Transmission Perspective on COVID-19 and the Future of Singing

Donald Milton, MD, DrPH / Professor / Institute for Applied Environmental Health
Wuhan
Timeline of Spread from Asymptomatic Patient 1 in Germany
Modes of Transmission?
Two ways to define droplets and particles that can carry respiratory viruses

Medical categories

• Respiratory droplets
  • Droplets that do not travel very far
  • Mode of inoculation unclear but generally not thought to be ‘inhaled’
  • Not considered “airborne infection transmission”

• Aerosols
  • Sometimes called droplet-nuclei
  • Less than 5 µm in diameter
  • Small enough to travel long distances and cause infection far from the source.
  • Considered the only cause of “airborne infection”

Pulmonary physiology – exposure science based categories

FIGURE 11.3  Predicted total and regional deposition for light exercise (nose breathing) based on ICRP deposition model. Average data for males and females.
Aerosol emission and superemission during human speech increase with voice loudness
Mechanism of Breath Aerosol Formation

- side view:
  - arrows show wall movement direction
  - contracting bronchiole
  - partially contracted bronchiole
  - fully contracted bronchiole with blockage
  - expanding bronchiole with stretched fluid blockage
  - aerosol from film burst is drawn into the alveoli

- cross section:
  - airflow
  - fluid lined space

Time

Johnson & Morawska, 2009
The Elusive Pathway
The Aerobiological Pathway for Transmission of Communicable Respiratory Disease

A: Source, B: Transport and Dispersion, C: Deposition

Modes of Transmission?

- Gesundheit-II exhaled breath sampler
- Fine aerosol = tiny particle suspended in air
- **Influenza virus is present in exhaled breath** – even without coughing.
Modes of Transmission?

Amoy Gardens SARS Outbreak 187 Cases

Infectious MERS-CoV in Hospital Corridor Air


Aerodynamic analysis of SARS-CoV-2 in two Wuhan hospitals

P. Y. Chia et al., *medRxiv*, 2020, doi: [10.1101/2020.03.29.20046557](https://doi.org/10.1101/2020.03.29.20046557).

### Aerosols in Containment Unit, Singapore

<table>
<thead>
<tr>
<th>Patient</th>
<th>Day of illness</th>
<th>Symptoms reported on day of air sampling</th>
<th>Clinical Ct value*</th>
<th>Airborne SARS-CoV-2 concentrations (RNA copies m^-3 air)</th>
<th>Aerosol particle size</th>
<th>Samplers used</th>
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<tr>
<td>1</td>
<td>9</td>
<td>Cough, nausea, dyspnea</td>
<td>33.22</td>
<td>ND</td>
<td>--</td>
<td>NIOSH</td>
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<td>SKC Filters</td>
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<td>1,384</td>
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<td>5</td>
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<td>1-4 μm</td>
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Transmission Potential of SARS-CoV-2 in Viral Shedding Observed at the University of Nebraska Medical Center

<table>
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<th>Location</th>
<th>Day</th>
<th>Hallway Air Samples (copies/L of air)</th>
<th>Personal Air Samples (copies/L of air)</th>
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Percent Positive 66.7% 100.0%

Evidence for probable aerosol transmission of SARS-CoV-2 in a poorly ventilated restaurant

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Influenza Virus Copy Number In Aerosol Particles Exhaled By Patients With And Without Wearing Of An Ear-loop Surgical Mask

Evaluation of the Filtration Performance of Cloth Masks and Common Fabric Materials

Skagit Choir Outbreak

- March 10, 2020
- “About 55 people (roughly one-half of the group) attended.”
- At the time of the rehearsal, there were no known cases in Skagit Valley, nor were any closures in effect.
- Notice to members: “Anyone showing any symptoms of illness, no matter the cause, should not attend rehearsals.”
- ~70% infection rate
- 0.5 air changes per hour estimated
- Increase to 9 air changes per hour would have reduced to 14% infected, if airborne transmission
Upper-room Germicidal UV (gUV) Light Air Sanitation