RenewAire® Energy Recovery Ventilation

MITIGATE COVID-19 TRANSMISSION VIA INCREASED BUILDING VENTILATION

By Nick Agopian

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With the advent of the novel coronavirus (SARS-CoV-2 virus, which causes COVID-19 disease) pandemic, organizations worldwide are working intensely to understand how to beat the disease. This includes what can be done to protect the health of occupants inside structures of every type.

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In that vein, this white paper attempts to shed light on one particular area, the proper application of which can help to mitigate potential exposure to the virus. That subject is increased building ventilation. Science has modelled that lack of ventilation increases exposure to infection, while increased ventilation lowers exposure and potential for infection.

The crucial role of ventilation in the form of ventilators used by hospitals is well-documented for helping patients in intensive care units. But ventilation is also vital for furthering the health of building occupants via HVAC systems. Implementing *building ventilation* correctly can enhance indoor air quality (IAQ) and decrease the transmission of airborne infectious diseases, including COVID-19. This is what we'll discuss here in the white paper.

Specifically, we'll examine three primary topics. First, how SARS-CoV-2 is transmitted, with a focus on the airborne routes. Second, how increased building ventilation can decrease the amount of viruses and other contaminants in the air. Third, how energy recovery ventilation can be applied to reduce the energy consumption and costs incurred by realizing cleaner indoor air.

Before jumping in, a quick disclaimer. This white paper is based on the most recent evidence as of July 2020. However, due to the fast-moving nature of SARS CoV-2/COVID-19, information is in flux and constantly being updated. Also, since knowledge of the virus is still limited, many sources use past experiences with other similar viruses to offer recommendations.

With that, let's begin and take a look at the transmission of the SARS-CoV-2 virus.

Transmission Routes of the SARS-CoV-2 Virus

According to a COVID-19 guidance document from the Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA), the standard assumption is that SARS-CoV-2 is "transmitted" (meaning that the virus travels from an infected person to an uninfected one) via two primary routes. These include: 1) Airborne: large droplets or smaller particles emitted when sneezing, coughing or talking and 2) Surface: contact, such as shaking hands or touching something.[1]

Per the Centers for Disease Control and Prevention (CDC)'s information on how COVID-19 spreads, the disease is thought to spread mainly through close contact from person to person. This happens in the following ways:[2]

- Between people who are in close contact with one another (within about six feet)
- Through respiratory droplets produced when an infected person coughs, sneezes or talks
- These droplets can land in the mouths or noses of people who are nearby or possibly be inhaled into the lungs
- COVID-19 may be spread by people who are not showing symptoms

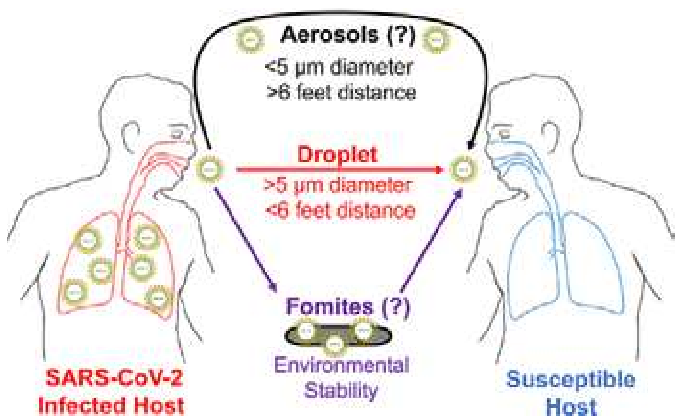

Figure 1: COVID-19 potential modes of transmission. *Source: Biola University via Frontiers in Public Health*[3]

[1] All information in this paragraph sourced from: "REHVA COVID-19 guidance document," Federation of European Heating, Ventilation and Air Conditioning associations (REHVA), April 3, 2020, https://www.rehva.eu/fileadmin/user_upload/REHVA_COVID-19_guidance_document_ver2_20200403_1.pdf.

[2] All information in this paragraph and subsequent bullets sourced from: "How COVID-19 Spreads," Centers for Disease Control and Prevention (CDC), Updated June 16, 2020, https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html.

[3] Thushara Galbadage, Brent M. Peterson, Richard S. Gunasekera, "Does COVID-19 Spread Through Droplets Alone?," Biola University via Frontiers in Public Health, April 24, 2020, https://doi.org/10.3389/fpubh.2020.00163.

REHVA states that when it comes to airborne transmission, there are two exposure mechanisms, which are listed here and demonstrated below in Figure 2:[4]

- **Large droplets:** These droplets are larger in size (>10 microns) and are formed from coughing and sneezing. They fall to surfaces within 3-6 feet from the infected person. People can catch the infection by touching those contaminated surfaces or objects and then touching their eyes, nose or mouth. If people are standing within 3-6 feet of an infected person, they can also be infected by breathing in the droplets.
- **Smaller particles:** These smaller particles (also referred to as aerosols) are less than 5 microns in size and are generated by coughing, sneezing and talking. They may stay airborne for hours and can travel long distances carried by airflows in the rooms or in the extract air ducts of ventilation systems. Also, small particles (droplet nuclei or residue) are created from droplets that evaporate (usually within milliseconds) and desiccate. Note that the size of a SARS-CoV-2 particle is .08 to .16 microns. It's been shown to remain active at common indoor conditions up to three hours in indoor air and 2-3 days on room surfaces at common indoor conditions. This finding implies that keeping 3-6 feet from an infected person might not be enough, and increasing ventilation is useful because of removal of more particles.

