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Yes, the Coronavirus Is in the Air

Transmission through aerosols matters — and probably a lot more than we've been able to prove yet.

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By Linsey C. Marr
Dr. Marr is a professor of engineering.

Finally. The World Health Organization has now formally recognized that SARS-CoV-2, the virus that causes Covid-19, is airborne and that it can be carried by tiny aerosols.

As we cough and sneeze, talk or just breathe, we naturally release droplets (small particles of fluid) and aerosols (smaller particles of fluid) into the air. Yet until earlier this month, the W.H.O. — like the U.S. Centers for Disease Control and Prevention or Public Health England — had warned mostly about the transmission of the new coronavirus through direct contact and droplets released at close range.

The organization had cautioned against aerosols only in rare circumstances, such as after intubation and other medical procedures involving infected patients in hospitals.

After several months of pressure from scientists, on July 9, the W.H.O. changed its position — going from denial to grudging partial acceptance: "Further studies are needed to determine whether it is possible to detect viable SARS-CoV-2 in air samples from settings where no procedures that generate aerosols are performed and what role aerosols might play in transmission."

I am a civil and environmental engineer who studies how viruses and bacteria spread through the air — as well as one of the 239 scientists who signed an open letter in late June pressing the W.H.O. to consider the risk of airborne transmission more seriously.

A month later, I believe that the transmission of SARS-CoV-2 via aerosols matters much more than has been officially acknowledged to date.

In a peer-reviewed study published in Scientific Reports on Wednesday, researchers at the University of Nebraska Medical Center found that aerosols collected in the hospital rooms of Covid-19 patients contained the coronavirus.

This confirms the results of a study from late May (not peer-reviewed) in which Covid-19 patients were found to release SARS-CoV-2 simply by exhaling — without coughing or even talking. The authors of that study said the finding implied that airborne transmission "plays a major role" in spreading the virus.

Accepting these conclusions wouldn't much change what is currently being recommended as best behavior. The strongest protection against SARS-CoV-2, whether the virus is mostly contained in droplets or in aerosols, essentially remains the same: Keep your distance and wear masks.

Rather, the recent findings are an important reminder to also be vigilant about opening windows and improving airflow indoors. And they are further evidence that the quality of masks and their fit matter, too.

The W.H.O. defines as a "droplet" a particle larger than 5 microns and has said that droplets don't travel farther than one meter.

In fact, there is no neat and no meaningful cutoff point — at 5 microns or any other size — between droplets and aerosols: All are tiny specks of liquid, their size ranging along a spectrum that goes from very small to really microscopic.

(I am working with medical historians to track down the scientific basis for the W.H.O.'s definition, and we have not found a sensible explanation yet.)

Yes, droplets tend to fly through the air like mini cannonballs and they fall to the ground rather quickly, while aerosols can float around for many hours.

But basic physics also says that a 5-micron droplet takes about a half-hour to drop to the floor from the mouth of an adult of average height — and during that time, the droplet can travel many meters on an air current. Droplets expelled in coughs or sneezes also travel much farther than one meter.

Here is another common misconception: To the (limited) extent that the role of aerosols had been recognized so far, they were usually mentioned as lingering in the air, suspended, and wafting away — a long-distance threat.

But before aerosols can get far, they must travel through the air that's near: meaning that they are a hazard at close range, too. And all the more so because, just like the smoke from a cigarette, aerosols are most concentrated near the infected person (or smoker) and become diluted in the air as they drift away.

A peer-reviewed study by scientists at the University of Hong Kong and Zhejiang University, in Hangzhou, China, published in the journal Building and Environment in June concluded, "The smaller the exhaled droplets, the more important the short-range airborne route."

So what does this all mean exactly, practically?

Can you walk into an empty room and contract the virus if an infected person, now gone, was there before you? Perhaps, but probably only if the room is small and stuffy.

Can the virus waft up and down buildings via air ducts or pipes? Maybe, though that hasn't been established.

More likely, the research suggests, aerosols matter in extremely mundane scenarios.

Consider the case of a restaurant in Guangzhou, southern China, at the beginning of the year, in which one diner infected with SARS-CoV-2 at one table spread the virus to a total of nine people seated at their table and two other tables.

Yuguo Li, a professor of engineering at the University of Hong Kong, and colleagues analyzed video footage from the restaurant and in a preprint (not peer reviewed) published in April found no evidence of close contact between the diners.

Droplets can't account for transmission in this case, at least not among the people at the tables other than the infected person's: The droplets would have fallen to the floor before reaching those tables.

