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# Garth Hunter
# Ventilation as a key control for COVID-19

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PETRONAS

# Content

- To achieve the following understanding:
  - Transmission mechanisms
  - Types of ventilation systems
  - Controls / recommendations specific to COVID-19

**Notes:**

This presentation pulls the outstanding work of multiple people / organisations together particularly Dr Greg Kew, REHVA, AIHA & ASHRAE

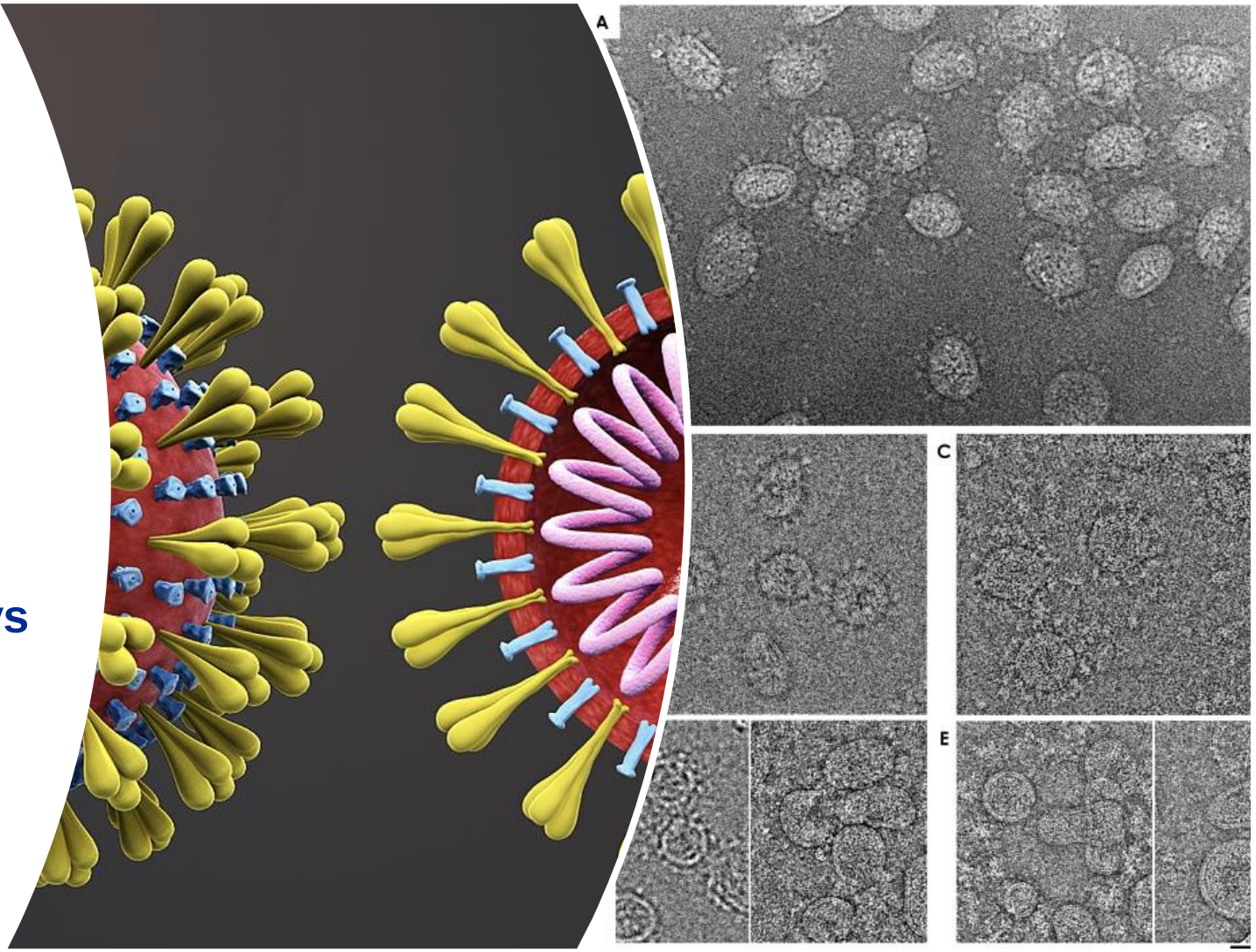
# SARS CoV-2

**Size 0.05-0.15µm**

- **Practically 0.1 µm**

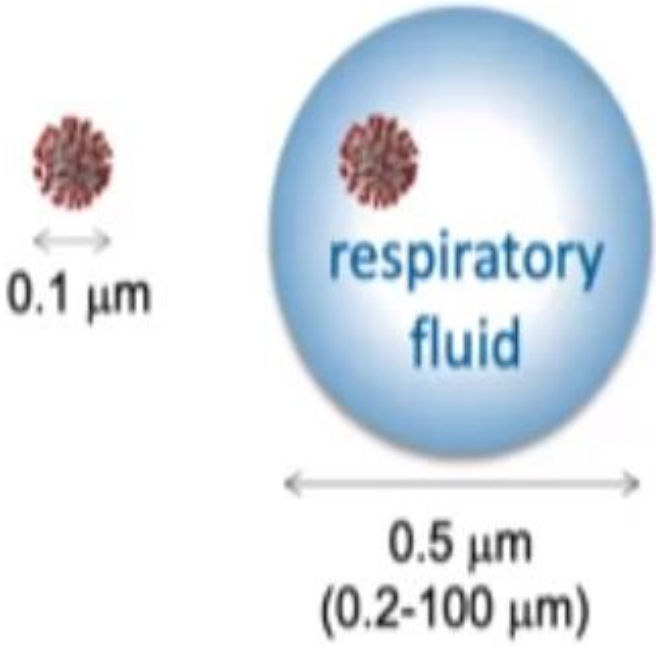
**Dies at 56 C°**

**Viable up to 9 days**
**(based on 22 studies)**



# Size of Droplet / Aerosol Critical

1. Airborne virus is not naked
2. Size of carrier droplet/aerosol defines transport



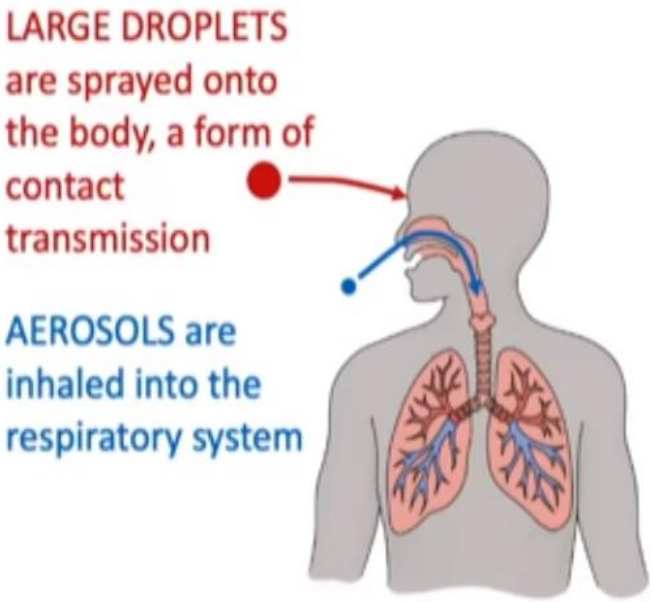

- How long it stays aloft
- How far it can travel
- How quickly it falls to surfaces
- Where it deposits in the respiratory system
- How efficiently it is removed by masks and filters Not only N95 & HEPA
- Physics is the same for all viruses

# Defining transmission by Exposure path

Droplets / Aerosol ***inside*** the body & ***outside*** the body are different sizes – important for ventilation

**Inside the body:**
RESPIRATORY VS NON-RESPIRATORY
> 5µm URT < 5µm LRT

**Outside the body:**
DROPLETS, physics based cut-off ***60-100µm***
Sprayed: Ballistic drops > 100µm, direct hit on eye nostril or mouth

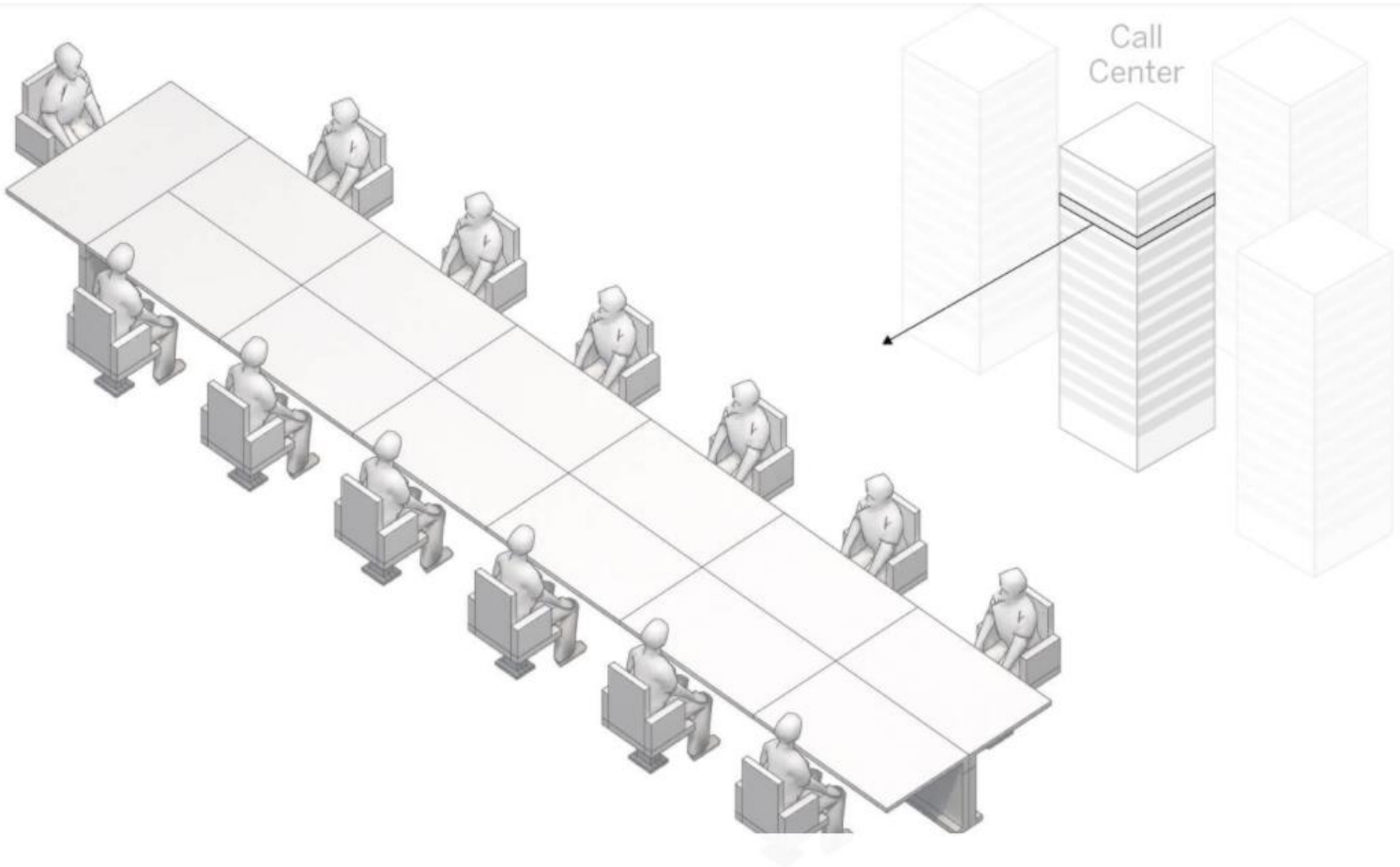



**WHO** – has created confusion by using the same numbers inside / outside body

Respiratory droplets are >5-10µm in diameter whereas droplets ≤5µm in diameter are referred to as droplet nuclei or aerosols. ~~Respiratory droplet transmission~~ can occur when a person is in close contact (~~within 1 metre~~) - WHO 9 July 2020
https://www.who.int/news-room/commentaries/detail/transmission-of-sars-cov-2-implications-for-infection-prevention-precautions

