

Indoor air quality risk assessment and management in Singapore

AIVC-ASC Technical Conference
18 April 2024

Shuzhen SIM, PhD
Director
Environmental Epidemiology and Toxicology Division
Environmental Health Institute, National Environment Agency
sim_shuzhen@nea.gov.sg

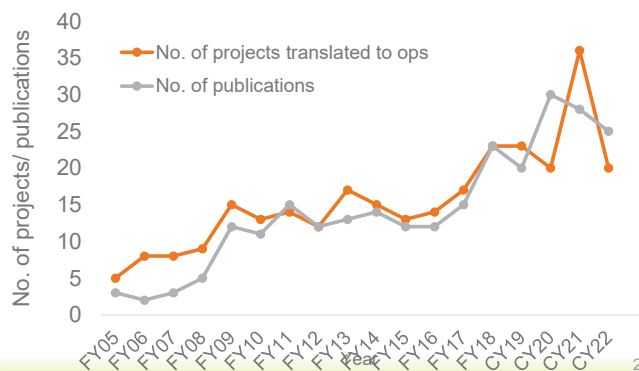


Environmental Health Institute (EHI)

As an environmental public health laboratory at NEA, EHI's mission is to:

- Conduct **research, surveillance, and risk assessment** to acquire knowledge on environmental issues affecting public health
- Develop evidence-based, cost-effective **tools and strategies** to safeguard a healthy environment

>260 scientific papers published and >280 research projects translated to operations since 2005



Cross-disciplinary research programmes



Need for action to manage IAQ in Singapore

People spend more time indoors

Increased A/C use in buildings

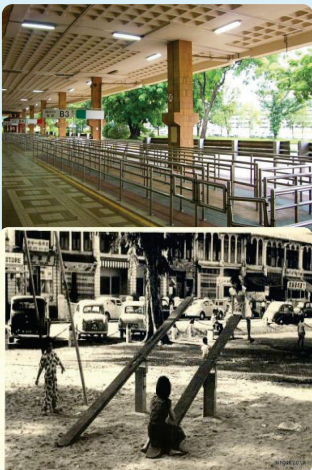
Increasing IAQ feedback related to chemical emissions

Poor ventilation increases risk of aerosol transmission

Possibility of transboundary haze

Emphasis on energy savings

Poor knowledge / neglect of IAQ



1 IAQ risk assessment

Survey of IAQ in Singapore premises: poor ventilation and pollution sources among risks identified

2013-2019 national IAQ survey led by NEA and supported by public agencies and research institutions

- Childcare centres
- Shophouses (small business units)
- Offices
- Transport hubs (MRT stations and bus interchanges)
- Food establishments

Assessment of indoor air quality in air-conditioned small business units with no mechanical ventilation

Gayatri Sankaran^a, Sze Tat Tan^a, Joanna Shen^a, Ramona Gutiérrez^{a,b}, Lee Ching Ng^{a,c}, Shuzhen Sim^{a,*}

Air quality in underground metro station commuter platforms in Singapore: A cross-sectional analysis of factors influencing commuter exposure levels

Sze Tat Tan^a, Nazeem Mohamed^a, Lee Ching Ng^b, Joel Aik^{a,c,*}

Characterization of size-differentiated airborne particulate matter collected from indoor environments of childcare facilities

Gayatri Sankaran^a, Sze Tat Tan^a, Rowena Yap^a, Mei Ling Chua^b, Lee Ching Ng^{a,c,**}, Saji George^{b,d,*}

Exposure and risk assessment of volatile organic compounds and airborne phthalates in Singapore's Child Care Centers

Shenglan Jia^a, Gayatri Sankaran^b, Bei Wang^a, Hongtao Shang^a, Sze Tat Tan^b, Hooi Ming Yap^b, Joanna Shen^b, Ramona Alikiteaga Gutiérrez^b, Wenjuan Fang^a, Min Liu^c, Victor Wei-Chung Chang^{a,d,**}, Lee Ching Ng^b, Mingliang Fang^{a,c,e,*}

Risks identified:

