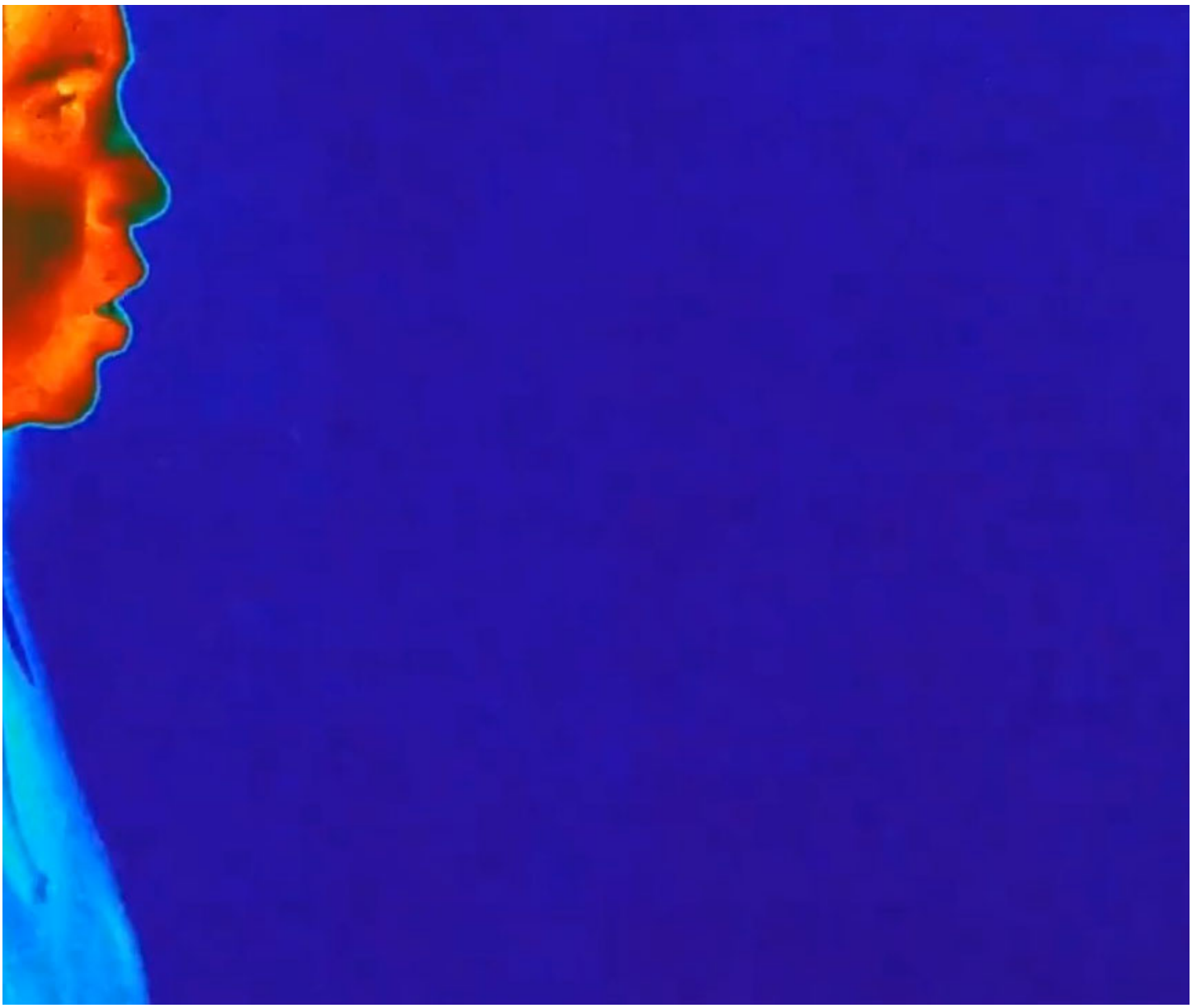
COVID-19 >

Avoiding coronavirus infection in indoor spaces: don’t breathe other people’s air

Constant ventilation and permanent control of CO_2 levels are two of the keys to avoiding transmission in closed rooms, as fresh air dilutes the infected particles



In closed spaces with no ventilation, such as this car, a meter shows that parts-per-million (ppm) of CO_2 accumulate to the extent that within 15 minutes we re-inhale 4% of the air we have already breathed.