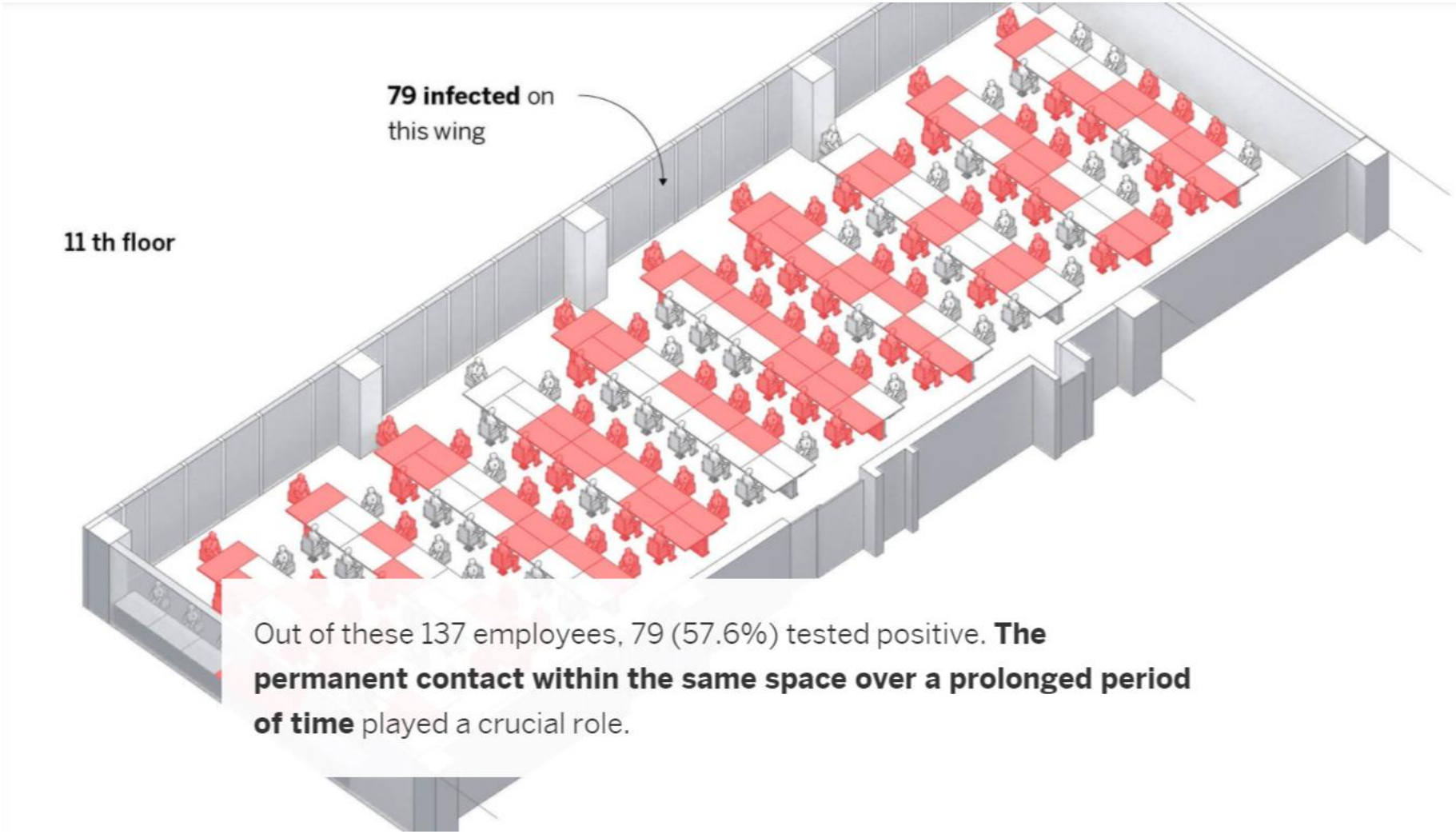
# S Korea – call centre

South Korea




The staff at the call center on the 11th floor **work together** at desks containing 13 work stations.

