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Learning from COVID-19: uses and misuses of the IAQ toolkit and where we need to do more

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with the support of
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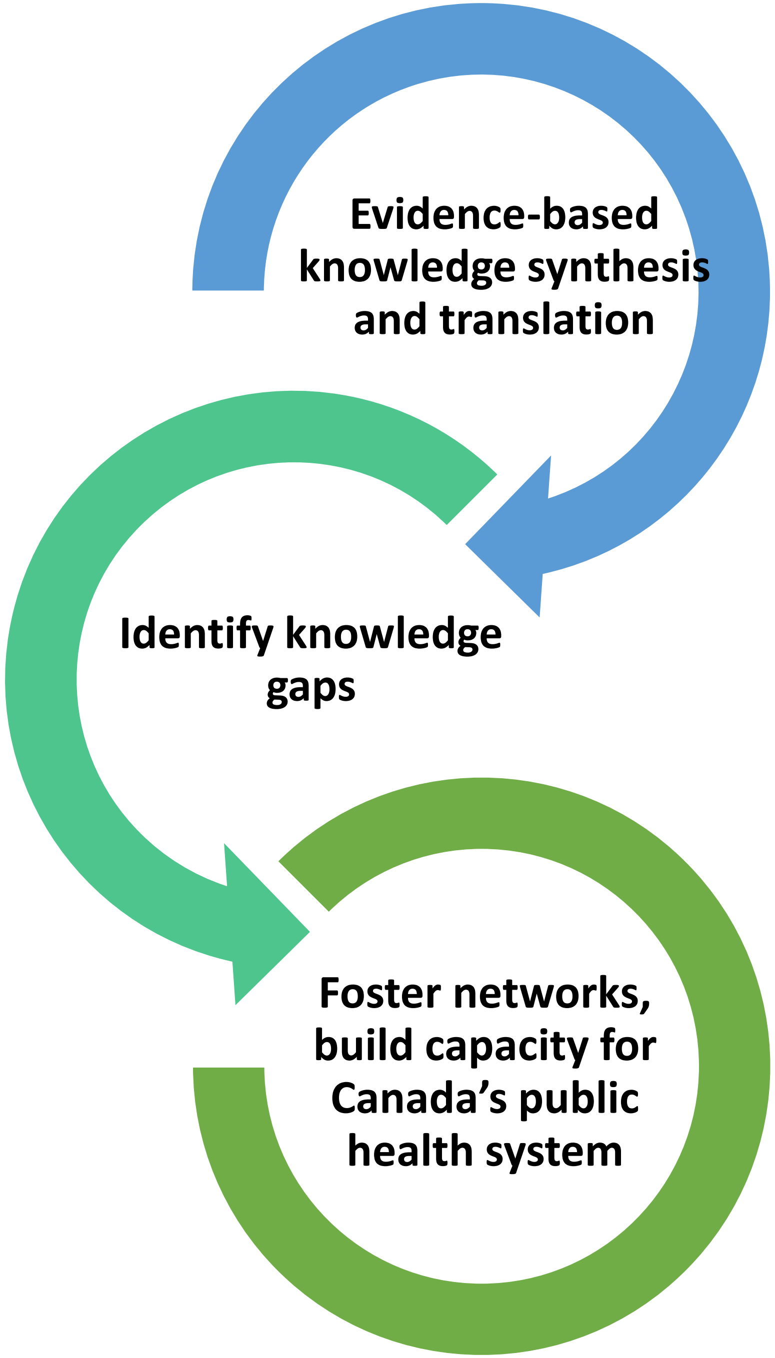
September 20th, 2022

Established by the Public Health Agency of Canada in 2005 to promote evidence-informed public policy.

All currently working on the COVID-19 response.



Today

- Highlight some new developments in the research on transmission via respiratory particles, as they are relevant to the IAQ response.
- Basic tools to reduce transmission via respiratory particles; their advantages and disadvantages.
- Zooming out: pandemic and climate change resilience and health equity demand major changes to how we deal with IAQ.

