



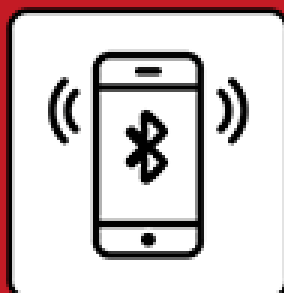
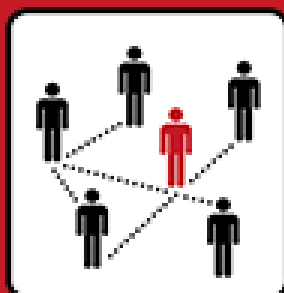
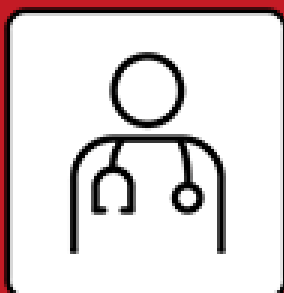
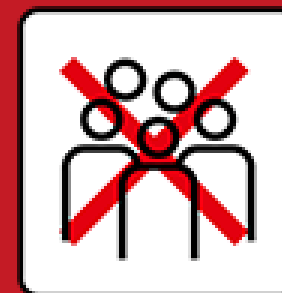
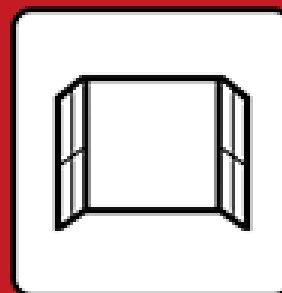
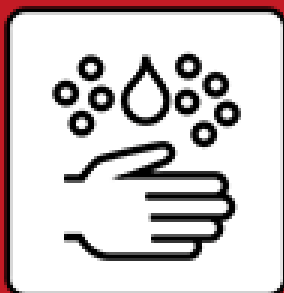
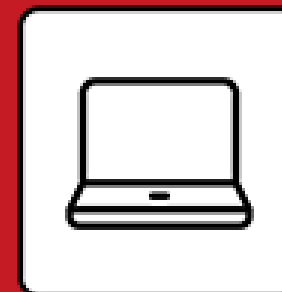
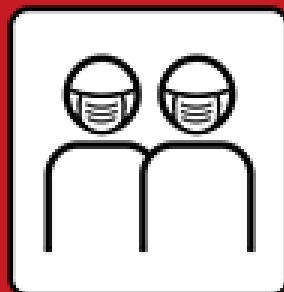
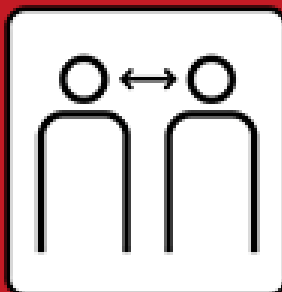
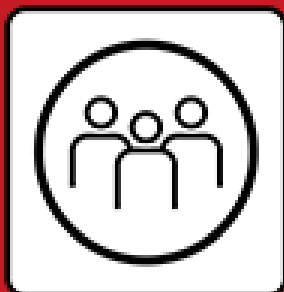
Aerosol distribution in rooms and the importance of proper ventilation

Urs Baltensperger

**Laboratory of Atmospheric Chemistry,
Paul Scherrer Institute, Villigen , Switzerland**

ENE Division General Information Event, 29 October 2020

First, and most importantly: All these measures are important!



This does not mean that other precaution measures are not important!

Such as:



Matthias #WashYourHands Egger
[@eggernsf](#)

What are aerosols?

- Aerosols are liquid or solid particles suspended in the air sufficiently long to be measured
- For us (the LAC) aerosols is a synonym to particulate matter, PM, or in German Feinstaub. Only sizes up to 10 μm are relevant
- Droplets for the inhalation and pulmonary deposition of pharmaceutical drugs are also called aerosols; these droplets are also typically smaller than 10 μm

Are aerosols relevant for COVID transmission? I get tweets confirming the importance of aerosol in COVID transmission every day



Linsey Marr ✓
@linseymarr

Six feet is not enough. Now at 44 primary cases + 17 secondary. The gym did health screening, cleaning, masks before and after class, 50% capacity, and 6' around each bike. NOTHING ABOUT VENTILATION.

[Tweet übersetzen](#)



One client in one spin studio that followed all the rules triggers a coronavirus out...
A spin studio that public health officials say followed all Covid-19 protocols is now reporting 61 positive cases of Covid-19 and up to 100 staff, clients and family ...

