



Alliance Lunch 'n' Learn Webinar

COVID-19 and indoor air quality:

How community spaces can reduce transmission using ventilation, filtration and ultra-violet disinfection



Alliance for Healthier Communities
Alliance pour des communautés en santé

Welcome & Introduction

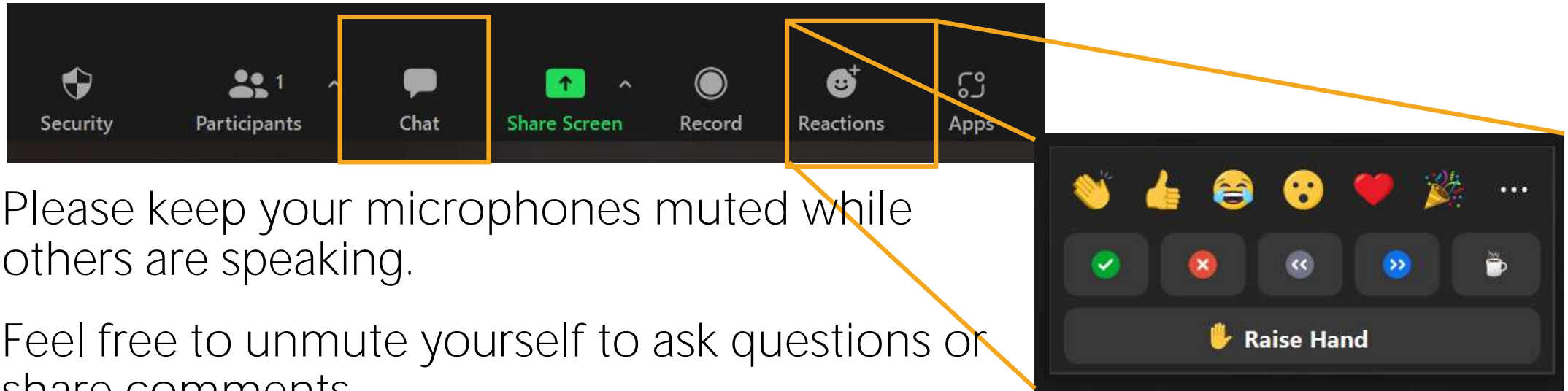
- Housekeeping
- Land Acknowledgement
- Panelists
 - Dr. Amy (Tianyuan) Li, Research assistant, Department of Civil & Mineral Engineering, University of Toronto
 - Dr. Jeff Siegel, Department of Civil & Mineral Engineering, University of Toronto
- Q&A/Discussion

Housekeeping



- All attendees are automatically muted when joining Zoom
- Please keep your microphones muted during the presentation
- Open up the chat window to chat with other participants or ask questions
- Our Sign Language interpreters' video windows will be spotlighted along with Amy's and Jeff's.

Housekeeping



- Please keep your microphones muted while others are speaking.
- Feel free to unmute yourself to ask questions or share comments.
- If you prefer, you may use the chat function for questions or comments.
- Open the “reaction” button to access “raise hand” and other tools.

Acknowledgement of Traditional Indigenous Territories

We recognize that the work of the Alliance for Healthier Communities and Alliance members takes place across what is now called Ontario on traditional territories of the Indigenous people who have lived here since time immemorial and have deep connections to these lands. We further acknowledge that Ontario is covered by 46 treaties, agreements and land purchases, as well as unceded territories. We are grateful for the opportunity to live, meet and work on this territory.

Ontario continues to be home to vibrant, diverse Indigenous communities who have distinct and specific histories and needs, as well as constitutionally protected and treaty rights. We honour this diversity and respect the knowledge, leadership and governance frameworks within Indigenous communities. In recognition of this, we commit to building allyship relationships with First Nation, Inuit and Métis peoples in order to enhance our knowledge and appreciation of the many histories and voices within Ontario. We also commit to sharing and upholding responsibilities to all who now live on these lands, the land itself and the resources that make our lives possible.

Agenda

- Introduction and layers of protection
- Ventilation, filtration, and other IAQ strategies
- Strategy integration and case studies

“When ‘the wise women buildeth her house,’ the first consideration will be to the health of the inmates. The first and most indispensable requisite for health is pure air, both by day and by night.”

~ Harriet Beecher Stowe, 1869

“Tight sleeping-rooms, and close, air-tight stoves, are now starving and poisoning more than one half of this nation.”

~ Harriet Beecher Stowe, 1869

No. 1031

VENTILATION REQUIREMENTS

By C. P. YAGLOU,* E. C. RILEY ** (MEMBERS), AND D. I. COGGINS ** (NON-MEMBER), BOSTON, MASS.

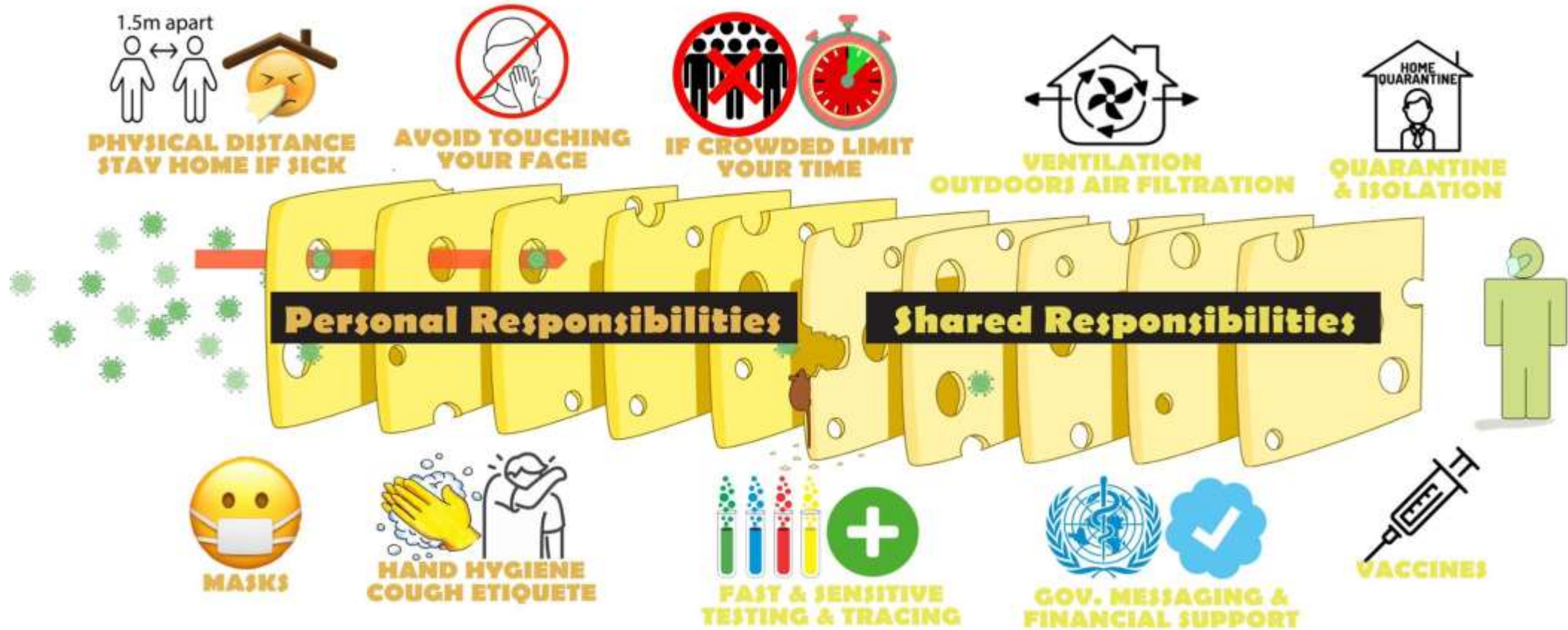
This paper is the result of research sponsored by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS in cooperation with the School of Public Health, Harvard University

