

Reducing transmission of respiratory illness through improved indoor air quality

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The following is an edited summary of a conversation with [Dr. Jeffrey Siegel](#), Professor of Civil Engineering at the University of Toronto. Dr. Siegel is an expert on indoor air quality and ventilation. The conversation took place in late December, 2020. Some information was also added following the conversation by MAP.

Respiratory illnesses like COVID-19 are spread in a few ways, including through the air. When people are together indoors, infections can spread more easily. But there are things you can do to improve indoor air quality and help reduce transmission. While this is particularly urgent during the COVID-19 pandemic, improvements to indoor air quality are important long-term investments at any time. For example, these improvements can help reduce transmission of long-standing respiratory illnesses such as flu and tuberculosis.

Please note, the below focuses on airborne transmission, and does not address or replace other infection control measures such as masks, handwashing and the disinfection of surfaces.

Characteristics of a safer space

While there will always be risk to gathering indoors during a pandemic, there are many steps you can take to improve the safety of your space. Here are the characteristics of spaces that have been optimized to reduce airborne transmission of COVID-19:

- Very low occupancy level—a small fraction of allowed occupancy, ensuring a small number of people in a large space.
- People wear appropriate, comfortable and clean masks at all times when not eating.
- People maintain physical distance from each other.
- If appropriate and feasible, time spent together in indoor space is limited.
- Space has appropriate processes in place to improve indoor air quality.

What processes are generally used to improve indoor air quality?

- **Ventilation**, which involves bringing outside air into a room. This can be done by opening windows and doors to let fresh air in. In addition, some heating, ventilation and air-conditioning systems (also known as HVAC systems) bring fresh air into buildings. Exhaust fans that move stale air from the inside to the outside are also part of the ventilation system.

Ventilation does not mean moving the same air around in a room. For example, ceiling fans do not provide ventilation. If a room feels stuffy or there are a lot of odours, this may be an indication that it is not well-ventilated.

- **Filtration**, which involves passing indoor air through a high-quality filter. This can be done using portable air filters. Some HVAC systems can also be equipped with high-quality filters.

What can I do to reduce airborne transmission in indoor spaces?

Easy things you can do right away do make some improvements in indoor air quality*

- Run fans that exhaust to the outdoors continuously, or as often as possible. For example, kitchen and bathroom fans.
- Where possible, open windows and doors.
- Use high-quality portable air filters.
- Consult a professional to see if low-cost improvements can be made in your heat, ventilation and air conditioning system (also known as HVAC). For example, it may be possible to increase the ratio of outdoor air coming in through your HVAC system. Your HVAC system may also accommodate a higher-quality filter, or you may be able to improve the seal on the filter you do have.

* For details about what to consider when taking the above steps, please review the rest of this document.

The best way to reduce airborne transmission is to ensure that everyone has access to their own healthy living space. In settings where people have no choice but to gather, ensure that: there are very few people in a large room; everyone wears an appropriate, comfortable and clean mask when not eating; and, everyone maintains physical distance at all times. If appropriate and feasible, limit time spent together in indoor space.

Improving indoor air quality can also help reduce airborne transmission. When it comes to air quality, each space is different, and will require different solutions. Ideally, in settings where people gather outside of their homes, the HVAC system will change the air over in each room at least six times per hour. Some of this will be fresh air from outside, and some will be indoor air that passes through high-quality filters.

For more detail on optimizing HVAC systems during the pandemic, see “COVID-19: Heating, Ventilation and Air Conditioning (HVAC) Systems in Buildings” from Public Health Ontario and “COVID-19: Guidance on indoor ventilation during the pandemic” from the Public Health Agency of Canada in the resources. Your best bet will always be to consult an HVAC expert to assess your current situation, and implement improvements.

You can use a variety of methods in combination to increase the air changes per hour in your space and improve air quality. And even if you can’t get up to six air changes per hour right away, any improvement will help.

Short-term improvements

- If resources are available, work with a professional to **upgrade ventilation**. This will improve indoor air quality and reduce airborne transmission. This doesn’t always mean a complete overhaul or replacement of HVAC systems. It can include consulting with an HVAC professional to see if you can circulate more outside air through your HVAC system, and if your HVAC system can accommodate a higher-quality filter, or needs an improved seal around the filter. It may also include working with a professional to upgrade fans and systems that exhaust to the outside, such as bathroom fans.
- Bring in **high-quality portable air filters**, and position them strategically in your space. Portable air filters are particularly important if there is no central forced air system with a well-installed and maintained high-quality filter as part of your building’s HVAC system. For more on the choice and use of portable air filters, see “Use of Portable Air Cleaners and Transmission of COVID-19” from Public Health Ontario in the resources.

Here are some things to consider when using portable air filters:

- Choose portable air filters based on the room size and the clean air delivery rate of the unit. Large rooms may require multiple units.
- If people are sleeping together in a space, place portable air filters between beds.
- If your portable air filter vents from the bottom (as opposed to the top), ensure it is elevated so the unit does not disturb particles that may have been deposited on the floor, and so clean air reaches people while they sleep.
- Turn portable air filters up to maximum levels during higher risk activities. For example, when people take their masks off to eat.
- Change filters as often as indicated, and take care when doing so. Use a mask and gloves, and change outdoors where possible. Immediately place the filter in a plastic bag and seal bag.
- As per Public Health Ontario guidance, “Directing air flow from a portable unit such that the air does not directly blow from one individual to another will help reduce the potential spread of respiratory droplets.” (See resource on portable air filtration below.)
- Do not use portable air filters in bathrooms. Bathrooms are full of smooth surfaces such as toilets and tile. Particulate matter doesn’t adhere well to these surfaces. As a result, there is

a greater chance that portable air filters will disturb these particles and send them back into the air

