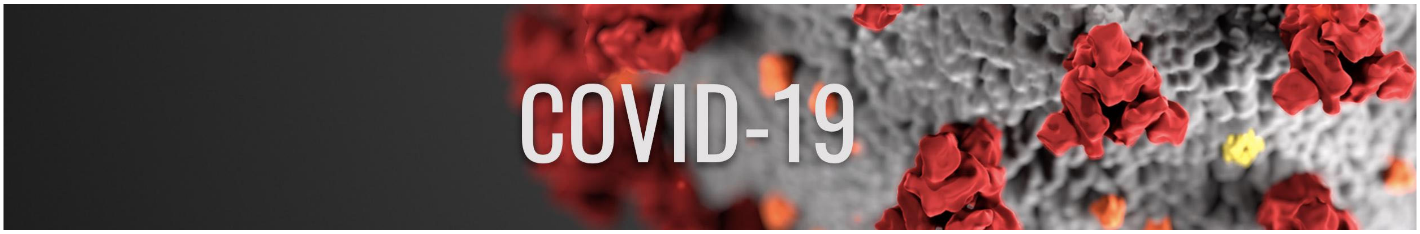

What Scientists Know About Airborne Transmission of the New Coronavirus

Aerosol experts, from engineers to doctors, weigh in on the ability of tiny droplets to transmit the virus that causes COVID-19

A customer talks to a waiter in a mask while eating his meal at a table divided with transparent panels in Bangalore, India. (Photo by MANJUNATH KIRAN/AFP via Getty Images)

By Jim Daley
smithsonianmag.com
August 12, 2020

Over the past few months, an increasing number of scientists, clinicians, and engineers have called for greater recognition that aerosols, in addition to larger droplets can transmit the novel coronavirus that causes COVID-19. While the difference is literally miniscule, acknowledging this route of transmission would result in significant changes in how the public can bring an end to the global pandemic. In the near term, it would inform social distancing and mask wearing recommendations from local governments, and in the long term, engineers and architects will need to rethink ventilation and air filtration in the design of everything from schools to cruise ships.

Aerosols are microscopic particles that can remain airborne for hours, and carry pathogens up to dozens of meters, under the right conditions. Scientists who study airborne infection generally consider aerosols to be particles smaller in diameter than five micrometers, or 0.005 millimeters, less than one-tenth the width of a human hair. Larger droplets, commonly referred to as "droplets," expelled by sneezing or coughing tend to fall to the ground or other surfaces rather quickly, while aerosols hang around for minutes to hours. How long a virus can remain airborne depends on the size of the droplet containing it. "That determines everything about how far it can travel, how long it can stay airborne before it falls to the ground," says Linsey Marr, a professor of civil and environmental engineering at Virginia Tech.

How long aerosolized viruses, including SARS-CoV-2, the novel coronavirus, can remain infectious is still unclear, but some experiments have shown it is possible "for many hours," says Marr. In one such experiment, published in April in the *New England Journal of Medicine,* researchers found that aerosols of SARS-CoV-2 sprayed from a nebulizer had a half-life—the time it takes for 50 percent of virus to stop being infectious—of more than an hour. In another, published in June by the Centers for Disease Control and Prevention, aerosols containing SARS-CoV-2 stayed infectious for up to 16 hours after being similarly aerosolized.

All of the experts who spoke to *Smithsonian* for this article agreed that the likelihood of the virus being transmittable through aerosols only underscores the need for the public to continue their hand-washing and mask-wearing—which blocks aerosol sprays to varying degrees depending on the type of mask worn. The concentration of aerosols is heaviest near an infected person, so social distancing also remains very important for limiting the virus' spread.

Jones adds that the possibility of airborne transmission raises the issue of how to protect workers in healthcare and other settings alike. A shortage of respirators means that the devices should go to healthcare workers first, but if they become more widely available, service industry and transportation workers might benefit substantially from access to them. Surgical masks offer some protection, but it may not be enough for workers who routinely interact with the public.

For months after the pandemic began, the World Health Organization (WHO) had been hesitant to accept aerosols were a likely transmission route for the coronavirus. The agency suggested that airborne transmission was likely only during certain medical procedures such as intubation, and focused its warnings on infection risks associated with larger droplets expelled by coughing or sneezing. But evidence that the coronavirus could travel via aerosols began piling up. In a study that was published online in May before being peer reviewed, researchers found SARS-CoV-2 could be carried on a person's breath, and in June, Marr co-authored a study in *Indoor Air* that added to the evidence the novel coronavirus could be airborne. A commentary published on July 6 in *Clinical Infectious Diseases* and co-signed by 239 scientists, clinicians, and engineers called on health officials to recognize the possibility of airborne transmission. A day later, the WHO officially announced that the novel coronavirus SARS-CoV-2 can spread via aerosols. Benedetta Allegranzi, technical leader of the WHO task force on infection control denied that the publication of the commentary had any relation with WHO softening its position.

"Outside of health care settings, some outbreak reports suggest the possibility of airborne transmission in indoor crowded spaces with poor ventilation," says Allegranzi in an email to *Smithsonian*. "More (and high quality) research is needed to elucidate these kind of settings [and] outbreaks and the relative importance of different transmission routes."