TABLE 4. BATHS, ODOR INTENSITY AND VENTILATION REQUIREMENTS
Experiments with Simple Ventilation

TYPE OF SUBJECTS	AIR SPACE PER PERSON 200 CU FT		
	OUTDOOR AIR SUPPLY CFM PER PERSON	AVERAGE ODOR INTENSITY	COMPUTED VENTILATION REQUIREMENT CFM PER PERSON
Grade School Children			
0.5 Days after Bath and Complete Change of clothing.....	14.2	2.26	18
6.5 Days after Bath.....	14.3	2.90	29
Medical Students			
1.2 Days after Bath and Change of Underwear.....	14.5	2.11	16
7.0 Days after Bath.....	16.6	2.18	20

The Swiss Cheese Respiratory Virus Pandemic Defence

RECOGNISING THAT NO SINGLE INTERVENTION IS PERFECT AT PREVENTING SPREAD



Each intervention (Layer) has imperfections (holes).
Multiple Layers improve success.

Ian M Mackay (@MackayIm)
virologydownunder.com
with thanks to Jody Lanard, Katherine Arden & The Uni of Qld
Based on the Swiss Cheese Model of Accident Causation by James T Reason, 1990
Icon version @sillenojunior

Ventilation and Filtration

Fresh air from outside

Recirculated air that has been filtered to remove infectious respiratory particles
Can be central or room-based

- **Are not silver bullets**
- Are not a replacement for vaccination, masks, physical distancing, etc.
- Have to be done well to make a difference to transmission risk
- Offer benefits beyond COVID-19 transmission risk reduction
- Have been underutilized (generally and specifically in pandemic response)

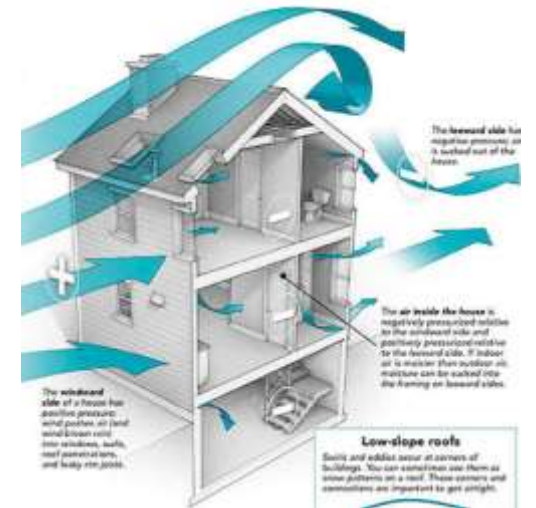
Ventilation

Bring outdoor air in, exhaust indoor air out

- Mechanical ventilation
 - Mechanical systems (e.g. HVAC, ERV/HRV)
 - Kitchen and bathroom exhaust fan
- Natural ventilation

Considerations:

- Outdoor air quality
- Thermal comfort
- Energy use



Measured Pollutants at Toronto Downtown

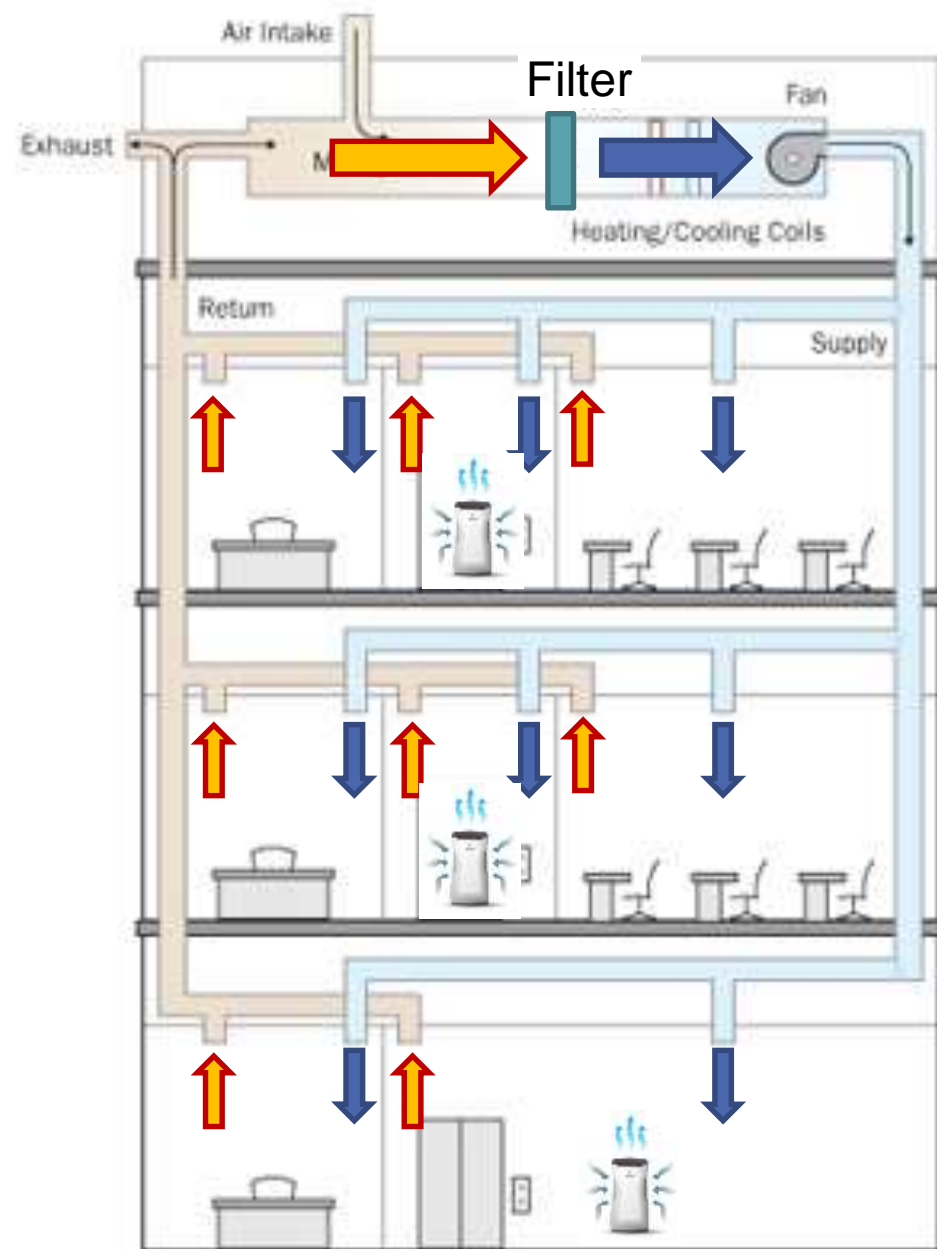
Pollutant	Measured 1-Hour Concentration	
O ₃	33 ppb	<input checked="" type="checkbox"/>
PM _{2.5}	8 µg/m ³	<input checked="" type="checkbox"/>
NO ₂	5.3 ppb	<input checked="" type="checkbox"/>

