

## INDOOR ENVIRONMENTS AND CREATING A HEALTHY CLIMATE


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# INDOOR ENVIRONMENTS AND CREATING A HEALTHY CLIMATE

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- ✓ This presentation is not intended to be a comprehensive program covering all aspects of this topic.
  - ✓ All participants are encouraged to read and follow applicable standards, codes and regulations related to this topic.
  - ✓ The views and opinions following are the presenter's opinions and not necessarily the official position of the National Air Duct Cleaners Association.

# DEFINING A HEALTHY BUILDING

## National Center for HEALTHY HOUSING

### THE PRINCIPLES OF A HEALTHY HOME

Housing conditions can and should support good health. But what makes a healthy home environment? Since the 1930s, public health and housing stakeholders have offered guidance on fundamental housing characteristics as they relate to health. Today, NCHH supports the following 10 principles as a framework for describing the critical components of a healthy home. Healthy homes are:

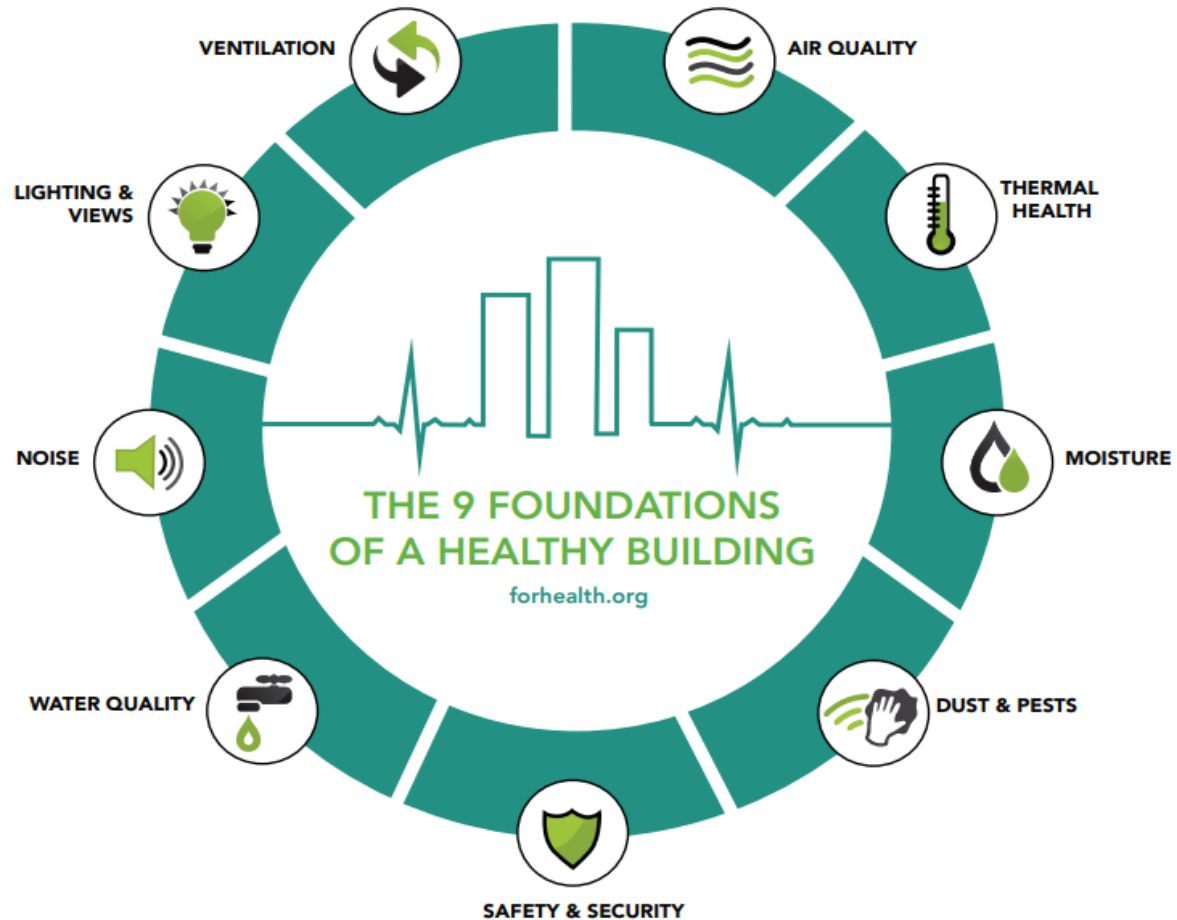
<b>DRY</b>		Damp houses provide a nurturing environment for mites, roaches, rodents, and molds, all of which are associated with asthma.
<b>CLEAN</b>		Clean homes help reduce pest infestations and exposure to contaminants.
<b>PEST-FREE</b>		Exposure to mice and cockroaches increase asthma episodes in children. Inappropriate treatment for pest infestations can exacerbate health problems as pesticide residues pose risks for neurological damage and cancer.
<b>VENTILATED</b>		Increasing the fresh air supply improves respiratory health.
<b>SAFE</b>		Falls are the most frequent cause of residential injuries to older adults and children, followed by injuries from objects in the home, burns, and poisonings.
<b>CONTAMINANT-FREE</b>		Chemical exposures include lead, radon, pesticides, volatile organic compounds, PFAS, and environmental tobacco smoke. Many of these exposures are far higher indoors than outside.
<b>MAINTAINED</b>		Poorly maintained homes are at risk for moisture and pest problems. Deteriorated lead-based paint in older housing is the primary cause of lead poisoning.
<b>THERMALLY CONTROLLED</b>		Prolonged exposure to excessive heat or cold when homes do not maintain adequate temperatures put residents at risk for various health problems.

