Supplemental Air Purification for Hospitals and Health Care Facilities

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This report reviews health care applications in which portable air purification units can be used to effectively control and contain the spread of airborne nosocomial pathogens. The control of infections in hospitals may require more measures than are currently specified in infection control guidelines, especially if the pathogen of concern is known to transmit by the airborne route.

Current codes and guidelines for hospital ventilation systems require the use of MERV filters for ventilation air supplied to areas for inpatient care and treatment and HEPA filters for protective environments (ASHRAE 2003). Filtering the supply air removes contaminants from the outside air and return air but does not necessarily create a sterile environment nor does it control pathogens at the source. Recirculation units employing filters and ultraviolet (UV) lights are often placed in critical locations such as isolation rooms to augment the ventilation system. **Increasingly, hospitals are resorting to unitary or stand-alone air cleaning devices to help bring outbreaks under control and to reduce airborne contaminants around patients who disseminate pathogens.** The effectiveness of UV systems in controlling TB has been well established and is acknowledged by the CDC and other organizations (CDC 2005). UV systems have also been demonstrated to be effective against a wide variety of airborne nosocomial pathogens and the use of this technology has been sanctioned for the augmentation of existing air cleaning systems.

One of the acknowledged shortcomings of existing hospital ventilation systems is the inability to reduce airborne concentrations of pathogens to levels that significantly reduce the risk of infection. Mean levels of bacteria in general wards are typically in the range of 50-200 cfu/m^3 while levels of fungal spores are on the order of 30-150 cfu/m^3 (Kowalski 2012). Since WHO recommends limits of 100 cfu/m^3 for bacteria and 50 cfu/m^3 for fungi, it would appear that many hospitals would not meet these criteria (WHO 1988). Considering that MERV 15 filters used for supply air should eliminate all fungal spores, it is clear that the intrusion of spores from the environment is not being effectively controlled by the current design approach and new options are needed.

Pressurization control in isolation rooms, ICUs, and operating rooms (ORs) can greatly reduce internal airborne levels of pathogens below levels in the general wards but these levels rarely approach zero even when unoccupied. Negative pressure isolation rooms protect individuals outside the zone from the potential infections contained by patients within the zone. **The problem, especially in ORs, is that the occupants themselves are disseminating opportunistic pathogens such as *Staphylococcus* and *Streptococcus* that may be hazardous to patients. In such situations, controlling pathogens at the source may be the only effective way to provide a more sterile environment and reduce the risk of infection.** Portable air purification units can be used to scrub the air inside the isolation zone as a supplemental form of decontamination and since these units deal with the problem at the source they are likely to decrease the overall risk of infectious disease spread. Air purification units must be evaluated to ensure they are appropriately sized for any given hospital zone, in terms of floor area or room volume, and methods for analyzing and testing air cleaners have been developed (Janney et al 2000, Foarde et al 1999). FDA clearance may be required for air cleaners that are considered medical devices.

In any hospital, different wards may have specific arrays of nosocomial pathogens that pose a threat to patients and staff. It is worthwhile to consider the specific pathogens that are germane to particular hospital environments in order to assess whether supplemental air purification will be effective.

General Wards and Intensive Care Units (ICUs) are subject to a wide variety of nosocomial infections that include respiratory infections, gastrointestinal infections, urinary tract infections, and food-borne illness. Known airborne pathogens include *Aspergillus* spores, *Clostridium difficile* spores, *Histoplasma* spores, *Mycobacterium tuberculosis*, Norwalk virus, *Pseudomonas aeruginosa*, *Staphylococcus aureus* (MRSA), and *Streptococcus* species. Patients in general wards are also subject to outbreaks of common infections that result from seasonal patterns in the local community. Most of these are respiratory infections that include the known nosocomial pathogens *Bordetella pertussis*, Coronavirus & SARS virus, Influenza, Measles, Mumps, RSV, VZV, and *Legionella*. Many of these respiratory infections may result in pneumonia.

Operating Rooms (ORs) are among the cleanest environments in the hospital and are rarely subject to intrusion by fungal or bacterial spores that afflict other areas of the hospital environment. ORs are, however, frequently contaminated by bacteria that hail from surgeons, nurses, and the patients themselves. Surgical site infections (SSIs) that are known to transmit by the airborne route include *Pseudomonas aeruginosa, Staphylococcus aureus* (MRSA), and *Streptococcus pyogenes*. *Aspergillus* spores have also been known to contaminate wounds in operating rooms.