But the three tables were in a poorly ventilated section of the restaurant, and an air conditioning unit pushed air across them. Notably, too, no staff member and none of the other diners in the restaurant — including at two tables just beyond the air conditioner's airstream — became infected.

Similarly, just one person is thought to have infected 52 of the other 60 people at a choir rehearsal in Skagit County, Wash., in March.

Several colleagues at various universities and I analyzed that event and in a preprint (not peer-reviewed) published last month concluded that aerosols likely were the dominant means of transmission.

Attendees had used hand sanitizer and avoided hugs and handshakes, limiting the potential for infection through direct contact or droplets. On the other hand, the room was poorly ventilated, the rehearsal lasted a long time (2.5 hours) and singing is known to produce aerosols and facilitate the spread of diseases like tuberculosis.

What about the outbreak on the Diamond Princess cruise ship off Japan early this year? Some 712 of the 3,711 people on board became infected.

Professor Li and others also investigated that case and in a preprint (not peer reviewed) in April concluded that transmission had not occurred between rooms after people were quarantined: The ship's air-conditioning system did not spread the virus over long distances.

The more likely cause of transmission, according to that study, appeared to be close contact with infected people or contaminated objects before the passengers and crew members were isolated. (The researchers did not parse precisely what they meant by contact, or if that included droplets or short-range aerosols.)

But another, recent, preprint (not peer reviewed) about the Diamond Princess concluded that "aerosol inhalation was likely the dominant contributor to Covid-19 transmission" among the ship's passengers.

It might seem logical, or make intuitive sense, that larger droplets would contain more virus than do smaller aerosols — but they don't.

A paper published this week by The Lancet Respiratory Medicine that analyzed the aerosols produced by the coughs and exhaled breaths of patients with various respiratory infections found "a predominance of pathogens in small particles" (under 5 microns). "There is no evidence," the study also concluded, "that some pathogens are carried only in large droplets."

A recent preprint (not peer reviewed) by researchers at the University of Nebraska Medical Center found that viral samples retrieved from aerosols emitted by Covid-19 patients were infectious.

Some scientists have argued that just because aerosols can contain SARS-CoV-2 does not in itself prove that they can cause an infection and that if SARS-CoV-2 were primarily spread by aerosols, there would be more evidence of long-range transmission.

I agree that long-range transmission by aerosols probably is not significant, but I believe that, taken together, much of the evidence gathered to date suggests that *close-range* transmission by aerosols is significant — possibly very significant, and certainly more significant than direct droplet spray.

The practical implications are plain:

- **Social distancing really is important**. It keeps us out of the most concentrated parts of other people's respiratory plumes. So stay away from one another by one or two meters at least — though farther is safer.
- **Wear a mask.** Masks help block aerosols released by the wearer. Scientific evidence is also building that masks protect the wearer from breathing in aerosols around them.

When it comes to masks, size *does* matter.

The gold standard is a N95 or a KN95 respirator, which, if properly fitted, filters out and prevents the wearer from breathing in at least 95 percent of small aerosols.

The efficacy of surgical masks against aerosols varies widely.

One study from 2013 found that surgical masks reduced exposure to flu viruses by between 10 percent and 98 percent (depending on the mask's design).

A recent paper found that surgical masks can completely block seasonal coronaviruses from getting into the air.

To my knowledge, no similar study has been conducted for SARS-CoV-2 yet, but these findings might apply to this virus as well since it is similar to

seasonal coronaviruses in size and structure.

My lab has been testing cloth masks on a mannequin, sucking in air through its mouth at a realistic rate. We found that even a bandanna loosely tied over its mouth and nose blocked half or more of aerosols larger than 2 microns from entering the mannequin.

We also found that especially with very small aerosols — smaller than 1 micron — it is more effective to use a softer fabric (which is easier to fit tightly over the face) than a stiffer fabric (which, even if it is a better filter, tends to sit more awkwardly, creating gaps).

- **Avoid crowds.** The more people around you, the more likely someone among them will be infected. Especially avoid crowds indoors, where aerosols can accumulate.
- **Ventilation counts.** Open windows and doors. Adjust dampers in air-conditioning and heating systems. Upgrade the filters in those systems. Add portable air cleaners, or install germicidal ultraviolet technologies to remove or kill virus particles in the air.

It's not clear just how much this coronavirus is transmitted by aerosols as opposed to droplets or via contact with contaminated surfaces. Then again, we still don't know the answer to that question even for the flu, which has been studied for decades.

But by now we do know this much: Aerosols matter in the transmission of Covid-19 — and probably even more so than we have yet been able to prove.

Linsey C. Marr (@linseymarr) is a professor of civil and environmental engineering at Virginia Tech.

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