IN-ROOM HEPA AIR CLEANERS: SIMPLE TECHNOLOGY WITH COMPLICATED IMPLICATIONS

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ABSTRACT

Objective: To evaluate current practice related to in-room high-efficiency particulate air (HEPA) cleaners and provide recommendations regarding best practice.
Methods: Phone interviews were conducted with sixteen Ontario hospitals, to which six site visits were made, to understand how in-room HEPA cleaners were being used and supported. Standards were researched and an Infection Control Expert Panel was convened to establish best practice.
Results: There are over 500 in-room HEPA cleaners being used in over 100 Ontario healthcare organizations. However, there is a large variance in practice and a need for guidance targeted at the following issues: 1. There is insufficient knowledge regarding the risks and appropriate use of these units; 2. Best practice management processes were not always rigorously followed regarding the planning, use, and support of units.
Conclusions: A sequential series of recommendations has been compiled to support facilities to appropriately plan, acquire, operate and support in-room HEPA cleaners.

INTRODUCTION

With the increasing complexity of healthcare technology, the planning and management requirements of simpler technologies are easily overlooked. In-room high-efficiency particulate air (HEPA) cleaners are a seemingly simple technology, which are used to quickly and inexpensively improve ventilation to manage patients requiring airborne infectious disease precautions. However, this technology requires the cooperation of multiple stakeholders (e.g., Infection Control, Facilities Engineering, Biomedical Engineering, clinical areas) and has demanding support requirements. Insufficient planning, commissioning, support, and delegation of accountabilities, compromise its safe and effective use, potentially resulting in airborne infection isolation (AII) rooms not meeting standards.

In November 2005, the Ontario Health Technology Advisory Committee (OHTAC) reviewed the available evidence on air cleaning technologies compiled by the Medical Advisory Secretariat (MAS) of the Ontario Ministry of Health and Long-Term Care (MoHLTC) [1]. Based on this evidence, OHTAC indicated that in-room air cleaners may be used to decrease the concentration of airborne infectious pathogens in a room, but are unlikely to be of benefit in the containment of non-airborne infectious diseases such as influenza and SARS, as these diseases are not transmitted primarily by the airborne route [2]. In addition, OHTAC commissioned a field evaluation by the Healthcare Human Factors Group (HHFG) at the University Health Network (UHN) to evaluate the current use of in-room HEPA cleaners in Ontario hospitals [2]. Consequently, the goal of this research was to determine and evaluate the current practice of in-room HEPA cleaners in Ontario health care facilities, specifically their installation, use, and maintenance, and provide recommendations regarding best practice.

BACKGROUND

The management of airborne infectious diseases (varicella, tuberculosis, measles, and to some extent smallpox) is achieved using the following hierarchy of controls: administrative (work practice) controls, environmental controls, and personal protective equipment (PPE). The precise effectiveness of environmental controls, particularly ventilation, in reducing the risk of airborne transmission is unknown [3,4]. However, two key ventilation-related factors required for effective airborne isolation include: the direction of airflow between the room and its surroundings, and the air dilution within the room [5,6]. In particular, standards typically require that new AII rooms have inward airflow from adjacent spaces (i.e., negative pressure) and have a minimum airflow rate of 12 air changes her hour (ACH) [6,7,9-11]. In-room HEPA cleaners are devices that can provide secondary ventilation to a room to help meet these two requirements.

In-room HEPA cleaners work by pulling particle-laden air into the unit, passing it through a series of filters to remove airborne particles and then exhausting the air

out of the unit (Fig. 1). Some manufactures offer optional ultraviolet germicidal irradiation (UVGI) lamps, but OHTAC advises that there is insufficient evidence regarding the benefits of combining HEPA and UVGI units over those with HEPA filtration only [2].

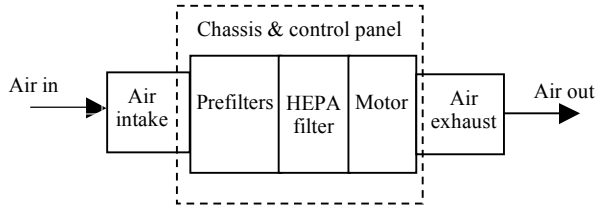

Figure 1: General design components of an in-room HEPA cleaner

Some in-room HEPA cleaners may be configured to be mobile (on casters) or permanently installed. However, in-room HEPA cleaners can only create a negative pressure environment if the unit is installed so its filtered air is exhausted outside the room (Fig. 2). If the unit is only used to recirculate air within a room (e.g., mobile unit that is not exhausted outdoors), it can only remove pathogens by recirculating filtered air back into the room, increasing the equivalent room ACH. When used in this manner, the air concentration within the room is diluted, thus creating a potentially safer environment, but negative pressure is not achieved, so the room does not meet the requirements to adequately support a patient requiring airborne precautions.