### Nazaroff's Principles

- 1 Minimize indoor emissions
- 2 Keep it dry
- 3 Ventilate well
- 4 Protect against outdoor pollution
- 5 Satisfy occupant needs



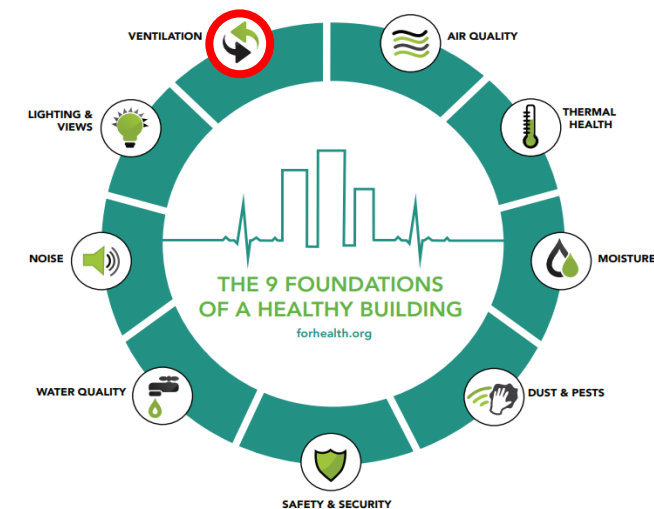
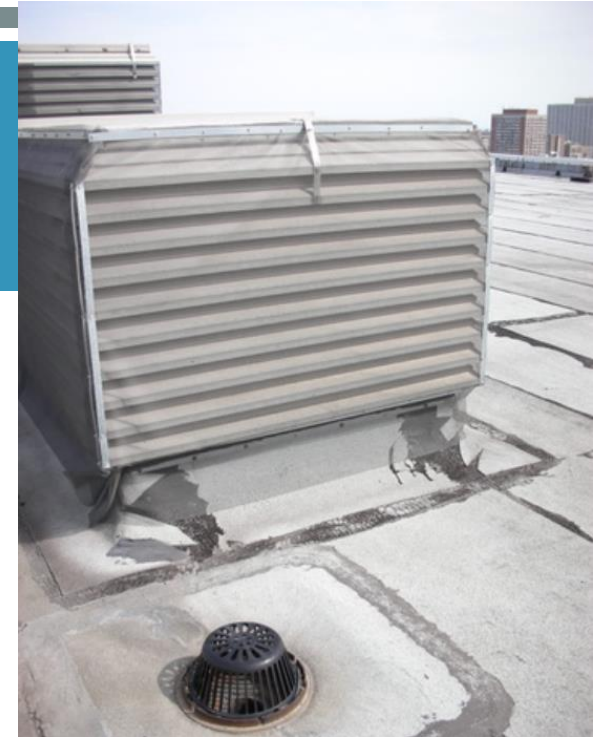
# THE 9 FOUNDATIONS OF A HEALTHY BUILDING



