Possible link between seasons and COVID-19

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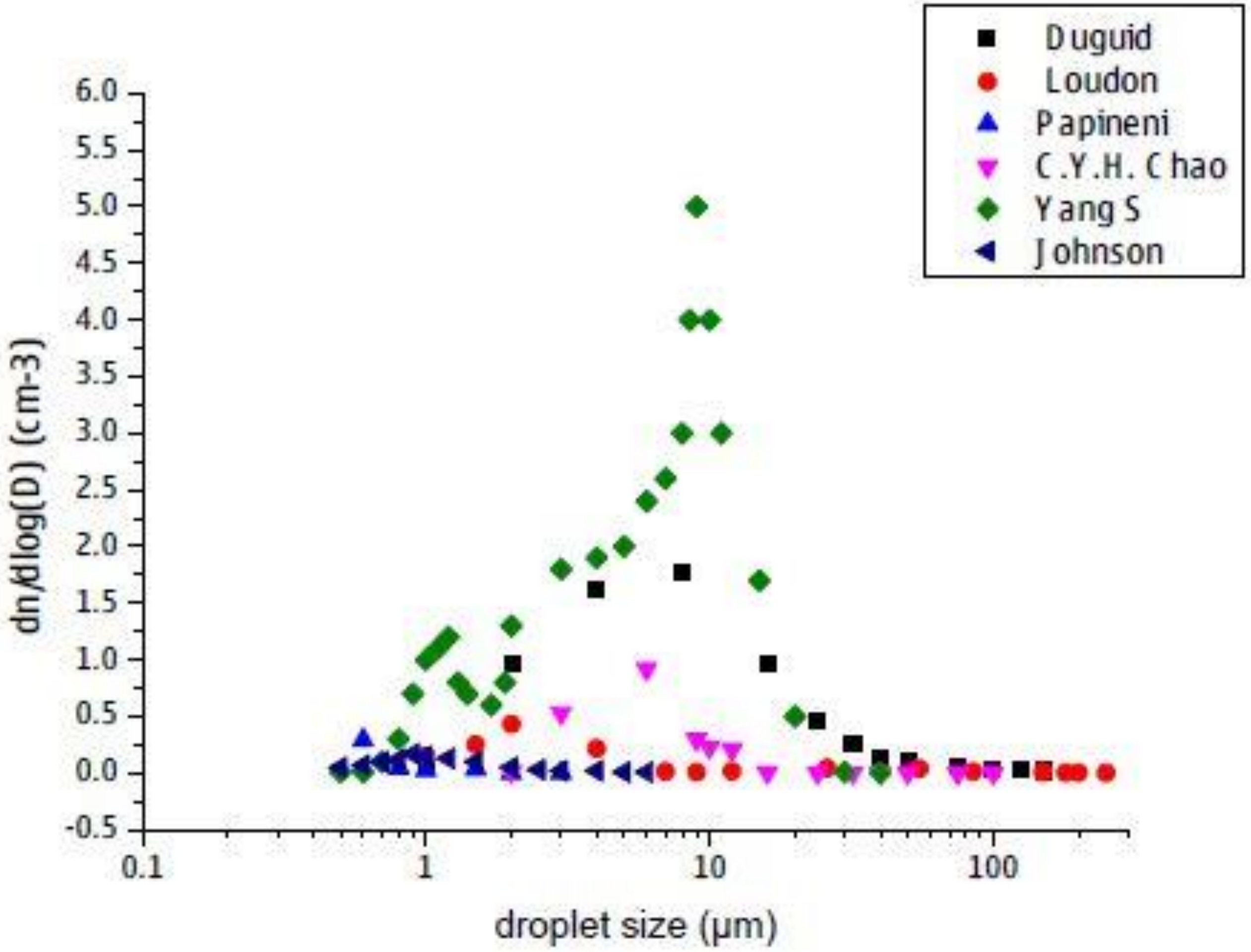
Objectives

- WHO: According to current evidence, COVID-19 virus is primarily transmitted between people through respiratory droplets and contact routes.
- WMO: Current peer-reviewed publications on the COVID-19 disease do not show a robust and consistent response to meteorological and environmental drivers.
- Therefore we made a qualitative study of the behavior of the respiratory droplets in different humidity conditions.
- Conduct a literature study on mask efficiency.

