Occupational Health Clinics for Ontario Workers

Centre de Santé des Travailleurs(ses) de l'Ontario

Addressing Airborne Transmission by Doing Something about Ventilation

John Oudyk

Occupational Hygienist

January 20, 2021

Index case – contact tracing

- My grandson: 3 weeks into JK (end of September)
- Isolated in sick room because of a runny nose
- Mom comes and brings him home (1/2 hr drive in the car with sister)
- We pick him up for the afternoon because Mom's at the end of her rope
- Next day Mom is sick too and Dad has a scratchy throat (stays home from work)
- Grandson comes over again and shows us his school work (cough etiquette drawing) – coughs in my face and when reminded about etiquette, says "that's just for school"
- I get sick that evening, a few days later my partner and my son get sick (a few days later his girl friend) and my grandson's sister also gets a mild case
- Grandson and his Dad get tested for COVID – both negative
- Whatever it was, symptoms came on fast (1-2 days) and everyone got it (half his class off sick, eventually it went through all the other classes and half the teachers have been off)

COVID is different:

- Most cases don't spread to more than 1 or 2 people
- A minority of cases spread to a lot of people (supers-spreader events)
- Super-spreading event is an interaction between person, environment and the time trend of the disease
- Pareto distribution (power law), 10-20% of cases cause 80% of further infections

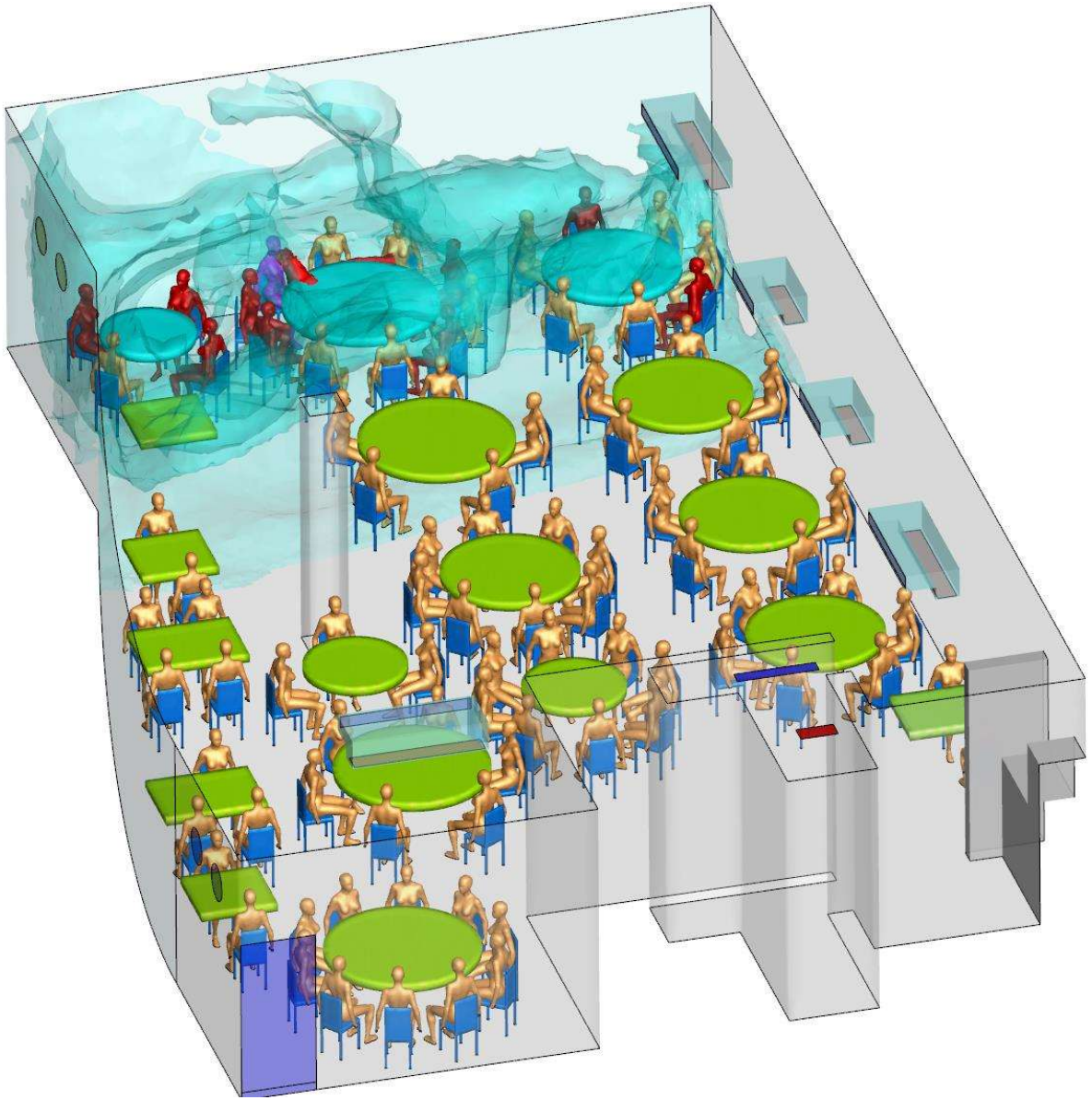
Restaurant in Guangzhou (Jan 24)

- Lu et al (Apr 2 2020) “COVID-19 Outbreak Associated with Air Conditioning in Restaurant, Guangzhou, China, 2020”
  - “We conclude that in this outbreak, droplet transmission was prompted by air-conditioned ventilation. The key factor for infection was the direction of the airflow.”
  - “Our study has limitations. We did not conduct an experimental study simulating the airborne transmission route.”

The restaurant in Guangzhou, China

- Li et al (Apr 23 2020) “Evidence for probable aerosol transmission of SARS-CoV-2 in a poorly ventilated restaurant”:
  - “In summary, our epidemiologic analysis, onsite experimental tracer measurements, and airflow simulations support the probability of an extended short-range aerosol spread of the SARS-CoV-2 having occurred in the poorly ventilated and crowded Restaurant X on January 24, 2020.”
  - “Specifically, although close contact and fomite exposure may play a major role in the transmission of SARS-CoV-2, extended short-range aerosol transmission of the virus is possible in crowded and poorly ventilated enclosures. Our study suggests that it is crucial to prevent overcrowding and provide good ventilation in buildings and transport cabins for preventing the spread of SARS-CoV-2 and the development of COVID-19.”

Li et al (Apr 23 2020)
“Evidence for probable aerosol transmission of SARS-CoV-2 in a poorly ventilated restaurant”



Skagit Valley Chorale outbreak (March 10):

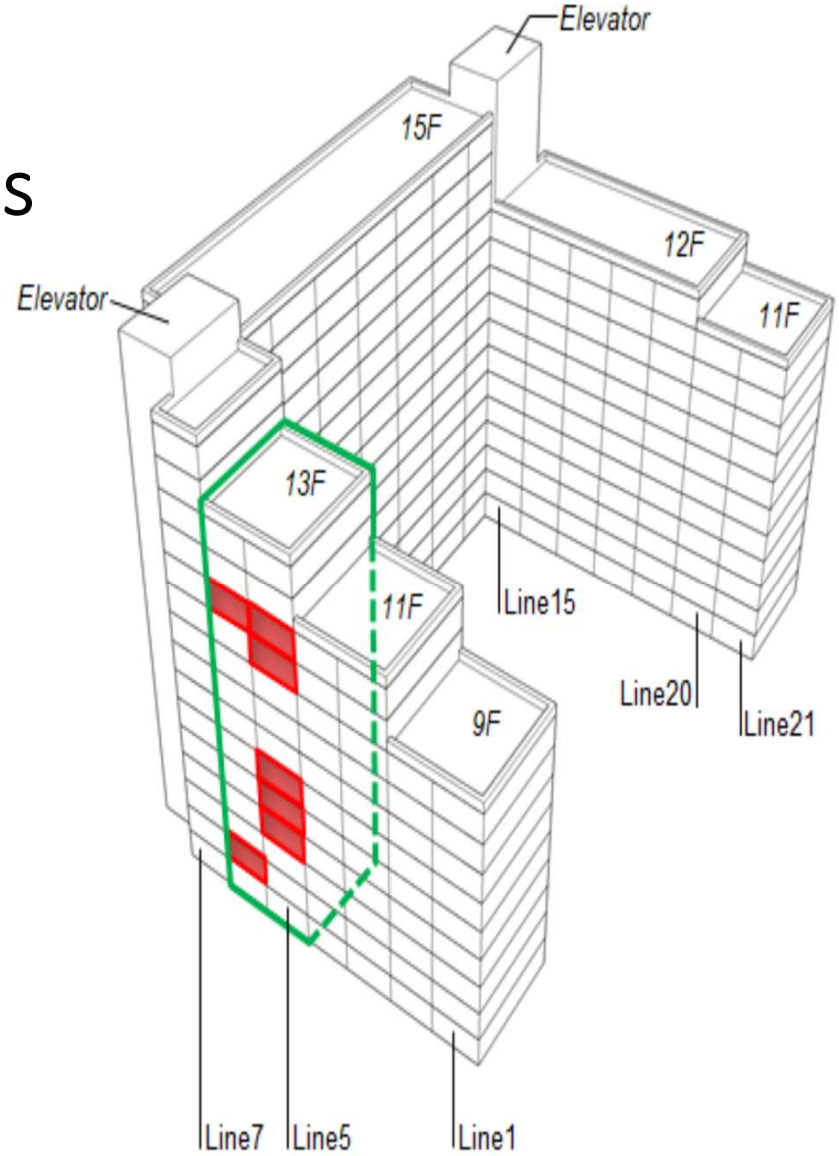
"61 attended rehearsal on March 10, amid concerns about COVID-19 transmission. Precautions were taken during rehearsal, including the use of hand sanitizer, no hugging or handshakes, and maintaining distance between singers."