If the car is shared and there is no ventilation, **within the space of 10 minutes, 8% of the air we breathe in will have already been exhaled** by the other passenger. That means we are sharing the air with another person and the risk of transmission is high.

If one of the two people in the car is Covid-positive, the risk of the other catching the virus is 30% in 30 minutes or 71% in an hour.

If both people **open their windows** just five centimeters, cross-ventilation can **renew the air up to nine times every minute.** The exhaled air disappears and the probability of transmission is low.

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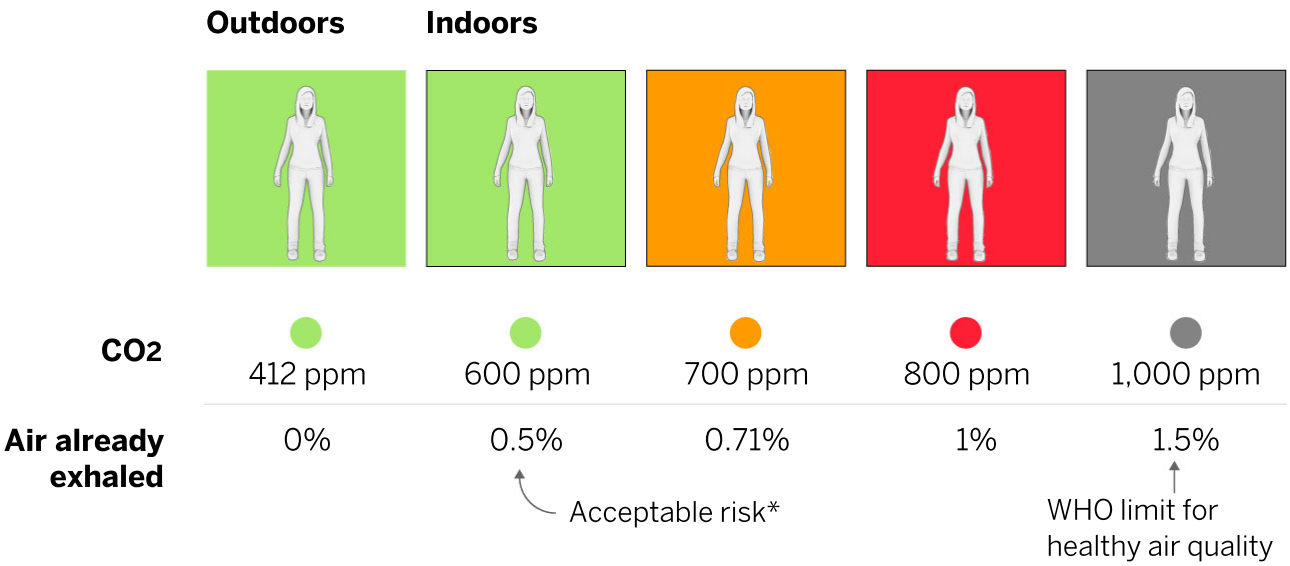
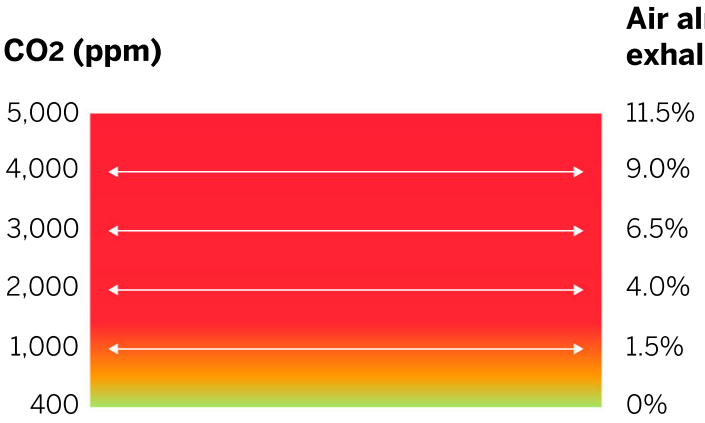
During this pandemic, it has been shown that **poorly ventilated buildings** are the most dangerous environments of all because particles containing the virus can linger in the air until someone breathes them in. And although we do not have a device that can show these particles, we can measure the air quality and CO_2 concentration using a meter. The higher the concentration of CO_2, which is exhaled when we breathe, the worse the room's ventilation. A simple measurement allows us to know if the room is loaded with air exhaled by other people or if it is well ventilated, thereby drastically reducing the risk of infection.