[cnn.com](#)

15 October 2020

Size of the corona virus: 60 - 140 nm

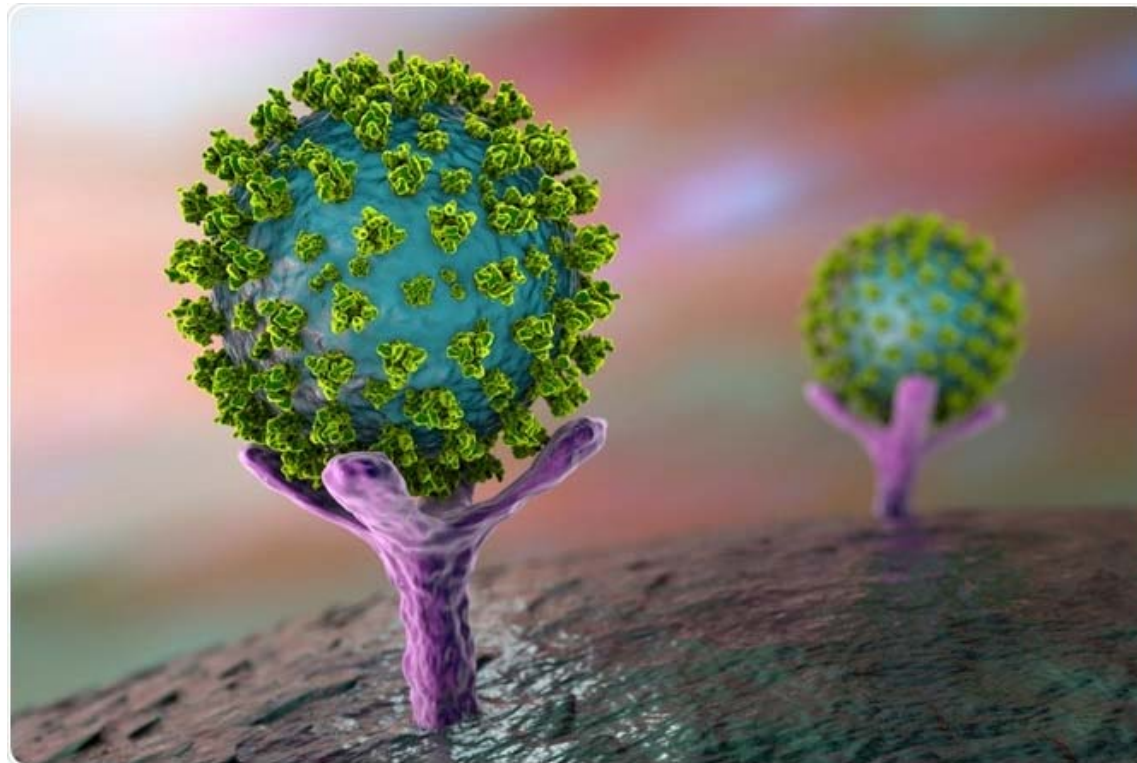
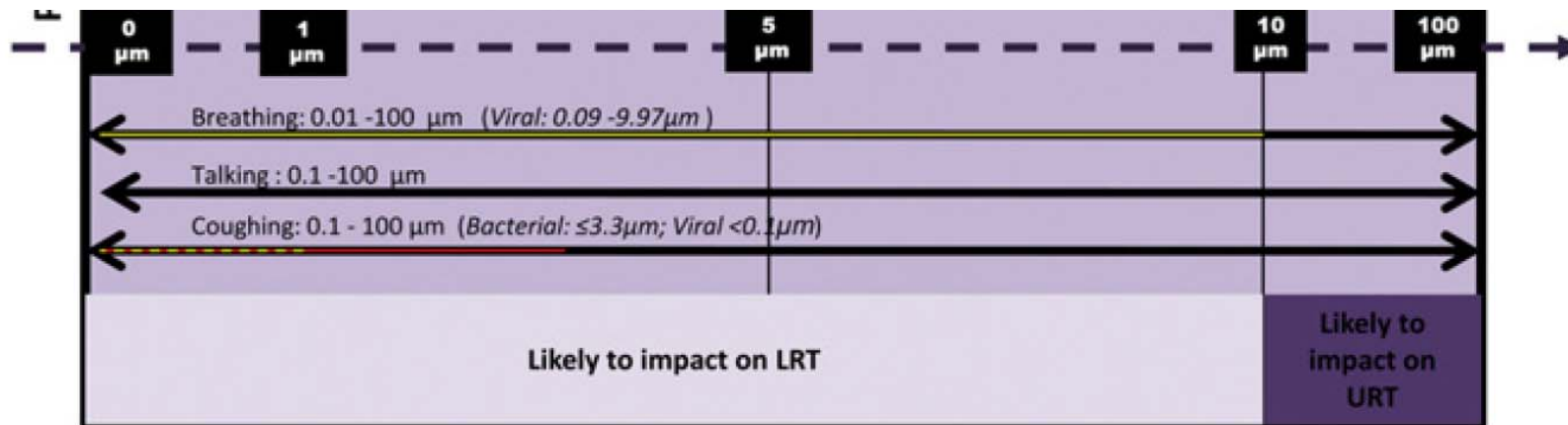


