

# Reducing transmission of respiratory illness (Covid-19) through improved indoor air quality

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# Indoor Air Quality (IAQ)– A brief history

**Leviticus 14:33-53** New International Version (NIV)

<sup>33</sup> The LORD said to Moses and Aaron, <sup>34</sup> “When you enter the land of Canaan, which I am giving you as your possession, and I put a spreading mold in a house in that land, <sup>35</sup> the owner of the house must go and tell the priest, ‘I have seen something that looks like a defiling mold in my house.’ <sup>36</sup> The priest is to order the house to be emptied before he goes in to examine the mold, so that nothing in the house will be pronounced unclean. After this the priest is to go in and inspect the house. <sup>37</sup> He is to examine the mold on the walls, and if it has greenish or reddish depressions that appear to be deeper than the surface of the wall, <sup>38</sup> the priest shall go out the doorway of the house and close it up for seven days. <sup>39</sup> On the seventh day the priest shall return to inspect the house. If the mold has spread on the walls, <sup>40</sup> he is to order that the contaminated stones be torn out and thrown into an unclean place outside the town. <sup>41</sup> He must have all the inside walls of the house scraped and the material that is scraped off dumped into an unclean place outside the town. <sup>42</sup> Then they are to take other stones to replace these and take new clay and plaster the house.

<sup>43</sup> “If the defiling mold reappears in the house after the stones have been torn out and the house scraped and plastered, <sup>44</sup> the priest is to go and examine it and, if the mold has spread in the house, it is a persistent defiling mold; the house is unclean. <sup>45</sup> It must be torn down—its stones, timbers and all the plaster—and taken out of the town to an unclean place.

“If there is a pile of manure in a space, do not try to remove the odor by ventilation. Remove the pile of manure.”  
~ *Max von Pettenkofer, 1858*

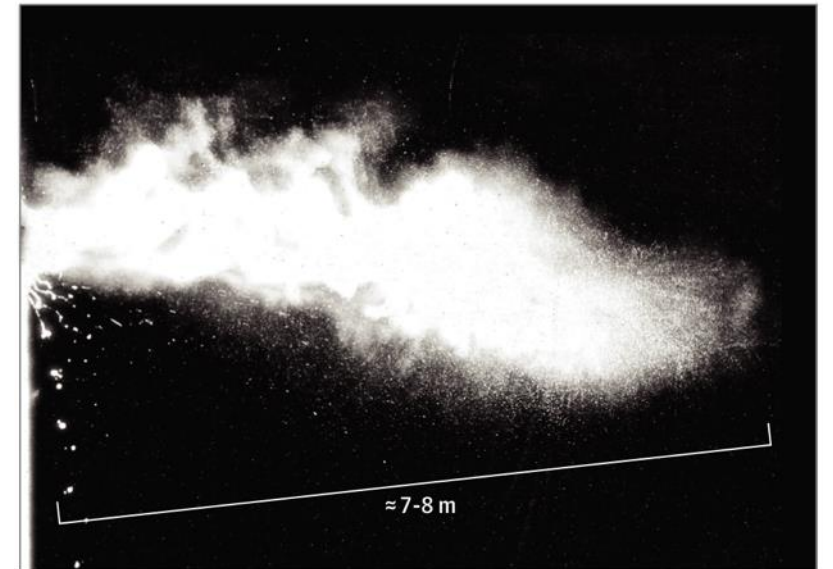
“When `the wise women buildeth her house,’ the first consideration will be to the health of the inmates. The first and most indispensable requisite for health is pure air, both by day and by night.”  
~ *Harriet Beecher Stowe, 1869*

Indoor air quality impacts respiratory disease transmission, acute health outcomes (e.g., allergies an asthma), chronic health outcomes, cognitive function, well-being, productivity, etc.

Indoor air quality is largely unregulated, represents the greatest environmental health risk for most Canadians, and poor IAQ disproportionately impacts vulnerable populations.

