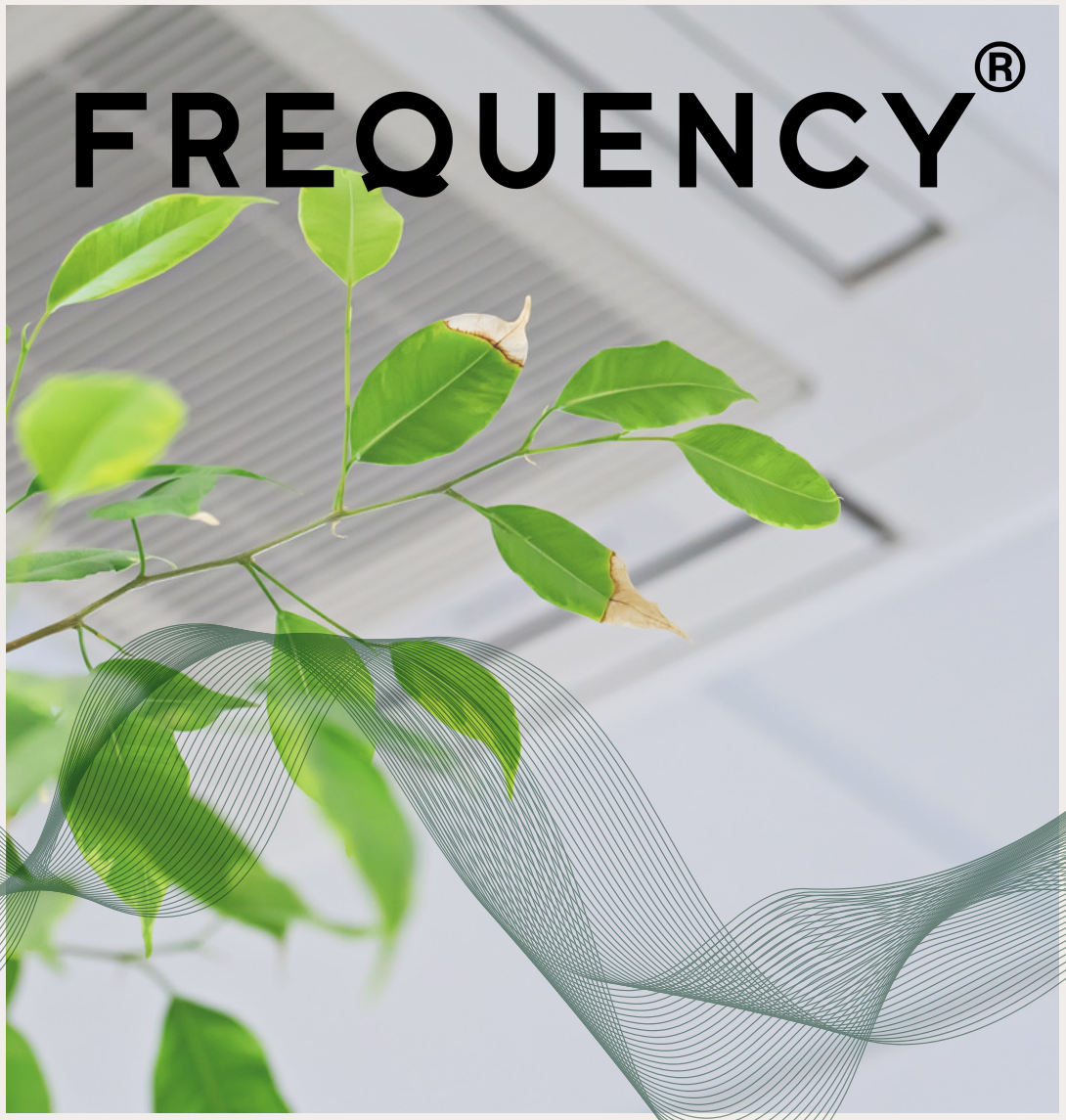


Deep Dive:
Air Quality

Academic Insights

Air quality is a measure of the quantity and quality of pollutants and compounds existing in the air, which vary depending on building vintage, insulation, ventilation, outdoor conditions, and a number of other variables. These pollutants include (but are not limited to) lead, nitrogen dioxide, radon, particulate matter, and volatile organic compounds.

