IMPROVING INDOOR AIR QUALITY FOR BETTER HEALTH

KEY FACTORS THAT IMPACT INDOOR AIR AND HOW TO ADDRESS THEM

Delos™

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INTRODUCTION

Clean air is essential for optimal health. Air pollution is a significant contributor to many noncommunicable diseases, and is considered one of the greatest killers of our generation. In addition, air can be the medium through which infectious diseases spread, as became evident during the Covid-19 pandemic. Globally, air pollution is estimated to contribute to nearly 6.7 million deaths per year, making it the fourth largest risk factor for mortality (after high blood pressure, tobacco, and dietary risks). In 2015, air pollution was responsible for 19% of all cardiovascular deaths, 24% of all deaths caused by ischemic heart disease, 21% of all stroke deaths, and 23% of all lung cancer deaths globally. And while most of the pollution is generated outdoors through both natural and man-made means, research suggests that concentrations of toxins, allergens and other pollutants can be two to five times higher indoors than they are outside.

> As the Covid-19 pandemic requires us to spend more time indoors, the quality of our indoor air has become more important than ever

Our homes, workplaces and schools are foundational to our well-being, providing shelter, comfort, security, and space for learning, collaboration and socialization. We typically spend about 90% of our time indoors, primarily in our homes, followed by workplaces or schools. As the Covid-19 pandemic requires us to spend more time indoors, the quality of our indoor air has become more important than ever — as a way of helping protect against the novel coronavirus, as well as helping to ensure overall health and well-being.

The pandemic has changed our lives in many ways. Beyond the obvious examples, it has introduced additional risks for poorer indoor air quality. Spending more time at home can mean engaging in activities that generate more indoor pollutants. For example, more frequent cooking or cleaning can result in a range of harmful pollutants, e.g., particulate matter (PM) and volatile organic compounds (VOCs), which can pose risks to our health. Similarly, more frequent and extensive cleaning practices to mitigate Covid-19 in schools and workplaces can generate a range of harmful pollutants or spread hazardous chemicals, leading to eye, nose, throat and lung irritation, as well as an increased risk of respiratory issues such as asthma.

But our indoor environments have a tremendous potential to act as vehicles for health promotion, and present many ways in which their environmental conditions at large, and air quality specifically, could be improved. For example, sustainable and natural elements built into our homes, careful material selection, and reliable natural or mechanical ventilation systems can support good air quality, helping to promote our overall well-being. Similarly, adequate ventilation and air purification in classrooms and workplaces can create better learning and work environments, which can result in better test scores and enhanced productivity.

> Our indoor environments have a tremendous potential to act as vehicles for health promotion

Healthy People 2020, the U.S. government's health prevention agenda, identifies creating “environments that promote good health for all” as a national objective. In alignment with these goals, Delos - the global wellness pioneer - is excited to share its white paper, Improving Indoor Air Quality for Better Health. Informed by leading research on health and the built environment, this white paper explains the science behind clean air and the ways in which air quality impacts our health, and proposes strategies for achieving better air quality in order to transform our indoor spaces into healthier places to be.

2 COVID-19 AND TRANSMISSION OF AIRBORNE VIRUSES

Air that is free of pathogens and chemical contaminants has always been essential to our health. During the Covid-19 pandemic, it has become even more important. Based on current scientific facts, we now know that buildings may influence the spread SARS-CoV-2 (the virus that causes Covid-19).

SARS-CoV-2 was initially thought to be spread from person to person through respiratory droplets that are released when an infected person sneezes, coughs, or speaks. However, informed by scientific research conducted by experts worldwide over the past nine months, it has now been established that SARS-CoV-2 can also be spread via airborne transmission. In addition, studies show that viral pathogens can travel further than the physical distancing recommendation of 6 feet—for example, if an infected person who is not wearing a mask sneezes, viral particles can travel up to 27 feet in some cases. While larger respiratory droplets quickly fall onto surfaces, smaller aerosolized particles containing SARS-CoV-2 can remain suspended in the air indoors for long periods of time (up to several hours), travel distances beyond 6 feet, and might be breathed in by others.

In addition, research shows that the severity of a Covid-19 infection is related to other parameters of air quality, namely fine particulate matter (PM2.5). People who live in areas with greater long-term ambient PM2.5 pollution have been found to have a greater risk of severe outcomes from Covid-19. Specifically, an increase of just 1 µg/m3 in long-term average PM2.5 exposure was associated with an 11% increase in Covid-19 mortality rate. For reference, the EPA's standard for public health protection is that PM2.5 levels in any area should not exceed 12 µg/m3.

Because buildings play a critical role in shaping and remediating indoor air quality—through processes such as ventilation and air purification—they present an important opportunity to influence the transmission of SARS-CoV-2.

Ventilation and Air Purification

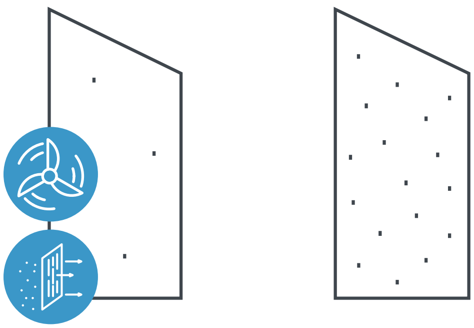
Ventilation and air purification are two different strategies to improve the quality of indoor air. Ventilation helps dilute the bacterial and viral load within the air, which reduces the chance of occupants being exposed to bacteria and viruses that may be present in the air, whereas air purification helps to physically remove and/or deactivate them.

Experts believe that the risk of Covid-19 transmission is greater in indoor environments that do not have adequate ventilation or air purification, which allows viral particles to become more concentrated within the space, increasing the probability of infection. Many HVAC systems rely on recirculated air instead of fresh air (from the outdoors). Unfortunately, while this may be beneficial for maintaining a stable temperature, recirculated air may increase the risk of viral transmission.