Because of its reduced dimensions, the interior of a car serves as a microcosm of what happens in larger rooms. When a person gets into a car where there is one other person and the windows are closed, the concentration of CO_2 soars, as a percentage of what is breathed in has already been exhaled by the other passenger. However, simply by opening the windows just a few centimeters and generating cross-ventilation, the air gets constantly refreshed. In a **house, a bar or a classroom**, the premise is basically the same.

Link between CO_2 and breathed air

The air we breathe outside contains an average of 412 parts-per-million (ppm) of CO2. If we observe this figure on a meter, the air has not been exhaled by anyone.





*Harvard and IDAEA-CSIC-LIFTEC recommended guidelines

While the **virologist Margarita del Val** keeps an eye on the levels of CO_2 in cars that she uses with her own meter because "it is an indirect indication that helps us to ventilate correctly," she is not in favor of promoting its use in the daily lives of normal people. She is, however, in favor of it being regulated and its use promoted as a tool for the authorities. "In many stable environments, such as schools, it is not necessary to have one installed; just a few measurements and you know what is required to maintain good air renewal," notes Del Val, who is in charge of the Spanish National Research Council (CSIC) platform for Covid-19. "And that includes limiting exposure to the cold, because sometimes it is enough to open the windows just a little."

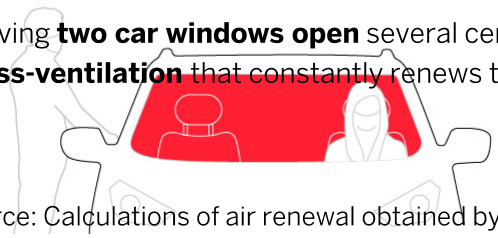
Last week, Del Val and 100 other scientists and health professionals **sent a letter** to the Spanish authorities in which they demanded that urgent measures be taken to prevent transmission caused by poor ventilation. Among the measures advocated was the use of CO_2 concentration as a benchmark by which to measure air quality. Another of the letter's signatories, Javier Ballester of the University of Zaragoza, is critical of the fact that the government is doing little to tackle existing confusion on the issue. "It's not enough to provide information via Twitter," he says. "It's all very complex – biology and behavior – but there are two indisputably effective factors: ventilation and masks." Just as the government regulates the quality of masks, it should provide information on how to properly ventilate. There have been many anecdotes describing how some individuals and educational centers ventilate prior to occupancy, leaving the room freezing cold, then close the windows as soon as people arrive, which is when the risk exists. "If they don't know this, they won't open the windows, or they won't sit by the window in the bar: individual awareness is decisive," says Ballester.

Risks entering closed spaces and how to avoid them

Entering a closed space occupied by others **entails a risk** if we don't know if it contains air that has already been exhaled.

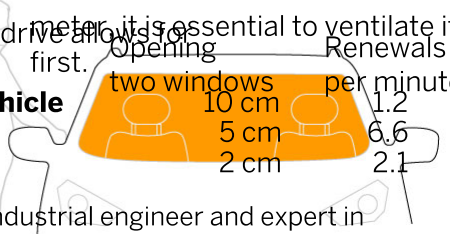
Both CO_2 and the coronavirus **can linger for hours** in an unventilated closed space.

Leaving **two car windows open** several centimeters while we drive allows for **cross-ventilation** that constantly renews the air.



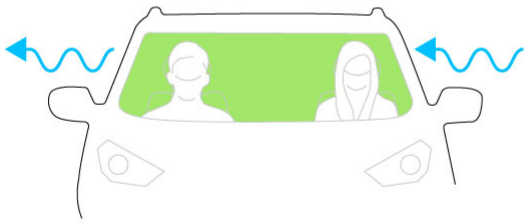
Stationary vehicle
50km/h
100 km/h

If we are going to enter a closed space that does not have a CO_2 meter, it is essential to ventilate it first.