An evolving view of virus transport

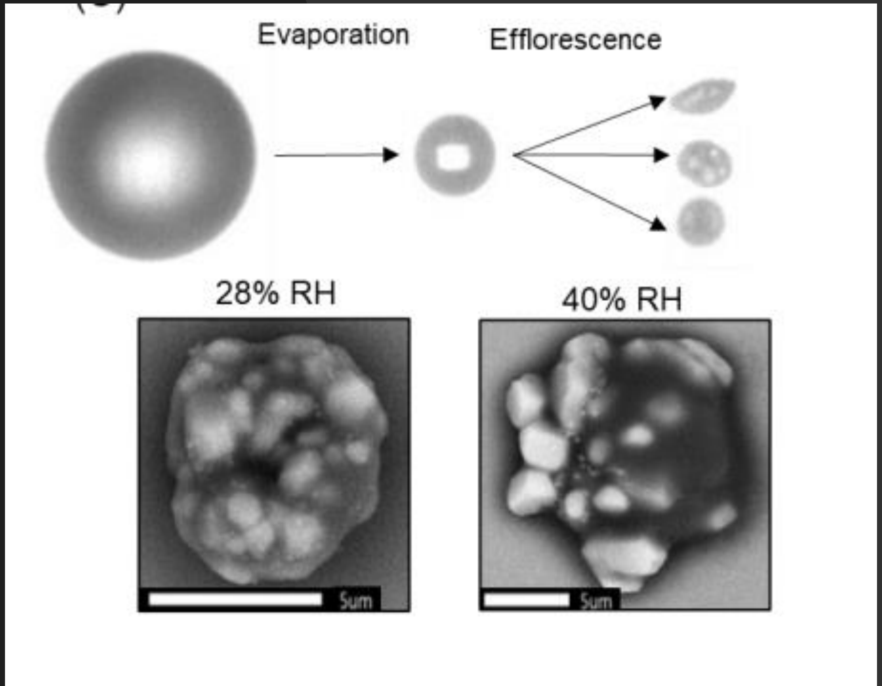
- Early on: focus on droplets vs. aerosols.
- Shorter- vs. longer-range transmission via respiratory particles → Feb 2022 PHO document
- Focus on the aerosol, not the virus
  - Numerous studies on particle/gas transport (req. well mixed room, particles sizes <3 um).
  - Wells-Riley: infection limited by deposition or removal

  Duchaine and Roy 2022. Bioaerosols and airborne transmission: Integrating biological complexity into our perspective

How long does the virus remain active during aerosol transport?

- Virus may not survive aerosol transport as long as believed:
  - Difficult to culture from air samples
  - Rotating drum experiments → $t_{1/2}$ is 1-2 h
  - Electrodynamic levitation → 90% of virus inactivated within 20 min. (Oswin et al. 2022, pre-print).
    - First of a 2-phase process?
    - Room-scale vs. building scale?

How well does SARS-CoV-2 survive on/in aerosols?