Inadequate ventilation

- Use of split unit A/C with no outdoor air provision commonly observed

Exposure to chemical pollutants

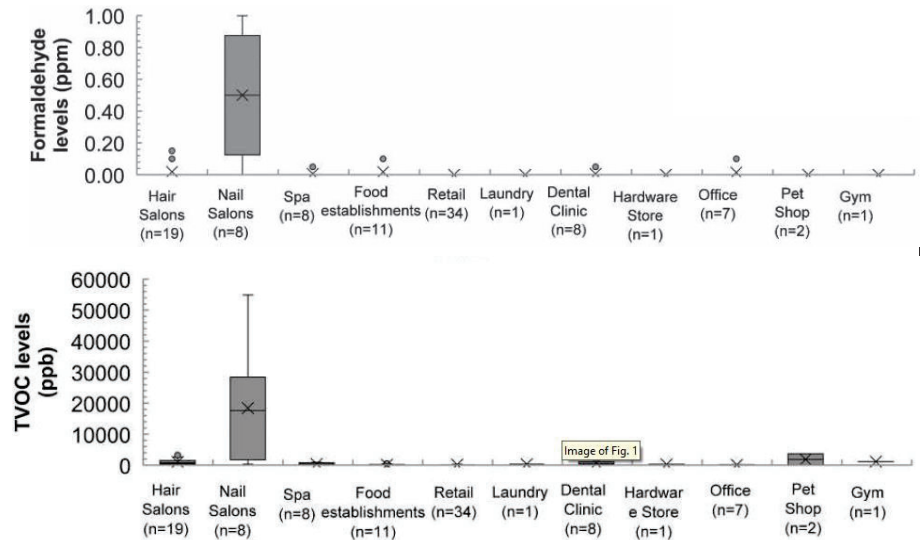
- From products e.g. formaldehyde, VOCs from building/cosmetic products
- From activities e.g. CO from cooking

Infiltration of outdoor pollutants e.g. PM2.5

- Risk when outdoor air quality is poor, e.g. during transboundary haze episodes

2018 air-conditioned shophouse survey: no outdoor air provision in 90/100 units

- Lack of ventilation contributes to high chemical pollutant levels in spaces with a pollutant source (e.g. nailcare products)
- Formaldehyde and TVOC levels significantly correlated with indoor CO₂ levels



Sankaran 2023. Assessment of indoor air quality in air-conditioned small business units with no mechanical ventilation. *Atmospheric Environment*. doi.org/10.1016/j.atmosenv.2023.119645

COVID-19: environmental risk assessment and raising awareness of public hygiene measures



Field risk assessments to understand environmental transmission and recommend mitigation measures

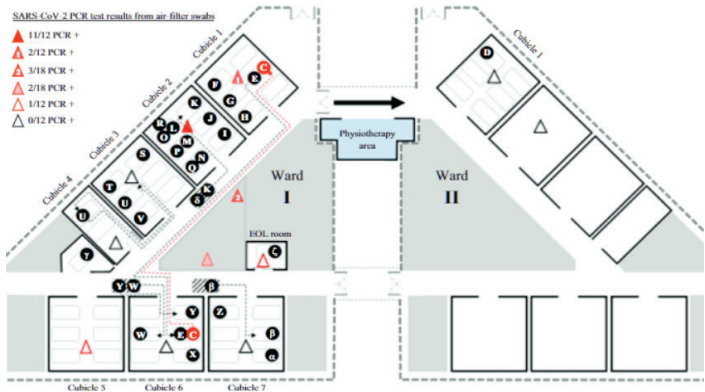
- Hotels
- Changi Airport
- Hospital wards
- Vaccination centres
- Food processing facilities
- Residential
- Childcare centres
- Nursing homes
- Markets and hawker centres

With Building and Construction Authority (BCA), Ministry of Health (MOH), and other government agencies

Singapore hospital ward: epidemiological and aerosol studies support role of aerosol-mediated transmission

First nosocomial cluster of COVID-19 due to the Delta variant in a major acute care hospital in Singapore: investigations and outbreak response

W.-Y. Lim^{a,b,*}, G.S.E. Tan^c, H.L. Htun^a, H.P. Phua^a, W.M. Kyaw^a, H. Guo^a, L. Cui^d, T.M. Mak^d, B.F. Poh^e, J.C.C. Wong^f, Y.X. Setoh^f, B.S.P. Ang^{b,c}, A.L.P. Chow^{a,b}