Opening two windows	Renewals per minute
10 cm	1.2
5 cm	6.6
2 cm	2.1

Source: Calculations of air renewal obtained by David Higuera, an industrial engineer and expert in

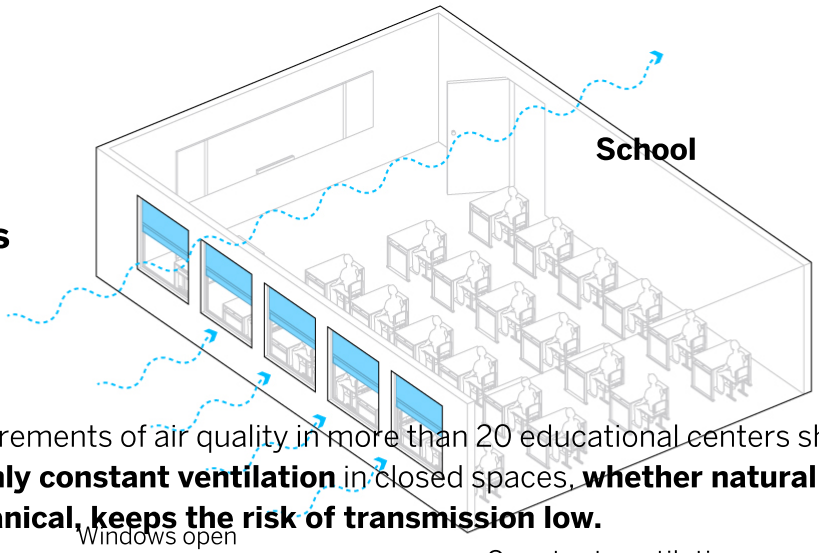


Scientist Pedro Magalhães de Oliveira, from Cambridge University, has studied how infected aerosols – the suspended viral particles exhaled when talking, singing or breathing – work. To calculate optimum conditions for daily scenarios, Oliveira has developed an online tool called **airborne.cam**. "The potential for measuring indoor CO_2 levels has been largely overlooked," he says. "Health authorities could do this to identify high-risk locations and better inform the people who manage them." He does point out, however, that even in a well-ventilated space, there could be short-range transmission when viral particles are breathed in soon after a positive Covid case exhales if there is not enough time for the aerosols to be diluted. "That's why it's so important to wear a mask and keep a safe distance, even outdoors," he says.

Some authorities have taken note. For example, the regional government of Navarre in northern Spain includes the measurement of CO_2 as a important tool for the hospitality sector. A document advising on measures to be taken during the Easter holidays states: "Ventilate as much as possible and measure air quality, using CO_2 meters... If the concentration of CO_2 exceeds 800 parts per million, increased ventilation is recommended or decreased attendance until it [CO_2] falls below that indicator." In the event, the region has