- Developed by the Healthy Buildings program at the Harvard T.H. Chan School of Public Health
- [https://forhealth.org/9\\_Foundations\\_of\\_a\\_Healthy\\_Building.February\\_2017.pdf](https://forhealth.org/9_Foundations_of_a_Healthy_Building.February_2017.pdf)

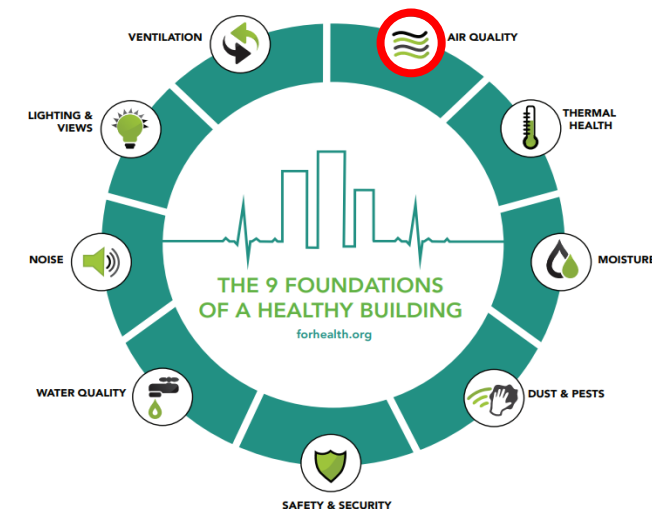
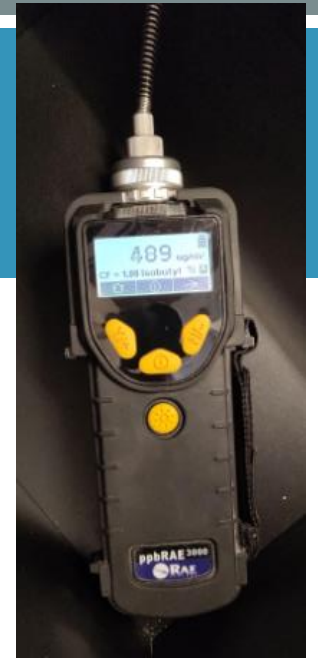
# VENTILATION

- Outdoor air ventilation dilutes contaminants.
- Different types:
  - Mechanical vs natural
  - Supply vs exhaust
- Outdoor air isn't always "fresh."
- ASHRAE is an organization with standards regarding the quantity of ventilation.
- Filtration is also an important aspect of ventilations systems.



# AIR QUALITY

- Many people are concerned about their diet but ignore air quality.
- Indoor air quality concerns include VOCs, mold, radon, asbestos, allergens, CO, particulate matter, and more.
- Sources of VOCs can be from building materials, cleaners, personal care products, activities, etc.
- Combustion by-products from furnaces, boilers, vehicles, stoves, outdoor pollution.
- Asbestos could conceivably be in newer buildings too!

