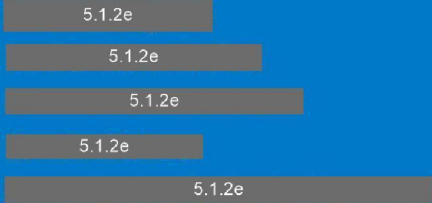


National Institute for Public Health  
and the Environment  
*Ministry of Health, Welfare and Sport*

# Risk assessment of SARS-CoV-2 transmission by aerosols in aircraft cabins

## CORSICA project





## Quantitative Microbial Risk assessment

- Data from measurements + simulations on particle numbers and sizes
  - Viral concentration data in mucus of infected individual
  - Inhalation volume
  - Flight duration
  - Mask wearing
  - DOSE FOR A RANGE OF SCENARIOS
- 
- Dose response model → for other human coronavirus
  - PROBABILITY OF ILLNESS FOR A RANGE OF SCENARIOS



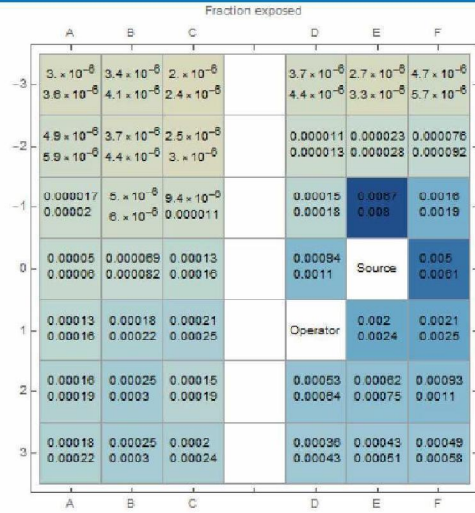
## First observations of the data

Measurement data:

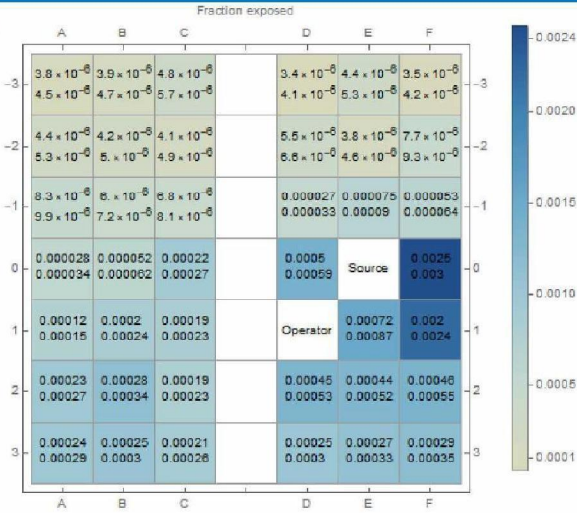
- A good and useful set of observations
- Aerosolized artificial saliva spreads several meters through aircraft cabin within minutes. Direction depends on aircraft type.
- Aerosolized artificial saliva concentration in air reaches a plateau within minutes
- After source is switched off, aerosol concentration declines to background level within minutes
- Likely due to high ventilation, 30 air changes per hour
- Concentration (aerosol volume / air volume) depends on distance