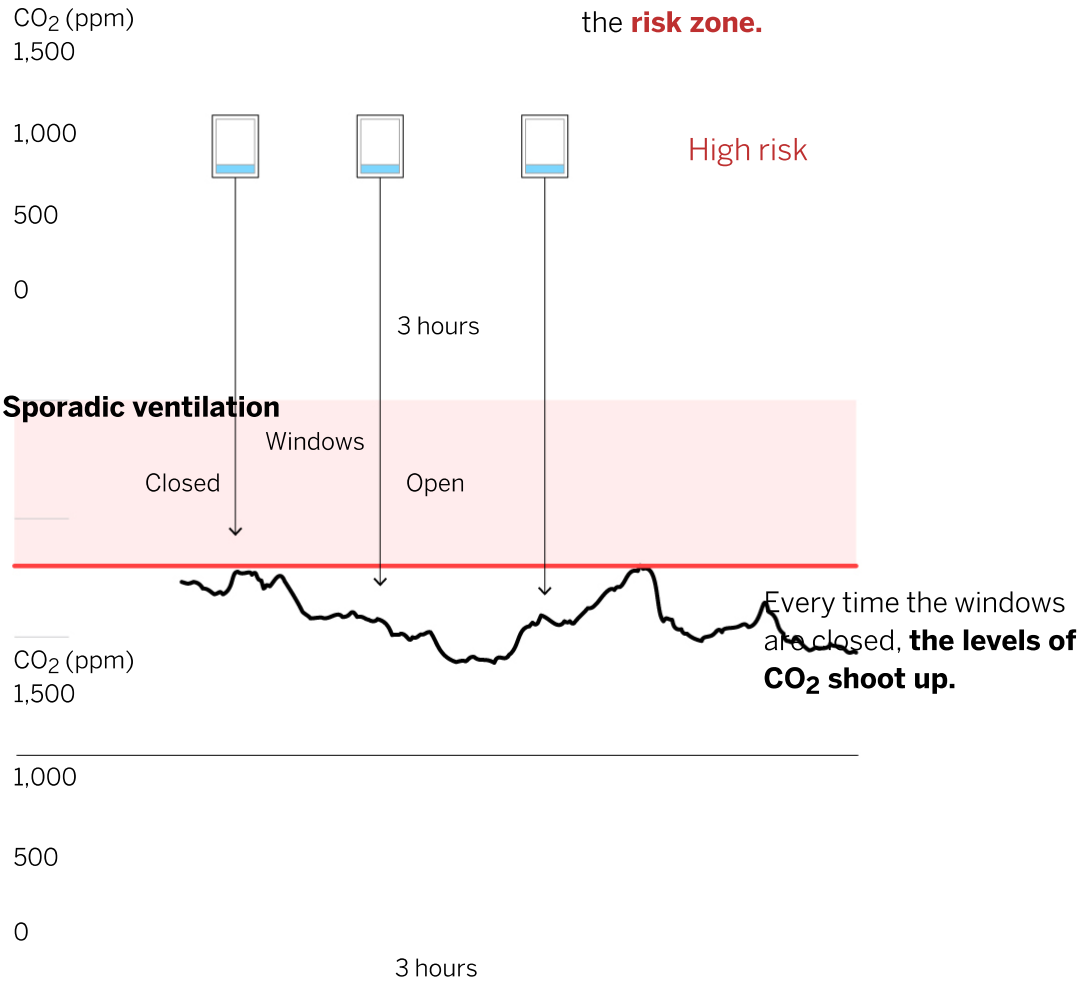
opted to ban indoor drinking and dining altogether over the Easter period.

Effectiveness of constant ventilation

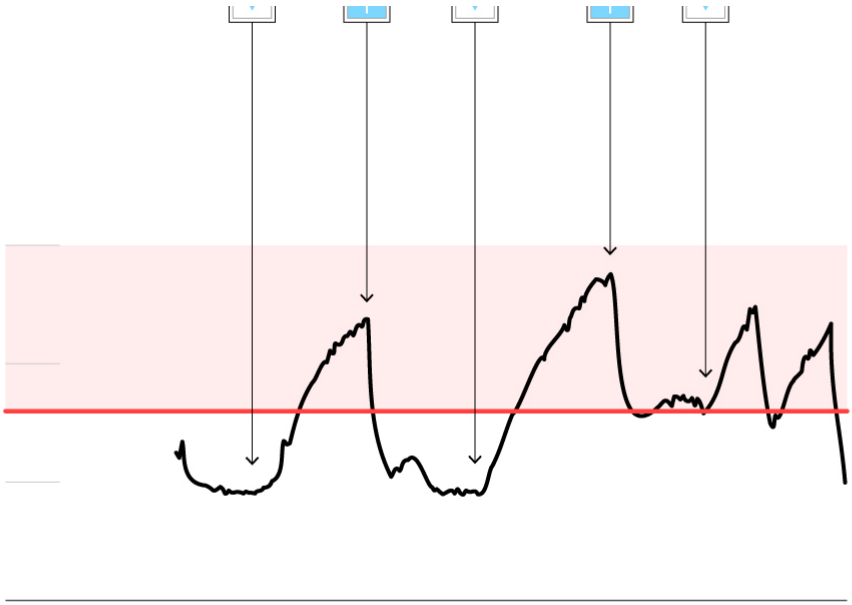


Measurements of air quality in more than 20 educational centers show that **only constant ventilation** in closed spaces, **whether natural or mechanical, keeps the risk of transmission low.**

Constant ventilation maintains the concentration of exhaled air outside the **risk zone.**