The toll of Covid-19 and indoor air solutions to address it

COVID-19 TRANSMISSION

Risk is greater indoors



Adequate Ventilation and Filtration

Without Adequate Ventilation and Filtration

2ND LEADING CAUSE OF DEATH

Covid-19 is projected to be the second leading cause of death in the U.S. in 2020

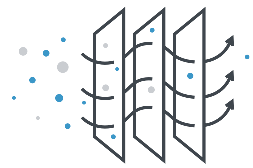
#01 Ischemic Heart Disease

#02 Covid-19

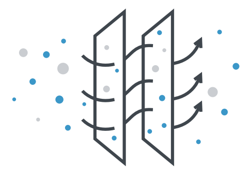
#03 Tracheal, Bronchus and Lung Cancer

FILTRATION EFFICIENCY MATTERS

Covid-19 particles are very small (0.06 to 0.14 µm)



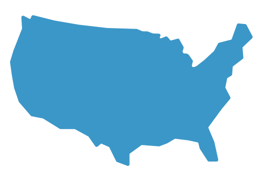
ADVANCED ELECTROSTATIC FILTRATION, HEPA FILTRATION



TRADITIONAL MECHANICAL FILTERS IN THE HVAC SYSTEM

- Particles that carry the virus
- Other particles

NUMBER OF DEATHS DUE TO COVID-19*



401,128

2,051,049

* as of Jan 19, 2021

Furthermore, there is strong and sufficient evidence to demonstrate the association between ventilation, air movement in buildings, and the transmission of other infectious diseases such as measles, tuberculosis, chickenpox, influenza, smallpox and SARS. While these methods alone are not enough to protect people from airborne viruses such as SARS-CoV-2, they can help mitigate risk when used in conjunction with best practices recommended by the CDC and other credible institutions. These same measures also help to reduce the spread of other infectious diseases such as influenza. Thus, experts from the CDC and Harvard T.H. Chan School of Public Health recommend increasing ventilation rates and adding air purification technologies in indoor environments, especially in high-density facilities such as schools and offices, to help reduce the spread of Covid-19 and other infectious diseases.

Portable air purification units are an effective and easily implementable solution to immediately start addressing airborne viral load with minimal disruption

The virus causing Covid-19 (SARS-CoV-2) ranges in size from 0.06 to 0.14 microns, which is significantly smaller than particles that are captured by conventional filters in most mechanical systems. Viral particles as small as SARS-CoV-2 can, however, be captured by advanced air purification technologies, such as electronic air filters and HEPA filters.

As the Covid-19 pandemic continues, installing or retrofitting existing HVAC systems and/or renovating buildings for improved ventilation tend to be time-consuming and require more resources. Portable air purification units are an effective and easily implementable solution to immediately start addressing airborne viral load with minimal disruption.

Humidity

Relative humidity (RH) levels can impact the transmission of viruses as well as the defence mechanisms of our immune systems. Dry air facilitates moisture evaporation from droplets that contain viruses, making the droplets smaller—which in turn enables them to travel further and remain suspended in the air for longer. Dry air can also diminish our body's immune defenses against various pathogens. Finally, extremely dry and humid air can reduce sleep quality, thus weakening our immune system and decreasing our body's ability to defend itself from invaders.

During the Covid-19 pandemic, as homes became primary spaces for remote learning and working-from-home, air quality interventions have become more important than ever

Importance of Good Air Quality In the Long Run

Maintaining good indoor air quality in enclosed environments—such as homes, schools and workplaces—is important for mitigating exposure to pathogens and pollutants. During the Covid-19 pandemic, as homes became primary spaces for remote learning and working-from-home, air quality interventions have become more important than ever. However, good air quality is key across all indoor spaces. For example, occupants of buildings (primarily offices) with low ventilation rates and high occupant densities experience far higher rates of respiratory illnesses compared to occupants of similar buildings with higher ventilation rates. Similarly, in schools—which typically have around four times as many occupants as office buildings for the same amount of floor space—greater occupancy and higher volume of exhaled air may result in increased accumulation of viral particles in the air. Thus, taking steps to improve air quality during Covid-19 can have benefits that last long after the pandemic's end.

3 KEY AIR POLLUTANTS AND PATHOGENS IN INDOOR SPACES

Covid-19 and Other Airborne Pathogens

> The CDC indicates that SARS-CoV-2 has the potential to be transmitted over long distances and periods of time in indoor spaces

Microorganisms, also called microbes or germs, are present everywhere in our environment and include viruses, bacteria, and fungi. While most microorganisms are harmless, some microbes, called pathogens, can cause disease in humans, which can range from mild inflammation to life-threatening medical conditions. There are multiple routes of exposure to pathogens, including via air. Some pathogens can be transmitted through droplets in the air that the infected person may release through sneezing and coughing (sending small water or mucus droplets with pathogens in them out), such as SARS-CoV-2 (the novel coronavirus), influenza viruses, and common cold viruses. If close enough in proximity to the infected person, other people can then also get infected by inhaling those droplets. Some pathogens can also attach themselves onto smaller particles in the air such as dust, which is called airborne transmission. These small particles can stay in the air longer and travel farther distances than droplets, potentially affecting people within a wider spatial range. Some examples of diseases caused by airborne transmission include tuberculosis, measles, and Legionnaires disease. CDC also indicates the potential of SARS-CoV-2 to be transmitted over long distances or times. Circumstances under which airborne transmission of SARS-CoV-2 appears to have occurred include: enclosed spaces, prolonged exposure to respiratory particles, and inadequate ventilation/air handling.

PM2.5 has been linked to a range of chronic and acute respiratory conditions

Particulate Matter

“Particulate matter” refers to very small particles of solid or liquid matter that can stay suspended in the air and be transported by the wind. Particles sized 2.5 micrometers (0.0025 millimeters) or less (PM2.5) have received the greatest attention from scientists and government agencies due to their ability to enter the smallest regions of the lungs and therefore pose serious health concerns. PM2.5 contributes to diabetes, chronic pulmonary obstructive disorder (COPD), stroke, ischemic heart disease, atherosclerosis, tracheal, bronchus and lung cancer, and lower respiratory infections. Exposure to PM2.5 has also been linked to respiratory conditions such as allergies, asthma, airway irritation and inflammation, and tuberculosis.

Allergens & Asthma Triggers

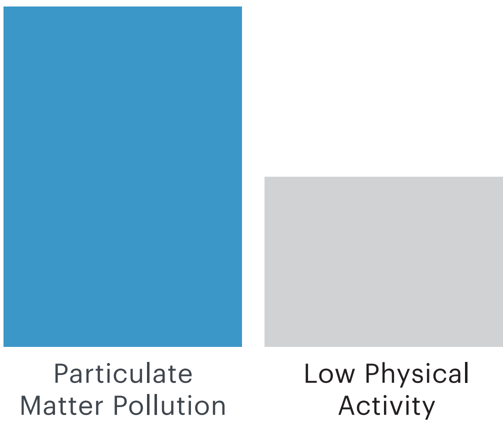
Substances like pollen, pet dander, saliva, and pest waste can cause allergic reactions in many people. Common symptoms of allergic reactions are similar to those of a cold, such as a runny nose and congestion, sneezing, and watery eyes. Allergens can also trigger asthma symptoms for some people with asthma.

Mold

Mold is very common in damp buildings and homes. Mold can enter through open windows, vents, and heating and cooling systems or be carried indoors via shoes, clothes, and pets. Common materials that support mold growth include, but are not limited to, paper products, wood products, ceiling tiles, paint, wallpapers, carpet,

Particulate matter pollution is harmful to our health

HEALTHY LIFE YEARS LOST DUE TO:



*in the U.S.

TOP CONTRIBUTORS TO HEALTH LOSS

#01 Smoking

#15 Particulate Matter

#19 Secondhand Smoke

*in the U.S.

