



ARCHITECTURAL
ENGINEERING

INFECTIOUS AEROSOLS AND IMPACT OF COVID-19 ON HVAC SYSTEMS

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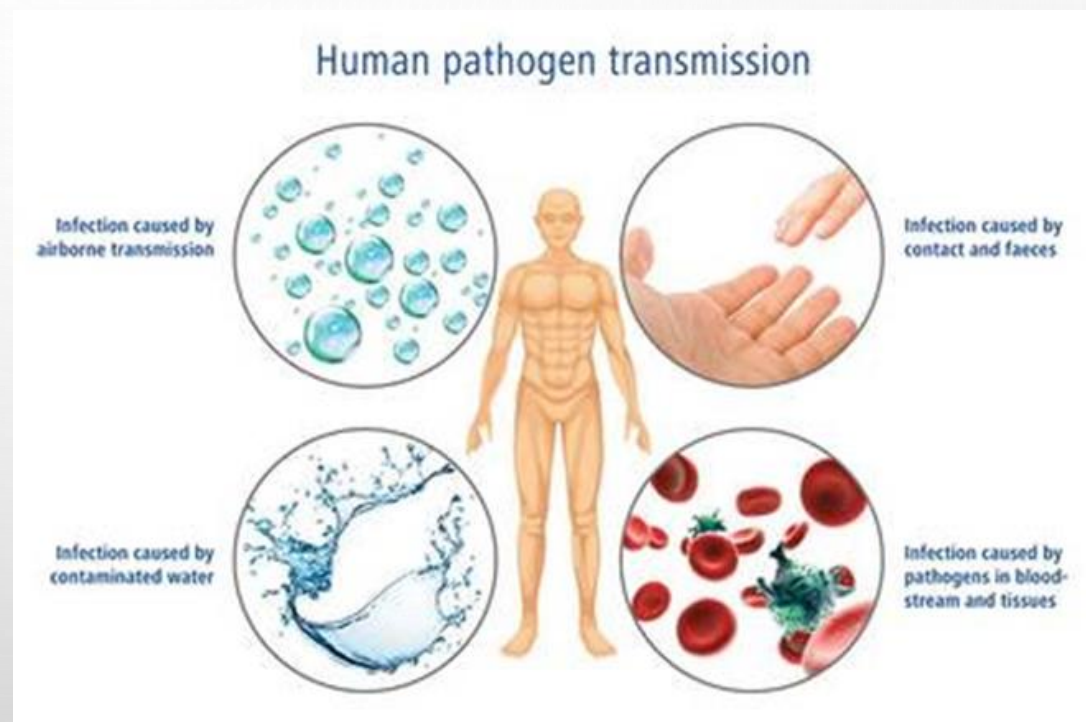
KEY POINTS

- Modes of infectious disease transmission
- Airborne/aerosol transmission of COVID-19
- HVAC systems and COVID-19
- HVAC systems and the future epidemics

INFECTIOUS DISEASE TRANSMISSION MODES

- Airborne
 - Large droplet/short range
 - Aerosol
- Fomite – intermediate surface
- Water/food
- Physical contact
- Insect/animal vector

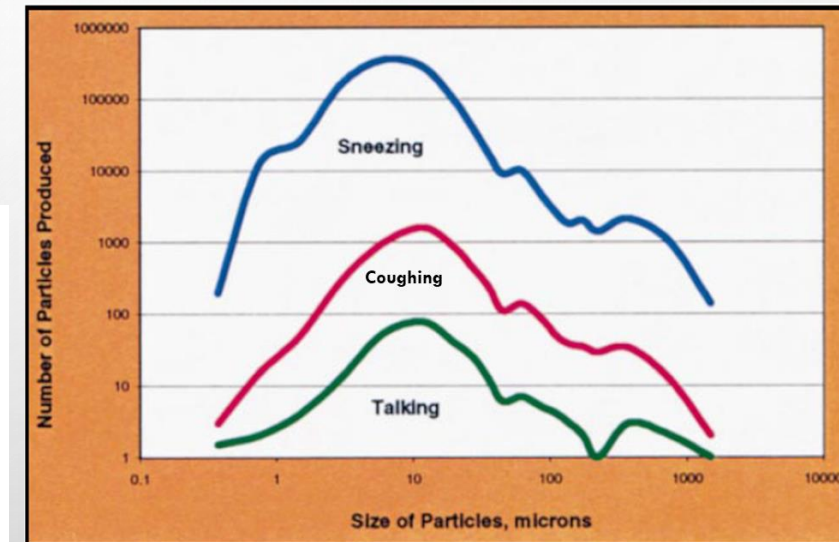
...HVAC mainly impacts aerosol and fomite transmission – only part of a solution