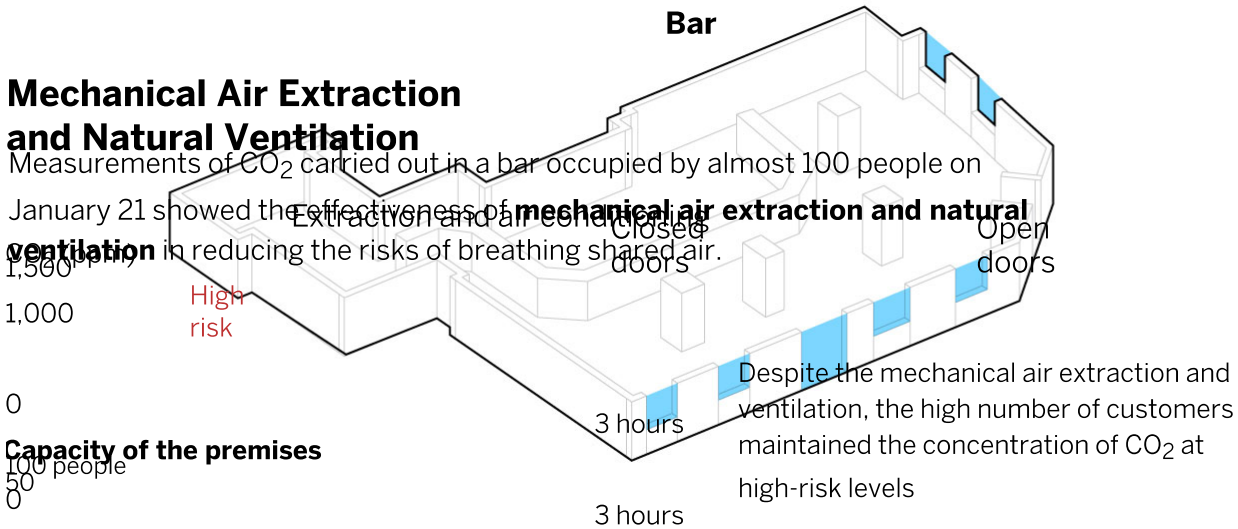


Source: Measurements of CO_2 coordinated by **Francisco Javier Moya López,** director of Indoor Air Quality at Auding Control.