Pediatric Infections form another distinct class of nosocomial infections that affect Neonatal Intensive Care Units (NICUs) and Pediatric ICUs (PICUs) as well as child care facilities and nurseries. Known airborne nosocomial pathogens include *Clostridium difficile* spores, Influenza, Measles, *Mycobacterium tuberculosis, Pseudomonas aeruginosa*, RSV, *Staphylococcus aureus* (MRSA), and VZV.

Patients may be immunocompromised due to AIDS, transplantation, cancer treatment, or physical injuries. Infections in the immunocompromised are mainly due to opportunistic pathogens that hail from humans or from the environment. Known airborne nosocomial pathogens include *Aspergillus* spores, *Clostridium difficile* spores, *Histoplasma capsulatum* spores, Influenza, *Mycobacterium tuberculosis, Pseudomonas aeruginosa*, RSV, *Staphylococcus aureus* (MRSA), and VZV.

Burn Wound Infections place patients at higher risk for nosocomial infections and the pathogens involved are most often the same microbes that normally live as commensals or are environmental. Known airborne nosocomial pathogens include *Aspergillus* spores, *Pseudomonas aeruginosa, Staphylococcus aureus* (MRSA), and *Streptococcus pyogenes*.

Nursing Homes, including long-term care facilities (LTCFs) and long-term acute care facilities (LTACs), are subject to outbreaks of respiratory and gastrointestinal infections due to the decreased immune system response of the elderly. Respiratory infections often follow seasonal community outbreaks. Known airborne nosocomial pathogens include *Bordetella pertussis, Clostridium difficile* spores, Coronavirus, *Haemophilus influenza*, Influenza, *Legionella*, *Mycobacterium tuberculosis*, Parainfluenza, RSV, *Staphylococcus aureus* (MRSA), *Streptococcus pneumoniae*, and *Streptococcus pyogenes.*

Clostridium difficile spores present a unique problem since health care facilities are the primary reservoir and health care workers commonly carry it asymptomatically. These spores are disseminated from patients, especially newborns, and since the spores can survive for weeks they may spread widely via airborne transport from the index patients and contaminate entire wards. Aerosolization of *C. difficile* spores occurs commonly but sporadically in patients with symptomatic infection (Best et al 2010). *C. difficile* infections (CDI) were reduced in Northwick Park Hospital (UK) using ultraviolet air cleaning technology, which had previously proven effective against MRSA (Nielsen 2008). In this latter application, CDI cases were reduced by 33%. Surface contamination with *C. difficile* spores has been successfully dealt with using UV light at the University of Rochester Medical Center's Highland Hospital in 2009, in which contaminated rooms were first scrubbed with disinfectants and then irradiated with UV for one hour. With a settling time of about 0.4-4 m/hr, *Clostridium* spores may be transported far from the source by air currents and the use of air purification equipment may be the most effective means of preventing the internal spread of spores in hospital wards (Kowalski 2012).

Any type of spore such as *Clostridium* or *Aspergillus* will survive for weeks or months in indoor environments. Such extended survival times are conducive to widespread indoor dissemination as these spores are lifted into the air by activity and transported by local air currents. Surface disinfection techniques can be effective against such pathogens but a complete solution requires the use of air cleaning technology in conjunction with surface cleaning.

The Viratech™ UV400 air purification unit is an air recirculation unit that employs UV to kill pathogens, including bacteria, viruses, and fungal spores, and which has been demonstrated to significantly reduce airborne levels of nosocomial bacteria such as *Pseudomonas aeruginosa* and *Staphylococcus aureus* (MRSA). Although fungal spores are resistant to UV, the recirculation of air through the unit will result in multiple UV doses being imparted to the spores (chronic dosing), which will continuously reduce spore levels while it is operating. Recirculation units that use filters, such as the **HEPA-filtered RX3000**, will also have a major impact on reduction of airborne pathogens and, with a filter efficiency of 99.97%, will remove essentially all spores in a single pass.

Summary

Although existing health care procedures, methods, and technology can be highly effective against known agents of infection when they are properly and assiduously applied, the changing nature of modern nosocomial threats, including evolving multidrug resistance and the appearance of new pathogens, may warrant the use of new technologies and methodologies. Perhaps the most reliable approach to controlling airborne infections today is the use of source control methods, or spot infection control, in increasingly more localized situations. Such applications, in which air purification units are located in each patient’s room, may prevent them from becoming an index patient for the next hospital outbreak. Interdicting new infections at the source may be far more cost effective than relying on traditional building ventilation systems to remove the threat.

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