Oswin et al. 2022

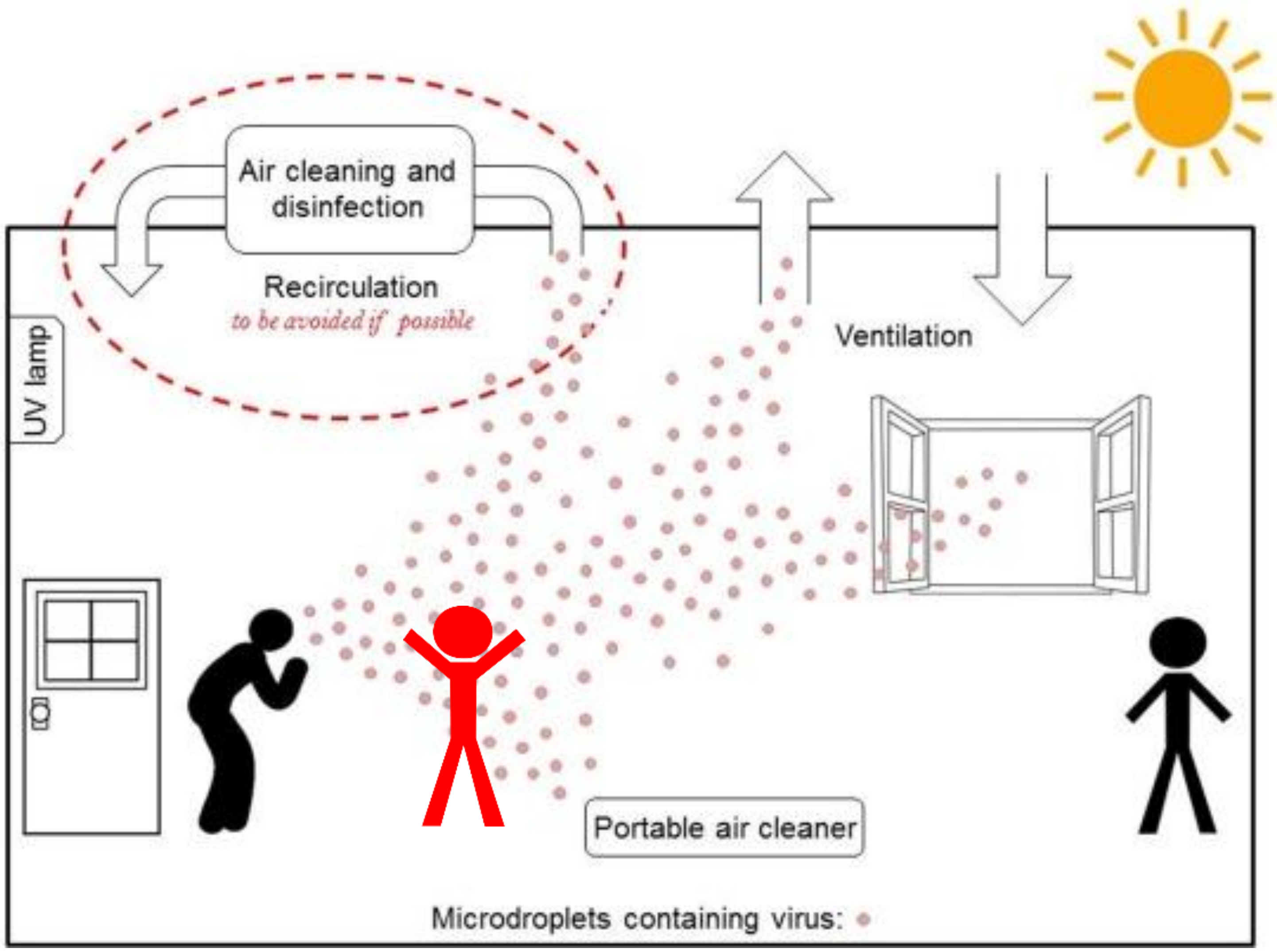
- What factors influence virus inactivation?
  - Temperature and RH → rate of evaporation → deposition on surfaces
  - UV → outdoors → ☠
  - Low RH: evaporation → solute concentration → crystallization → ☠
  - High RH: Volatilizing CO_2 → increasing pH → ☠
  - Oswin et al. 2022 → 90% loss in 20 min.
  - Much remains to be understood!

- Further reading:
  - Oct 2020: *High-humidity Environments and the Risk of COVID-19 Transmission*
  - Morris et al., 2021; Marr et al., 2019; Dabisch et al. 2020; Amaro et al. 2022.

Distance matters for the IAQ response to respiratory pandemics

Risk of infection is a **duration vs. distance equation.**

If virus is unlikely to transmit at the building-scale, makes more sense to have IAQ resources in the room rather than in the HVAC duct (for SARS-CoV-2).