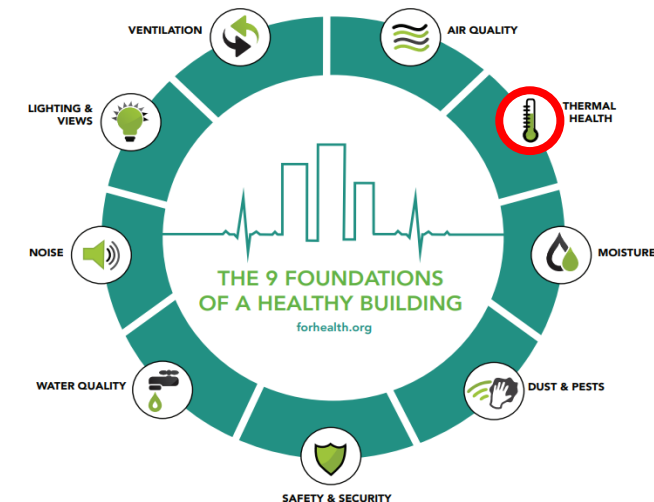


# THERMAL HEALTH

- Comfort is impacted by temperature, humidity, air speed, activity levels, clothing, etc.
- A recent study used objective data to compare the relative importance of different indoor environmental factors to enhance office work performance. It assigned the following weighting: thermal comfort 36.5%, acoustic comfort 30.7%, air quality 24.4%, and visual comfort 8.4%.

- Source:

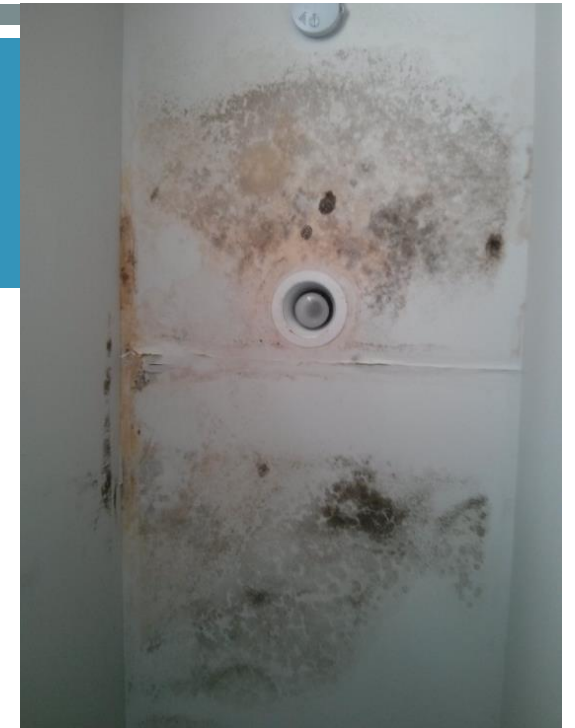
<https://www.sciencedirect.com/science/article/abs/pii/S0360132323003050>





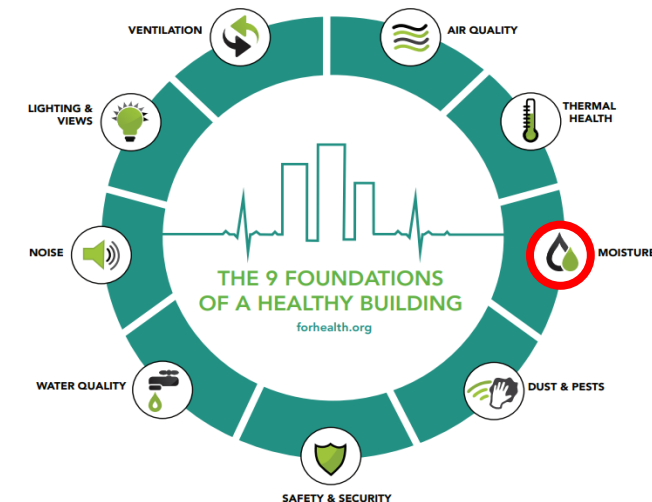
# MOISTURE

- Moisture indoors leads to mold growth
- Mold can cause allergies and more severe health effects such as infection and toxic effects
- Exposure to residential dampness and mold contributed to estimated 21% of asthma cases
- Mold inhalation can interfere with cognitive processing in different ways depending on the task and the presence of mycotoxins.