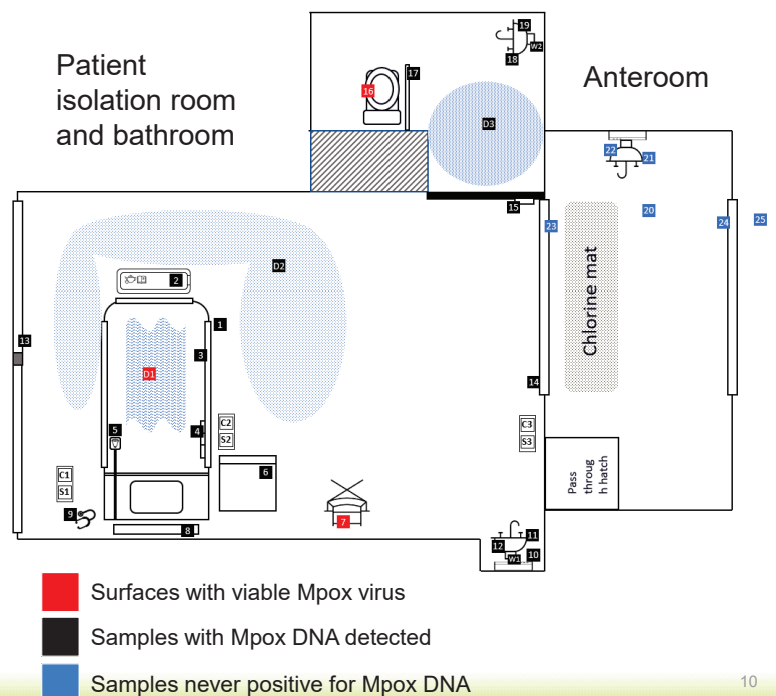
- Though designed as naturally ventilated, the ward was air-conditioned with limited ventilation
- Epidemiological investigation and smoke test performed by EHI and IMRE (A*STAR) showed **likelihood of long-range airborne spread**, in addition to close contact spread through droplets
- Cases cluster in section with the poorest ventilation
- Study led to installation of exhaust fans in wards



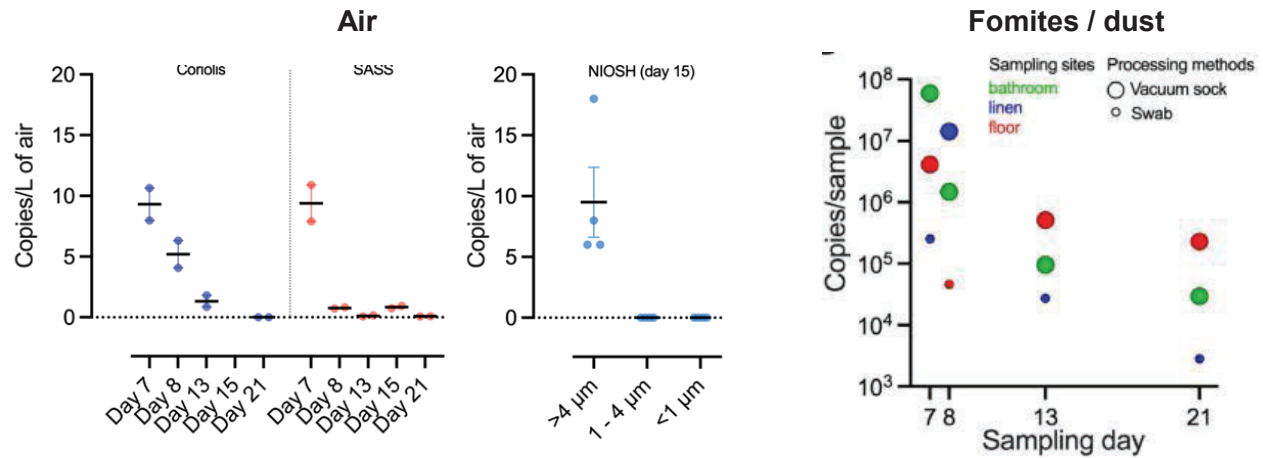
Mpox: environmental sampling in patient isolation room informed disinfection and PPE guidance

Study done with National Centre for Infectious Diseases

- Widespread environmental contamination of surfaces in patient's room
- Viable virus detected on seats and dust from case's linen
- Highlights possibility of fomite-based transmission, importance of disinfection, and need for precautions when handling linen



