



## SARS-CoV-2 transmission

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Building engineer, indoor environment, indoor air flow, ventilation, thermal comfort

# Was this necessary?



# According to WHO not...

At least at the start of the pandemic



World Health Organization (WHO) ✓

@WHO

FACT: #COVID19 is NOT airborne.

The #coronavirus is mainly transmitted through droplets generated when an infected person coughs, sneezes or speaks.

To protect yourself:

- keep 1m distance from others
- disinfect surfaces frequently
- wash/rub your 🙌
- avoid touching your 👁️ 🧻 👄

[Tweet vertalen](#)

## 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.**

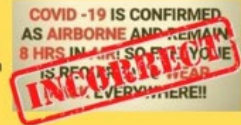
You can be infected by breathing in the virus if you are within 1 metre of a person who has COVID-19, or by touching a contaminated surface and then touching your eyes, nose or mouth before washing your hands.

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.



World Health Organization

March 28 2020



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

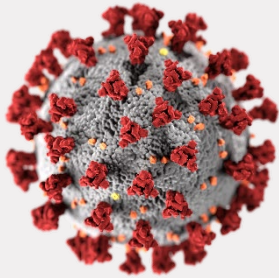
#Coronavirus #COVID19

PAHO/WHO en 6 anderen

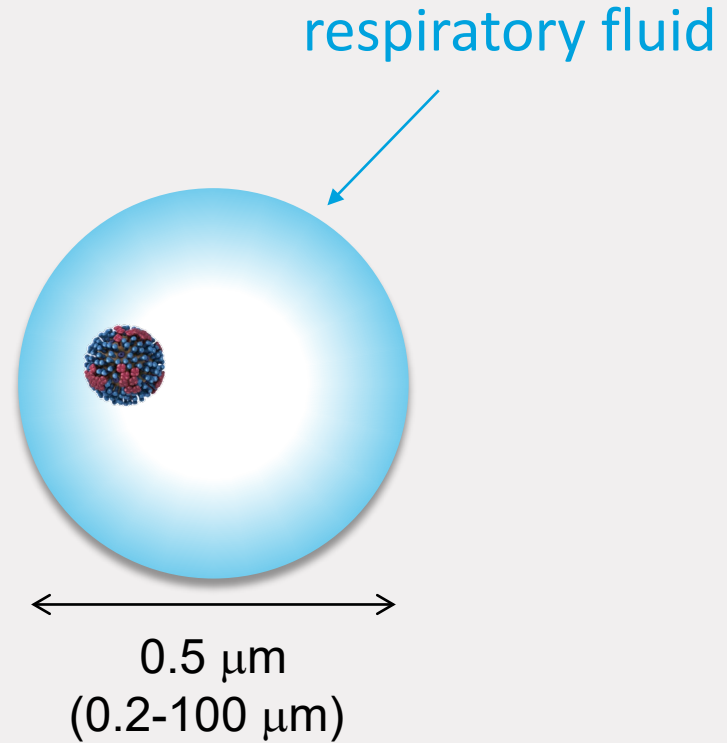
7:44 p.m. · 28 mrt. 2020 · Twitter Web App



# The point of attention

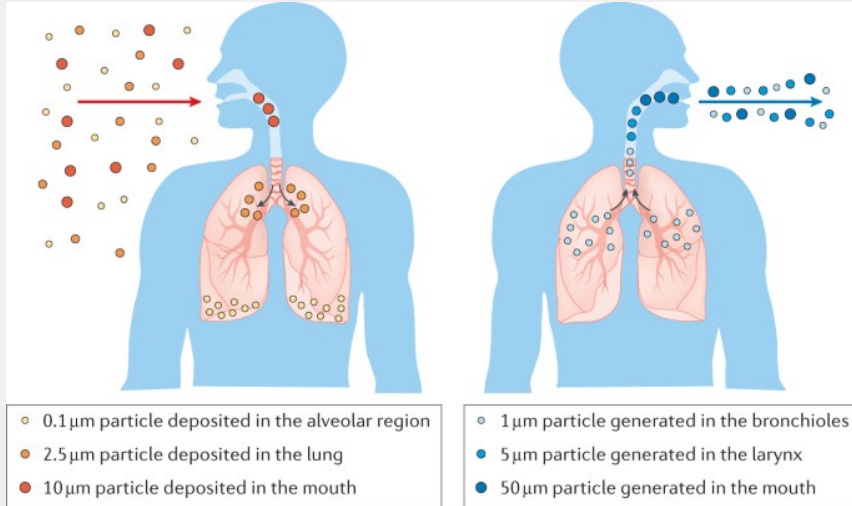


SARS-CoV-2  
0.12  $\mu\text{m}$



Inspired by presentation from Linsey C. Marr -  
Transmission of Viruses in Droplets and Aerosols  
- March 26<sup>th</sup> 2020