Respiratory droplets: size distribution

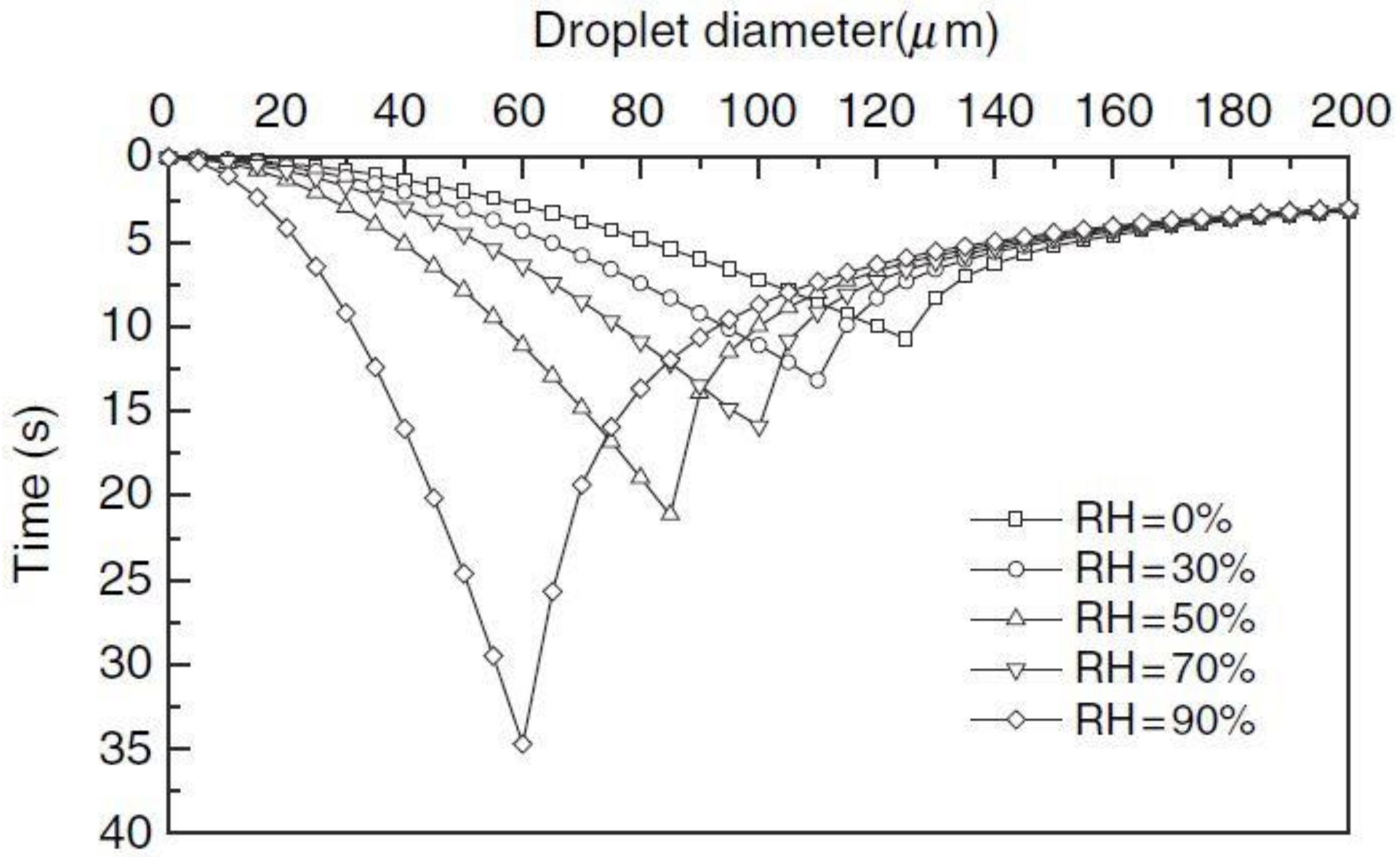
Respiratory droplet **distribution** varies greatly between breathing, coughing and sneezing. H. Zhang et al. made a table with results form different research articles. Distributions from 0.3 µm for breathing and up to 2000 µm for coughing and sneezing were found.



H. Zhang et al.: The relation of cough droplet size and concentration, from 6 research articles.

Evaporation and deposition of respiratory droplets (Wells curve)

After expulsion, droplets are subjected to environmental conditions and either **evaporate** or are **deposited**, depending on initial airflow speed, initial diameter and environmental conditions.