Unfortunately, these pollutants affect us in major ways, from cardiovascular and respiratory health to emotional wellbeing and cognitive performance. Given that air carries the most foundational fuel necessary for cellular function, it's no surprise that contaminated air has a wide-reaching impact.

It's estimated that over 100,000 premature deaths occur each year due to illness related to pollution. Along with the premature casualties, these air pollution-related illnesses cost an estimated $150B per year, $90B of that attributed to sick building syndrome.

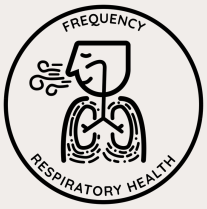
Given that air quality is largely a function of what's not there, much of our research covers the negative ramifications of poor air quality. Between high rates of indoor air pollution and increasing rates of wildfires, there is reason to believe that sources of pollution aren't going anywhere and that poor air quality and its repercussions are here to stay.

Fortunately, most of these negative impacts are avoidable by upholding high indoor air quality standards and adhering to best practices, as covered below.

Findings and Impact by Badge

Cognitive

- Better ventilation in schools improved performance on math and cognitive exams by 14%.2
- Short-term particulate matter exposure is associated with cognitive and executive dysfunction.8

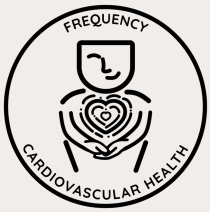


Respiratory

- Reduced mold exposure in homes can ease the symptoms of steroid-resistant allergic asthma.3
- Asthma control improved in homes equipped with HEPA filtration.4
- Lung-function growth in children was found to be positively associated with long-term improvements in air quality.12

Emotional Sustainability

- Based on a study made in seven metropolitan cities of South Korea (Seoul, Busan, Incheon, Daejeon, Daegu, Gwangju, and Ulsan), higher levels of particulate matter are associated with a 9% increase in suicide risk when particles measure 10 micrometers or less, and a 10.1% increase when particles measure 2.5 micrometers or less.9



Cardiovascular

- A decline in particulate matter and nitrogen dioxide is linked to a decline in the incidence of heart attacks and premature deaths caused by cardiovascular diseases.1
- Air filtration reduces levels of von Willebrand factor, indicating a lower risk of thrombosis.5

Resilience

- Indoor particulate matter exposure is associated with reduced heart rate variability.11

Circadian

- High levels of carbon dioxide and particulate matter and high temperatures are associated with lower-quality sleep.7

Role in Our Human Story

Traditions Throughout History

Houses with open courtyards were developed in different Bronze age societies such as the Egyptian-Sumerians, Asia Minor, the Indus Valley, and a variety of populations across the Mediterranean. In Islamic architecture, residences featured walled gardens, (called wast ad-dar in Arabic) that contained pools of water and lots of vegetation.14 These were purposed not only for aesthetic appeal, but also to improve air quality with the water and vegetation cooling and cleaning incoming air, often polluted with dust and sand.

A variation of this can also be seen in more recent structures in Maracaibo, Venezuela. The roads of El Saladillo, built in the 19th century, were constructed to be very narrow with houses built close to one another15, creating small wind tunnels that enhance the sensation of cooling air. Each row of houses would create shadow for the next, and their tall windows and doors would allow for maximum airflow. Similar architecture can be seen in Old San Juan district in Puerto Rico.

Principles of Human Nature

Air pollution erupted at the same time humans evolved to use tools. Ancient communities burned wood to make energy for food and warmth, often inside caves where they could be safe from outside elements and predators13. However, these communities were largely hunter-gatherers, so most of the day was spent outdoors, scavenging for food, where they could breathe fresh air.

