

BUILDING EVIDENCE



HEALTHY BUILDINGS

FOR HEALTH



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AIR QUALITY



What is indoor air quality (IAQ)?

Indoor air quality (IAQ) depends on the presence and abundance of pollutants in the indoor environment that may cause harm. It includes chemical and biological pollutants in gas, liquid or solid states that we are exposed to indoors. When IAQ is poor, occupants can experience building-related illnesses such as asthma, fatigue, irritation, and headache. Because humans spend up to 90% of their time in offices, schools, and residences, and inhalation exposure is continuous, our largest exposure to pollutants (of both indoor and outdoor origins) occurs indoors.^{1,2}

Which types of indoor air pollutants concern us?

Air pollutants can be found in all indoor spaces throughout the world. We absorb them into our bodies through breathing, swallowing them and some enter through our skin. While the effects of outdoor pollutants have been researched extensively, a growing body of research has demonstrated indoor air pollutants to be just as harmful.^{2,3} The U.S. Environmental Protection Agency states that indoor pollutants pose higher human health risks than those outdoors, as outdoor sources are more tightly regulated to control the formation of photochemical smog and particulate matter. Common indoor pollutants that pose risks to human health include nitrogen oxides, carbon monoxide, ozone, particulate matter (PM), and volatile organic compounds (VOCs) such as formaldehyde, limonene, and benzene.⁴ In offices, schools, and residences alike, these pollutants may come from printer emissions, pest and rodenticides, cleaning supplies, personal care products, paint, pollen, and fungal spores.^{5,6} Radiological hazards such as radon, a gas that naturally emanates from soil and rock and can enter buildings through cracks and fissures in the foundation, are carcinogens. Radon is considered the second leading cause of lung cancer, behind smoking.⁷ And while we know a lot about exposure and risk associated with many indoor air pollutants, there are 82,000 chemicals in commercial use, 85% of which do not have any available health data.

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How does poor indoor air quality affect human health?

Volatile organic compounds (VOCs) are a class of chemicals that are commonly associated with IAQ issues. VOCs are chemicals with a high vapor pressure that emit gas into the air and can come from building materials, consumer products, paints, personal care products, furniture, and many other products. Exposure to VOCs has been associated with everything from minor irritation of the eyes to certain forms of cancer. While extensive evidence has documented adverse respiratory health effects of outdoor air pollutants, more recent studies have shown that indoor air pollutants can have similar consequences. For example, the substantial presence of indoor ozone has been linked to irregular heartbeats and poor lung function as well as irritation to the eyes, skin, nose, and throat.^{4,8} Concentrations of pollutants indoors, in some instances have been shown to be twice as high as those outside (EPA).

Exposure to indoor air pollutants have been repeatedly linked to asthma, allergies, bronchitis, and chronic obstructive pulmonary disease.^{4,9,10} Research examining indoor pollutants in the food service sector observed a positive correlation between kitchen PM, VOCs, polycyclic aromatic hydrocarbons (air pollutants produced in the process of broiling meat and burning fuel) and kidney inflammation.¹¹ Allergic



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reactions are also commonly associated with exposure to indoor air pollutants, among both sensitive and non-sensitive individuals.¹²

“Health effects from indoor air pollutants may be experienced soon after exposure or, possibly, years later.”²

Poor IAQ disproportionately effects vulnerable individuals (WHO 2010),³ with the elderly particularly impacted, given their limited time spent outdoors. A comprehensive geriatric study in Europe (GERIE) observed a correlative relationship between exposure to indoor particulate matter and reports of wheezing and asthma-related symptoms among occupants.¹³ Substantial evidence has also been collected indicating the sensitivity of children to poor air quality due to their smaller airways and higher ventilation rates of air relative to body size as compared to adults.¹⁴ Research conducted on school populations found that VOCs in

carpet cleaner (toluene), cleaning supplies (limonene is commonly used to provide citrus scent), and pest control mechanisms can harm children’s lungs.^{14,15}

What is the cost of poor air quality?

Not only does poor IAQ harm occupant health and well-being, it also negatively impacts productivity. The buildup of indoor pollutants contributes to absenteeism through the increased prevalence of sick building symptoms.^{16,17} Exposure to indoor pollutants such as VOCs and carbon dioxide can also have direct impacts on cognitive function.^{1,18} A 2009 meta-analysis evaluated the monetary and societal costs of indoor air pollutant-related damages, and observed a range of reported damages associated with poor IAQ including productivity loss, healthcare costs, and building damages (from moist air and mold development). Each study estimated upwards of \$10 million in annual “air pollution costs”.¹⁹ There are also significant economic benefits from cleaner indoor environments. In the U.S. alone the savings and productivity gains from improved indoor environments have been estimated at \$25 to \$150 billion per year.²⁰

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What are “chemicals of concern”?

Increasing attention is being paid to “chemicals of concern” that are used in some building materials and consumer products and which can adversely impact human health. Many of these chemicals are called “semi-volatile” compounds, meaning that they can reside in both air and dust. We opted to include them in this section on IAQ, but they fit equally well in the section on dust, as well.

Three classes of chemicals of concern, in particular, warrant mention: chemicals that are used as flame retardants, as stain repellents, and as plasticizers. Flame retardant chemicals can be found in many common furnishings and building materials used in schools. The majority of these chemicals don’t stay in their products – they migrate out of products into the air and dust over time and they accumulate in our bodies. Many flame retardant chemicals are endocrine disrupting chemicals that interfere with the reproductive system and are associated with thyroid disease.^{21,22} Stain repellent chemicals are widely used in many products because they confer resistance to water, oil and greases. These classes of chemicals, called polyfluorinated alkyl substances (PFASs) or polyfluorinated chemicals (PFCs), are used in furnishings, carpets, clothing, non-stick cookware and paints, among others. People are exposed to these chemicals through air, dust and drinking water.²³ In fact, a study published in 2016 found that over 6 million U.S. residents have PFASs in their drinking water above limits set by EPA.²⁴ Phthalates are a class of chemicals that are used as plasticizers to make products soft and flexible. They can be found in many products in schools such as vinyl tile, PVC, school supplies, and artificial leather, to name a few (phthalates are also commonly found in personal care products like nail polish, hair spray and skin lotions).²⁵ And, like flame retardant and stain repellent chemicals, phthalates can leach out of their original product and enter air and dust in our homes, offices, and schools. Future versions of “Building Evidence for Health” will include more details about these “chemicals of concern” and other specific IAQ topics.



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