- **Fans that exhaust air** to the outside also contribute to air quality improvement. Run existing fans such as bathroom exhaust fans that exhaust to the outside at their highest levels, and run them continuously or as often as possible.
- **Open doors and windows.** This may not always be feasible, but letting in air from the outside can improve ventilation.
- **Install upper-room ultraviolet (UV) air disinfection.** These units are installed in the ceiling, and help to neutralize viruses and bacteria that circulate through them. It is important that they are properly installed by professionals, as UV light can be harmful to people, and they will only be safe and effective when there is appropriate air circulation and sufficient assurance that UV illumination is contained to the part of the room near the ceiling.
- **Keep people away from some types of airflow.** For example, take care with placement and use of portable fans, air-conditioning units, ceiling fans and portable air filters. For more information about this, see related resources at the end of this document from Public Health Ontario and Toronto Public Health.

Longer-term improvements

Work with an HVAC professional to equip your building with a well- and regularly-maintained HVAC system that has the capacity to change the air in each room at least six times an hour and use a filter with a high MERV rating. High quality HVAC systems can be supplemented with high-powered fans in bathrooms, and portable filtration units and in-duct or upper room UV air disinfection in high risk areas and during high risk activities.

* In all cases it's important to use professional, licensed contractors to select, install and maintain HVAC systems, exhaust fans, and UV air disinfection units. Choose professionals that have specialized knowledge of technologies such as UV disinfection. UV disinfection can be very helpful, but has to be done well.

What can I do to reduce airborne transmission in bathrooms?

Bathrooms are small, so it's easier for a higher concentration of virus to build up in the air. In addition, flushing can release small particles that carry the virus. There are many ways to help reduce transmission in bathrooms:

- Leave the bathroom exhaust fan running on its highest setting at all times. If it's possible to engage a professional to install a more powerful fan, do so.
- If possible, ensure only one person uses the bathroom at once, even in multi-person bathrooms.
- Leave the bathroom empty for as long as possible between uses.
- If possible, leave windows open.
- Leaving the toilet seat down while flushing may help reduce the dispersion of particles.

- As described above, portable air filtration units are not appropriate for bathrooms.

* As noted earlier, these recommendations are only related to airborne transmission and do not address or replace other infection control measures such as masks, handwashing and the disinfection of surfaces between uses.

How will I know when I have created a space that is safe?

During a pandemic, no indoor space where people gather will be 100 per cent safe. In addition, calculating risk is difficult, as each situation is different. The good news: we know that **places that are proactive see fewer infections**.

To get a sense of your ventilation situation right now, you can try to calculate the "air changes per hour" in a particular room. To reduce airborne transmission, you are looking to achieve at least six changes per hour. This will likely require some new measures such as those suggested here—most buildings currently have air change rates that are far below this benchmark. Remember—in some spaces many of these measures will be achievable in the short term, and taken together could bring you to six air exchanges per hour. And even if you can't get there right away, any improvement will help.

To figure out your "air changes per hour" (ACH), you will likely need an HVAC expert. It's easy, however, to calculate the contributions that high quality portable air filters make to ACH. Most will list the room size they can serve (typically based on an assumption of eight foot high ceilings and four ACH). Or you can calculate yourself: $ACH = CADR * 60 / \text{Room volume}$. CADR is the clean air delivery rate, and is typically expressed in cubic feet per minute. The room volume is expressed in cubic feet.

Additional resources

FAQs and fact sheets

- Public Health Ontario. (Dec. 31, 2020). "Use of Portable Air Cleaners and Transmission of COVID-19." Available at: <https://www.publichealthontario.ca/-/media/documents/ncov/ipac/2021/01/faq-covid-19-portable-air-cleaners.pdf?la=en>
- Public Health Ontario. (August 8, 2020). "COVID-19: Heating, Ventilation and Air Conditioning (HVAC) Systems in Buildings." Available at: <https://www.publichealthontario.ca/-/media/documents/ncov/ipac/2020/09/covid-19-hvac-systems-in-buildings.pdf?la=en>
- Public Health Ontario. (2020). "The Use of Portable Fans and Portable Air Conditioning Units during COVID-19 in Long- term Care and Retirement Homes." Available at: <https://www.publichealthontario.ca/-/media/documents/ncov/ltrh/2020/08/covid-19-fans-air-conditioning-ltrh.pdf?la=en>
- Toronto Public Health. (Nov. 4, 2020). "COVID-19: Transmission, Aerosols and Ventilation." Available at: <https://www.toronto.ca/wp-content/uploads/2020/10/8de9-COVID19-Transmission-Aerosols-Ventilation.pdf>

Reports

- American Society of Heating, Refrigerating and Air-Conditioning Engineers. (Oct. 20, 2020). ASHRAE Epidemic Building Readiness. Available at: <https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-building-readiness.pdf>
- Canadian Standards Association. (Sept. 2020). “Workplaces and COVID-19: Occupational Health and Safety Considerations for Reopening and Operating During the Pandemic.” Available at: <https://www.csagroup.org/wp-content/uploads/CSA-Group-Research-Workplaces-and-COVID-19-Occupational-Health-and-Safety-Considerations.pdf>
- Public Health Agency of Canada. (Jan. 11, 2020). ““COVID-19: Guidance on indoor ventilation during the pandemic.” Available at: <https://www.canada.ca/en/public-health/services/diseases/2019-novel-coronavirus-infection/guidance-documents/guide-indoor-ventilation-covid-19-pandemic.html>