Exposure assessment for airb

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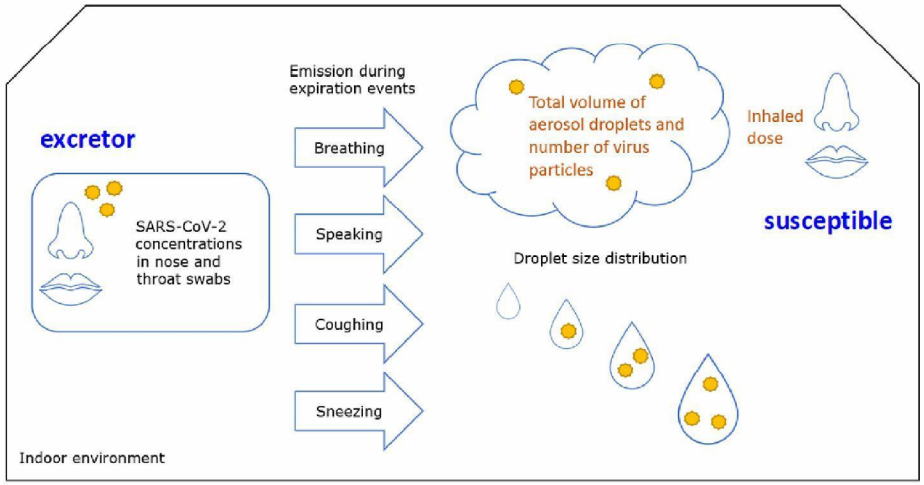
EA Airborne Transmission SARS-CoV-2

Aim and approach

Assess exposure to airborne SARS-CoV-2 particles from breathing, speaking, coughing and sneezing in an indoor environment.



Limitations

Nr of infectious viruses in the droplets is unkown
Infectious dose is unknown ($P_{exposure}$, not P_{inf})
complete & instant mixing is assumed

Scenarios

Expelling of virus by one infected person in all scenarios		
Abbreviation	Source	Reference of size distribution data
Breath	20 minutes breathing	Fabian et al. (2011)
Speak-Lo	20 minutes speaking	Asadi (2019)
Speak-Hi	20 minutes speaking	Duguid (1946)
Cough-Lo	One cough	Lindsley et al. (2012)
Cough-Hi	One cough	Duguid (1946)
Sneeze-Lo	One sneeze	Gerone et al. (1966)
Sneeze-Hi	One sneeze	Duguid (1946)

Exposure of one or more uninfected persons
One person in a bus for 20 minutes
Thirty persons in a bus for 20 minutes
Ten persons in a room for one hour
Ten persons in a room for four hours

Virus concentration in mucus 10^3, 10^4, 10^5, 10^6, 10^7, 10^8, 10^9, 10^{11} virus particles per mL

