Office of the Prime Minister's Chief Science Advisor
Kaitohutohu Mātanga Pūtaiao Matua ki te Pirimia

Is SARS-CoV-2 airborne?

14 May 2020 – prepared under urgency

At a glance

- Aerosols are small particles of fluid that can be produced by activities such as talking and breathing.
- Coughing and sneezing can also produce aerosols, alongside a mixture of larger particles called droplets.
- Droplets contaminate surfaces within 1.5–2m while aerosols remain airborne for longer and can spread further.
- An airborne virus is said to be one that can be transmitted via aerosols as well as droplets.
- Emerging evidence, especially from laboratory studies, suggests SARS-CoV-2 could be transmitted by aerosols and so could be 'airborne'.
- But studies outside labs have not conclusively shown airborne, infectious SARS-CoV-2.
- While airborne transmission is possible, touching contaminated surfaces and droplet exposure via close contact are the most important transmission routes.
- Physical distancing and good hand hygiene are the most important interventions to stop the spread.

What does airborne transmission mean?

Airborne transmission of a respiratory virus occurs when the virus is spread from person to person over time and distance by small particles in the air called aerosols. When an aerosol is produced by a living organism it is called a bioaerosol.

Droplets vs aerosols

We know that SARS-CoV-2 is spread via droplets: tiny spheres of mucus, water and virus that are emitted from the body by coughing and sneezing. While inside the droplet, the virus is protected from drying out and even a fragile virus remains infective. Droplets are too heavy to travel very far– usually about one metre. This is the reason for the 1.5–2 metre physical distancing recommendation and the focus on cleaning surfaces.

Coughing and sneezing also produces smaller particle called aerosols (or sometimes 'droplet nuclei'). Aerosols remain in the air longer and travel further than droplets but evaporate quickly, exposing and even inactivating fragile virus particles.[1] However, the extent to which SARS-CoV-2 can survive and travel in aerosols remains contentious.

Why is there debate?

Part of the debate comes down to definitions: technically, 'airborne' refers to aerosol (<5µm diameter) transmission. However from a layperson's perspective, the term may be understood as droplets travelling through the air.[2] The aerosol-droplet distinction impacts the distance the virus can spread and influences public health guidelines, including the type of personal protective equipment (PPE) that should be used.