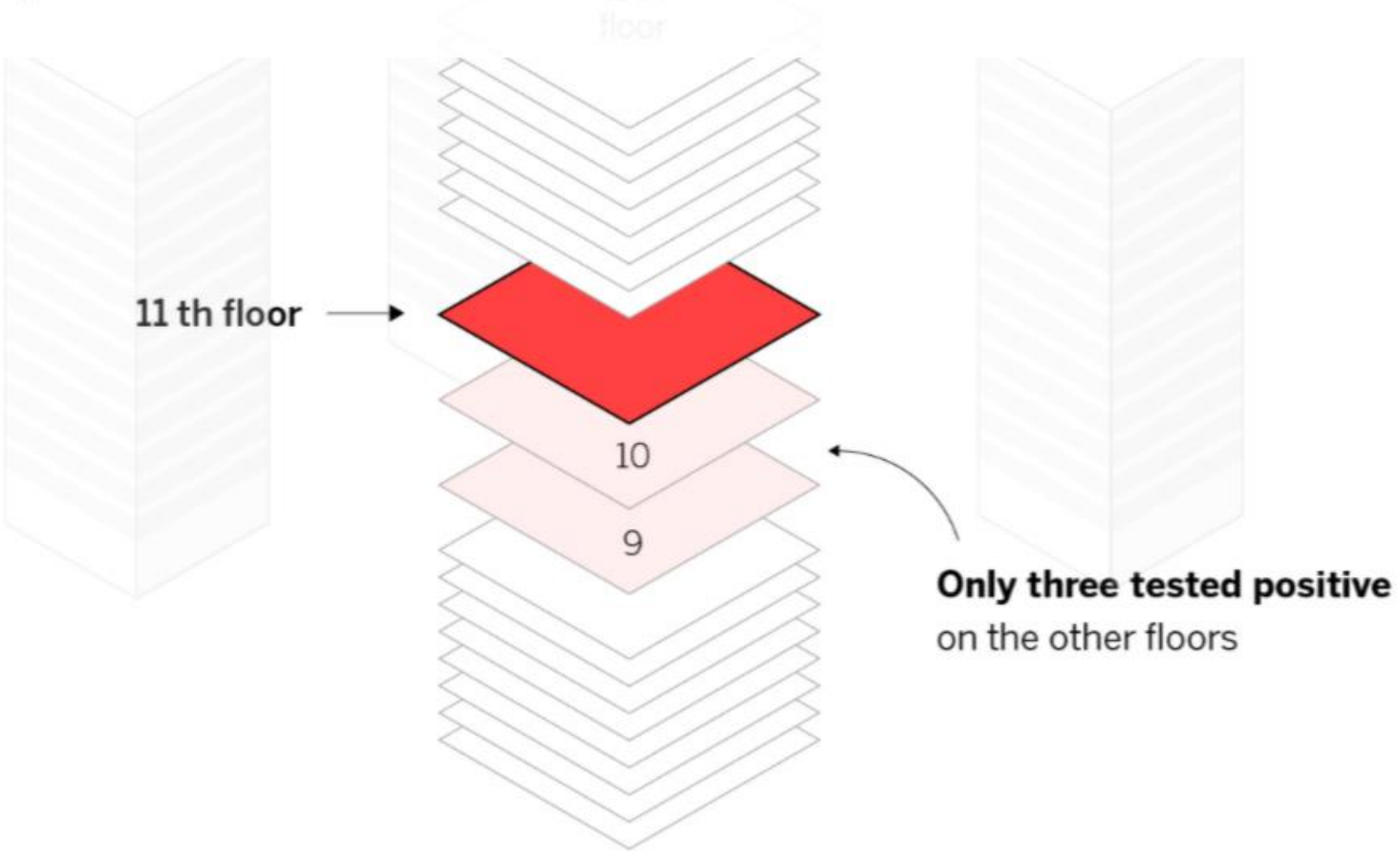
# S Korea – call centre



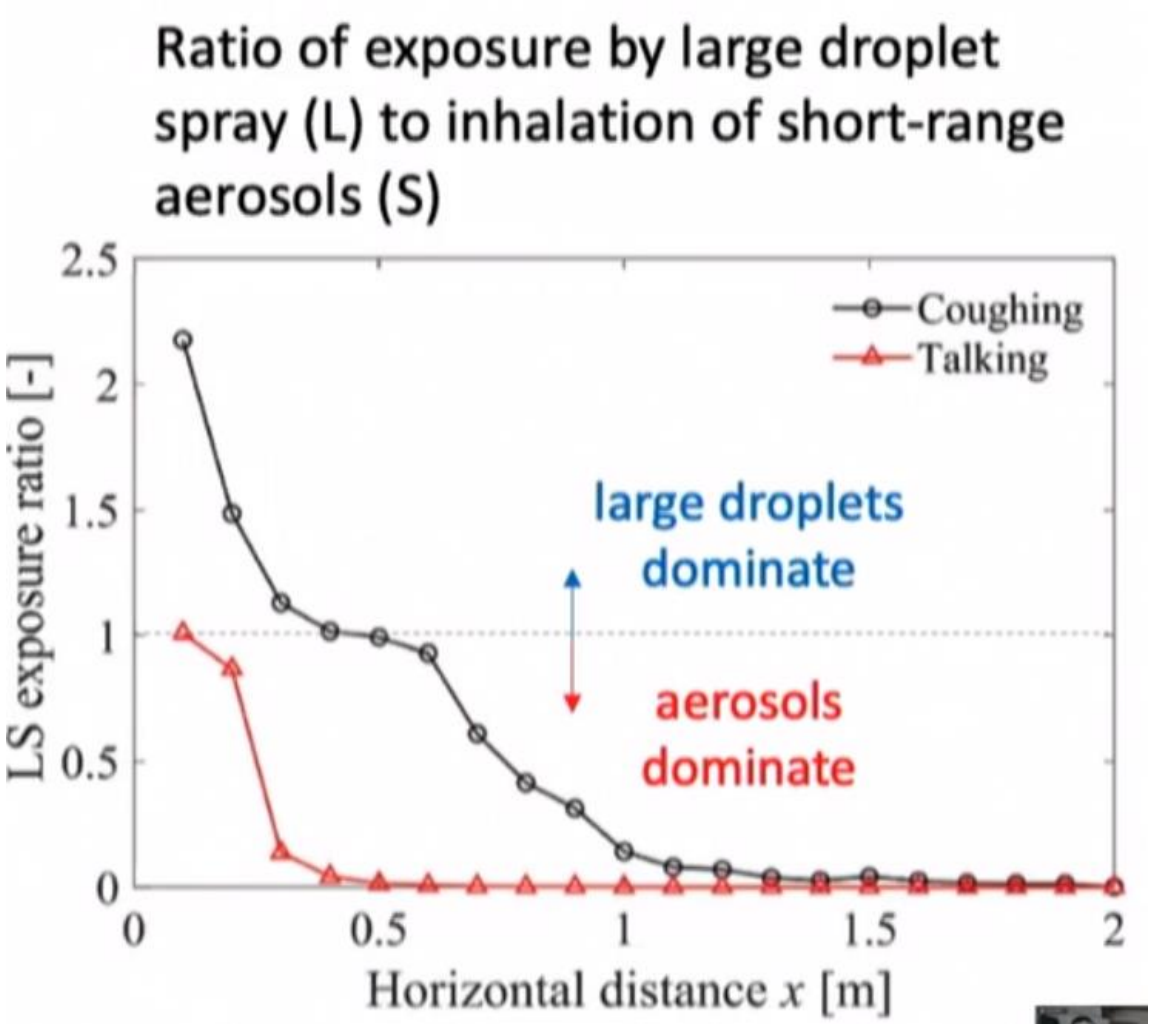

Out of these 137 employees, 79 (57.6%) tested positive. **The permanent contact within the same space over a prolonged period of time** played a crucial role.

# S Korea – call centre

In the rest of the building, **only three people tested positive** out of 927 who underwent checks (0.3%) despite the fact they shared lobbies, elevators and other communal areas.



# Transmission: Droplets vs Aerosols




Primary transmission mechanism of COVID-19 is through aerosol not large droplets

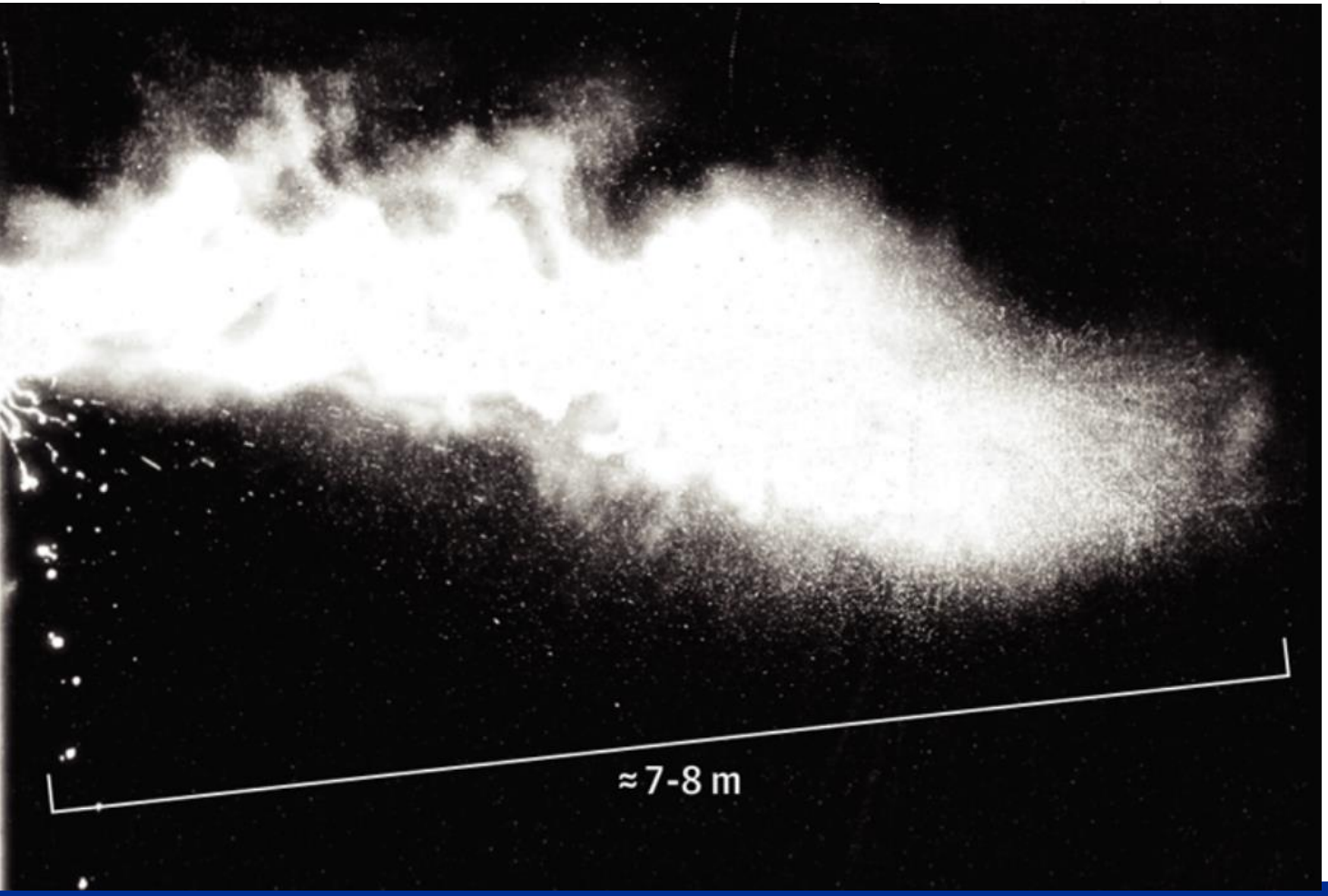
Being transmitted through aerosol does not mean that it is an “airborne” disease

Airborne means it has a high R0 number and needs very little virus to infect

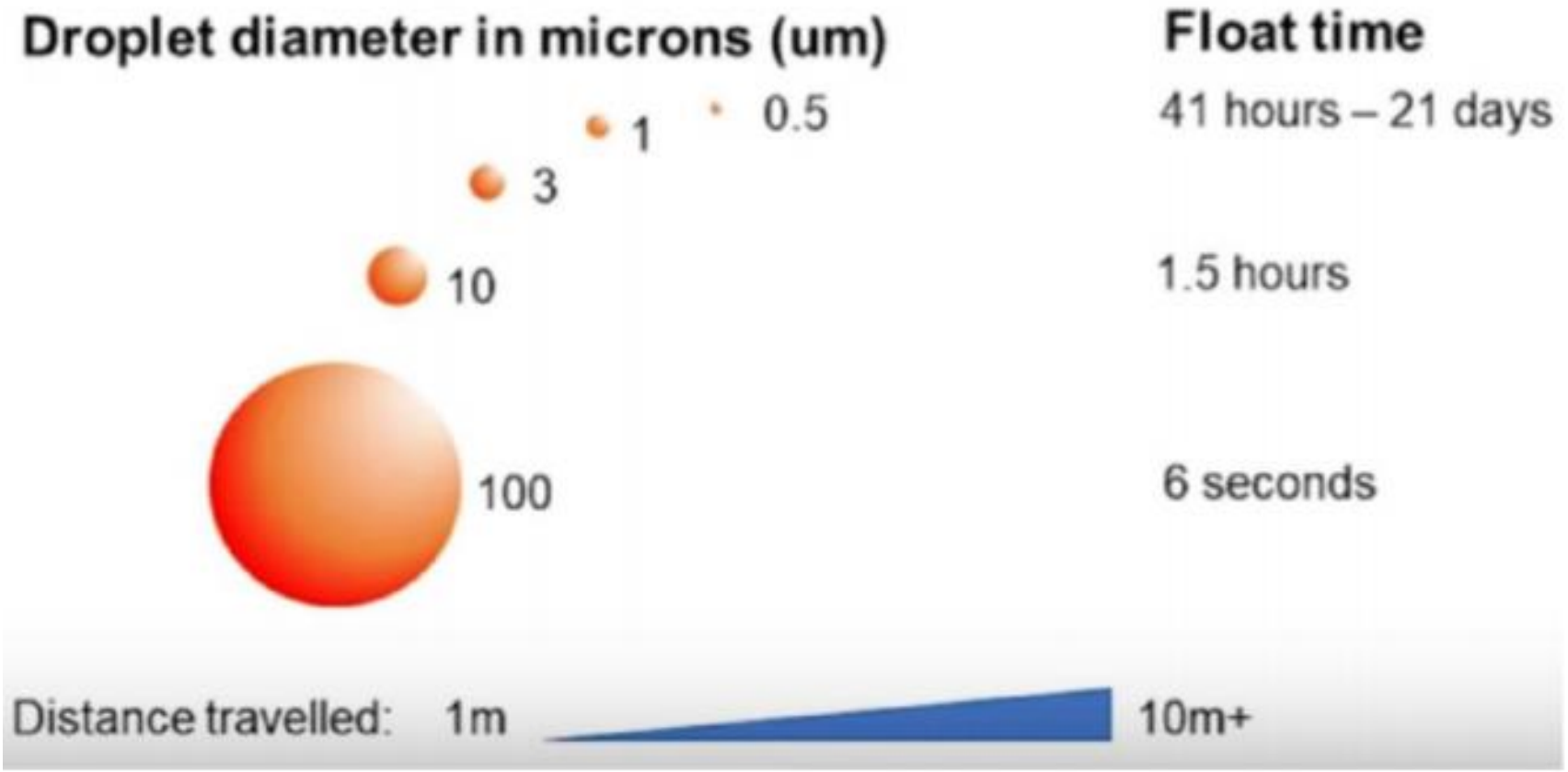
Measles has R0 of 15
COVID-19 has R0 of 5.7, flu has R0 of 1.3

COVID-19 does not spread between floors because its (R0) number is not high enough