# Now we have COVID-19.....

- It spreads most in
  - Indoor
  - Crowded
  - Poorly-ventilated environments

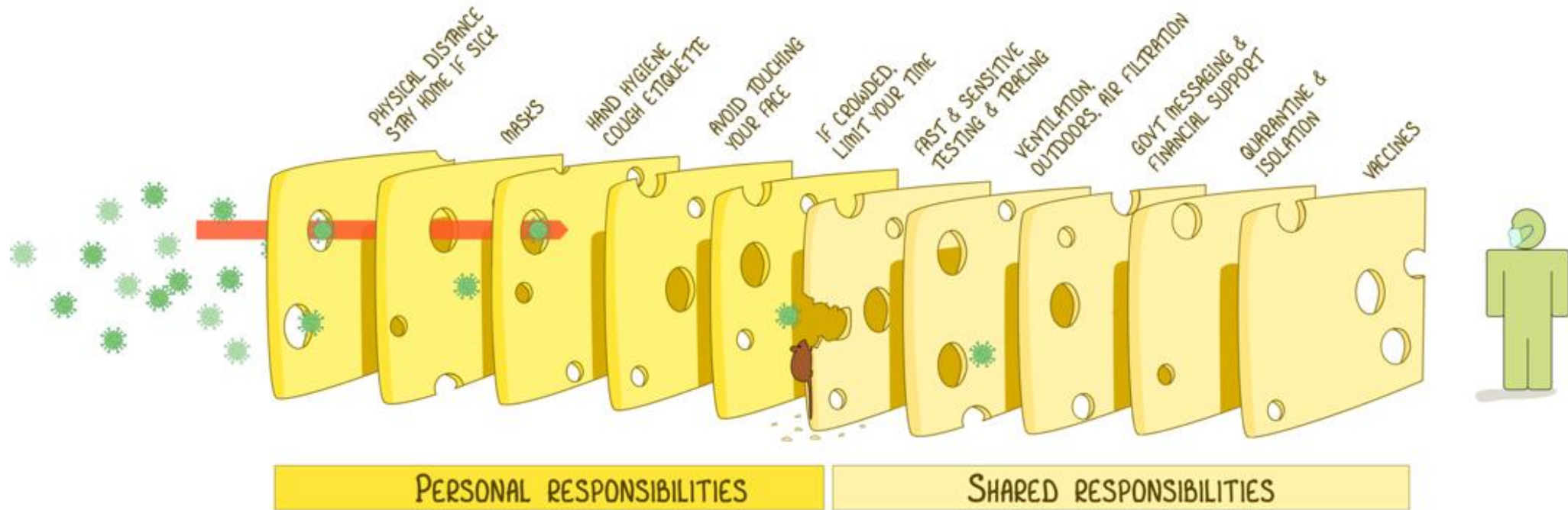


Bourouiba (2020) JAMA

# There are no Silver Bullets

## 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.

# Our Job

1. Have as many layers of protection as possible
2. Do each layer as well as we can
3. Recognize higher risk situations and manage appropriately
4. Continuously evaluate and provide transparent communication



Things that I wish that everyone would remember:

- a) There are no absolutes
- b) The virus doesn't care
- c) Our goal is risk reduction not perfection