Dose *D* and probability of exposure P_{exp}

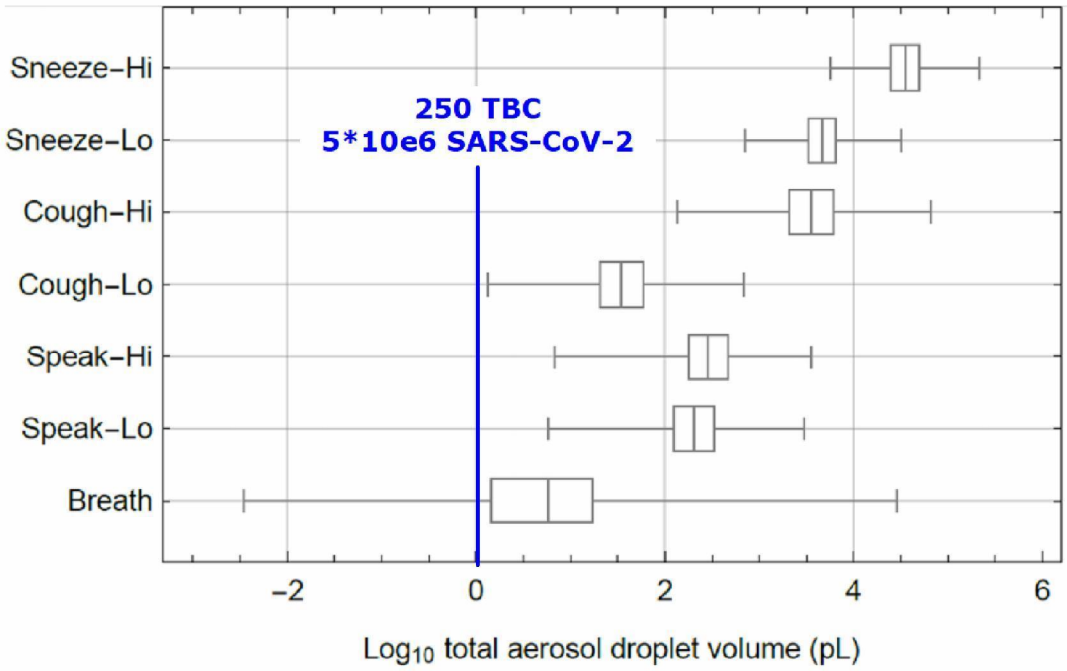
- $D \sim \text{Pois}\left(\frac{c v_{br,sp,co,sn}}{v_r} v_{inh}\, s\right)$

- *D = dose (number of inhaled virus particles*
- *C = virus concentration in mucus (numbers per ml)*
- $V_{br,sp,co,sn}$ *= total volume of aerosol droplets (initial diameter <60µm)*
- V_r = volume of the air in a room
- V_{inh} is inhalation rate (liter/minuut)
- *S* = sensitivity factor (can also be number of exposed persons)

- $P_{exp} = 1 - e^{-D}$

If D increases, P_{exp} closer to 1

If D is very small, P_{exp} closer to 0

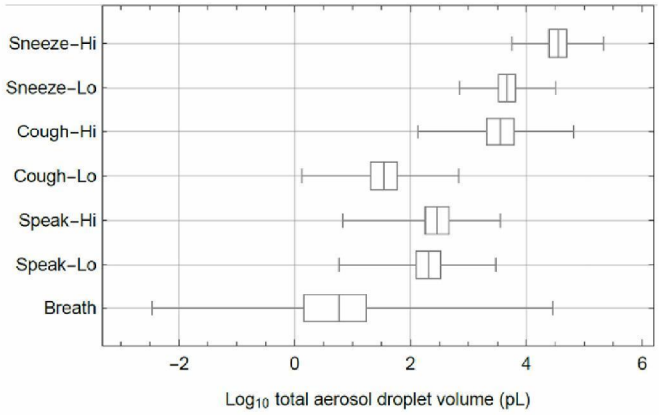

Sneeze–Hi
Sneeze–Lo
Cough–Hi
Cough–Lo
Speak–Hi
Speak–Lo
Breath
250 TBC
5*10e6 SARS-CoV-2
−2
0
2
4
6
Log10 total aerosol droplet volume (pL)

VARIATION

Probability of exposure, Pexp

Reference scenario (S =1)

- 1 person expels virus for 20 min by speaking or breathing, or 1 sneeze or cough
- 1 person in a bus for 20 min (V= 12 x 2.55 x 3.05 m^3 = 93 m^3)