Also, REHVA mentions that a third airborne transmission route gaining attention from the scientific community is the fecal-oral route. This transmission route for SARS-CoV-2 infections is implicitly recognized by the WHO in a technical briefing from March 2, 2020. In it, the organization proposes as precautionary measure to flush toilets with the lid closed.[5]

The below chart from REHVA demonstrates airborne transmission routes of SARS-CoV-2. Some routes have been confirmed, while others are highly likely based on experience with SARS and other flu viruses.[6]

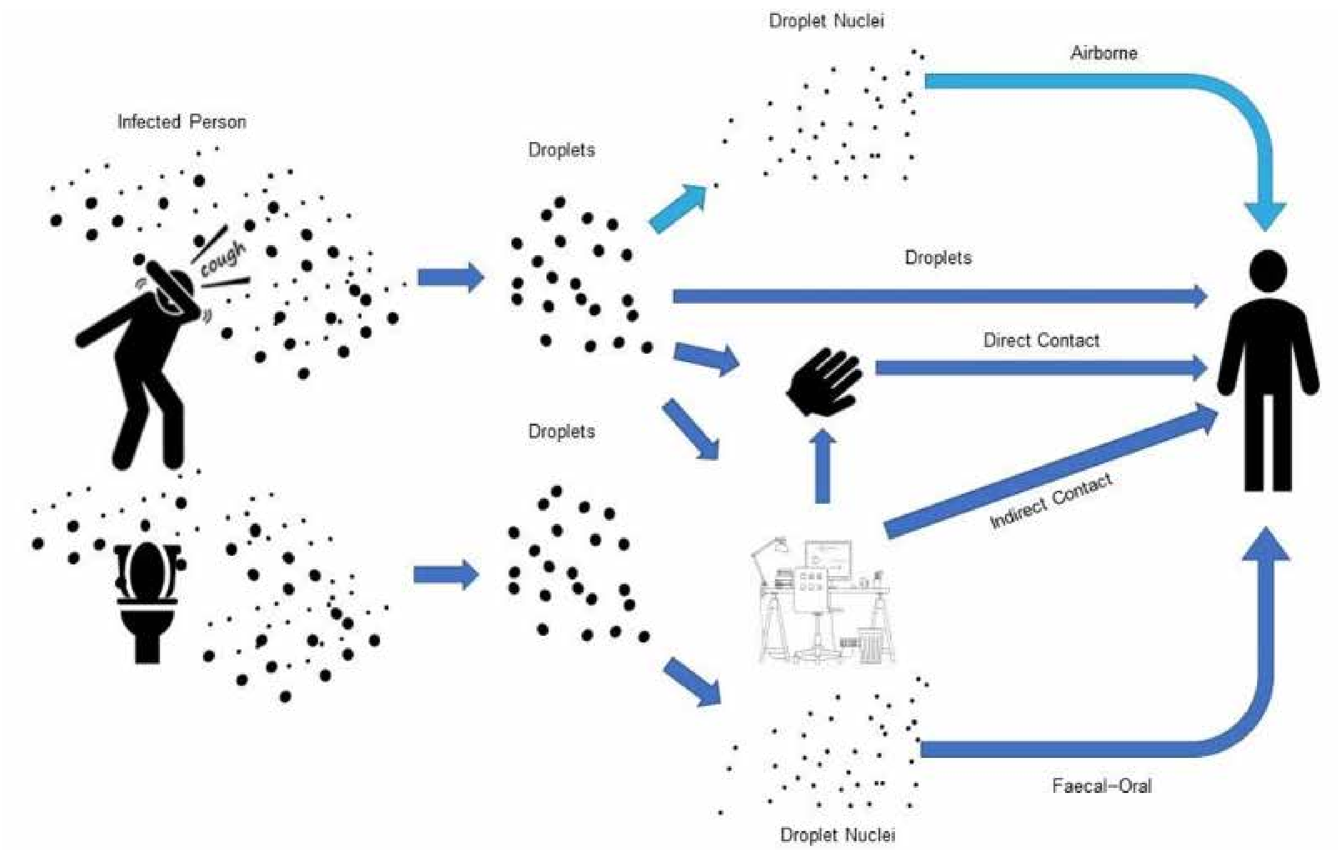

Figure 2: Dark blue: WHO-reported exposure mechanisms of COVID-19 (SARS-CoV-2) droplets. Light blue: airborne mechanism known from SARS (SARS-CoV-1) and other flu; currently there's no reported evidence specifically for SARS-CoV-2 of this route (figure: courtesy Francesco Franchimon). *Source: REHVA*[7]

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) produced a position document on airborne infectious diseases. Like the REHVA document, it also says that exposure through the air occurs through: 1) droplets, which are released and fall to surfaces about three feet from the infected and 2) small particles, which stay airborne for hours at a time and can be transported long distances.[8]

[4] All information in this paragraph and subsequent bullets sourced from: "REHVA COVID-19 guidance document," Federation of European Heating, Ventilation and Air Conditioning associations (REHVA), April 3, 2020, https://www.rehva.eu/fileadmin/user_upload/REHVA_COVID-19_guidance_document_ver2_20200403_1.pdf.

[5] All information in this paragraph sourced from: "REHVA COVID-19 guidance document," Federation of European Heating, Ventilation and Air Conditioning associations (REHVA), April 3, 2020, https://www.rehva.eu/fileadmin/user_upload/REHVA_COVID-19_guidance_document_ver2_20200403_1.pdf.

[6] All information in this paragraph sourced from: "REHVA COVID-19 guidance document," Federation of European Heating, Ventilation and Air Conditioning associations (REHVA), April 3, 2020, https://www.rehva.eu/fileadmin/user_upload/REHVA_COVID-19_guidance_document_ver2_20200403_1.pdf.