Filtration

- Pass indoor air through filter
 - Central forced-air HVAC systems
 - Portable air cleaners with HEPA filters



<https://www.dreamstime.com/illustration/purifier.html>

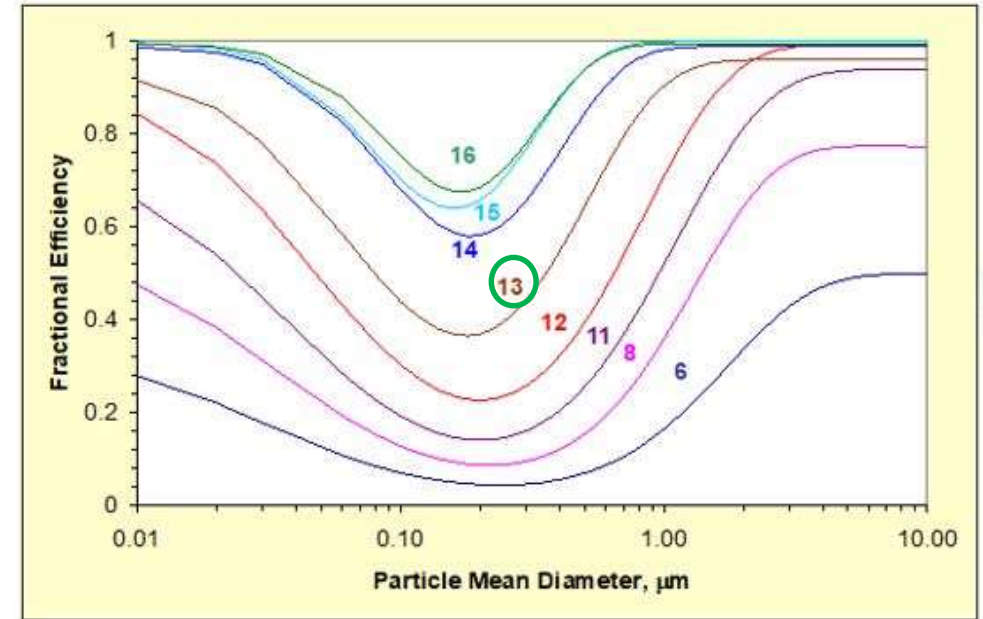


https://www.centerforhealthsecurity.org/resources/interactives/protecting_building_occupants/hvac_basics.html 11

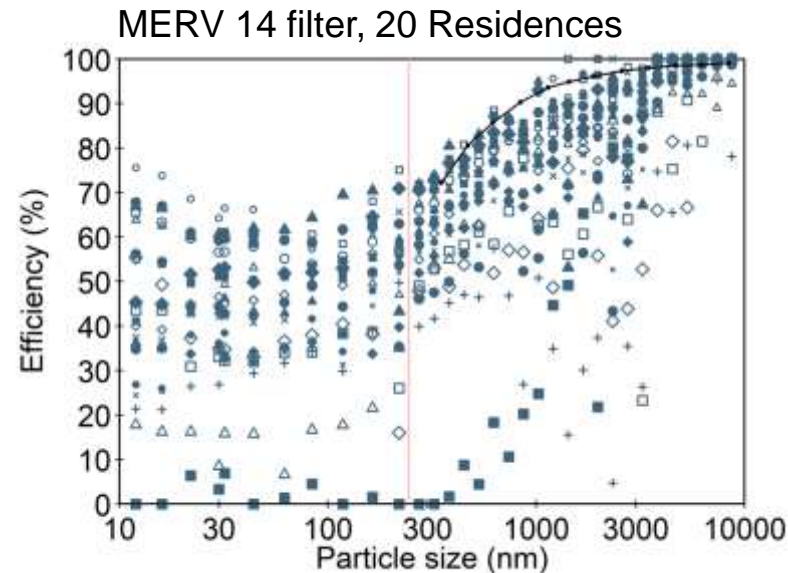
Filtration through HVAC

- Providing whole building filtration
- Considerations:
 - Operation time
 - Filter MERV
 - Filter in-situ efficiency
 - Filter replacement

Ensure the filter is compatible



ASHRAE Standard 52.2-2017



Li and Siegel (2020) *Indoor Air*



Image: Courtesy Geoffroy Allard

Filtration through portable air cleaners

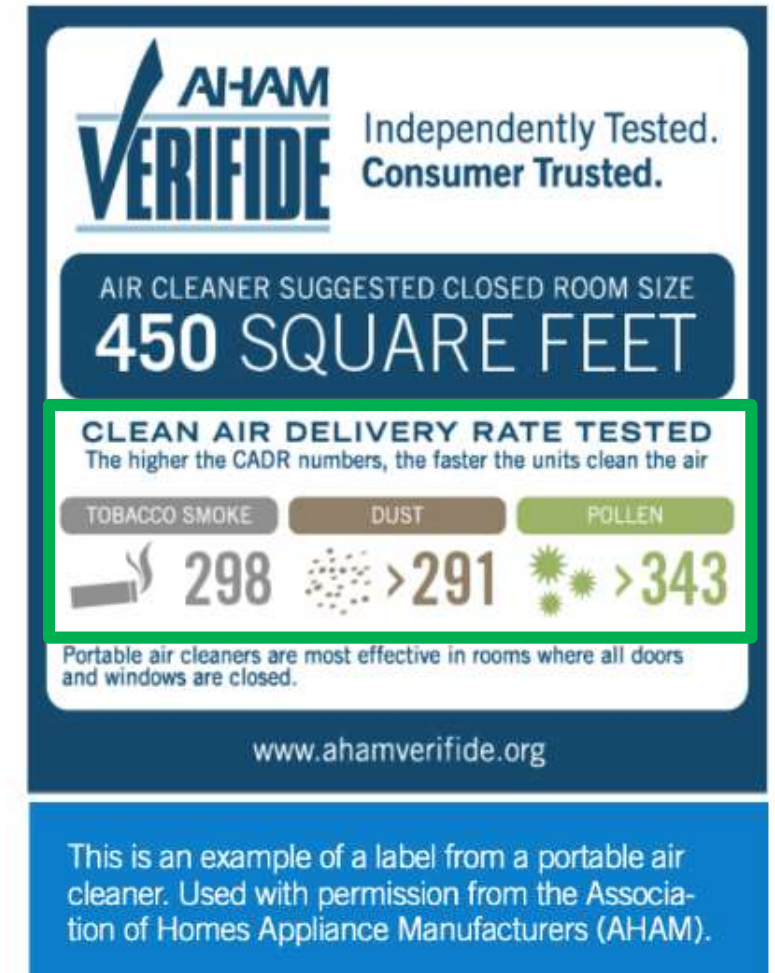
- Providing localized filtration



HEPA filters

<https://www.sentryair.com/high-efficiency-air-filter.htm>

- Considerations:
 - Clean air delivery rate (CADR)
 - Speed setting
 - Position
 - Filter replacement
 - Noise



AHAM VERIFIDE Independently Tested. Consumer Trusted.

