INFECTIOUS DISEASE | MOVERS AND SHAKERS

Aerosol expert Jose-Luis Jimenez is sounding the alarm about airborne transmission of COVID-19

The University of Colorado chemist is communicating directly with the public about how people can protect themselves

by ***Carmen Drahl, special to C&EN***

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An academic researcher's frenetic life sounds relaxing to Jose-Luis Jimenez these days. Since March, the analytical and atmospheric chemist at the University of Colorado Boulder has worked nonstop, urging the US Centers for Disease Control and the World Health Organization to acknowledge that airborne aerosols play an important role in transmitting COVID-19. He's one of 239 experts in multiple scientific fields who in July signed an open letter to the agencies (*Clin. Infect. Dis.* 2020, DOI: **10.1093/cid/ciaa939**). The CDC has since updated its stance, stating that **inhalation is the main mode of transmission** of the novel coronavirus, which causes COVID-19. As of C&EN's deadline, the WHO's guidance still suggests a **minor role for aerosols**.

Credit: Courtesy of Jose-Luis Jimenez

To Jimenez, the CDC's update was a long time coming, and the WHO's position is a start but not enough. So he has gone directly to the public, explaining in interviews and written opinion pieces in English and Spanish how people can protect themselves. So many people have asked him for advice on social media that he and his collaborators created a **public Google Doc with frequently asked questions**.

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Carmen Drahl squeezed into an empty spot on Jimenez's packed calendar to ask about aerosol chemistry, COVID-19, and being a reluctant interviewee. This interview has been edited for length and clarity.

VITALS

Hometown: Zaragoza, Spain

Education: BS-MS, mechanical engineering, University of Zaragoza and University of Technology of Compiègne, 1993; PhD, mechanical engineering, Massachusetts Institute of Technology, 1999; postdoc, Aerodyne Research, 1999–2000, and California Institute of Technology, 2000–2002

Best analogy for aerosol transmission: Breathing in cigarette smoke that builds up in a room. Before smoking in restaurants was forbidden, in Spain you would enter a restaurant and there was a cloud. The limitation of the analogy is that a room where people were smoking will stink the next day or even the next month, but by then the virus is gone.

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Health must-have: I used to have a backache and gained weight when I was an assistant professor. I discovered treadmill desks in 2012. The backache went away, and I lost a lot of weight. Often, I'm walking 6 h a day.

Toughest audience to reach: It was only when my *Time* magazine and *El Pais* newspaper op-eds appeared that my family finally took me seriously. Since then, most of my family follows my advice —except my mom. I think the WHO will accept that aerosol transmission is major before my mom wears a mask.

What defines an aerosol versus a droplet, and what difference does it make for infection?

From the point of view of infectious disease transmission, an aerosol is a particle of saliva or respiratory fluid that floats in the air and that infects us when we breathe it in. That's different from a droplet, which is a projectile that infects by hitting us on the eyes, nostrils, or mouth. People generate particles of many sizes when they cough, talk, or sing. When we talk, particles above about 300 µm are droplets because they have enough inertia to do this projectile-like ballistic impaction. When coughing or sneezing we exhale more forcefully, so smaller particles may act like droplets, and in those situations 100 µm may be a better threshold. Particles larger than that can impact like a droplet. At 100 µm in diameter and below, the particles are aerosols and they can only infect by inhalation.

You usually investigate aerosols in Earth's atmosphere. How did you become part of a COVID-19 project?

I was worried, like everyone else. I saw that COVID-19 wasn't being controlled. I saw it was arriving in Spain, where I'm from. When I was telling my family to wear masks early on, they thought I was crazy. They seemed to think, "What do you know? You're an atmospheric chemist."

In parallel, I was talking to other scientists. I started talking to Linsey Marr at Virginia Tech, with whom I've worked on pollution but who I knew was also working on aerosol transmission of viruses. I asked her, "Do you think COVID-19 could be transmitted through the air?" She said, "Yes, I think so."

