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COVID-19

Airborne transmission: Are CO₂ monitors a long term solution or “pandemic hack?”

As more people have acknowledged the airborne transmission of SARS-CoV-2, CO₂ monitors have emerged as a cost effective way to tell how well ventilated a space is. **Chris Baraniuk** asks what the evidence is and if they should be adopted more widely

Chris Baraniuk *freelance journalist*

There is ample evidence that SARS-CoV-2 can become airborne¹ and that ventilation reduces the risk of transmission,² but the difficulty is what to do about it. For all the sensitivity of the human senses, our eyes and ears cannot tell us whether the air in a room is full of aerosols harbouring SARS-CoV-2.

But what if we could measure the freshness of that air and, therefore, get a rough idea of how safe we'd be in a particular indoor space—or at least how well ventilated it is?

Carbon dioxide (CO₂) monitors, which measure concentrations of the gas in parts per million (ppm), have emerged as one way to do that. CO₂ levels build up when people exhale indoors but can remain low if a space is well ventilated. The idea is that a CO₂ reading provides an immediate, understandable proxy or surrogate measurement of ventilation and, by extension, an indication of the risk that SARS-Cov-2 aerosols might be accumulating in that space.

Various countries around the world have used these devices to give some sense of how safe an indoor space is during the pandemic. Japan is one of the most prominent, with CO₂ monitors installed in shopping centres,³ cinemas,⁴ and offices.⁵ In Washington State in the US, restaurants and bars have used the devices⁶ when setting up covered outside seating areas “to ensure adequate exchange with outdoor air.”

In the UK, the government has distributed more than 350 000 CO₂ monitors to schools⁷ in England to help teachers identify classrooms or other indoor spaces that are poorly ventilated. According to the CoSchools project⁸—from the universities of Cambridge and Surrey, and Imperial College London, which assisted the government programme—a CO₂ reading of 800 ppm or lower is indicative of good ventilation. Matt Butler, a consultant geriatrician at Cambridge University Hospitals, who is using CO₂ monitors in a hospital study, says the devices can help building managers identify places that require improved ventilation.

CO₂ monitoring is not currently mentioned in the UK's official infection prevention and control guidance⁹ for health and care settings. The guidance does, however, stipulate the need to evaluate the quality of ventilation in such settings.

Evidence base

Our understanding of how CO₂ monitors, specifically, can help in the pandemic is arguably still nascent.

In one study in Belgium, researchers installed CO₂ monitors in 12 patient rooms at Imelda Hospital in the municipality of Bonheiden and told staff to try and keep readings below 800 ppm by, for example, opening windows and reducing crowding. But this was easier said than done. “We identified significant barriers towards implementation, mainly patients complaining of the cold and draught discomfort from increased ventilation, as well as lack of attention drawn by the monitors,” the study authors wrote.¹⁰

A separate study in Italy reported that implementing a ventilation protocol, which included the use of CO₂ monitors, resulted in lower average CO₂ levels in school classrooms.¹¹ The researchers of that study did not, however, specifically evaluate whether this was also associated with lower SARS-CoV-2 transmission among pupils and staff.

Butler and colleagues are beginning a study at Addenbrooke's Hospital in Cambridge that will track patient infections on two wards—one that has a HEPA filtration system (see box) and one that does not.

HEPA filters and CO₂

HEPA grade air filtration systems have emerged as one of the recommended ways to make spaces safe from SARS-CoV-2. Early tests by Matt Butler, at the University of Cambridge, and colleagues have confirmed that they remove viruses, fungi, and bacteria from the air as intended. But it's important to note that HEPA filtration doesn't actively remove CO₂ from the air, so in theory the CO₂ level in a room could remain elevated while the air is made safe. Butler's team is using CO₂ monitors to track air freshness over time to see whether that also has any relation to cases of infection.

HEPA devices could still affect CO₂ concentrations, says Butler. The machines produce a breeze, potentially distributing CO₂ and any pathogen carrying aerosols that remain in the air around the room more evenly.