- Source:

<https://www.sciencedirect.com/science/article/abs/pii/S0166432823000128?dgcid=author>



# DUST & PESTS

- Allergens can be found in house dust:
  - Dust mites, Cockroaches
  - Mice and rats
  - Cats and dogs
  - Outdoor pollen
- Dust can become resuspended with activity indoors (walking, vacuuming, etc.) and trigger allergies and asthma
- Does a hygienic indoor environment = a healthy environment?
  - It's complicated (“There are numerous contradictory studies, and the totality of the evidence remains inconclusive”)



Image Source: Jacopo Werther

CLINICAL & EXPERIMENTAL  
**ALLERGY** TRUSTED EVIDENCE IN ALLERGY

Open Access

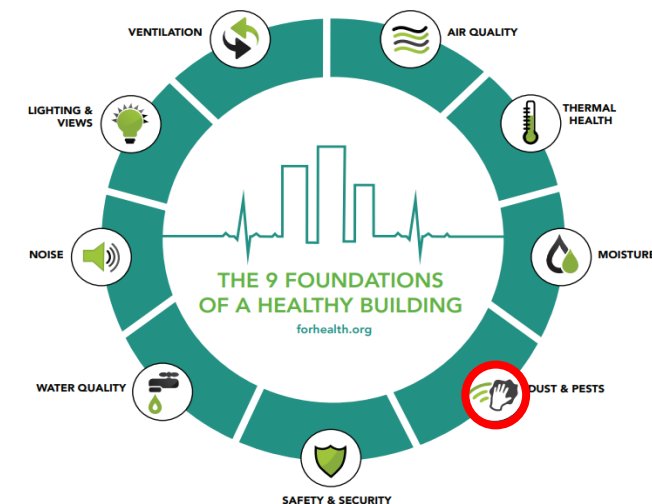
**Too clean, or not too clean: the Hygiene Hypothesis and home hygiene**

S. F. Bloomfield, R. Stanwell-Smith, R. W. R. Crevel, J. Pickup

First published: 24 March 2006 | <https://doi.org/10.1111/j.1365-2222.2006.02463.x> | Citations: 183

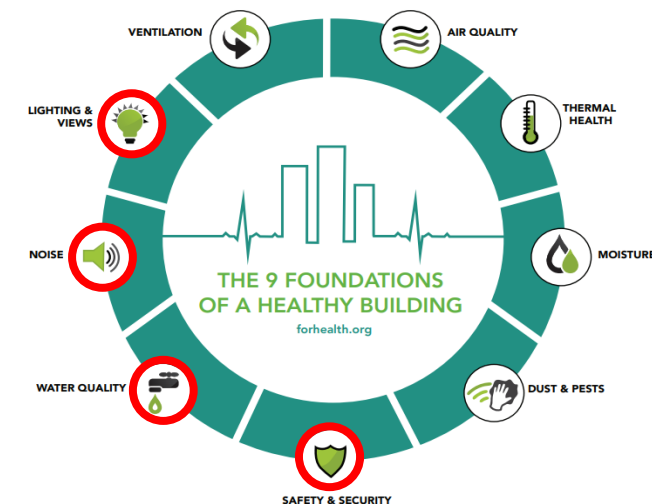
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# OTHER FOUNDATIONS

- Safety & Security
  - Being 'very worried' about crime has been significantly associated with higher levels of psychological distress.
- Water Quality
  - Lead, *Legionella*, and PFAS are important risks.
- Noise
  - More than 20 studies have shown environmental noise exposures to be negatively correlated with children's learning outcomes and cognitive performance.
- Lighting & Views
  - Daylight exposure and access to windows at work has been linked to improved sleep duration and mood, reduced sleepiness, lower blood pressure and increased physical activity.