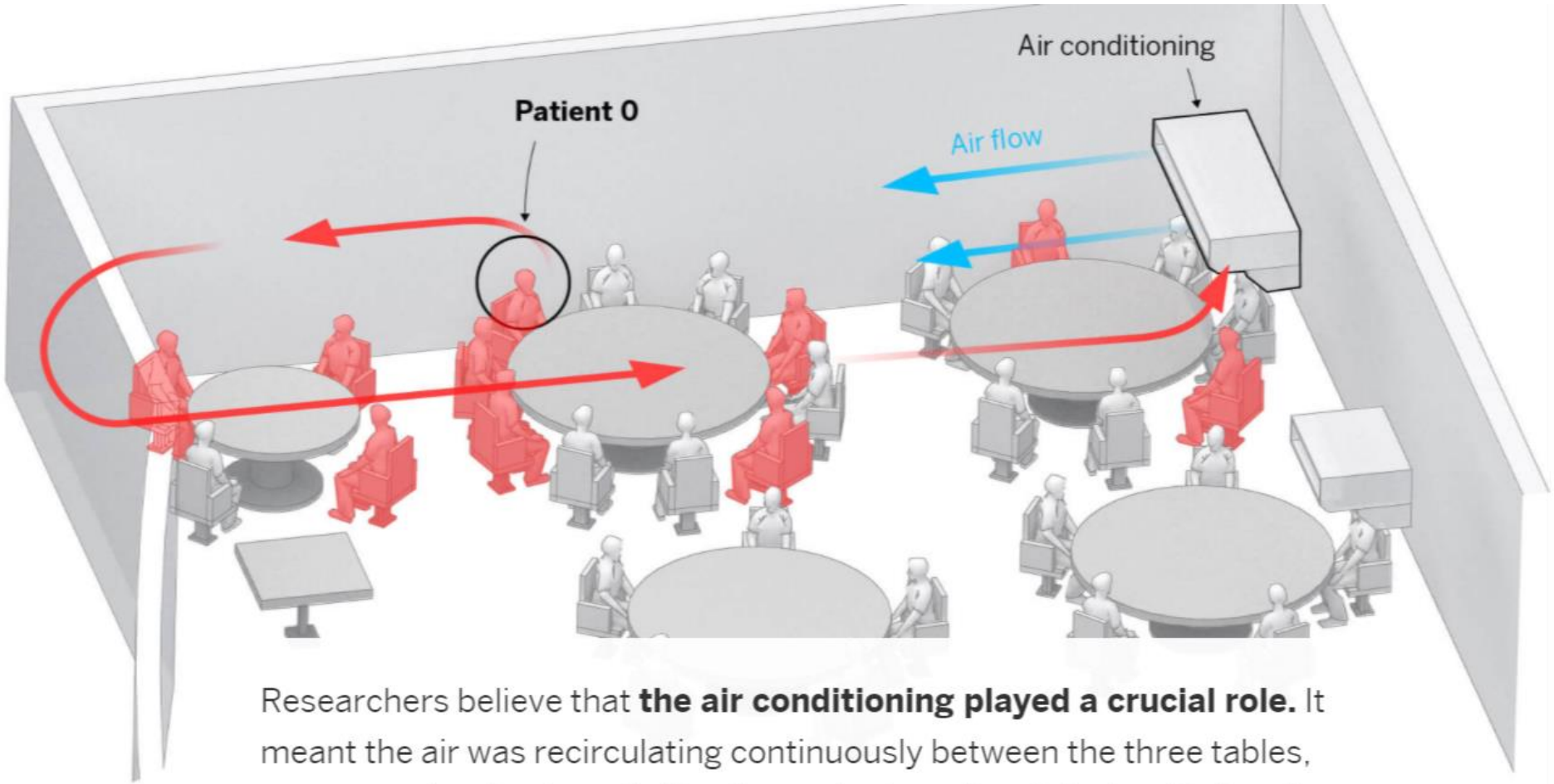
https://jamanetwork.com/journals/jama/fullarticle/2763852

# Speaking produces 100x more aerosol than droplets



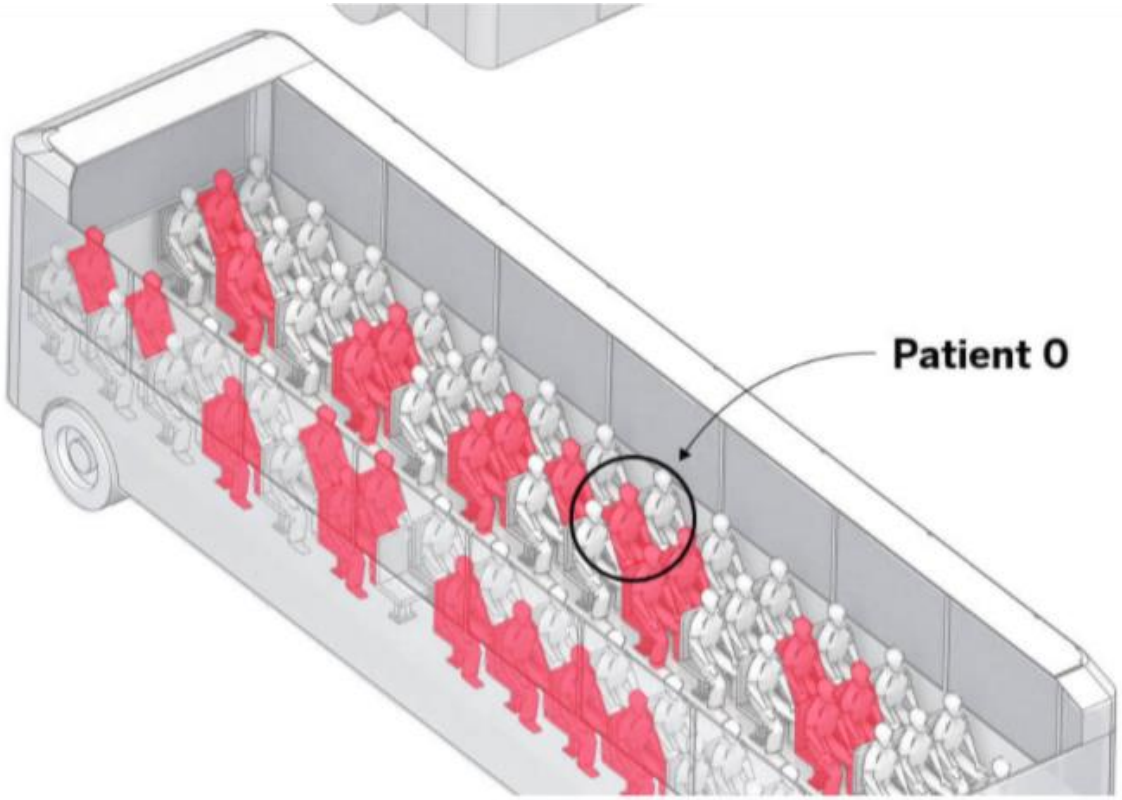
# Chinese Restaurant




Researchers believe that **the air conditioning played a crucial role.** It meant the air was recirculating continuously between the three tables, concentrating the tiny, **virally charged micro-droplets** that Patient 0 was expelling into the atmosphere among these customers.

# Chinese – Buddhist bus

**23 infected from Covid-19** on the bus

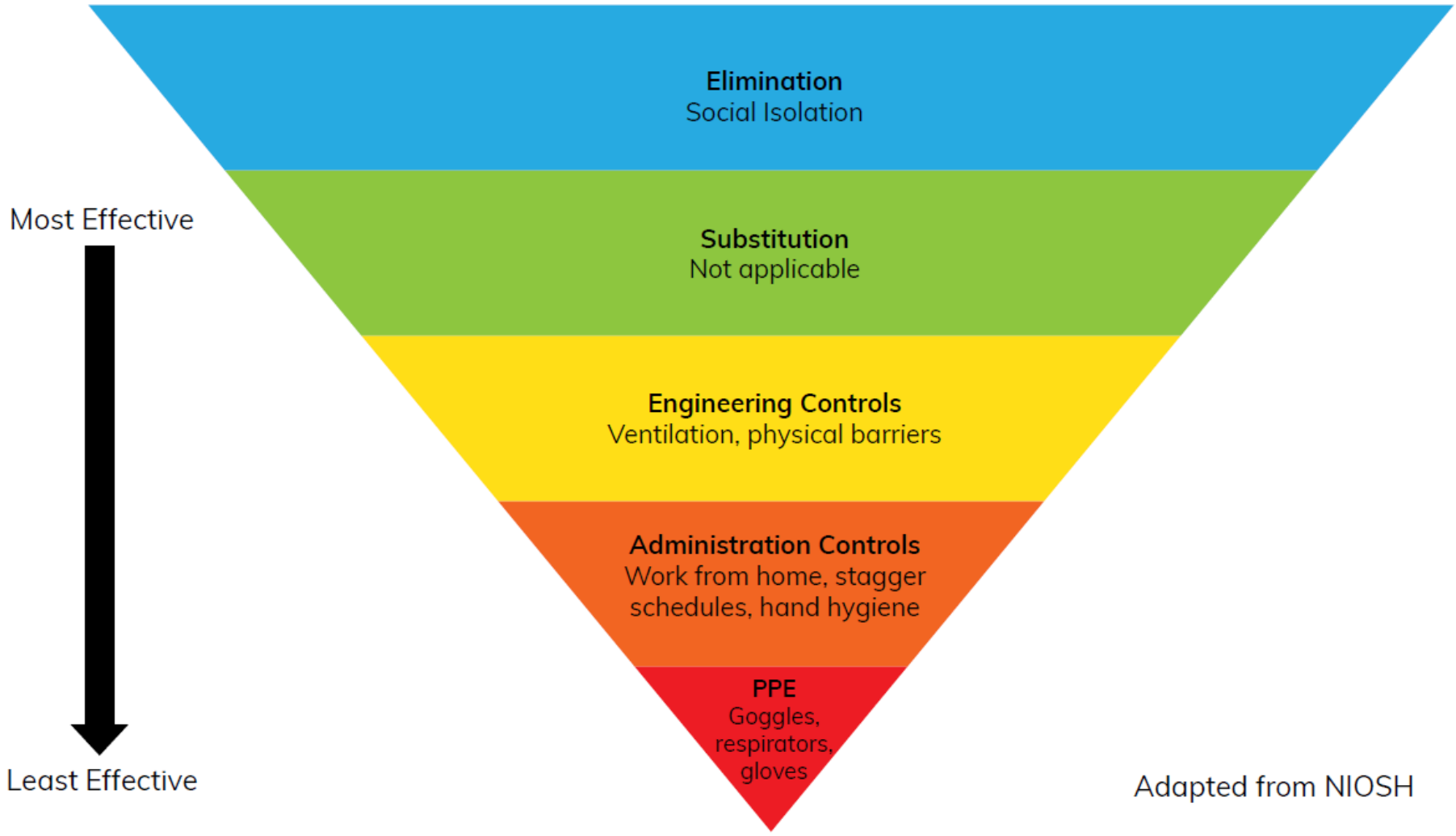



In total, **23 people got infected** on the bus. No one became ill on the other bus, despite the fact they were all mixing at the ceremony.