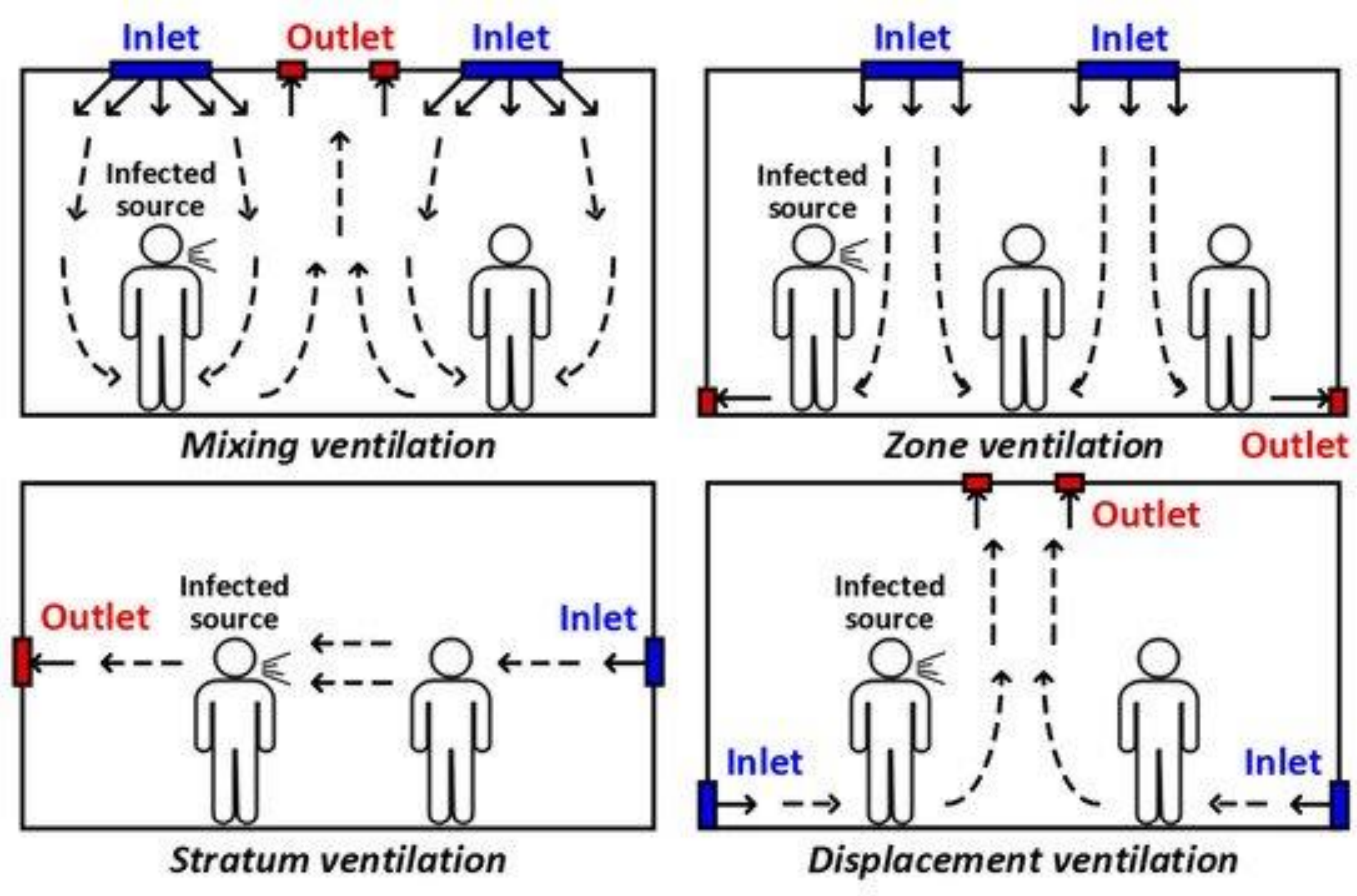


Adapted from Morawska et al. 2020

The IAQ Toolkit

- Ventilation
- Air cleaning
- Partitions
- Environmental controls
- CO_2 sensing