Image Credit: Kateryna Kon/Shutterstock.com

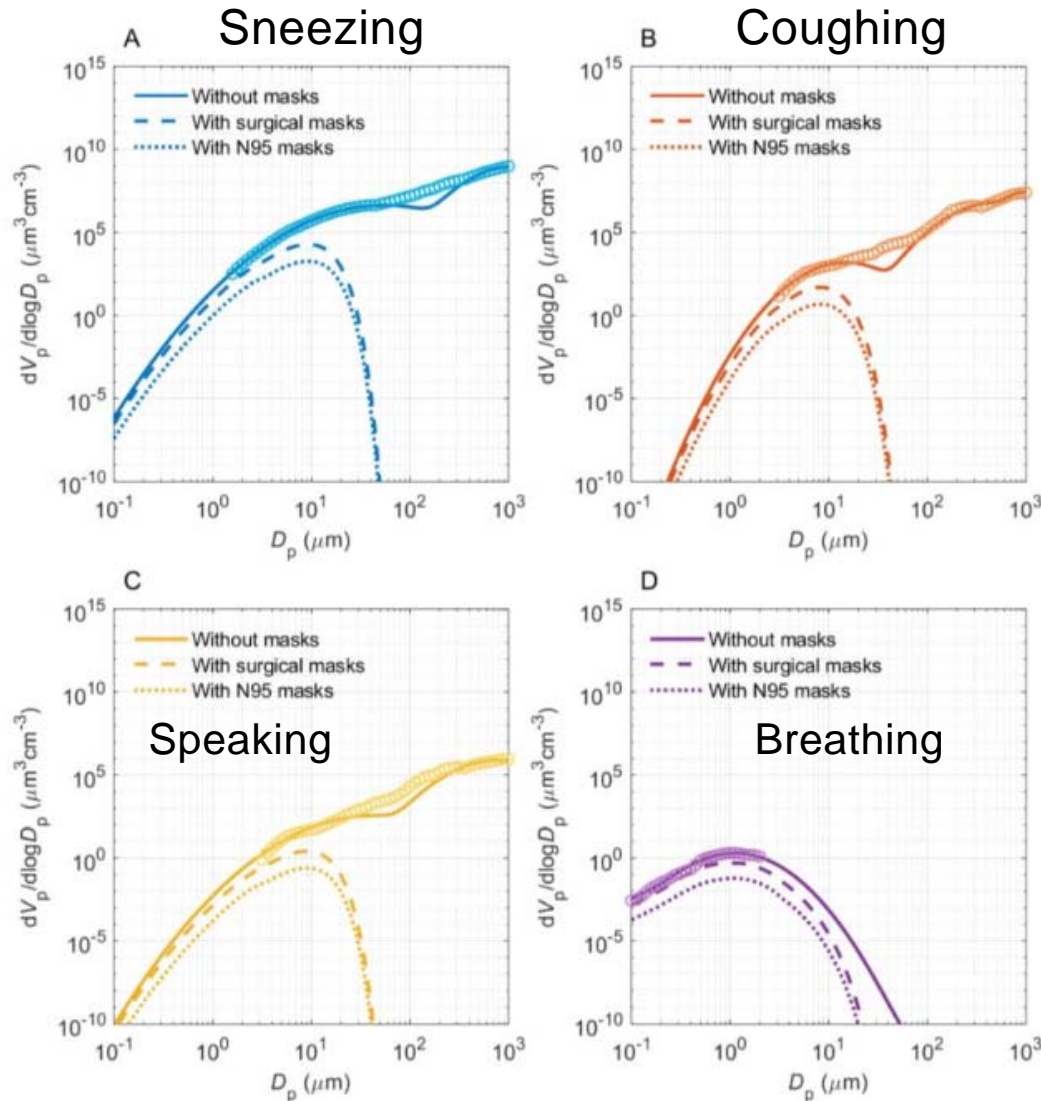
<https://www.news-medical.net/health/The-Size-of-SARS-CoV-2-Compared-to-Other-Things.aspx>

Droplets contain a lot of other material besides viruses
 → droplets are always much larger than size of a virus



Gralton et al., J. of Infection 2011

The volume size distribution of exhaled aerosols



Note:

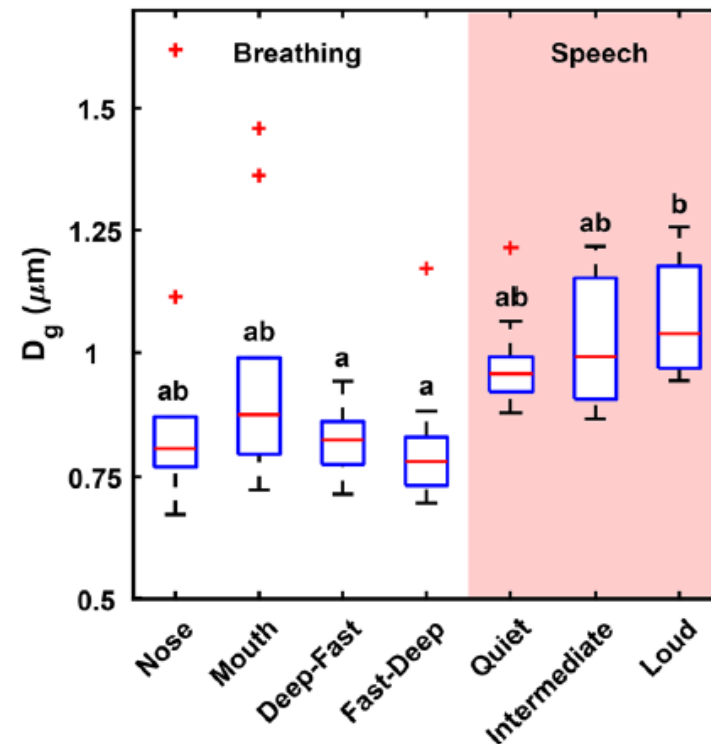
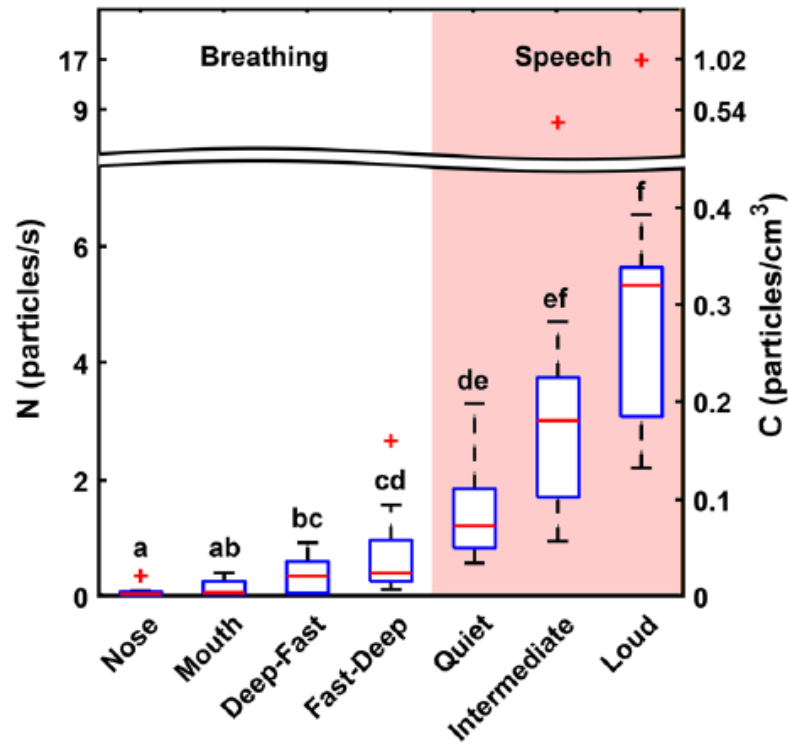
- This is volume size distribution; Number size distribution peaks between 1 and 10 μm
- The viral load in the aerosols may be equal or even higher than in the larger droplets

Cheng et al., Preprint
Submitted 11 Sep 2020

<https://doi.org/10.1101/2020.09.10.20190348>

Number and size of droplets:

Speaking produces more aerosols than breathing;
Singing can produce 10^2 x more aerosol particles than breathing



Superemitters can emit 10x more particles than other people

How many viruses needed for an infection?

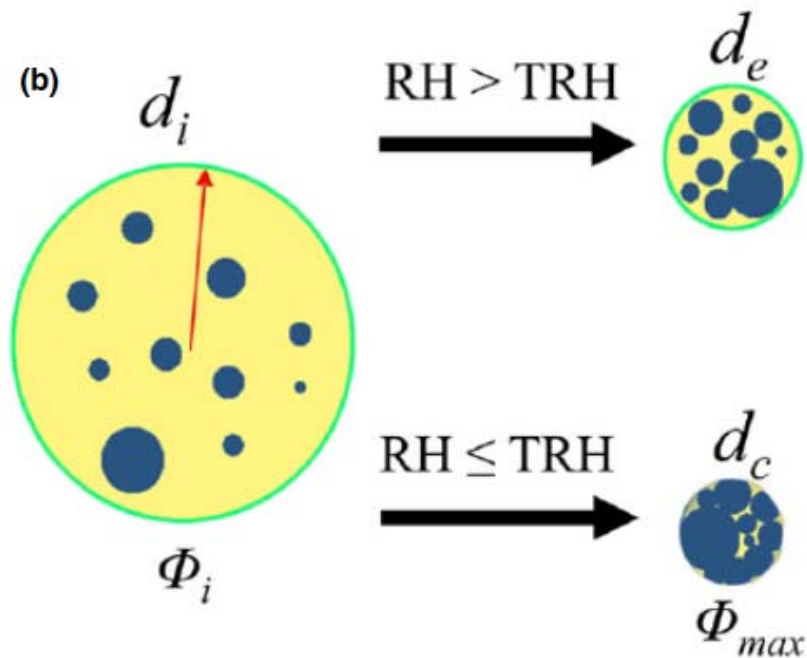
- Mean viral load of about 5×10^8 mL⁻¹,
- Superinfectious subjects: 5×10^9 mL⁻¹,
- This corresponds to ~0.1-1 virus copies per 10µm droplet
- 100 – 1000 viral copies needed for 50% probability to be infected
- Speaking results in ~100-1000 aerosols per liter of air
- 1 liter of air (=1 to 2 undiluted breaths) can be sufficient for an infection

What happens after emission?