EXPOSURE TO AIR POLLUTION

Small increases are associated with decreases in lung function equivalent to:

65% of what you would see in a former smoker

04x that which you would get from secondhand smoke exposure at home

IN 2015 GLOBALLY,

air pollution was responsible for:

- **19%** of all cardiovascular deaths
- **24%** of all deaths caused by ischemic heart disease
- **21%** of all stroke deaths
- **23%** of all lung cancer deaths

and upholstery. Exposure to mold and mildew are known asthma triggers and may also cause coughing, wheezing, shortness of breath, sinus congestion, sneezing, nasal congestion, and sinusitis.

Volatile Organic Compounds (VOCs)

Exposure to VOCs is associated with both short-term and long-term health effects

Certain complex chemicals, found in many products used in everyday life, can emit gases called volatile organic compounds (VOCs) through a process referred to as "chemical off-gassing". These gases can diffuse in the air and may have detrimental effects on human health. Exposure to VOCs is associated with both short-term health effects such as eye, nose and throat irritation, headaches, loss of coordination and nausea, and long-term health effects such as damage to liver, kidney and central nervous system and cancer.

Carbon Dioxide (CO_2)

Carbon dioxide, which humans produce when breathing, is a good indicator of the availability of fresh air in an indoor space; the more CO_2 there is in a space, the poorer the indoor air quality (however, there are other indoor air pollutants that can contribute to diminished air quality). Without fresh air, it is harder for indoor pollutants to disperse, and their levels can build up. CO_2 might also have more direct impacts on our cognitive performance. Elevated levels of CO_2 have been associated with increased student absence and wheezing among children attending daycare. Higher CO_2 levels in the classroom have also been linked to poorer concentration and cognitive performance, among other indicators of academic performance.

Chemicals from Building Materials and Furnishings

Many building components and finishings—from pipes and insulation to doors and paints—can be constructed from dangerous substances such as lead or asbestos, or can contain materials that off-gas various chemicals. Furniture (especially upholstered furniture) and floor coverings can also contain harmful chemicals. For example, materials like vinyl, halogenated flame retardants, and stain-guard coatings that are often used in furnishings can contain semivolatile VOCs.

Cooking Emissions

Cooking, especially using gas stoves, can generate harmful pollutants—such as carbon monoxide (CO), nitrogen dioxide (NO_2), and particulate matter—that can linger at high concentrations, particularly without effective ventilation.

Solid Fuels

Household air pollution (HAP) from the combustion of solid fuel, such as wood, is among the top five environmental health risks across the globe. The World Health Organization (WHO) estimates that annually, 3.8 million premature deaths from noncommunicable diseases, including stroke, ischemic heart disease, COPD and lung cancer, are due to exposure to household air pollution. Cooking with solid fuels is not common in high-income countries such as the U.S., however, solid fuel burning is not uncommon in fireplaces, which can be a source of HAP.

Radon

Radon is estimated to cause around 21,000 deaths a year in the U.S.

Radon is a colorless, odorless, radioactive gas that is released from the breakdown of radioactive elements in rocks and soil, and typically enters the home through cracks and other holes in the foundation. According to EPA estimates, radon is the number one cause of lung cancer among non-smokers and is the second leading cause of lung cancer in the U.S, after smoking. Radon is estimated to cause around 21,000 deaths a year in the U.S.

4 AIR QUALITY AND HUMAN HEALTH

Homes

A growing body of evidence suggests that the air within our homes and other buildings can have a greater concentration of pollutants than outdoor air — even in the largest and most industrialized cities. In fact, in the U.S., almost 75% of our exposure to very small particulate matter (PM2.5), one of the most dangerous air pollutants, occurs in our homes.

Similarly, the air in our homes—particularly during the fall and winter months when we spend more time inside—can have greater levels of airborne pathogens, including SARS-CoV-2. This may be especially so for homes without adequate ventilation or air purification.

> Given that we spend around 90% of our time indoors, with two-thirds of this time spent at home, ensuring good indoor air quality within our homes is crucial

HEALTH FACTORS

1 **Covid-19 and Other Airborne Pathogens:** A recent study has found that Covid-19 spreads faster and more widely in U.S. households than previously thought, with 53% of people living with someone who tested positive for Covid-19 becoming infected themselves.

2 **Infiltration of Ambient Air Pollution:** Over a third of Americans live in counties where air quality is sub-optimal and exceeds the maximum thresholds set by the Environmental Protection Agency (EPA) for key pollutants, such as ozone and particulate matter.

3 **Pollutants Generated by Cooking:** It has been estimated that during a typical week in winter (when it is more likely that windows are closed and ventilation rates are lower), 1.7 million Californians who cook on gas stoves without using a range hood could be exposed to levels of carbon monoxide (CO) that are above the threshold levels set by state and national air quality standards, and 12 million could be exposed to excessive levels of nitrogen oxide (NO).

4 **Allergens & Asthma Triggers:** Allergens such as dust mites, pet dander, and pest wastes (from cockroaches and rodents) are commonly found in homes and are known to trigger allergies and asthma symptoms. A study found that of the 831 housing units surveyed, 51.5% had at least 6 detectable allergens and 45.8% had at least 3 allergens exceeding elevated levels. Researchers also found that among allergic individuals, high allergen burden was associated with increased odds of having asthma symptoms.

5 **Mold:** Dampness and mold affect almost half of U.S. homes, with causes including everything from rain, snow, leaking plumbing systems and flooding, to indoor activities such as cooking or showering. Moldy and damp homes are believed to increase the risk of health outcomes such as bronchitis, asthma development or exacerbation, respiratory infections, coughing, and wheezing by an estimated 30-70%.

6 **Radon:** Nearly one out of every 15 homes in the United States is estimated to have an elevated radon level (4 pCi/L or more).

> Literally millions to many millions of people are routinely being exposed to air pollutants at levels that we don’t allow outdoors.

BRETT SINGER
Lawrence Berkeley National Laboratory

BENEFITS OF GOOD INDOOR AIR QUALITY IN HOMES

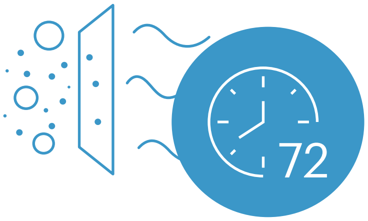
The EPA notes that when used properly, and in combination with other Covid-19 precautions recommended by the CDC, air purifiers and HVAC filters can help reduce airborne contaminants, including viruses, in the home.

Implementation of electrostatic air filters in homes has also been found to substantially decrease indoor PM2.5 levels and has been associated with improved lung function as well as decreased systolic and diastolic blood pressure.

Studies have also shown that the use of air purifiers in homes is associated with improved cardiac and respiratory health. Reducing indoor particulate matter concentrations via air purifiers was found to improve asthma symptoms and increase the number of symptom-free days among asthmatic children. HEPA filtration has also been associated with improvements in non nasal-eye symptoms (tiredness, fatigue, feeling worn out, reduced productivity, poor concentration, and thirst) and nasal symptoms (stuffy/blocked nose, sneezing, runny nose, itchiness) among those with allergic rhinitis.

