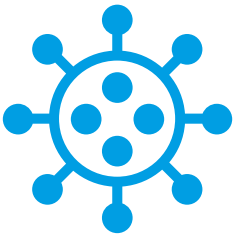
DROPLETS AND AEROSOL – AIRBORNE TRANSMISSION OF COVID-19

An examination of possible methods to reduce the risk of aerosol transmission in buildings.



Our understanding of COVID continues to evolve. Health and safety plans and procedures we worked hard to establish early in the pandemic need to be modified to account for changing knowledge. Perhaps the most substantial, and most confusing, development has been the recognition that the SARS-CoV-2 virus can exist as an "aerosol" with the possibility of airborne transmission of disease. The following provides a brief explanation and suggestions for how to reduce the risk of aerosol transmission.

Droplets and aerosol

Earlier in the pandemic it was believed that transmission of COVID-19 was almost exclusively through droplets. Droplets can transmit disease by close personal contact or by settling on, and contaminating, nearby surfaces. The push for social distancing and enhanced cleaning protocols was driven by this understanding.

The terminology can be confusing and is often misleading. Aerosols are just very small droplets. There is debate over what size is considered an aerosol but for simplicity we will refer to "aerosols" as smaller than droplets and "airborne" meaning it suspends in the air longer and travels further.

A January 24, 2019 lunch service in a restaurant located in Guangzhou started events that would change our understanding of the transmission of COVID-19. An outbreak of 10 people from three different families was traced back to this restaurant. The families were in the restaurant at the same time, but some did not come within 2 meters of the person who had the virus. The configuration of the restaurant was studied, and it appeared that air currents from a wall mounted air conditioning unit caused the virus to travel further than would be expected by droplet transmission alone. This was an indication that aerosol transmission was in play. [1] There have since been numerous other reports of the virus being transmitted further than 2 meters including through choirs in Washington State, France and Germany. Other studies have been completed that detected viral particles in the air in and outside of hospital rooms of COVID-19 patients. These studies are important indicators that the virus can remain airborne and travel some distance from an ill person, but it remains unclear how much airborne virus is necessary to start an infection in a healthy, but susceptible, person. [2]

Implications of airborne transmission

The implication of airborne transmission is that the virus could travel further and might accumulate in air within rooms with poor ventilation, and that the physical distances usually recommended (6' in the US, 3' elsewhere) may not be sufficient to reduce risk of infection. We often look at exposures as "near field" and "far field". Near field exposures are closer to the source therefore contain higher concentrations of both aerosols and droplets. Far field exposures – which contain aerosols only and at lower concentrations but with inadequate ventilation and/or longer exposure duration – can result in disease transmission.

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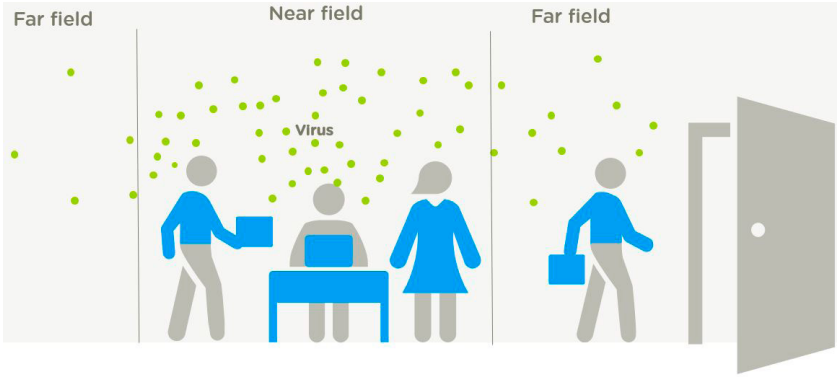
[1] Lu, J, Gu, J, Li, K, Xu, C, Su, W, Lai, Z, . . . Yang, Z. 2020. COVID-19 Outbreak Associated with Air Conditioning in Restaurant, Guangzhou, China, 2020. Emerging infectious diseases 26(7).

