COVID-19, Air Pollution, and HVAC

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Four themes

1. Higher mortality rates for COVID-19 and SARS are associated with lifetime exposure to higher air pollution
2. What is the “Natural experiment” of lock-downs on air pollution telling us about sources and solutions for reducing air pollution?
3. Evidence of airborne transmission and aerosols
4. Reducing risks of airborne transmission in indoor environments and implications for heating, ventilation and air conditioning (HVAC)

1. Air pollution and novel coronavirus

- A small increase in long-term exposure to $PM_{2.5}$ (1 microgram per m^3) may have **increased the mortality from COVID-19 by 8%** in US (Wu et al., 2020 Apr 27 preprint)
- Correlation studies:
  - Higher air pollution suggested as co-factor for COVID-19 higher mortality rates in Northern Italy (Conticini et al., 2020)
  - 78% of more than 4,000 deaths in France, Italy, Spain, and Germany were in regions with the highest NO_2 concentrations (Ogen, 2020)
  - SARS patients in China from regions with high air pollution index (API) were twice as likely to die as patients from regions with low API (Cui et al., 2003)

2. Lock-down and air pollution

- Lock-downs in response to the pandemic curtailed vehicle travel and manufacturing, and commercial energy use dramatically reducing NO_2 emissions (a precursor for ozone and secondary aerosol)
- Some areas experienced increases in tropospheric ozone levels
  - Reduced levels of NO_x can lead to increases in tropospheric ozone
    - E.g. Wuhan China saw increase of O_3 by 25%; Delhi India saw a slight increase in O_3
- Some areas also saw decreases in particulate matter (PM) concentration
  - Wuhan saw decrease of $PM_{2.5}$ by 32.4% (compared to typical observations during the Lunar New Year) and by 43.5% (compared to climatological average)
  - Delhi saw a decrease of PM_{10} by as much 60% and $PM_{2.5}$ by 39%
- Other areas—like Beijing—saw an increase in PM as a result of meteorological influence (increased humidity, decreased wind speed and shift in wind direction, more stagnant air from a more stable boundary layer, and no precipitation to “wash out” pollution)

2. Lock-down and air pollution – lessons from "Natural experiment"

"Reductions in NO_x and SO_2 from traffic and manufacturing sectors have long been considered as the normal protocol in implementing regulatory policies. Our work shows that such a protocol achieves only limited effects on PM and ozone levels, without simultaneous emission controls from power plants and heavy industry, such as petrochemical facilities."

Le T., *et al.* (2020) *Unexpected air pollution with marked emission reductions during the COVID-19 outbreak in China*, SCIENCE, Online Advance Publication, 1–9.