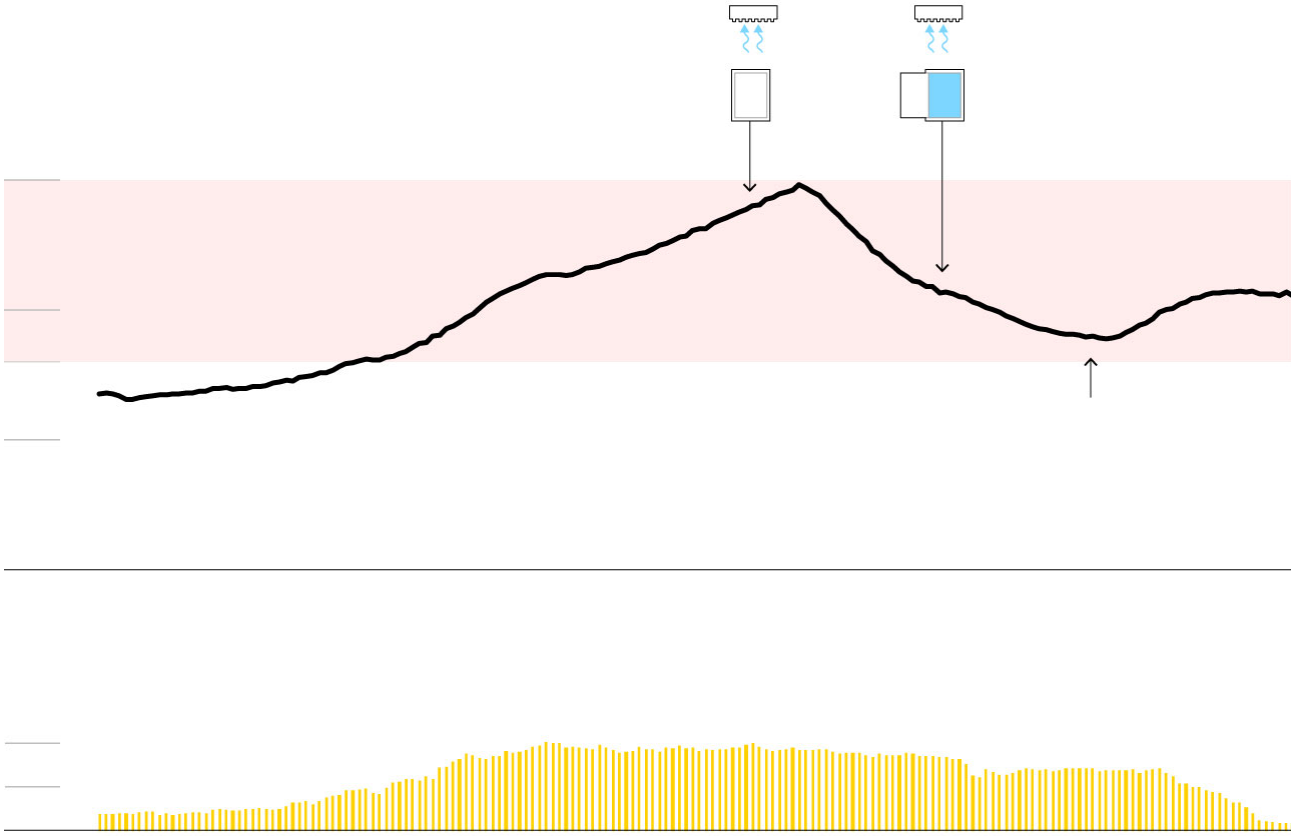


Source: Measurements of CO_2 coordinated by Francisco Javier Moya López, director of Indoor Air Quality at Auding Control.

Meanwhile, countries such as Germany, Canada and the UK include CO_2 monitoring in their pandemic guidelines. Last summer, the Harvard School of Public Health **published a guide** for reopening schools that became a reference. The guide points to these monitors as a key tool for calculating the air quality of classrooms. The CSIC also included them in its recommendations. And the World Health Organization has just released its own detailed manual for adequate ventilation against Covid.



Source: Measurements of CO_2 coordinated by **Javier Ballester,** professor of Fluid Mechanics at the



But Del Val highlights a major drawback in CO_2 measurement, namely that it does not distinguish between scenarios in which masks are worn or taken off. "Measuring CO_2 in a bar where you can uncover your mouth and talk and shout should not be the same as in a theater or a museum, where you are quiet all the time and wearing a mask," she says. Del Val believes that the benchmark CO_2 levels for premises where the mask can be removed should be stricter. "It would be a perfect tool for the hospitality industry, to get them on our side," she says. "You have to support the bars, but first there needs to be a good understanding of what a lower-risk environment consists of, if using these tools."

Methodology: The infrared camera images were recorded by the Leeds Environmental Fluid Dynamics Laboratory. In-car measurements were taken with an air quality monitor *(Aranet Pro Home) in a vehicle with the windows closed and no ventilation last February 25. The risk*

*of transmission was obtained using the **airborne.cam** simulator developed by the University of Cambridge and the calculations of air renewal inside the vehicle were obtained with an anemometer (David Higuera, industrial engineer and expert in installations.)*

*Development: **Jacob Vicente López**.*

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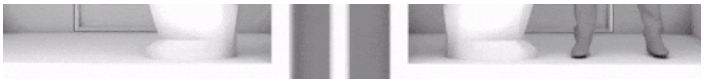

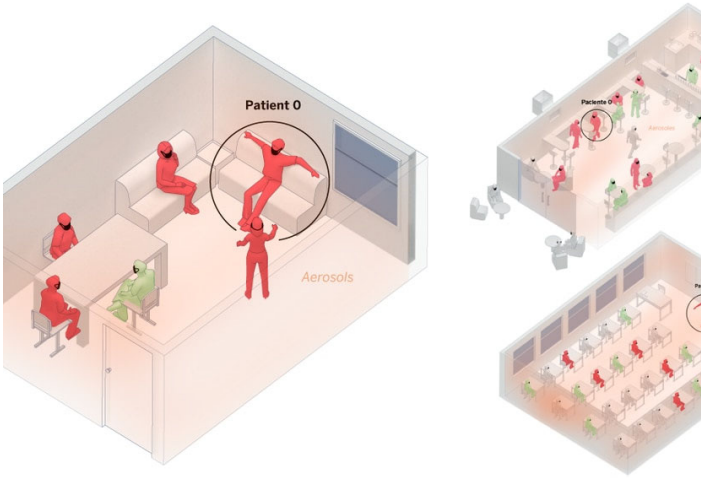

CORONAVIRUS

A room, a bar and a classroom: how the coronavirus is spread through the air