[2] Lednicky, J, Lauzardo, M, Hugh Fan, Z, Jutla, A...Wu, C. 2020. Viable SARS-CoV-2 in the air of a hospital room with COVID-19 patient. https://www.medrxiv.org/content/medrxiv/early/2020/08/04/2020.08.03.20167395.full.pdf

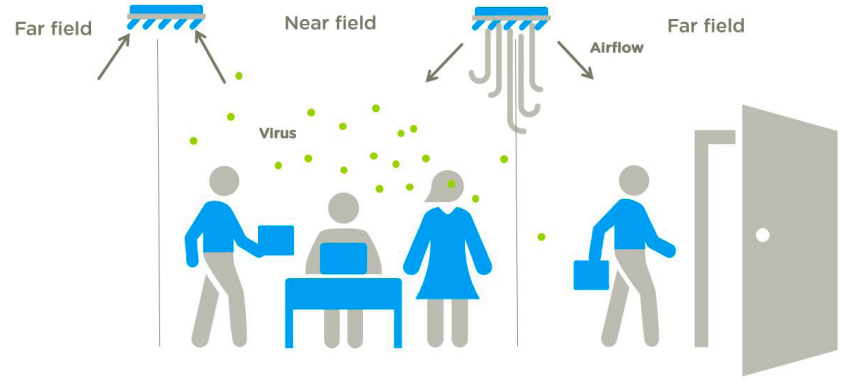
Consider standard shared office space. If the space has poor ventilation and someone with the virus is working in the space then it is possible that the amount of viral matter in the air may increase over time, creating higher risk of exposure to others in the area.

Airborne transmission (aerosols) may accumulate in poorly ventilated space

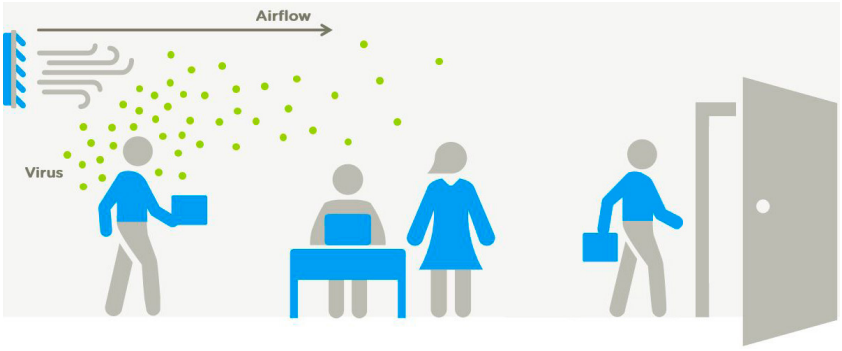


If the same space has a centralized ventilation system capable of continuously bringing in outdoor air, then accumulation of viral matter in the air could be reduced by dilution, reducing risk to others.

Ventilation provides dilution reducing accumulation



Avoid directional airflow across people



There are still things we do not know. We currently don't know exactly how far aerosols travel, how long they remain infectious in the air, what the definition is for "good" ventilation when controlling airborne disease in non-healthcare buildings, and how much virus at what concentration is necessary to cause infection in a susceptible person.

Ventilation and protection

Though there is evidence that maintaining good distancing, wearing quality face coverings and practicing good hand hygiene can reduce risk of infection with SARS-CoV-2, these measures need to be reevaluated as new information comes to light. Guidelines often imply face coverings are not needed if distancing is maintained, but how far apart is far enough? If airborne transmission is an important factor, as seems likely, and if the virus can travel further than two meters and possibly accumulate in the air of a room, then ventilation rises in importance as a control measure to supplement distancing and face coverings.