Mpox: environmental sampling in patient isolation room informed disinfection and PPE guidance



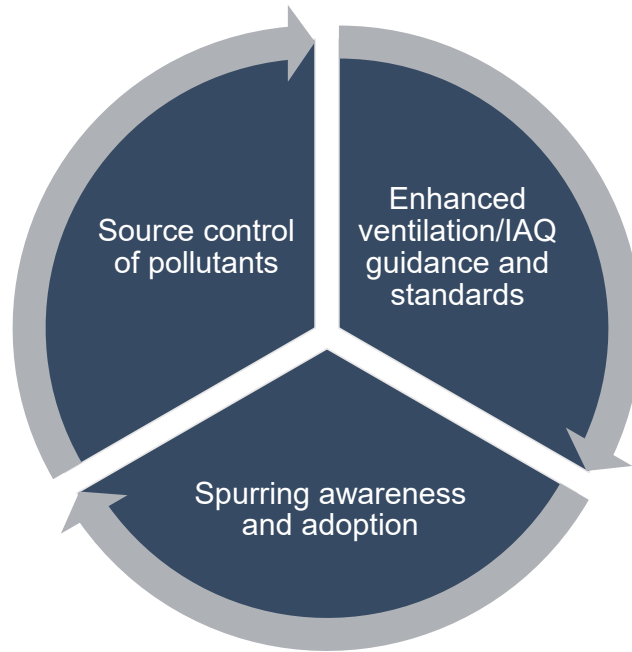
- Viral load generally decreased after 7-8 days of illness
- Detection in air, in 12 HEPA-filtered ACH, highlights possibility of airborne transmission
 - Positive detection only in particles >4 μm suggests that breathing/talking may not be source of virus
 - Live virus in dust samples suggests that lesion shedding could be potential source of contaminated particles in air.

11

2 IAQ management efforts

12

Key IAQ management strategies



13

Upstream control of VOCs from indoor sources

Promote the good:

- Recognise low-emissions indoor building products through green labelling schemes by industry groups
- E.g. paints, adhesives, flooring, composite woods, furniture



Singapore Environment Council



Singapore Green Building Council

Keep out the bad:

- Regulation of formaldehyde content in products:
 - NEA: paints
 - Health Sciences Authority: cosmetics e.g. nail products

Singapore to ban formaldehyde in interior paints over health concerns from 2026

Short-term exposure to formaldehyde may cause eye and nose irritation, and long-term exposure could increase the risk of asthma and cancer, authorities say.

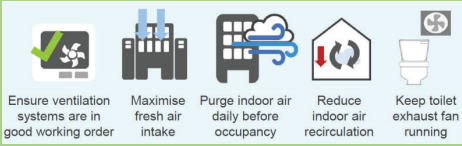
SINGAPORE: Singapore will ban the addition of formaldehyde in paints used for the interiors of buildings from 2026, Minister for Sustainability and the Environment Grace Fu said on Monday (Mar 4).

(CNA, 4 March 2024)

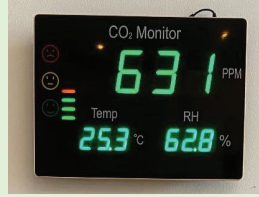
14

COVID-19 guidance to enhance ventilation and indoor air quality

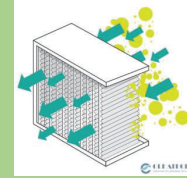
Guidance on **enhancing ventilation and IAQ in buildings** to mitigate infectious aerosol risk, e.g:



Advisory on **CO2 monitoring** to assess ventilation adequacy



Advisory on effective and safe **air cleaning technologies**; whitelist of portable air purifiers



Guidance for **quarantine hotels**, e.g. ensuring functioning ventilation and exhaust, sealing of gaps in partition walls, deployment of HEPA air purifiers

Enhanced measures for **new worker dormitories**, e.g. adequate fans in dormitories, exhaust fans for toilets, MERV14 filters for A/C spaces

