HEPA filtration reduces transmission of SARS-CoV-2 and prevents nosocomial infection: A call to action

HEPA filtration is beneficial in reducing bioaerosols, including SARS-CoV-2, as well as other respiratory pathogens in the hospital environment. It should be used in combination with other prevention strategies, including improved ventilation; appropriate isolation; and, during periods of high community transmission, widespread testing and N95 masking.

Susan M. Lee, MD, FRCPC, MAS, Jean Warneboldt, MD, CCFP(PC), FCFP

Dr Lee is an anesthesiologist, research lead, and National Surgical Quality Improvement Program anesthesia champion at Royal Columbian Hospital and Eagle Ridge Hospital. Her research and quality improvement interests include how best to optimize patients prior to elective surgery, including engaging patients in perioperative smoking cessation and ensuring good preoperative patient education. Since the pandemic, she has participated in research and quality improvement activities to help ensure a safe perioperative and inpatient environment. Dr Warneboldt has been practising hospital medicine since 2006 and is the first quality improvement leader for the Fraser Health Regional Department of Hospital Medicine. She started the resident elective program at Eagle Ridge Hospital and obtained certification in palliative medicine. She has an interest in quality improvement and undertook further training from Fraser Health's Physician Quality Improvement initiative and the Institute for Healthcare Improvement. She lives with her family and is ruled by a tuxedo cat.

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Like everyone, I want the pandemic to be over, but I want it to end in the safest way possible for our most vulnerable members of society. A conversation in mid-2022 with Dr Jean Warneboldt, my friend, hospitalist, and quality champion, reminded me that for some of these most vulnerable patients, the air in the hospital can be deadlier than the diagnosis that brought them in. Dr Warneboldt had just finished a devastating time managing a multi-unit inpatient COVID-19 outbreak where three of her patients died of nosocomial COVID, all within 1 week. To the undiscerning observer looking at the statistics, these were a handful of the many incidental COVID hospitalizations; the patients were admitted with another diagnosis and later tested positive for COVID. However, COVID for them couldn't be further from incidental, as it was in fact the cause of their deaths. It saddened us that these patients sought help and died of nosocomial COVID, something potentially preventable. We felt a moral imperative to do whatever we could to ensure that, as a health care system, we were doing everything we could to prevent similar iatrogenic deaths. There was and continues to be little motivation or funding for reintroducing or reinforcing the behavior-related changes that could potentially quell outbreaks (for example, physical distancing, masking, and testing).

However, in my search for something we could do, I found there were some measures we could take that required no frontline behavior changes. For example, cleaning the air! Dr Warneboldt and I worked hard to advocate for improved indoor air quality to reduce the risk of nosocomial spread of respiratory pathogens on inpatient units. We presented evidence from the literature, we filled out Patient Safety and Learning System event forms, we attended quality review meetings, and we met with anyone who would listen to us. Unfortunately, there were many barriers in implementing something as simple as portable HEPA filtration units on inpatient wards. Some were due to general fatigue in pandemic management (such as the belief that a certain segment of society would need to be sacrificed in this new phase of the pandemic), some were from misinformation (such as the belief that an air-cleaning unit would somehow blow viruses around), and some were that high-level guidance was missing ("there's no policy for that" or "it's not in my portfolio"). We've been at a loss as to what else we can do to induce change in the hospital setting.

Recently, we stopped getting replies from our institutional leaders.

The review that follows was first presented during safety briefings but was largely ineffective in evoking change. I was ecstatic when, after months of advocacy, our hospital purchased air filters, then woefully disappointed when we were never given the regional clearance to use them. Despite the end to the emergency era of the pandemic, sadly, Dr Warneboldt still regularly sees nosocomial COVID cause significant morbidity and mortality in her most vulnerable patients. If we are to learn to live with COVID, we ought to be doing our best to ensure that we've safeguarded our most vulnerable.

I've updated this rapid review with the latest evidence and hope that it may help further the conversation in terms of simple measures we can take to protect our most vulnerable.

Let's clear the air about HEPA filtration. When adequate air exchange rates are not achievable, the addition of HEPA filtration reduces respiratory particles and has the potential to reduce nosocomial COVID, as well as other pathogens. I hope someone with the power to implement HEPA filtration will read the state of the evidence and find it a call to action. I hope that my friend will never have to go through another week when three of her patients die from a pathogen they breathed in the hospital air.

This rapid review of the literature was performed in response to high levels of COVID transmission in the inpatient setting.[1] The original search of Medline, Embase, and LitCovid was performed on 10 November 2022 and updated on 13 March 2023 with the assistance of a College of Physicians and Surgeons of BC librarian.

A systematic review conducted in 2021 identified 11 studies on the effectiveness of portable HEPA filters for eliminating airborne SARS-CoV-2.[2] A HEPA filter filters 99.97% of aerosols with a size of 0.15 μm, with even greater efficiency for other particle sizes (larger and smaller). SARS-CoV-2 is thought to be around 0.1 μm. All 11 studies showed that portable HEPA purifiers were able to significantly reduce airborne SARS-CoV-2 surrogate particles and augmented other decontamination strategies such as ventilation. Seven of the studies were performed in settings with minimal or no additional ventilation. Placement of the portable air cleaner in front of the subject removed more particles, although placement both in front of and behind the subject were effective. Portable air cleaners with HEPA filtration should be placed in open space near the source of the pollutant, near the breathing zone of residents, and not behind furniture.