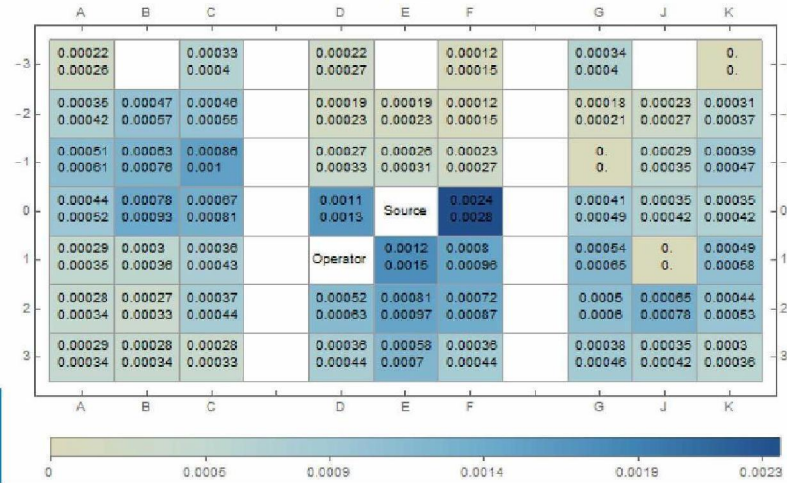
A320



B737



B787





## Risk calculations –assumptions (1)

- One index case (=source) was present in the aircraft, who was emitting aerosol droplets based on the particle emission profiles for breathing 80% of the time and breathing + speaking 20% of the time
- Number of virus excreted by source was based on RIVM data from nose/throat swabs (Monte Carlo samples log<sub>10</sub> mean 7.53, sd 1.28)
- The results pertain to the passengers seated on the 7 rows surrounding the index patient. The number of passengers per aircraft in case of full capacity is for the A320: 180; B737: 215; B787: 330.
- A supershedder: viral concentration in the mucus of 10<sup>10</sup> RNA copies / mL. RIVM data indicated that 2.7 % of the people infected with SARS-CoV-2 have concentrations of 10<sup>10</sup> RNA copies / mL or higher in their mucus (Schijven et al. 2021).



## Risk calculations – assumptions (2)

- Average flight duration is 0.9 hours for A320, 1.4 hours for B737 and 8.7 hours for B787.
- High (95<sup>th</sup> percentile) flight duration is 2.5 hours for A320, 3.6 hours for B737 and 11.1 hours for B787.
- Average taxi duration was estimated at 10 minutes, high taxi duration was estimated at 20 minutes. This refers to the time the engines are running and does not include boarding or disembarking time at the gate
- The typical time duration that masks are not worn (due to consumption of drinks, snacks and meals on board) was estimated at 10% of the flight duration
- Mask efficiency was based on literature (assuming 60% removal for the emission source, and 30% removal for inhalation by the receiver, so the fraction of aerosol passing the masks was  $(1-0.6)*(1-0.7)=0.28$ )



## Results – typical cruise flight + supershedder

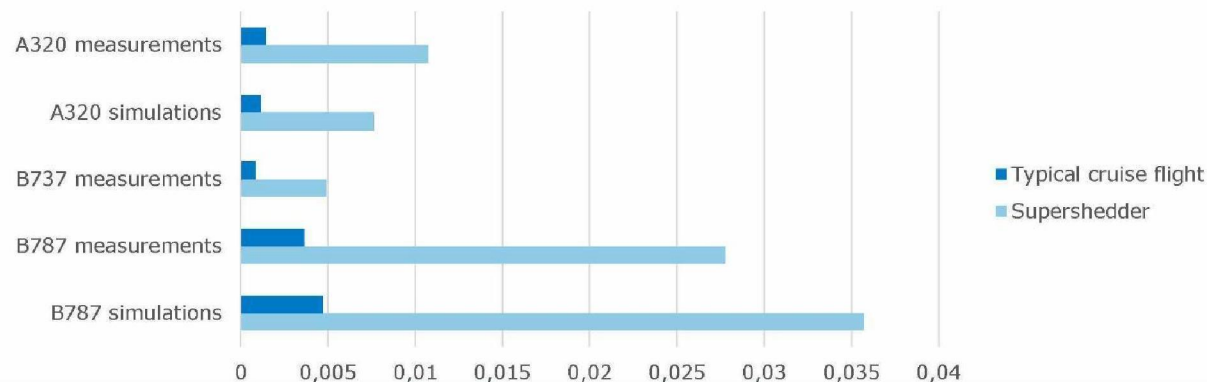
*What was the predicted risk of SARS-CoV-2 transmission via aerosols during typical cruise flight conditions?*

- Highest for the B787 (due to long typical flight duration)

*What if a supershedder was on board?*

- In the case that a supershedder was on board, risk of SARS-CoV-2 transmission may be considerably (5-10x) higher than for an 'average shedder'.

