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NEWS HEALTH & MEDICINE

Cleaning indoor air may prevent COVID-19's spread. But it's harder than it looks

Ventilation, filtration and few other tricks help, but no solution works for all

Pedestrians walk along an overpass from a train station in Perth, Australia, where lockdown restrictions were recently lifted, though face masks remain mandatory.

PAUL KANE/GETTY IMAGES

By Tina Hesman Saey

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As restaurants, bars, businesses and schools reopen and mask requirements drop for the fully vaccinated, some people are asking how to bring in customers and students while still preventing COVID-19 infections from spreading. Some scientists and engineers are doing research that may help clear the air, making it safer for everyone to breathe.

Though no one solution works for all places, public spaces need to focus on proper

ventilation, air filtration, germicidal ultraviolet lights and air quality monitoring rather than rigorously disinfecting surfaces, say many scientists who cite evidence that the virus lingers in the air.

"This is what's really frustrating," says Jose-Luis Jimenez, an aerosol scientist at the University of Colorado Boulder. "We've wasted billions and billions of dollars on disinfecting, which doesn't serve any purpose whatsoever, yet things like having a $50 filter in every classroom, we haven't done."

Scientists have hotly debated whether SARS-CoV-2 counts as an airborne virus. While some researchers maintain that coronavirus can be picked up from infected saliva droplets that have landed on surfaces, many others counter that the possibility is a slim one. Touching a contaminated surface has a 1 in 10,000 chance of causing an infection, according to the U.S. Centers for Disease Control and Prevention. So, handwashing and standard cleaning practices are probably enough to eliminate any coronavirus that lands on surfaces or strays to hands.

A wealth of data now suggests that COVID-19 is spread mainly through inhaling fine aerosol particles that can hang in the air for hours, researchers argue in separate publications that appear online April 14 in the *British Medical Journal* and in the May 1 *Lancet*. Ten lines of scientific evidence support airborne transmission, the *Lancet* report says, and little data favor droplets or contact with contaminated surfaces as the primary way the virus is spread. On April 30, the World Health Organization updated its transmission information to acknowledge aerosols as a source of spread.

Learning how to clean the air of potentially virus-laden aerosols could have long-term benefits for health and allow businesses and schools to remain open during future outbreaks. That's promising because though COVID-19 cases, hospitalizations and deaths are falling in the United States thanks to vaccinations, mask wearing and people moving outside as the weather warms, the virus is still spreading widely in some places. On May 13, the U.S. Centers

for Disease Control and Prevention updated its recommendations saying that fully vaccinated people no longer have to wear masks, except where required by federal, state, local or tribal requirements, including business or workplace guidelines. It's not yet known if or how that will affect cases, though some researchers predict the coronavirus will make a comeback as people congregate inside in the fall and winter, which may require masking up again (*SN: 4/23/21*). Air cleansing strategies may help stop the resurgence, as well as prevent flu, colds and many other illnesses, including possible future pandemics.

Indoor air ought to be regulated for infection control, much like food and water are, air experts propose in the May 14 *Science*. Indoor air has mainly been conditioned to control odors and temperature, but systems should be upgraded to strip out pathogens, too, the scientists say.

Knocking respiratory viruses out of circulation wouldn't just improve health, it would also be good for the bottom line. In the United States alone, yearly economic losses from flu total $11.2 billion, and other respiratory viruses cost about $40 billion. COVID-19's global monthly harm is estimated to be $1 trillion.

"There needs to be a shift in the perception that we cannot afford the cost of control, because economic costs of infections can be massive and may exceed initial infrastructure costs to contain them," the scientists wrote.

Science News spoke to several researchers who shared tips about easy ways to clean the air, how to gauge whether those steps are working and what to avoid.

Ventilation

Cleansing the air is mostly a matter of proper ventilation and filtration. The equipment needed to do those things has been around for decades.

"We have the tools. We have the knowledge," says Charles Haas, an environmental engineer at Drexel University in Philadelphia.

Ventilation replaces stale indoor air with fresh air from outside, which dilutes the concentration of any virus that's present. Simply circulating air with fans isn't enough, Haas

says. "If all you're doing is moving around dirty air, the net effect is not going to be beneficial."

