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Review

Science tells us that portable air filters reduce infection risk. It's time for public health authorities to make this clear

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A B S T R A C T

Throughout the COVID-19 pandemic, Canadian public health advisors and politicians have shared mixed messages about the utility of portable air filters (PAFs) for mitigating the transmission of airborne infectious diseases. Some public health advisors and decision-makers have also suggested that PAFs are cumbersome or require expert advice. We take this opportunity to review evidence and address myths about PAFs. In short, PAFs are an important tool to help reduce the risk of transmission of airborne infectious diseases. Moreover, PAFs are relatively simple to use, and there is a variety of high-quality guidance available for their deployment. We share this science here with the expectation that, going forward, public health authorities will position PAFs appropriately in infection prevention and control plans for both health care and community settings.

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Over the course of the COVID-19 pandemic, Canadian public health advisors and decision-makers have shared conflicted and confusing messages about the effectiveness of portable air filters (PAFs) in controlling the spread of airborne infectious diseases [14].

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Additionally, there have been suggestions that placing and maintaining PAFs may require expert advice, and that PAFs are costly and hard to use [15,2,8]. As a multidisciplinary team with expertise in engineering, aerosol science, occupational hygiene, infectious diseases, epidemiology, public health, primary care, community services and knowledge translation, we aim to dispel these myths about PAFs by sharing relevant evidence from the existing literature and guidelines, as contextualized by our collective training and applied experience.[1] We present this information here to encourage public health authorities to integrate PAFs in infection prevention and control plans for both health care and community settings.

The evidence

Diseases such as COVID-19 are transmitted through respiratory particles that contain infectious material. If these particles come in contact with the mucous membranes of a susceptible individual, there is a risk of infection [21]. In general, there is a dose-response relationship—the more infectious material in the air, the greater the risk of infection [11]. Thus, any mitigation measures that remove these particles from the air (or inactivate infectious materials) will reduce the risk of transmission. These measures include ventilation (i.e. bringing outside air inside and exhausting stale air outside); high-efficiency heating, ventilation, and air conditioning (HVAC) filters; PAFs; respirator-grade masks; and, germicidal ultraviolet irradiation [9].

This science is supported by decades of research and public health and health care practice demonstrating the effectiveness of PAFs in reducing the transmission of airborne diseases. For example, high-efficiency particulate air (HEPA) filtration, including portable filtration, has been standard practice in hospitals for infection reduction for decades [16]. There is also a body of research specifically related to COVID-19 demonstrating that PAFs help to reduce concentrations of SARS-CoV-2 RNA in the air. For instance, Myers et al., [10] sampled air from the rooms of patients with newly diagnosed COVID-19. They found that 44 per cent of air samples in rooms with sham PAFs without filters tested positive for SARS-CoV-2 RNA. This decreased to 25 per cent in rooms with operational PAFs running at their lowest settings.

The evidence is also reflected in guidance documents from the American Society of Heating, Refrigerating and Air-Conditioning Engineers; the Centers for Disease Control; and the Ontario Society of Professional Engineers (e.g., [18]). There is consensus among all of these bodies that PAFs are an important component of any engineering strategy to reduce transmission of airborne diseases.

While evidence demonstrates that filtration reduces concentrations of SARS-CoV-2 RNA in the air, this research should not have been required by public health authorities before implementation. PAFs, like other engineering interventions such as seat belts, parachutes and bridges, are designed and evaluated according to the laws of physics. Respiratory particles that may contain infectious materials have a wide range of diameters from smaller than 1 micron (μm) to more than 100 μm [17]. Evidence demonstrates that even particles with a diameter of 50 μm could take around 20 seconds to settle from breathing height, and particles of up to 20–30 μm can remain suspended and travel considerable distances with air currents [17]. Smaller particles (i.e., < 5 μm) are also responsible for more transmission than very large particles (i.e., > 100 μm) at both short- and long-range [3]. PAFs equipped with high-efficiency filters—HEPAs or HVAC filters with a minimum efficiency reporting value of 13 (MERV 13) or higher—are engineered to effectively remove particles of different sizes that may contain infectious materials from the air, including those that are small. This reduces the risk of infection, especially at longer distances.