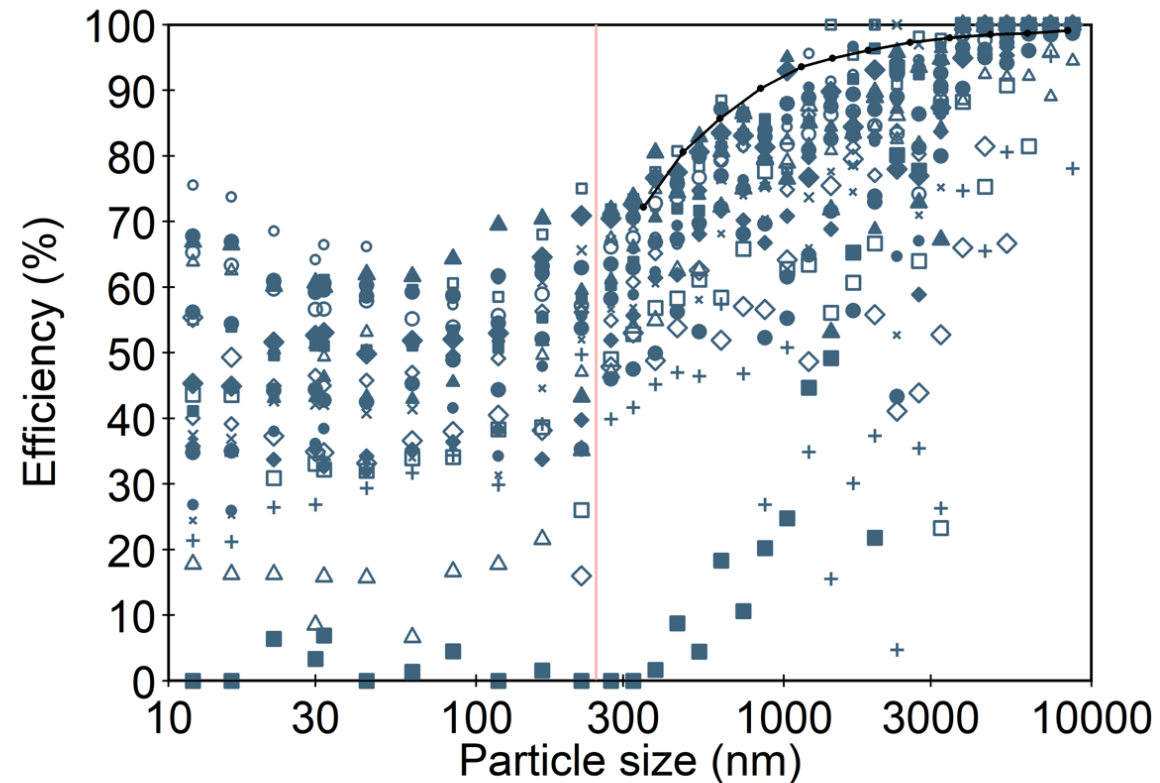
# Mantra: Two of Three

1. Outdoors
2. Masks
3. Physically distant\*

If you can't do two, you need more layers.

# Filtration and Ventilation

- We focus on the technology when we should focus on the context



# Potential Layers

- **Masks (fit is important, mask is important)**
- **Physical distancing (the further the better, 2 m is only acceptable outdoors or in well-ventilated indoor spaces).**
- Mechanical ventilation with fans/central system- (outdoor air pollution, noise, conditioning, humidity, maintenance)
- Natural ventilation with open windows (all of the above + safety/security, control)
- Portable filtration (sizing, placement, noise, maintenance)
- Central filtration (installation, air flow, maintenance, capacity)
- Room flush outs before/after occupancy (3 room volumes or 2 hours)
- Upper room or in-duct UV systems (cost, sizing, maintenance)



# Example 1: Dining Area

Constraints: No masks for those dining, crowded, limited control of mechanical ventilation

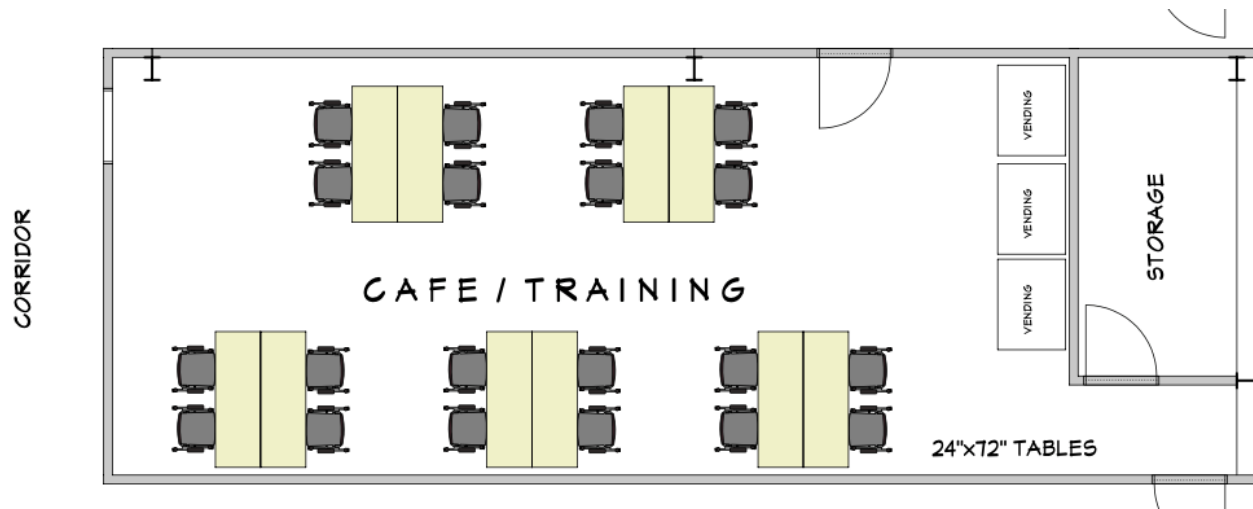
- Communicate risks to population being served **and to staff**
- Scheduling to maximize physical distancing
- Is indoor dining essential for all?
- Open windows/doors with fans if possible
  - Portable HEPA air cleaners
  - Investment in upper room UV system
  - Flush out for 2 hours after eating