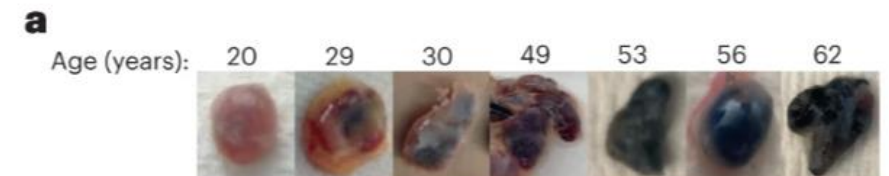
# THE MOST RESENT IAQ RESEARCH (2023-PRESENT)



# IAQ IMPACT ON HEALTH

- Poor ventilation in bedrooms, which results in elevated carbon dioxide concentrations, contributes to reduced sleep quality and other symptoms. [Buildings](#)
- In contrast to the hygiene hypothesis, this study found that mice given a rich microbial exposure from birth did not experience a protective effect, but rather increased allergic inflammation. [Science Immunology](#)
- Among household activities, incense burning contributed the most to carcinogenic risks, followed by cooking, smoking, and air freshener spraying. [Aerosol and Air Quality Research](#)
- Hoarseness of voice was strongly correlated with indoor air pollutants. It improved following remediation. [Indoor and Built Environment](#)
- This study found different effects from exposure to particulate matter (PM) indoors vs outdoors. Indoor PM2.5 from occupied residences caused higher inflammation in mice compared to outdoor PM2.5. [Indoor Air](#)
- An average relative humidity of <38% was associated with an increased risk of upper respiratory symptoms. [Indoor Air](#)
- Over decades of exposure to particulate matter, the lymph nodes connected to the lungs become clogged with particles, and as a result, they are not able to carry out essential functions. [Nature Medicine](#)

Fig. 1: Lung-associated lymph nodes accumulate carbon particulates with age.



# CHILD HEALTH

- Higher risk of asthma was associated with prenatal exposure to PM2.5 and postnatal exposure to PM10. [Building and Environment](#)
- Wildfire smoke exposure during early postnatal developmental periods impact subsequent early life respiratory health. [Environmental Health](#)
- Prenatal exposure to ambient air pollution may increase the risk of childhood allergy and asthma. Air pollution exposure during pregnancy can have independent, long-term health effects in offspring. [JACI](#)
- The protective effect of farm living on allergic rhinitis persists from childhood to early adulthood. The window of opportunity for a protective effect is probably limited to childhood. [JACI](#)
- Lower respiratory tract infections during the first two years of life almost doubled the risk of respiratory disease-related death during adulthood. [The Lancet](#)
- In a similar study, not being infected with RSV during infancy was associated with a 26% lower risk of developing asthma by age 5. [The Lancet](#)
- High levels of house dust mite allergen in the mattress was associated with rhinitis and eczema among children, especially when the Der f I allergen was greater than 4500 ng per gram of dust. [Building and Environment](#)

# COGNITIVE PERFORMANCE

- This meta-analysis provides new evidence to support the recommendation for a stricter carbon dioxide (CO<sub>2</sub>) limit of 1,000 ppm in workplaces that require high cognitive demands. [\*Building and Environment\*](#)
- Total volatile organic compounds (TVOCs) had a significant negative effect on creativity scores. PM<sub>2.5</sub> and Carbon Dioxide (CO<sub>2</sub>) did not. [\*Scientific Reports\*](#)
- Elevated PM<sub>2.5</sub> levels indoors can detrimentally affect cognitive performance, even during short-term exposure. [\*Building and Environment\*](#)
- This study found that small increases in outdoor PM<sub>2.5</sub> exposure in utero were associated with slightly lower IQ in late childhood. [\*Environmental Health Perspectives\*](#)
- Transitioning to WELL Building certified offices had a positive impact on occupant satisfaction, occupant perceived health, well-being, and productivity. [\*Building and Environment\*](#)

# HVAC

- Ultraviolet-based air cleaners can negatively affect indoor air quality by producing unwanted particles and chemicals. [\*Environmental Science & Technology Letters\*](#)
- Ultraviolet light at 222 nm (GUV222) was found to generate ozone and hydroxyl radicals, leading to oxidized VOCs and fine particulate matter. [\*Environmental Science & Technology\*](#)
- When operating whole house mechanical ventilation, homes had lower formaldehyde, radon, CO<sub>2</sub>, NO, and faster PM<sub>2.5</sub> decays following indoor emission events. [\*Building and Environment\*](#)
- This study found that increasing the ventilation rate in schools was more effective than increasing social distancing in reducing the risks of an airborne viral infection. [\*Buildings\*](#)
- Using modeling software, this study found that in-duct air treatment would be insufficient for mitigating COVID infection risks and additional in-room treatment devices would be needed. The study also found there is potential for zone-to-zone transmission. [\*Buildings\*](#)
- A bipolar ionization air cleaner did not show a statistically significant reduction of airborne virus at 0, 15, 30, 90, or 120 minutes of operation. It did show a statistically significant reduction at 60 minutes. [\*Building and Environment\*](#)



