Q1. Can HVAC (heating, ventilation, and air conditioning) systems play a role in the transmission of COVID-19?

In general, while there is plausibility of COVID-19 transmission by inhaled virus in air particularly in crowded, poorly ventilated settings, there is limited epidemiological evidence that this occurs. Specifically, the overall scientific evidence does not indicate that transmission of COVID-19 occurs via HVAC systems at this time. Although viral RNA has been detected in air and HVAC systems, the viability of virus in or infection from air circulated through HVAC systems has not been demonstrated.

COVID-19 is primarily transmitted via direct contact and droplets propelled for various distances. Screening and self-isolation of infected individuals; physical distancing; hygiene measures such as hand hygiene, cough and sneeze etiquette, respiratory source control; and environmental cleaning and disinfection are the mainstay of measures to reduce transmission risk.

Ventilation is the supply/distribution or removal of air from space by mechanical or natural means. Mechanical systems often involve heating, ventilation and air conditioning (HVAC) systems. Few studies to date examine the role of HVAC systems in COVID-19 transmission.

Reviews by Institut National de Santé Publique du Québec (INSPQ) and Leclerc et al report COVID-19 outbreaks and clusters in various indoor spaces, including homes, means of transportation, as well as religious, elder care, meal and office settings. Few clusters are reported in exclusively outdoor settings where ventilation is not an issue. Various studies and reviews cite poorly ventilated spaces and high occupant density as possible contributors for transmission via inhalation. There are experimental and modeling studies that show respiratory aerosols during breathing and speech, droplet dispersion in the air and that suggest the plausibility of transmission through inhaled virus. Environmental sampling studies that demonstrate viral RNA in air and surfaces where COVID-19 patients have been, including HVAC systems. These studies lend support to the possibility of transmission by inhaled virus, however few reports document clusters that suggest actual transmission via this route.

Lu et al and a further pre-peer review analysis by Li et al are cited often, regarding transmission of COVID-19 between families at three tables in a densely occupied restaurant (Table A had the index case and was between Table B and Table C). A wall air conditioner with no fresh air intake may have facilitated transmission by dispersing infectious particles from the infected customer; none of the other diners or staff in the restaurant were infected. The three tables involved in the outbreak were also directly along the line of the likely airflow of the unit to the opposite wall and back to the unit – i.e.,
there appears to have been little mixing with the air in the rest of the room. Exposure time to droplets may also have been a factor in transmission. Diners at Table A with the index case and Table B overlapped for 53 minutes and Table A and Table C overlapped for 75 minutes. Tracer gas experiments demonstrated that droplets from the index case would have been elevated at Tables A, B and C and another adjacent table. However, this table only had 18 minutes of exposure to Table A. The preprint analysis concluded that the adjacent table and servers were likely uninfected due to the relatively short exposure time to exhaled droplets from the index patient.

Other reports of outbreaks in fitness dance classes, and a call centre in South Korea, and choir practices in Washington State, are examples where poor ventilation may have contributed but specifics on ventilation are not available and transmission through close contact and fomites were also plausible.

Q2. Does recirculation come with a risk of increased contamination with infectious particles?

There is limited information on recirculated air specifically as a cause of COVID-19 transmission.

Recirculation in the context of HVAC systems refers to indoor air returned to and filtered in the central system, then redistributed within the building. There is limited information on recirculated air specifically as the cause of COVID-19 transmission. Lu et al reported COVID-19 transmission in a restaurant, described above, that may have been facilitated by a wall air conditioner. The pre-peer review analysis, in addition to demonstrating a zone around the three tables where air was somewhat contained based on air currents from the AC, also reported that there was no outdoor air supply and that ventilation was only achieved by infiltration of air through occasional door openings and an exhaust fan in the restroom. Note, this account suggests an extreme case of recirculation (compared to how air would be recirculated in HVAC systems), one where there is virtually no ventilation with outdoor air and minimal dilution even with building air.

Q3. What can be done to minimize the risk from infectious aerosols?

Enhancing outdoor air ventilation and good maintenance of HVAC systems will complement other public health measures to reduce COVID-19 transmission, e.g., screening, self-isolation when sick, physical distancing, hand hygiene, respiratory source control, environmental cleaning and disinfection.

In addition to the risk reducing measures outlined in Q1 to prevent droplet and close contact transmission, good ventilation is important in indoor environments for the general health and comfort of occupants. Optimization of HVAC systems can be done on the basis of best practices for ventilation, as COVID-19 transmission from HVAC systems has not been observed. In general, avoiding stagnant air conditions and ventilating indoor environments with fresh outdoor air, whether by increasing the outdoor air ratio of the HVAC system or by opening windows, will dilute exhaled air from the occupants including any infectious particles. Thus, most guidance encourage ventilation with outdoor air, avoiding recirculation as far as practically possible and ensuring clean filters.