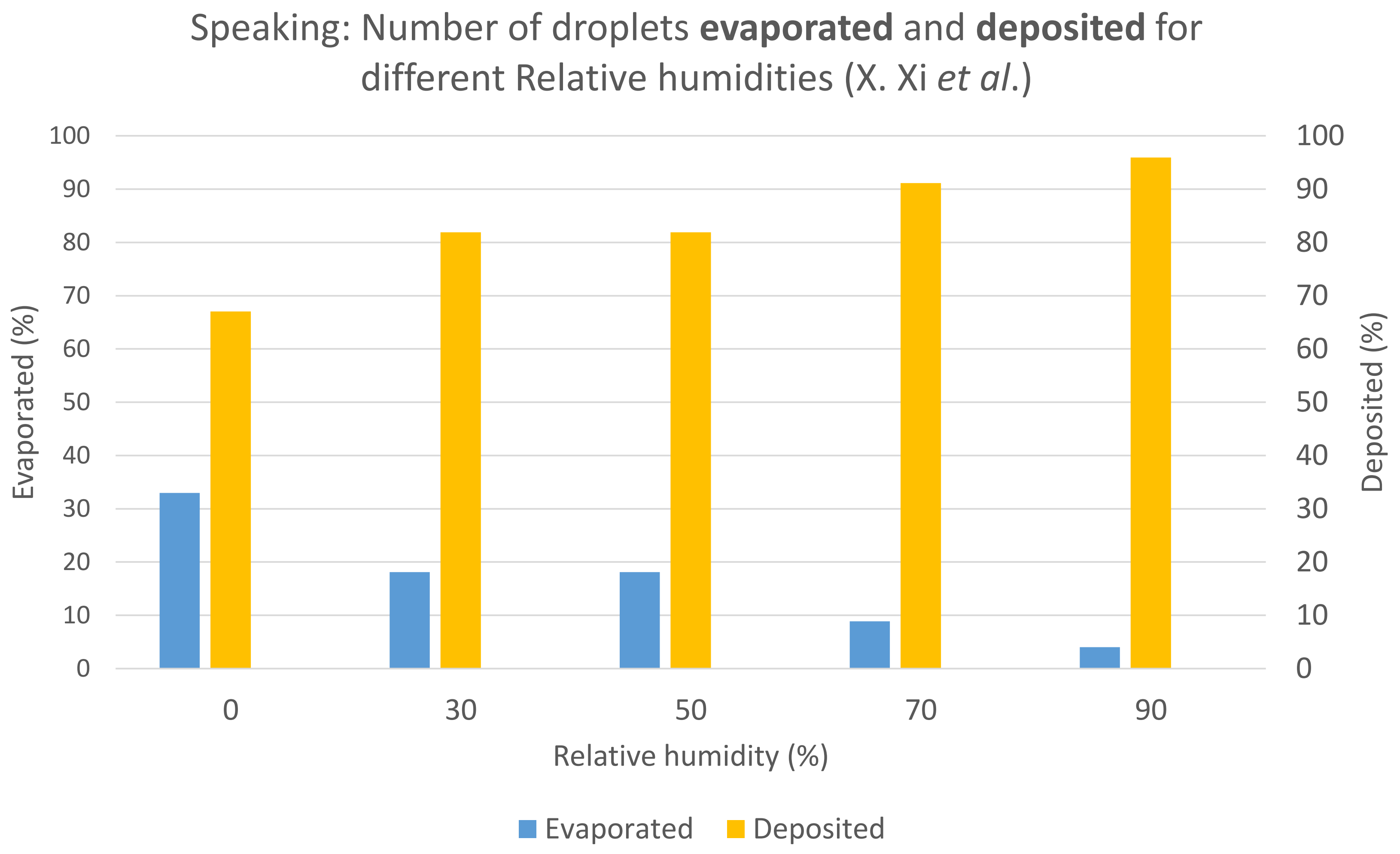


Source: X. Xie

Evaporation time and falling time of droplets of varying diameter under different atmospheric conditions (T_{p0} = 33 °C, T_∞ = 18 °C)
(error in legend; 50% and 70%)

Evaporation and deposition during speaking

Using the distribution found by C.Y.H. Chao *et al.* and the critical diameters found by X. Xi *et al.*, normalized values (%) can be calculated for evaporation and distribution.