Another systematic review of heating, ventilation, and air conditioning (HVAC) for indoor bioaerosols in hospitals was performed in 2021.[3] The use of HEPA filtration reduced bacteria and fungi concentrations. The review did not find any evidence for increased transmission of SARS-CoV-2 related to HVAC systems,[4] nor did a 2021 systematic review of 21 studies on air-conditioning systems in hospitals.[5] The studies found that properly managed HVAC systems reduced microbial loads compared with naturally ventilated areas, although poorly maintained HVAC systems increased infections. HEPA filtration decreased the concentration of airborne bioaerosols (most pathogens, including fungi, bacteria, and encapsulated viruses) and reduced the risk of infections. The review concluded that HEPA filters appear to be an indispensable part of air-conditioning systems and have the theoretical potential to eliminate airborne SARS-CoV-2.

More recent studies have confirmed the above findings of improved clearance of bioaerosols in older hospital infrastructure with HEPA filtration and natural ventilation compared with only natural ventilation.[6] A 2022 study of a COVID hospital ward detected SARS-CoV-2 in the air during weeks when air filtration was turned off but did not detect SARS-CoV-2 in the air sampled when air was being filtered,[7] consistent with other recent studies indicating efficient and fast (within 5.5 minutes) clearance of bioaerosols using portable air cleaners with HEPA filtration.[8] Similarly, in a natural experiment, particle sensors were set up during commissioning of an air cleaning unit (ACU) on an older multibed bay in a UK hospital in 2022.[9] Interestingly, when the ACU was inadvertently shut off, particle counts increased dramatically (notably in the size range associated with respiratory viruses), returning to low levels only once the ACU was turned on again. The authors hypothesized that ACUs had the potential to reduce nosocomial spread of not only respiratory viruses, but also fungal and bacterial pathogens. A 2022 comprehensive review[10] of strategies to prevent SARS-CoV-2 and respiratory viral infections in health care settings included the following key points and recommendations:

- Traditional binary categorization of droplet versus airborne precautions is outdated.
- Tachypnea, heavy breathing, and coughing can increase respiratory emissions and transmission.
- High viral loads, proximity, prolonged exposure, lack of masking, and poor ventilation are all risk factors for in-hospital transmission.
- Testing all patients on admission and potentially periodically during admission is recommended when community transmission rates are high due to the large number of occult infections and the high transmissibility (viral loads) prior to symptom onset.
- HEPA filtration should be used in combination with ventilation to achieve more than six air changes per hour.
- Minimize shared rooms, use N95 masks more widely, and maintain universal vaccination policies for health care workers.

A recent review based on international guidelines concluded that while mechanical ventilation with the requisite air exchange rates should be met, in situations where this is not achieved, HEPA filtration is recommended over taking no measures.[11] In these situations, the HEPA filter should be operated continuously, placed close to the source (in the patient breathing zone), and placed away from the door.

Data from simulations of an indoor school environment[12] indicate that HEPA filtration is effective in reducing modeled

SARS-CoV-2 cumulative dose absorption by exposed individuals, with one HEPA filter as effective as two windows partly open all day in winter (threefold decrease in transmission). A study of school transmission rates indicated that improved ventilation and air filtration reduced cases of COVID by about half.[13] A real-world study of HEPA filtration in homeless shelters showed that portable air cleaners were effective in reducing indoor particle levels.[14]

Internationally, since at least 2021, the World Health Organization has been recommending HEPA filtration in settings where adequate ventilation cannot be achieved, as part of its road map to improve and ensure good ventilation in the context of COVID.[15] Federally, the Canadian government encourages the use of HEPA filtration when adequate ventilation cannot be achieved.[16,17] The United States Centers for Disease Control and Prevention recently released clear guidelines for improving indoor air quality, which include improving both ventilation and air filtration.[18] Despite national and international guidance and an abundance of evidence that HEPA filtration reduces bioaerosols, regional and provincial guidance continues to be either lacking or conflicting. The BC Centre for Disease Control[19] emphasizes the importance of environmental controls, including "suitable indoor ventilation," in its hierarchy for infection prevention and exposure control measures for communicable diseases, but specific ventilation guidance refers to federal recommendations mentioned above or predates the COVID pandemic, as do the latest guidelines from the Provincial Infection Control Network of BC.[20] Regionally, without clear provincial guidance, health authorities have been reluctant to lead with standardized indoor air quality standards, with at least one actively removing the availability of HEPA filtration (Keeping You Informed newsletter, Fraser Health Authority, 2 March 2023).

In summary, HEPA filtration reduces bioaerosols, including SARS-CoV-2, and is an important component of a multipronged prevention strategy for reducing in-hospital transmission of respiratory pathogens. In BC, public health policies such as universal masking and universal admission testing are no longer in effect. We know from other jurisdictions that discontinuation of universal admission testing was associated with a significant increase in hospital SARS-CoV-2 transmission and that nosocomial transmission remains common in the Omicron era, with infections that carry a 3% to 13% mortality risk.[21] Updated, evidence-based, and precautionary provincial guidance is urgently needed to improve indoor air quality throughout BC's acute care settings, particularly in settings where nosocomial COVID poses a risk to the lives of those under our care. ■

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