A study conducted among inner city children with atopic asthma found that use of home-based environmental interventions, including HEPA filters and HEPA vacuums, decreased exposure to indoor allergens and was associated with reduced asthma-associated mortality.

A study conducted among healthy older adults found that reduction of particle exposure after using portable HEPA filter-based interventions for only 48-hours improved microvascular function by 8.1%. In a similar study, 3-day use of portable air filtration systems reduced PM2.5 exposures and systolic blood pressure in older adults living in homes in an urban setting.



AIR FILTERS

Portable air filters reduce PM2.5 exposure and have been found to lower systolic blood pressure in older adults after 3-day use

Schools

Before schools re-open for in-person learning, adequate ventilation and/or air purification strategies must be in place across the school to increase the delivery of clean air and dilute potential pathogens (including Covid-19) and contaminants.

Children breathe a greater volume of air relative to their body weight and thus absorb more pollutants per pound of body weight compared to adults in the same environment. Because their bodies and vital organs are still in the process of developing, this increased exposure makes them more likely to be adversely affected by poor indoor air quality. It is also important to note that children's natural defenses against potential toxins are less developed than they are in adults. For example, children have highly permeable skin, lower filtration efficiency in their nasal passages, a more permeable blood-brain barrier, and many organs, systems and processes that are continuing to develop, such as the digestive system, kidney clearance, metabolic pathways, and other vital organs. Children and adolescents continue to grow physically and develop psychologically throughout their school years, thus these and other developmental processes extend beyond early childhood.

Studies have shown that many schools exceed recommended thresholds for indoor pollutants such as carbon dioxide (CO_2), particulate matter ($PM_{2.5}$ and PM_{10}), formaldehyde, and ozone. While air quality within schools is of particular concern, according to the Centers for Disease Control and Prevention (CDC), only 48.9% schools reported implementation of indoor air quality management programs in 2016.

HEALTH FACTORS

1 **Covid-19 and Other Airborne Pathogens:** While school-aged children are less susceptible and less likely to die from Covid-19 than adults, so far 1,555,536 children aged 5-17 have been infected, and 168 have died from the virus (as of January 19, 2021).

2 **Infiltration of Ambient Air Pollution:** Outdoor air pollutants can infiltrate indoor spaces, thus impacting indoor air quality. One study of public schools in Michigan found that schools located in areas with the highest air pollution levels had the lowest attendance rates and the highest proportions of students failing to meet state educational testing standards.

3 **Radon:** The EPA estimates that more than 70,000 schoolrooms in the U.S. that are in use today have high short-term radon levels. The risk of lung cancer in children resulting from exposure to radon may be up to three-fold higher when compared to similarly exposed adults, due to differences in lung shape and size.

4 **Carbon Dioxide (CO_2):** Elevated CO_2 levels in classrooms have been linked to increased student absence, symptoms of wheezing among children in daycare centers, poorer concentration and cognitive performance, and other indicators of academic performance.

Higher levels of CO_2 are also a proxy for poor ventilation. Lower ventilation rates have been linked to more upper respiratory symptoms and a higher number of missed school days caused by respiratory infections; greater prevalence and incidence of symptoms of sick building syndrome (described in Section 3.3); greater mean number of school nurse visits caused by respiratory symptoms; and increased asthmatic symptoms, nasal patency, and risk for viral infections.

5 **Mold:** Students and staff can be exposed to mold by breathing in airborne mold spores and/or coming into contact with moldy objects and surfaces. Indoor building dampness and mold in schools have been associated with increased respiratory health symptoms such as coughing, wheezing and allergic rhinitis; greater prevalence of asthma; and respiratory-related absenteeism. Furthermore, a study of over 1,000 school children found that the concentration of mold found in floor dust was associated with headache, dizziness, and concentration problems.

Effects of Poor Indoor Air Quality on Students

SCHOOL DAYS LOST PER YEAR

Among children and adolescents

ALLERGY
~ 2 MILLION

ASTHMA
~ 7 MILLION

EDUCATIONAL OUTCOMES

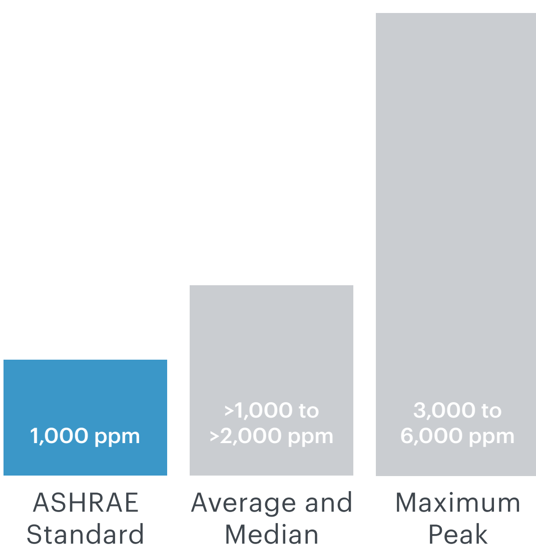
Seasonal pollen allergies are linked to poorer cognitive performance

POLLEN/ALLERGY ↑

SCORES ↓

CO_2 LEVELS IN CLASSROOMS

Often exceed recommended maximums



INCREASED LEVELS OF CO_2

Can lead to reduced attention in students*

↑ CO_2 — 690 PPM TO 2,909 PPM

› 5% ↓ DECREASE IN ATTENTION

similar to the impact a student might feel from skipping breakfast

*Study conducted among students aged 10-11 years

BENEFITS OF GOOD INDOOR AIR QUALITY IN SCHOOLS

Preliminary research shows that the use of portable air purifiers in a school classroom reduced the concentration of aerosols by over 90% within a 30 minute period, compared with a neighboring classroom without air purifiers. The reduction was uniform throughout the classroom, for all particle sizes. Based on additional calculations, researchers concluded that when staying in a closed classroom for two hours with a super infective person, the inhaled dose is reduced by a factor of six when using air purifiers with a total air exchange rate of 5.7 exchanges per hour (meaning that the air in the space is fully replaced 5.7 times in one hour). This study demonstrates that air purifiers are a well-suited strategy for substantially reducing the amount of SARS-CoV-2 particles in the air of an indoor space.

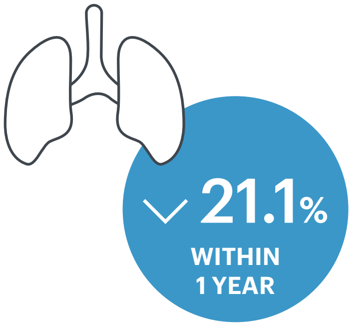
Programs that promote healthy indoor air quality, or IAQ, have been shown to improve student's physical health, increase their ability to learn, improve test scores, and improve the productivity of school staff.