[7] "REHVA COVID-19 guidance document," Federation of European Heating, Ventilation and Air Conditioning associations (REHVA), April 3, 2020, https://www.rehva.eu/fileadmin/user_upload/REHVA_COVID-19_guidance_document_ver2_20200403_1.pdf.

[8] All information in this paragraph sourced from: ASHRAE Position Document on Airborne Infectious Diseases, ASHRAE, February 5, 2020, https://www.ashrae.org/file%20library/about/position%20documents/airborne-infectious-diseases.pdf.

ASHRAE illustrates the aerobiology of transmission of droplets and small particles produced by a patient with acute infection in the below depiction:

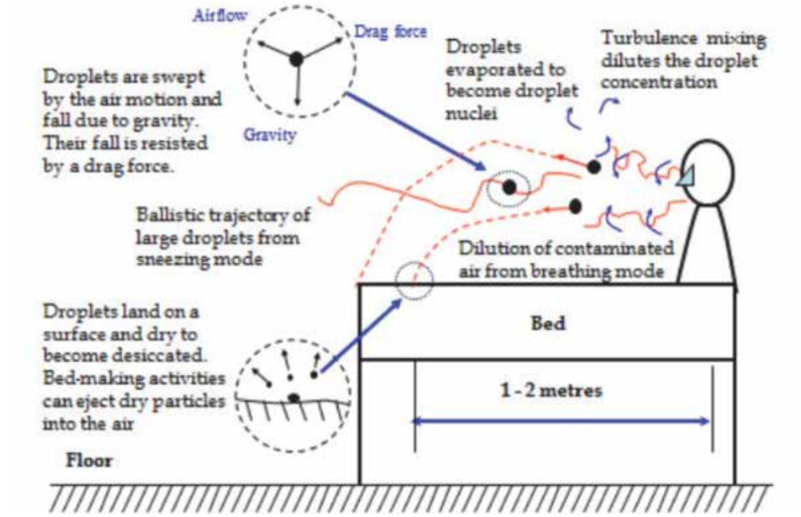

Figure 3: Droplet suspension: illustration of the aerobiology of droplets and small airborne particles produced by an infected patient. *Source: ASHRAE*[9]

Similar mechanisms for airborne transmission of SARS-CoV-2 are described in a study published in the Journal of the American Medical Association. It found that under the right conditions, liquid droplets from sneezes, coughs and even exhaling can travel more than 26 feet and linger in the air for minutes.[10]

The study focused on the existence of a turbulent gas cloud, which is emitted when someone coughs, sneezes or exhales. Liquid droplets of various sizes drop onto surfaces, while others can be trapped in a cloud that can swirl around. Pathogens in the cloud could potentially reach air circulation systems inside buildings.[11]

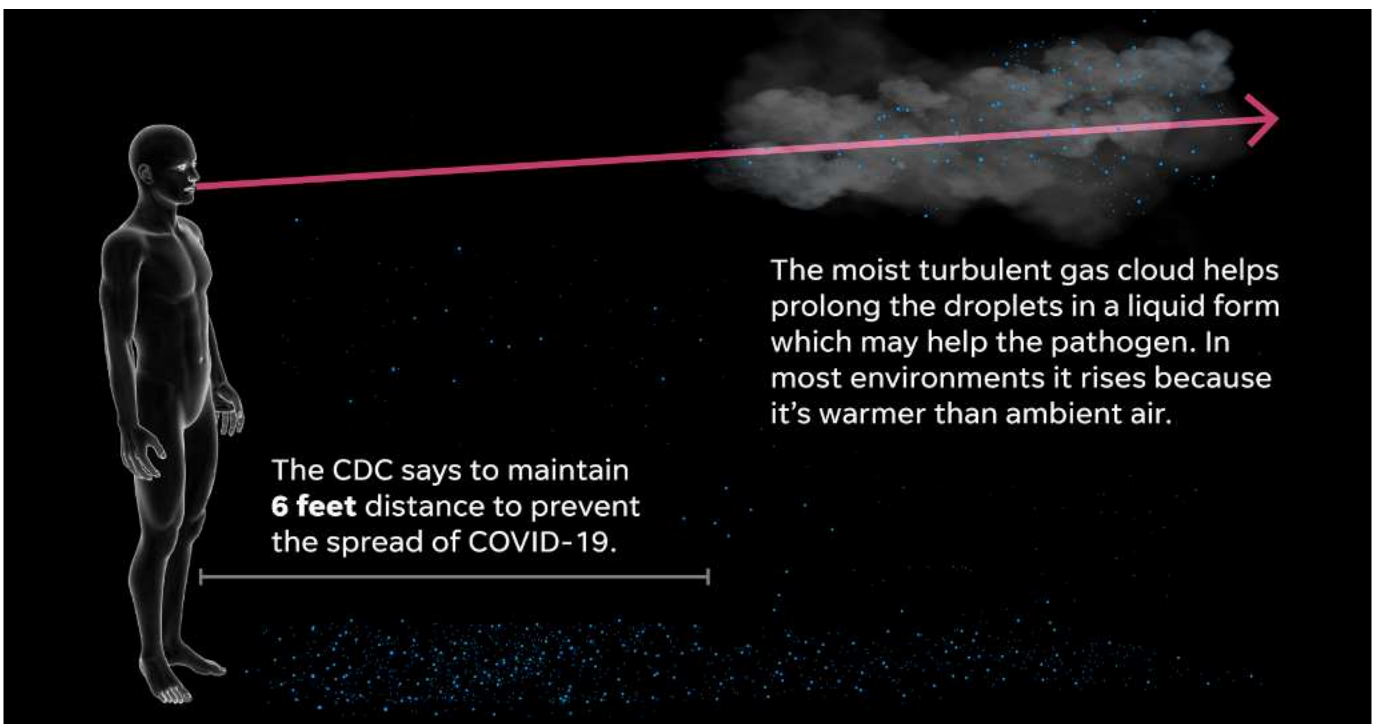

Figure 4: Floating airborne droplets – some shielded by turbulent gas clouds – can stay suspended long enough for someone to walk through and inhale the virus. Pathogens in the cloud could potentially reach air circulation systems inside buildings. *Source: USA Today*[12]

9 ASHRAE Position Document on Airborne Infectious Diseases, ASHRAE, February 5, 2020, https://www.ashrae.org/file%20library/about/position%20documents/airborne-infectious-diseases.pdf.

