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## Portable Air Purifiers for Airborne Infection Control



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Public health officials are concerned that infectious diseases are a growing threat to our nation's health. After the SARS outbreak of 2003, many lessons were learned about inadequate infection control and the recognition that the health care community had to improve preparation for any future large-scale epidemic. Infection-control professionals and government agencies are now devising new strategies and evaluating equipment, including portable air purifiers, for controlling the spread of airborne infections in healthcare facilities and government and commercial buildings to protect workers in case of a pandemic.

There have been three pandemics in the past century, the most deadly being the Spanish Flu that killed millions. Since the last pandemic in 1968–1969, the risk of an influenza pandemic has never been considered greater than the present time. Officials fear that a virus in birds, the H5N1 virus, could mutate and spread from human to

human. The World Health Organization reports at least 229 people are known to have contracted bird flu since 2003, of which 131 have died, which is a high mortality rate.

Due to concern over the potential for viral epidemics, the Centers for Disease Control and Prevention upgraded its infection control standards "Guidelines for Environmental Infection Control in Health Care Facilities" in 2003. This document provides specifications for airborne infection isolation and protective environments used for high-risk immunocompromised patients.

Of major concern to the CDC is that some human viral and bacterial diseases are transmitted from person to person via droplet aerosols. Airborne transmission of measles has been documented in health care facilities. In addition, institutional outbreaks of influenza viral infections have occurred predominantly in nursing homes and less frequently in intensive care units, chronic care facilities and pediatric wards. Smallpox virus, a potential agent of bioterrorism, is spread via direct contact with infectious droplets but it can also be associated with airborne transmission.

It was proposed, by Dr. Ho in the *Annals of Medicine*, that in the era of bioterrorism, SARS and annual epidemics of influenza, the number of negative air pressure isolation rooms, or NPIRs, in hospitals is an essential part of managing the spread of airborne infection. It was recommended that large hospitals develop plans for clustering approximately 10 negative air pressure rooms that could be used in an urgent situation. Currently, isolation rooms in most U.S. hospitals are not clustered, and infected patients could expose healthcare workers on various floors to an infective viral or bacterial agent.

One of the drawbacks of constructing dedicated NPIRs is their high cost, which is a barrier to already financially strained hospitals and healthcare facilities. Also, there is concern that, in an epidemic, there could be a surge of patients entering hospitals that require isolation rooms and there would not be enough rooms to handle this number of patients.

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According to an article published by the Working Group on Civilian Bio-Defense, there are many circumstances, including mass casualty situations, in which the use of NPIRs may not be possible. In an outbreak of a viral epidemic or pandemic, hospitals and medical facilities could be swamped with infected patients who would have to be placed in standard rooms or cohorted in wards. In such conditions, other infection control measures would have to be taken. In addition to standard infection control procedures such as exhausting air through separate duct systems to the outside atmosphere after passing through HEPA filtration, and dilution ventilation of six to 12 air changes per hour, supplemental air cleaning with UVGI and placing portable air purifiers in regular patient rooms, could reduce airborne infection distribution in group settings.

The use of portable HEPA filters is already included in the CDC guidelines under certain circumstances in hospitals, which, in addition to other infection-control precautions, reduces the risk of nosocomial transmission via small particle aerosols. However, if portable air filters are used to supplement infection controls, then the units must be capable of reducing pathogens in an air stream.

The CDC infection-control guidelines for portable air filters are specified as:

- “Use portable industrial-grade HEPA filter units capable of filtration rates in the range of 300–800 ft<sup>3</sup>/min to augment removal of respirable particles as needed.
- “Select portable HEPA filters that can recirculate all or nearly all of the room air and provide the equivalent of [greater than 12 air changes per hour].
- The use of “portable HEPA filter units” whose filter performance has been verified by appropriate particle testing. The filtration efficiency is 99.97 percent at 0.3 microns DOP.
- “Situate portable HEPA units” toward the airborne disease patient.
- “Ensure that fresh-air requirements for the area are met.”

What is of critical importance in any effective use of portable air filters to control airborne infection is that in addition to aerosol droplets, there are droplet nuclei that have to be reduced in the airstream. Droplet nuclei are the residuals of droplets that when suspended in air, subsequently dry and produce particles ranging in size from one to five microns. These particles can contain potentially viable microorganisms, be protected by a coat of dry secretions, remain suspended

indefinitely in air, or be transported over long distances.

The microorganisms in droplet nuclei persist in favorable conditions, i.e. a dry cool atmosphere with little or no direct exposure to sunlight or other sources of radiation. Pathogenic microorganisms that can be spread via droplet nuclei include mycobacterium, measles virus (*Rubeola*) and Smallpox virus (*Variola major*) and the spores of *Aspergillus fumigatus*.

Due to the fact that viral droplet nuclei and free viruses are low micron or submicron size, there is the probability that they will pass through HEPA filters or portable machines that are not sealed properly. Also, since a HEPA-only portable filter does not have any germicidal UVGI or other germicidal technology, the viruses that pass through the HEPA filter may still be viable and infective. The portable unit design should therefore include a tight seal around the filter so that 100 percent of the airstream goes through the filter and there is no bypass. Also, a combination HEPA or better than HEPA filter with UVGI or other germicidal technology should be used to inactivate the microorganisms as they pass through the filter.