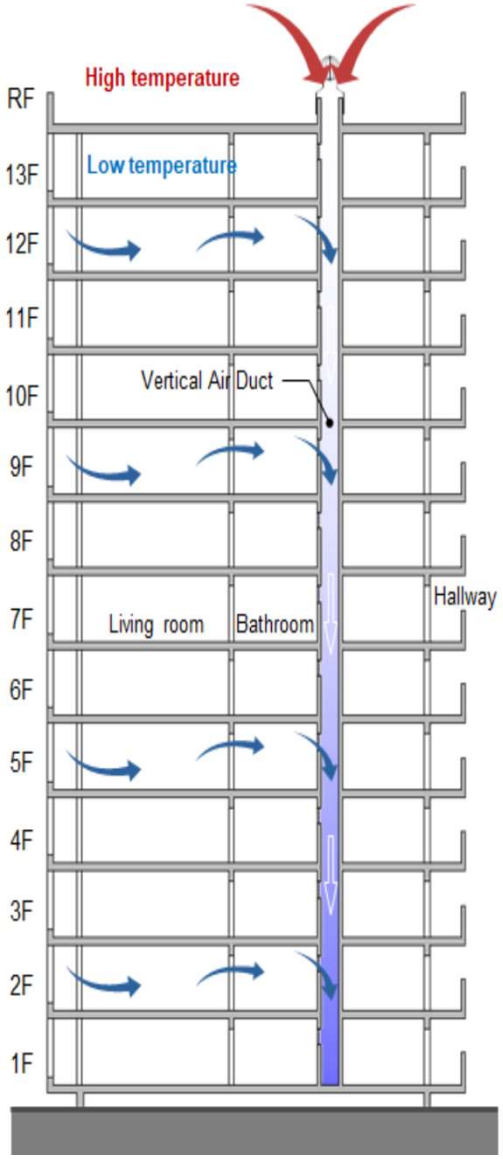
"53 cases in total were subsequently identified including the index case, with 33 confirmed through positive COVID-19 tests and 20 unconfirmed but probable secondary cases based on symptoms and timing."

https://onlinelibrary.wiley.com/doi/10.1111/ina.12751

Transmission via bathroom air vents

(South Korea, August 2020)





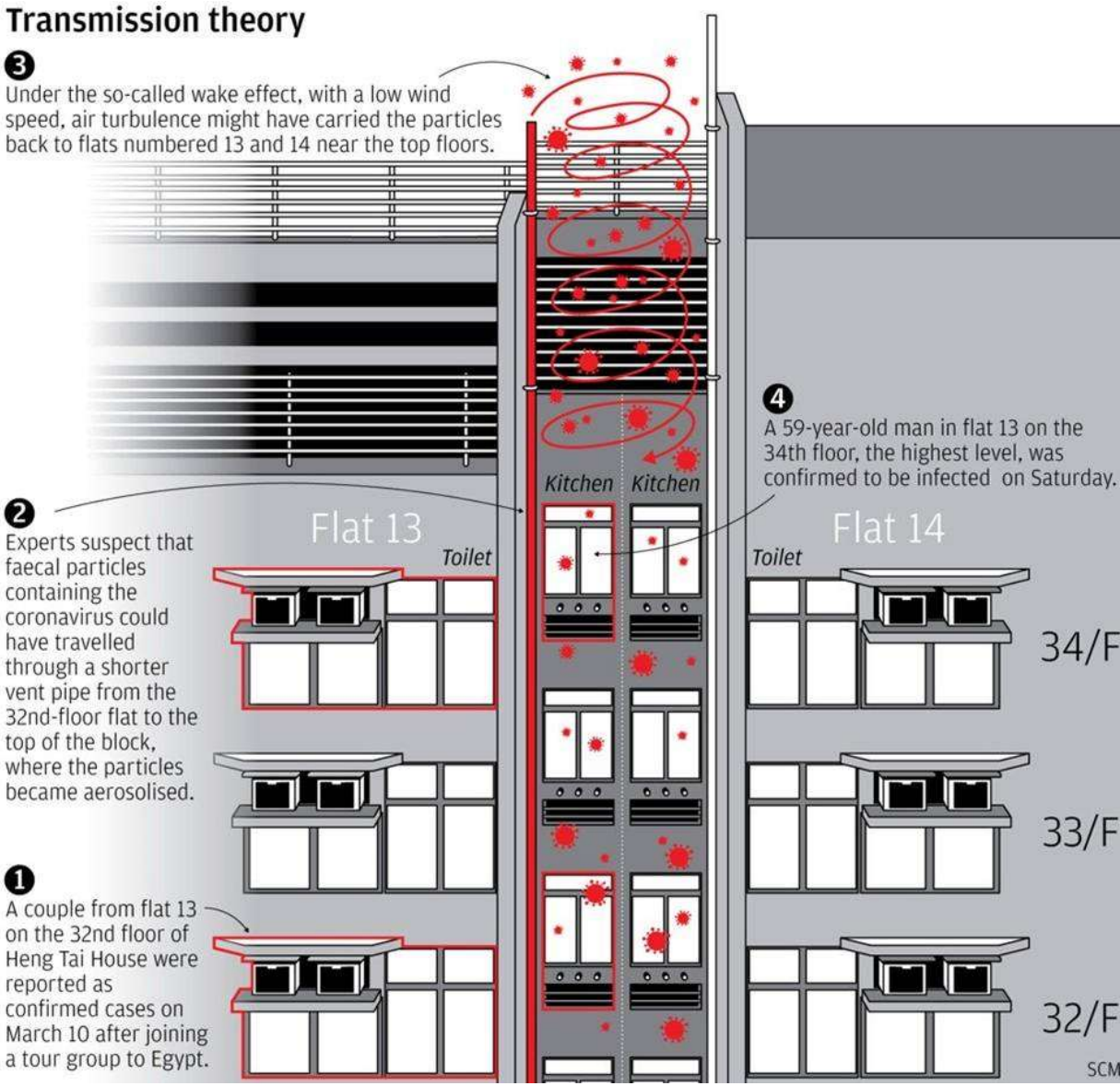
Hwang et al. (2020) “Possible Aerosol Transmission of COVID-19 Associated with an Outbreak in an Apartment in Seoul, South Korea, 2020”

Similar case in Hong Kong

(March 2020)

Coronavirus: eight more households evacuated from Hong Kong housing block after three earlier infections in building

https://www.scmp.com/news/hong-kong/health-environment/article/3075275/coronavirus-eight-more-households-evacuated-hong



SARS1 outbreak

(Hong Kong 2003)

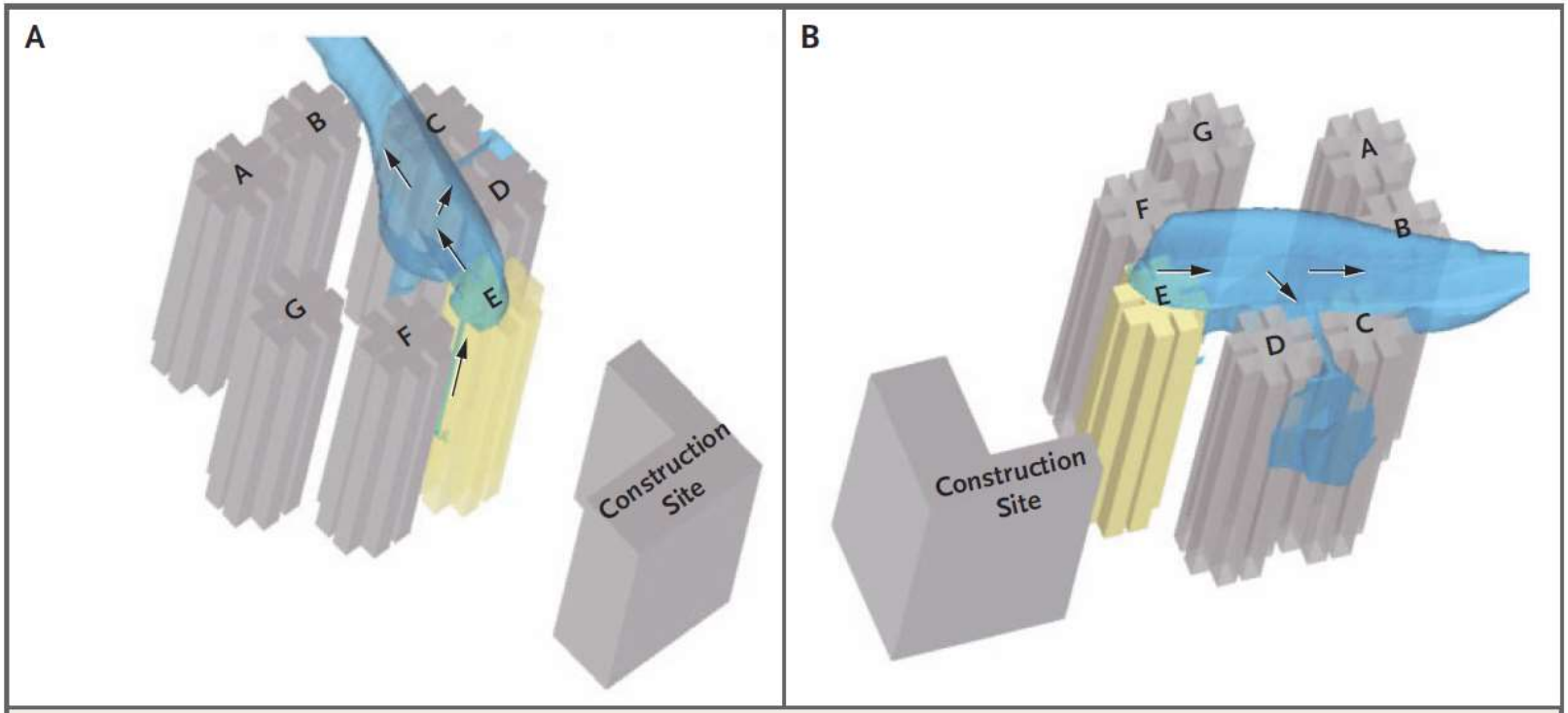


Figure 3. Model of the Movement of the Virus-Laden Plume.