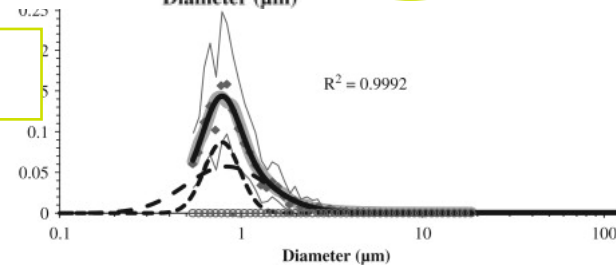
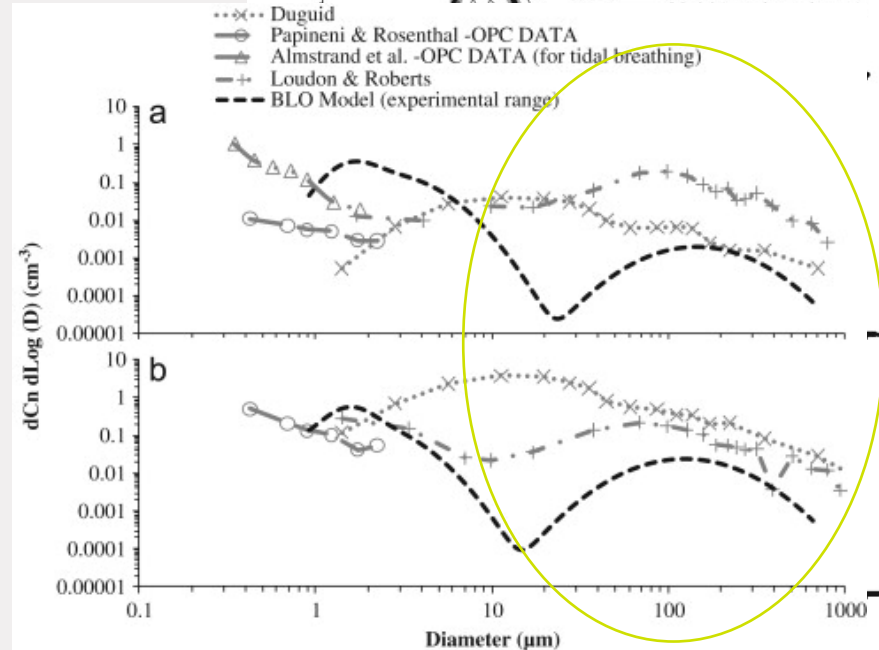
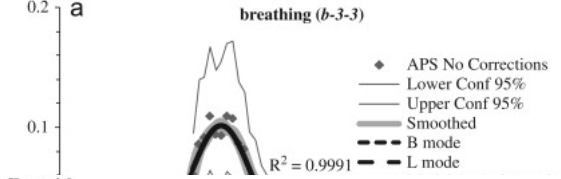
# Human source



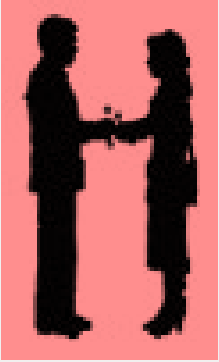
Morawska, L., Buonanno, G. 2021. The physics of particle formation and deposition during breathing. Nature Reviews Physics volume 3, pages300–301

Inspired by presentation from Linsey C. Marr - Transmission of Viruses in Droplets and Aerosols - March 26<sup>th</sup> 2020

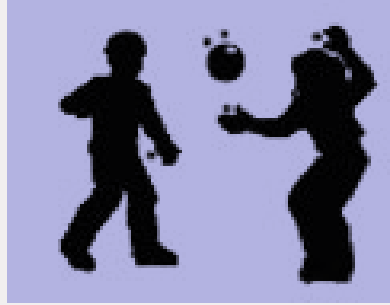
Measured by droplet deposition analysis over the range 20-2000 μm  
 sizer over the range 0.3-20 μm