In fact, the implementation of the EPA IAQ Tools for Schools (TfS) program has helped to address indoor air quality problems in over 800 schools in Connecticut.

- The Hartford school district saw a 21.2% decrease in asthma cases within a single year (from 11,334 to 8,929), after (TfS) was implemented in most schools.
- In the Hamden school district, absenteeism rates in one elementary school fell by more than half within a single year (from 484 days to 203 days) after TfS was implemented.
- In the North Haven school district, school nurse visits were reduced by 11% (4,978) and reported respiratory cases declined by 48% two years after TfS was implemented
- The Chester school district saw a decrease in health office visits related to headaches, dizziness, and sinus difficulties among both students and staff after TfS was implemented.

REDUCTION IN ASTHMA CASES IN HARTFORD SCHOOL DISTRICT

With the implementation of the EPA IAQ Tools for Schools program



Workplaces

Due to the Covid-19 pandemic, many homes now function as workplaces. A survey conducted by Harvard Business School suggests that at least 16% of American workers will switch from professional offices to working from home at least two days per week even when the pandemic subsides. Thus, the health factors discussed in the 3rd chapter (Homes) should also be taken into consideration. However, this section explores the unique aspects of office environments.

On average, workers spend approximately 40 hours a week in their workplace. While workplaces have many of the same indoor air quality problems as homes and schools, offices are unique as they are often located in "sealed buildings" which are designed to reduce energy costs. These sealed buildings usually present high pollution levels due to

It is important to note that due to the Covid-19 pandemic, many homes now function as workplaces

low internal/external air exchange rate and have been identified as a major contributor to worker-reported health symptoms. A controlled study in office buildings found a link between short-term sick leave, often associated with respiratory illness, and low ventilation rates.

A major area of concern among office workers is the prevalence of “sick building syndrome” (SBS) and “building-related illness” (BRI). SBS is used to describe a situation in which the occupants of a building experience acute health- or comfort-related effects that seem to be linked directly to the time spent in the building. While the exact cause of SBS remains unknown, it is thought to be promoted or caused by indoor air pollution. Unlike SBS, BRI is used when symptoms of diagnosable illness are identified and can be attributed directly to airborne building contaminants. Common symptoms of SBS are headache; eye, nose, or throat irritation; dry cough; dry or itchy skin; dizziness and nausea; difficulty in concentrating; fatigue; and sensitivity to odors. Common BRI symptoms are cough; chest tightness; fever, chills; and muscle aches. While SBS symptoms typically go away shortly after leaving the building, BRI often requires a more prolonged recovery. SBS and BRI can occur in many indoor settings including homes and schools, however they are an increased health problem for workers of modern office buildings.

HEALTH FACTORS

1. **Covid-19 and Other Airborne Pathogens:** Many working people may be more susceptible to Covid-19 due to their age or existing health conditions. As of January 19, 2021, nearly 13 million adults ages 18-64 have been infected with Covid-19 (85.7% of all cases), and 52,727 have died (18.8% of all cases).

2. **Long-term Exposure to Poor IAQ:** Given that time spent in the workplace is only second to time spent at home, frequent and prolonged exposure to poor indoor air quality may also result in long-term health consequences among working adults. Long-term effects due to continuous exposure to indoor air pollutants may be associated with aggravation of asthma and allergic responses, oxidative stress and inflammation, chronic obstructive and pulmonary disease, lung cancer, and cardiovascular diseases; however, these health effects are not normally evaluated in office workers due to the resources that would be required for such testing, as well as the complex nature of the testing that would be needed.

3. **Infiltration of Ambient Air Pollution:** Indoor air quality is significantly influenced by outdoor air quality, due to the infiltration of air from outdoors. Prolonged exposure to ambient air pollution has been associated with adverse health outcomes such as reduced lung function, respiratory infections, and aggravated asthma. Given that many workplaces such as offices are located in urban areas, infiltration of ambient air pollution may further contribute to poor indoor air quality and result in negative health outcomes. A study conducted in Milan found that more than half of urban particulate matter entered indoor office environments.

4. **Allergens and Asthma Triggers:** Common indoor air pollutants found in office buildings — such as pollen, dust, and pest droppings — may trigger allergic reactions such as hypersensitivity pneumonitis, allergic rhinitis, and asthma.

5 **High Levels of Carbon Dioxide (CO_2):** CO_2 levels have been considered a major factor associated with SBS symptoms. A study in Taiwan found more complaints of eye irritation and respiratory symptoms when employees were exposed to an indoor CO_2 concentration higher than 800ppm.

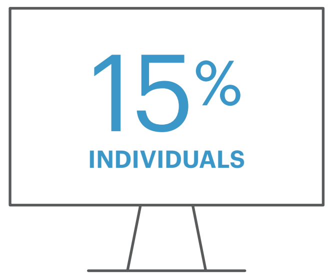
6 **Mold:** Studies have indicated that mold may cause or contribute to SBS and BRI symptoms. Air conditioning and humidification systems contaminated with bacteria and molds have been linked to outbreaks of hypersensitivity pneumonitis in office buildings.

7 **Total Volatile Organic Compounds (TVOCs):** TVOC refers to the total concentration of multiple airborne VOCs present simultaneously in the air, rather than the concentration of many individual VOCs. Building materials, furnishings, office equipment, cleaning agents and pesticides used in the workplace can off-gas VOCs into the air. One study found that exposure to TVOCs impacted higher-level cognitive function and decision making of office workers, in which a 500 µg/m3 increase in TVOCs was associated with a 13% decrease in cognitive scores.

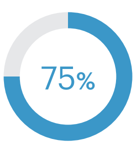
Effects of Poor Indoor Air Quality on Employees

SICK BUILDINGS
New or remodeled buildings, including office buildings, may have unusually high rates of sick building complaints

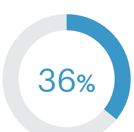
WORKPLACE EXPOSURES
Asthma was caused or made worse for



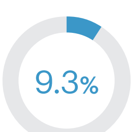
SURVEY AMONG ASTHMATIC EMPLOYED
Adults in Brazil, Canada, Germany, Japan, Spain, and the UK found that



Reported an impact on their productivity at work was caused by asthma



Overall productivity loss (including time off and productivity while at work) due to asthma



Proportion of the working week missed due to asthma (3.4 hours per week, on average)

WORKERS WITH ASTHMA*

Workers with **poorly controlled** asthma**

WORK AND ACTIVITY IMPAIRMENTS (up)

Workers with **well-controlled** asthma

WORK AND ACTIVITY IMPAIRMENTS (down)

*Study in the U.S.
**39.7% of respondents

BENEFITS OF GOOD INDOOR AIR QUALITY IN WORKPLACES

The Covid-19 pandemic will forever change the way we work, and has emphasized the importance of an already essential workplace factor: air quality. Cleaning the air helps to reduce the airborne viral load in a space, and is key to helping ensure that employees feel safe when they ultimately return to workplaces. For this, it is essential that buildings upgrade their HVAC systems and increase ventilation rates, supplementing these approaches with the use of portable air purifiers, especially in spaces where it is difficult to achieve adequate ventilation.