3. Transmission pathways

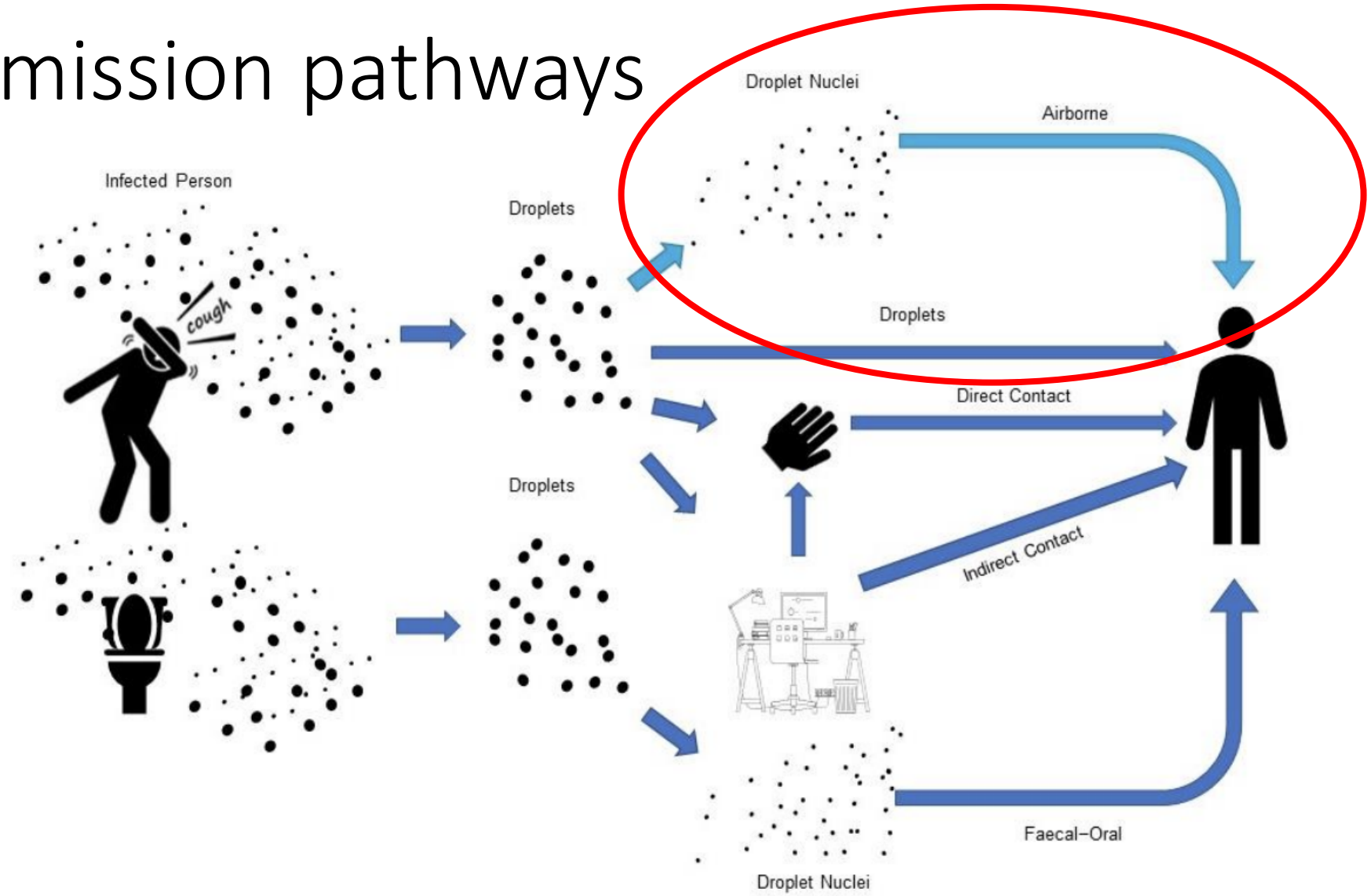
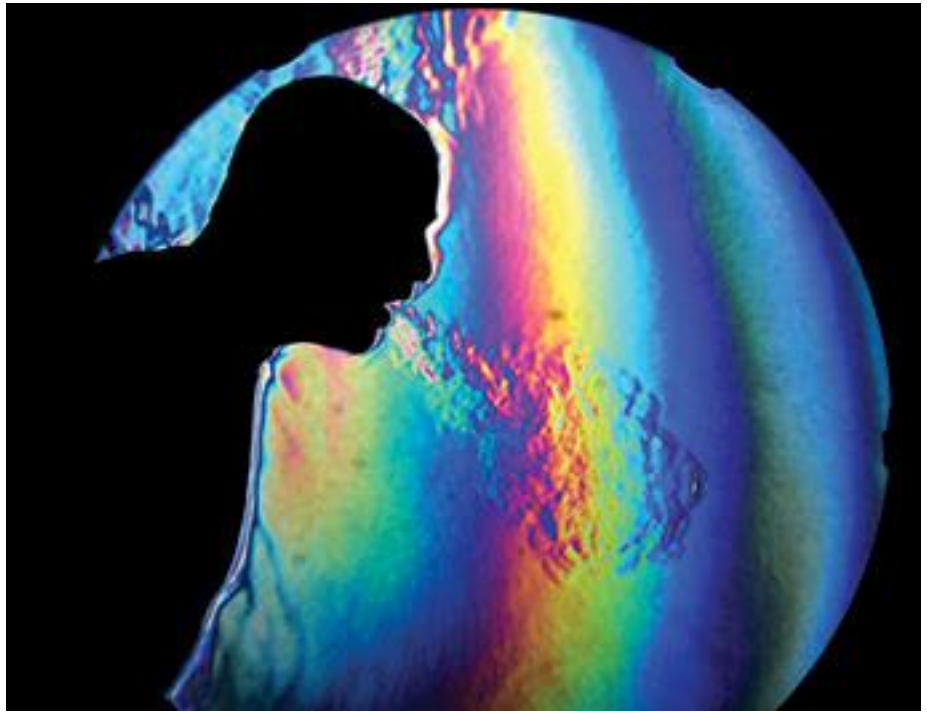