According to our computational fluid-dynamics modeling, the buoyant plume (blue) rose from the air shaft between two housing units in building E (yellow) and was carried by a northeasterly wind toward the middle-level floors in buildings C and D. The L-shape structure (Panels A and B) was a nearby construction site that blocked the wind flowing toward lower-level floors in buildings E, C, and D. The wake flow of the construction site created a region of negative air pressure in the space between buildings E, C, and D (Panel B) that caused the plume to bend downward, toward buildings C and D.

Yu et al. (2004) "Evidence of Airborne Transmission of the Severe Acute Respiratory Syndrome Virus", *New England Journal of Medicine*, 350:1731-9

Particles emitted after flushing the toilet

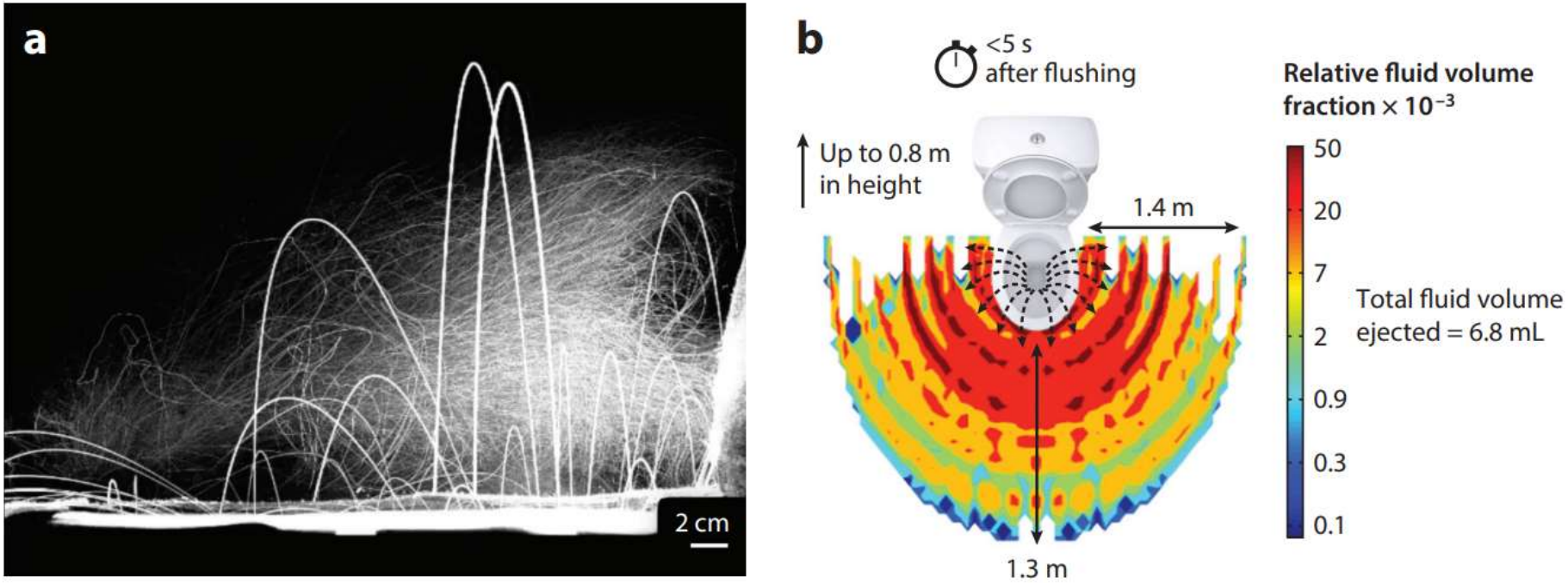


Figure 6

(*a*) High-speed imaging of droplet trajectories emitted from a high-pressure flush of a typical hospital toilet, showing ballistic trajectories for larger droplets and meandering droplet suspension for smaller ones (L. Bourouiba, original data). (*b*) Quantification and visual illustration of the projected relative surface and air contamination (up to 0.8 m above ground) from toilet flush emissions within 5 s after flushing (C. Lu & L. Bourouiba, original data).

Bourouiba (Oct 6 2020) "The Fluid Dynamics of Disease Transmission"

FACT CHECK: COVID-19 is NOT airborne

The virus that causes COVID-19 is mainly transmitted through droplets generated when an infected person coughs, sneezes, or speaks. These droplets are too heavy to hang in the air. They quickly fall on floors or surfaces.

You can be infected by breathing in the virus if you are within 1 metre of a person who has COVID-19, or by touching a contaminated surface and then touching your eyes, nose or mouth before washing your hands.

To protect yourself, keep at least 1 metre distance from others and disinfect surfaces that are touched frequently. Regularly clean your hands thoroughly and avoid touching your eyes, mouth, and nose.

This message spreading on social media is incorrect. Help stop misinformation. Verify the facts before sharing.

World Health Organization

March 28 2020

#Coronavirus #COVID19

FACT CHECK: COVID-19 is NOT airborne

The virus that c
generated wher
droplets are toc
or surfaces.

You can be infe
person who has
touching your e

To protect your
disinfect surfac
thoroughly and

World He
Organiza

Airborne transmission of SARS-CoV-2 can occur under special circumstances

Pathogens that are mainly transmitted through close contact (i.e., contact transmission and droplet transmission) can sometimes also be spread via airborne transmission under special circumstances. There are several well-documented examples in which SARS-CoV-2 appears to have been transmitted over long distances or times. These transmission events appear uncommon and have typically involved the presence of an infectious person producing respiratory droplets for an extended time (>30 minutes to multiple hours) in an enclosed space. Enough virus was present in the space to cause infections in people who were more than 6 feet away or who passed through that space soon after the infectious person had left. Circumstances under which airborne transmission of SARS-CoV-2 appears to have occurred include:

- **Enclosed spaces** within which an infectious person either exposed susceptible people at the same time or to which susceptible people were exposed shortly after the infectious person had left the space.
- **Prolonged exposure to respiratory particles,** often generated with expiratory exertion (e.g., shouting, singing, exercising) that increased the concentration of suspended respiratory droplets in the air space.
- **Inadequate ventilation or air handling** that allowed a build-up of suspended small respiratory droplets and particles.

Prevention of COVID-19 by airborne transmission

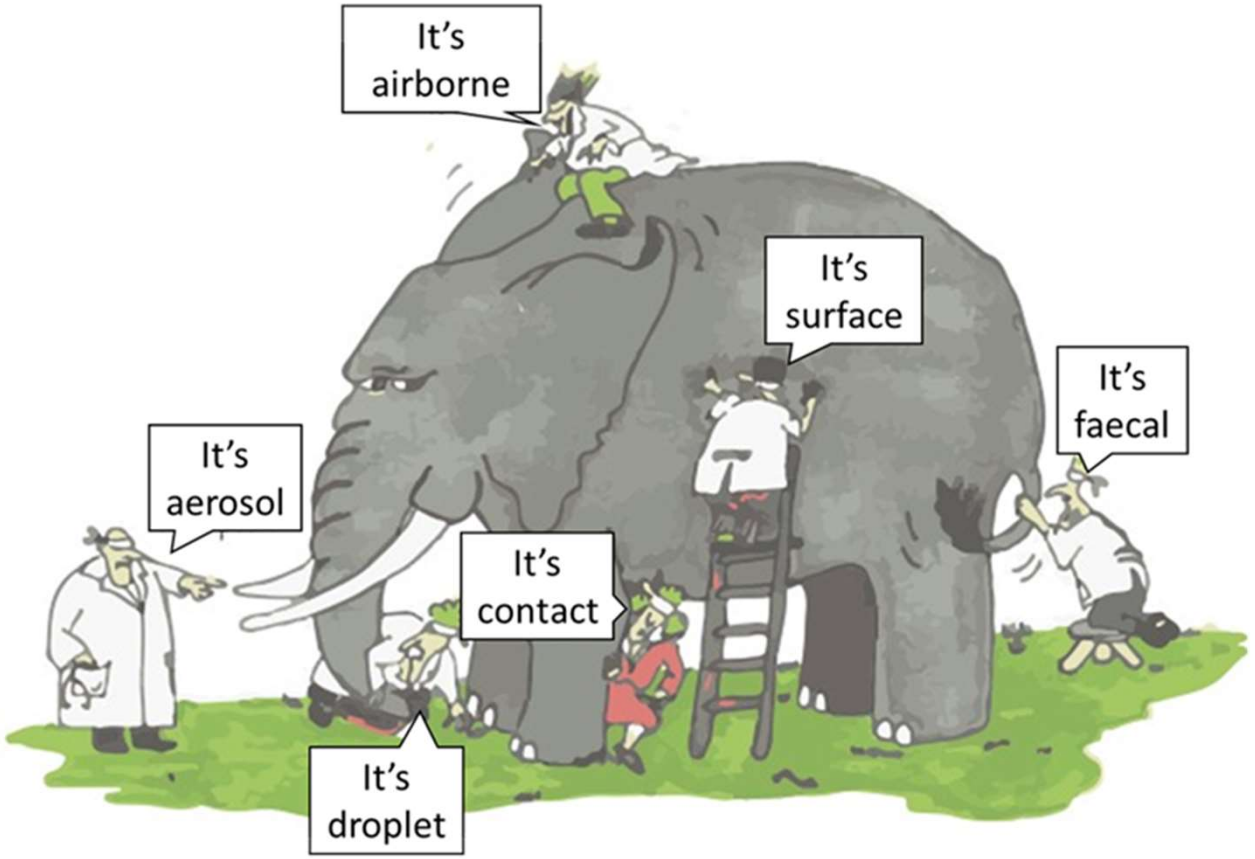
Existing interventions to prevent the spread of SARS-CoV-2 appear sufficient to address transmission both through close contact and under the special circumstances favorable to potential airborne transmission. Among these interventions, which include social distancing, use of masks in the community, hand hygiene, and surface cleaning and disinfection, **ventilation** and **avoidance of crowded indoor spaces** are especially relevant for enclosed spaces, where circumstances can increase the concentration of suspended small droplets and particles carrying infectious virus. At this time, there is no indication of a general community need to use special engineering controls, such as those required to protect against airborne transmission of infections, like measles or tuberculosis, in the healthcare setting.