- Drying, i.e., shrinking of droplet due to adjustment to ambient relative humidity
- Deposition of particles depending on their size
- Dilution depending on mixing with fresh air
→ 'Lüften, lüften, lüften, but even better: outdoor activity
- Decay of virus in the droplet: The half-life of the SARS-CoV-2 virus on aerosols is about 1 hour (strongly dependent on environmental conditions (UV light, relative humidity, etc))

What happens after exhalation of a droplet?

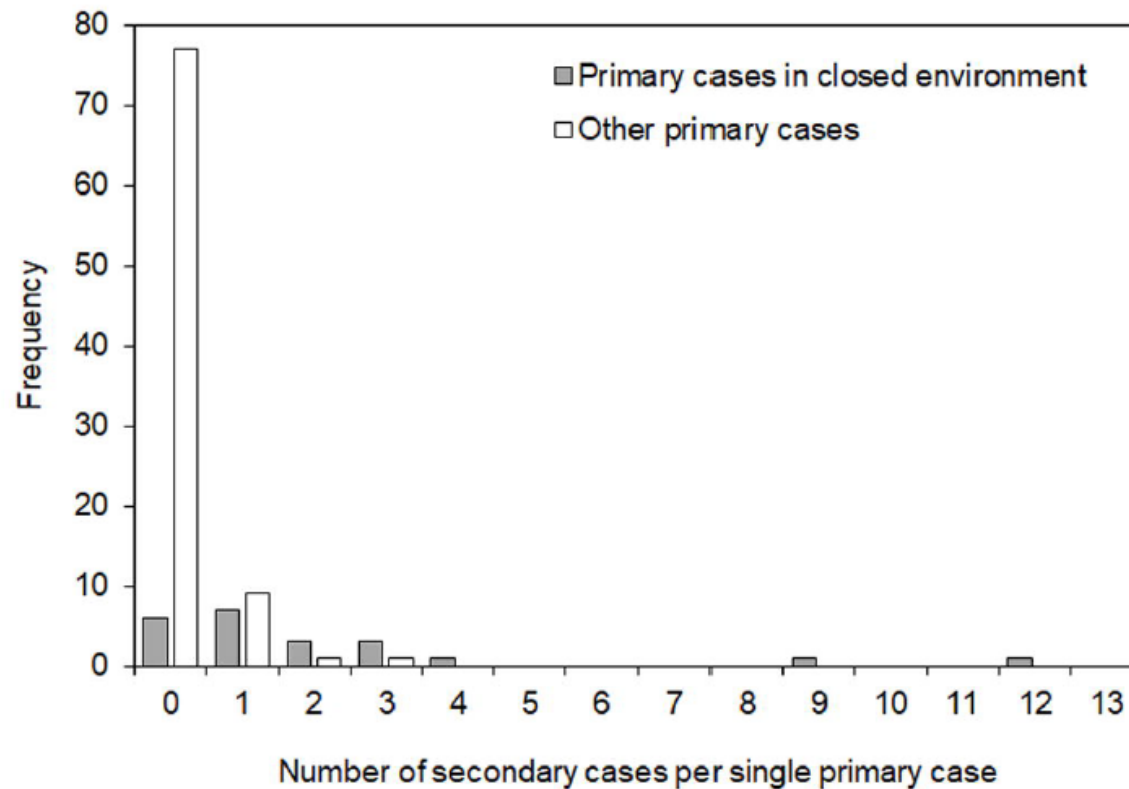
Water evaporates to reach equilibrium with ambient relative humidity, RH



This happens in milliseconds, as seen above aircraft wings



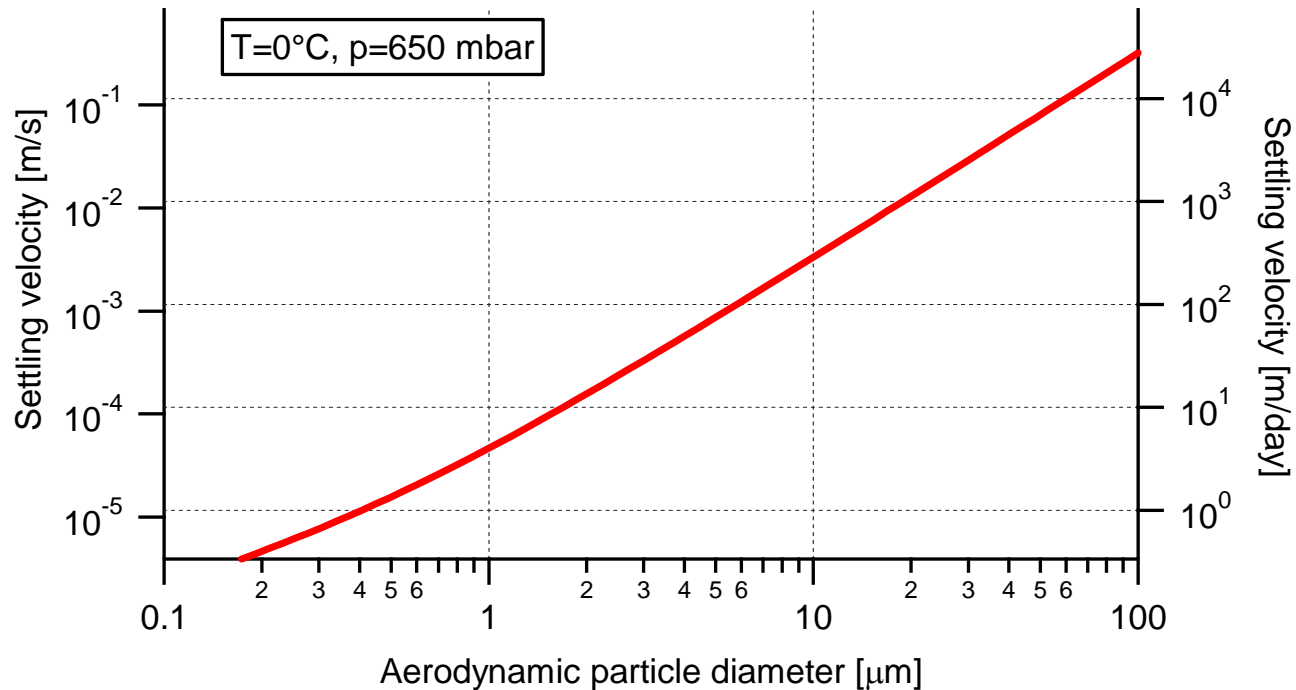
➔ 19 times higher probability for indoor than for outdoor transmission of virus, (Nishiura et al., 2020):