Airborne droplets

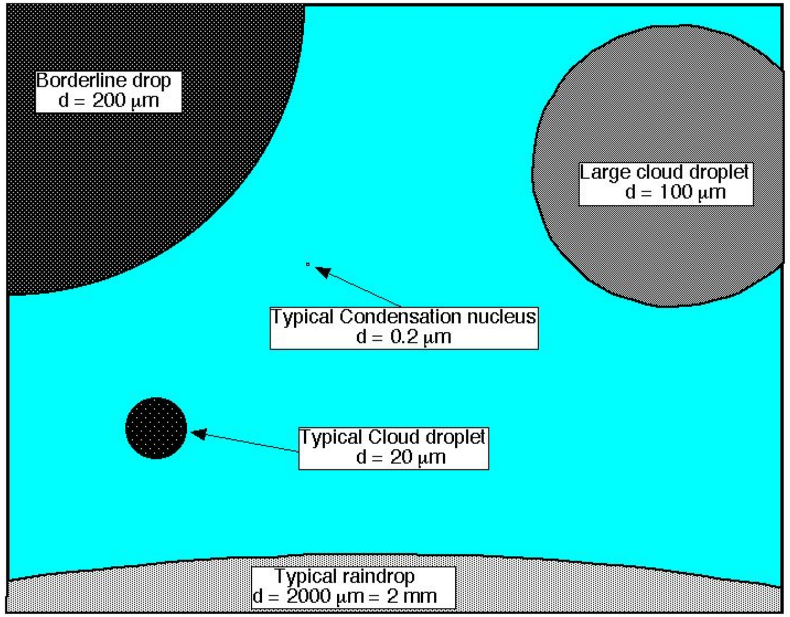
Research on the topic of evaporation and deposition of droplets makes the assumption that droplets evaporate completely and neglect partial evaporation of deposited droplets.

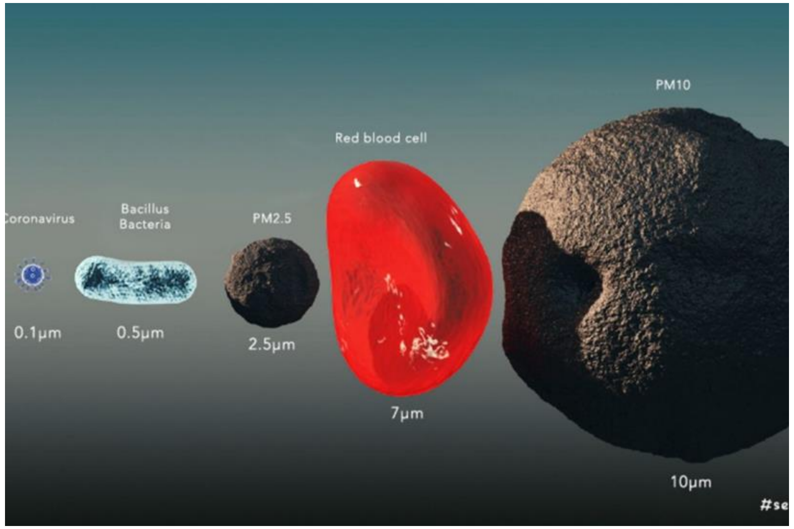
Cloud condensation nuclei (CCN) act as the initial sites for condensation of water vapor into small droplets.

Various studies have reported a direct relationship between the spread and contagion capacity of some viruses with the atmospheric levels and mobility of air pollutants (Ciencewicki and Jaspers, 2007; Sedlmaier et al., 2009)

