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Air cleaning technologies: an evidence-based analysis

Medical Advisory Secretariat

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Abstract

Objective: This health technology policy assessment will answer the following questions: When should in-room air cleaners be used?How effective are in-room air cleaners?Are in-room air cleaners that use combined HEPA and UVGI air cleaning technology more effective than those that use HEPA filtration alone?What is the Plasmacluster ion air purifier in the pandemic influenza preparation plan? The experience of severe acute respiratory syndrome (SARS) locally, nationally, and internationally underscored the importance of administrative, environmental, and personal protective infection control measures in health care facilities. In the aftermath of the SARS crisis, there was a need for a clearer understanding of Ontario's capacity to manage suspected or confirmed cases of airborne infectious diseases. In so doing, the Walker Commission thought that more attention should be paid to the potential use of new technologies such as in-room air cleaning units. It recommended that the Medical Advisory Secretariat of the Ontario Ministry of Health and Long-Term Care evaluate the appropriate use and effectiveness of such new technologies. Accordingly, the Ontario Health Technology Advisory Committee asked the Medical Advisory Secretariat to review the literature on the effectiveness and utility of in-room air cleaners that use high-efficiency particle air (HEPA) filters and ultraviolet germicidal irradiation (UVGI) air cleaning technology. Additionally, the Ontario Health Technology Advisory Committee prioritized a request from the ministry's Emergency Management Unit to investigate the possible role of the Plasmacluster ion air purifier manufactured by Sharp Electronics Corporation, in the pandemic influenza preparation plan.

Clinical need: Airborne transmission of infectious diseases depends in part on the concentration of breathable infectious pathogens (germs) in room air. Infection control is achieved by a combination of administrative, engineering, and personal protection methods. Engineering methods that are usually carried out by the building's heating, ventilation, and air conditioning (HVAC) system function to prevent the spread of airborne infectious pathogens by diluting (dilution ventilation) and removing (exhaust ventilation) contaminated air from a room, controlling the direction of airflow and the air flow patterns in a building. However, general wear and tear over time may compromise the HVAC system's effectiveness to maintain adequate indoor air quality. Likewise, economic issues may curtail the completion of necessary renovations to increase its effectiveness. Therefore, when exposure to airborne infectious pathogens is a risk, the use of an in-room air cleaner to reduce the concentration of airborne pathogens and prevent the spread of airborne infectious diseases has been proposed as an alternative to renovating a HVAC system. Airborne transmission is the spread of infectious pathogens over large distances through the air. Infectious pathogens, which may include fungi, bacteria, and viruses, vary in size and can be dispersed into the air in drops of moisture after coughing or sneezing. Small drops of moisture carrying infectious pathogens are called droplet nuclei. Droplet nuclei are about 1 to 5µm in diameter. This small size in part allows them to remain suspended in the air for several hours and be carried by air currents over considerable distances. Large drops of moisture carrying infectious pathogens are called droplets. Droplets being larger than droplet nuclei, travel shorter distances (about 1 metre) before rapidly falling out of the air to the ground. Because

droplet nuclei remain airborne for longer periods than do droplets, they are more amenable to engineering infection control methods than are droplets. Droplet nuclei are responsible for the airborne transmission of infectious diseases such as tuberculosis, chicken pox (varicella), measles (rubeola), and dessiminated herpes zoster, whereas close contact is required for the direct transmission of infectious diseases transmitted by droplets, such as influenza (the flu) and SARS.