But also outdoor probability is not zero (example: cigarette smoke)

<https://doi.org/10.1101/2020.02.28.20029272>

Settling velocity increases strongly with size → Large particles deposit rapidly



Very large droplets: social distancing helps as droplets settle to the ground

Droplets $\leq 10 \mu\text{m}$: social distancing does not help.

In the following: focus on these smaller droplets

- Office, 4 persons, 120 m³, exposure 16 hours
- Classroom: 25 persons, 180 m³, exposure 12 hours
- Choir: 25 singers, 400 m³, exposure 3 hours
- Reception: 100 persons, 400 m³, exposure 3 hours

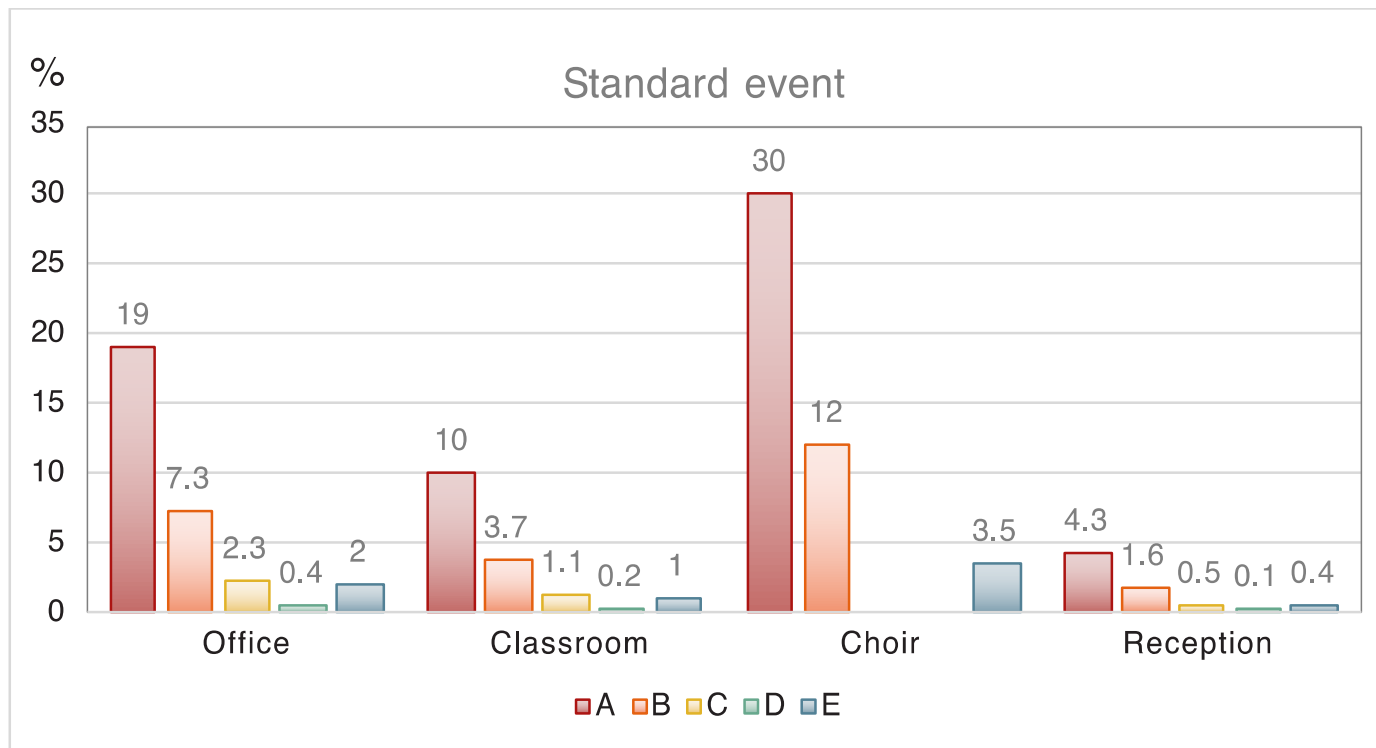
A: passive ventilation (ventilation rate VR= 0.35 / hour), no masks.