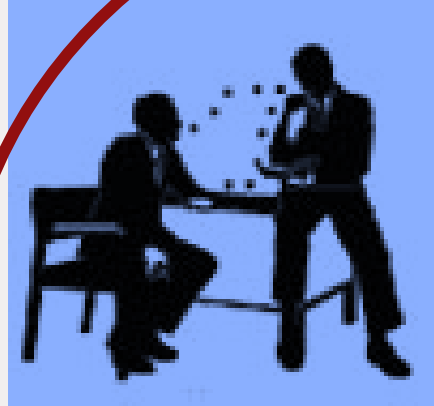
# Transmission modes



direct contact

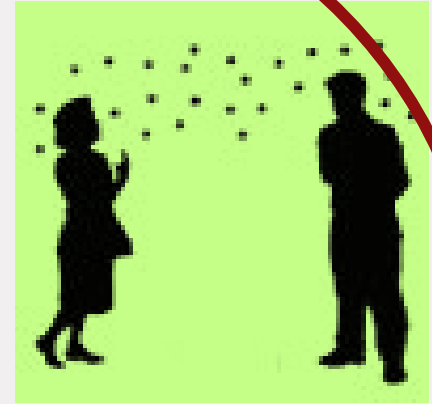


indirect contact



large droplets

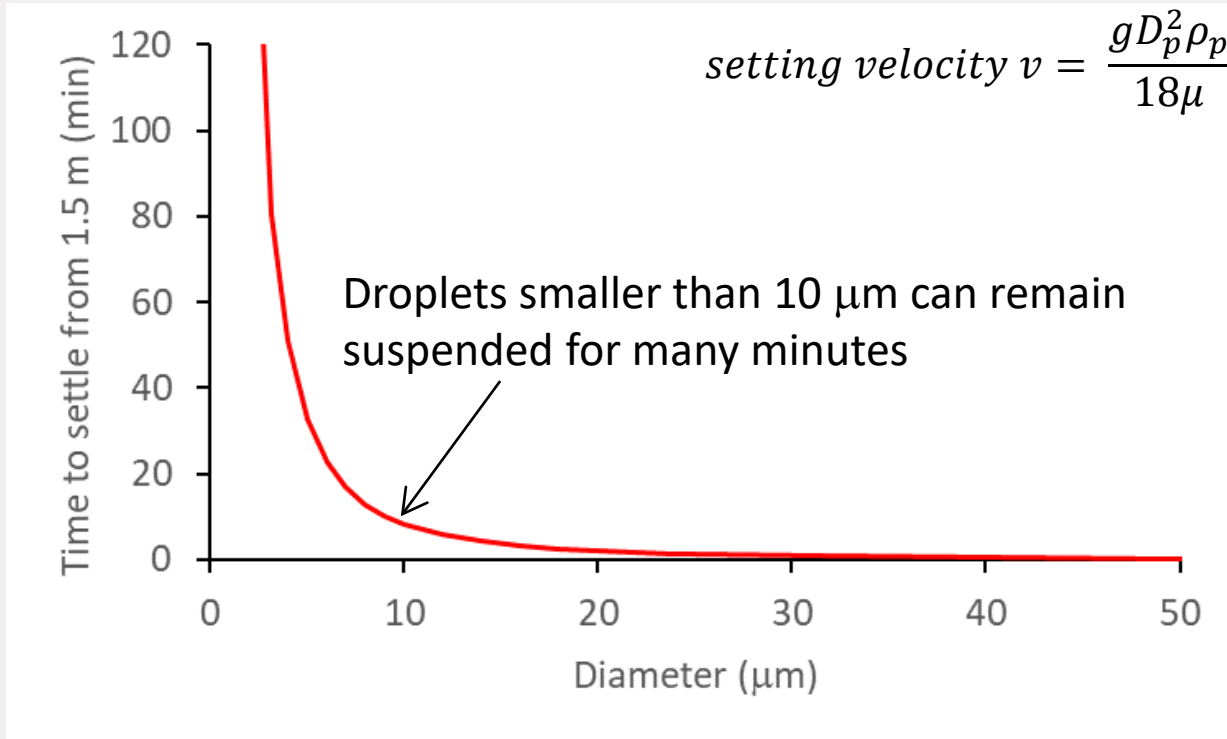
Defined as  $>5 \mu\text{m}$  and happening at close-range only ( $<2 \text{ m}$ )



aerosols

Defined as  $<5 \mu\text{m}$  and happening mainly at long-distance ( $>2 \text{ m}$ )