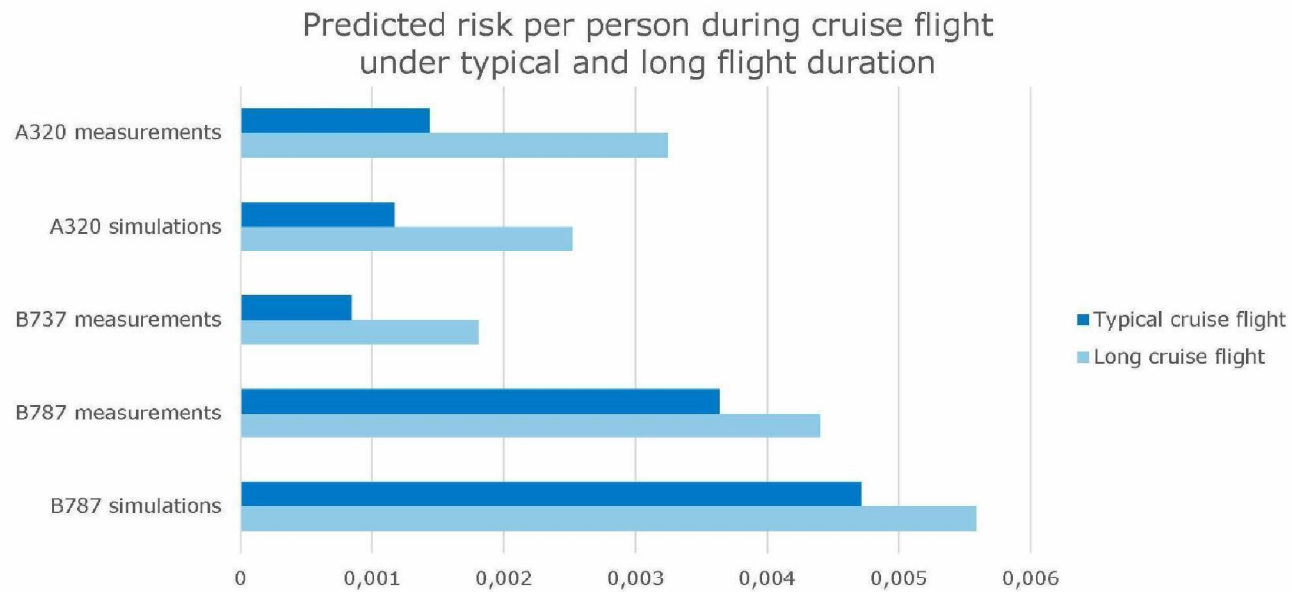
Predicted risk per person during cruise flight for a typical viral shedder and a supershedder as index patient





## Results – typical vs. long flight

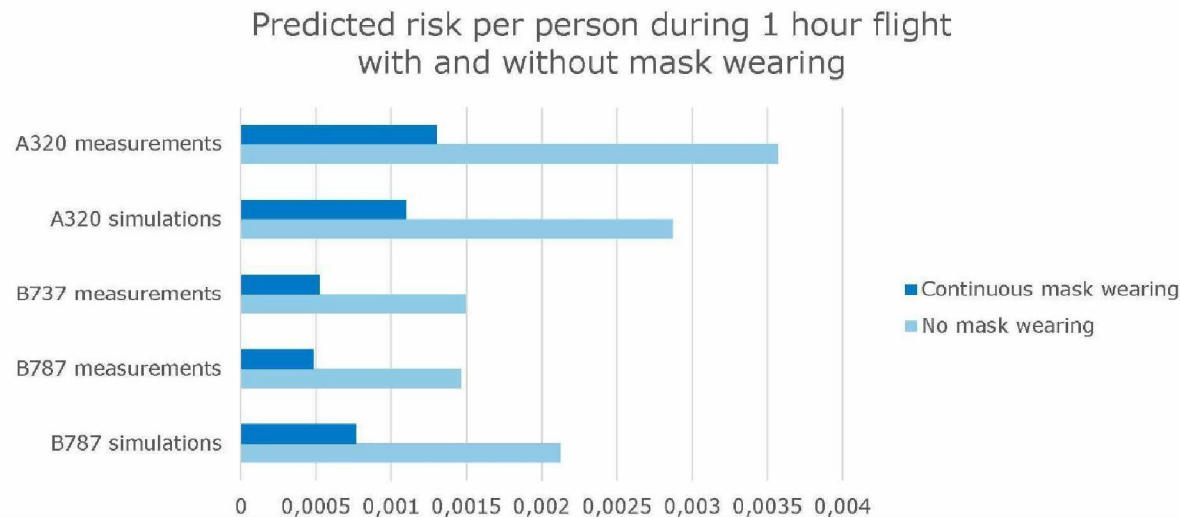
Risk increases with increasing flight time