Most experts recommend completely replacing all the air in a room six times every hour. That's about average for many schools, offices and nursing homes, says Nora Wang Esram, senior director for research at the Washington, D.C.–based nonprofit American Council for an Energy-Efficient Economy. Hospitals often exceed that level of ventilation. Homes are among the least-ventilated places where people spend their time, with some exchanging air only once every two hours, she says.

See all our coverage of the coronavirus outbreak

Getting proper ventilation might be as easy as opening a window or turning up the fan on a heating and cooling unit. But there are trade-offs in increased energy costs, Esram warns. "Generally, we say increase ventilation, which means your fan has to run faster. Open up the damper and bring in more fresh air. Put in a filter. But there is a limit, and a balance. It's not like you can maximize everything at once," she says.

For instance, opening a window might be fine on breezy, balmy days. But when it's scorching hot or freezing cold out, during allergy season or when wildfires or pollution make breathing outdoor air dangerous, windows aren't an option. In that case, a building's heating, ventilation and air conditioning, or HVAC, system may be a good — if not better — substitute.

Researchers in Germany tested how cross-ventilation from two open windows performed against an HVAC system for clearing aerosol particles from a university lecture hall. In the winter, drafts of cold air from the open windows quickly made conditions in the lecture hall unpleasantly chilly. People would need to repeatedly open the windows for 10 minutes and close them for five minutes to perform similarly to the HVAC system, which did six air changes per hour and kept temperatures comfy, the researchers report March 20 at medRxiv.org. The work is preliminary and hasn't been reviewed by other scientists yet. But in this case, the HVAC was the winner.

In many places, including office buildings, hotels and stores, windows don't open. There, the

heating and cooling system is the only option for dumping stale air and bringing in fresh outside air. Many modern buildings already have HVAC systems that provide proper ventilation, says Martin Bazant, a physicist and chemical engineer at MIT who developed a tool to help people calculate how much ventilation they need for their space.

What's going on in a room makes a big difference in how much virus may need to be cleared from the air, Bazant and MIT colleague John Bush, an applied mathematician, report April 27 in the *Proceedings of the National Academy of Sciences*. "An interesting bit of science that has developed over the last year ... is the strong dependence on vocalization [for] aerosol generation," Bazant says. "For instance, just breathing heavily while exercising doesn't generate that many more droplets. It's really coming from your vocal chords." Speaking or singing generate more aerosol particles, and the louder the sound, the more aerosols are generated. So, a choir room would need more ventilation than the school library where people are sitting quietly.

Filtration

Another wrinkle to consider: Increasing ventilation in one room may carry infectious viruses into connected rooms through HVAC vents, researchers report in the June 15 *Building and Environment*. Central heat and air handling systems that serve multiple rooms are common in schools, strip malls, residential and office buildings, says coauthor Timothy Salsbury, a mechanical engineer at Pacific Northwest National Laboratory in Richland, Wash. If a person with COVID-19 were in one room and the HVAC were turned off, infectious virus particles would stay in that room, he says. "As soon as you start adding air flow to the space, you move the virus from the infected room to the uninfected [connecting] room."

And that's where filtration comes in. Experts recommend filtering air through materials that can trap airborne particles containing the virus. Such devices include HEPA filters or furnace and air conditioner filters with a Minimum Efficiency Reporting Value, or MERV, rating of 13. (MERV ratings range from 1 to 16. The higher the number, the more effectively the filter can catch small particles.) Ramping up filtration to pull the coronavirus out of the air can be a good substitute for increasing ventilation, Jimenez says.

Most new buildings in the United States follow building codes that require filters rated MERV8 or higher. But many older buildings have HVAC systems that can't handle higher level filters,

which have more resistance and require more pressure to push air through, Esram says. "If the pressure builds up [too much], it's going to damage your HVAC system," she says.

If buildings can't handle extra filtration at the central unit and building owners can't afford to upgrade the HVAC system, portable air-purifying machines may help. Many small units that can filter the air in a room are available. Among the best are high-efficiency particulate absorbing filters, better known as HEPA filters.