10 All information in this paragraph sourced from: Ramon Padilla, Javier Zarracina, "Coronavirus might spread much farther than 6 feet in the air. CDC says wear a mask in public.," USA Today, April 5, 2020, https://www.usatoday.com/in-depth/news/2020/04/03/coronavirus-protection-how-masks-might-stop-spread-through-coughs/5086553002/.

11 All information in this paragraph sourced from: Ramon Padilla, Javier Zarracina, "Coronavirus might spread much farther than 6 feet in the air. CDC says wear a mask in public.," USA Today, April 5, 2020, https://www.usatoday.com/in-depth/news/2020/04/03/coronavirus-protection-how-masks-might-stop-spread-through-coughs/5086553002/.

12 Ramon Padilla, Javier Zarracina, "Coronavirus might spread much farther than 6 feet in the air. CDC says wear a mask in public.," USA Today, April 5, 2020, https://www.usatoday.com/in-depth/news/2020/04/03/coronavirus-protection-how-masks-might-stop-spread-through-coughs/5086553002/.

Furthermore, scientists in China identified genetic markers of the virus in airborne droplets, many with diameters smaller than one-ten-thousandth of an inch. It's unknown if the virus in the samples they collected was infectious, but droplets that small – expelled by breathing and talking – can remain aloft and be inhaled by others.[13]

Finally, in an open letter to the WHO, 239 scientists in 32 countries outlined the evidence showing that smaller coronavirus particles can infect people, and urged action. They state: "We appeal to the medical community and to the relevant national and international bodies to recognize the potential for airborne spread of COVID-19. There is significant potential for inhalation exposure to viruses in microscopic respiratory droplets (microdroplets) at short to medium distances (up to several meters, or room scale), and we are advocating for the use of preventive measures to mitigate this route of airborne transmission."[14]

Consequently, these findings heighten the dangers of airborne transmission of SARS-CoV-2. Without sufficient air circulation to disperse virus droplets, they can linger in the indoor air. This underlines the importance of indoor spaces being ventilated frequently to reduce the concentration of pathogens.[15]

All of this said, one source of confusion is that at this stage, cases of aerosol (small-drop) transmissions to otherwise healthy humans by SARS-CoV-2 have not been officially "confirmed." However, airborne transmission is assumed by the CDC, WHO, REHVA and ASHRAE to be possible.[16]

For example, ASHRAE states that "Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of heating, ventilating and air-conditioning systems, can reduce airborne exposures."[17]

Perhaps surprisingly, "confirmation" is very difficult to accomplish in the midst of a pandemic, during which all efforts are on medical treatments and precautionary measures. Hence, such confirmation may not be accomplished until after a pandemic is brought under control.

Building Ventilation Mitigates Disease Transmission

Since carriers of infectious diseases, such as small particles and aerosols, can be airborne, removing them via building ventilation can be a powerful tool in mitigating transmission. The fundamental role increased building ventilation plays in combatting viruses and other harmful indoor air contaminants is addressed by several leading organizations. These include:

ASHRAE

Ventilation is essential in healthcare facilities. As such, ANSI/ASHRAE/ASHE Standard 170, "Ventilation of Healthcare Facilities," defines ventilation system design guidelines for hospitals and other medical buildings. This standard's recommendations provide environmental control for comfort and odor, as these two things can be compromised without proper care and act as a hindrance to patient recovery.[18]

Regarding the relationship Between COVID-19 and HVAC systems, ASHRAE released a statement in support of ventilation: "Ventilation and filtration provided by heating, ventilating and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk of transmission through the air. Unconditioned spaces can cause thermal stress to people that may be directly life threatening and that may also lower resistance to infection. In general, disabling of heating, ventilating and air-conditioning systems is not a recommended measure to reduce the transmission of the virus."[19]

ASHRAE asserts that because small particles remain airborne for some period of time, the design and operation of HVAC systems that move air can minimize disease transmission in several ways. These include:[20]

- Supplying clean air to susceptible occupants
- Containing contaminated air and/or exhausting it to the outdoors
- Diluting the air in a space with cleaner air from outdoors and/or by filtering the air
- Cleaning the air within a room

At a greater level of detail, to reduce airborne infectious disease transmission through ventilation, ASHRAE recommends implementing the following ventilation strategies:[21]

- Dilution ventilation
- Directional ventilation
- In-room airflow regimes
- Room-pressure differentials
- Personalized ventilation

[13] All information in this paragraph sourced from: Kenneth Chang, "Airborne Coronavirus Detected in Wuhan Hospitals," NY Times, April 28, 2020, https://www.nytimes.com/2020/04/28/health/coronavirus-hospital-aerosols.html.

[14] All information in this paragraph sourced from: Lidia Morawska, Donald K. Milton, "It is Time to Address Airborne Transmission of COVID-19," Oxford University Press for the Infectious Diseases Society of America, Clinical Infectious Diseases, https://academic.oup.com/cid/article-pdf/doi/10.1093/cid/ciaa939/33478095/ciaa939.pdf.