sage spreading on social media
ect. Help stop misinformation.
y the facts before sharing.

ronavirus #COVID19

https://www.cdc.gov/coronavirus/2019-ncov/more/scientific-brief-sars-cov-2.html
WHO, October 5, 2020

Confusion and misinformation about transmission routes, reminds me of the Indian folk story: the 6 blind people and the elephant



PHAC: on modes of transmission

"Spreads from an infected person to others through respiratory droplets and aerosols created when an infected person coughs, sneezes, sings, shouts, or talks. The droplets vary in size from large droplets to smaller droplets, sometimes called aerosols, which linger in the air under some circumstances."

"Reports of outbreaks in settings with poor ventilation suggest that infectious aerosols were suspended in the air and that people inhaled the virus. These settings have included a choir practice, fitness classes, and restaurants. Transmission in these settings may have been facilitated by certain environmental conditions, such as re-circulated air."

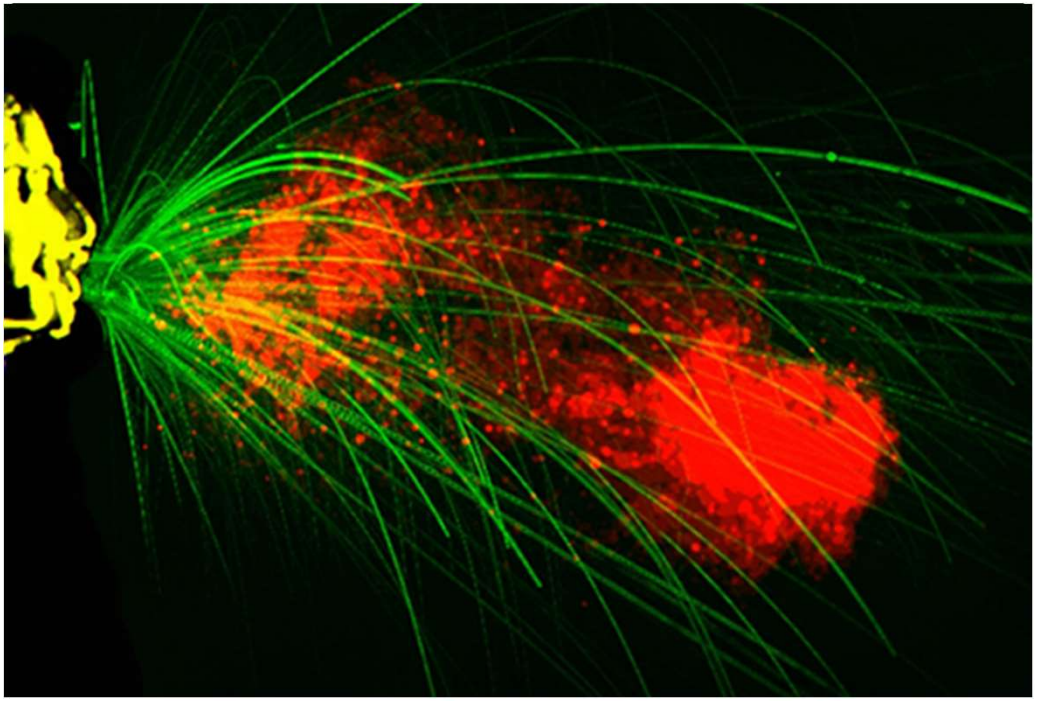
"Avoid or take additional measures and keep exposure very brief in:

- closed spaces
- crowded places
- close-contact settings and close-range conversations
- settings where there is singing, shouting or heavy breathing, for example, during exercise

It is particularly important to avoid settings where these risks overlap, e.g., closed, crowded spaces where close-range conversations occur."

"Maximize ventilation by ensuring that heating, ventilation and air conditioning (HVAC) systems are in good working order. Drawing as much fresh air as possible from outside will decrease the concentration of aerosols. Reduce the noise level in public spaces, for example turn off the music, so people can speak as quietly as possible."

https://www.canada.ca/en/public-health/services/diseases/2019-novel-coronavirus-infection/health-professionals/main-modes-transmission.html

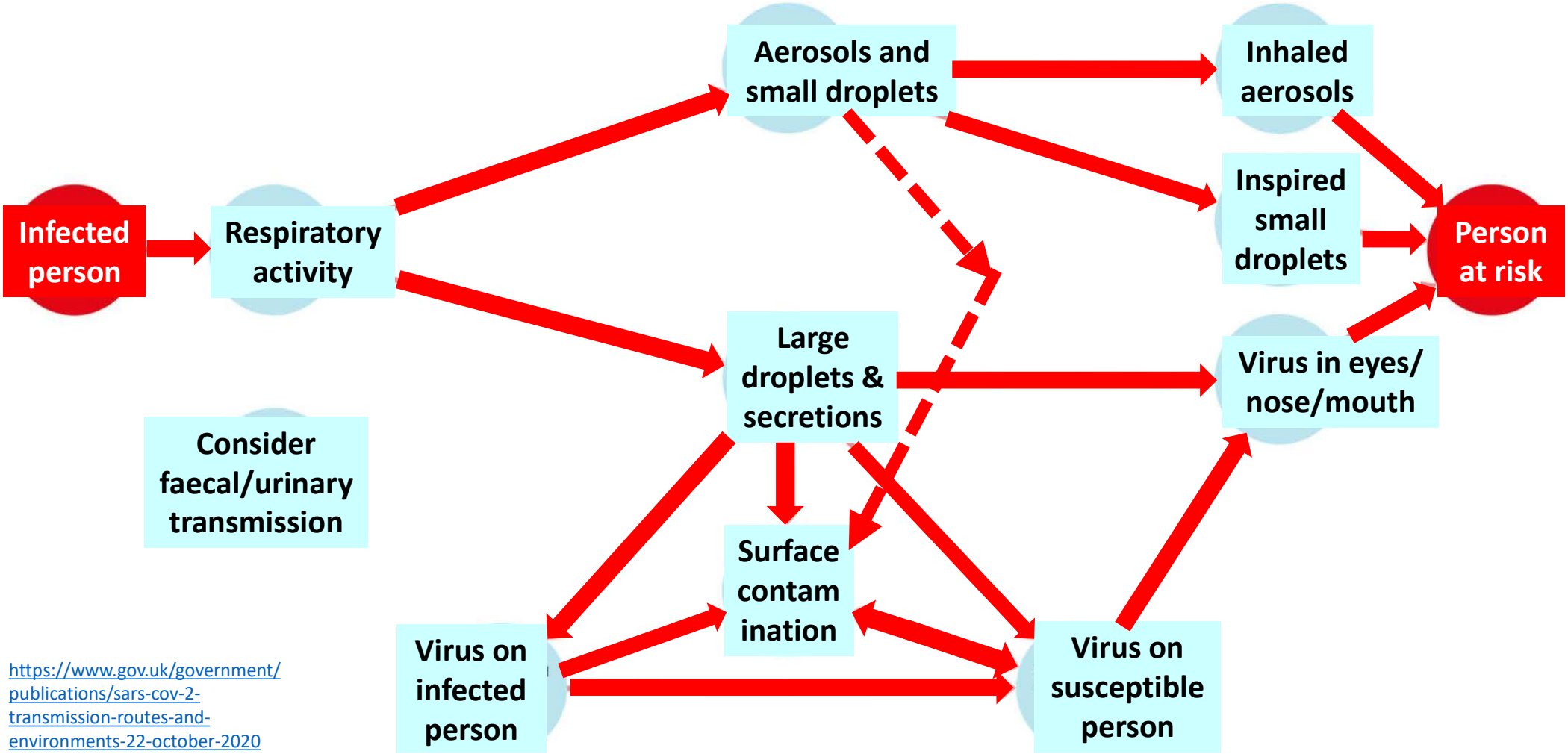


"plume" and "room" dispersion aerodynamics ("plume" independent of room air flow patterns) – stop it with a mask

Figure 1: Image reproduction showing the semi-ballistic largest drops, visible to the naked eye, and on the order of mm, which can overshoot the puff at its early stage of emission [14, 15]. The puff continues to propagate and entrain ambient air as it moves forward, carrying its payload of a continuum of drops [13], over distances up to 8 meters for violent exhalations such as sneezes [17].