AIR CLEANER SUGGESTED CLOSED ROOM SIZE
450 SQUARE FEET

CLEAN AIR DELIVERY RATE TESTED
The higher the CADR numbers, the faster the units clean the air

TOBACCO SMOKE	DUST	POLLEN
298	>291	>343

Portable air cleaners are most effective in rooms where all doors and windows are closed.

www.ahamverifide.org

This is an example of a label from a portable air cleaner. Used with permission from the Association of Homes Appliance Manufacturers (AHAM).

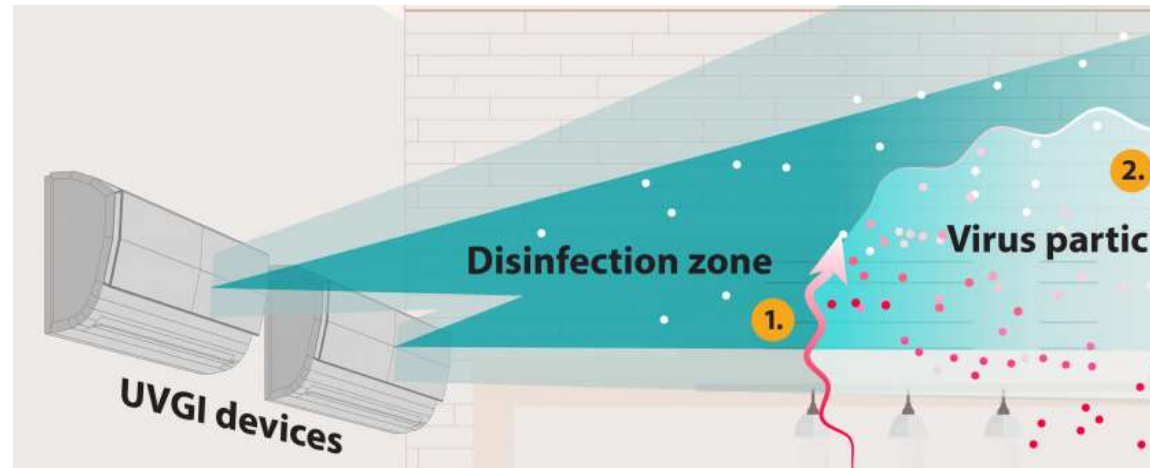
Other IAQ strategies

Open windows



<https://www.freshaireductcleaning.com/blog/2019/december/why-you-should-open-your-windows-especially-duri/>

Upper-room UV



<https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation/uvgi.html>



Typical UV-C energy pattern of a baffled fixture

<https://www.ashrae.org/technical-resources/filtration-disinfection>

Other IAQ strategies (2)

Localized exhaust units



<https://www.thespruce.com/quietest-bathroom-exhaust-fans-1821003>



<https://www.rollingstone.com/product-recommendations/lifestyle/best-window-fan-1001919/>

Be careful with powerful exhaust fans

Air out rooms between use

Table B.1. Air changes/hour (ACH) and time required for airborne-contaminant removal by efficiency *

ACH (h ⁻¹)	Time (mins.) required for removal 99% efficiency	Time (mins.) required for removal 99.9% efficiency
2	138	207
4	69	104
6*	46	69
8	35	53
10*	28	42
12*	23	35
15*	18	28
20	14	21
50	5	8

* This table is revised from Table S3-1 in reference 4 and has been adapted from the formula for the rate of purging airborne contaminants presented in reference 1435.

<https://www.cdc.gov/infectioncontrol/guidelines/environmental/appendix/air.html>

“Ions: Mother Nature's Little Air Scrubbers.”

Strategies to Avoid (1)



“Our technology is in The Whitehouse”

- Unproven air cleaning technologies, often with marketing claims
 - No reporting of clean air delivery rate (CADR)
 - Mechanisms including ionization, plasma, photocatalytic oxidation, hydroxy oxidation, and hydroxyl radical
 - Missing information on ozone emission/byproduct formation
 - Unrealistic microbiological surrogates/presentation of microorganisms
 - Biological kill tests are not reflective of real performance



“Kills 99.9% of SARS-CoV-

2”

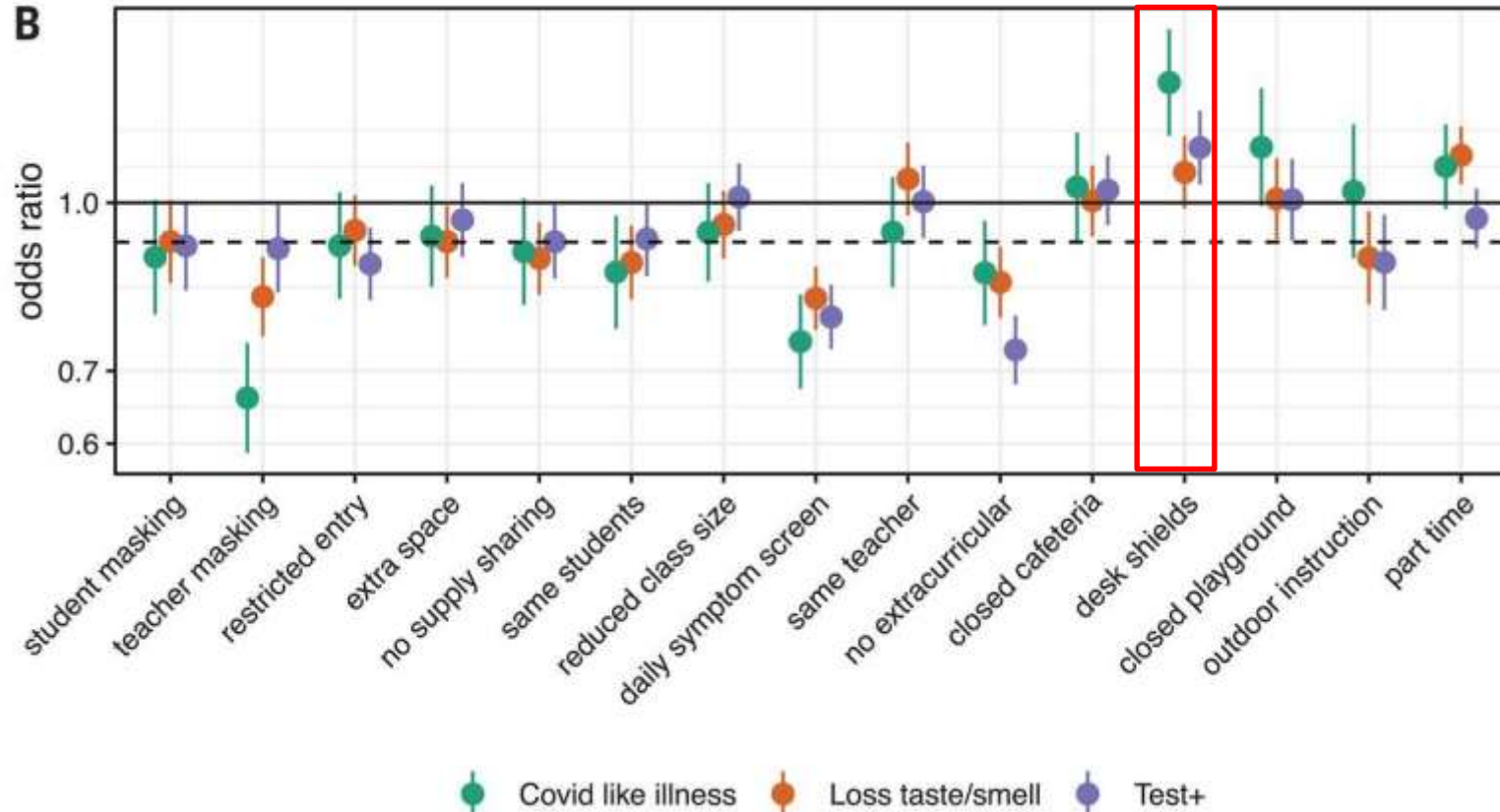
“40X better than a HEPA filter”