[15] All information in this paragraph sourced from: Ramon Padilla, Javier Zarracina, "Coronavirus might spread much farther than 6 feet in the air. CDC says wear a mask in public.," USA Today, April 5, 2020, https://www.usatoday.com/in-depth/news/2020/04/03/coronavirus-protection-how-masks-might-stop-spread-through-coughs/5086553002/.

[16] Note that for SARS-CoV-1, aerosol infection was not confirmed until months after the peak of the pandemic due to the later adoption of the standard for "confirmation."

[17] "ASHRAE Issues Statements on Relationship Between COVID-19 and HVAC in Buildings," ASHRAE, April 20, 2020, https://www.ashrae.org/about/news/2020/ashrae-issues-statements-on-relationship-between-covid-19-and-hvac-in-buildings.

[18] All information in this paragraph sourced from: Brad Kelechava, "ANSI/ASHRAE/ASHE Standard 170-2017: Ventilation of Health Care Facilities," American National Standards Institute (ANSI), April 8, 2020, https://blog.ansi.org/2020/04/ansi-ashrae-170-2017-health-care-ventilation/#gref.

[19] "ASHRAE Issues Statements on Relationship Between COVID-19 and HVAC in Buildings," ASHRAE, April 20, 2020, https://www.ashrae.org/about/news/2020/ashrae-issues-statements-on-relationship-between-covid-19-and-hvac-in-buildings.

[20] All information in this paragraph and subsequent bullets sourced from: ASHRAE Position Document on Airborne Infectious Diseases, ASHRAE, February 5, 2020, https://www.ashrae.org/file%20library/about/position%20documents/airborne-infectious-diseases.pdf.

[21] All information in this paragraph and subsequent bullets sourced from: ASHRAE Position Document on Airborne Infectious Diseases, ASHRAE, February 5, 2020, https://www.ashrae.org/file%20library/about/position%20documents/airborne-infectious-diseases.pdf.

- Source-capture ventilation
- Filtration
- Ultraviolet germicidal irradiation (UVGI)

REHVA

According to REHVA, to remove virus particles out of the building and from surfaces, air supply and exhaust ventilation should be increased. This can be done via the following ways:[22]

- In buildings with mechanical ventilation systems, extended operation times are recommended. Change the clock times of system timers to start ventilation at nominal speed at least two hours before the building usage time, and switch to lower speed two hours after the building usage time. In demand-controlled ventilation systems, change the CO2 setpoint to the lower, 400 ppm value, in order to assure the operation at nominal speed. Keep the ventilation on 24/7, with lowered (but not switched off) ventilation rates when people are absent.
- In buildings that have been vacated due to the pandemic (some offices or educational buildings) it's not recommended to switch ventilation off, but to operate continuously at reduced speed. Considering a springtime with small heating and cooling needs, the recommendations above have limited energy penalties, while they help to remove virus particles out of the building and to remove released virus particles from surfaces.
- The general advice is to supply as much outside air as reasonably possible. The key aspect is the amount of fresh air supplied per person. If, due to smart working utilization, the number of employees is reduced, do not concentrate the remaining employees in smaller areas but maintain or enlarge the social distancing (minimum physical distance of 2-3 meters between people) among them in order to foster the ventilation cleaning effect.
- Exhaust ventilation systems of toilets should always be kept on 24/7, and make sure that the right pressure is created, especially to avoid fecal-oral transmission.

Centers for Disease Control and Prevention (CDC)

The CDC backs the role of ventilation in protecting against SARS-CoV-2. The CDC recommends considering improving engineering controls as they relate to the building ventilation system. This may include increasing ventilation rates and the percentage of outdoor air that circulates into the system.[23]

Specifically, the CDC recommends taking the following steps to improve ventilation in a building to counter disease transmission:[24]

- Ensure that ventilation systems in the facility operate properly. For HVAC systems in commercial buildings that have been shut down or setback, review new construction start-up guidance provided in ASHRAE Standard 180-2018.
- Increase the percentage of outdoor air (e.g., using economizer modes of HVAC operations) potentially as high as 100% (first verify compatibility with HVAC system capabilities for both temperature and humidity control as well as compatibility with outdoor/indoor air quality considerations).
- Increase total airflow supply to occupied spaces, if possible.
- Disable demand-control ventilation (DCV) controls that reduce air supply based on temperature or occupancy.
- Consider using natural ventilation (i.e., opening windows if possible and safe to do so) to increase outdoor air dilution of indoor air when environmental conditions and building requirements allow.
- Improve central air filtration:
  - Increase air filtration to as high as possible (MERV 13 or 14) without significantly diminishing design airflow.
  - Inspect filter housing and racks to ensure appropriate filter fit and check for ways to minimize filter bypass.
- Consider running the building ventilation system even during unoccupied times to maximize dilution ventilation.
- Generate clean-to-less-clean air movement by re-evaluating the positioning of supply and exhaust air diffusers and/or dampers and adjusting zone supply and exhaust flow rates to establish measurable pressure differentials. Have staff work in areas served by "clean" ventilation zones that do not include higher-risk areas such as visitor reception or exercise facilities (if open).

Open Letter to the WHO from 239 Scientists in 32 Countries: "It is Time to Address Airborne Transmission of COVID-19"

In this open letter, which is also mentioned above, scientists state that "we must address every potentially important pathway to slow the spread of COVID-19." The building ventilation measures they say should be taken to mitigate airborne transmission risk include:[25]

- Provide sufficient and effective ventilation (supply clean outdoor air, minimize recirculating air) particularly in public buildings, workplace environments, schools, hospitals and aged care homes.
- Supplement general ventilation with airborne infection controls such as local exhaust, high-efficiency air filtration and germicidal ultraviolet lights.