Ventilation Types



Ren et al. 2022

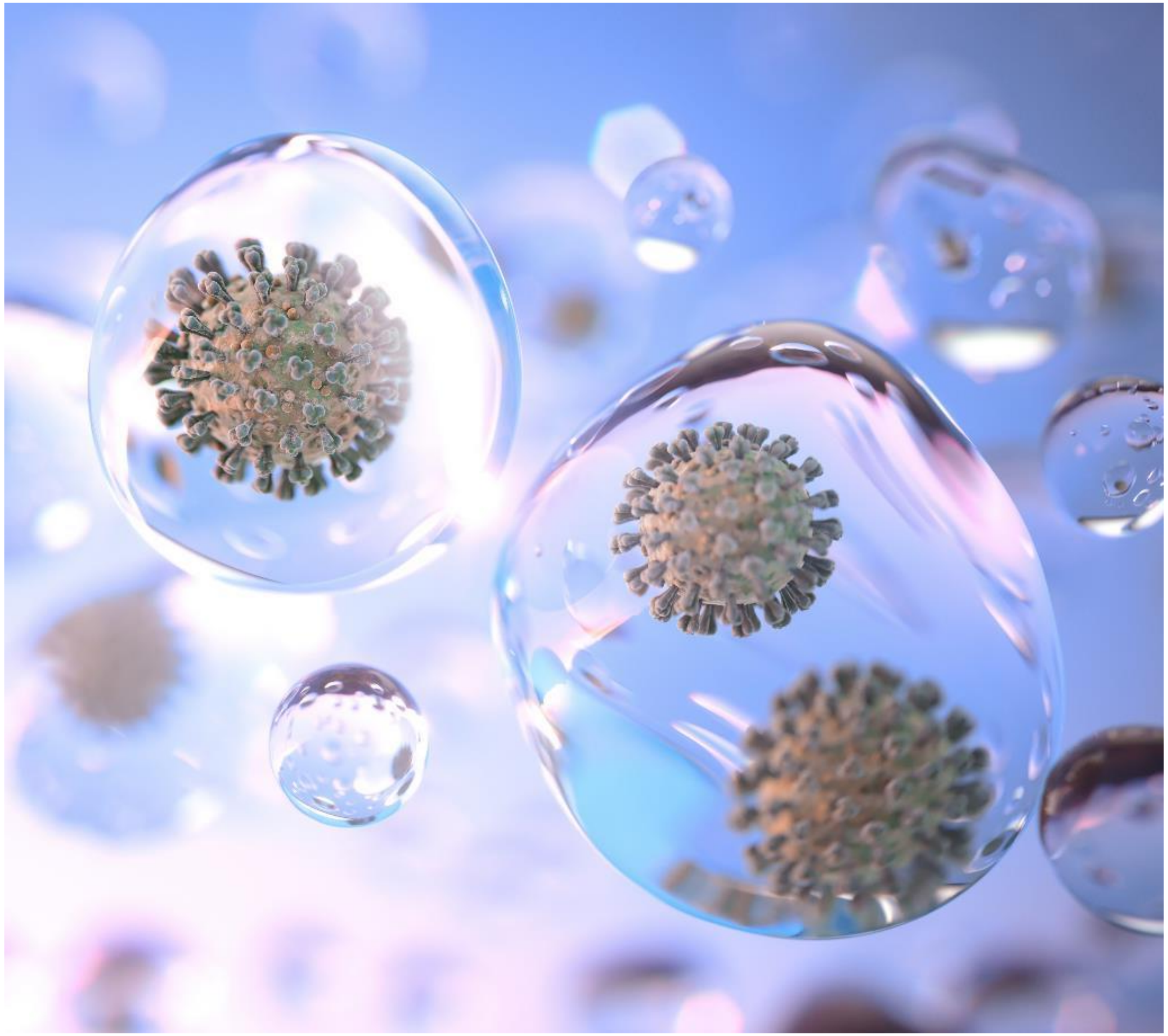
- No clear effect on transmission: depends on your position
- Other types:
  - Natural ventilation (passive, automatized, or manual)
  - Personalized ventilation (ducted or ductless) in seated rooms

Ventilation for a respiratory pandemic

- Adequate (not over) ventilation
- Increase outdoor air fraction
- Airflow management: want gentle mixing, but not drafts or dead zones
- Open windows frequently
- Use HEPA air cleaners if in doubt

Limits of ventilation for risk mitigation

- Many spaces under-ventilated at any given moment, and occupants are unaware
- <u>**Does not prevent close-range transmission**</u>
- Over emphasis on ventilation in research and media?



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Air Cleaning Technologies

- Removal of airborne contaminants
  - **HEPA Air filtration** units
  - Precipitation
- Destruction of airborne contaminants
  - Disrupt, denature or oxidize cell components
  - **UVGI (254 nm)**, far-UVC (222 nm), ozone, ionizers, thermal (moist/dry), photocatalysis, many others

Factors influencing effectiveness

- Need adequate Clean Air Delivery Rate
- Bioaerosol concentration
- Placement and maintenance of device
- Room needs to well mixed
- Lacking generalizable data on single/combo interventions wrt transmission in real-world settings.