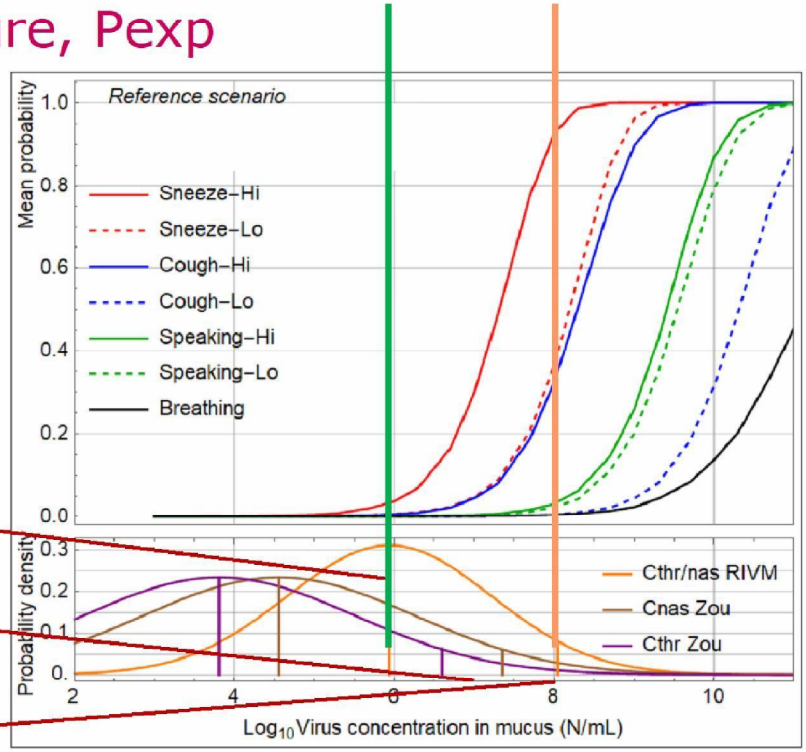
- $D \sim \text{Pois}(\frac{cv_{br,sp,co,sn}}{v_r} v_{inh}\, s)$
- $P_{exp} = 1 - e^{-D}$

Note: Inhalation (V_{inh}) is about 5-12 L/min, eg 300-700 L/h

Probability of exposure, Pexp

Mean Pexp in scenario 10^8/mL

Sneeze-Hi 93%
Sneeze-Lo 34%
Cough-Hi 32%
Speaking-Hi 3%
Speaking-Lo 2%
Cough-Lo 0.3%
Breathing 0.3%



Nasopharyngeal swab at Ct 25-26

50% ≥10^6/ml

20% ≥10^7/ml

Ct 18-19

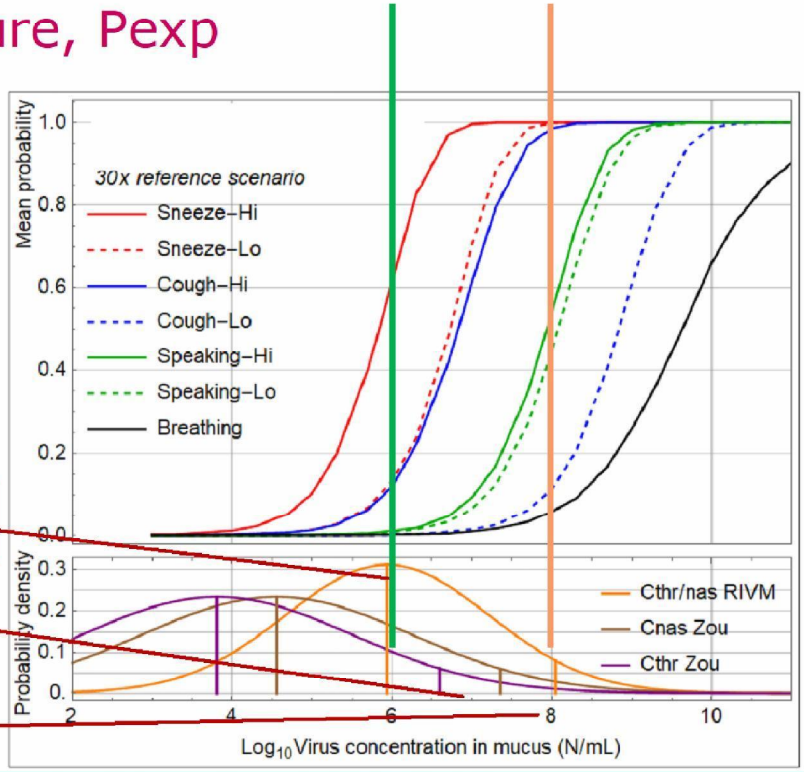
5% ≥10^8/ml

Probability of exposure, Pexp

- 1 person expels virus for 20 min.
- 30 persons in a bus for 20 min. (30x reference scenario, S=30)