Marr, who co-signed the commentary in *Clinical Infectious Diseases*, penned an op-ed in the *New York Times* that called the agency's updated position "grudging partial acceptance." She described the difficulties in determining whether a virus can be airborne to *Smithsonian*. First, a researcher has to sample the air in a potential area of infection with a device like vacuum cleaner, and then they have to show that any viruses collected with it are still alive and infectious, Marr explains. Finally, they have to determine whether people can get sick if they breathe in the airborne virus. "All those steps are actually very hard to demonstrate for any particular route of transmission," she says. Researchers have been able to confirm the first two steps—that the novel coronavirus can be carried on aerosols and that it can remain infectious—and so far demonstrated the third step with ferrets, but not humans.

When suggesting infection control measures, epidemiologists typically don't consider aerosols unless they are seeing transmission travel longer distances, such as between rooms. But that could be looking at airborne transmission backwards, according to Marr. "I guarantee it's more important when people are close together," because the plume of aerosols and respiratory droplets an infected person exhales gets diluted farther away.

Rachael Jones, a professor of family and preventative medicine at the University of Utah, published a framework for determining the likelihood of a virus going airborne in the *Journal of Occupational and Environmental Medicine* in 2015. Jones says prevailing ideas about infection control that emphasize large-droplet respiratory sprays generated by sneezing or talking don't reflect the current understanding of aerosols. "When we measure the viruses in respiratory aerosols, we find a lot of [them] in the smallest particles which can be inhaled," she says. Infection control procedures oriented around large-droplet transmission focus on controlling droplets that splash onto the face, she added, but if the coronavirus can initiate infection deep in the respiratory tract, tiny aerosols that can carry virus down into it would require procedures be implemented that prevent people from breathing them in.

Lidia Morawska, who co-authored the commentary in *Clinical Infectious Diseases*, was one of the first researchers to argue that the novel coronavirus could travel on aerosols. Morawska, a professor of atmospheric sciences and environmental engineering at Queensland University of Technology in Australia, published a study online in April in *Environment International* that argued SARS-CoV-2 was likely airborne based on previous studies of other coronaviruses. She says a small community of scientists has been advocating for health experts to acknowledge the likelihood of aerosols as an avenue of respiratory infection for decades. Most buildings are completely unprepared for an airborne respiratory disease because they lack the kind of ventilation and air filtration systems that could minimize spread, she says. "For years, we've been trying to bring this to their attention to prepare the right approaches for building interiors to be prepared against respiratory infection transmission."

Reluctance to accept the likelihood of airborne infection is not new, says Donald Milton, the other co-author of the commentary. Milton is a professor of environmental and occupational health at the University of Maryland, though he calls himself an "aerobiologist." He has been studying aerosols as infection routes for four decades. He says a book published more than a century ago by the noted public health administrator Charles Chapin, titled *The Sources and Modes of Infection*, still influences infection control beliefs today. At the time of its publication, the medical community was working hard to dispel the ancient fallacy that so-called miasmas, or "bad airs," were the source of all disease. "Transmission via aerosols sounded too much like miasmas and pestilential vapors," Milton says.

Tuberculosis was widespread in Chapin's day: in 1900, it was the leading single cause of death in the United States, killing 194 of every 100,000 Americans. Microbiologist Robert Koch discovered it was caused by bacteria in 1882, but many still blamed it on "bad airs," and the New York City Department of Health officially acknowledged it was infectious only in 1894. While Chapin briefly acknowledged the possibility tuberculosis could be transmitted by "dust-borne bacteria," he wrote that it was better to concentrate on contact and spray-borne (or droplet-borne) transmission. "He said we shouldn't talk about [aerosols] because it might dissuade people from washing their hands and being hygienic," Milton says.

That dogma was adhered to for decades, and Milton says it is pretty much what you hear today from a lot of infectious disease people.

Until 2004, no one had definitively established whether tuberculosis could be airborne. Kevin Fennelly, a pulmonologist at the National Institutes of Health, published the first study to quantify tuberculosis-causing pathogen amounts in aerosol droplets, but even then he wasn't sure it could be carried on a patient's breath. Fennelly says it wasn't until an "unexpected and kind of revolutionary" study published in 2014 in *PLOS One* changed the thinking around pathogens and exhaled breath. "Over time, I've become a convert to the data," he says. Last month, he published a viewpoint in *The Lancet* arguing that in light of the COVID-19 pandemic, infection-control measures need to include guidelines around masks and respirators to protect healthcare workers from aerosols.

Jones adds that installing effective ventilation systems in public buildings and businesses is critical, but acknowledges that doing so will be a complex endeavor. "We don't have a lot of off-the-shelf designs for those systems, so I think it's an area to look in terms of research development and major changes in how we think about the configuration of public spaces."

Morawska says old dogma around routes of transmission that ignore aerosols as a possible avenue must be updated to include them, and added that she hopes the pandemic will inspire everyone from public health officials to architects to rethink how they approach infection control. Humanity is "better prepared to deal with an incoming asteroid" than with a novel virus, she says. "We need to completely rethink the issue of design of buildings, provision of ventilation and how we operate buildings."

Editors' Note, August 13, 2020: This article originally misstated the name of Donald Milton. We regret the error.