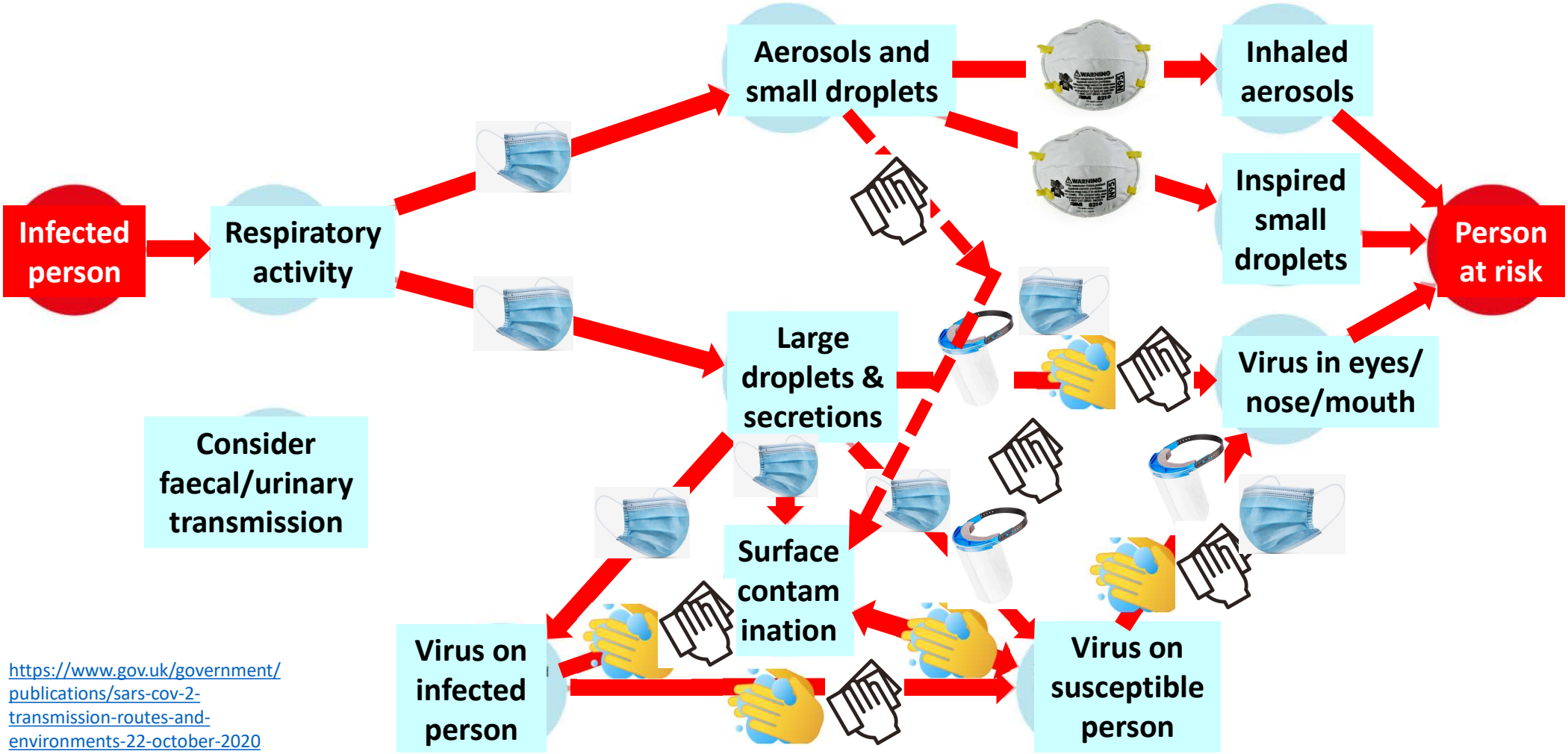
https://www.sciencedirect.com/science/article/pii/S0301932220305498

Various paths of transmission



https://www.gov.uk/government/publications/sars-cov-2-transmission-routes-and-environments-22-october-2020

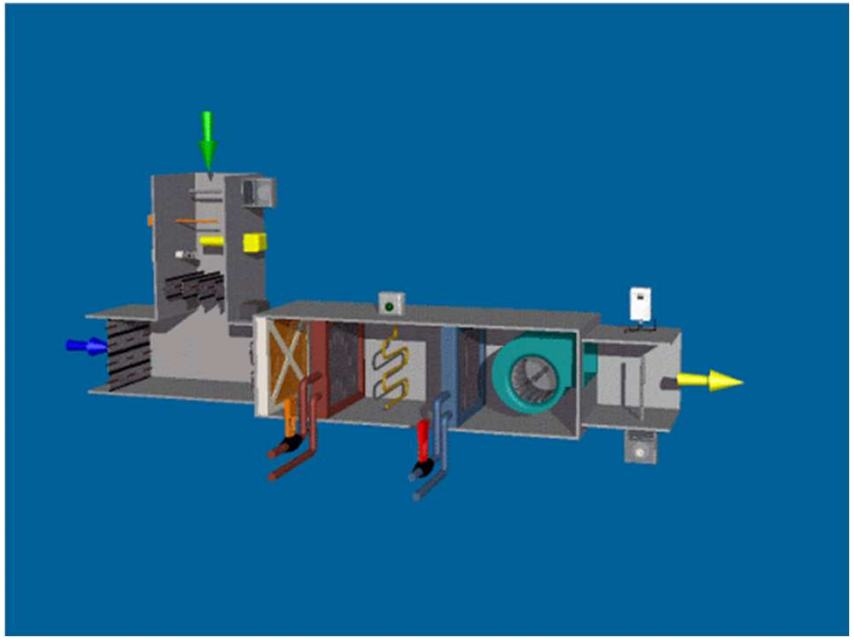
Various paths of transmission

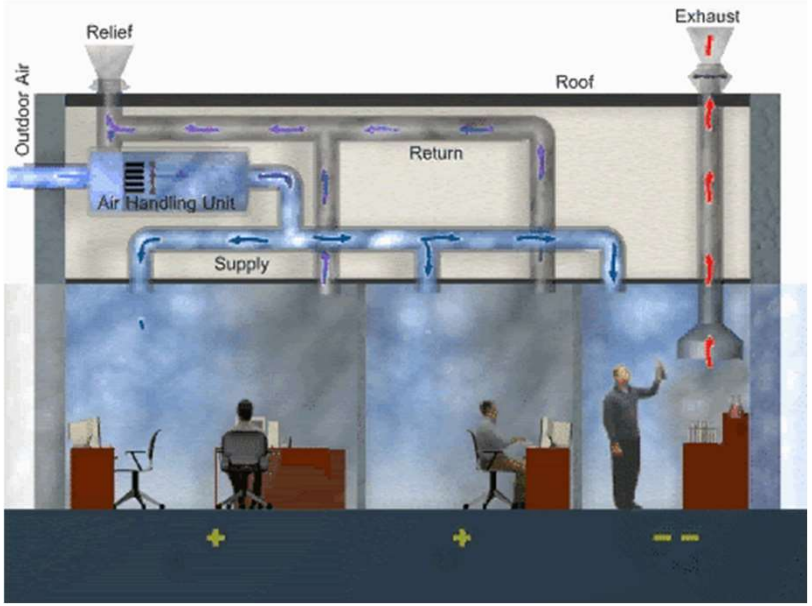


https://www.gov.uk/government/publications/sars-cov-2-transmission-routes-and-environments-22-october-2020

… so does ventilating fit into all this?

Heating Ventilating and Air Conditioning (HVAC) unit






Supply
air blows into the room
Return
air leaves the room

go look on the roof …

make sure you look inside

never know what you'll find …

2do list: go look inside your HVAC unit

Measuring air flow (the proper way):

The problems with air changes (ACH):

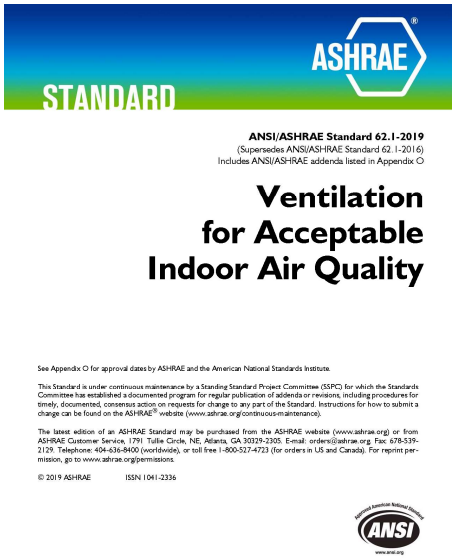
2do list: make fan setting is on "ON"