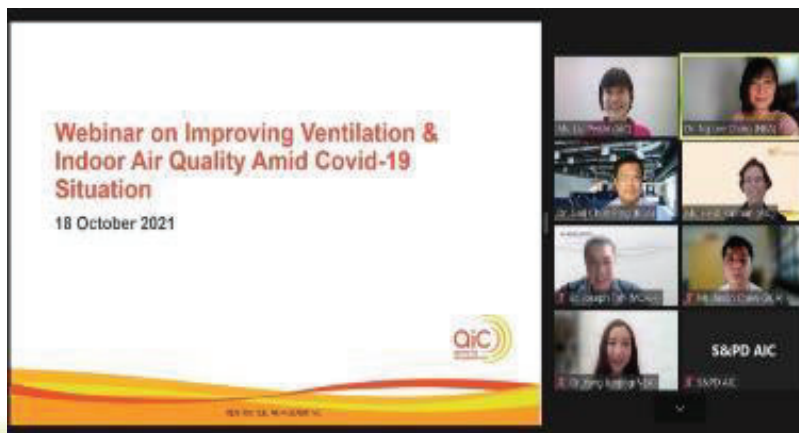
Interim update of Singapore Standards on ventilation and IAQ to provide pandemic guidance to mitigate aerosol transmission

Efforts to provide expert guidance/training and raise public awareness

Outreach to government agencies, building owners/managers, public

- Site assessments and expert advice provided to >100 critical facilities
- Conducted training webinars reaching >3,000 facilities managers
- Social media posts to reach general public

Endemicity: ongoing efforts to spur adoption of standards



#DidYouKnow? Poor ventilation increases the risk of COVID-19 transmission in enclosed spaces.

You can enhance ventilation by introducing fresh air intake or improving air exchange in enclosed spaces. Follow the tips shown in these infographics to reduce COVID-19 transmission risk.

Poor Ventilation Increases Risk of COVID-19 Transmission

COVID-19 can be spread through virus aerosols in the air

- Good ventilation reduces risk of transmission by reducing amount of virus in air

Naturally-ventilated spaces are safer if well ventilated

- To enhance natural ventilation, open doors and windows
- Position fans to blow air outwards

In air-conditioned spaces, ensure fresh air intake

- Centralised air-con systems usually provide fresh air; split-unit systems may not
- Check with facility managers if in doubt
- To introduce fresh air, open doors and windows, and install exhaust fans

High CO₂ levels indicate poor ventilation

- In public spaces, premises owner/ operators may consider using a CO₂ meter to measure CO₂ levels
- Improve ventilation if CO₂ levels are above 800ppm

Use air cleaners in enclosed, poorly ventilated spaces

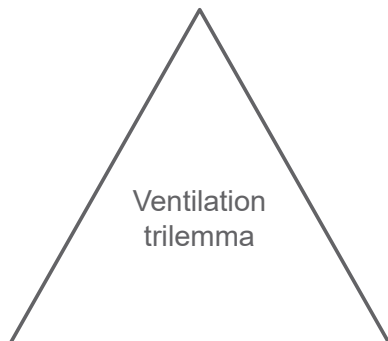
- Recommended if no options to ventilate, and where transmission risk is high (e.g. mask-off activities, swabbing)
- Use air cleaners with HEPA filters, and turn to maximum setting

More info: go.gov.sg/indoor-air-quality-guidance-note

Building and Construction Authority | MINISTRY OF HEALTH | National Environment Agency

Ongoing update of local ventilation/IAQ standards to address evolving threats

Peacetime: optimise outdoor air intake to balance IAQ and energy efficiency



Pandemic: provide sufficient clean air to remove virus aerosols

Haze: Use high efficiency filter to minimise outdoor contaminants

Local standards:

- Singapore Standard (SS) 553: Air-conditioning and mechanical ventilation in buildings
- SS554: Indoor air quality for air-conditioned buildings

Current review to incorporate concepts from ASHRAE 241

- Equivalent clean air for infection control
- Standard and resilient modes to mitigate risk from pandemic/haze when needed

Acknowledgements

- National Environment Agency
 - Environmental Health Institute
 - Ng Lee Ching (Group Director)
 - Judith Wong
 - Yang Junjing (Built Environment lead)
 - Built Environment Branch members (past and present)
 - Policy/ops divisions
- Building and Construction Authority
- Ministry of Health
- Tan Tock Seng Hospital
- National Centre for Infectious Diseases
- Prof Tham Kwok Wai
- Prof Chandra Sekhar
- SS553 and SS554 working group members

Our Environment

Safeguard • Nurture • Cherish