Improved air quality also contributes to a more comfortable and productive working environment. When air quality improves, worker productivity has been shown to increase significantly. In one study, the prevalence of symptoms associated with SBS was found to be 40% to 50% lower six months after office workers moved into a building with an improved ventilation system. Workers in buildings with adequate air quality showed reduced rates of symptoms related to poor air quality such as eye, nose, throat, and skin irritation, dizziness, nausea, and fatigue.

- A Harvard study found that when ventilation was increased from 20 to 40 cfm/person, the decision-making performance of the office workers increased from the 62nd percentile to the 70th percentile, on average, which was an increase in productivity equivalent to $6,500 per worker (when compared to the distribution of office workers salary).

- One study estimated that doubling the ventilation rate to 24 L/s^{-1} per person would lower sick-leave prevalence in an office by 0.5% (1.2 days per year).

- Researchers also predicted that if building occupants become 10% more satisfied with the quality of their indoor air, office work performance (text typing, addition, and proofreading) can increase by 1.1%.

5 SOLUTIONS FOR IMPROVING INDOOR AIR QUALITY

General

There are three major ways to reduce pollutants in the indoor air: source control (adding local pollution control and reducing the use of materials that emit pollutants), increased ventilation (increasing the fresh air intake from the outdoors), and enhanced air filtration (cleaning the air indoors).

Source control, which seeks to eliminate individual sources of pollution, is usually the most effective way to improve indoor air quality. In some cases, source control is also a more cost-effective approach to protecting indoor air quality; for example, removing furniture that releases organic pollutants and using paints and finishes that are low in VOCs. When source control is not feasible, other approaches to reduce the level of pollutants indoors should be considered.

Increasing ventilation by introducing outdoor air can dilute the concentration of pollutants indoors. When the HVAC system has the capability to introduce outdoor air through fan systems (mechanical ventilation), increasing ventilation, along with adding a filtration unit to the ventilation system, can effectively reduce the levels of indoor pollutants. However, mechanical ventilation systems are not always available, and most home heating and cooling systems, including forced air heating systems, do not mechanically bring outdoor air into the house. And while the installation or retrofitting of ventilation systems usually takes a long time and can be a costly investment, making full use of operable windows is a simple and free option for natural ventilation. There can be some limitations to natural ventilation, such as unfavorable weather conditions or high levels of ambient pollution, in which case opening windows may compromise thermal comfort and/or result in poor indoor air quality.

Air filtration could be a more feasible solution for lowering the levels of indoor air pollutants and airborne viral load in most indoor spaces. In the following sections, we will focus on introducing air purification technologies and outline the factors that need to be considered when selecting air purification products.

The following strategies can further remediate poor indoor air quality, but should be implemented alongside ventilation and/or air purification (alone, they may not help to improve indoor air quality in most spaces).

- **HEPA Vacuum Cleaners:** HEPA filters are designed to remove at least 99.97% of particles larger than 0.3 microns in diameter. HEPA filter-equipped vacuums (as well as damp mopping and dusting) can also help reduce the re-suspension of particles that have settled in the home, as vacuuming (and dusting) can cause a temporary release of fine dust.
- **Home Air Quality Monitoring:** An indoor air quality monitor can help track particulate matter pollution and other air quality parameters across the home. Many consumer-grade, easy-to-use monitors are available online.
- **Outdoor Air Quality Monitoring:** It is important to stay informed about outdoor air quality in your area. If outdoor air quality is poor, keep all windows, doors, and the fresh-air intake of the AC unit closed. Information about outdoor air quality and pollen is available on public websites such as AirNow, pollen.com, and Breezometer.

The Importance of Relative Humidity for Covid-19

Maintaining relative humidity (RH) at an optimal level can help reduce the risk of viral transmission. Joseph G. Allen, an associate professor and director of the Healthy Buildings program at Harvard University's T.H. Chan School of Public Health, emphasizes the importance of maintaining relative humidity in the 40 to 60% range as a key defense strategy against Covid-19.

Preliminary research shows that the novel coronavirus decays faster when relative humidity is close to 60%, and research studies on other coronaviruses similarly show that they decay more quickly at 40-60% RH. In addition, when the air is more humid, the droplets containing viral particles shrink less in size and are not able to travel as far (because they are heavier), settling on the ground faster. Finally, adequate humidity helps to maintain our immune system defenses, helping ensure that the mucus lining our respiratory tract and the cilia in our lungs function properly, trapping and removing pathogens as a first line of defense. Humidifiers can effectively raise humidity levels when they are low, and maintain them between 40 and 60% RH.

Air Purification Technologies

TYPES OF AIR PURIFICATION TECHNOLOGIES

There are two major types of air pollutants: gaseous pollutants and particulate matter (viruses and bacteria, which have attracted considerably more attention recently due to the Covid-19 pandemic, are bioaerosols, a type of particulate matter). Different air purification technologies are necessary to effectively target different types of pollutants.

REMOVAL OF PARTICULATE MATTER

Two types of air purification technologies are commonly used in duct-mounted and standalone air purifiers to remove particles from the air: mechanical air filters using fibrous media, and electronic air filters.

- **Mechanical air filters:** Mechanical filters use media with porous structures that contain fibers or stretched membrane materials in a variety of sizes, densities, and media extension configurations. Particles are thus removed from airstreams through straining (large coarse particles), inertial impingement (large or dense particles), interception (medium-size particles), and diffusion (small particles). High Efficiency Particulate Air (HEPA) filters are a special type of air filter capable of removing at least 99.97% of particles 0.3 microns in diameter and larger. The CDC also indicates that HEPA filters have a high efficiency for removing fine particles with a diameter less than 0.1 microns, through a process called diffusion. HEPA filters are the standard for spaces with strict particulate matter level requirements and severe toxic particulate matter pollution, such as cleanrooms and nuclear applications, and are increasingly used in numerous medical and pharmaceutical applications.

  The actual removal efficiency of particles smaller than 0.3 microns by individual HEPA filters are not included in standard HEPA testing. The individual SARS-CoV-2 particles range in size from 0.06 to 0.14 microns, so without additional testing, it is difficult to determine the exact effectiveness of removal of SARS-CoV-2 by HEPA filters.

- **Electronic air filters:** Electronic air filters remove particles via an active electrostatic charging process that requires electricity to charge particles. These particles are attracted to oppositely charged plates (electrostatic precipitators) or other indoor surfaces (ionizers). However, electronic air filters have a major disadvantage in that they may produce ozone, a pollutant that can be harmful for building occupants. Exposure to ozone can lead to wheezing and shortness of breath, and potentially to more severe respiratory outcomes.