Due to space limitations, an expanded list of supporting evidence is available in Supplementary Information (SI) Table S1.

Clearing up misconceptions: HVAC syste ms vs. portable air filters

At times, public health discourse has implied that facilities must choose between portable filtration and ventilation as supplied by HVAC systems. To be clear, supplying sufficient amounts of outdoor air to any room through HVAC systems or through windows is often an important indoor air quality measure to reduce transmission [7]. Ventilation also has other indoor air quality benefits such as reducing indoor-generated pollutant concentrations [4]. However, supplementing HVAC systems or natural ventilation with PAFs serves to further reduce infection risk, in keeping with a layered strategy of infection prevention and control [1].

As a reference, ASHRAE Standard 62.1 (2019), which specifies ventilation rates and other measures to provide acceptable indoor air quality and minimize adverse health effects, recommends a minimum mechanical ventilation rate of 5 L/s per person and a rate of 0.6 L/s per m^2 for classrooms [20]. For a classroom of approximately 60 m^2 occupied by 15 people with a ceiling height of 3 m, this is equivalent to an air change per hour (ACH) of 2.2. A single do-it-yourself (DIY) PAF, made with a box fan and MERV-13 filters, can increase the effective ACH in this room by up to five ACH, reaching a total of seven ACH, and reducing the exposure to simulated respiratory particles by 30–70 %, depending on the occupants' locations [6]. This increase in ACH can also be achieved by one or more commercially available PAFs with HEPA filters. A more detailed summary of ACHs from DIY and commercially available PAFs reported in recent studies is available in Table S2. It is also important to note that ASHRAE Standard 241 (2023), which aims to reduce the risk of disease transmission through exposure to infectious aerosols, recommends a minimum equivalent clean airflow of 20 L/s per person in classrooms under infection risk management mode, which equals to a minimum of six equivalent ACH for the aforementioned example classroom [18]. However, in many settings, achieving this level of equivalent ACH solely through a mechanical system would be challenging without substantial system upgrades and increased energy use.

PAFs are particularly important in the many facilities that do not have forced-air HVAC systems, or that have forced-air HVAC systems that: cannot increase outdoor air rates without compromising comfort; are poorly maintained; are in need of repair; do not effectively distribute air to all rooms; and/or, do not accommodate high-efficiency filters. Many of these same facilities cannot open windows in winter and/or summer, or do not have windows that open at all. Further, for facilities located near major roadways or industrial sources, open windows may bring outdoor pollutants inside. The same is true during wildfire events. In these contexts, PAFs can be easily implemented to help reduce transmission and improve indoor air quality overall.

Finally, it has been implied that while ventilation works to reduce COVID-19 transmission, PAFs may not [2]. This assertion is not consistent with the physics that governs both interventions. Ventilation removes particles that contain infectious material by replacing room air with outdoor air. Filtration removes these same particles by passing room air through a high-efficiency filter. In both cases, particles that contain infectious material are removed, *and equivalency in particle removal rates is widely accepted*, such as the equivalent clean airflow defined in ASHRAE Standard 241 [18]. PAFs will be at their most effective when they are well-maintained and are appropriately sized and placed for a specific room. Achieving this

[1] We review English-language literature we are familiar with through our work. We aim to address issues raised in the context of Canadian public health responses to COVID-19 and portable air filters. Where the literature we review discusses infections, it is related to specific types of infections, please see references.

is not particularly complicated and there is a variety of high-quality guidance available (e.g.,[5]).