The technology: In-room air cleaners are supplied as portable or fixed devices. Fixed devices can be attached to either a wall or ceiling and are preferred over portable units because they have a greater degree of reliability (if installed properly) for achieving adequate room air mixing and airflow patterns, which are important for optimal effectiveness. Through a method of air recirculation, an in-room air cleaner can be used to increase room ventilation rates and if used to exhaust air out of the room it can create a negative-pressure room for airborne infection isolation (AII) when the building's HVAC system cannot do so. A negative-pressure room is one where clean air flows into the room but contaminated air does not flow out of it. Contaminated room air is pulled into the in-room air cleaner and cleaned by passing through a series of filters, which remove the airborne infectious pathogens. The cleaned air is either recirculated into the room or exhausted outside the building. By filtering contaminated room air and then recirculating the cleaned air into the room, an in-room air cleaner can improve the room's ventilation. By exhausting the filtered air to the outside the unit can create a negative-pressure room. There are many types of in-room air cleaners. They vary widely in the airflow rates through the unit, the type of air cleaning technology used, and the technical design. Crucial to maximizing the efficiency of any in-room air cleaner is its strategic placement and set-up within a room, which should be done in consultation with ventilation engineers, infection control experts, and/or industrial hygienists. A poorly positioned air cleaner may disrupt airflow patterns within the room and through the air cleaner, thereby compromising its air cleaning efficiency. The effectiveness of an in-room air cleaner to remove airborne pathogens from room air depends on several factors, including the airflow rate through the unit's filter and the airflow patterns in the room. Tested under a variety of conditions, in-room air cleaners, including portable or ceiling mounted units with either a HEPA or a non-HEPA filter, portable units with UVGI lights only, or ceiling mounted units with combined HEPA filtration and UVGI lights, have been estimated to be between 30% and 90%, 99% and 12% and 80% effective, respectively. However, and although their effectiveness is variable, the United States Centers for Disease Control and Prevention has acknowledged in-room air cleaners as alternative technology for increasing room ventilation when this cannot be achieved by the building's HVAC system with preference given to fixed recirculating systems over portable ones. Importantly, the use of an in-room air cleaner does not preclude either the need for health care workers and visitors to use personal protective equipment (N95 mask or equivalent) when entering AII rooms or health care facilities from meeting current regulatory requirements for airflow rates (ventilation rates) in buildings and airflow differentials for effective negative-pressure rooms. The Plasmacluster ion technology, developed in 2000, is an air purification technology. Its manufacturer, Sharp Electronics Corporation, says that it can disable airborne microorganisms through the generation of both positive and negative ions. (1) The functional unit is the hydroxyl, which is a molecule comprised of one oxygen molecule and one hydrogen atom. Plasmacluster ion air purifier uses a multilayer filter system composed of a prefilter, a carbon filter, an antibacterial filter, and a HEPA filter, combined with an ion generator to purify the air. The ion generator uses an alternating plasma discharge to split water molecules into positively and negatively charged ions. When these ions are emitted into the air, they are surrounded by water molecules and form cluster ions which are attracted to airborne particles. The cluster ion surrounds the airborne particle, and the positive and negative ions react to form hydroxyls. These hydroxyls steal the airborne particle's hydrogen atom, which creates a hole in the particle's outer protein membrane, thereby rendering it inactive. Because influenza is primarily acquired by large droplets and direct and indirect contact with an infectious person, any in-room air cleaner will have little benefit in controlling and preventing its spread. Therefore, there is no role for the Plasmacluster ion air purifier or any other in-room air cleaner in the control of the spread of influenza. Accordingly, for purposes of this review, the Medical Advisory Secretariat presents no further analysis of the Plasmacluster.

Review strategy: The objective of the systematic review was to determine the effectiveness of in-room air cleaners with built in UVGI lights and HEPA filtration compared with those using HEPA filtration only. The Medical Advisory Secretariat searched the databases of MEDLINE, EMBASE, Cochrane Database of Systematic Reviews, INAHATA (International Network of Agencies for Health Technology Assessment), Biosis Previews, Bacteriology Abstracts, Web of Science, Dissertation Abstracts, and NIOSHTIC 2. A meta-analysis was conducted if adequate data was available from 2 or more studies and where statistical and clinical heterogeneity among studies was not an issue.

Otherwise, a qualitative review was completed. The GRADE system was used to summarize the quality of the body of evidence comprised of 1 or more studies.

Summary of findings: There were no existing health technology assessments on air cleaning technology located during the literature review. The literature search yielded 59 citations of which none were retained. (ABSTRACT TRUNCATED)

Figures

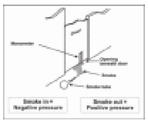

Figure 1:. Smoke tube testing to determine...

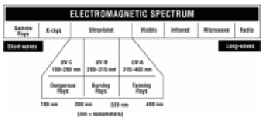

Figure 2:. Electromagnetic Spectrum

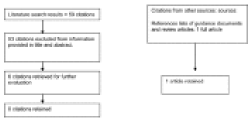

Figure 3:. Summary of the Literature Review

Figure 4

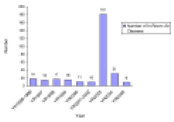

Figure 5:. In-Room Air Cleaners in Ontario

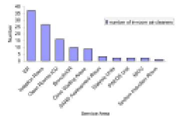

Figure 6:. In-Room Air Cleaner Use in...

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