HEPA filters effectively remove viruses, pollen, dust, bacteria and other particles from the air. Some units can be expensive, Esram says, and they tend to move air slowly, effectively reducing the number of air changes per hour. Some large rooms, or rooms where lots of people congregate, such as classrooms, may need several units.

A study in the Netherlands found that HEPA units cleared the air of bubbles standing in for coronavirus-carrying aerosols better than open windows and doors did. But study participants said the units were too noisy and created bothersome drafts, the researchers reported in the Jan. 15 *Building and Environment*. Some restaurants are experimenting with tabletop filters that can suck in diners' exhalations and send the filtered air skyward instead of toward a dining companion's face.

Many people have the mistaken idea that air purifying equipment has to be high tech and expensive to be effective, says Marwa Zaatari, a building scientist with expertise in indoor air quality and a partner at D Zine Partners, a Texas-based company that designs indoor air quality systems. All you really need is a fan and a filter, she says. Well, five filters.

Corsi boxes, named after environmental engineer Richard Corsi of Portland State University in Oregon, consist of cubes made of five MERV filters with a box fan as the sixth side. The DIY filtration unit is a relatively low-cost alternative that even tenants who don't control their building's central HVAC system can use.

A Corsi box (pictured) is a low-cost, DIY indoor air filtration solution that consists of one box fan plus five filters arranged in a cube.

COURTESY OF TEX-AIR FILTERS

Filters will remove viruses from the air over the long term, but unless there is a filter between two people it won't stop short-range virus transmission, Bazant says. That's why masks are important (*SN: 2/12/21*). If both people are wearing masks, it's like having two filters, he says.

Restaurants and bars have an extra challenge in the filtration department because patrons don't wear masks while they eat and drink. And lingering over dinner can create a cloud of particles that other diners can breathe in, says Kimberly Prather, an aerosol scientist at the Scripps Institution of Oceanography in La Jolla, Calif. The longer people spend in potentially virus-laden air, the higher the infection risk, she says. "It's all about time. It's not just a whiff" as people pass on the street.

Monitoring

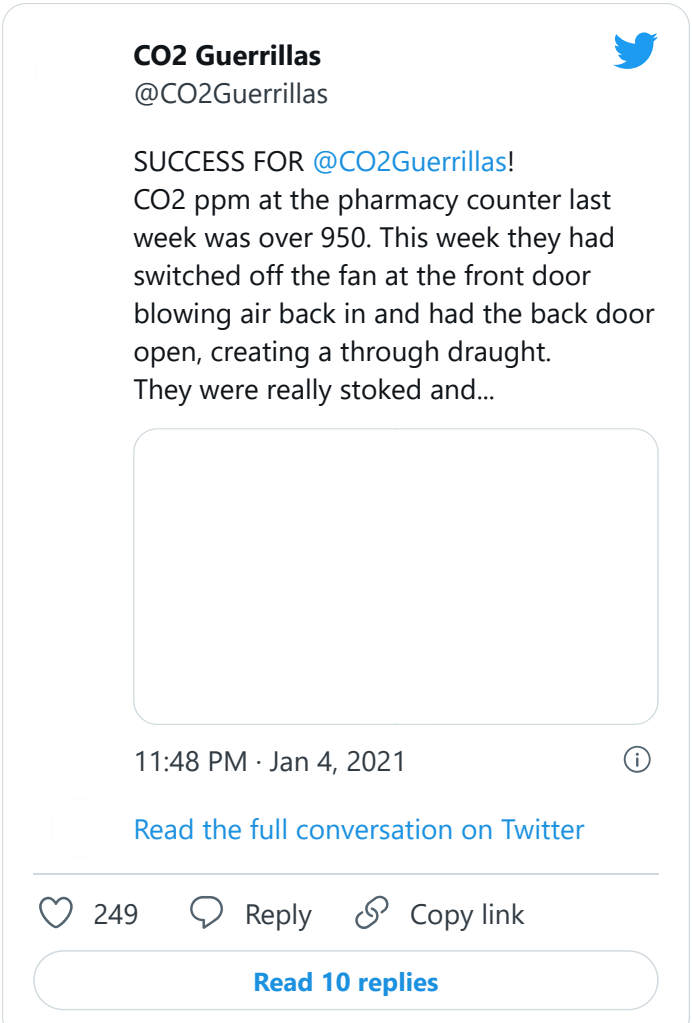
How can diners, store patrons, students and teachers know whether they are breathing safe air? There are no guarantees, but Jimenez, Prather and other experts think the United States should take cues from other countries and post carbon dioxide levels outside businesses and classrooms as a proxy for air freshness.