There are a number of technologies being promoted to inactive SARS-CoV-2 in air to control airborne transmission. Many of these are appropriate and may reduce risk of disease in certain situations, while others provide much less risk reduction. As illustrated above, we are most concerned about virus in the air space within a room. There are currently no reported outbreaks where COVID-19 has been transmitted from one room to another through a ventilation system. While we spend time studying alternative approaches to inactive the virus in air, we should not ignore one of best strategies to reduce contaminant levels in a room: bringing in outdoor air for dilution.

The concept of bringing in outdoor air to prevent disease has been around for hundreds of years, but as buildings have become more complex so has this relatively simple concept. Modern office buildings frequently have centralized ventilation systems that pull in outdoor air from intakes rather than using functional windows. Heating or cooling air requires energy, so buildings are often programmed to reduce the amount air brought in when outdoor temperatures are too hot or too cold. Some buildings do rely on opening windows to provide outdoor air. This is fine when outdoor temperatures cooperate. It would not be surprising if we come to find that increase of disease correlates with inclement weather-when people congregate indoors, and windows are closed, or the ventilation systems bring in less outdoor air.

The World Health Organization (WHO) recommends opening windows and increasing the amount of outdoor air brought into an HVAC system, potentially as high as 100%. [3] The Center for Disease Control and Prevention (CDC) recommends increasing outdoor air as much as possible, potentially as high as 100% and refers the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) for further guidance. [4] The ASHRAE guidance referenced by the CDC is a bit more nuanced stating that outside air should be increased as much as the ventilation system can accommodate and still maintain acceptable indoor conditions. [5] The fact is, many ventilation systems cannot operate at 100% outdoor air. There are times when cold air could freeze mechanical components or too much warm, moist outdoor air could result in condensation and mold growth. Another consideration is 100% outdoor air may not be enough if a ventilation system is undersized or could be too much if it is a large unit for a sparsely populated space.

Ideally, an HVAC engineer should be consulted to review the ventilation systems design, controls and operating parameters. While it is understood that it may not be practical to perform detailed study of each building and each HVAC zone in a building, measuring concentrations of carbon dioxide gas may provide an idea if the amount of outdoor air being brought into a space is sufficient for the number of occupants. The engineer also may perform tests on the system that measure the volume of outdoor air being brought

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[3] World Health Organization; Q&A Ventilation and air conditioning in public spaces and buildings and COVID-19 https://www.who.int/news-room/q-a-detail/q-a-ventilation-and-air-conditioning-in-public-spaces-and-buildings-and-covid-19 accessed August 13, 2020

[4] Center for Disease Control and Prevention (CDC); COVID-19 Employer Information for Office Buildings https://www.cdc.gov/coronavirus/2019-ncov/community/office-buildings.html accessed August 13, 2020

[5] ASHRAE General Recommendations https://www.ashrae.org/technical-resources/commercial#general accessed August 13, 2020

into parts of the building accounting for fluctuations and apply seasonably appropriate settings. Nevertheless, while there are guidelines for general indoor air quality there is no accepted definition of “adequate” ventilation as it relates to transmission of COVID-19. It may be that guidelines established by indoor air quality organizations for acceptable carbon dioxide concentrations can serve as a screening tool to help define adequate ventilation.

Carbon dioxide is generated by human respiration. More people and heavier breathing in a space generates more carbon dioxide. If the amount of outdoor air is insufficient, concentrations of this gas will increase. Conversely, if there is sufficient outdoor air, carbon dioxide will be diluted and concentrations will stay relatively low. . . In theory, carbon dioxide is a good screening tool that can be used to determine if a more detailed assessment of a building is needed. The relationships between air dilution, viral concentration, and infectivity remain to be defined, however.

Expert support
Ramboll’s Health Sciences and Building teams include engineers, industrial hygienists, epidemiologists and toxicologists who are monitoring the emerging science to understand COVID-19 and mitigate risks of infection with SARS-CoV-2. We are prepared to answer questions and assist with managing these risks, as well as other potential concerns, during these unprecedented times.

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