bode-science-center.com

PRODUCTION OF INFECTIOUS AEROSOLS

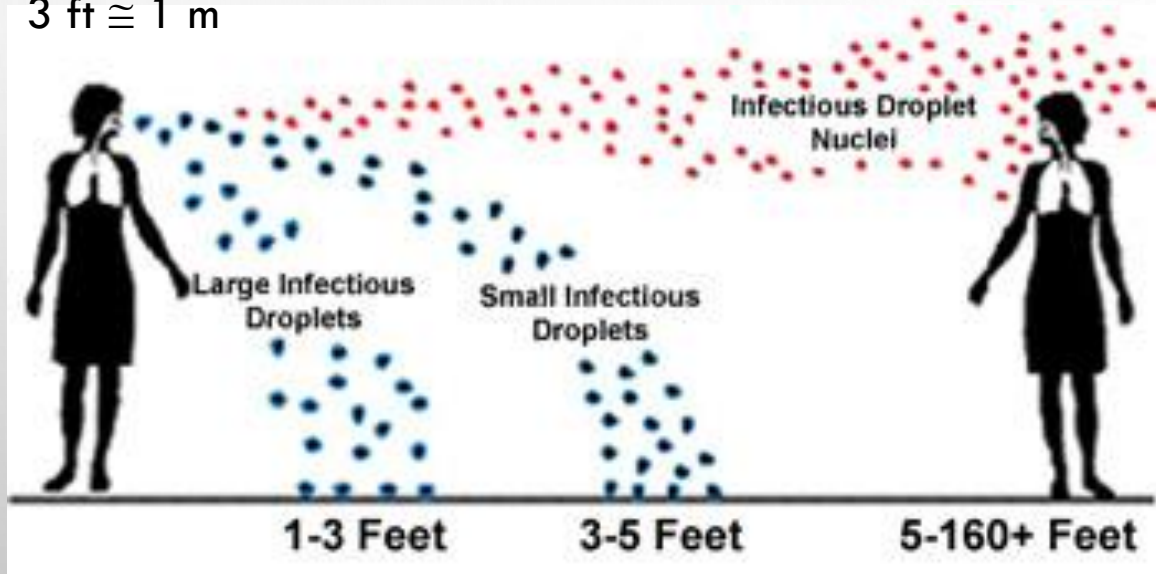
- Breathing, talking, singing, coughing, sneezing produce aerosols that may contain pathogens with a wide spectrum of sizes
- Although viruses like SARS-CoV-2 are very small ($O(100 \text{ nm})$), they typically exist in droplets and droplet residues
- Multiple recent studies find that more than 50% of shed viruses are in particles $<5 \mu\text{m}$



Duguid, et al. 1945

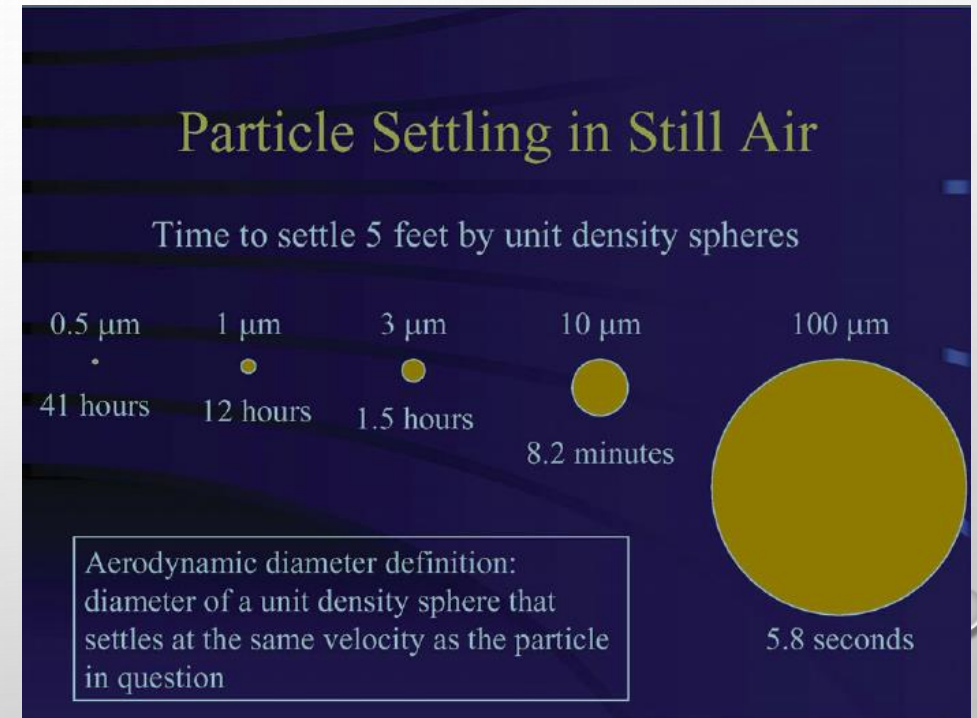
MANY RESPIRATORY PARTICLES CAN REMAIN AIRBORNE FOR HOURS, SARS-CoV-2 CAN SURVIVE FOR HOURS IN AIR