## Results – 1 hour flight with and without mask

- *How do the three aircraft types compare per hour of cruise flight?*
- Predicted risk per hour is highest for the A320 aircraft
- *What is the effect of mask usage on board?*
- Risk during continuous mask wearing is predicted to be approximately a factor three lower than risk without any mask wearing (literature).

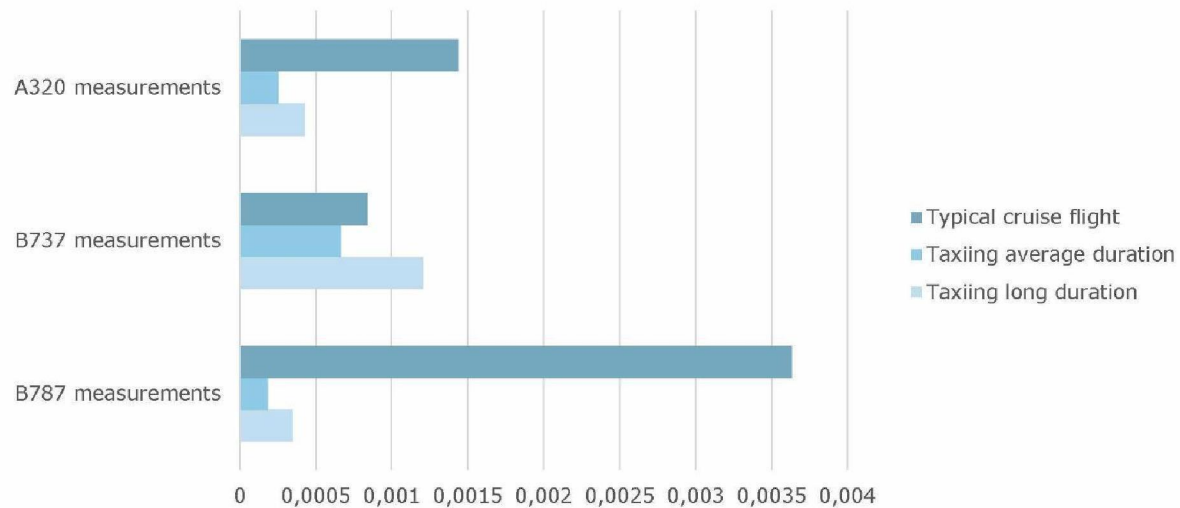




## Results - taxiing

- *What is the risk during taxiing?*
- Risk during taxiing appears to differ per aircraft type, with highest risk predicted for the B737

Predicted risk per person during typical cruise flight vs. taxiing (average and long duration)





## Discussion points

- There is variability and uncertainty in the data (averages shown)
- Not included:
  - The effect of coughing and sneezing
  - Other routes than aerosol route (e.g. ballistic droplets, fomites)
  - Moving index (e.g. infectious crew member) or multiple indices
  - Newer SARS-CoV-2 variants (e.g. British, Brazilian, South African), and the risk of introduction of new variants in the Netherlands (independent of risk of infection on board)
  - Other aircraft than the three tested
  - Risk for passengers outside the 7 rows



## Comparison (1) – Other aircraft studies

- Risk and exposure from other studies modelling / measuring in aircraft are comparable in order of magnitude
  - 5.1.2e et al. schatte op basis van modellering het gemiddelde risico voor typische scenario's en voor een 'super spreader' in dezelfde orde van grootte als onze studie
  - 5.1.2e et al. schatte op basis van simulaties, het gemiddelde risico op infectie per vlucht-uur voor een matig besmettelijke en voor een zeer besmettelijke index passagier in dezelfde orde van grootte als onze studie
  - Experimenteel bepaalde transfers in Kinahan et al. (TRANSCOM) lagen binnen een factor 3 van die bepaald in CORSICA
- Modelling for other (less ventilated) indoor spaces of similar size (Schijven et al. AirCoV2 tool)