People breathe out CO_2 all the time. In fact, every exhaled breath is about 4 percent carbon dioxide, Jimenez says. (The rest is mainly nitrogen and oxygen, but may contain small

amounts of thousands of other compounds.) Without proper ventilation, CO_2 levels build up. And that's not good at all, Jimenez says. "We get dumber when there is high CO_2," he says. Studies have shown that student performance suffers and people have trouble making decisions as carbon dioxide levels rise.

Worse, high carbon dioxide levels mean a higher chance that "the air you breathe in has already been in somebody else's lungs," Jimenez says. "You don't want your lungs to touch the air that has been touched by other lungs."

Outside, the air people breathe is quickly diluted. Out of every million molecules of outside air, about 400 are carbon dioxide — a concentration of 400 parts per million. Ideally, indoor air shouldn't get much above 700 parts per million of CO_2, Jimenez says.



An Australian group called CO2Guerrillas tweets carbon dioxide readings to raise awareness about poor air quality. Small CO_2 monitors (one pictured) in public spaces could help visitors assess how well the air is ventilated.

A portable carbon dioxide monitor can cue people in to whether the store or movie theater they're walking into has enough ventilation. But it's not a perfect measure, Jimenez stresses. Filtered air may be a bit stuffy, but would have lower infection risks than unfiltered air. And activities, such as an exercise class or choir practice, in a room may produce CO_2 levels similar to other situations, but carry 100 times the infection risk, he and University of Colorado colleague Zhe Peng reported online April 5 in *Environmental Science & Technology Letters*.