# CLEANING

- A hydrogen peroxide-based disinfectant produced fewer volatile organic compounds compared to ones based on bleach, isopropanol, and citric acid. [\*Environmental Health Perspectives\*](#)
- The use of “green” cleaning products, especially fragrance-free products, may reduce exposure to VOC emissions. [\*Chemosphere\*](#)
- In a comparison of hospital disinfection methods, ultraviolet light (UV-C) successfully disinfected 75.5% of surfaces, whereas manual disinfection using alcohol-based wipes achieved 98.1%. [\*Journal of Hospital Infection\*](#)
- Cleaning and ventilation in homes can decrease dampness, mold, and building-related symptoms. [\*Building and Environment\*](#)
- Traditionally, it has been believed that quaternary ammonium disinfectants do not emit VOCs. This study came to a different conclusion. [\*Royal Society of Chemistry\*](#)
- A large study of cleaning products found that 75% of the highest VOC emissions came from conventional cleaning products compared to “green” products. Although green products were associated with fewer elevated air concentrations, they still resulted in exposure to some chemicals of concern. [\*Indoor Air\*](#)

# VOCS AND CHEMICALS

- Although essential oils are often perceived as having a beneficial effect on indoor air quality, the VOCs produced can exceed recommended exposure levels by more than an order of magnitude. [\*Atmospheric Environment\*](#)
- Formaldehyde exposure in residences, offices, and schools was associated with asthma but not dermatitis or rhinitis. [\*Building and Environment\*](#)
- Chemical intolerance was found to be initiated by exposures to mold, pesticides, remodeling/new construction, medical/surgical procedures, combustion products, and others. [\*Environmental Sciences Europe\*](#)
- In this study of newly constructed apartment buildings, the indoor concentration of hazardous chemicals was lower when buildings were both baked-out and mechanically ventilated for 7 days. [\*Buildings\*](#)
- Residential natural gas heating is a source of indoor nitrous acid (NOHO) emissions. [\*Environmental Science & Technology\*](#)
- This review study found that 12.7% of current childhood asthma in the US is attributable to gas stove use. [\*International Journal of Environmental Research and Public Health\*](#)
- Residential renovation and buying new furniture in prenatal and postnatal periods consistently increased odds of childhood airway diseases and allergies. [\*Building and Environment\*](#)

# MISC

- This study found that the moisture conditions tested inside air-conditioning ductwork were not favorable for promoting extensive microbial growth. [Buildings](#)
- High-pressure washing decreased fungal abundance by over 99% on air-conditioning parts. [Indoor Air](#)
- Indoor plants in healthcare facilities can pose risks (e.g., infections, allergies) and bring benefits (e.g., subjective well being, reduced emotional stress). [Building and Environment](#)
- Opening school windows can have positive *and* negative effects in areas with elevated outdoor PM2.5. Schools need a strategy to balance these two conflicting risks. [Building and Environment](#)
- Non-smoking areas adjacent to smoking sections had PM2.5 concentrations exceeding WHO air quality guidelines in entertainment venues. [Indoor Air](#)
- Temperature might have a greater effect on mold growth compared to relative humidity. [Buildings](#)
- Mold inhalation can interfere with cognitive processing in different ways depending on the task and the presence of mycotoxins. [Behavioural Brain Research](#)

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# Questions?






## PRESENTER CONTACT INFORMATION

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Email me to receive my newsletter,  
“IAQ Research of the Month”





Thank You for  
Participating!