Then, on March 28, the WHO posted a graphic to its official accounts on social media saying, "**#COVID-19 is NOT airborne**" and "**Help stop misinformation**." On March 31, Lidia Morawska at Queensland University of Technology wrote to me and asked if I wanted to join a group of scientists she was leading to appeal to the WHO about the importance of airborne spread. So I said, "Yes, of course." And then I started learning much faster, because this group has many of the world leaders in aerosol transmission of disease.

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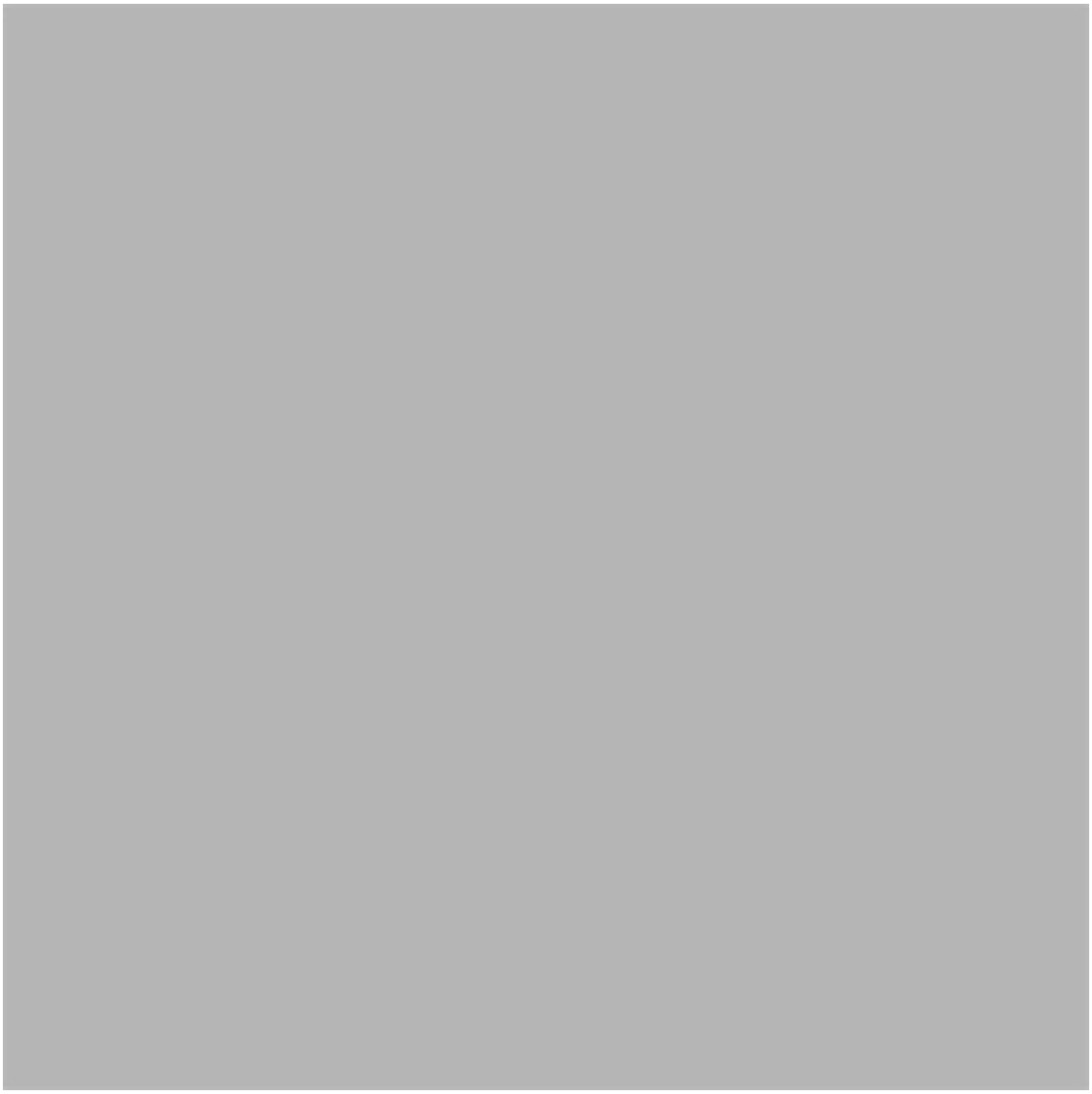
What did you have to learn? How does studying atmospheric aerosols differ from studying human-generated aerosols?