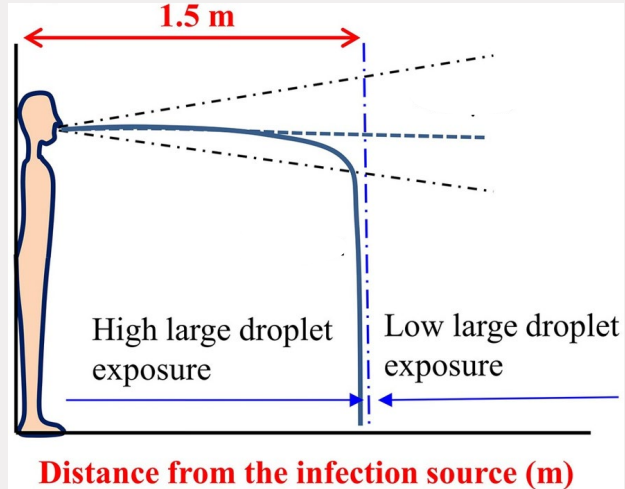
# Particle behavior



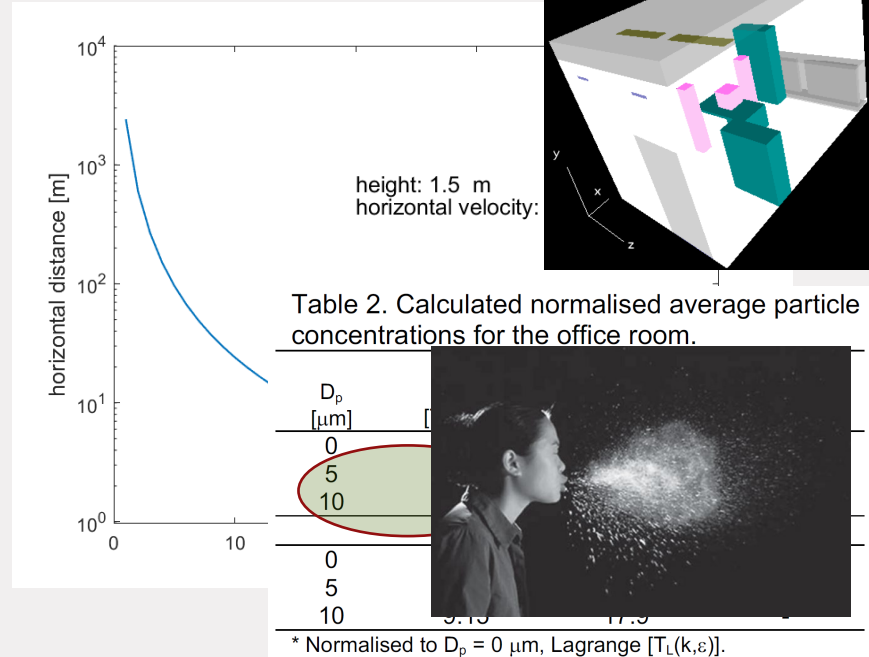
From Linsey C. Marr -Transmission of Viruses in Droplets and Aerosols – March 26<sup>th</sup> 2020