- Mean Pexp in scenario 10^8/mL

  Sneeze-Hi 100%
  Sneeze-Lo 100%
  Cough-Hi 98%
  Speaking-Hi 55%
  Speaking-Lo 46%
  Cough-Lo 11%
  Breathing 6%



Probability of exposure, Pexp

- 1 person expels virus for 20 min.
- 10 persons in a meeting room for 1 hour
  (4x reference scenario, S=4)

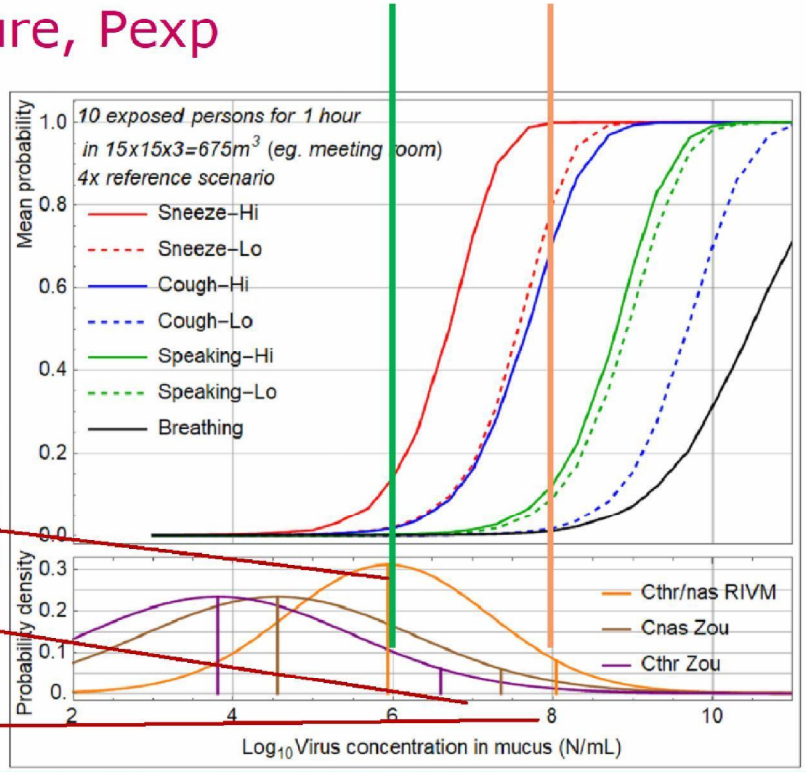
- Mean Pexp in scenario 10^8/ml

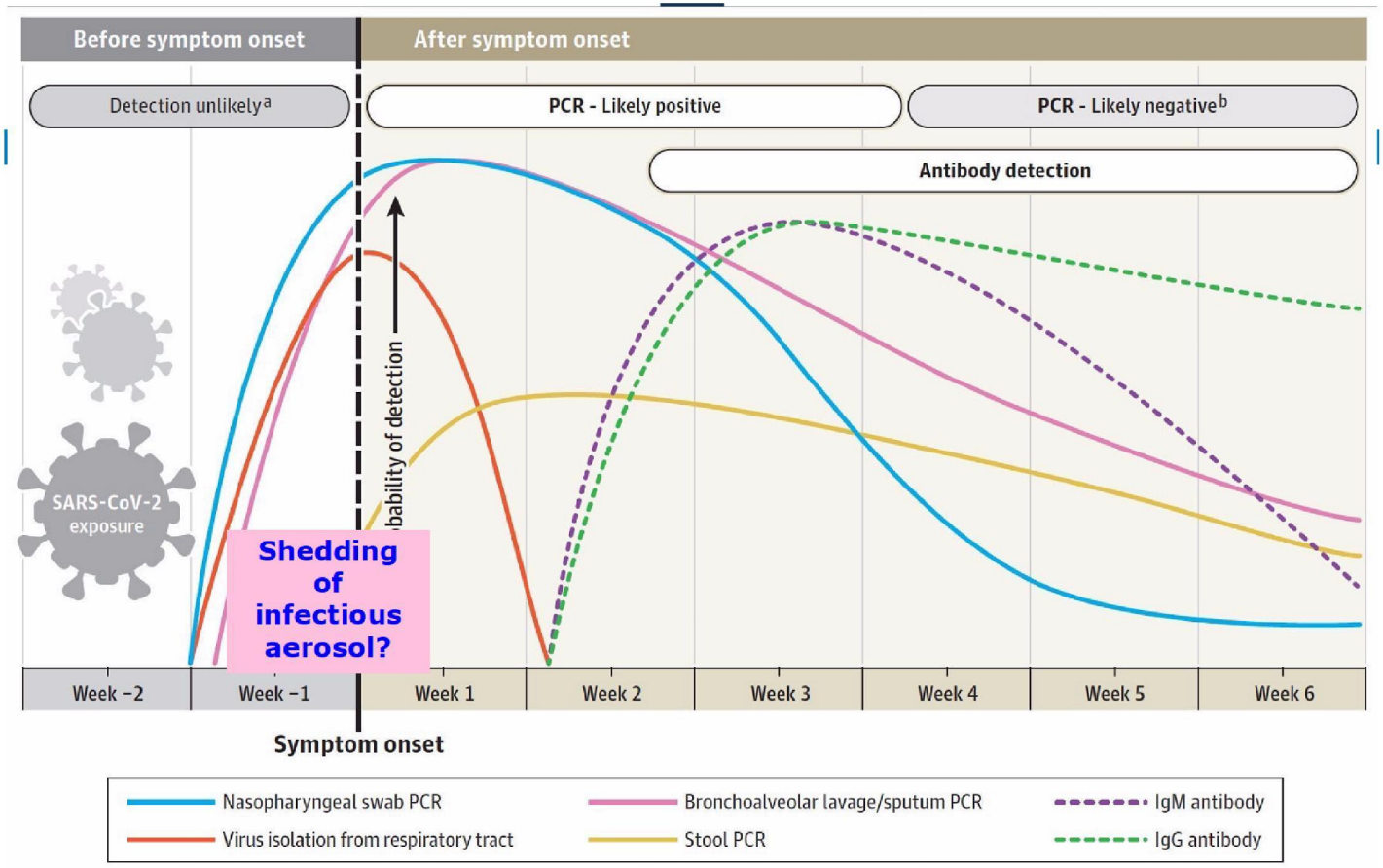
  Sneeze-Hi 100%
  Sneeze-Lo 80%
  Cough-Hi 71%
  Speaking-Hi 12%
  Speaking-Lo 9%
  Cough-Lo 2%
  Breathing 1%

50%
≥10^6/ml

20%
≥10^7/ml

5%
≥10^8/ml




Before symptom onset
After symptom onset
Detection unlikely[a]
PCR - Likely positive
PCR - Likely negative[b]
Antibody detection
SARS-CoV-2 exposure
Shedding of infectious aerosol?
Week −2
Week −1
Week 1
Week 2
Week 3
Week 4
Week 5
Week 6
Symptom onset
Nasopharyngeal swab PCR
Virus isolation from respiratory tract
Bronchoalveolar lavage/sputum PCR
Stool PCR
IgM antibody
IgG antibody

Conclusions

- **Size** distribution **and amounts** of **aerosol droplets** generated by breathing, speaking, coughing and sneezing **vary widely**.

- **Number of viruses expelled vary widely**

This study suggests:

- The average or low end excretor is unlikely to participate significantly in transmission of SARS-CoV-2 via aerosols
- High end excretors are very likely to transmit SARS-CoV-2 via aerosols

Aerosol transmission of SARS-CoV-2 is possible and cannot be ignored