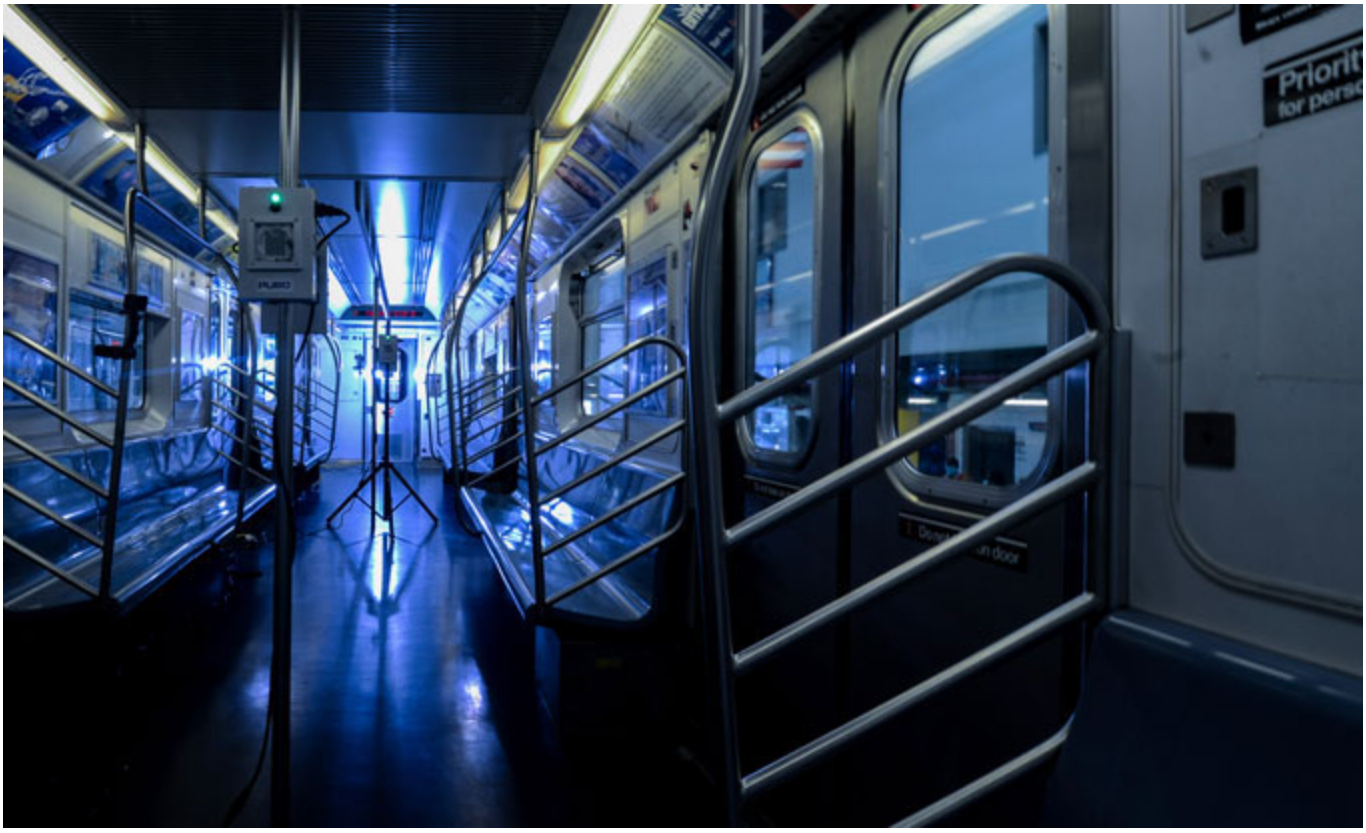
Sterilization

Some companies have proposed spraying chemical disinfectants that could kill the virus in the air, Esram says. One proposal would release a fog of the chemicals into a movie theater to sanitize the air. That might be fine when people aren't there. But it wouldn't help with the cloud of aerosols moviegoers constantly emit when they breathe, cheer, laugh or gasp at the antics on screen. "Nobody wants to get sprayed down while they're eating their popcorn," Esram says.

There is a sterilizing technique that could be used while people are in the room, Prather says. Germicidal ultraviolet light may zap the virus and kill it in the air. At least ultraviolet-C radiation has been shown to destroy the outer protein coat of the original SARS virus. No one knows exactly how much UV-C is needed to inactivate SARS-CoV-2.

Still, UV-C lights installed in the upper parts of rooms and shielded from people's eyes may kill lingering viruses and bacteria, making air safer, Prather says. "But you can do it wrong," she says. Such systems need to be installed by professionals and can be costly. Still, properly installed germicidal UV lights can help protect against a variety of pathogens, not only SARS-CoV-2.

Not all UV lights are created equal, though. Consumers should beware of UV photocatalytic oxidation, or PCO, lamps, says Zaatari, the Texas building scientist. Those lamps shine UV light on a catalyst to create chemicals, which can kill pathogens. But the reaction can produce formaldehyde and other potentially harmful chemicals that may damage people's lungs.



The Metropolitan Transit Authority in New York City recently launched a pilot program to sterilize subway cars, buses and other facilities with virus-killing UV light (pictured).

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Another product to shy away from is ionizers, which often come built into air purifiers along with HEPA filters. Companies have also been marketing "bipolar ionization" as a way to kill the virus in the air. Those electronic air cleaners work by creating ozone, gaseous hydrogen peroxide and other chemicals that may or may not kill the virus, but could also damage lungs, Zaatari says. She wrote an open letter urging schools and organizations that set building standards to not use the devices.

Some companies say that their ionizers don't produce ozone. That may well be, but ozone is what is doing the work to kill pathogens, Zaatari says. "So, when they show us a test with no ozone, we know the effectiveness is close to zero."

The effectiveness of those products has not been proven the way ventilation, filtration and UV-C irradiation have, she says. "At best they don't work, and at worst they produce harmful by-products," Zaatari says. "We don't have a shortage of proven solutions. So why would we, in uncertain times, do uncertain things?"

Editor's Note: This story was updated on May 18, 2021, to provide a different image of a Corsi box.

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