When humans settled and agriculture changed the means of survival, populations grew and cities emerged. With that shift, air pollution became more prevalent in day-to-day lives. Philosopher and physicist Maimonides (born 1138 AD) found that air is "stuffy, smoky, polluted, obscure and foggy", and that poor air quality inferred "dullness, preventing understanding, lack of intelligence and amnesia" in the population13. Maimonides, with other physicians of their times, understood the necessity of breathing clean air.

Testimonies of Trusted Voices

Joseph Allen, Harvard professor and researcher, discussed the importance of good indoor ventilation in his book Healthy Buildings.

"A frequently referenced estimate from the Environmental Protection Agency says that indoor levels of some contaminants can be 3–5 times higher than outdoors. For many pollutants, the number can rise as high as 10 times or more. [...] When workers were in an optimized indoor environment, meaning high ventilation rates, low VOCs, and low carbon dioxide, we found a dramatic improvement in higher-order cognitive function across all nine cognitive function domains. [...] Research has demonstrated that enhanced ventilation has been shown to reduce sick building syndrome, cut absenteeism, and even reduce infectious disease transmission."

Dr. Ravi Kalhan, director of the Asthma and COPD Program at Northwestern University Feinberg School of Medicine, commented on the short-term consequences of air pollution, and ways to counteract these effects on our homes.

"The people who are the most vulnerable are children and teens, older people, people with chronic lung diseases and people with heart conditions. When they are exposed to and inhale wildfire smoke, which is mostly made up of fine particles, those particles are tiny enough to get deep into the lungs and trigger an inflammatory response in the body, which can worsen chronic health conditions. [...] If people have air purifiers, turn them on. Keep the windows closed. If they have central air conditioning, they should run the fan and if possible upgrade the filter to MERV13, which is efficient at capturing fine particles."

Scientific American senior health editor, Tanya Lewis, wrote an article highlighting the role of improving indoor air quality on preventing COVID-19 and other respiratory ailments.

"SARS-CoV-2 isn't the only virus that spreads through the air indoors. Influenza and other respiratory viruses also spread this way. Studies have also shown that poor ventilation leads to cognitive impairment and "sick building syndrome." [...] A best practice is to upgrade filters to at least MERV 13 for most indoor settings. Many HVAC systems can be upgraded to this standard—but some very old ones may have trouble with higher-efficiency filters, and this could cause air to leak around the filters."

Suggested Habits

Ventilation

One aspect of air quality that isn't necessarily solved by a new purification system is ventilation. Given that high levels of carbon dioxide can reduce cognitive performance by up to 15% and will increase in a space simply because there are people present, making small tweaks to a space's ventilation can make a big impact. To improve ventilation, simply leave the windows cracked open or make sure the HVAC system is set to Fan On rather than Fan Auto while there are people occupying the space.

Monitoring

Another helpful tool is to invest in air quality monitors so you know when your air is unhealthy. As mentioned, some air purifiers include air quality monitoring. However, if this is not the case, Frequency has used Piera Systems Canaree i5 (excellent PM, general VOCs) and Aranet4 (great CO2) sensors to get a comprehensive gauge on indoor air quality. Of course, there are more specialized sensors for specific use-cases and pollutant concerns; we will be outlining these more in-depth in future reports, focused specifically on environmental monitoring and diagnostics.

Buyer's Guide

Size

Sizes depend on the type of air purifier you need. HVAC air filters come in an extensive variety of standard sizes, from 6 ⅞" x 15 ⅞" x 1" to 30" x 36" x 4". Manufacturers also provide custom made filters that adjust to case-by-case requirements.
Portable air purifiers can be as tiny as 6.7" x 6.7" x 11.1" and larger than 12" x 12" x 26", cleaning areas from 387 square feet to 3800 square feet in a 15 minute span.