Size CCN : 0.2-1 µm

Coronavirus : 0.1 µm

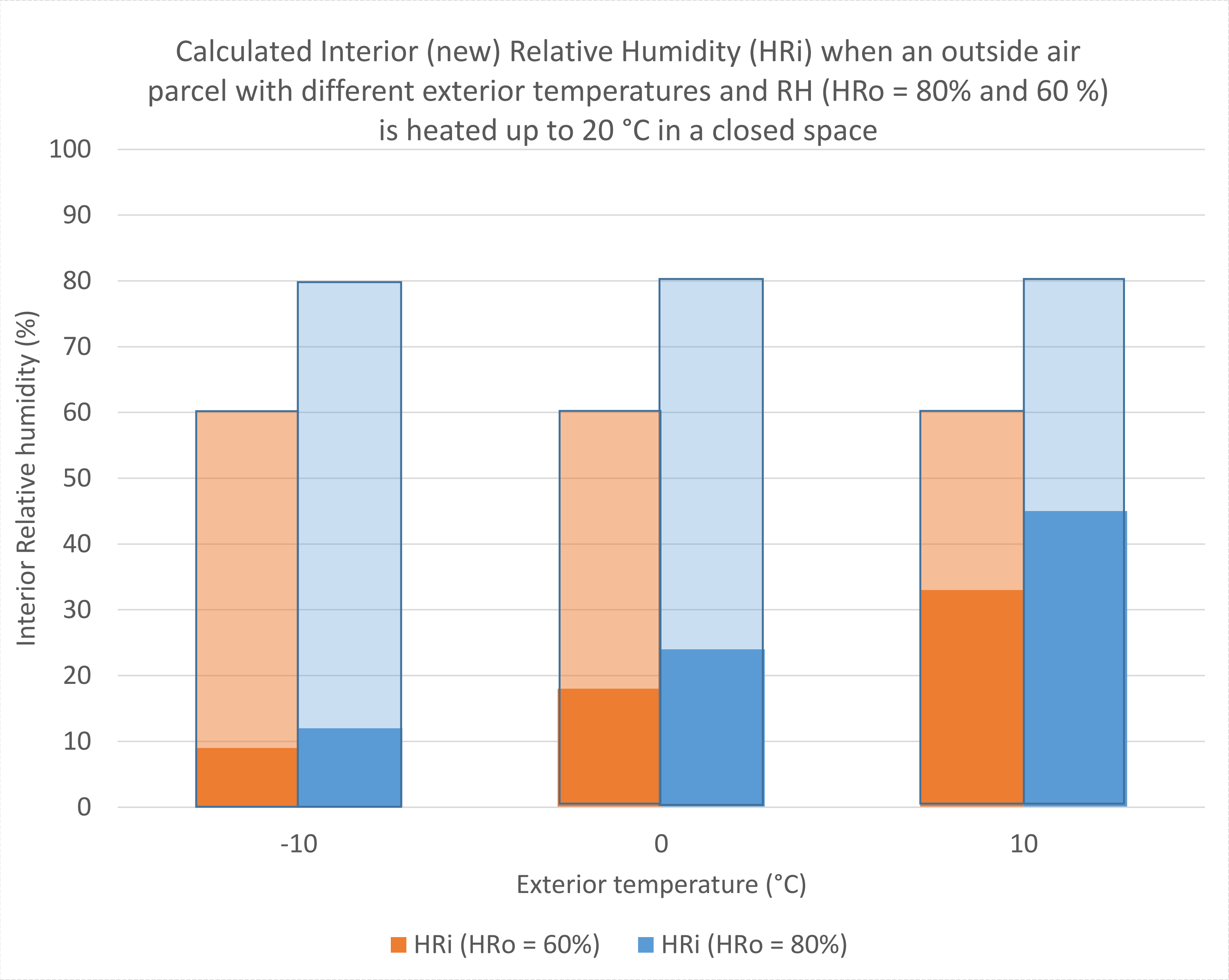




Calculating a "new" RH indoor

In this instance, cold air with a relative humidity of 60% to 80% and temperatures of -10, 0 and 10 °C were used to calculate the "new" relative humidity of that parcel at room temperature of 20 °C.

$$H_{Ri} = \frac{T_i}{T_e} e^{\frac{H}{R}\left(\frac{1}{T_i} - \frac{1}{T_e}\right)} H_{Re}$$