Dec 2020: *Air cleaning technologies for indoor spaces during the COVID-19 pandemic*

Bueno de Mesquita et al. 2022 for research priorities

Physical Barriers

- Barriers are a **complement** to ventilation and air cleaning:
  - Blocks rapid exchange of particles so that other technologies have time to clear the air.
  - A poorly fitted mask is functionally similar to a plexiglass barrier

Nov. 2021: *A rapid review of the use of physical barriers in non-clinical settings and COVID-19 transmission*

What does the evidence say?

- Modelling + chamber studies: barriers reduce exposure by redirection and adsorption.
- In the real world: **mixed results**.
    - Poor design?
    - Ventilation in place?
    - Appropriate for the setting?

https://www.newsherald.com/story/news/2020/08/14/bay-county-schools-getting-creative-protect-students-covid-19/3350688001/

Not for every setting

- Likely more useful for frequent high-risk interactions (i.e., people whose infection status is unknown)
- Protection afforded is between worker and the changing clientele, not between workers!
- In seated environments, very important that ventilation in working in concert with barriers

Environmental Controls

- Humidity and temperature influence survival in aerosols
- **Pretty limited in practice based on what humans and buildings can tolerate**

Oct. 2020: *[High-humidity environments and the risk of COVID-19 transmission]*

CO_2 Sensing

- Most people don't know if their space is adequately ventilated or not.
- **Popular pandemic hack**: install CO_2 sensors to provide visual feedback that more ventilation is needed, then adjust manually by opening windows
- Pros → Sensors are cheap, can be moved around, relatively intuitive

Issues with implementing CO_2 sensing as a public health tool

- Generally poor understanding of what *different risks* high CO_2 levels might be indicating.
- Because CO_2 concentration don't directly equate with COVID risk, what is an appropriate threshold (for COVID or other pathogens)?
- May 2021: *Indoor CO_2 sensors for COVID-19 risk mitigation: Current guidance and limitations*

Manual ventilation and CO_2 sensing in schools

- Many schools recommended to open windows and doors to increase ventilation during the pandemic.
- Usually followed some sort of protocol or schedule.
- Was fairly effective in terms of increasing ACH. Upcoming evidence review (Sept 2022)

Thermal and acoustic comfort

Most studies from warmer climates, but….

Thermal and acoustic comfort wasn’t necessarily an issue even under cold conditions.

Comfort WAS impacted by pre-existing problems in the school and personal preferences.

Can we use CO_2 sensing to avoid discomfort?

Did CO_2 sensors in classrooms help?

- Not really! Did not consistently result in better ventilation in classrooms with CO_2 sensors compared to without.
- Results seem to strongly depend on individual effort.
- Good idea, but requires a good deal of training and engagement before implementing.

Good uses of CO_2 sensors…

- Use CO_2 sensors to identify problem areas and then **fix it**.
- Peterborough Library CO_2 sensors program → 15 sensors + info sheet prepared by public health partners.
- Empowers through learning

Knowledge gaps

- Difficult to quatify the relationship between IAQ tech and impact on transmission/infection
  - How many ACHI to reduce infections by X%?
  - Difficult to provide guidance and/or plan spending
- Need PH-oriented tools to help users adaptively select an appropriate IAQ strategy
  - Must consider setting, users, cost, complexity (ease of use/installation), flexibility, need for maintenance/consumables, operational feasibility, and **equity**.

Zooming out

- Good IAQ is hard to "hack" in poorly designed buildings… and those hacks are being enacted in under-resourced environments, enhancing and entrenching health inequities.
    - Need **health-based building standards** and **building codes** to explicitly address IAQ deficits and prevent inequities.
- Climate change will impact IEQ in many ways; now is the time to prepare for pandemic and climate resilience.
- Other needed work?

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Thank you!

Questions?

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Production of this presentation has been made possible through a financial contribution from the **Public Health Agency of Canada**.