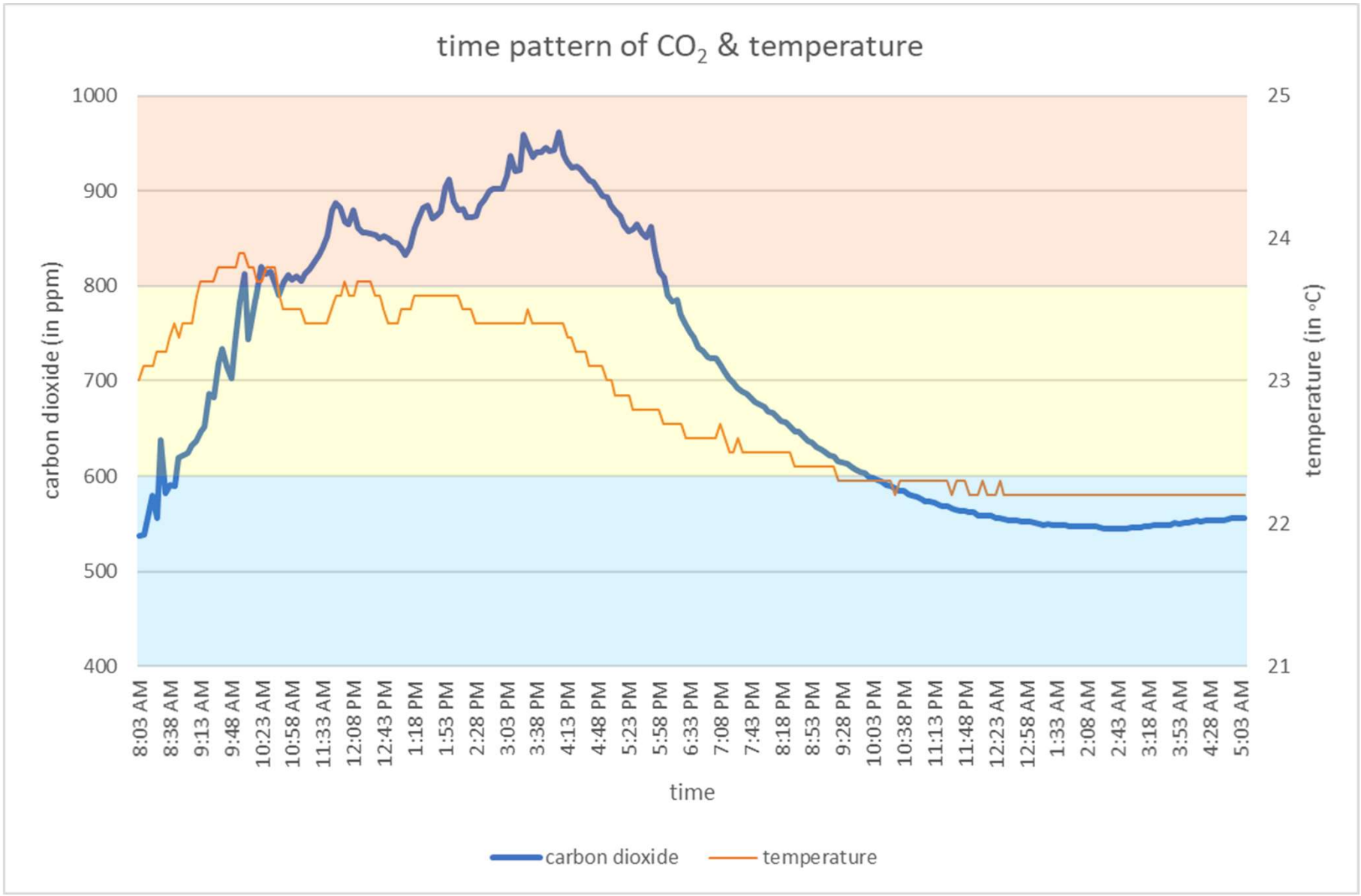
- Most HVAC systems designed to turnover the volume of the room about 5 to 6 time per hour (if the fan setting left on "ON" not "AUTO")
- Usually only 10-25% of the air being circulated by the HVAC unit is outdoor air
- Thus, if you have 5-6 air turnovers per hour, and only 10-25% of that air is outdoor air ("fresh air"), then actually the rate is 0.5-1.5 outdoor ACH.
- This all assumes you have "perfect mixing" i.e. the air circulates over the whole volume of the room leaving no "dead air" spaces
- Open windows and doors will give you more air exchanges and possibly more outdoor air supply
- If you go to 100% outdoor air supply you won't be able to manage the temperature and humidity in extreme weather (very hot or very cold)

CO_2 as a surrogate measure for outdoor air supply:

- **carbon dioxide** as an evaluation criteria (measures air turnover rates)
- standards (surrogate, not exposure)
  - **ASHRAE** #62.1-2019
    - 17 cfm/person (equivalent to 900 ppm CO_2 if outside CO_2 is 400 ppm; 15 cfm/person equivalent to 1100 ppm CO_2 or CO_2 level no more than 700 ppm above background)
  - **Ministry of Labour**

background (outside air)	400-500 ppm
no problem	500-600 ppm
possible problem	600-800 ppm
probable problem	800-1000 ppm
more outdoor air needed	1000+ ppm
TWAEV	5000 ppm



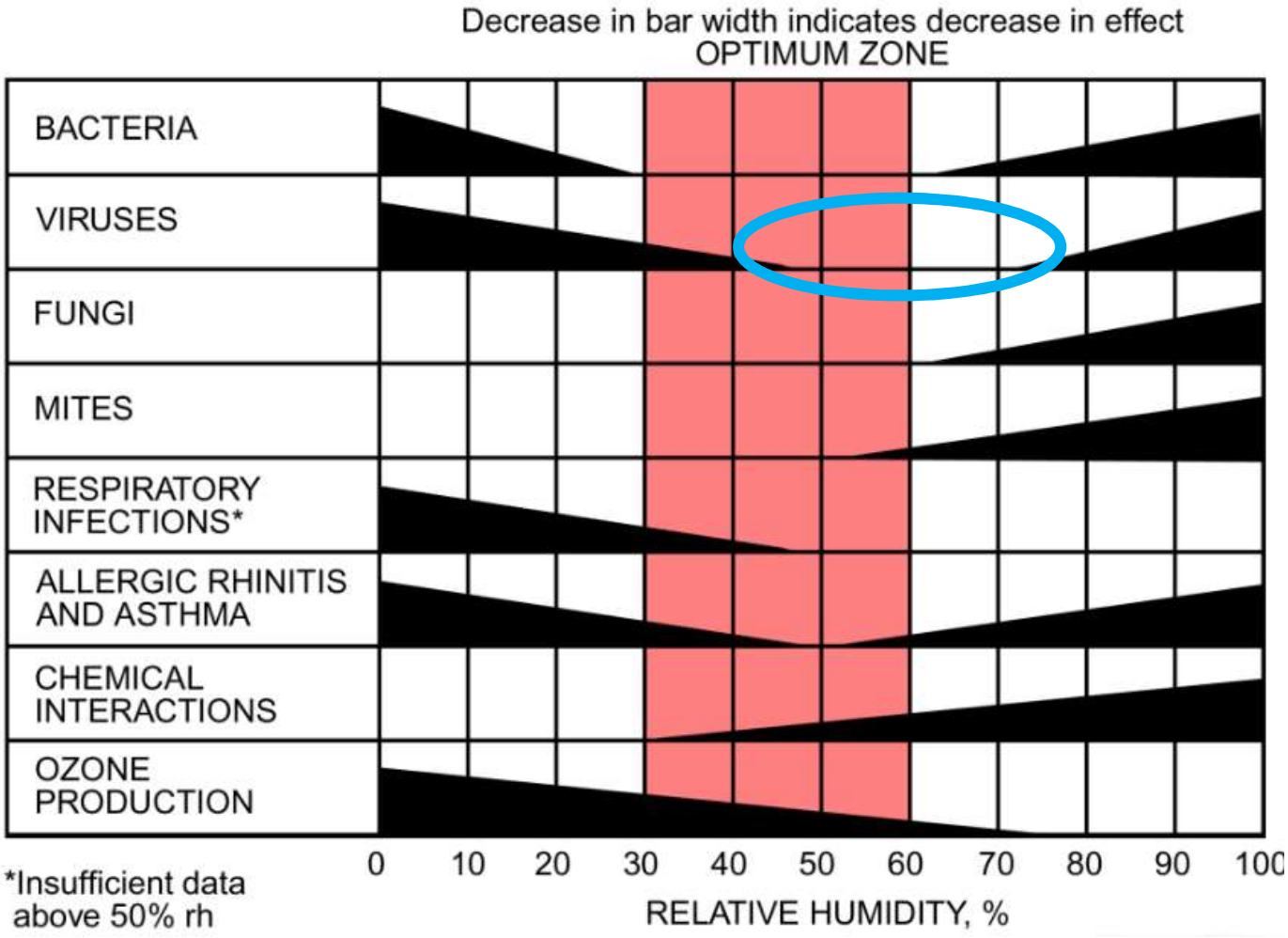

time pattern of CO_2 & temperature
carbon dioxide (in ppm)
temperature (in °C)
1000
900
800
700
600
500
400
25
24
23
22
21
8:03 AM
8:38 AM
9:13 AM
9:48 AM
10:23 AM
10:58 AM
11:33 AM
12:08 PM
12:43 PM
1:18 PM
1:53 PM
2:28 PM
3:03 PM
3:38 PM
4:13 PM
4:48 PM
5:23 PM
5:58 PM
6:33 PM
7:08 PM
7:43 PM
8:18 PM
8:53 PM
9:28 PM
10:03 PM
10:38 PM
11:13 PM
11:48 PM
12:23 AM
12:58 AM
1:33 AM
2:08 AM
2:43 AM
3:18 AM
3:53 AM
4:28 AM
5:03 AM
time
carbon dioxide
temperature