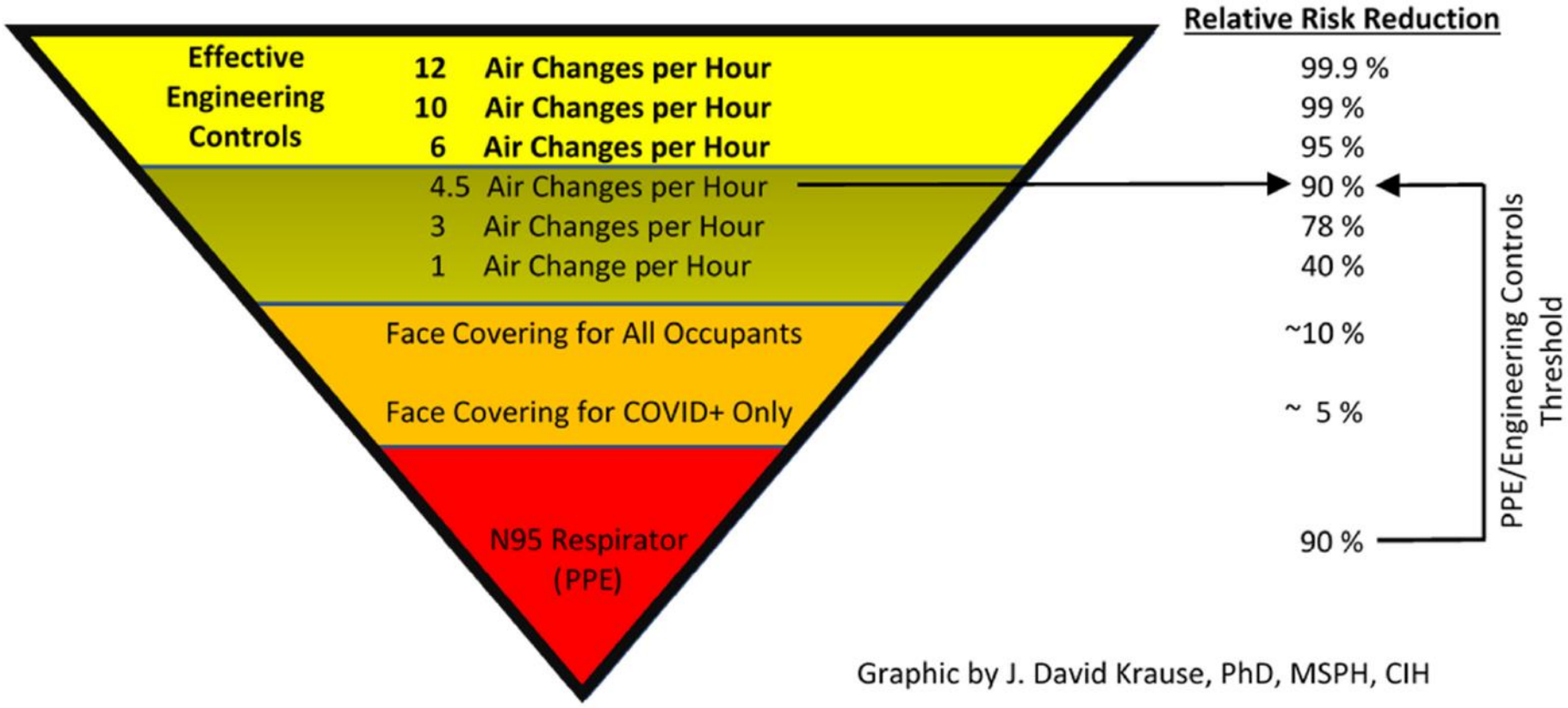
# Definition ventilation

**Ventilation (alternate definition)**
Designed supply and removal of air to and from a treated space. (EN 12792)

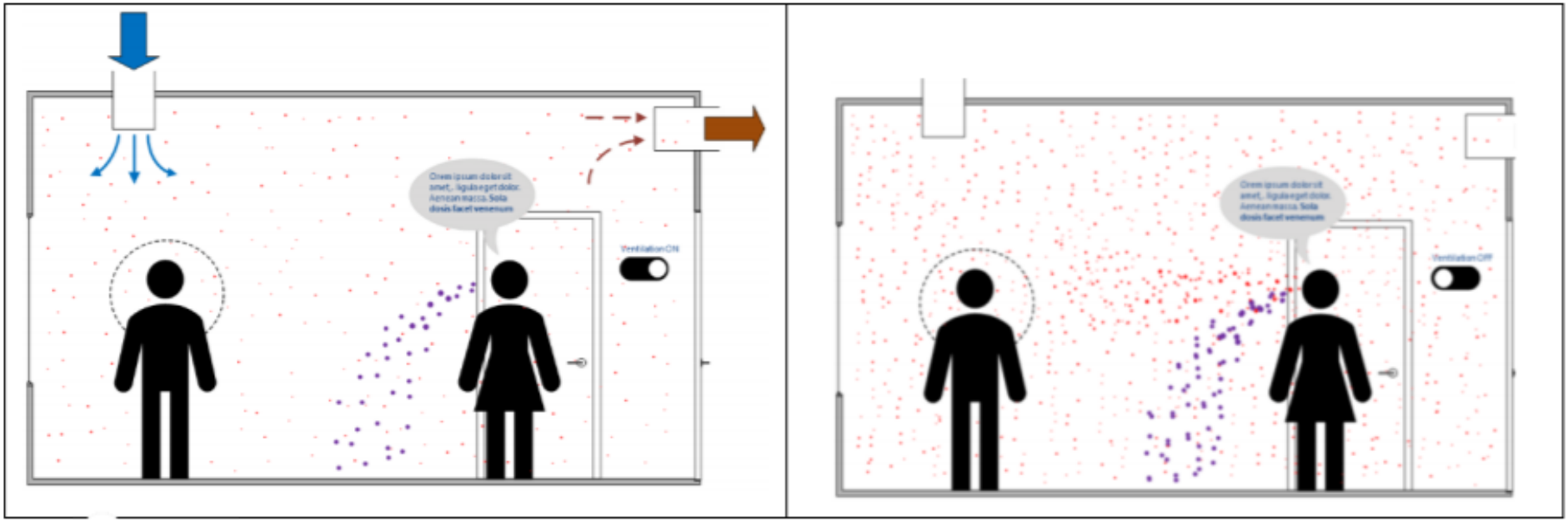
# Not all barriers are equal



# % Risk reduction



# Virus concentration & ventilation



# Ventilation STD's – South Africa

***SANS 10400-O (2011):*** Buildings either naturally ventilated (4.3.1) or artificially ventilated (4.3.2).

ARTIFICIAL

| Type of occupancy | Minimum outdoor air requirements | | Requirement |
|---|---|---|---|
| | Air changes per hour | L/s per person | |
| **Educational buildings** | | | |
| Classrooms | 2 | 7,5 | Air supply required per person with required minimum air changes per hour |
| Laboratories | 2 | 7,5 | |
| Libraries | 2 | 6,5 | |
| **Health care facilities** | | | |
| **Surgical and critical care**: | | | |
| Operating theatres and suites | 20 | – | Pressure relative to adjacent area shall be positive |
| Wound intensive care (burns) | 6 | – | Pressure relative to adjacent area shall be positive |
| Critical and intensive care, treatment and delivery rooms | 6 | – | Pressure relative to adjacent area shall be positive |
| Trauma, ER waiting rooms, radiology waiting rooms and triage | 12 | – | Pressure relative to adjacent area shall be negative |

2 ACPH – allows comfort & prevents body odour – doesn't smell stuffy
12 ACPH – prevents transmission of HBA – Influenza / COVID-19

# Current ASHRAE CO2 guidance

- Research shows ASHRAE guidance of 700 ppm above ambient does not prevent measles, influenza, or rhinovirus in a school or office
- SANS 10400 Part O, EN 16798 and research all align

| Cat | Indoor Air Quality | $CO_2$ above outdoor air (ppm) | Fresh Air Face (L/s/person) |
|---|---|---|---|
| IDA1 | High | <400 | >15 |
| IDA2 | Medium | 400-600 | 10-15 |
| IDA3 | Moderate | 600-1000 | 6-10 |
| IDA4 | Low | >1000 | <6 |

Indoor Air Quality and $CO_2$ levels and Fresh Air Face delivery (EN 16798)

Require 15L/s per person - approximately 12 ACPH

# CO2 – proxy for SARS CoV2 concentrations

- Recommended COVID-19 guidance for CO2 = <400 above ambient / 800ppm
- Practically continuous CO2 dataloggers should be set to alarm at 800ppm