Strategies to Avoid (2)



<https://www.theitem.com/stories/a-new-safety-feature-in-pandemic-desk-shields-will-be-used-in-each-sumter-school-district,358287>

- Plexiglass barriers and screens



Strategy Integration

1. Assess risk to prioritize spaces
 - Crowded, time in environment, poorly ventilated
 - Risk factors for individuals/populations
2. Know limitations
 - Noise, physical features, users, maintenance, cost
3. Aim for 6 ACH_{eq} combination of all measures
 - Adjust based on risk

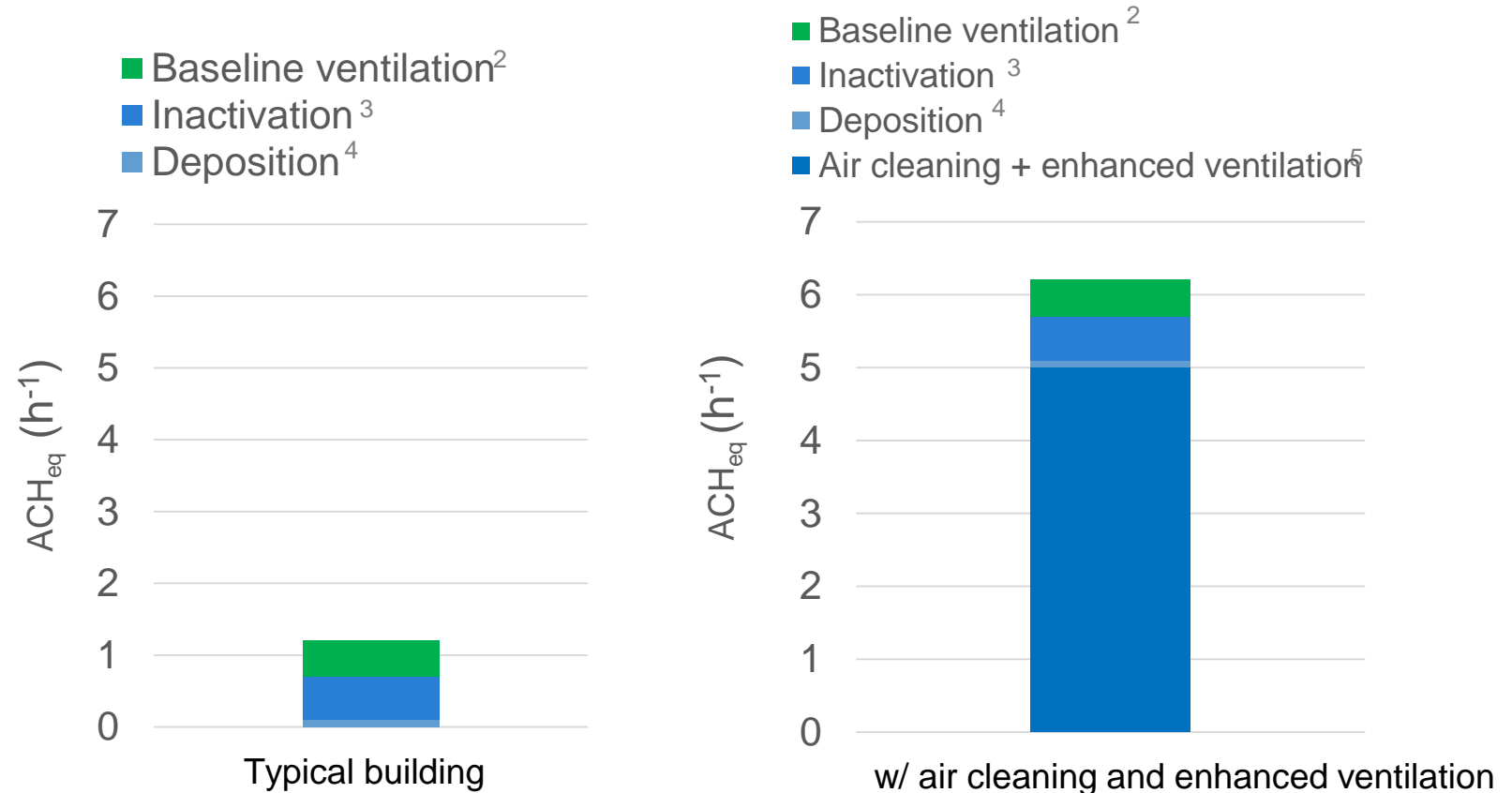
TARGET IS AT LEAST 5 TOTAL AIR CHANGES PER HOUR



schools.forhealth.org/wp-content/uploads/sites/19/2020/08/Harvard-Healthy-Buildings-program-How-to-assess-classroom-ventilation-08-28-2020.pdf

Loss processes determine intervention effectiveness

- Four “loss” processes:
 - Ventilation
 - Air cleaning
 - Deposition to surfaces
 - Inactivation
- Strength of removal by each process equivalent air changes per hour (ACH_{eq})



¹Allen et al. 2021, JAMA. 325(20):2112-2113 ²Murray and Burrmaster 1995, Risk Analysis 15(4): 459–465; ³van Doremalen et al. 2020, N Eng J Med 382(16):1564–1567; ⁴Hussein and Kulmala, 2008, *Water Air Soil Pollut.* 8:23–34 (2008); ⁵ANSI/AHAM AC-1

Calculating ACH_{eq}

- ACH for each measure is *delivery rate of clean air ÷ room volume**

Approach

Relevant Flow Rate

Ventilation

flow rate of outdoor air

Central filtration

flow rate through filter × installed filter efficiency

Portable filtration

clean air delivery rate (CADR)

Ultraviolet (UV)

flow rate through unit × installed efficacy

*you might have to do a unit conversion (×60) to convert from CFM to CFH, volume and delivery rate should be in same units