[22] All information in this paragraph and subsequent bullets sourced from: "REHVA COVID-19 guidance document," Federation of European Heating, Ventilation and Air Conditioning associations (REHVA), April 3, 2020,https://www.rehva.eu/fileadmin/user_upload/REHVA_COVID-19_guidance_document_ver2_20200403_1.pdf.

[23] All information in this paragraph sourced from: "Interim Guidance for Businesses and Employers to Plan and Respond to Coronavirus Disease 2019 (COVID-19)," Centers for Disease Control and Prevention (CDC), March 21, 2020, https://www.cdc.gov/coronavirus/2019-ncov/community/guidance-business-response.html.

[24] All information in this paragraph and subsequent bullets sourced from: "COVID-19 Employer Information for Office Buildings," Centers for Disease Control and Prevention (CDC), https://www.cdc.gov/coronavirus/2019-ncov/community/office-buildings.html.

[25] All information in this paragraph and subsequent bullets sourced from: Lidia Morawska, Donald K. Milton, "It is Time to Address Airborne Transmission of COVID-19," Oxford University Press for the Infectious Diseases Society of America, Clinical Infectious Diseases, https://academic.oup.com/cid/article-pdf/doi/10.1093/cid/ciaa939/33478095/ciaa939.pdf.

World Health Organization (WHO)

On July 9, 2020, the WHO released an update to their scientific brief from March 29, 2020. The new document, "Transmission of SARS-CoV-2: implications for infection prevention precautions," lists the following points on airborne transmission and ventilation:[26]

- Airborne transmission is defined as the spread of an infectious agent caused by the dissemination of droplet nuclei (aerosols) that remain infectious when suspended in air over long distances and time. Airborne transmission of SARS-CoV-2 can occur during medical procedures that generate aerosols ("aerosol generating procedures"). WHO, together with the scientific community, has been actively discussing and evaluating whether SARS-CoV-2 may also spread through aerosols in the absence of aerosol generating procedures, particularly in indoor settings with poor ventilation.
- Outside of medical facilities, some outbreak reports related to indoor crowded spaces have suggested the possibility of aerosol transmission, combined with droplet transmission, for example, during choir practice, in restaurants or in fitness classes. In these events, short-range aerosol transmission, particularly in specific indoor locations, such as crowded and inadequately ventilated spaces over a prolonged period of time with infected persons cannot be ruled out.
- At all times, practice frequent hand hygiene, physical distancing from others when possible, and respiratory etiquette; avoid crowded places, close-contact settings and confined and enclosed spaces with poor ventilation; wear fabric masks when in closed, overcrowded spaces to protect others; and ensure good environmental ventilation in all closed settings and appropriate environmental cleaning and disinfection.

Institute of Medicine of the U.S.

In 2000, the Institute of Medicine of the U.S. (IoM), which is now called the National Academy of Medicine (NAM), produced a pivotal report on the impact of indoor air contaminants and asthma. The results of the study are relevant across many areas, including the SARS-CoV-2 virus.[27]

The IoM found that the higher the ventilation rate, the lower the concentration of the smallest indoor air contaminants.[28] This means that higher ventilation rates can be effective at removing SARS-CoV-2 virus particles, which are small in size. The correlation between the relative concentration of indoor air contaminants and the air exchange rate is demonstrated in the below IoM chart:

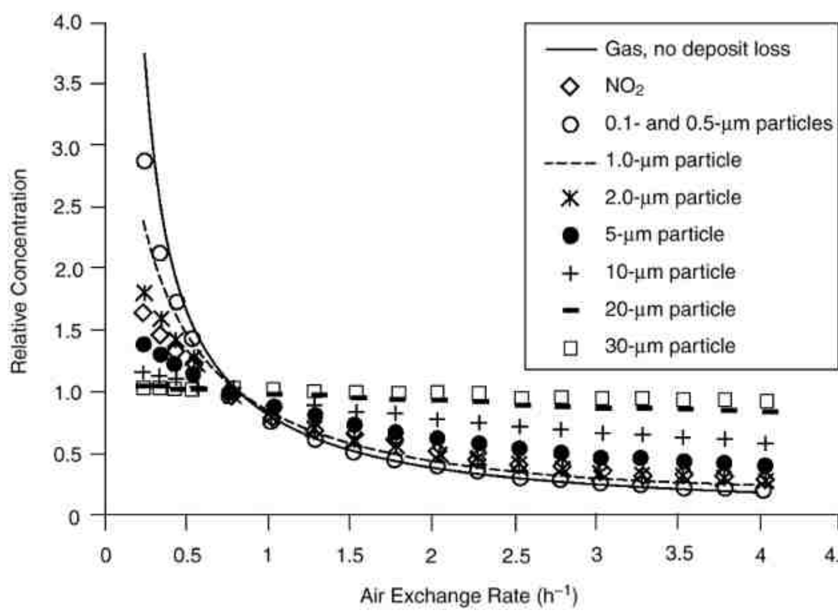

Figure 5: Predicted trends in the relative concentrations of indoor-generated pollutants with ventilation rate. *Source: Institute of Medicine (U.S.)*[29]

Occupational Safety and Health Administration

The Occupational Safety and Health Administration (OSHA) also believes in the importance of ventilation to get people back to work in the post-COVID-19 landscape. It states that engineering controls involve isolating employees from work-related hazards. In workplaces where they are appropriate, these

[26] All information in this paragraph sourced from: "Transmission of SARS-CoV-2: implications for infection prevention precautions," World Health Organization (WHO), July 9, 2020, https://www.who.int/news-room/commentaries/detail/transmission-of-sars-cov-2-implications-for-infection-prevention-precautions.