3 ft \cong 1 m



ASHRAE Position Document on Infectious Aerosols

Building Energy Issues and the COVID-19 Response

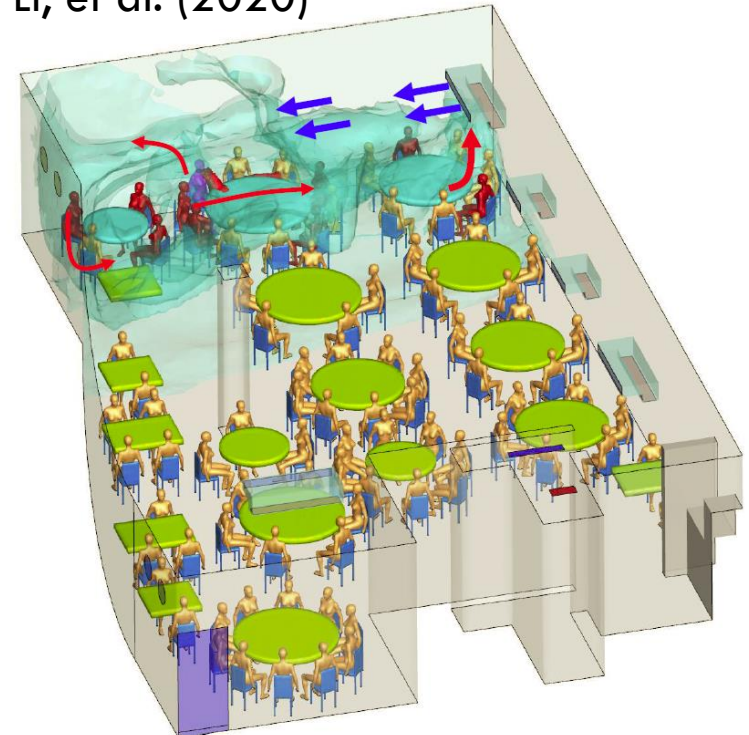


ASHRAE Position Document on Infectious Aerosols

CIRCUMSTANTIAL CASE FOR AEROSOL TRANSMISSION OF COVID-19 SEEMS STRONG, BUT PUBLIC HEALTH ORGANIZATIONS HAVE HIGH STANDARDS OF PROOF

- SARS outbreak associated with aerosol transmission through plumbing, within buildings, between buildings at Amoy Gardens
- Multiple “community spread” incidents with COVID-19, some investigated more thoroughly than others (e.g., Guangzhou restaurant)
- However, definitive data on source strength, infectious dose are not available yet
- If there is aerosol transmission, HVAC systems have potential to increase or decrease risk

Li, et al. (2020)



<https://www.medrxiv.org/content/10.1101/2020.04.16.20067728v1>

ASHRAE'S POSITION IS CONSERVATIVE

(LIKE MANY OTHER ORGANIZATIONS)

AIRBORNE TRANSMISSION

Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of heating, ventilating, and air-conditioning systems, can reduce airborne exposures.

OPERATION OF HVAC SYSTEMS

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.*

Source: [ashrae.org/covid19](https://www.ashrae.org/covid19)

IMPACTS OF COVID-19 ON HVAC

- “Healthcare” mindset suddenly applicable to all facilities...mostly not designed to implement it
- In the short term, limited repertoire of engineering/environmental controls to complement social distancing, hand hygiene, personal protective equipment
- Some measures...
 - increase energy use and cost
 - are expensive to implement
 - have potential to compromise operations or damage building and systems...implementation of high level guidance implies (demands) competent technical assistance

POSSIBLE HVAC OPERATIONAL CHANGES

- More outside air (ventilation)
 - Air flow control (pressurization -clean to less clean)
 - Enhanced filtration
 - Air disinfection (UVGI or?)
 - No recirculation (? – depends on multiple factors)
 - Humidification (? – mixed evidence, confirmation bias)
- Issues
 - Grasping at straws
 - The Devil is in the details – the problems of high-level/generic guidance
 - Lack of prioritization – must have vs. good to have
 - Today - protection is everything; Tomorrow – weighting of energy use, cost, cost-effectiveness will (should) increase
 - Still don't know what good IAQ is, especially with respect to microbial exposures

POST-PANDEMIC HVAC

- Changes to standards
 - Emphasis on health in non-healthcare standards
 - Higher bar for IAQ that presents challenges with respect to energy goals
 - Resilience as a fundamental design parameter
- Many research needs
 - IEQ criteria
 - Alternatives to ventilation that are less energy intensive
 - Flexible system operation
 - Monetization of benefits of infection control measures outside healthcare settings – epidemic response measures have every-day benefits