Sufficient centralized filtration and ventilation example

1000 ft² room, 10 ft ceilings = 10,000 ft³ volume

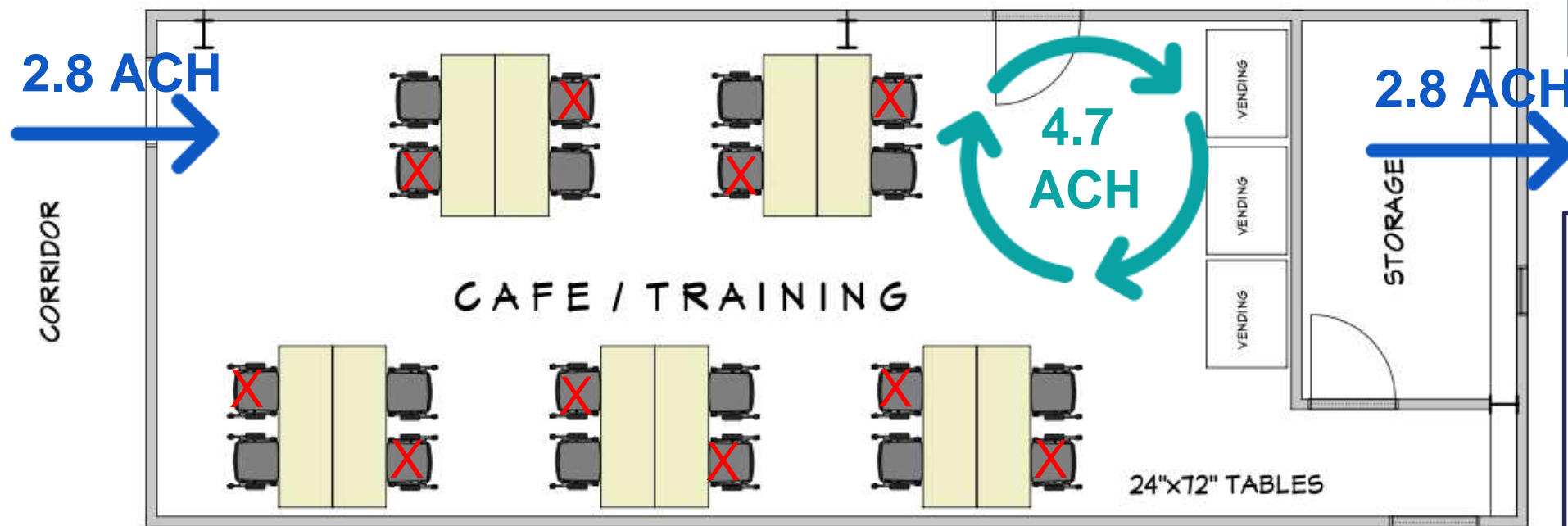
→ Outdoor Ventilation = 470 CFM × 60 ÷ 10,000 ft³ = 2.8 ACH