# Particle behavior

## 'large' droplets



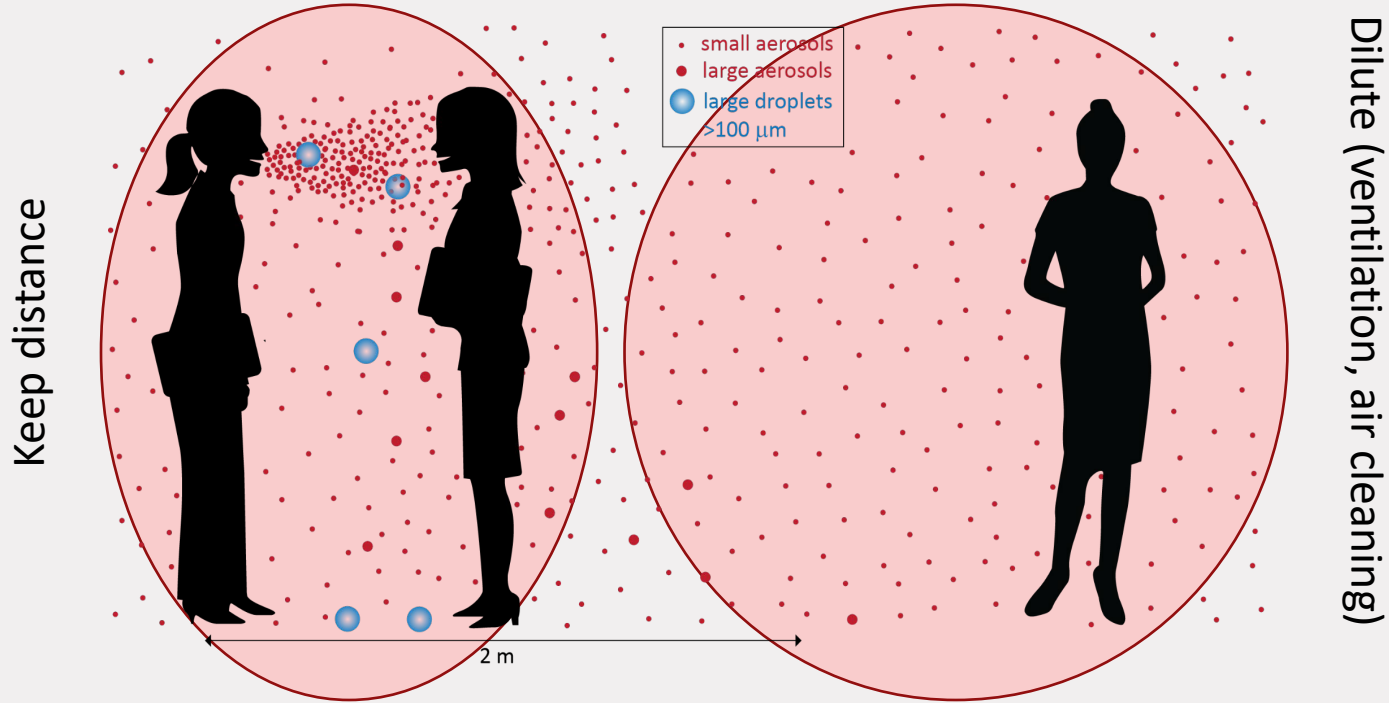
Adapted from Liu, L., Li, Y., Nielsen, P.V., Wei, J., Jensen, R.L., 2017. Short-range airborne transmission of expiratory droplets between two people. *Indoor Air* 27, 452–462.






# Summarizing

Airborne transmission is short- and long-range



# In due course acknowledgement (by some)...




**Heating, ventilation and air-conditioning systems in the context of COVID-19: first update**

10 November 2020

**Key messages**

- It is now well-established that COVID-19 transmission commonly occurs in closed spaces;
- If well-maintained and adapted for use in the COVID-19 pandemic, heating, ventilation and air-conditioning (HVAC) systems may have a complementary role in decreasing potential airborne transmission of SARS-CoV-2;



**Centers for Disease Control and Prevention**  
CDC 24/7: Saving Lives, Protecting People™

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

Pathogens that are mainly transmitted through close contact sometimes also be spread via airborne transmission. Examples in which SARS-CoV-2 appears to have been

## Transmission of SARS-CoV-2 from inhalation of virus in the air farther than six feet from an infectious source can occur

With increasing distance from the source, the role of inhalation likewise increases. Although infections through inhalation at distances greater than six feet from an infectious source are less likely than at closer distances, the phenomenon has been repeatedly documented under certain preventable circumstances.<sup>10-21</sup> These transmission events have involved the presence of an infectious person exhaling virus indoors for an extended time (more than 15 minutes and in some cases hours) leading to virus concentrations in the air space sufficient to transmit infections to people more than 6 feet away, and in some cases to people who have passed through that space soon after the infectious person left. Per published reports, factors that increase the risk of SARS-CoV-2 infection under these circumstances include:

- **Enclosed spaces with inadequate ventilation or air handling** within which the concentration of exhaled respiratory fluids, especially very fine droplets and aerosol particles, can build-up in the air space.
- **Increased exhalation** of respiratory fluids if the infectious person is engaged in physical exertion or raises their voice (e.g., exercising, shouting, singing).
- **Prolonged exposure** to these conditions, typically more than 15 minutes.