Clearing up misconceptions: PAFs can't help in a crowded room with close contact

There have been suggestions that PAFs are pointless in crowded spaces because of close-range transmission [2,13]. Close contact and crowded conditions in particular can present a risk for transmission of infections such as COVID-19. In these conditions (and all others), well-fitted respirator-grade masks can help protect those who are not infected and reduce the amount of particles released into the room by those who are. We note that when infections are circulating in the community, no indoor space will be perfectly safe, even with excellent ventilation and filtration. This is particularly true in settings such as daycares, where children are often directly face-to-face for extended periods of time. However, the total concentration of bacteria or virus-carrying particles (i.e. the total bacterial or viral load in the air) will make a difference as to how many people get infected, and how quickly they do so (i.e., the time of exposure) [12]. For example, recent studies demonstrated that PAFs have the capacity to reduce viral or particle concentrations at close range [6].

Clearing up misconceptions: PAFs are prohibitively expensive and complicated

Some public health discourse has implied that PAFs are very expensive to purchase and maintain. While every building and room is different, many resources allow for a selection of low-energy consumption PAFs that have appropriate cleaning power, while considering capital and operating costs as well as factors such as noise. These options include DIY PAFs and high-efficiency HVAC filters that are considerably cheaper than many commercial options with the same cleaning power [6].

It has also been occasionally implied that the placement and maintenance of PAFs is complicated. This is inaccurate. While knowledge of specific room air flows can further optimize PAF placement and maximize their benefits, in general, a PAF can be placed as close to the centre of a space as possible. If multiple PAFs are used, they can be evenly distributed in the room. Placement near walls or open windows should be avoided, as this undermines effectiveness. If floor-level PAFs present a concern due to tripping hazards, there are PAFs that can be mounted on the wall or ceiling. In terms of maintenance, it is generally limited to changing filters based on the manufacturer's recommendations.

Finally, there is justified concern about the possible hazards of substances such as ozone. PAFs that only contain a filter and fan, however, have no risk of ozone production. PAFs or other portable air cleaners that include more than a filter and fan and that may generate ozone or other harmful by-products can be easily avoided based on the air cleaner type [19].

We are not aiming to provide comprehensive guidance on using PAFs here, but rather to address selected misconceptions and concerns. A range of high quality guidance is available for choosing, placing and maintaining PAFs (e.g., [5]).

Conclusion

In summary, PAFs composed of a HEPA or MERV-13 filter and a fan are relatively low cost, easy to maintain, can be moved to respond to changes in occupancy and activity level, and do not generate harmful pollutants.

There have been few large randomized control trials that specifically address PAFs and the transmission of COVID-19 [21]. This may be why some public health advisors have been reluctant to embrace PAFs. However, the lack of this specific evidence is not evidence of a lack of benefit. Further, given the strong and long-standing evidence demonstrating that PAFs help to reduce risk of airborne disease transmission, designing a trial that leaves some people without this protection would be unethical and lack equipoise. Importantly, we are aware of no compelling published counter-evidence that suggests that PAFs do not reduce transmission of airborne diseases. Finally, for measures like PAFs, which, when implemented appropriately, pose no documented health risks and have considerable co-benefits, such as filtering allergens and wildfire smoke, public health authorities should always apply the precautionary principle.

The stakes are high. The cost of not using PAFs is measured in terms of human lives and long-term health impacts. The utility of PAFs for reducing airborne infectious diseases such as COVID-19 is not an open question. Public health advisors and organizations who imply otherwise are sharing misinformation. Going forward, we expect that public health advisors and organizations will position PAFs appropriately in infection prevention and control plans for both health care and community settings.

Author Contribution

T.L., A.K., and J.A.S. contributed in Conceptualization, Investigation, Writing – Original Draft, and Writing – Review & Editing. J.O., L.J., and P.O. contributed in Conceptualization and Writing – Review & Editing. V.L., P.B., and N.P. contributed in Writing – Review & Editing.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests. JS has received in-kind donations or discounts on portable air cleaners, replacement filters, and low-cost sensors to support his research program.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jiph.2024.102650.

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