# Effective Use of Portable air Cleaners

- Clean air delivery rate (CADR) is the most important parameter associated with an air cleaner
  - Most focus on efficiency – this is incomplete
- Calculate room air changes through the air cleaner (ACH)
- $ACH = CADR \times 60 \div \text{room volume}$ , CADR is in CFM, room volume in  $\text{ft}^3$ 
  - 3/hour for general protection
  - **6/hour for higher risk spaces** (comes from tuberculosis literature)
- Secondary: Noise, placement, maintenance (filter change)

# Once you have CADR

- Calculate room air changes through the air cleaner (ACH)
- $ACH = CADR \times 60 \div \text{room volume}$

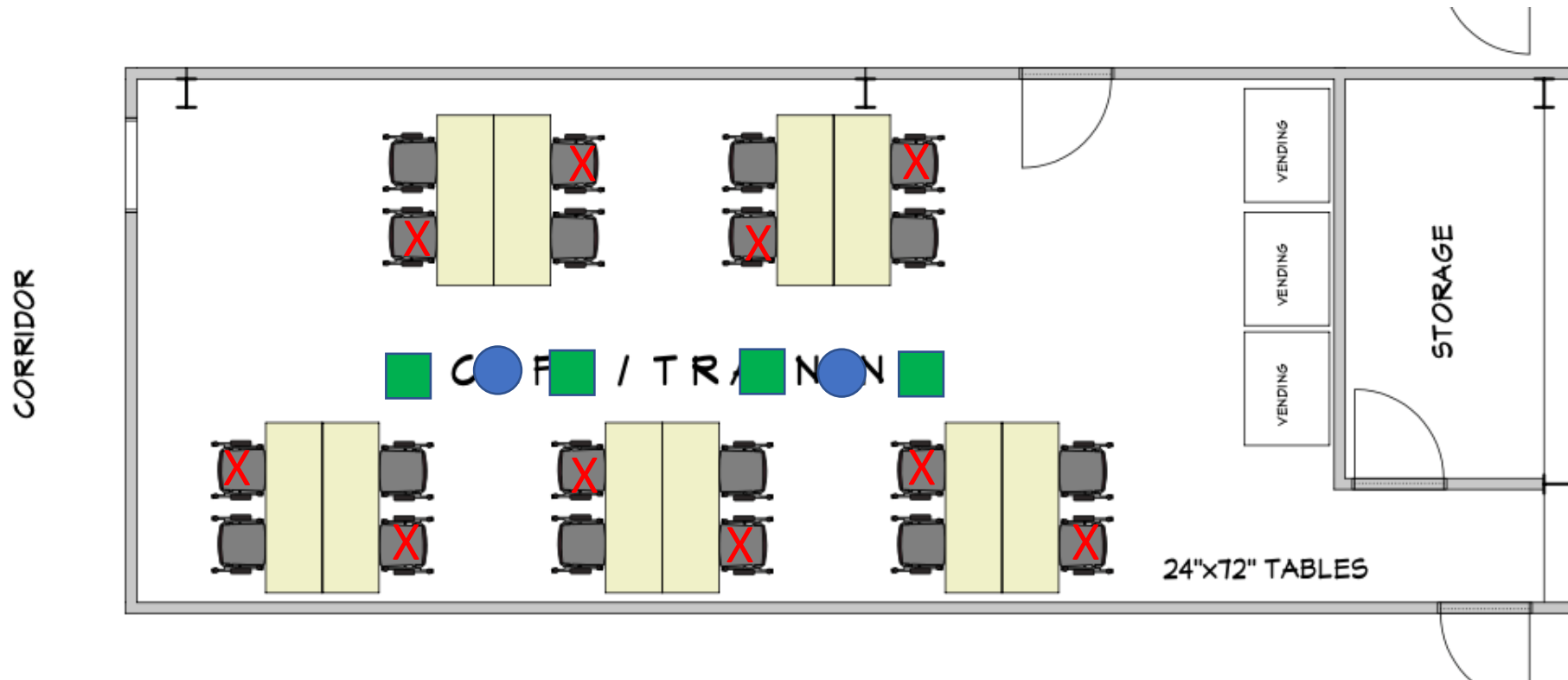


Floor Area = 900 ft<sup>2</sup>  
Ceiling Height = 8 ft  
CADR = 400 CFM (2  
200 CFM units)