Intelligence

The latest technology in HVAC filters is the integration of data collected by the filter into automated HVAC operations. Companies are equipping their products with IoT sensors that grant the user instant detection of particulate matter and other pollutants, allowing the device to connect to many smart-home devices and grant users access to real-time IAQ data. Some products also contain sensors to save energy and maximize efficiency, reducing fan speed when air pollution is low and increasing it when particles are detected.

Pricing

HVAC air filters can be found from $20 all the way up to $100 per filter. Portable air purifiers can be pricier on a per-unit basis, with costs that range from $80 to $500. Of course, portable air purifiers also involve filter replacement within the unit, with replacement filters costing at least $30 per recommended quarterly refill.

Installation

Portable air purifiers are the easiest to install. For most, it’s as simple as installing the device’s filter and plugging in the unit. It is recommended to place them at least 3 inches off the walls to ensure proper air circulation; of course, be mindful of tripping hazards and other factors at play when deciding the purifier's location.

HVAC air filters can be installed in the air return vent, air handling unit, or furnace of the system. Before changing or installing a new filter, the air conditioner ought to be turned off. In all cases, HVAC filters are installed the same as any other filter in your particular system. New filters often have arrows that indicate airflow, and they must be pointing into the duct.
Some smart HVAC units do require power, so be mindful of having outlets/power supply near your filter’s destination prior to placing an order.

Upkeep

The filters may have different replacement requirements, ranging from replacement every three months to once per year. Is important to replace these filters, as dust and debris may obstruct ducts and not only reduce air quality, but damage the air purifier or HVAC system.

Notable Vendors and Products

Product	Type	Fiiltration Level	Intelligence	Size	Price
Blade Air Pro Filter	HVAC filter	Fiberglass Filter Electrostatic filtration, Active polarization. MERV-14	Sensors and light emitters to detect when maintenance is needed. Collects data on the indoor air quality. Notifications via home/building WiFi network.	Smallest size: 14 x 14 x 1" Biggest size: 25 x 13 x 1" Custom sizing available	Contact Blade Air for pricing.
Coway Airmega AP-1512HH(W)	Portable air purifier	4 Stage Filtration System (Pre-filter, Deodorization filter, True HEPA filter, Vital Ion)	Pollution sensor communicates indoor air quality in real-time. LED light indicating quality of indoor air. Timer and filter lifetime indicator.	16.8 x 18.3 x 9.7"	$151.47
BLUEAIR Air Purifier Pure 311i Max	Portable air purifier	HEPASilent dual filtration technology	Blueair smart air purifier app scheduling. Clean Air ETA. Welcome Home geofencing and RealTrack accurate 6–9 month filter tracking technology are customizable features. Compatible with Alexa.	12.5" x 12.5" x 19"	$229
FilterBuy MERV 13 air filters	HVAC filter	PM2.5 Filtration, up to 80% of particles sized 1.0 µm to 3.0 µm.		Smallest size: 6 ⅞" x 15 ⅞" x 1" Biggest size: 30" x 36" x 4" Custom sizing available	From $39.19
AirDoctor MERV 14 HVAC Pleated Filter	HVAC filter	PM2.5 Filtration, up to 96% of particles sized 1.0 µm to 3.0 µm.		20" x 25" x 1"	$59.95
Filtrete™ Smart MPR 2500 Premium Allergen & Ultrafine Particles Air Filters	HVAC filter	PM2.5 Filtration, up to 96% of particles sized 1.0 µm to 3.0 µm.	Bluetooth enabled sensors. Wifi connection. Smart home integration. App controlled.	From 14 in X 14 in to 20 in X 30 in	$59.30
Medify Air MA-40 Air Purifier	Air purifier	HEPA H13 & H14 Filters, active carbon composite, removes 99.9% of particles down to 0.1 microns.	Tempered glass touch screen. 0-8 hour timer. Filter lifetime indicator.	22" x 9.9" x 10.9"	$249.99

Please reach out to research@afrequencyproject.com with any questions, suggestions, concerns or inquiries. Thank you for being a part of our community and your commitment to creating spaces that feel good.

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HELLO@AFREQUENCYPROJECT.COM

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