↻ Centralized Filtration = 940 CFM × 60 * 85% ÷ 10,000 ft³ = 4.7 ACH

MERV 13
1 – 3 μm particles

7.5
ACH_{eq}

No need for portable
air cleaners



- X Unused seat
- ↻ Filtration
- Ventilation

Insufficient filtration and ventilation example

1000 ft² room, 10 ft ceilings = 10,000 ft³ volume

→ Outdoor Ventilation = 235 CFM × 60 ÷ 10,000 ft³ = 1.4 ACH

↻ Centralized Filtration = 470 CFM × 60 * 20% ÷ 10,000 ft³ = 0.6 ACH

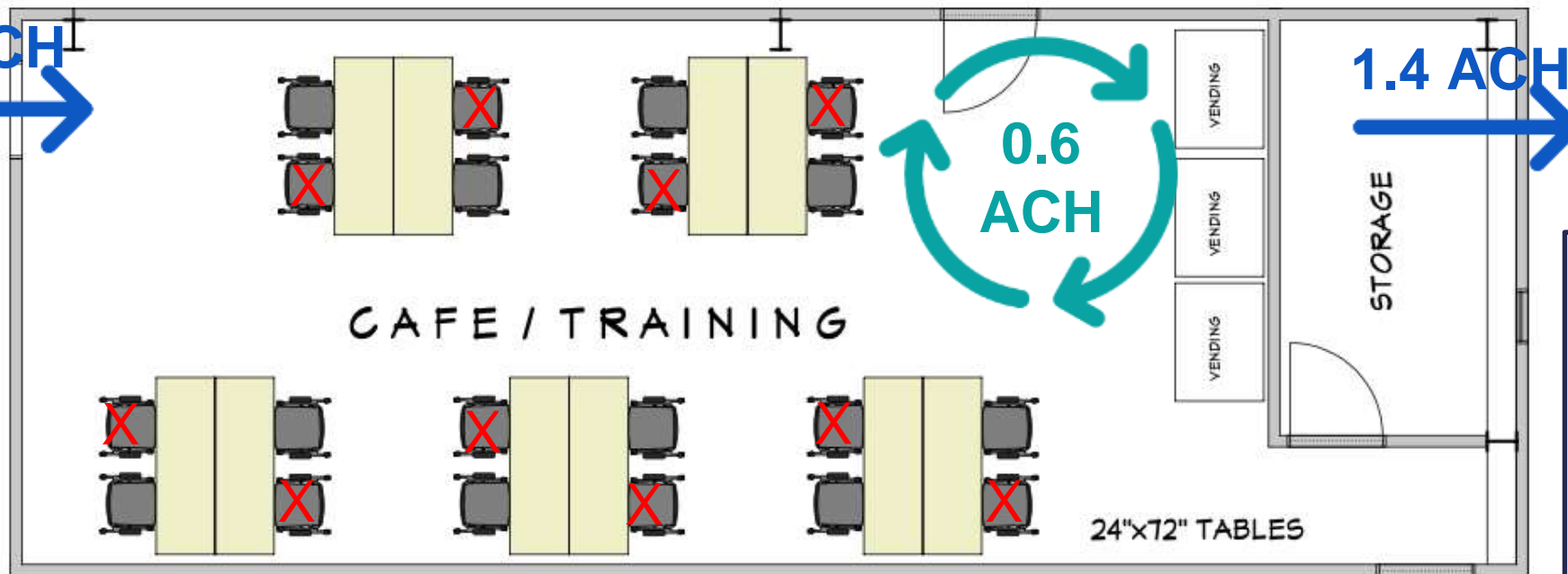
MERV 8
1 – 3 μm particles

2.0
ACH_{eq}

NEED portable
air cleaners

1.4 ACH

CORRIDOR



- X Unused seat
- ↻ Filtration
- Ventilation

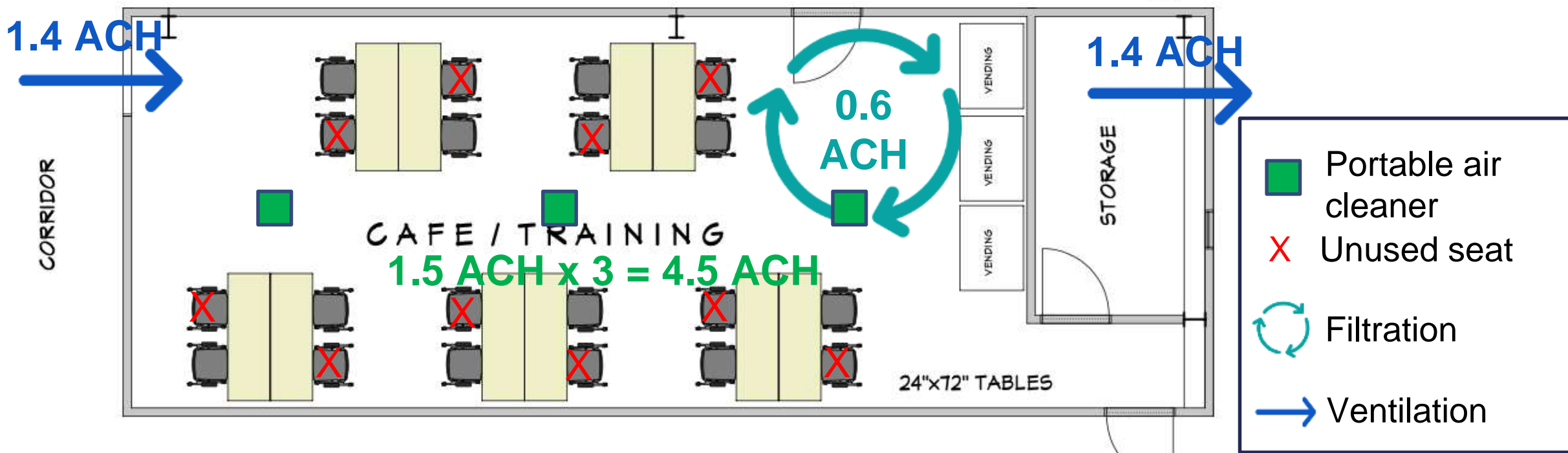
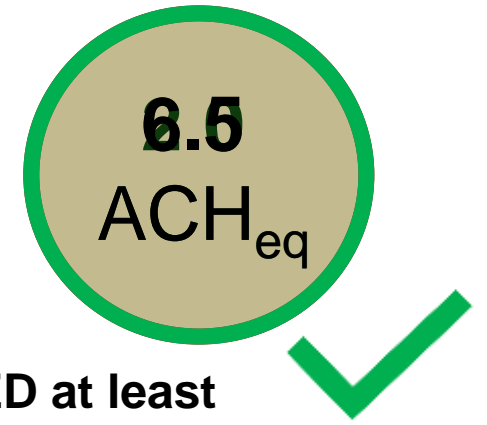
Insufficient filtration and ventilation example

1000 ft² room, 10 ft ceilings = 10,000 ft³ volume

Assumed Portable HEPA filter CADR = 250 CFM

Portable HEPA filter ACH = $250 \text{ CFM} \times 60 \div 10,000 \text{ ft}^3 = 1.5 \text{ ACH}$

NEED at least 3 cleaners



High-risk setting example

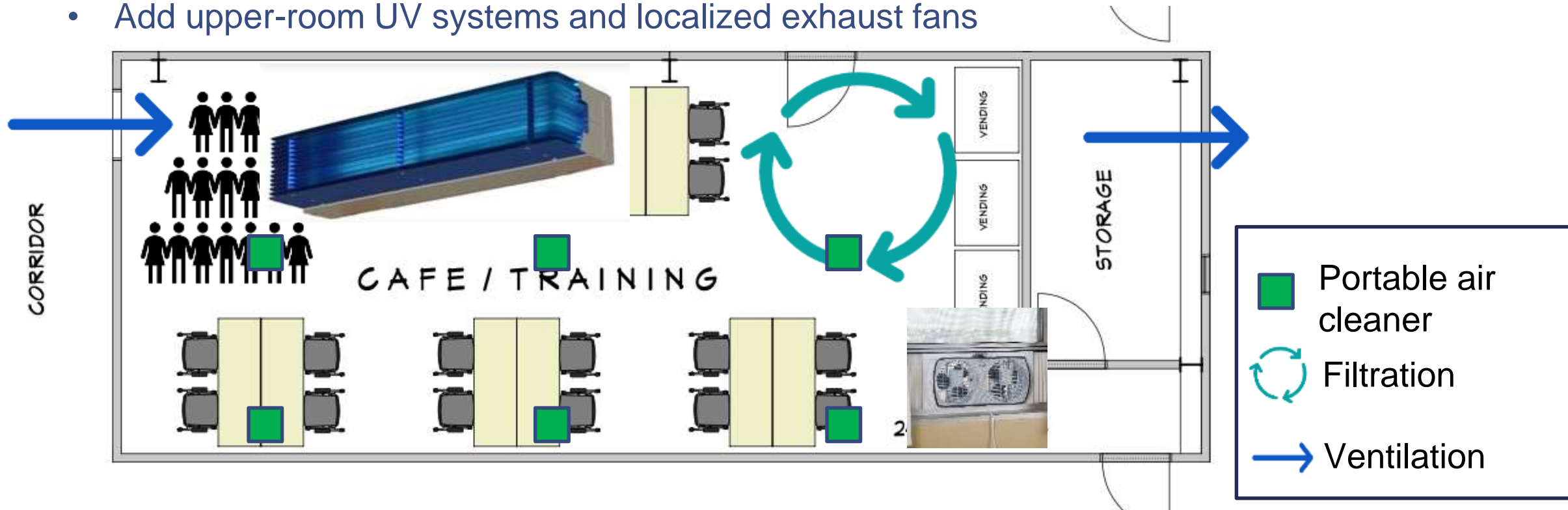
1000 ft² room, 10 ft ceilings = 10,000 ft³ volume

High occupancy, close contact, limited space, no unused seat

Take additional measures!

- Increase portable air cleaner numbers
- Add upper-room UV systems and localized exhaust fans

6.0
ACH_{eq} ?



Talking to your HVAC Contractor

1. Value their expertise
2. Understand their motivations
 - Distributor model
 - Diminish callbacks and complaints
3. Get multiple quotes
4. Have a plan ahead of time
5. Maintenance really matters

Summary

- Indoor air quality has always been important
- COVID-19 has increased focus
- Use opportunity to improve IAQ
- Easy to get overwhelmed
 - Address what you can, as you can
 - Building capacity will have long-term benefits

Office hour

Indoor air quality consultations for community spaces and congregate settings

*Presented by University of Toronto and MAP Centre for Urban Health Solutions,
with funding from the School of Cities at the University of Toronto.*

What: A free, 20 minute, online consultation with indoor air quality experts from the University of Toronto.

When: April 12, 19 & 26, 2022

What time: Each week, we have two 20 minute online appointments available. The first one starts at 11:00 am, and the second one starts at 11:25 am.

How to register: To schedule an online appointment or join the waiting list for May appointments, please contact Pearl Buhariwala at: Pearl.Buhariwala@unityhealth.to. Please include your preferred appointment day and time, the type of facility you work at, and any specific questions you have so our experts can prepare for your appointment.

How you can prepare: Please explore [this backgrounder](#) about reducing transmission of COVID-19 using indoor air quality measures. Please also bring as much specific information as possible. For example, if you have questions about your HVAC system, find out as much about it as you can before the appointment.

Additional resources

- Reducing transmission of respiratory illness in community spaces through improved indoor air quality.
<https://maphealth.ca/wp-content/uploads/Ventilation-Summary.pdf>
- ASHRAE filtration/disinfection resources.
<https://www.ashrae.org/technical-resources/filtration-disinfection>
- Portable air cleaner (HEPA filter) buying guide.
<https://cleanaircrew.org/air-cleaners/>

Questions?

- Please enter your questions into the chat panel. We'll be moderating them in an attempt to combine and group similar and related questions, and to prioritize those that seem to be common.
- If you'd prefer to ask your question out loud, please send a direct message to Josephine and Amanda, and we'll unmute your microphone when we call on you.