Both mechanical and electronic air filters can be integrated into heating, ventilation and air conditioning (HVAC) systems, or be self-contained as standalone air purifiers. In some cases, manufacturers may combine these two technologies to enhance the effectiveness of particle removal.

Minimum Efficiency Reporting Values (MERVs) are used to report a filter's ability to capture particles, which is helpful when comparing the performance of different filters. Most mechanical filters will be MERV-rated (except for HEPA filters*), in compliance with the ANSI/ASHRAE Standard 52.2-2017. A filter with a higher MERV rating will perform better when filtering particles than a filter with a lower MERV rating. For more information, please check the information in ANSI/ASHRAE Standard 52.2-2017, and Chapter 29 of the 2019 ASHRAE Handbook—HVAC Systems and Equipment.

Clean Air Delivery Rate (CADR) is a metric for evaluating the rate of particle removal in standalone and self-contained air purifiers. CADR is measured by multiplying the airflow rate and the contaminant removal efficiency. An air purifier with a higher CADR will clean the air faster. The methods to measure CADR may vary based on different regions. Please refer to the local guidance for more details about the CADR metric**.

REMOVAL OF GASEOUS POLLUTANTS

A number of air purification technologies are designed to either remove gases or convert them to harmless by-products. This is achieved through a combination of physical and chemical processes including sorbent media air filters, photocatalytic oxidation, and ionization technologies. Across the different types of air purification technologies, sorbent media air filters are the most commonly used air purification technology for removing gaseous pollutants from the air.

A sorbent media air filter may involve physical adsorption and/or chemisorption. Physical adsorption is the process in which gaseous pollutants adhere to solid porous materials due to the physical forces between objects (Van der Waals forces). The most commonly used adsorbent is activated carbon. Some other adsorbents include activated aluminas (aluminum oxides), natural and synthetic zeolites in granular form, oxides of silicon, molecular sieves, and various polymers. Chemisorption involves both adsorption and instantaneous irreversible chemical reactions on the sorbent surface. Common adsorbents include activated alumina impregnated with potassium or sodium permanganate and activated carbons impregnated with acidic or basic compounds. One benefit of chemisorption is that once the targeted pollutant is adsorbed and chemically reacted by the sorbent, there will be no desorption of the pollutants (pollutants will not be released back into the air).

Air purification technologies (for removing gaseous pollutants) that are installed in the HVAC system can be tested using ANSI/ASHRAE Standard 145.2. However, there is no well-accepted standardized testing method method for evaluating the performance of standalone air purifiers in removing gaseous pollutants using a metric similar to CADR.

*HEPA filters are not MERV-rated and are not regulated by ASHRAE/ANSI 52.2 due to the extremely rigorous conditions of the experimental set-up and the complexity of the test. Instead, the performance of HEPA filters is regulated by UL Standard 586, Standard for Safety for High-Efficiency, Particulate, Air Filter Units# and CSN EN 1822-1, High efficiency air filters (EPA, HEPA and ULPA).

**In the U.S., CADR is primarily tested using the protocol of the Association of Home Appliance Manufacturers (AHAM): ANSI/AHAM AC-1, The Method for Measuring Performance of Portable Household Electric Cord-Connected Room Air Cleaners for dust (0.09-1.0µm), tobacco smoke (0.5-3µm), and pollen (5-11µm). In China, GB/T 18801-2015 Air Cleaner Standard was adopted for testing the CADR for PM2.5.

COMPARISON OF DIFFERENT AIR PURIFICATION TECHNOLOGIES

Tables 1 and 2 summarize the targeted pollutants, and the advantages and disadvantages of common air purification technologies mentioned in the above section. The lists do not include other potential air purification strategies such as biofiltration by indoor plants or active bio-walls, or photocatalytic oxidation, which is not yet a widely implemented technology. For more information about these technologies, please refer to the guidelines from ASHRAE and EPA, or request more information from Delos Labs.

Table 1. Effectiveness of Air Purification Technologies on Different Pollutants

Pollutant	Delos Powered by Healthway Compact Air Purification System	Mechanical Filtration	Sorbent Media Filtration	Bipolar Ionization	Ultraviolet Germicidal Irradiation (UVGI)
Deactivates Bacteria and Viruses (antimicrobial treatment)	Yes	No	No	Varies[1]	Yes[2]
Captures Bacteria	Yes	Yes, requires MERV 13 or higher rating	No	Varies [1,3]	No
Captures Viruses	Yes	Yes, requires HEPA filter	No	Varies[1,3]	No
Removes PM10 (particle size > 2.5 µg)	Yes	Yes	No	Yes	No
Removes PM2.5 (particle size between 0.1 and 2.5 µg)	Yes	Yes, requires MERV 13 or higher rating	No	Yes	No
Removes Ultrafine Particles (< 0.1 µg)	Yes	Yes, requires HEPA filter; testing is needed to determine efficacy	No	Varies[3]	No
Removes Volatile Organic Compounds (VOCs)	Yes	No	Yes	Yes	Yes
Meets Ozone Emission Standards[4]	Yes	Yes	Yes	Varies[5]	Varies[6]
Maintenance Requirement	Replace filters	Replace filters	Replace filters	Clean indoor surfaces that have PM deposition; Replace filters; Replace ionizers	Replace lights; Add additional air purification technology to remove PM
Filter Replacement Frequency	Every 12 months	Typically every 6 - 12 months	Typically every 3 - 6 months	Typically every 6 -12 months	Typically every 6 -12 months
Air Flow Resistance	Low	Medium	High	Low	Low
Energy Consumption under the same use case	Low	Medium	High	Low	Low

1. Laboratory and real-world efficacy testing would need to be evaluated to determine if they support claims of antimicrobial efficacy.
2. Deactivates microorganisms on-the-fly as they pass through the irradiated zone. However, due to limited exposure time, this process requires high doses of UV light. This makes the implementation of UV irradiation in the HVAC system complicated.
3. As a result of bipolar ionization, bacteria, viruses, and ultrafine particles may stick together, becoming larger particles, and fall from the air to surfaces more quickly. While this process may remove the particles from the air (which in effect is similar to particle capture), the particles may then still be transmittable if encountered on the surface).
4. Ozone generation/emission testing is required for air purifiers in order to satisfy applicable safety requirements (e.g., ozone safety limits required by CARB).
5. Different designs and modes of engineering of bipolar ionization technologies vary in ozone emissions. In addition, the ions released into the air can react with oxygen and other particles, leading to additional production of ozone, as well as generation of ultrafine particles.
6. UV-C technologies may generate ozone.