Numerous HEPA-only filters available in the marketplace claim to reduce bacteria in the units’ HEPA filter. However, very few if any units have been tested with live non-pathogenic bacteria or viruses to see if they can reduce microorganism counts on the outflow side of the filter. Rather, most bacterial-reduction claims of HEPA units are based upon the rating of HEPA particle reduction, without any microorganism surrogate testing or testing of the seals of the portable unit.

This lack of efficiency testing leaves engineers and infection-control professionals with little information to base decisions on which unit or units would be effective for use in controlling airborne infections.

Several manufacturers have combined their HEPA units with one or more UVGI lamps either on the inflow side of the HEPA or after the HEPA. Killing pathogens in an airstream requires a relatively high dose of UVGI radiation with an adequate amount of contact time to deliver a sufficient germicidal dosage to kill (inactivate) pathogens. In some portable HEPA/UV combinations, the seals may not be tight enough to prevent bypass, or generate sufficient UVGI dosage to kill a high percentage of pathogens.

Dr. Wladyslaw Kowalski, in ASHRAE Transactions published in 2000, pointed out that “current available design information has not

guaranteed predictable performance for UVGI air disinfection systems.” Guidelines were issued that sanctioned the use of UVGI only in combination with HEPA filters, by ASHRAE in 1991. However, no studies were undertaken to determine the root cause for any UVGI system failures. Kowalski also states that part of the problem is that they fail to define the intensity field, instead merely using the lamp rating. Another flaw in UVGI design is that lamps are specified without regard to lamp location or type. So it is critical that manufacturers test their UV-HEPA systems before making claims that they can be effective in killing bacteria or viruses.

Other air purification technologies should also be evaluated to see if they are effective in reducing pathogens in infected patient environments.

A newer technology called EMF or EGF (enhanced germicidal filtration) uses a HEPA-type filter that is bathed or permeated by a high-voltage electrical field of about 18 kilovolts. Fungi, molds and some bacteria are trapped in the filter; as viruses pass through the filter, they are exposed to the high-energy field with a germicidal effect that inactivates microorganisms in the germ-killing zone. Independent laboratory testing with a portable EMF/EGF unit in which the unit was challenged with large amounts of non-pathogenic microorganisms revealed more than 99 percent inactivation of viable phage viruses, and 94–98 percent of two bacteria and a penicillin strain. The germicidal equivalent dosage generated by the EGF field is approximately 12,000 microwatts/cm<sup>2</sup>/second based upon percentage of kill and the microorganism’s listed dosage on GE germicidal charts. Also, this germicidal technology has been listed by the Food and Drug Administration as a Class II medical device.

There are two advantages of an EMF/EGF portable unit over a HEPA or HEPA/UV portable units. One advantage is that the EMF/EGF energy does not degrade over time like UV. At 9,000 hours, most UV lamps degrade 25 percent or more depending on the type and quality of the UV lamps. Also, there can be a “shielding effect” with UV technology. Bacteria and viruses attached to small particles may not be completely exposed to the UV unless there is a well designed system incorporating reflective material in the germicidal chambers. This problem is avoided in the EGF system since the filter is completely bathed in energy so there is no “shielding effect” problem.

Ozonation is another method that could be considered for infection control. Ozone is a molecule composed of three atoms of oxygen. The

third oxygen atom can detach from the ozone molecule and reattach to other molecules, thereby altering their chemical composition. It is this ability to react with other substances that forms the basis of manufacturer’s claims. However, when inhaled, ozone can damage the lungs. The FDA requires ozone output of indoor medical devices to be no more than 0.05 parts per million.

High concentrations of ozone in air, when people are not present, are sometimes used to help decontaminate an unoccupied space from certain chemical and biological contaminants.

According to the Environmental Protection Agency’s Web publication on ozone, “Some data suggest that low levels of ozone may reduce airborne concentrations and inhibit the growth of some biological organisms while ozone is present, but ozone concentrations would have to be 5-10 times higher than public health standards allow before the ozone could decontaminate the air sufficiently to prevent survival and regeneration of the organisms once the ozone is removed. Even at high concentrations, ozone may have no effect on biological contaminants embedded in porous material such as duct lining or ceiling tiles. In other words, ozone produced by ozone generators may inhibit the growth of some biological agents while it is present, but it is unlikely to fully decontaminate the air unless concentrations are high enough to be a health concern if people are present.”

Therefore, in a healthcare facility, ozone cannot be used when patients with respiratory disease are in the room. After patients are removed and the room is being disinfected with standard hospital biocides, then ozone may be used as a supplemental disinfectant with an appropriate clearing time. However, it could not be used as a primary airborne infection-control method.

It has been recognized that, if there is an outbreak of an infectious disease such as SARS or avian flu or a terrorist attack using a biological agent, hospitals currently could not provide sufficient airborne infection isolation capacity to care for a surge of infected patients. Infection-control options can be engineered using portable air purifiers that can provide effective filtration and inactivation (killing) of viral pathogens in combination with other infection control methods. This would expand the number of hospital rooms that could be used to place and treat infected patients at a much lower cost than building NPIRs.

Portable air purifiers that have germicidal capability could also be used in government and

commercial buildings during disease outbreaks and for reducing bioburdens in the workplace.

Finally, new testing criteria and standards for portable units should be established. The portable units should be tested for their ability to inactivate different non-pathogenic microorganisms and their effectiveness in reducing aerosolized particles in the size range of pathogenic bacteria and viruses. The new standard would certify these units as portable germicidal air purifiers for use in medical facilities or any application requiring airborne infection control.

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