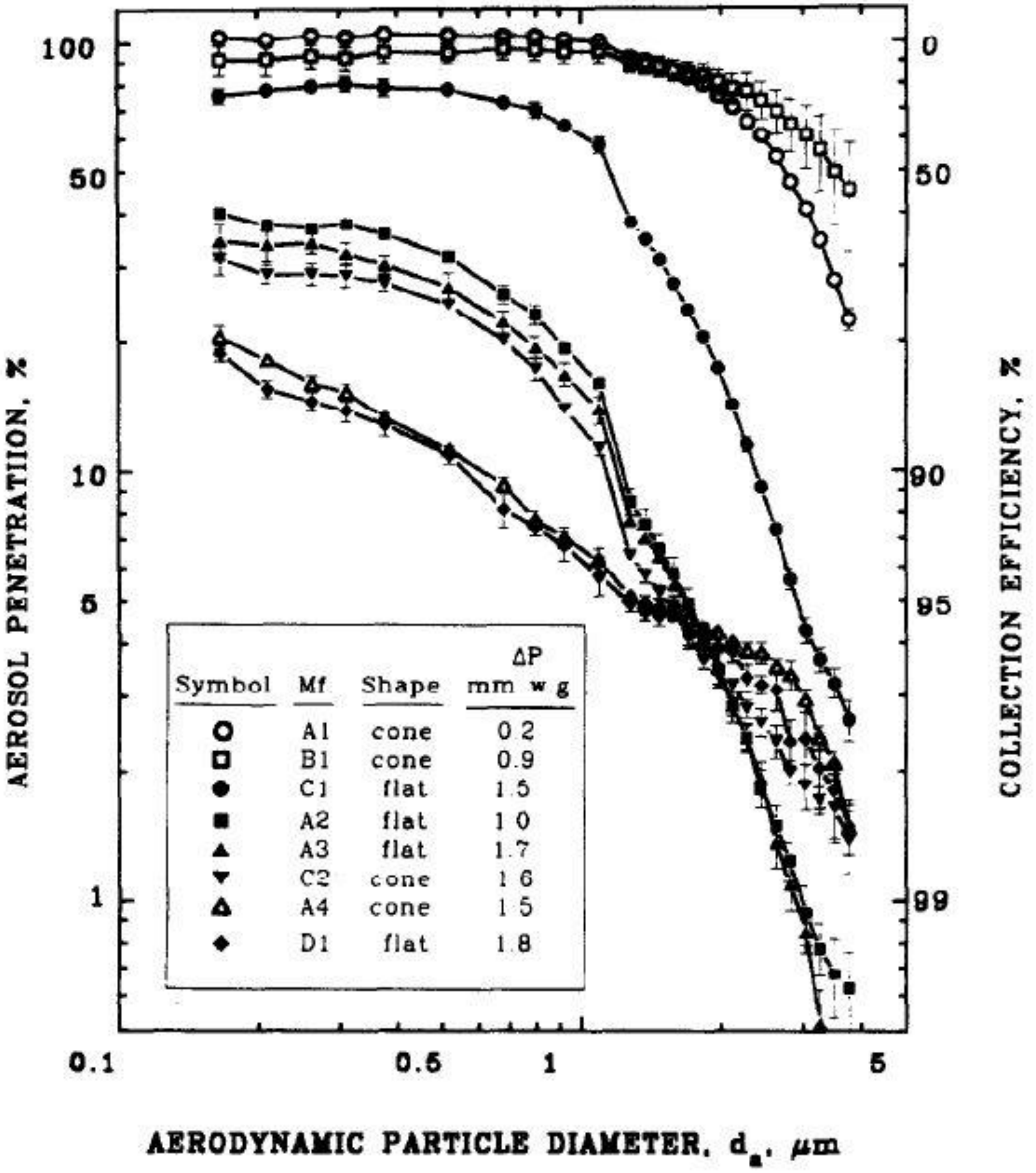


Mask efficiency

A. Weber et al. compared mask efficiencies for different masks, types and make.

‘The percentage of filter penetration ranged from 20% to nearly 100% for sub-micrometer-sized particles’. (A. Weber *et al.* 1993)