Table 2. Summary of Air Purification Technologies

	MECHANICAL FILTRATION	ELECTRONIC AIR FILTRATION	SORBENT MEDIA FILTRATION
Advantages	• Mechanical filters are a mature technology that has been widely implemented • The mechanism of the technology is simple • Mechanical filters can be installed in most HVAC systems • Building managers can choose different grades (MERV ratings) of mechanical filters based on air purification needs in different buildings • The cost of mechanical filters is relatively lower than other technologies when considering installation and maintenance	• Low pressure drop • Lower energy consumption compared to mechanical filtration systems • Can be implemented together with mechanical filters to enhance the performance of the overall filtration system	• Potential for high removal efficiency of many gaseous pollutants • No by-product formation • Pollutants are captured via chemisorption - an irreversible process - meaning that the pollutants are never released back into the air
Disadvantages	• Mechanical filters may cause an increased pressure drop across the filter, which will impact the performance of the HVAC system. Before installing a mechanical filter in an HVAC system, ensure that the HVAC system can handle filter upgrades without negative impacts to pressure differentials and/or air flow rates • Fans in the HVAC system may cause additional energy consumption • Filters need to be cleaned/ replaced periodically to ensure high performance	• The ionization process may generate ozone and other by-products due to high-voltage charging. These by-products might be harmful to human health • Collection plates on electrostatic precipitators (ESPs) can gather dust, which can significantly reduce the removal efficiency. Collection plates need to be cleaned periodically with detergent and hot water • For ionizers that release ions into the indoor space, particles that have been charged are not physically removed by the filters. Instead, these particles deposit on indoor surfaces	• Regular replacement is required • Effectiveness of many consumer-grade systems with small amounts of activated carbon is unknown • High pressure drops in some sorbent media filters can negatively impact the HVAC system • Different removal efficiency for different gases at different concentrations
Test standards	Filters: • ANSI/ASHRAE Standard 52.2 (MERV) • UL Standard 586 (HEPA) • EN 1822 (HEPA) • ISO 29463 (HEPA) Standalone air purifier: • AHAM AC-1 (CADR) • GB/T 18801-2015 (CADR)	Similar to mechanical filters. Electrical safety: • ANSI/UL Standard 867	Filter Media: • ANSI/ASHRAE Standard 145.1 (no rating metric) In-duct air cleaners: • ANSI/ASHRAE Standard 145.2 (no rating metric) No standards for effectiveness

FACTORS TO CONSIDER WHEN CHOOSING AN AIR PURIFIER

Selecting air purification technologies for specific spaces or settings depends on several factors, such as targeted pollutants, area of the space, and the potential health risks of using certain types of air purifiers.

STANDALONE AIR PURIFIERS

Targeted pollutants: Mechanical and electronic air filters are the most common and effective approaches for removing particles from the air. To filter gaseous pollutants, choose a standalone air cleaner with an activated carbon or other sorbent media filter. While some emerging technologies, such as photocatalytic oxidation, may also work for removing gaseous pollutants, their performance may not be consistent or reliable. Also, these emerging technologies may generate some harmful by-products, such as ozone, during the air purification process. Certain standalone air purifiers may combine these two technologies to enhance removal scope and efficiency.

Effectiveness: CADR is a good metric for evaluating the effectiveness of particle removal. The higher the CADR, the more particles the system can filter and the larger the area it can serve. The maximum square footage of a room that an air cleaner can effectively serve is usually indicated on the package of the filter, or the instructions manual. Table 3 summarizes the room area air purifiers can cover under different CADR values. There are no widely used performance rating systems for standalone air purifiers or filters designed to remove gases. Some manufacturers may provide single-pass removal efficiency for gaseous pollutants. Typically, the gas removal is greater when single-pass removal efficiency and flow rate of the air purifier are higher.

Potential health risks: Some air purifiers, especially electronic air filters with high-voltage devices, may generate ozone. Ozone generation by a standalone air purifier should not exceed the requirements set by California Air Resources Board (CARB). Before purchasing a standalone air purifier, remember to check the California Certified Air Cleaning Devices list to make sure that the air purifier does not release ozone, or only releases an amount below the thresholds set by CARB.

Filter maintenance: Filter maintenance is very important for the performance of standalone air purifiers, and depends on the type of filter. Please refer to the manufacturer's instructions for guidance on how to clean and maintain your air filter.

Table 3. Standalone Air Purifier Sizing for Particle Removal

Room area (square feet)	100	200	300	400	500	600
Minimum CADR (cfm)	65	130	195	260	325	390

*Note that this chart is for estimation purposes only. The CADRs are calculated based on rooms with an 8-foot ceiling. If the ceiling is higher, a portable air cleaner with a higher CADR may be needed.

AIR PURIFICATION UNITS IN THE HVAC SYSTEM

Targeted pollutants: Similar to standalone air purifiers, considering the targeted pollutants is important when selecting air purification technology for an HVAC system. Please refer to Table 3 to see what the best air purification solutions are for different pollutants.

Limitations of HVAC systems: In-duct air purification units should be selected based on the requirements of the HVAC system. The designed flow rates of the air filter and the HVAC system should match. In addition, the designed face velocity of the air filter (average velocity of air moving perpendicular to the filter) should align with the face velocity of the HVAC system. For some filters, such as mechanical air filters, the installation of the purification system will increase the resistance of the fan system. The capability of the fan system should be taken into consideration when installing the air purification system.

Potential health risks: Some air purifiers, especially electronic air filters with high-voltage devices, may generate ozone. When inhaled, ozone can damage the lungs. Relatively low amounts can cause chest pain, coughing, shortness of breath and throat irritation. Ozone may also worsen chronic respiratory diseases such as asthma and compromise the ability of the body to fight respiratory infections. Select air purifiers that generate no or little ozone. The ozone emission of electronic in-duct air cleaning devices should not exceed 50 ppb based on the regulation from CARB. An on-site test should also be performed after the installation to confirm the low ozone emission.

Filter maintenance: Periodic filter maintenance is necessary for in-duct air filters. Please refer to the manufacturer's instructions for guidance on how to clean and maintain your air filter.

CONCLUSION

Air quality is not just a theoretical parameter within the indoor environment; it is an essential determinant of our health and well-being, affecting a spectrum of symptoms and outcomes from productivity rates and cognitive performance to asthma, allergies, and airway irritation to diabetes, ischemic heart disease, and respiratory system cancers. As we spend the majority of our time indoors during the Covid-19 pandemic, the air we breathe in our homes, schools and workplaces is of utmost importance. In fact, our indoor environments have the greatest potential to provide us with air that is clean of biological, chemical and organic pollutants.

Depending on the space and the key pollutants of concern, we can implement high quality mechanical ventilation systems, in-duct or standalone air purification units, as well as indoor and outdoor air quality monitoring systems to better respond to suboptimal air quality. We have a tremendous opportunity to improve air quality across our indoor environments, both as a way to reduce our risk of infections like Covid-19 and to promote our overall health and well-being.

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TABLE 1. EFFECTIVENESS OF AIR PURIFICATION TECHNOLOGIES ON DIFFERENT POLLUTANTS

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