$ACH = 400 \text{ CFM}$   
 $\times 60 \div (900 \text{ ft}^2 \times 8 \text{ ft})$

$ACH = 3.3/\text{hour}$   
(2.7/hour if 10 ft  
ceilings)

- X Active seat
- Portable air cleaners (2) for ~ 3 ACH
- Portable air cleaners (4) for ~ 6 ACH



- Additional notes
  - Unmasked individuals (eating) -  $\frac{1}{4}$  capacity would be better
  - Good application for upper room UV
  - Good application for 6 ACH because of higher risk

# Additional Strategies

- High-speed (and noisy) when risk is highest, turn down at other times
- Communicate with users of space

# Example 2: Congregate sleeping area

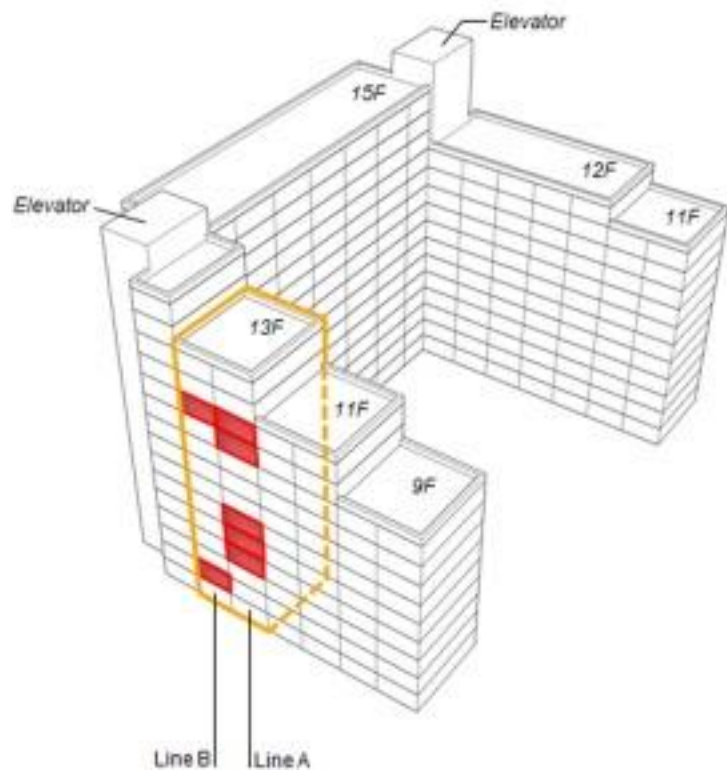
Constraints: long occupancy duration, safety and security are important, noise is problematic, no masks, too much space for upper room UV or other “expensive” approaches

1. Arrange sleeping to maximize physical distancing
2. Portable air cleaners between respiratory plume generation
3. Pay attention to specifics of portable air cleaner, particularly noise profile
4. Communicate with occupants about risks (e.g., wear mask if possible)