## Comparison (2) – Examples of epidemiological evidence

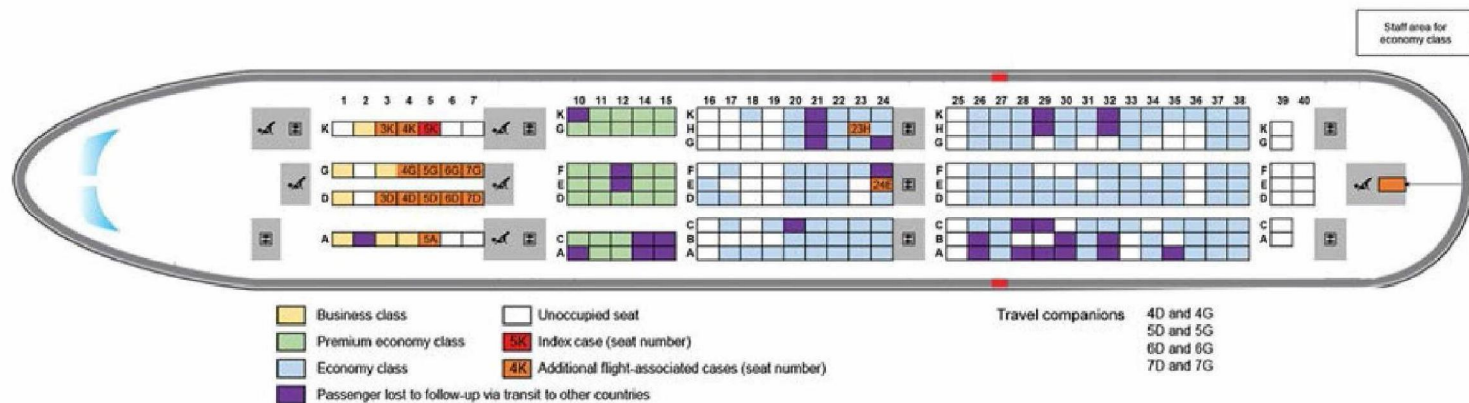
- 5.1.2e et al. 2020 <https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2020.25.42.2001624>
- Thirteen cases were passengers on the same flight to Ireland, each having transferred via a large international airport, flying into Europe from three different continents. Four of these flight cases were not seated next to any other positive case, had no contact in the transit lounge, wore face masks in-flight and would not be deemed close contacts under current guidance from the European Centre for Disease Prevention and Control (ECDC). Findings confirmed by phylogeny of virus variants.





## Comparison (3) – Examples of epidemiological evidence

- 5.1.2e et al. 2020 [https://wwwnc.cdc.gov/eid/article/26/11/20-3299\\_article](https://wwwnc.cdc.gov/eid/article/26/11/20-3299_article)
- Among the 16 persons (out of 217 passengers and crew) in whom SARS-CoV-2 infection was detected, 12 (75%) were passengers seated in business class along with the only symptomatic person (attack rate 62%). Seating proximity was strongly associated with increased infection risk (risk ratio 7.3, 95% CI 1.2–46.2). Flight without intervention measures such as masks, social distancing etc. Transmission among 1<sup>st</sup> class passengers or 2<sup>nd</sup> class passengers may have occurred during lounge stay, immigration passage or baggage claim.





## Conclusions (1)

- Good and useful set of observational data
- Aerosolized droplets from a source breathing / speaking in an aircraft travels several meters through cabin and the concentration reaches a plateau phase within minutes
- Concentration depends on distance and direction
- People seated in aircraft are exposed to a fraction of this aerosol cloud and can be exposed to SARS-CoV-2 virus via this route



## Conclusions (2)

- In case an infectious person does get on board there is a chance of virus transmission
- Therefore, control measures (triage, testing) that are targeted at preventing infectious people from boarding aircraft are necessary
- There is variability and uncertainty in the estimates
- Risk is higher with
  - Higher viral load of the source (supershedder)
  - Longer flight duration
  - No mask wearing
  - Aircraft type + taxiing:
    - > Typical flight duration: B787 highest
    - > Per hour: A320 highest
    - > Taxiing: B737 highest