The aerosol part is very much the same. How they behave in the air, all the tools we use to study them, and the mathematical models that we use—those are the same. The part I didn't know is the infection part. How many viruses are inside the aerosol? How do they infect? How long will they survive in aerosols? That's hard to learn on your own. Basically, I've done a master's—on steroids—through this group. We've had hours of discussions about every question that comes up. I wouldn't say I'm an expert in the infection part, but I'm knowledgeable enough.

What other chemistry knowledge is valuable for understanding COVID-19 transmission?

Understanding atmospheric chemistry, including gases and aerosols, is extremely useful. Once you accept that the virus is in the air, you can use this science to ask what would happen in a certain situation. Understanding how these aerosols gain or lose water, how exposure to oxidants or



Credit: America L. Edwards/University of California, Santa Barbara

University of California, Santa Barbara, communication PhD student America L. Edwards created infographics from Jose-Luis Jimenez's messaging about how people can better protect themselves from aerosol transmission of COVID-19.

ultraviolet light may damage the virus's molecules and make it noninfective, is all very useful. We have written mathematical models of how aerosols containing the virus behave in a room.

> **I am not someone who seeks the limelight or enjoys being so public. But I feel it's a civic duty.**

How are you adjusting to doing constant science communication alongside your research?

It's a pain. I'm an introvert. I am not someone who seeks the limelight or enjoys being so public. But I feel it's a civic duty. I am convinced that this disease is transmitted mostly through aerosols and that governments and the WHO are not giving people the tools or the explanations they need to protect themselves.

How do you envision the future of your research, postpandemic? Is its direction forever shifted?

I have to see how useful we would be. There are many good researchers already in the field of airborne disease transmission. I think my group has found some areas of modeling of aerosol transmission in shared room air (*Indoor Air* 2020, DOI: **10.1111/ina.12751**) and the use of carbon

dioxide as an indicator of infection risk (medRxiv 2020, DOI: **10.1101/2020.09.09.20191676**) where we have already contributed. If we can get funding, some fraction of our activity may be in transmission of diseases.

I will definitely continue studying the atmosphere because—crazy as this may sound now—climate change is a bigger problem than COVID-19.

COVID-19 will pass. Climate change will get worse and be with us forever.

Carmen Drahl is a freelance writer based in Washington, DC, who covers the chemistry-biology interface. A version of this story appeared in *ACS Central Science*: **cenm.ag/jimenez**.

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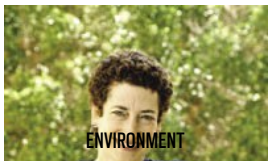

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COMMENTS

L Norman
(January 4, 2021 7:14 PM)

I read an article back in March that covid-19 was an airborne virus. I started wearing a mask immediately and enacted a "contactless " policy at work.
I understand why the CDC has not been forthcoming about this issue but cannot fathom why the WHO would try to suppress this information. Of course, covid is airborne transmissible, how else could it have traveled around the globe so rapidly? I seriously don't think the Public even understands what airborne means. Even if they did, how many would care? Washing hands is hardly enough safety measure unless you actually touch live virus particles and then touch your face (or orafice). I have been telling anyone who would listen that covid-19 is a virulent airborne disease, some don't understand the implications of that and some just pshaw. Now I'm telling them to take a stroll in the cemetery and take note of the overwhelming amount of fresh graves.
Please get this information out there in layman's terms and pressure the incoming administration to get control over the CDC's messaging!