B: active ventilation with outside air (VR =2 / hour), no masks.

C: active ventilation, facial masks (70% efficiency).

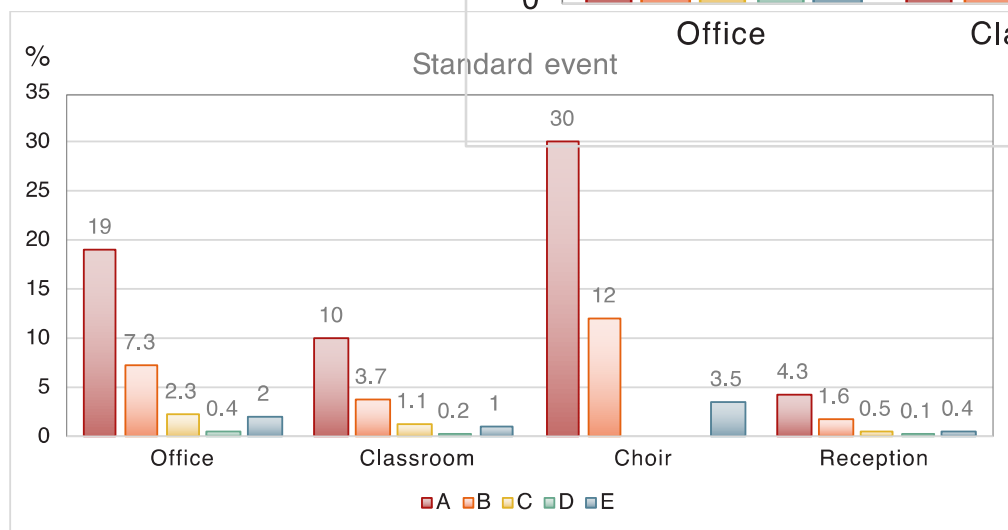
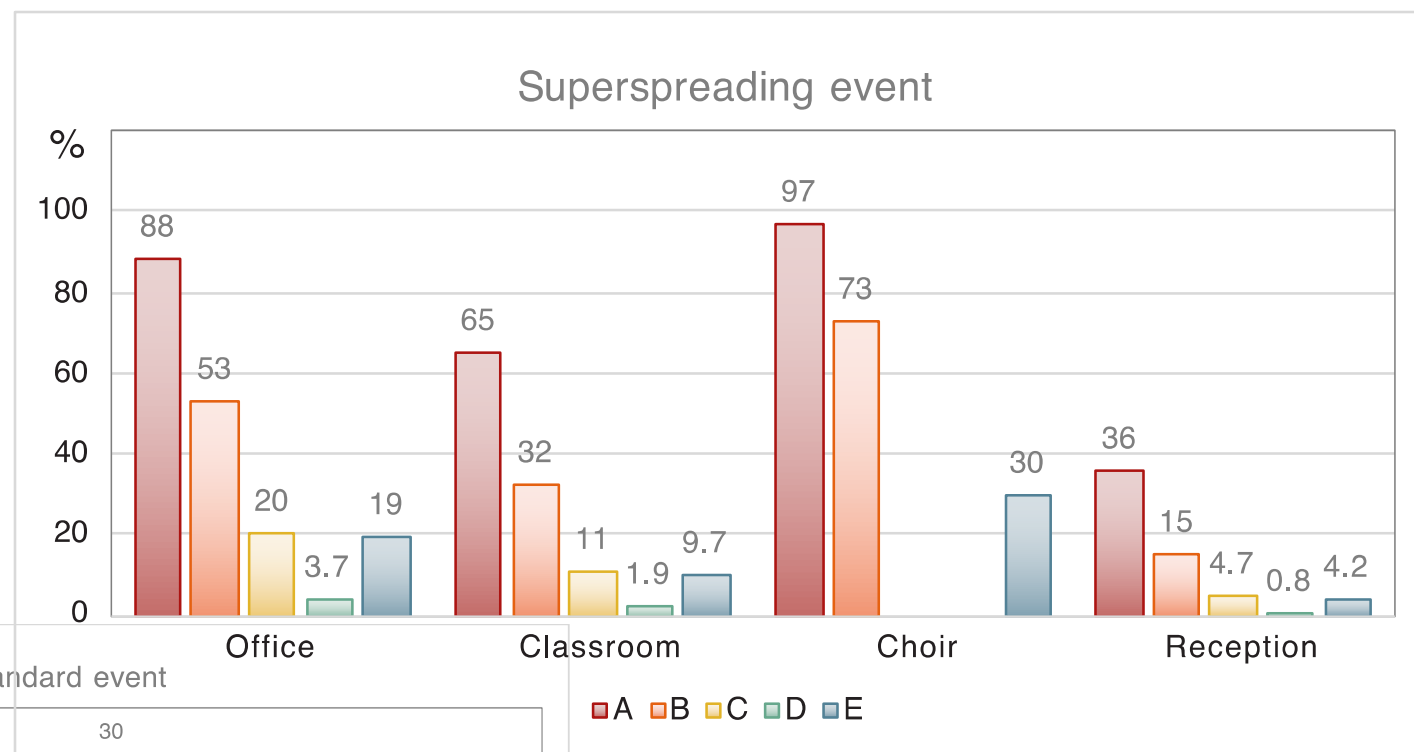
D: active ventilation, high-quality masks (95% efficiency).