[27] All information in this paragraph sourced from: "Clearing the Air: Asthma and Indoor Air Exposures," Section: IMPACT OF VENTILATION AND AIR CLEANING ON ASTHMA, Institute of Medicine (U.S.), National Center for Biotechnology Information, U.S. National Library of Medicine, National Institutes of Health, 2000, https://www.ncbi.nlm.nih.gov/pubmed/25077220.

[28] "Clearing the Air: Asthma and Indoor Air Exposures," Section: IMPACT OF VENTILATION AND AIR CLEANING ON ASTHMA, Institute of Medicine (U.S.), National Center for Biotechnology Information, U.S. National Library of Medicine, National Institutes of Health, 2000, https://www.ncbi.nlm.nih.gov/pubmed/25077220.

[29] "Clearing the Air: Asthma and Indoor Air Exposures," Section: IMPACT OF VENTILATION AND AIR CLEANING ON ASTHMA, Institute of Medicine (U.S.), National Center for Biotechnology Information, U.S. National Library of Medicine, National Institutes of Health, 2000, https://www.ncbi.nlm.nih.gov/pubmed/25077220.

types of controls reduce exposure to hazards without relying on worker behavior and can be a cost-effective solution. Ventilation engineering controls for SARS-CoV-2 include:[30]

- Installing high-efficiency air filters
- Increasing ventilation rates in the work environment
- Specialized negative-pressure ventilation in some settings, such as for aerosol-generating procedures (e.g., airborne infection isolation rooms in healthcare settings and specialized autopsy suites in mortuary settings).

American Lung Association

The American Lung Association states that effective ventilation may help keep bacteria, viruses and other pollutants out of the indoor air. Along these lines, the association affirms that research shows how airflow and ventilation can affect the spread of diseases indoors. The more stagnant the air is, the more likely diseases are to spread.[31]

Further, the association asserts that ventilation can limit moisture. Damp indoor spaces foster the growth and transmission of viruses and bacteria. Controlling moisture indoors can limit the spread of infectious diseases and also limit the growth of mold, dust mites and cockroaches.[32]

School of Energy and Environment (China)

Research from the School of Energy and Environment in China highlights a role for ventilation in battling SARS-CoV-2. An article from the school states that the role of ventilation in removing exhaled airborne bio-aerosols and preventing cross-infections was extensively studied after the SARS outbreak.[33]

The article mentions that the characteristics of droplet-borne, short-range airborne and long-range airborne transmission of infectious diseases were identified. It was determined that increasing the ventilation rate can effectively reduce the risk of long-range airborne transmission (even though it may be of little use in preventing droplet-borne transmission).[34]

University of Amsterdam (Netherlands)

Researchers at the University of Amsterdam conducted a study to better understand the spreading of respiratory droplets and possible preventive measures. They analyzed droplet production due to coughs and speech by measuring the droplet size distribution, travel distance and velocity, and the airborne time in relation to the level of air ventilation. Below are their main conclusions:[35]

- Better ventilation of spaces substantially reduces the airborne time of respiratory droplets. This finding is relevant because typically poorly ventilated and populated spaces, like public transport and nursing homes, have been reported as sites of viral transmission despite preventive physical distancing.
- The persistence of small respiratory droplets in such poorly ventilated spaces could contribute to the spread of SARS-CoV-2. Improving ventilation of public spaces will dilute and clear out potentially infectious aerosols.
- To suppress the spread of SARS-CoV-2, healthcare authorities should consider the recommendation to avoid poorly ventilated public spaces as much as possible.
- The implications are also important for hospital settings where aerosolization by coughing and medical treatments and close contact with COVID-19 patients is very common.

Indoor Air Quality and SARS-CoV-2 Virus (COVID-19)

The criticality of high-level indoor air quality (IAQ) on the health and cognition of occupants is well-documented. As this relates to the current pandemic, research from Harvard University's T.H. Chan School of Public Health now attributes aggravated effects of SARS-CoV-2 with a greater incidence of PM 2.5 (tiny particulate matter with diameters of less than 2.5 micrometers). In fact, PM 2.5 can be a primary contributor to deficient IAQ. According to the study:[36]

- In an analysis of 3,080 counties in the U.S., researchers found that higher levels of PM 2.5 were associated with higher death rates from COVID-19.
- Most fine particulate matter comes from fuel combustion, but it also comes from indoor sources like tobacco smoke.
- Breathing in such microscopic pollutants inflames and damages the lining of the lungs over time, weakening the body's ability to fend off respiratory infections. Multiple studies have found that exposure to fine particulate matter puts people at heightened risk for lung cancer, heart attacks, strokes and even premature death.
- In 2003, SARS patients in the most polluted parts of China were found to be twice as likely to die from the disease as those in places with low air pollution.

[30] All information in this paragraph and subsequent bullets sourced from: "Guidance on Preparing Workplaces for COVID-19," Occupational Safety and Health Administration (OSHA), March 2020, https://www.osha.gov/Publications/OSHA3990.pdf.

[31] All information in this paragraph sourced from: "Bacteria and Viruses," American Lung Foundation, https://www.lung.org/clean-air/at-home/indoor-air-pollutants/bacteria-and-viruses.

[32] All information in this paragraph sourced from: "Bacteria and Viruses," American Lung Foundation, https://www.lung.org/clean-air/at-home/indoor-air-pollutants/bacteria-and-viruses.

[33] All information in this paragraph sourced from: Hua Qian, Xiaohong Zheng, "Ventilation control for airborne transmission of human exhaled bio-aerosols in buildings," Journal of Thoracic Disease, Submitted June 12, 2017, Accepted for publication January 4, 2018, http://jtd.amegroups.com/article/view/18723/17349.