Thermal comfort issues:

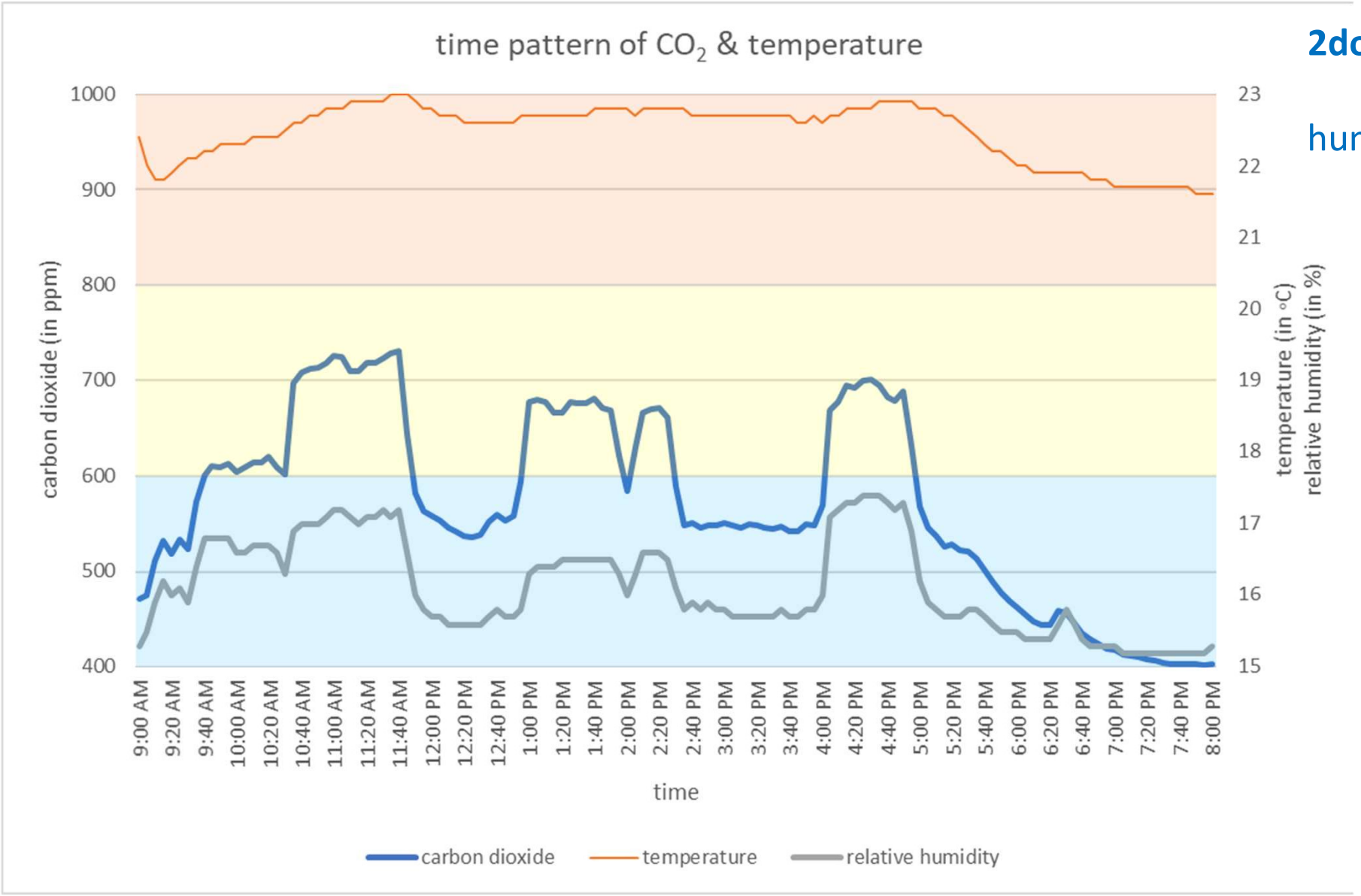
2do list: prepare for thermal discomfort

- Due to the heating/cooling load that 100% outdoor air may bring (ideal outdoor air temperature for air conditioning is 10°C (or 50°F in American)) occupants may experience some thermal discomfort
- Adjusting workplace clothing is a means of addressing this issue (lots of sweaters, blankets, even thin gloves) and space heaters
- Open windows and the use of barriers (e.g. Plexiglas dividers) may disrupt designed air flows (use soap bubble gun to see the air flow patterns)
- Relative humidity (e.g. 40-70%) will be very difficult to maintain in the Canadian winter – steam injection humidification systems are probably the best, if designed and maintain adequately

Health Risks vs. Relative Humidioty



E.M. Sterling, A. Arundel, and T.D. Sterling, Criteria for Human Exposure to Humidity in Occupied Buildings(ASHRAE Transactions, 1985), Vol. 91, Part 1



2do list: check into humidification

Guo BM, Xu P, Xiao T, He R, Dai M, Zhang Y, Review and comparison of HVAC operation guidelines in different countries during the COVID-19 pandemic, Building and Environment (2020)

Table A.1: comparison of the main strategies

	ASHRAE	REHVA	SHASE	Related Society of China
Outdoor air	1. Increase the amount of outdoor air. 2. Open outdoor air dampers, as high as 100% if possible.	1. Supplying as much outside air as reasonably possible. Switch the terminal devices to 100% outdoor air if possible. 2. Open windows regularly.	1. Supplying as much outside air as reasonably possible. Switch the terminal devices to 100% outdoor air if possible. 2. Open windows regularly.	1. Supply as much outside air as reasonably possible. Switch the terminal devices to 100% outdoor air if possible. 2. The ratio of outdoor air should be greater than 40%.
Operation of HVAC systems	1. Operate HVAC related device local 2. Keep the system on for 24 hours a day, 7 days a week if possible. 3. Disable DCV.	1. Run ventilation at the nominal speed for at least 2h before occupancies and at a lower speed 2h after occupancies. 2. Run toilet ventilation system for 24 hours a day, 7 days a week. 3. In DCV systems, change the CO_2 setpoint to 400 ppm.	1. Increase the running time of HVAC equipment, running it continuously for 24 hours if possible. 2. Run the exhaust system in toilets continuously. 3. Lower the CO_2 setpoint.	1. Increase the air supply temperature in heating mode and decrease the temperature in cooling mode.
Temperature and humidity setpoint	1. Control the temperature and humidity is beneficial. But the temperature and relative humidity setpoint should be considered on a case-by-case basis.	1. There is no need to adjust the temperature and humidity setpoint.	1. The temperature should be controlled between 17 and 28 ℃, and the relative humidity should be controlled between 40 and 70%.	Haven't mentioned.
Pressure Differential	1. The air should flow from safe areas to unsafe areas, from personal use areas to public areas.	1. Ensure the negative pressure in the toilets.	1. Ensure the negative pressure in the toilets.	1. A slight positive pressure should be maintained in the kitchen. 2. Keep negative pressure in toilets.
Filters equipped in the HVAC system	1. Improve the level of the central air filter as much as possible, at least to the grade of MERV-13.	1. Filters should be replaced and maintained as usual.	1. For a system with 100% outdoor air, the filter can be operated as usual. 2. For return air operation, check the differential pressure of the filter more often and replace the filter sooner than usual.	1. Maintain filters as usual.
Air cleaning	1. HEPA filters and UVGI are recommended.	1. It is recommended to locate the air-cleaning device close to the breathing zone. 2. Special UV cleaning equipment	1. Air cleaners are effective as an auxiliary device. 2. Ventilation is more effective than air cleaners.	1. Indoor air cleaners should be operated. 2. UV devices shouldn't be installed in the HVAC system.

OHCOW Ventilation Checklist:

2do list: download and review the OHCOW ventilation checklist

26 questions, some with guidance and references

- connecting with the people who operate the system
- increase outdoor air supply
- measure air changes per hour (ACH)
- check integrity of complete system (clean if necessary)
- operate system 24/7
- ensure adequate washroom supply and exhaust ventilation
- use at least MERV 13 filters if possible
- consider the use of air cleaners
- keep relative humidity between 40-60%
- perform risk assessment

https://www.ohcow.on.ca/ventilation-checklist-2.html

	ASHRAE	REHVA	SHASA	SQSIQA
outdoor air (OA)	100% outdoor air if possible	100% outdoor air if possible	100% outdoor air if possible	100% outdoor air if possible
hrs of operation	24/7 if possible	run at low volume from 2 hrs after, till 2 hrs before occupancy	run HVAC continuously for 24 hours if possible	**2do list:** here's a whole list to review with JHSC
temperature/ humidity set points (temp & RH)	case by case (depends on OA)	no need to adjust temperature and humidity setpoint	temp: 17-28°C RH: 40-70%	increase supply air temp in heating; decrease for cooling
demand-controlled ventilation (DCV)	disable	use CO_2 set point of 400 ppm	lower CO_2 set point	–
filters	MERV-13 or better	filters as usual	for 100% OA, filter as usual – otherwise, replace more often	maintain filters as usual
washrooms	(run ventilation 24/7 – implied)	run toilet ventilation system 24/7 close the lid when flushing avoid dry water seals	run toilet ventilation continuously close the lid when flushing check water seals	keep the plumbing vent pipe clear check water seals regularly

Jeffrey Siegel (U of T) IAQ expert on filters:

Possible particulate potentiating effective raising risk of infection

"There is no direct scientific evidence of benefit, but some reduced exposure can reasonably be inferred based on the ability of some filters to remove particles that contain a SARS-CoV-2 virus. In order for filters to have any impact on infectious disease transmission, transmission has to occur through the airborne route, filters have to be properly installed and maintained in appropriate systems to treat recirculated air, and filters have to be appropriately designed for the building in which they are used. More importantly, in most buildings and in most situations, filters may be considerably less effective than other infection control measures including social distancing, isolation of known cases, and hand-washing."

https://www.nafahq.org/covid-19-corona-virus-and-air-filtration-frequently-asked-questions-faqs/

Plumbing + HVAC
THE VOICE OF CANADA'S MECHANICAL INDUSTRY

http://plumbingandhvac.ca/ontario-to-unlock-50-for-school-hvac-upgrades/

HOME | FEATURE ARTICLES | DIGITAL ISSUES | PRODUCTS | NEWS | EVENTS

YOU ARE AT: Home » News » Ontario to 'unlock' $50M for school HVAC upgrades

Ontario to 'unlock' $50M for school HVAC upgrades

0

BY PLUMBING & HVAC STAFF ON AUGUST 14, 2020 NEWS

Toronto, ON — In announcing a nearly $1.5 billion package to support school boards reopening safely in September, the provincial government also said it will provide $50 million in one-time funding to support improved ventilation, air quality and HVAC system effectiveness in schools.

Boards will focus on improving air systems in older schools, portables and neighbourhoods with higher rates of community transmission, stated a release. School boards will "continue to maximize their use of existing school renewal funding, which totals over $1.4 billion this school year," said the government.

During the press conference Minister of Education Stephen Lecce noted that older schools can use individual HVAC mobile units with the funding to support current ventilation instead of entirely remodeling a school's airflow system.

$50 million for 5000 schools = $10,000/school

Just about enough to buy a bunch of air purifiers

An excuse not to bring in more outdoor air ($)

	Low	Mid	High
Air Purifier	Levoit LV-H134	Blue Pure 121	Medify MA-112
Image			
CADR	312 cfm	400 cfm	560 cfm
AHAM Verification	✖	✔	✖
Maximum Noise Level	54 decibels	56 decibels	70 decibels
Rated Power	45W	61W	95W
Pros & Cons	✓ 100% ozone-free ✓ 360-degree air intake ✗ Not AMAM approved	✓ Minimalist design ✓ Washable pre-filter ✗ No true HEPA filter	✓ Very high CADR ✓ Large filter surface ✗ No air quality monitor on V2.0
In-depth Review	-	Blueair Blue Pure 121 Review	Medify MA-112 Review
Customer Ratings	★★★★½	★★★★½	★★★★½
Prime Status	Prime	Prime	-
Current Price	$407.82	$439.99	Price not available

Clean Air Delivery Rate (CADR):
need roughly a CADR (dust) of **70 cfm per 100 ft² of floor space**

recommended background noise level: **30-40 dBA**

Jeffrey Siegel (U of T) on UV systems & other technologies:

"A properly designed and maintained UV system, often in concert with filtration, humidity control, and airflow management, has been shown to reduce infections from other viruses. The details of the system are very important (e.g., design of fixtures, lamp type, lamp placement airflow amount and mixing, etc.). Simply adding UV to an existing system without consideration of these factors has not been demonstrated to have a benefit."

"Ionizers, ozone generators, plasma, and other air cleaning technologies; None of these technologies have been proven to reduce infection in real buildings, even if they have promise based on tests in a laboratory or idealized setting. Some of them have substantial concerns about secondary issues (such as ozone production)."

https://www.nafahq.org/covid-19-corona-virus-and-air-filtration-frequently-asked-questions-faqs/

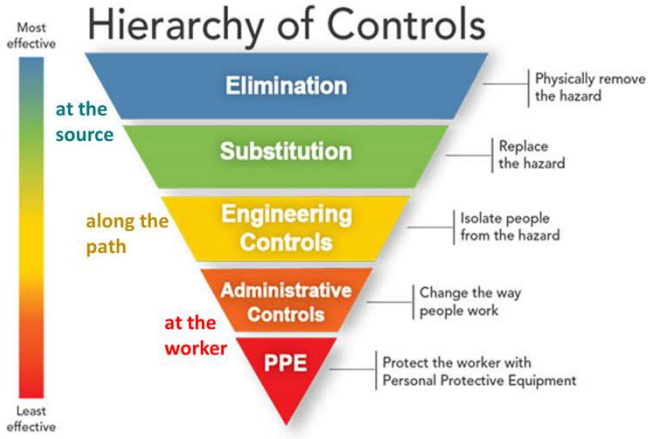
ECDC: Heating, ventilation and air-conditioning systems in the context of COVID-19: first update (Nov 10/2020)

1. **Removal and control of COVID-19 source(s)**
   - Hold off persons with COVID-19 or with COVID-19-related symptoms from staying with other people in closed indoor spaces.

2. **Engineering controls in mechanically ventilated (by HVAC systems) and naturally ventilated closed spaces**
   - Comply with best practice of maintenance and settings of HVAC systems in the context of COVID-19;
   - Ensure frequently opened windows in naturally ventilated closed spaces.

3. **Administrative controls**
   - Reduce occupancy of closed indoor spaces.

4. **Personal protective behaviour**
   - Keep physical distance;
   - Practise respiratory etiquette;
   - Wear a community face mask.



2do list: use creative communication tools in your workplace

Communicating,
Cleaning,
Handwashing,
Ventilating,
Distancing,
Screening, and
Masking

https://schools.forhealth.org/wp-content/uploads/sites/19/2020/06/Harvard-Healthy-Buildings-Program-Schools-For-Health-Reopening-Covid19-June2020.pdf

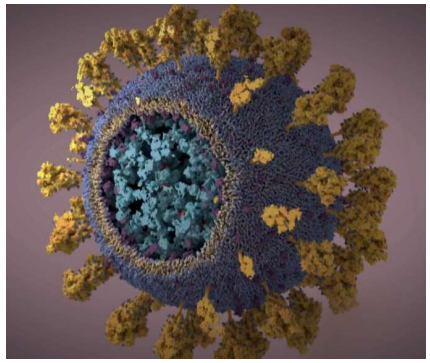
2do list

1. download and review the OHCOW ventilation checklist
2. monitor your local community risk of infection (adjust level of controls accordingly)
3. go look inside your HVAC unit (take some pictures)
4. make sure fan setting is on “ON” (keep outdoor air coming in – as much as possible)
5. prepare occupants for thermal discomfort (space heaters, extra clothes)
6. check into humidification (ideally between 45-70% - hard to achieve tho)
7. review HVAC standards (OHCOW checklist & slide 56) with JHSC
8. if you’re getting portable air cleaning units, make sure you do your homework (size & locate them properly) and take good care of them!
9. post posters (communicate!)– keep occupants aware of what you’re doing

don’t ignore all the other controls:

communicating, cleaning, handwashing, distancing, screening and masking

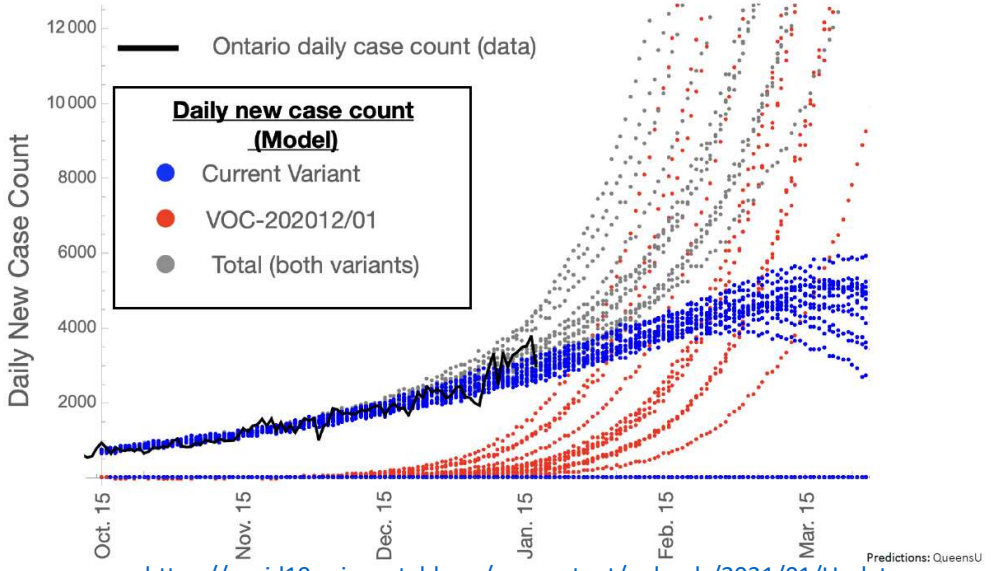
What about the new variants?



- increased transmissibility
- will make all these controls all the more important!
- in the EU people are being asked to wear N95s in crowded venues

https://themunicheye.com/ffp2-masks-now-compulsory-on-public-transport-3913

If the SARS-CoV-2 variant B.1.1.7 spreads in the community, doubling time for cases could drop to 10 days in March



https://covid19-sciencetable.ca/wp-content/uploads/2021/01/Update-on-COVID-19-Projections_January-12-2021_Final_English-2.pdf

Thanks for your time and attention!

"Open up the window, let the bad air out!" *Bruce Cockburn, 1999*