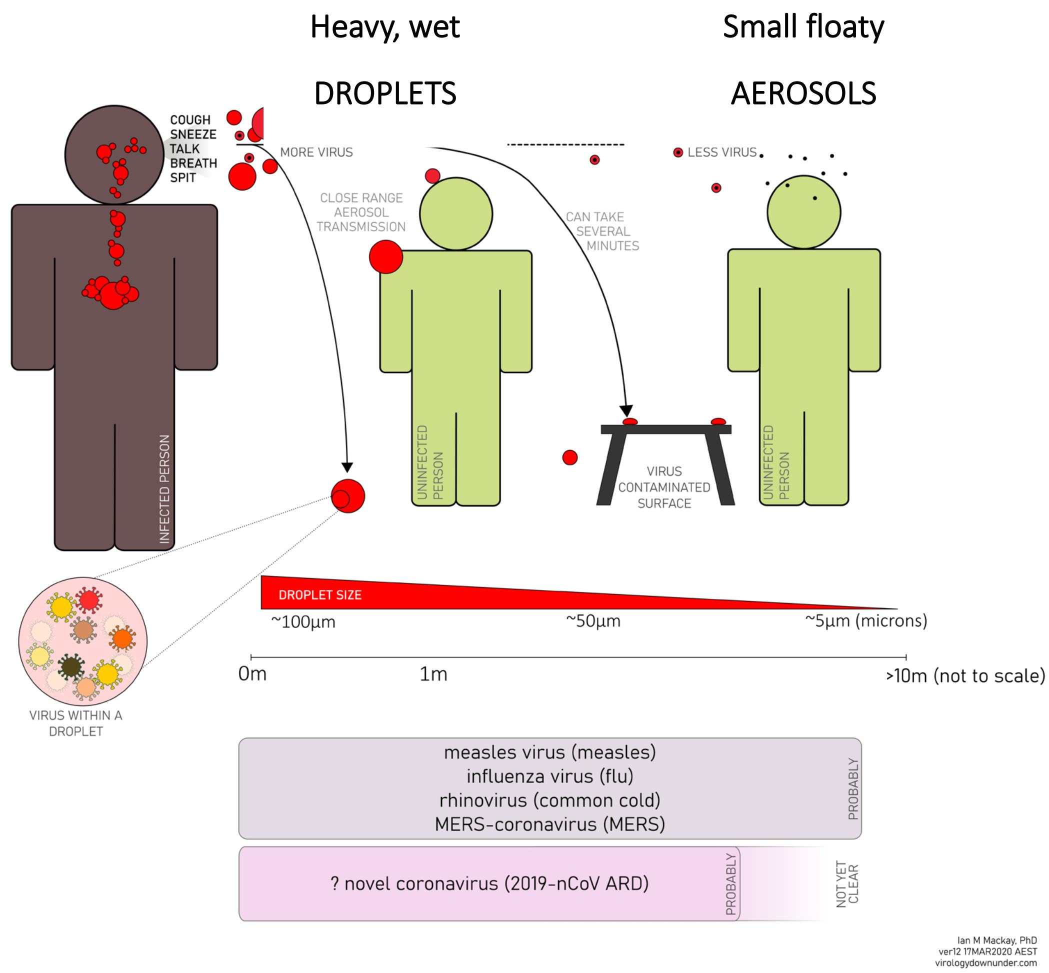

Figure 1: Diagram showing the difference between droplets and aerosols. Adapted with permission from Ian M Mackay PhD/Virology Down Under.

In fact, viruses do not always fall neatly into 'aerosol' and 'droplet' categories.[3] They exit the human body in a mixture of droplets and aerosols which can travel and linger for varying distances and times. While sneezing and coughing produce droplets and aerosols, talking and breathing are likely to only produce aerosols.[4] Some procedures performed in hospitals, such as intubation, also have a high chance of producing aerosols.[5]

Aerosol transmission has come to public attention because the US National Academies of Sciences, Engineering and Medicine wrote to the White House on April 1, stating that bioaerosol transmission of SARS-CoV-2 was possible based on current evidence.[6] However, they also noted that a variety of individual factors and circumstances (e.g. confined vs well-ventilated environments) contribute to the importance of different transmission routes.

The progression of the current pandemic suggests that SARS-CoV-2 transmission is mostly by droplets with infection occurring as a result of close contact and/or interaction with contaminated surfaces.[7]

What about other respiratory viruses?

Influenza: airborne transmission has been implicated in a 2011 epidemic of swine flu.[8] Further, one study of people with influenza found that nearly 40% of people exhaled aerosols.[9] However, ongoing studies of transmission routes for influenza viruses return conflicting results.[10, 11] The route of influenza transmission is dependent on the host and environmental conditions, and different routes predominate in different settings.[2] The SARS-CoV-2 virus may be similar to influenza in this regard.

Coronaviruses: there is evidence that the related coronaviruses that cause Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) can both be transmitted via aerosols.[12, 13]

What environmental studies show: no conclusive evidence yet

In February 2020, a WHO analysis of more than 75,000 cases in China did not find evidence of airborne transmission.[14] However, it is possible that airborne transmission is occurring in some circumstances (see discussion of influenza transmission above).

Subsequent research and case studies have since emerged, pointing to the possibility of aerosol transmission.

A recent study detected aerosolised SARS-CoV-2 RNA in two hospitals in Wuhan, China where COVID-19 patients were being treated.[15] Elevated RNA concentrations were found in toilets and in one public area prone to crowding. Areas with good ventilation had very low levels of RNA detected. This study did not detect whole virus particles (only RNA material) and did not establish whether any aerosols contained *infectious* virus.