For central air handling units at a building level or serving multiple zones, avoiding recirculation is ideal, e.g., operating on as high as possible or 100% outdoor air supply. Even if this is not feasible for the whole facility, it may be possible for specific high risk zones, e.g., highly occupied areas, or in healthcare settings, wards or rooms where COVID-19 patients are being treated. Some HVAC systems may not allow changes to outdoor air fractions, and those that do may require adjustments to filter maintenance protocols. In these situations, the outdoor air level can be enhanced by opening windows, checking filter adequacy or upgrading filters.
Additional measures include controlling humidity (e.g., relative humidity of 40%-60%), minimizing the number of people sharing the same environment, and individually avoiding being in the way of another person’s direct airflow.\textsuperscript{3,5,7,22}

Q4. Are there special considerations for the number of hourly air exchanges required?

\textit{Standards are set by various bodies for different types of building environments.}

Standards for air change rates are available from the Canadian Standards Association (CSA) for HVAC systems in specific zones or areas in healthcare facilities, CSA Z317.2:19.\textsuperscript{24} These air change rate standards for clinical settings account for the potential of airborne infection risks.\textsuperscript{24}

For other indoor settings, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) provides minimum ventilation rates for acceptable indoor air quality according to the type of setting (e.g., correctional facilities, offices, educational settings, hotels, food and beverage settings), occupancy and area.\textsuperscript{25} This standard was set in order to keep carbon dioxide (CO\textsubscript{2}) at levels where most occupants would not have complaints about air quality (e.g., from occupant odors) but were established before COVID 19 and do not take into account mitigation of infection transmission.

CO\textsubscript{2} levels serve as a proxy for determining whether outdoor air ventilation is adequate for the number of occupants. In order to have meaningful indoor CO\textsubscript{2} measurements, sampling during typical and peak occupancies and at different points during the day will be informative and can be compared with outdoor CO\textsubscript{2} levels. As occupants breathe out CO\textsubscript{2}, if sufficient outdoor air ventilation is occurring, CO\textsubscript{2} levels will not buildup in the room over the course of the day.

\textbf{Limited Occupancy Mode}

Q5. Is there guidance for HVAC systems running on partial or limited occupancy modes in buildings during a shutdown?

\textit{Generally, most HVAC guidance documents recommend against a complete shutdown of the HVAC system, even during a shutdown; during normal operations, they suggest running the system for longer than usual.}

ASHRAE suggests that if a building is operating at a partial or limited occupancy during a shutdown, it might be desirable to have the building automation system have an override so that the HVAC system is in unoccupied mode for shorter duration than is typical.\textsuperscript{26}

During routine operations, ASHRAE and the Federation of European Heating, Ventilation and Air Conditioning Associates (REHVA) recommend increasing outdoor air supply and exhaust ventilation and starting ventilation at least 2 hours before the building is occupied and continuing to run the ventilation for at least 2 hours after the building has been vacated.\textsuperscript{21,27} REHVA recommends keeping the outdoor air ventilation running with lowered ventilation rates when people are absent.\textsuperscript{21} Temperature and humidity settings could be adjusted to save on energy costs if desired as long as comfort levels are maintained for occupants.

\textbf{Inspection and Maintenance}

Q6. Are additional inspection or maintenance measures needed?
Routine inspections and maintenance as appropriate for the system are necessary.

Recommended maintenance measures for air handling systems (including inspection and replacement of filters, if applicable) are essential to follow. Adjustments to ventilation (e.g., increased outdoor air) may require more frequent inspections and filter changes. In addition, adjustments may benefit from consultation with a HVAC specialist to verify intended parameters and advise on appropriate maintenance procedures.

There is a joint standard from the American National Standards Institute (ANSI), ASHRAE and Air Conditioning Contractors of America (ACCA) for HVAC inspection and maintenance. ANSI/ASHRAE/ACCA standard 180-2018 (Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems) details procedures and establishes minimum HVAC inspection and maintenance requirements that preserve a system’s ability to achieve acceptable thermal comfort, energy efficiency, and indoor air quality in commercial buildings. This guidance can be considered by facility operators in order to optimize HVAC system operation on a routine basis, even in the absence of an infectious disease outbreak.

Air Currents Generated by Fans and Air Conditioners

Q7. Is there guidance for the use of room AC units and fans?

Avoiding direct airflow at head level (i.e., around people’s breathing zones) will reduce respiratory droplets being dispersed from person to person.

Air currents created by fans or air conditioning and HVAC systems could affect the dispersion of respiratory droplets in the air, hence directing air flow to avoid blowing air from one person to another may reduce risk. Manufacturer’s guidance should be followed for cleaning, disinfecting and maintaining fans and air conditioners on a routine basis. More detailed guidance on the positioning, use, and maintenance of fans and air conditioning units can be found in Public Health Ontario’s report titled “The Use of Portable Fans and Portable Air Conditioning Units during COVID-19 in Long-term Care and Retirement Homes”, found here.

References


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