“Exhaled breath hangs in pockets like drops of ink in a bathtub,” he says, “The HEPA acts like a whisk to the bath water.”

Not everyone is convinced, however, that we should rely on CO₂ monitors to give us an indication of covid-19 safety.

The devices are merely a “pandemic hack,” a short term solution, argues Angela Eykelbosh, environmental health and knowledge translation scientist at the British Columbia Centre for Disease Control’s National Collaborating Centre for Environmental Health. “When somebody says to me, ‘Can I use CO₂ as a proxy for covid risk?’ I say, ‘No, how do you know how many infected people are in the room?’”

In 2021, Eykelbosh published a report on the use of CO₂ monitors¹² during the pandemic that referenced examples from multiple countries. She concluded that CO₂ readings should not be interpreted as a proxy for covid risk given, among other reasons, the lack of strong evidence for a direct link between indoor CO₂ concentrations and covid-19 transmission, and the imprecision of CO₂ monitors. Speaking to *The BMJ*, she added that to suggest a low CO₂ reading shows, definitively, that there is a low covid-19 risk in an indoor space such as a cinema would be akin to “hygiene theatre.”

“As long as people can understand and hold on to the idea that a low CO₂ level means that it’s well ventilated and their risk is minimised, OK,” she adds. “But if this is incorrectly communicated so that people are understanding that number on the screen as covid risk, then it’s a disservice to the public.”

Julian Tang, clinical virologist in respiratory sciences at the University of Leicester, agrees about the caveats. “Clearly, if you have more people infected in that space you could have CO₂ levels that are relatively low but the virus concentration would be higher,” he says.

He points out, however, that a lack of uniformity dogs all non-pharmaceutical interventions, including masks and social distancing. That doesn’t mean we simply dispense with them, he says, adding that, overall, better ventilation and indications thereof are useful.

Sage advice

Clearly, improved ventilation does not prevent someone from catching covid-19 when they sit or stand in front of an infected person while they speak or sing, for example, since that would bring the uninfected person into contact with sprayed droplets containing the virus.

In a paper about the relation of ventilation to covid-19 transmission published in October 2020,¹³ the UK’s Scientific Advisory Group for Emergencies (SAGE) noted that the significance of a CO₂ reading is dependent on context. In a large, sparsely occupied space, there is greater uncertainty over CO₂ readings, for instance.

“Continuous CO₂ monitoring is not likely to be a reliable proxy for transmission risk in most environments,” SAGE concluded. They added, however, that it might be a better indicator in places where the same group of people regularly attend, such as offices and schools. Models suggest that, if you double the ventilation, you halve the amount of virus present, wrote SAGE in their paper.

For Eykelbosh, there is a risk of getting bogged down in monitoring CO₂ levels arbitrarily when we should concentrate on improving air quality overall. “I don’t want to see classrooms with CO₂ sensors stuck up on the wall when what they should have is proper ventilation,” she says.

But Adam Squires, Bath lead for the Engineering and Physical Sciences Research Council Centre for Doctoral Training in Aerosol Science, emphasises that CO₂ monitoring can be part of our transition towards better ventilated indoor spaces. “CO₂ monitoring

definitely does assess levels of exhaled breath,” he says, “That does correlate with increased transmission.”

For Butler, that’s what really matters, rather than getting obsessive over specific readings and the outcomes that may or may not be associated with them. “In a hospital, we’re almost always less than 800 ppm but we’ve still seen infections,” he says. Tracking CO₂ levels can still be reassuring despite this, he argues, because the readings can give a rough idea of how much fresh air is entering a given space. More of that is, generally, better than less.

Despite all the caveats with CO₂ monitors, there remain few other ways in which people can gauge indoor air quality. Indeed, the bigger need is raising public awareness around the importance of ventilation in the first place. Referring to covid-19 prevention protocols, Butler says, “It’s taken us two years in the UK to begin to move away from thinking it’s about hand washing and cleaning of surfaces—in fact, I think we’re still very much there.” CO₂ monitors at least help to “make an invisible problem visible,” he says.

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