E: High-volume filtration with HEPA (High Efficiency Particulate Air) filter



Lelieveld et al., Preprint 2020

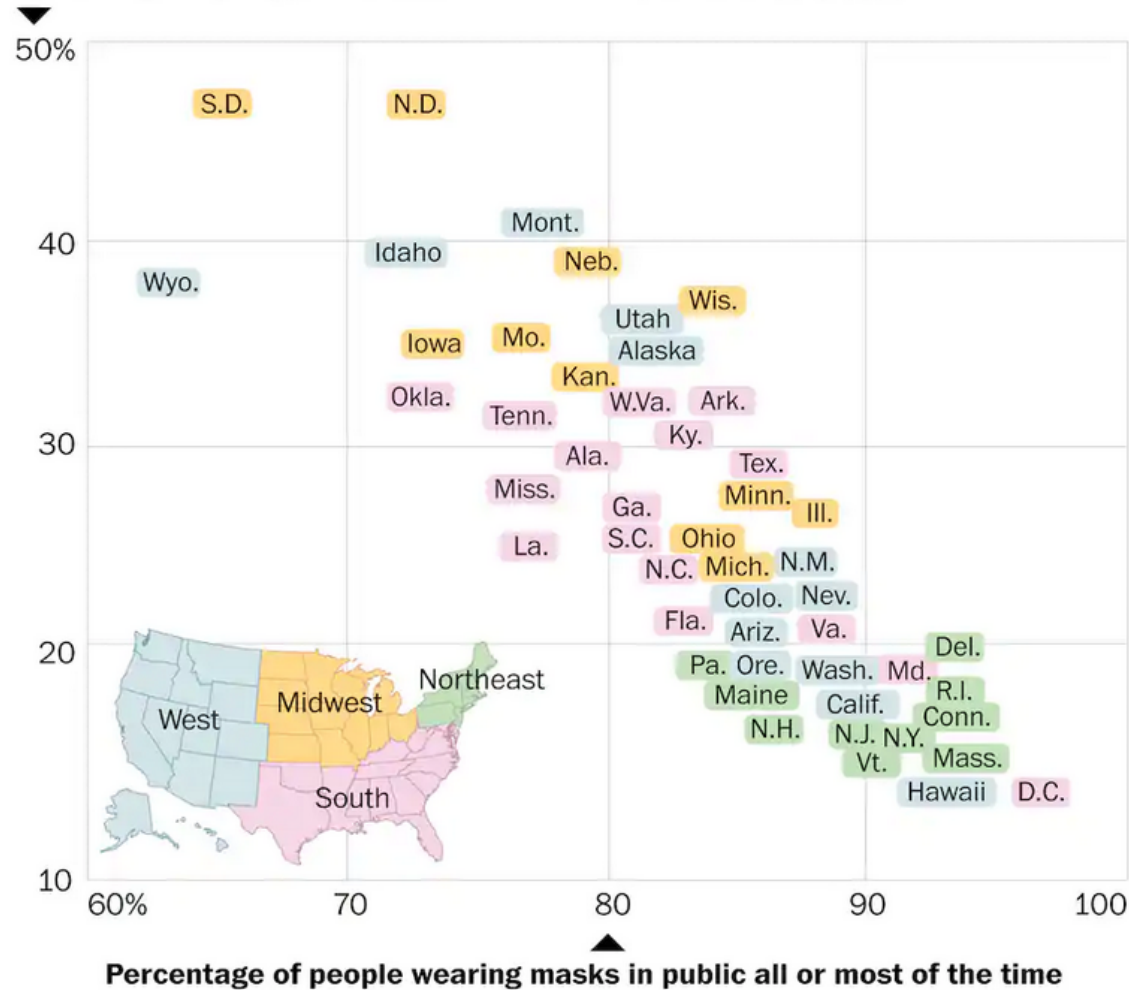
Risk of a particular person to be infected for a superspreading event



Lelieveld et al., Preprint 2020
doi: <https://doi.org/10.1101/2020.09.22.20199489>

US: States with higher mask use have lower frequency of observed covid-19 symptoms


Percentage of people who knows someone with covid-19 symptoms



Data as of Oct. 19, 2020

Source: Delphi COVIDCast, Carnegie Mellon University

THE WASHINGTON POST



A mouth-and-nose lockdown is far more sustainable than a full lockdown, from economic, social, and mental health standpoints (Kai et al., 2020).

Kai et al., Universal Masking is Urgent in the COVID-19 Pandemic: SEIR and Agent Based Models, Empirical Validation, Policy Recommendations. arXiv: 2020, 2004.13553



Thank you for your attention