Figure 1. WHO reported exposure mechanisms of COVID-19 SARS-CoV-2 droplets (dark blue colour). Light blue colour: airborne mechanism that is known from SARS-CoV-1 and other flu, currently there is no reported evidence specifically for SARS-CoV-2 (figure: courtesy Francesco Franchimon).

3. Evidence of airborne transmission and aerosols



- Mounting evidence that aerosol transmission can occur as a SARS-CoV-2 transmission route (Guangzhou, CHN restaurant; Skagit Valley, WA choir rehearsal; hospital air sampling multiple studies)
- SARS-CoV-2 RNA detected on particulate matter aerosols (Setti et al., 2020)

"In the best ventilated room, after 30 s the number of droplets had halved, whereas with no ventilation this took about 5 min, in agreement with the air drag calculation that shows that 5 µm drops from the average cough or speech height take 9 min to reach the ground. In a poorly ventilated room, the number of droplets was halved in 1.4 min." Somsen, et al. "Small Droplet Aerosols in Poorly Ventilated Spaces and SARS-CoV-2 Transmission." *The Lancet. Respiratory Medicine* 8, no. 7 (July 2020): 658–59. https://doi.org/10.1016/S2213-2600(20)30245-9.

4. HVAC and reducing indoor transmission risk

- Preliminary evidence indicates airborne transmission risk is increased in indoor environments with no or limited ventilation or air filtration
- ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) and REHVA (the Federation of European Heating, Ventilation and Air Conditioning Associations) have issued guidelines for increasing ventilation with outside air and avoiding recirculation to increase effective dilution per person and enhancing air filtration
- Increased ventilation and finer filtration require additional energy from HVAC systems

More resources: https://betterbuildingssolutioncenter.energy.gov/covid19

ASHRAE guidelines

- ASHRAE's statement on operation of heating, ventilating, and air-conditioning systems to reduce SARS-CoV-2/COVID-19 transmission

  Ventilation and filtration provided by heating, ventilating, and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk of transmission through the air. Unconditioned spaces can cause thermal stress to people that may be directly life threatening and that may also lower resistance to infection. In general, disabling of heating, ventilating, and air-conditioning systems is not a recommended measure to reduce the transmission of the virus.

- ASHRAE Position Document on Infectious Aerosols (14 April 2020)
  - "Based on risk assessments, the use of specific HVAC strategies supported by the evidence-based literature should be considered, including the following:
    - Enhanced filtration (higher minimum efficiency reporting value [MERV] filters over code minimums in occupant-dense and/or higher-risk spaces)
    - Upper-room UVGI (ultra violet germicidal irradiation) with in room fans as a supplement to supply airflow
    - Local exhaust ventilation for source control
    - Personalized ventilation systems for certain high-risk tasks (Evidence Level B)
    - Portable, free-standing high-efficiency particulate air (HEPA) filters
    - Temperature and humidity control"

REHVA guidelines

- REHVA COVID-19 Guidance Document (3 April 2020)
  - Increase air supply and exhaust ventilation
  - Use more window airing
  - Humidification, air-conditioning, and dust cleaning have no practical effect
  - Safe use of heat recovery sections
  - No use of recirculation
  - Change of outdoor air filters not necessary
  - Room air cleaners can be useful in specific situations
  - Toilet lid use instructions
- Recommendations presented in WHO document, Getting workplaces ready for COVID-19.