Additional slides

Monitoring air cleaning progress

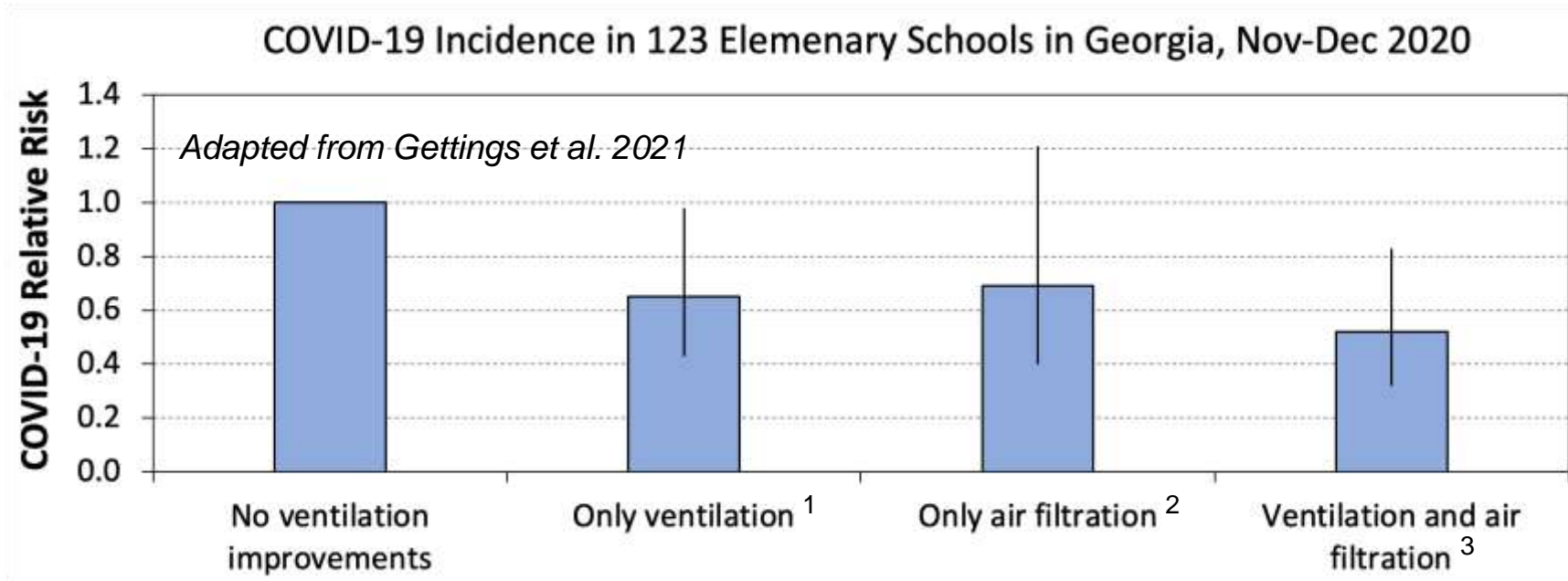
- Tracking air concentrations of carbon dioxide and particulate matter can help you improve ventilation and filtration.
- But there are things to consider:
 - Accuracy of the monitor
 - Sampling frequency and location
 - Interpreting the measurements

Ventilation and air cleaning reduce COVID risk

Improved ventilation and mask rules for staff in elementary schools resulted in fewer COVID-19 cases, CDC study finds

www.cbsnews.com/news/covid-school-masks-ventilation/

©CBS NEWS

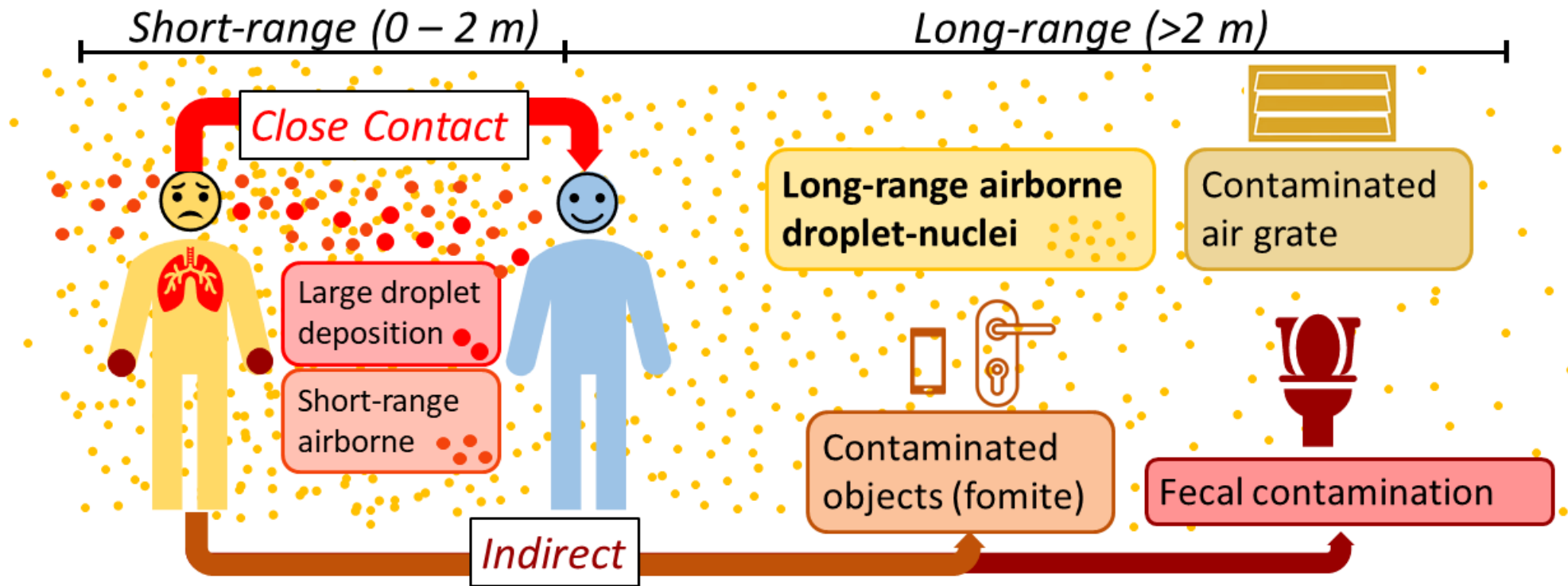


¹Ventilation only = open doors, open windows or fans

²Air filtration only = using HEPA filters with or without UVGI and no ventilation



³Ventilation and air filtration = both ¹ and ²

Is covid aerosolized in fecal matter when a toilet is flushed ? if a washroom has no ventilation system is it safe to use?



Filters Work Too

Are the Portable Air Cleaners (PAC) really effective to terminate airborne SARS-CoV-2?

María Rodríguez, M. Llanos Palop, Susana Seseña  , Ana Rodríguez

<https://doi.org/10.1016/j.scitotenv.2021.147300>

A total of 29 air and surface samples were collected inside 9 households, by using an air portable collector with gelatin filters and swabs. SARS-CoV-2 RNA detection was performed using real-time reverse transcription polymerase chain reaction (RT-PCR). Overall, all the air samples collected before using PAC and 75% of swab samples were positive for SARS-CoV-2. After the PAC usage, all samples except one were negative, displaying a 80% device effectiveness.

Thank you to our guests and partners

- Dr. Amy Tianyuan Li, University of Toronto
- Dr. Jeffrey Siegel, University of Toronto
- MAP Centre for Urban Health Solutions
- Indigenous Primary Health Care Council
- Toronto Sign Language Interpretation Service