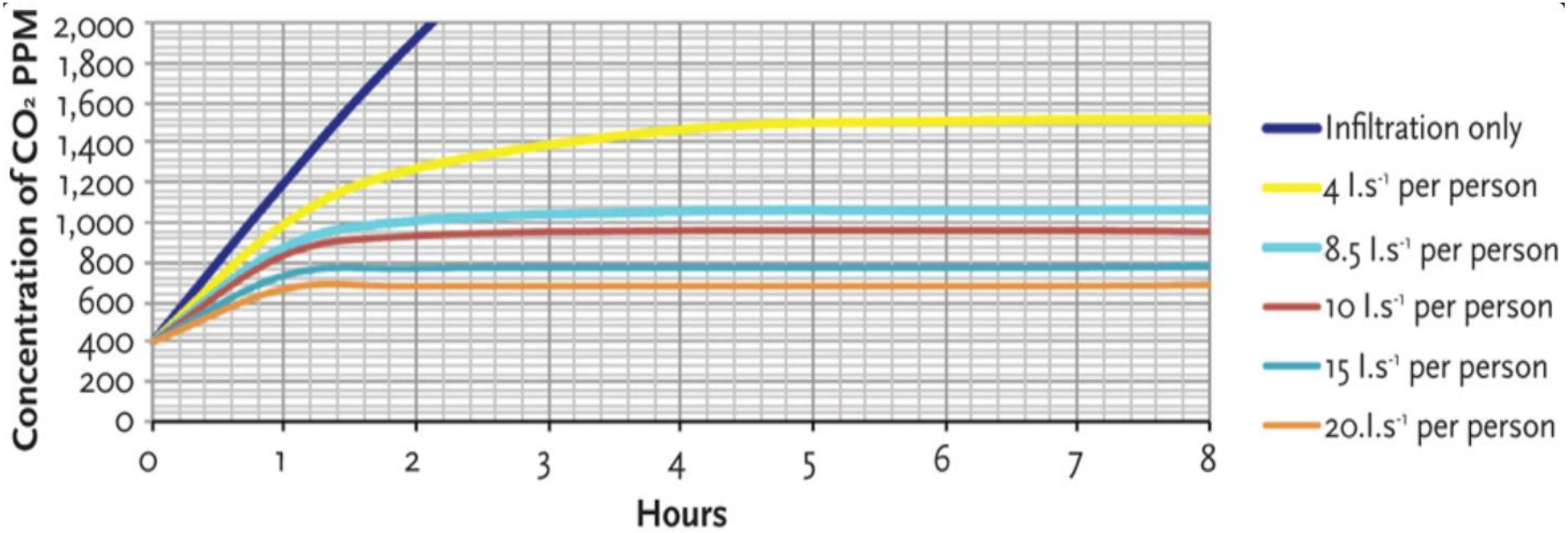
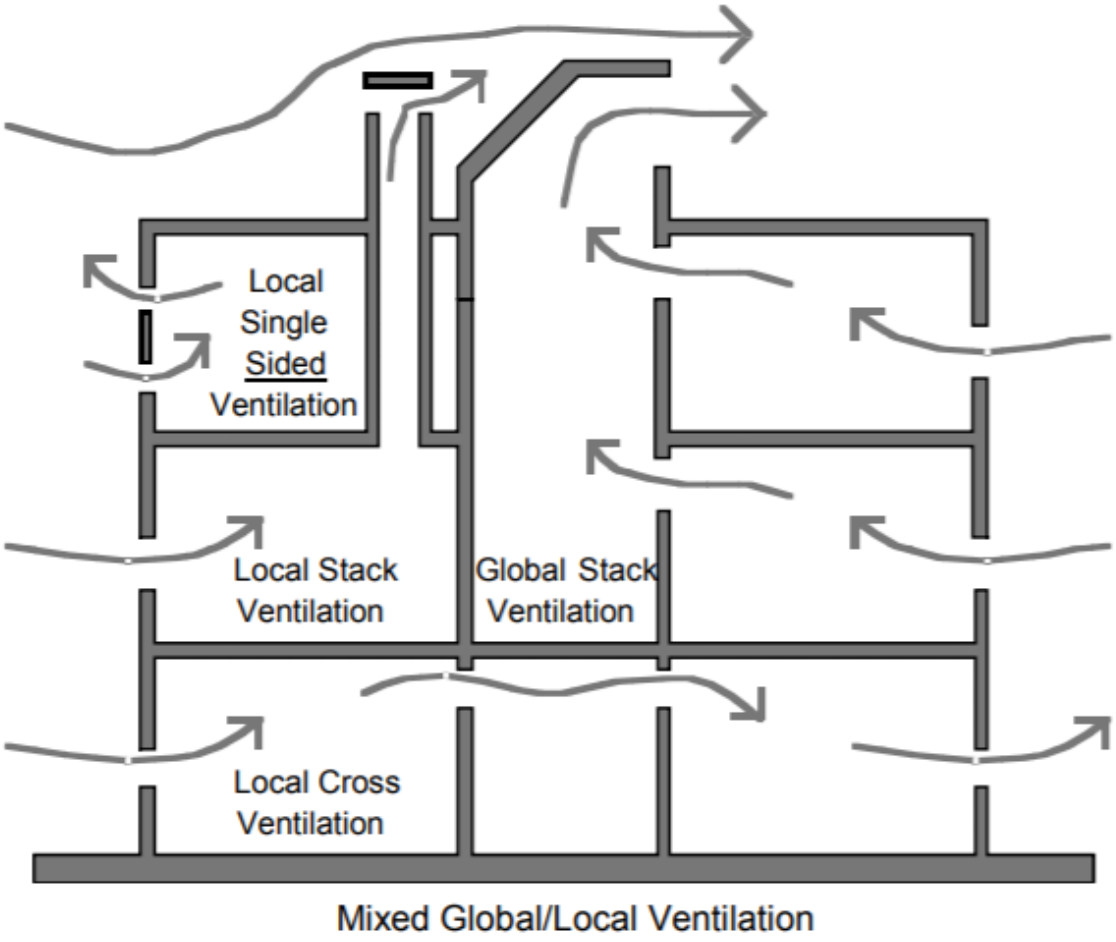



Figure 2: Average room $CO_2$ levels at various fresh air supply rates for example office with 20 people

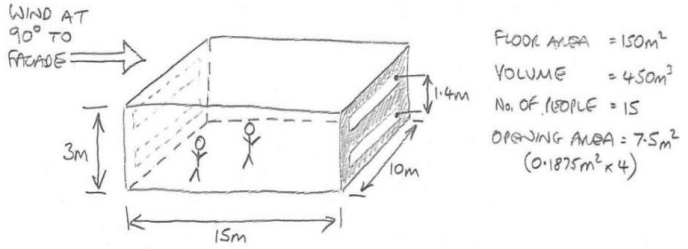
# Natural ventilation




Mixed Global/Local Ventilation

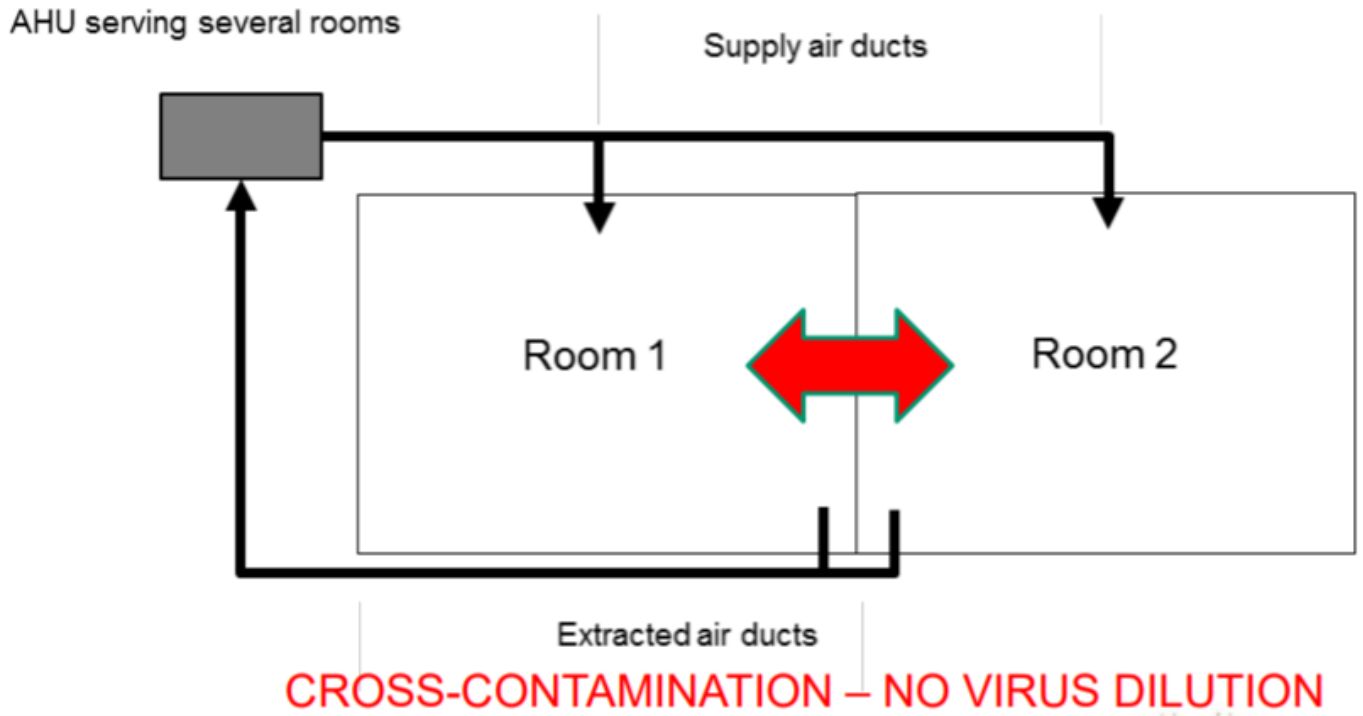
Three fundamental approaches to natural ventilation:

- Wind-driven cross ventilation - preferred
- Buoyancy-driven stack ventilation, and
- Single-sided ventilation

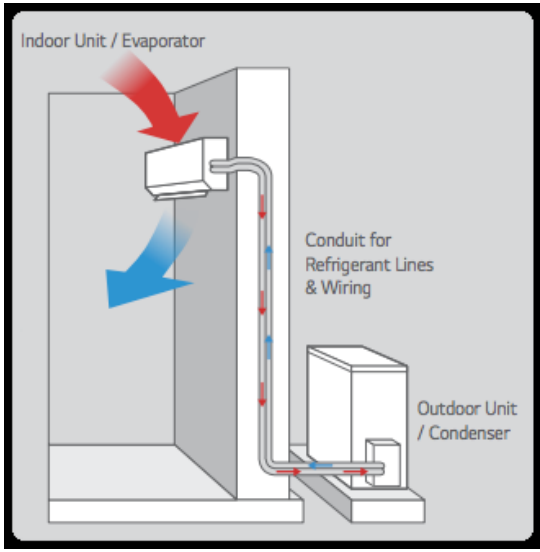



Example building zone with cross ventilation and 5% ventilation openings

# Air conditioning system – no ventilation

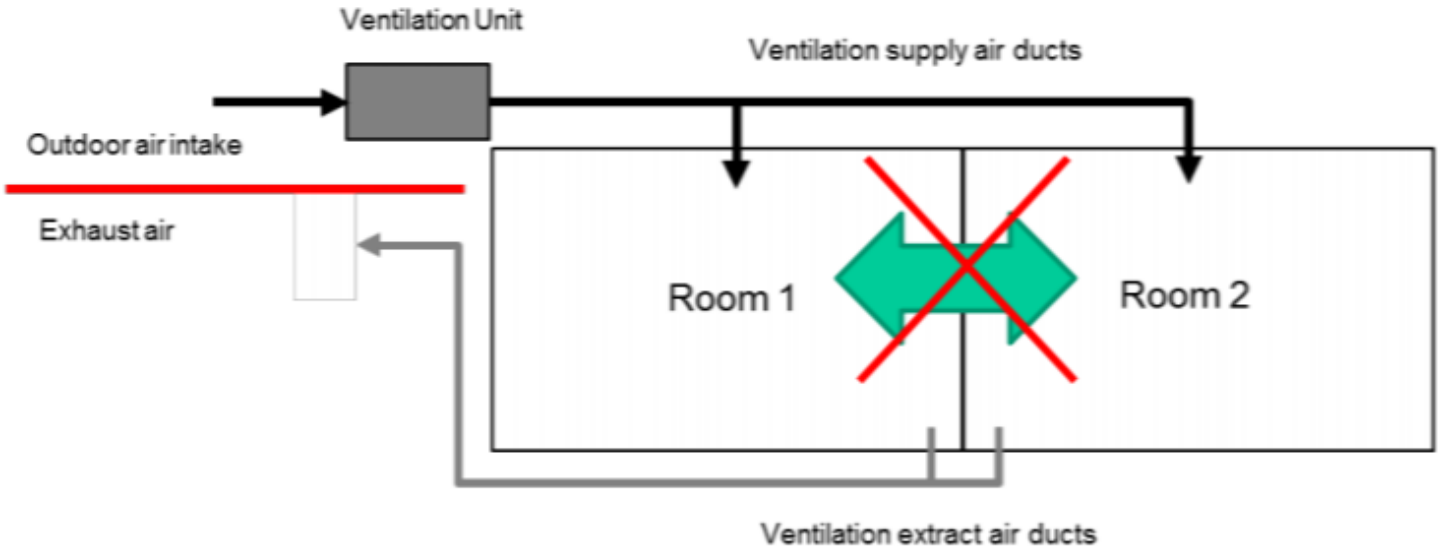


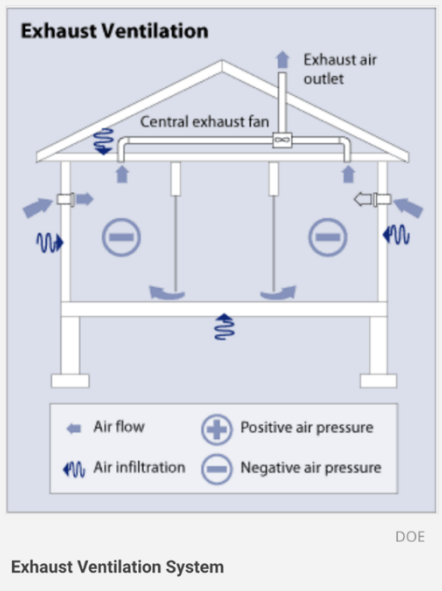

**Mid-wall split unit –** with no fresh make up air capability does not provide ventilation




- No artificial ventilation system – only ventilation possible is through opening windows / doors