L Hadlow
(January 5, 2021 12:43 PM)
From the beginning (last January), I guessed that airborne transmission would be a primary mode of transmission and began protecting myself accordingly.

Unfortunately, I believe there is more than one understanding of what the word 'airborne' means. To some, that word only triggers images of sci-fi horror "Deadly-Pathogen-Kills-90%-of-Humanity!" movies (where a character in said movie - say, someone sailing across the Pacific alone - can *still* be infected by it). Do we 'really" want to use a word that might have that effect on a significant chunk of the population?

But that's *not* what is meant in this context, of course. If we're going to use "The 'A' Word", I submit it should almost always be used in conjunction with the names of any two non-civilization-ending (but still potentially serious) airborne diseases like measles and TB, e.g., "Airborne; like measles and TB are airborne."

Bart Verheggen
(January 14, 2021 1:43 PM)
According to this article (first paragraph) the CDC now states that "inhalation is the main mode of transmission". From the context I infer that this is intended to mean in contrast to larger droplets.

The link goes to CDC, which states:
"It spreads through respiratory droplets or small particles, such as those in aerosols, produced when an infected person coughs, sneezes, sings, talks, or breathes.
- These particles can be inhaled into the nose, mouth, airways, and lungs and cause infection. This is thought to be the main way the virus spreads.
- Droplets can also land on surfaces and objects and be transferred by touch. A person may get COVID-19 by touching the surface or object that has the virus on it and then touching their own mouth, nose, or eyes. Spread from touching surfaces is not thought to be the main way the virus spreads."

This is likewise open to interpretation, but how I read this the former route (via inhalation) is mentioned in contrast to the route via contaminated surfaces. I.e. the contrast that CDC makes is not aerosols vs droplets (the point of this article), but inhalation (of droplets/particles of whatever size) vs contaminated surfaces. I don't think this qualifies as supporting what's asserted in this article.

Robert Perry
(January 18, 2021 3:59 PM)
So my take away from this article is aerosol, which can stay in the air a long time, or droplets that fall to the ground and must impact on person in front of you or be touched on surfaces. If most of infections come from people being indoors where air is recirculated and remains infectious than must be aware that aerosols remain airborne for a long time. Important to know how large a dose causes infections. 10 micron particles will reach the lungs.

Sean Delaney
(January 23, 2021 9:36 PM)
My host in Guanajuato Mexico, is like the author originally from Spain, she just informed me that the main mode of transmission is now believed to be via surface. Her Doctor friend in Mexico City who works on the Covid wing and does research says this is the latest thinking. She also claimed that is stays on surfaces much longer than the early reports I read. ie. plastic for 10 days, stainless for 24. Last night people were spraying themselves down and someone even fired a bit of disinfectant on my legs. She has provided a spray bottle of water and alcohol and suggested this is the new thinking.

This is all rather shocking to me, for since long before it came to the USA I felt it was primarily airborne and was frankly shocked it took the main agencies so long to say so or to even suggest masks actually might help. I can't help but think of the guests on the infamous cruise ship that got infected despite being sequestered to their respective rooms. This seemed to suggest it was being circulated through the air ducts (ie. high pressure toilets creating aerosols.)

It amazes me that despite this real life, worldwide experiment, we are still unsure of the primary mode of transmission. I can't help but think that it is due the biases and specialties of scientists. I commend the authors impressive strides to reach out the the public as well as his new "masters" in pathology but I can't help but wonder if he is not the proverbial "hammer seeing only nails"? In the meantime and until science can reach a consensus, I am further confused.

matt
(February 5, 2021 12:09 PM)
I've wondered just how effective the masks have been in stopping the transmission of covid-19? If the aerosol particles are indeed 100µm in diameter, I have suspicions that these cloth masks people are wearing probably aren't doing much. I'd have hoped that the government(s) would have made N95 masks available free of charge to those in high risk categories. This probably would have helped slow the spread early on and greatly reduced the amount of deaths we have seen thus far.

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