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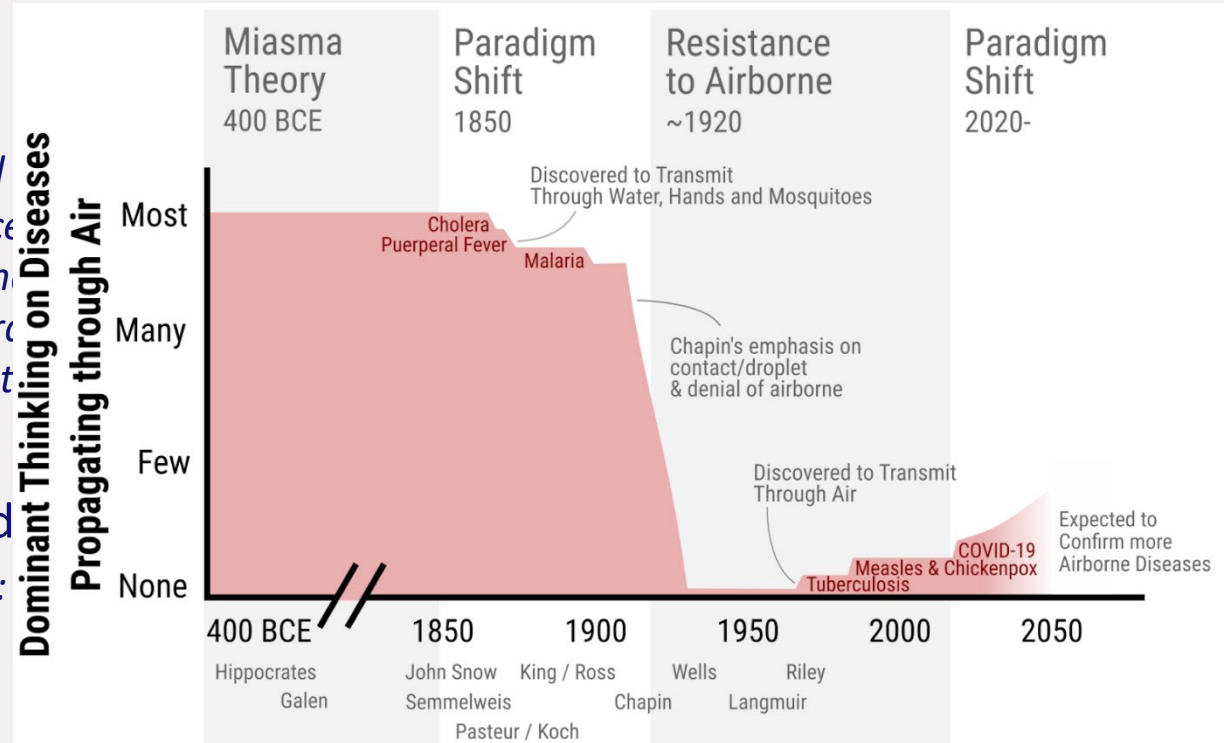
# But why so slow...

## History...?

- Miasma theory ('bad air')
- Second half of 19th century: Germ theory
- Early 20<sup>th</sup> century: Cholera, Typhoid
- 1910-1962: No natural airborne transmission
- 1962-2020: Reluctant to accept

## At the start of the pandemic

- WHO IPC committee:



# Summarizing evidence...

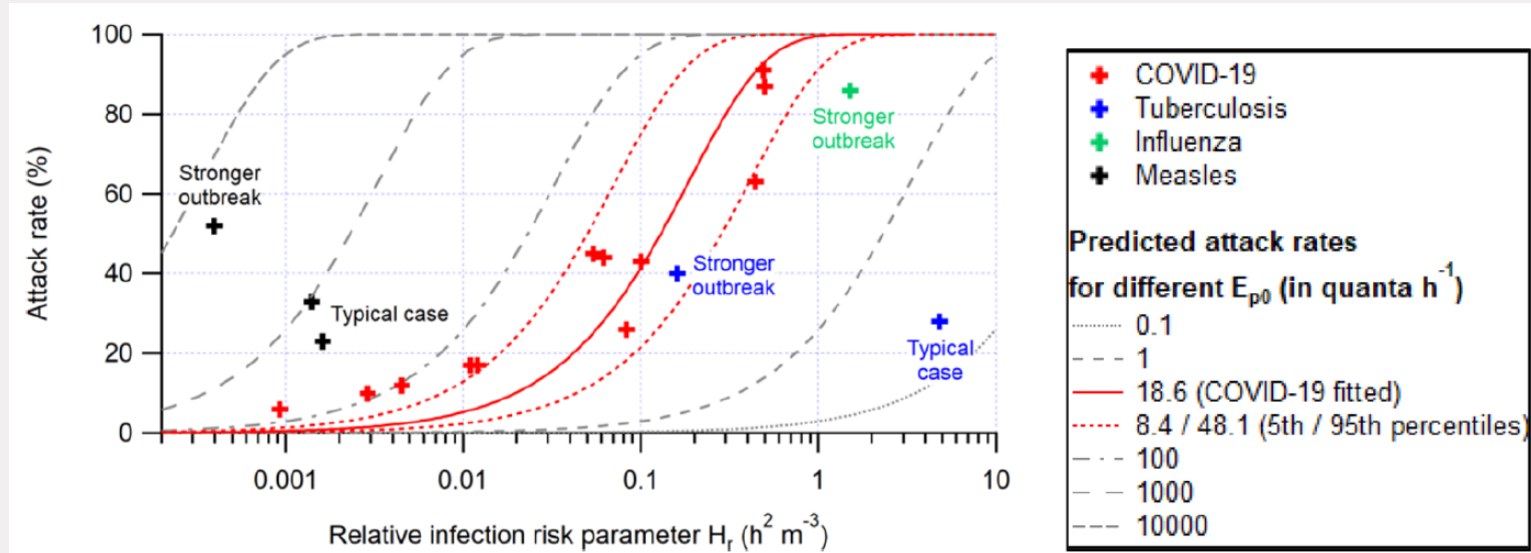
- *“superspreading events account for substantial SARS-CoV-2 transmission”*
- *“long-range transmission of SARS-CoV-2 between people in adjacent rooms but never in each other’s presence has been documented”*
- *“asymptomatic or presymptomatic transmission of SARS-CoV-2 from people who are not coughing or sneezing is likely to account for at least a third, and perhaps up to 59%, of all transmission globally”*
- *“transmission of SARS-CoV-2 is higher indoors than outdoors”*
- *“nosocomial infections have been documented in health-care organisations, where there have been strict contact-and-droplet precautions and use of personal protective equipment (PPE) designed to protect against droplet but not aerosol exposure.”*

# Summarizing evidence...

- *“viable SARS-CoV-2 has been detected in the air. In laboratory experiments”*
- *“SARS-CoV-2 has been identified in air filters and building ducts in hospitals with COVID-19 patients”*
- *“infected caged animals that were connected to separately caged uninfected animals via an air duct have shown transmission of SARS-CoV-2”*
- *“no study to our knowledge has provided strong or consistent evidence to refute the hypothesis of airborne SARS-CoV-2 transmission”*
- *“there is limited evidence to support other dominant routes of transmission—ie, respiratory droplet or fomite”*



# Evidence from cases...



$$H_r = r_{ss} r_E r_B f_e f_i D / (V \lambda)$$

D: duration of exposure

V: volume of the room

$\lambda$ : sink term (ventilation, decay, deposition, ...)

r: related to emission, breathing, transient effect

f: effect mask



# Was this necessary?





# Was this necessary?

- Addition to the risk reduction
- Reflection of the current status of indoor air quality in schools...
- Need for improvements in general. Not only good from a health perspective...





# Ventilation in the context of Covid-19...

## Ventilation during Covid-19

- *eye-opener for the importance of a good indoor environment*

## Ventilation in post-Covid-19 era

- *good ventilation important for a healthy indoor environment*
- *Investing in good ventilation is economically viable (also for our society as a whole - DALY), and not only for Covid-19*
- *Ventilation strategies for reduction infection risk*



# Thank you