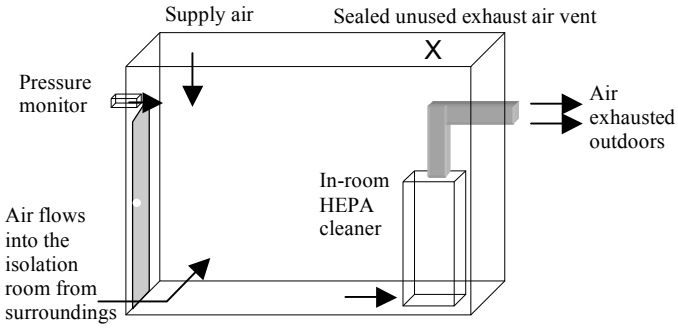

Figure 2: Sample in-room HEPA cleaner that is exhausted outside (out window or via exhaust air system) to create a negative pressure environment. This diagram is not meant to guide installations.

The effectiveness of this technology has been found to vary, but overall when properly used and supported it is effective at removing aerosolized particles [1,5,7]. The effectiveness is dependent on the following:

- Unit airflow rate [5,7] and filter efficiency
- Room airflow patterns, which will be affected by the unit's placement with respect to furniture, staff, patient, and air supply and exhaust registers [5,7]
- Routine maintenance and knowledgeable use [5,7]

METHODS

In order to gain an understanding of current practice regarding the use and support of in-room HEPA cleaners, the HHFG sent emails to over thirty Ontario hospitals known to use in-room HEPA cleaners to inquire about their participation in this review. These hospitals were geographically distributed around the province and ranged from large teaching hospitals to local community hospitals. The HHFG conducted phone interviews with sixteen of these hospitals, predominantly with infection control practitioners and facilities engineering staff. Of these sixteen hospitals, six site visits were made to further understand how the technology is being used and supported. In addition, three vendors and two service providers of in-room HEPA cleaners were interviewed to understand their perspective on the application, use, and support of this technology.

National and international standards and guidelines were researched to establish best practice. In addition, an Infection Control Expert Panel (ICEP) was convened for their advice on the issues arising from the interviews and site visits.

RESULTS

Based on available vendor data, it is estimated that there are over 500 in-room HEPA cleaners being used in over 100 Ontario health care facilities. These units are predominately used in Emergency Departments, but they are also used in wards, waiting rooms, and procedure rooms (e.g., labour and delivery rooms). Most of these units were bought to meet an urgent clinical need; for example during the SARS outbreak they were purchased to create surge capacity to manage the spread of an unidentified pathogen, whose mode of transmission was unknown at the time. In addition, units have been bought to meet long-term ventilation needs as an alternate to upgrading the central HVAC system or as a quick and flexible supplementary ventilation system.

The key issues found during the field study were:

1. Generally, there was insufficient knowledge regarding the risks and appropriate use of in-room HEPA cleaners:
- Some confusion existed regarding the overall benefits of certain AII methods (e.g., diluting room air compared to controlling the directional airflow between rooms using negative pressure). Most sites (n=13) did not have all their in-room HEPA cleaners permanently installed and exhausted outdoors so these rooms were not under negative pressure.

- There was a variance in practice and some uncertainty regarding the appropriate and reasonable precautions required during unit operation and service.
- Many sites (n=9) expressed a desire for more information and guidance about these units and/or had concerns about their current use.

2. Best practice management processes were not always rigorously followed regarding the planning, use, and support of in-room HEPA cleaners:
- Many interviewed sites indicated that not all stakeholders were included in the acquisition process. Some interviewees (n=4) reported "they just showed up one day".
- Many interviewees were uncertain of the safety and performance tests completed prior to placing the units into service, but typically they suspected the device performance and room ventilation were not fully verified (n=14). Interviewed sites with installed units often only ensured that the room could maintain negative pressure (n=8) and most interviewees suspected no commissioning tests were performed on their mobile units.
- Most sites (n=12) had not developed operating and support policies for in-room HEPA cleaners or staff were unaware of their existence, resulting in lack of clear accountability.