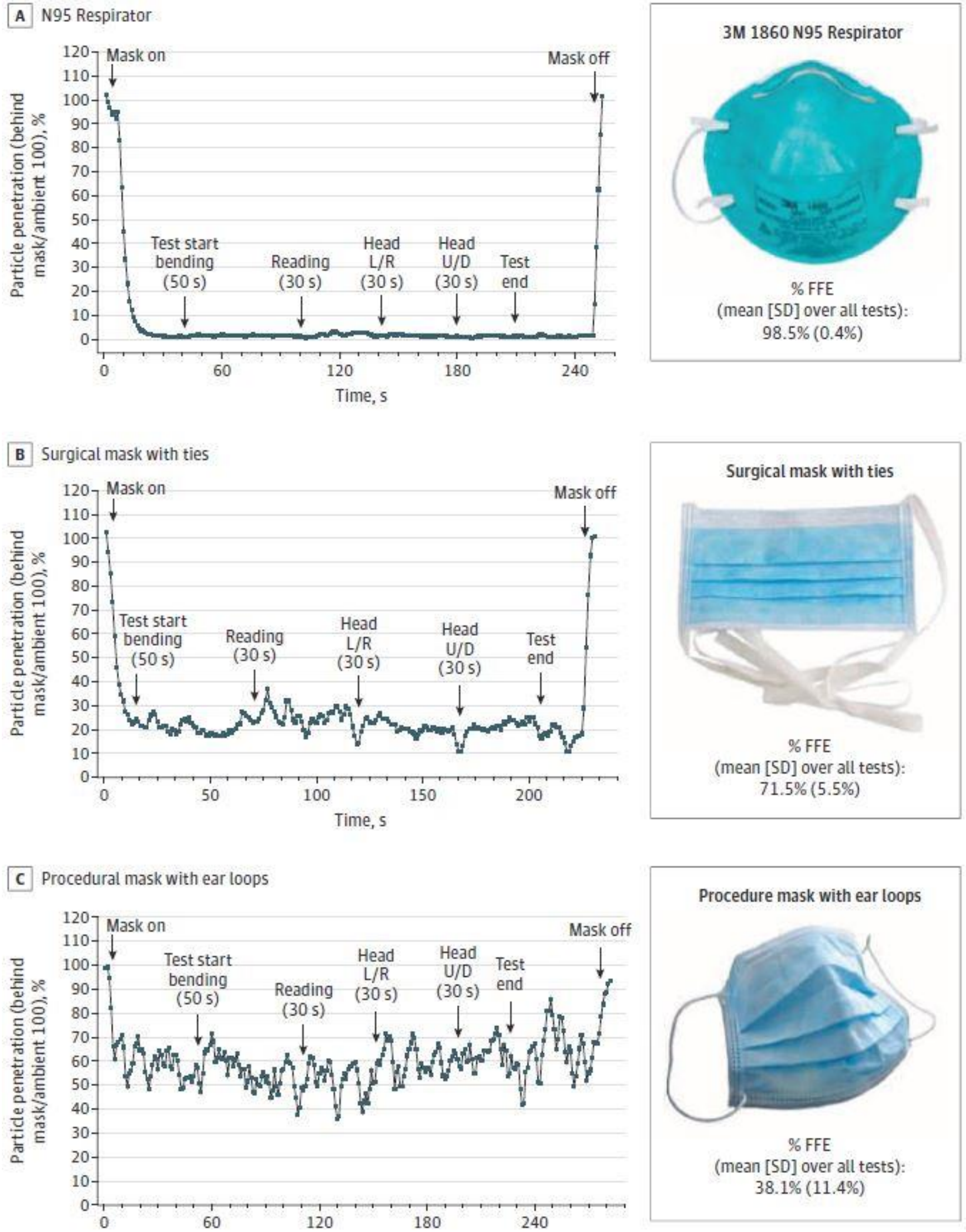
For droplets >5 µm a collection efficiency of >95% was reached for most masks.



Mask efficiency

E.E. Sickbert-Bennet assessed the fitted filtration efficiencies (FFEs) for face mask alternatives (to N95 mask) used during the COVID-19 pandemic.

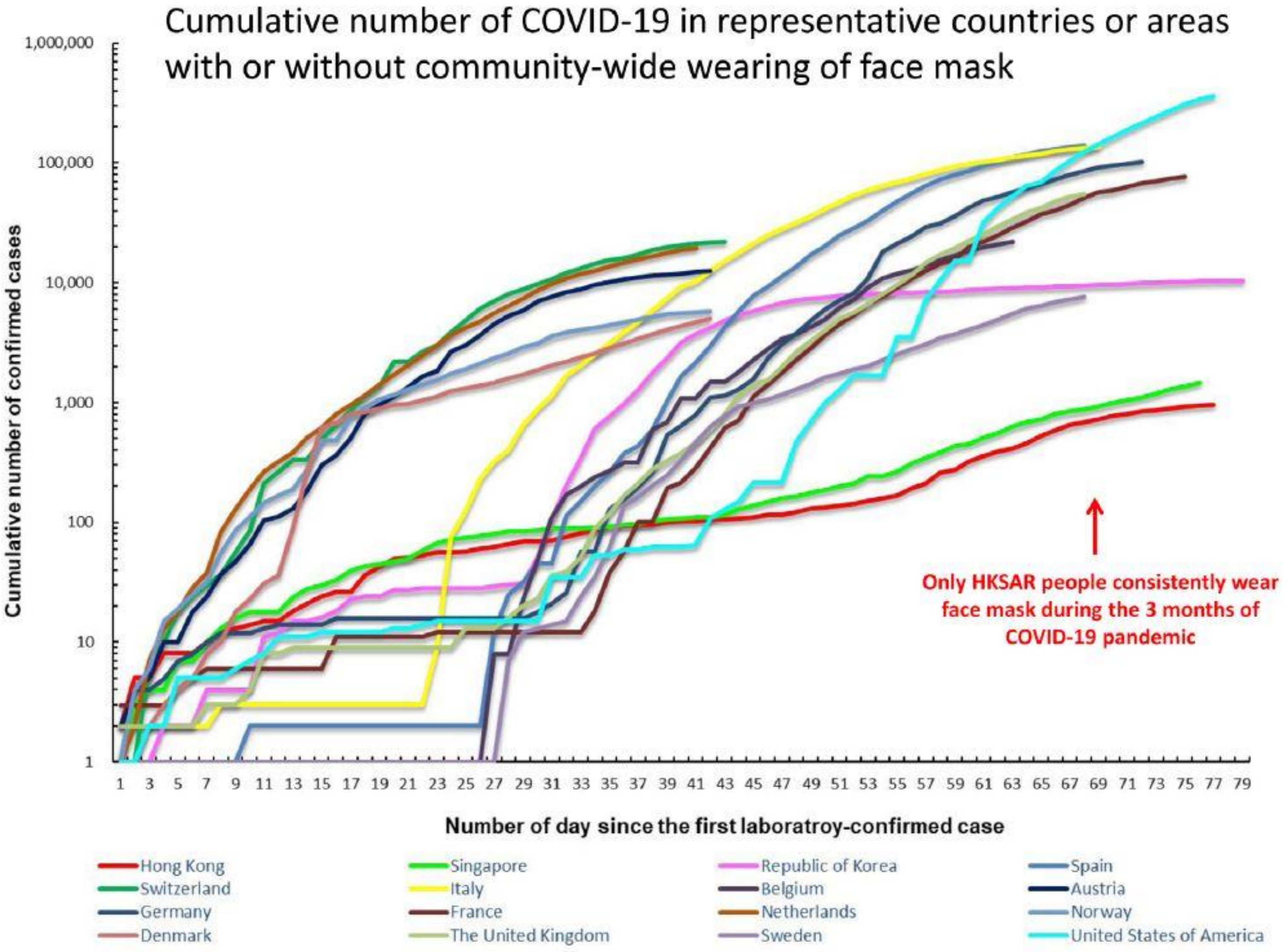
Efficiencies ranged from approx. 40% (for procedure mask with ear loops) to approx. 99% (for N95 masks).