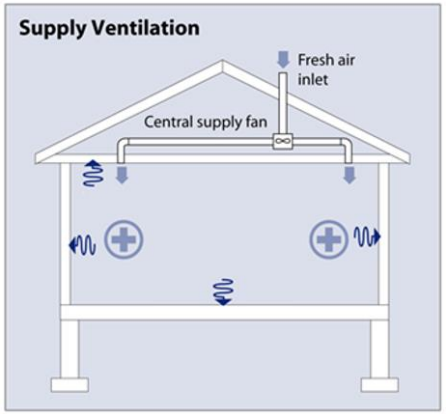
# Split unit air conditioner + Mechanical ventilation



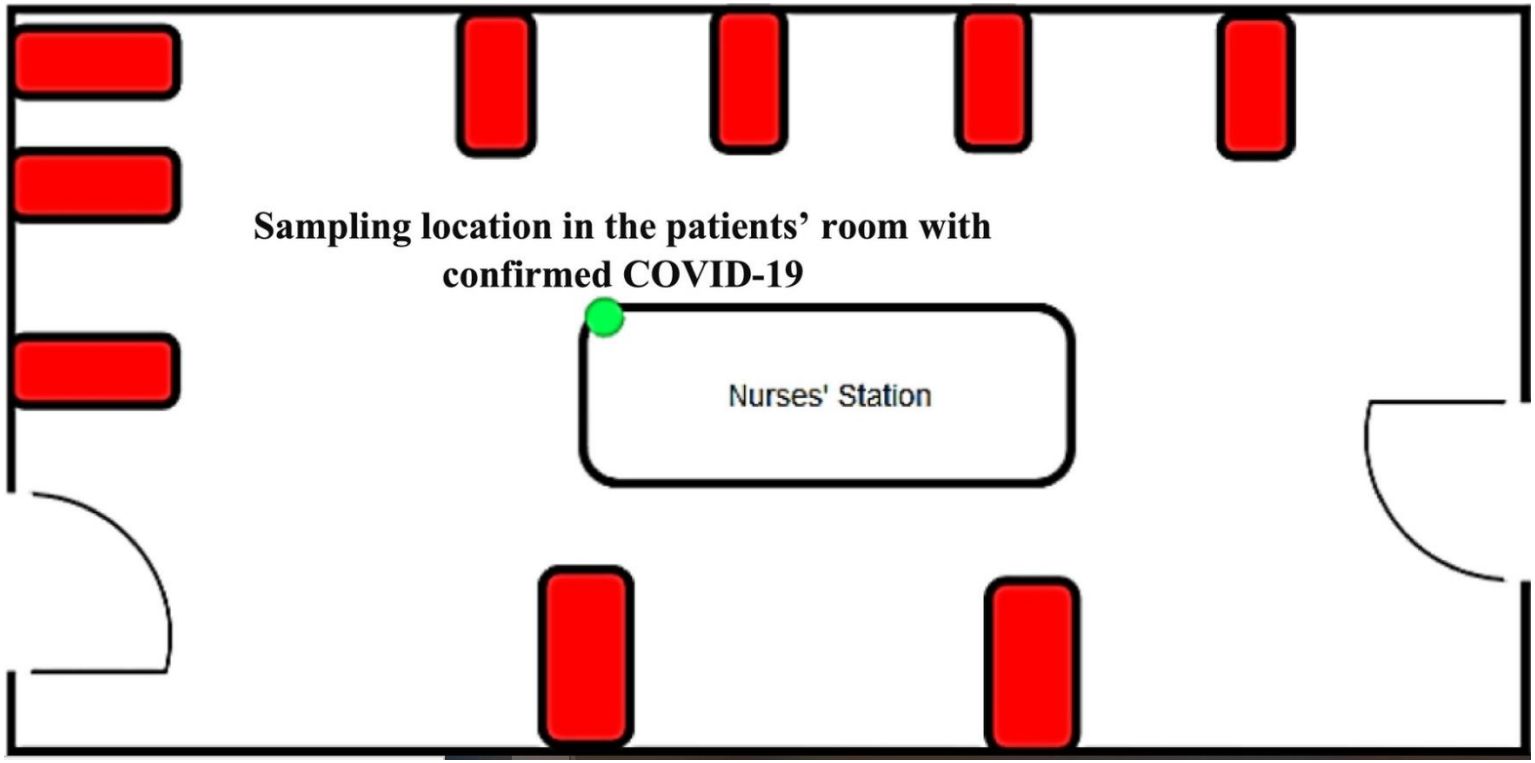

Exhaust Ventilation System

NO CROSS-CONTAMINATION AND VIRUS DILUTION




- Supply outdoor air is provided to each room, is extracted and expelled outdoor,
- Virus concentration reduced through dilution with provided outdoor air.

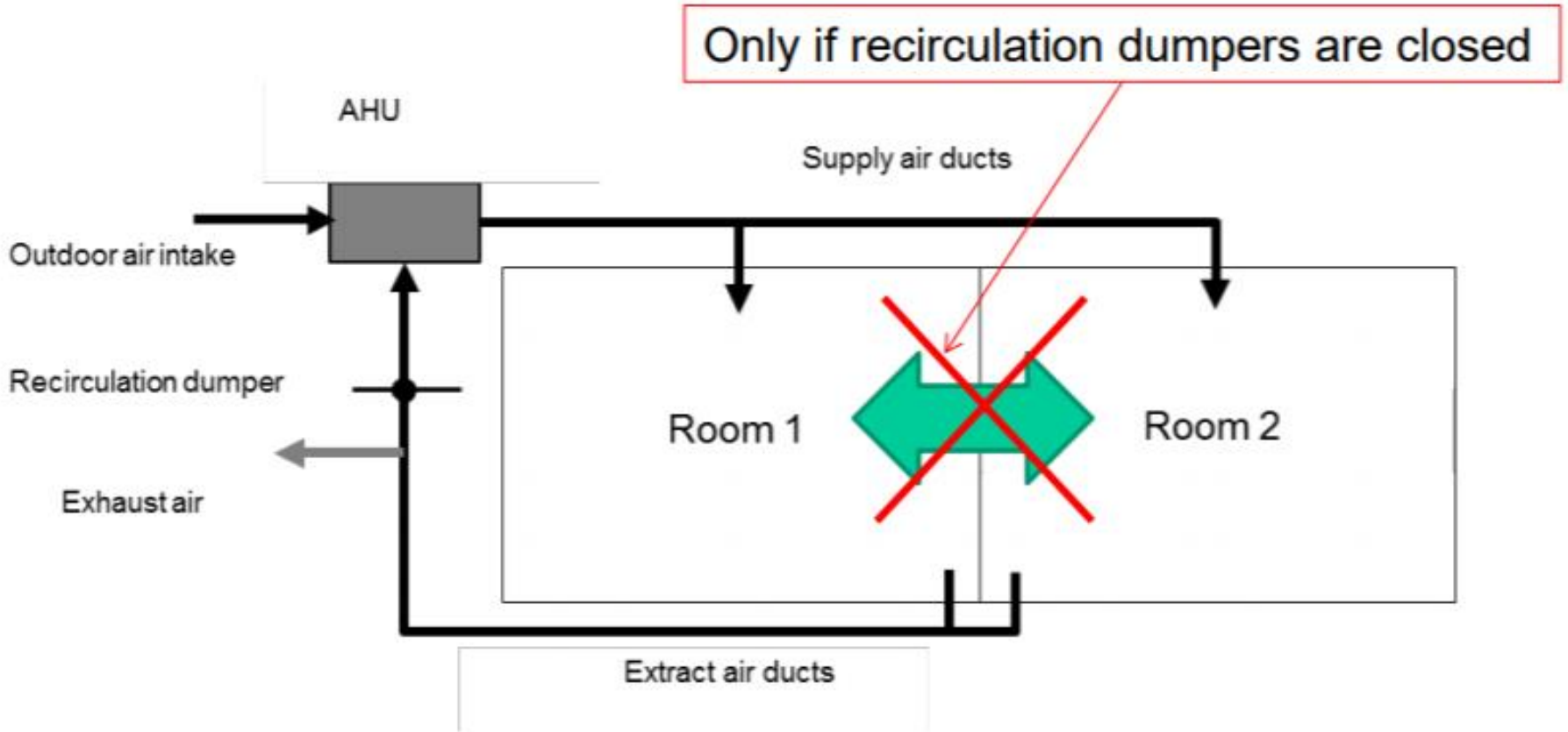
# Hospital Positive COVID-19 patients




Hospital evidence: no infection risk at 2 m distance, with ventilation rates at 36 L/s per person

https://doi.org/10.1016/j.scitotenv.2020.138401 –

# All-Air HVAC System




POSSIBLE CROSS-CONTAMINATION IF RECIRCULATION IS ALLOWED BUT VIRUS DILUTION

# Non-healthcare ventilation - REHVA

## SUGGESTED INTERVENTIONS

1. INCREASE AIR FLOW
2. FORCE DAMPERS TO INTRODUCE OUTDOOR AIR ONLY
3. DEACTIVATION OR BY-PASS OF THE HEAT RECOVERY UNIT
4. KEEP THE RELATIVE HUMIDITY SETPOINT ABOVE 40%
5. VENTILATION CONTINUOS OPERATION (H24)