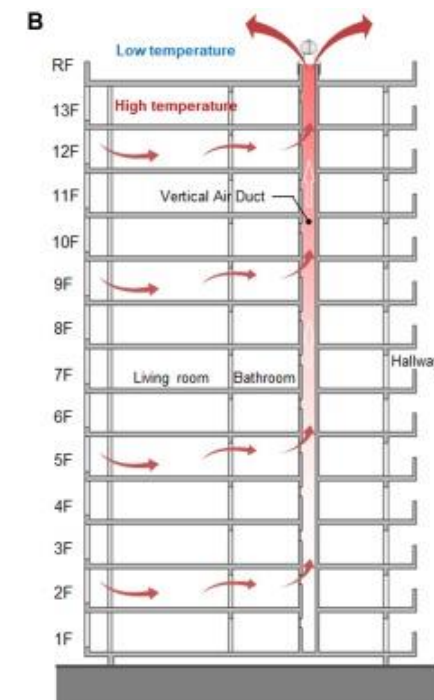
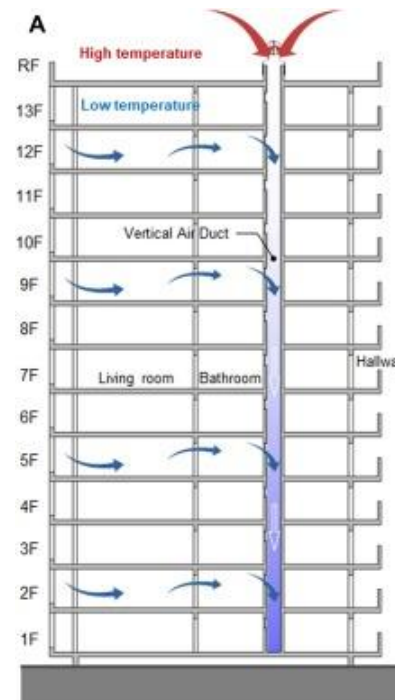
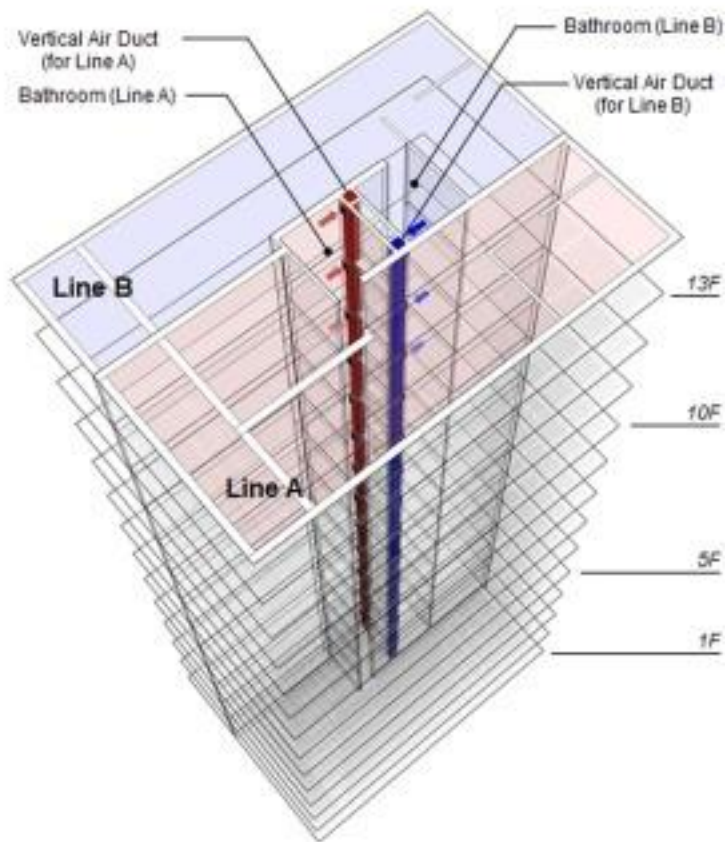
# Example 3: Multifamily Residential Building

1. Address common areas – minimize contact
2. Communicate – Occupants' biggest risk comes from infected person in their home
  - Provide isolation approach and space (if possible)
3. Address vertical risers (e.g., for plumbing, some corridor ventilation system)

### A. Confirmed Households



### B. Characteristic of Unit Plan



Possible aerosol transmission of COVID-19 associated with an outbreak in an apartment in Seoul, South Korea, 2020

Seo Eun Hwang<sup>a,b</sup>, Je Hwan Chang<sup>c,d</sup>, Bumjo Oh<sup>a</sup>, Jongho Heo<sup>e,f,\*</sup>

<https://doi.org/10.1016/j.ijid.2020.12.035>





Ref: Allergy Cosmos

“Reduce up to 99% of allergies, odors, mold, germs, and other contaminants.”

“40X better than a HEPA filter”

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

“The only air purifier to clean a whole room.”

“True-HEPA rated.”

“Our technology is in The Whitehouse”

“Captures and destroys pollutants 1000 times smaller than HEPA filters.”

# What About Other Air Cleaning Technologies

- Photocatalytic oxidation
- Plasma
- Ionization
- Sprays (chemical and biological)

This is a suitable place to give a most earnest warning against the use of so-called secret remedies and patent medicines.... Pettenkofer (1883)

- These are **not** terms with firm definitions
- There is not independent evidence of efficacy
- There is evidence of harm (ozone emission, ion concentration, byproduct formation)

**Buyer Beware.....**

# Overall Summary

- Filtration and ventilation have a role in protection from COVID-19, but
  - They are not magic and don't work by themselves
  - They have to be implemented carefully and thoughtfully
  - They are part of a larger layered strategy

HVAC & building measures should be in our toolkit.  
They take investment, but benefits far exceed costs.  
Single biggest challenge is overcoming decades of inaction.  
Substantial opportunity to address health disparities that  
arise because of indoor air exposures

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