[34] All information in this paragraph sourced from: Hua Qian, Xiaohong Zheng, "Ventilation control for airborne transmission of human exhaled bio-aerosols in buildings," Journal of Thoracic Disease, Submitted June 12, 2017, Accepted for publication January 4, 2018, http://jtd.amegroups.com/article/view/18723/17349.

[35] All information in this paragraph and subsequent bullets sourced from: G Aernout Somsen, Cees van Rijn, Stefan Kooij, Reinout A Bem, Daniel Bonn, "Small droplet aerosols in poorly ventilated spaces and SARS-CoV-2 transmission," University of Amsterdam via The Lancet, May 27, 2020, https://www.thelancet.com/journals/lanres/article/PIIS2213-2600(20)30245-9/fulltext#%20.

[36] All information in this paragraph and subsequent bullets sourced from: Lisa Friedman. "New Research Links Air Pollution to Higher Coronavirus Death Rates," New York Times, Published April 7, 2020, Updated April 17, 2020, https://www.nytimes.com/2020/04/07/climate/air-pollution-coronavirus-covid.html.

Moreover, the exacerbating effects of air pollution on the impact COVID-19 were also found in Italy. Scientists investigated why the mortality rate is up to 12% in the northern part of Italy and only about 4.5% in the rest of the country. They found a probable correlation between air pollution and mortality in two of the worst-affected regions in northern Italy.[37]

How Energy Recovery Ventilation Can Help

It's clear that increased building ventilation can fight COVID-19, but a serious consequence of this extra effort is greater energy use and costs. Utilizing Energy Recovery Ventilators (ERVs) can achieve the needed ventilation, while reducing energy use and costs. This is possible because ERVs use otherwise-wasted total energy (heat and humidity) from the exhaust airstream to condition incoming outdoor air. In fact, ERVs can be used in buildings and homes of every type, size and geography.

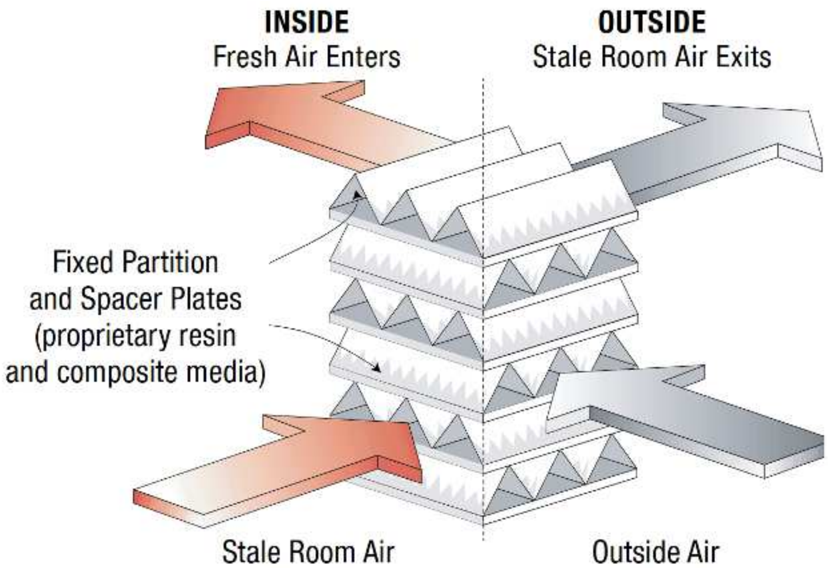

Figure 6: ERVs use otherwise-wasted total energy (heat and humidity) from the exhaust airstream to condition incoming outdoor air. Pictured here is an enthalpy-core ERV, which is less leaky and doesn't require as much extra purge air as other technologies. *Source: RenewAire.*

ERVs can also be extremely beneficial in hospital operating rooms. The indoor air in these settings needs to be as clean as possible, which means extra ventilation to exhaust out contaminants and bring in filtered outdoor air. Indeed, because of the substantial ventilation energy required, in some operating instances, it's not possible to maintain proper therapeutic indoor space conditions without applying an ERV.

Plus, ERVs can play an important role in other portions of medical facilities. ERVs using enthalpy-core exchangers are easier than some other options to apply in situations in which exhaust recapture must be minimized. This is because enthalpy-core ERVs are inherently less leaky and don't require as much extra purge air as other technologies.

What's more, in settings that need as much outdoor air as possible – such as hospitals,[38] offices, commercial buildings, institutions, homes and all residential structures – enthalpy-core ERVs can play a key role. Energy recovery ventilation technologies allow outdoor air – even 100% outdoor air – to be brought indoors at a fraction of the cost of conventional means.

In Summary

Although a lot still remains unknown about SARS-CoV-2 and COVID-19, one thing is certain: increased building ventilation can be utilized to mitigate the airborne spread of the virus. Further, to alleviate the extra energy and costs required to enhance IAQ, energy recovery ventilation should be applied. This is true for hospitals, homes, commercial structures, institutions and buildings of every type, size and geography.

For more information on the adverse effects of deficient IAQ and the benefits of increased building ventilation, visit RenewAire's Indoor Air Quality Matters website.

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[37] All information in this paragraph sourced from: "Link between air pollution and coronavirus mortality in Italy could be possible," Aarhus University, ScienceDaily, April 6, 2020, https://www.sciencedaily.com/releases/2020/04/200406100824.htm.

[38] It's important to note that standards for hospital HVAC systems, e.g., ASHRAE 170, don't allow ERVs using energy wheels or plates for the most critical spaces, such as isolation wards or spaces for immunocompromised patients.