Research on community-wide wearing of face masks

Community-wide mask wearing may contribute to the control of COVID-19 by reducing the amount of emission of infected saliva and respiratory droplets from individuals with subclinical or mild COVID-19. See graph. (V.C. Cheng *et al.* 2020)

With surgical masks (or equally efficient substitutes) and 80% and 90% adoption levels, **respiratory epidemics with R0 of about 3, and 4, respectively, would be theoretically extinguished**. (A.D. Kot *et al.* 2020)



V.C. Cheng *et al.* 2020

Results

- During winter periods indoor RH will be reduced due to indoor heating systems (proportional to outdoor temperature).
- The use of an air-conditioning in the tropics, dries the air by extracting moisture during cooling.
- Number of airborne respiratory droplets will likely increase with a factor of 2 between 70% and 50% RH.
- Masks efficiencies range from 40% up to 99%, depending on type and fit of the mask.
- With surgical masks and 80% and 90% adoption levels, respiratory epidemics with R0 of about 3, and 4, respectively, would be theoretically extinguished.

Conclusions

- Condensation Nuclei is considered to be important regarding the spread of airborne viruses.
- Therefore the risk of infection will likely increase during winter period and in AC cooled rooms in warm climates due to higher amounts of aerosols that could contain a virus.
- The type of mask heavily influences the efficacy of the mask.
- Models indicate that community-wide wearing of masks, even masks with a lower efficacies, could extinguish a pandemic.
- Further study: Seasonality of Condensation Nuclei

Thank you!

References:

- X. Xie[1], Y. Li[1], A. T. Y. Chwang[1], P. L. Ho[2], W. H. Seto[3,] (2007) *How far droplets can move in indoor environments – revisiting the Wells evaporation–falling curve.*
- C.Y.H. Chao[a,*], M.P.Wanb, L.Morawskac, G.R.Johnsonc, Z.D.Ristovskic, M.Hargreavesc, K. Mengersend, S.Corbette, Y.Lif, X.Xief, D.Katoshevskig (2008) *Characterization of expiration air jets and droplet size distributions immediately at the mouth opening.*
- Hualing Zhang[a,b*], Dan Li[a,c], Ling Xiea, YiminXiao[a,b] (2015) *Documentary Research of Human Respiratory Droplet Characteristics.*
- Ciencewicki and Jaspers (2007) *Air Pollution and Respiratory Viral Infection.*
- A. Weber *et al.* (1993) *Aerosol penetration and leakage characteristics ofmasks used in the health care industry.*
- E.E. Sickbert-Bennet *et al.* (2020) *Filtration efficiency of hospital face mask alternatives available for use during the COVID-19 pandemic.*