Another study in a Singapore hospital found SARS-CoV-2 contamination on high-touch surfaces and in toilets but did not detect viral RNA in the air.[16] Positive samples were taken from the surfaces of air vents, but these were sufficiently close to symptomatic patients that contamination could be attributed to droplets. Surfaces that underwent cleaning subsequently returned negative results, highlighting the importance of good cleaning and disinfection practices.

A similar study in Nebraska, US, detected SARS-CoV-2 RNA in more than 60% of air samples taken in a medical centre with COVID-19 patients.[17] The authors attribute this to aerosol production, even in the absence of patients coughing. However, these samples were not able to replicate or infect cells, which the authors suggest may be due to very small amounts of virus.

Selected case studies offer hints that airborne transmission may be occurring. In Seattle, 45 out of 60 choir members became infected with the virus, despite no one being symptomatic at the time the choir gathered and compliance with social distancing guidelines.[18] An outbreak associated with a restaurant in Guangzhou, China, was partially attributed to the air conditioning system spreading virus-laden aerosols throughout the room.[19]

What lab studies show: a robust virus that can exist in artificial aerosols

Some laboratory experiments have examined the airborne ability of SARS-CoV-2. These studies use a device called a nebuliser to create an artificial aerosol. When a virus is contained in the nebuliser's reservoir, it is almost certain that it will end up in the resulting aerosol. Such studies must therefore be interpreted with caution when being applied to virus coming from patients.

In a recent study, not yet peer-reviewed, four laboratories across the US created artificial SARS-CoV-2 aerosols using a nebuliser and compared them to the related SARS and MERS.[20] The data obtained suggest SARS-CoV-2 virus is more robust than both SARS and MERS, and remains infectious when airborne over short distances, according to the study authors.

One of the labs also measured how long SARS-CoV-2 could remain infectious in a suspended aerosol. They found that the aerosolised virus remained viable (i.e. could replicate) and infectious (i.e. could infect cells) for up to 16 hours.

A similar study, also using nebulisers, found that SARS-CoV-2 could remain viable and infectious up to three hours in aerosols.[21]

Although in these examples the virus might be able in infect individual cells on a lab benchtop, we don't know the infectious dose – the amount of virus necessary to cause infection person-to-person.[22] Droplets carry much higher viral loads than tiny aerosols, and different people produce varying amounts of aerosols through actions such as breathing. Length of exposure is also likely to be a factor: if you are sharing airspace with an infected person for an extended period of time, you may inhale sufficient virus to cause infection.

Acknowledgements

We thank Dr John A. Taylor and Professor John Kolbe from the University of Auckland for reviewing this paper.

Further reading

- Is the coronavirus airborne? Experts can't agree *Nature News*
- Coronavirus drifts through the air in microscopic droplets – here's the science of infectious aerosols *The Conversation*
- Is the coronavirus airborne? It's complicated. *Vox*

Glossary

aerosol	A mixture of tiny (<5µm) particles of water and mucus expelled from a patient, that can contain suspended viruses,mixed with air
bioaerosol	An aerosol that is produced by a biological source, such as a human breathing.
COVID-19	The name given to the disease currently causing a worldwide pandemic
droplet	A particle 5–10µm in diameter that consists of water, salts and suspended viruses or bacteria. Produced by actions such as sneezing and coughing, droplets are too heavy to remain airborne for long and quickly fall to the ground or other surfaces.
MERS	Middle East Respiratory Syndrome, a disease caused by a coronavirus related to SARS-CoV-2
nebuliser	A device that creates an artificial mist of aerosol particles
RNA	Ribonucleic acid, the genetic molecules that encode some viruses including SARS-CoV-2
SARS	Sudden Acute Respiratory Syndrome, a disease caused by a coronavirus related to SARS-CoV-2
SARS-CoV-2	The virus that causes the disease COVID-19

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