DISCUSSION

Given the large variance in practice with this seemingly simple technology, there is need for targeted guidance. The following section presents a sequential series of recommendations based on standards, guidelines and advice from our ICEP. The recommendations are in keeping with OHTAC's initial recommendations (Nov 2005) [2], but provide further details. These recommendations are not meant to be exhaustive, but rather address some of the key issues discovered as part of the Ontario practice survey (full report with a comprehensive list of recommendations is available online: http://www.ehealthinnovation.org/MOH_Publications).

Planning and Commissioning

- ❑ Health care facilities should periodically conduct an assessment of the risk of transmission of airborne infectious diseases to establish the required environmental controls to support their patient population (i.e., number and location of AII rooms and procedure rooms) [7,10,11]. If improved ventilation is required (i.e., need more AII rooms or existing AII rooms do not meet specification), an engineering assessment should be conducted to establish and document the gap between current ventilation performance in the room(s) of interest and the requirements outlined in standards [7].
- ❑ In-room HEPA cleaners should be purchased and installed only when the ventilation requirements outlined in standards cannot be met using the HVAC system [1,2,5,6]. Note: for new construction and major renovations, the performance requirements of the HVAC systems should be specified to meet standards at the outset so that in-room HEPA cleaners are not needed.
- ❑ In-room HEPA air cleaners should be installed by qualified personnel and formally commissioned prior to first clinical use, to ensure conformance to standards and that the unit does not adversely affect ventilation in surrounding areas [8].

Use

- ❑ As recommended by the ICEP, in-room HEPA cleaners should be installed. Mobile (not installed) in-room HEPA cleaners should only be considered in temporary emergency situations. In these acute situations, health care facilities should recognize that the room might not meet the ventilation requirements to adequately support a patient on airborne precautions; negative pressure must also be achieved. In these situations, facilities should focus on implementing proper administrative controls, employing PPE, and transferring the patient to a properly equipped facility for airborne infectious isolation.
- ❑ Before using in-room HEPA cleaners intermittently, a ventilation specialist should be consulted to ensure appropriate ventilation in the room and surrounding areas when the unit is on and off. In addition, health care facilities should ensure adequate time has passed between patient stays before turning units off, to ensure the room is clear of droplet nuclei [7,9].

Technology Management and Support

- ❑ Facilities should have appropriate operating and support policies which state: who is responsible for the management and maintenance of in-room HEPA cleaners, the procedure for monitoring and documenting the unit and room ventilation performance (e.g., filter condition, room air changes per hour, and room pressure), and the requirements for servicing the unit [1-11]. Key components that require regular monitoring and replacement include the unit's prefilters, HEPA filter, and UVGI bulb, if applicable. While standards typically defer to manufacturer recommendations to guide filter replacement,

ECRI Institute indicates the prefilters may need to be replaced as frequently as every 1-3 months and the HEPA filter every 1-3 years depending on the unit and its use [8]. Monitoring the pressure differential across the filters is the preferred method of measuring filter function in guidelines; this is more accurate than the operation hours [5,7,9,10]. Each facility should consider having the HEPA filter seal tested [7,8,10]. At a minimum, the HEPA filter seal should be tested upon initial commissioning, to validate the overall unit and filter construction and quality. Subsequent use of this test should be based on professional judgment (e.g., how the unit is used, manufacturer-specific recommendations, and the condition of the unit).

- ❑ As recommended by the ICEP, service on in-room HEPA cleaners does not need to be performed in a room with special environmental controls as re-aerosolization and transmission of viable pathogens from filter material is not probable. Furthermore, units do not need to be decontaminated prior to servicing or filters disinfected before disposal. However, as an added precaution, staff should use gloves and an N95 respirator during service, and internal components in the airflow channel up to and including the HEPA filter should be disposed of as biohazardous waste.

CONCLUSION

Seemingly simple technologies may require judicious planning, implementation and support to ensure its safety and effectiveness. These requirements may be easily overlooked, particularly when the technology involves multiple stakeholders and is purchased under urgent situations. As such, healthcare facilities should review current practice regarding in-room HEPA air cleaners and follow and implement the presented recommendations.

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