance-based analysis at the design stage can reduce reliance on reactive retrofits, support long-term resilience, and improve the capacity of buildings to respond adaptively to both routine public-health needs and future pandemic events [1,4,5,12].

4.2 Retrofitted measures

For the existing building stock, retrofitted interventions represent the most immediate opportunity to improve indoor air quality and reduce infection risk. A substantial body of real-world evidence demonstrates that targeted retrofits can deliver meaningful reductions in airborne pathogen exposure, particularly when applied in high-risk or high-occupancy settings [3,4,9,14–16].

High-impact retrofit measures include:

- *Ventilation optimisation*

Many buildings operate below their intended ventilation performance due to control settings, maintenance limitations, or energy-saving adjustments. Optimising outdoor air fractions, correcting system imbalances, and improving air distribution can increase effective ventilation and reduce airborne contaminant accumulation without major capital works [4,5,6,14].

- *High-efficiency filtration*
  Upgrading to higher-efficiency filtration (such as MERV-13 or HEPA filters, where system-compatible) has been shown to reduce concentrations of airborne particles in the respirable size range associated with viral transmission. The effectiveness of filtration does, however, depend on appropriate system design, installation, and ongoing maintenance [9,14].
- *Ultraviolet germicidal irradiation (UV-C)*
  UV-C air-disinfection technologies have demonstrated the ability to inactivate airborne viral and bacterial pathogens when properly designed and deployed. Upper-room and in-duct UV-C systems have been shown to reduce viable airborne pathogen concentrations in healthcare, aged-care, and other high-risk environments [3,15,16].
- *Operational controls and commissioning*
  The effectiveness of retrofitted measures depends on ongoing commissioning, performance verification, and operational oversight. Without these supporting practices, potential improvements may not translate into sustained real-world risk reduction [4,7,14].

Prioritisation of retrofit deployment is generally most effective in high-occupancy environments, settings serving vulnerable populations, and facilities providing essential public services, where potential public-health benefit is greatest [1,3,4].

4.3 Emerging technologies

Emerging technologies represent an important area of development in efforts to improve indoor air quality and manage airborne infectious disease risk. While many remain in early stages of deployment, they are directed at addressing recognised limitations of proxy-based monitoring approaches and static building control strategies [1,4,11,12].

Key areas of innovation include:

- *Real-time airborne pathogen detection*
  Traditional IAQ metrics infer infection risk indirectly. Emerging biological monitoring technologies seek to directly detect airborne pathogens, potentially enabling earlier warning and more informed operational response. Although these technologies are still maturing, international research and policy initiatives increasingly recognise their potential relevance to future pandemic preparedness [1,11,12].
- *Integrated sensing and automation*
  Advances in sensor integration, data analytics, and building automation allow IAQ

signals to inform operational responses, such as adjusting ventilation rates, activating filtration or disinfection systems, or alerting facility managers to elevated risk conditions [6,10,11].

- *Performance-based standards*
  Emerging technologies support a gradual transition from prescriptive requirements toward performance-based frameworks, in which outcomes such as effective clean-air delivery or risk reduction can be measured and verified [7,10,12].

Support for independent evaluation, piloting, and validation of emerging technologies is important to ensure that future adoption is safe, effective, and grounded in evidence, and that regulatory and operational frameworks evolve in a proportionate and informed manner [1,11,12].

5. Term of Reference – detailed response re 1(d): Implications for pandemic preparedness

The COVID-19 pandemic demonstrated that indoor environments play a significant role in the transmission of airborne infectious diseases, particularly in shared and enclosed settings. However, pandemic preparedness frameworks have historically focused on clinical capacity, testing, and behavioural interventions, with comparatively limited attention given to the role of buildings as contributors to transmission risk or as platforms for mitigation [1,3,4,5].

Recent national and international analyses emphasise that pandemic preparedness is strengthened by standing capabilities embedded within the built environment, rather than reliance on reactive and short-term measures alone. Within this framing, clean indoor air is increasingly recognised as a supporting element of public-health preparedness, alongside surveillance, vaccination, and healthcare system readiness [1,2,4,5].

5.1 From reactive measures to built-in preparedness

During recent pandemics, many indoor air interventions were deployed rapidly and inconsistently, often through temporary or ad hoc measures such as portable filtration units, short-term ventilation adjustments, or occupancy restrictions. While these measures provided some benefit, they were generally not designed for sustained operation, systematic deployment, or long-term integration across diverse building types [3,4,5,14].

Preparedness frameworks increasingly suggest that buildings should be capable of:

- operating safely under prolonged outbreak conditions;
- maintaining enhanced indoor air performance without disproportionate operational burden; and
- adjusting operational settings in response to changing levels of infection risk [1,4,5,7].

Embedding such capabilities at the design, retrofit, and operational levels can reduce reliance on emergency measures and support more timely and proportionate responses during future outbreaks [1,4,5,12].

5.2 Early warning and situational awareness

A recognised limitation of many pandemic response frameworks is the absence of environmental early-warning mechanisms within buildings. Public-health responses therefore tend to rely on clinical testing, reported case numbers, and analysis of symptoms presenting in healthcare settings, all of which occur after transmission has already taken place and therefore provide limited opportunity for early intervention [1,3,4].

Emerging approaches to indoor air monitoring, including real-time or near-real-time detection of airborne pathogens, are being explored as potential tools to provide earlier signals of elevated risk in specific environments. When appropriately validated and integrated with public-health and facility-management systems, such approaches may support [1,11,12]:

- earlier identification of conditions associated with increased transmission risk;
- targeted activation of ventilation, filtration, or disinfection measures;
- improved situational awareness for facility operators and public-health authorities.