## LEGENDA

- INTERVENTIONS THAT REQUIRE ACTIONS ON CONTROL SYSTEMS
- INTERVENTIONS THAT REQUIRE MAINTENANCE STAFF ACTIONS
- INTERVENTIONS THAT REQUIRE ORE MAY REQUIRE PLANT MODIFICATIONS

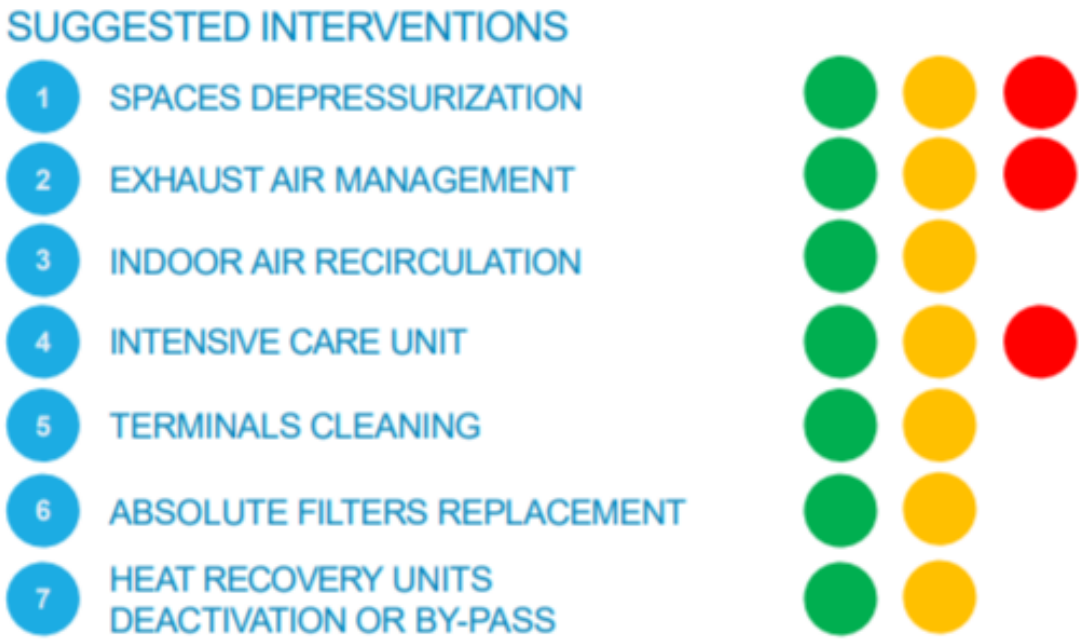
# Assessment of all buildings

## Developing “Limitations of use”

**Meeting Rooms**

| Meeting Rooms | Natural | Windows | Doors | Cooling system | Mechanical Ventilation | Dampers open | SANS 10400 Part O (Compliant Y/N) | Outdoor air | Floor area M2 | No of People (for Social Distance) | Limitations for use |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Central training rooms** | | | | | | | | | | | |
| 1 | Yes | 3 | 2 | HVAC | Yes | Yes | Yes | Yes | 100 | 23 | 23 people + Monitor CO2 |
| 2 | Yes | 1 | 1 | HVAC | Yes | Yes | Yes | Yes | 20 | 7 | 7 people + Monitor CO2 |
| 3 | No | 0 | 1 | HVAC | Yes | Yes | Yes | Yes | 10 | 3 | 3 people + Monitor CO2 |
| 4 | Yes | 4 | 1 | HVAC | Yes | Yes | Yes | Yes | 40 | 14 | 14 people + Monitor CO2 |
| 5 | Yes | 4 | 1 | HVAC | Yes | Yes | Yes | Yes | 40 | 14 | 14 people + Monitor CO2 |
| 6 | No | 0 | 2 | HVAC | Yes | Yes | Yes | Yes | 350 | 67 | 67 people + Monitor CO2 |
| **Ops training rooms** | | | | | | | | | | | |
| 7 | No | 0 | 1 | Split | No | N/A | No | No | 18 | 6 | 6 people + door open for duration + CO2 |
| 8 | Yes | 1 | 2 | Split | No | N/A | No | Yes | 18 | 6 | 6 people + windows/door open for duration + CO2 |
| 9 | Yes | 2 | 1 | Split | No | N/A | Yes | Yes | 20 | 7 | 7 people + windows/door open for duration + CO2 |
| 10 | Yes | 2 | 1 | Split | No | N/A | Yes | Yes | 20 | 7 | 7 people + windows/door open for duration + CO2 |
| 11 | Yes | 2 | 1 | Split | No | N/A | Yes | Yes | 36 | 12 | 12 people + windows/door open for duration + CO2 |
| 12 | Yes | 2 | 1 | Split | No | N/A | Yes | Yes | 26 | 9 | 9 people + windows/door open for duration + CO2 |
| 13 | Yes | 3 | 1 | Split | No | N/A | Yes | Yes | 18 | 6 | 6 people + windows/door open for duration + CO2 |
| 14 | Yes | 6 | 1 | Split | No | N/A | Yes | Yes | 28 | 9 | 9 people + windows/door open for duration + CO2 |
| 15 | Yes | 2 | 1 | Split | No | N/A | Yes | Yes | 38 | 12 | 12 people + windows/door open for duration + CO2 |
| 16 | Yes | 2 | 1 | Split | No | N/A | Yes | Yes | 21 | 7 | 7 people + windows/door open for duration + CO2 |

# Healthcare ventilation interventions




**E.g. Additional controls may include:**

- UVC 222nm - called ‘germicidal’ radiation because of its ability to kill bacteria and inactivate viruses
- HEPA filters

# HEPA vs MERV

- Minimum Efficiency Reporting Value (MERV). Scale of 1-20 rates efficiency of trapping small particles
- MERV 16 filter captures >95% of particles in the entire size range tested (0.3-10.0 microns), a HEPA filter captures 99.97% of particles with a size of 0.3 microns
- Balance: Higher ventilation rates vs HEPA / MERV filters to achieve CO2 <400ppm above ambient
- MERV filters ratings in 13-15 range can be used

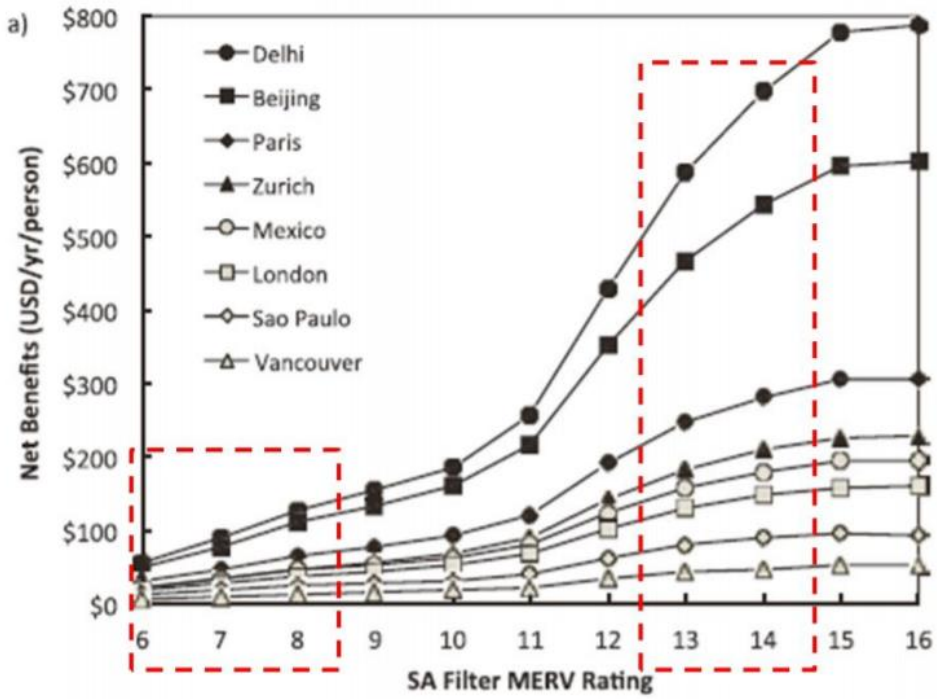
Changing filters not simple:

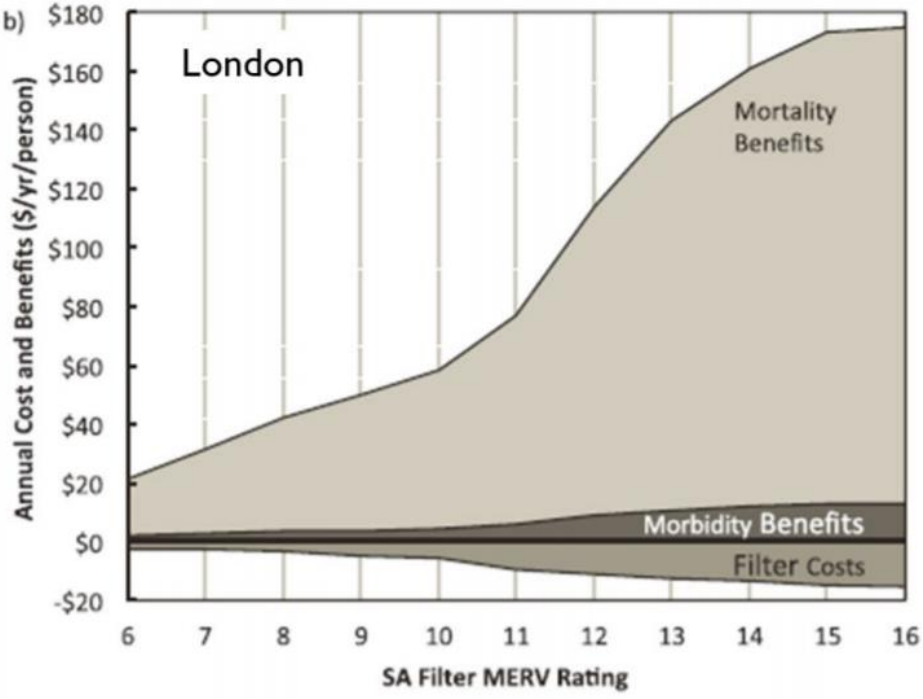
- Increased pressure load
- > Air bypassing filters
- > maintenance
- > filter changes

# Conclusion ventilation beyond COVID

- Understanding of the role of ventilation in reducing influenza infections not new – 2011 research
- Increasing the ventilation rate from 8L/s per person to 15L/s per person, US economy would save US$37.5bn dollars per year through reduced absenteeism and employee performance
- World pre and post COVID-19 different, including a permanent priority change in the control of HBA – including influenza
- Recommendation to achieve ventilation rates of 15L/s per person of outdoors air will stand even once the COVID-19 pandemic has passed

# Conclusion: consider pollution & HBA




**No one size fits all:**

- **Higher atmospheric pollution > reliance on filters ($CO_2$ becomes < useful)**
- **Lower atmospheric pollution > reliance on outdoor air**

# Thank you