Environmental surveillance within buildings is generally framed as complementary to clinical surveillance, with the potential to help reduce timing gaps in outbreak detection and response rather than replace existing public-health systems [1,4,12].

5.3 Operational readiness of buildings during outbreaks

Pandemic preparedness increasingly emphasises the importance of operational readiness within buildings, including the ability to transition into enhanced operating states when infection risk rises. This may include predefined operational responses linked to environmental indicators or public-health guidance, rather than *ad hoc* decision-making [5,7,8].

Examples of preparedness-oriented building operations described in guidance and reviews include:

- increasing outdoor air fractions and ventilation rates where system capacity allows [5,6,7];
- activating higher-efficiency filtration or air-disinfection systems where installed [9,14–16];
- adjusting airflow patterns to reduce cross-zone transfer in complex facilities [1,4,12];
- prioritising protection of high-risk areas or populations within facilities [1,3,4].

Formalising predefined operational protocols for buildings during outbreaks can help ensure more consistent, accountable and timely action in response to elevated infection risk. These approaches are discussed as practical preparedness tools, rather than as prescriptive or mandatory requirements [7,8,12].

5.4 Integration with public-health and emergency frameworks

Indoor air strategies are increasingly discussed as most effective when integrated within broader public-health and emergency-management frameworks, rather than treated solely as facilities or building-management issues. This includes alignment with:

- public-health emergency planning and guidance [1,4,5];
- work health and safety obligations relating to airborne hazards [4,8];
- infection-prevention frameworks in healthcare and aged-care settings [3,4];
- continuity and resilience planning for essential services [1,2].

Clear articulation of roles, responsibilities, and escalation pathways can help ensure that environmental controls are deployed in a coordinated and proportionate manner during public-health emergencies [1,4,5].

5.5 Long-term preparedness and system learning

Pandemics are increasingly characterised in the literature as recurring and foreseeable events, rather than isolated anomalies. As such, preparedness frameworks benefit from supporting ongoing evaluation, learning, and adaptation over time [1,2,12].

Data generated through indoor air monitoring, building operations, and intervention performance during outbreak periods can inform future policy development, standards evolution, and investment decisions, supporting progressively more effective and evidence-based responses to airborne disease threats [1,2,4,12].

By progressively embedding pandemic preparedness considerations into the built environment, NSW can strengthen its capacity to protect health, maintain essential services, and respond more effectively to future airborne infectious disease events [1,3,4,5].

6. Term of Reference – detailed response re 1(e): Other related matters

6.1 Governance and accountability

Effective management of indoor air quality benefits from clear governance arrangements and well-defined responsibilities. In practice, responsibility for indoor air quality often spans multiple domains, including building owners and operators, employers, health regulators, work health and safety authorities, and emergency management agencies. National and international reviews note that unclear accountability and fragmented

oversight can impede consistent implementation of indoor air quality measures, particularly during public-health emergencies [1,2,4,5].

Clarifying roles, coordination mechanisms, and decision-making responsibilities can support more consistent outcomes and reduce uncertainty for building operators and public institutions, especially during periods of elevated infection risk [1,2].

6.2 Workforce health and safety

Airborne infectious disease risk is increasingly recognised as a workplace health and safety consideration, particularly for workers in healthcare, education, transport, aged care, and other public-facing roles who experience higher levels of exposure in shared indoor environments. National reviews and guidance highlight that existing WHS frameworks can address airborne hazards, but that infection risk is not always explicitly considered in indoor air quality standards or monitoring practices [1,3,4,8].

Recognising airborne infection risk as part of occupational health and safety obligations can support clearer risk assessment, more consistent mitigation practices, and improved protection for workers in higher-risk settings [1,4,8].

6.3 Equity and access

Evidence consistently shows that poor indoor air quality disproportionately affects vulnerable populations, including children, older people, and individuals with chronic health conditions or disabilities. Public buildings, schools, healthcare facilities, aged-care settings, and social housing are repeatedly identified as environments where indoor air quality has direct implications for health equity and access to essential services [1-3].

Ensuring more equitable access to clean indoor air in publicly funded and publicly accessed buildings is therefore widely framed as a matter of public interest and social equity, rather than solely a technical or facilities-management issue [1,2].

6.4 Transition from guidance to implementation

Over recent years, guidance on clean indoor air and airborne infection risk has expanded significantly at both national and international levels. However, multiple reviews observe that implementation remains uneven, with variability in uptake across jurisdictions, sectors, and building types [1,2,4,12].

Bridging the gap between guidance and practice may require clear objectives, measurable performance indicators, and appropriate resourcing, alongside mechanisms for evaluation and learning. Such approaches can help translate policy intent into sustained, real-world improvements in indoor air quality and public-health protection [1,2,12].

7. Conclusion

Clean indoor air is fundamental to health, economic productivity, workplace health and safety, and equitable access to services across New South Wales. National and international evidence consistently shows that improving indoor air quality delivers significant economic, productivity and wellbeing benefits, while supporting public-health objectives and strengthening resilience to future pandemics and other airborne disease risks [1,2,13].

This submission has outlined the limitations of current indoor air quality standards and monitoring approaches, including the need to prepare for more direct and informative monitoring capabilities as technologies mature, and has identified practical and proportionate opportunities for NSW to strengthen preparedness through performance-based design, targeted retrofits, and the considered evaluation of emerging technologies. These measures can be advanced in ways that support public health objectives while avoiding unnecessary regulatory or operational burden.

OutbreakSafe appreciates the Committee's leadership in examining clean indoor air as a matter of public interest and welcomes continued engagement to support informed consideration of evidence-based options that advance indoor air quality and public health protection across New South Wales.

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