

Makeup Air		Synopsis
Title	Experts finally pinpointed the cause of so many coronavirus outbreaks	Experts have confirmed that the increase in coronavirus outbreaks were due to poor ventilation in buildings. It is suspected that more outbreaks will occur in schools because of the poor ventilation. Richard Corsi, dean of College of Engineering and Computer Science at Portland State University said that "the state of ventilation in schools in the United States right now is woefully inadequate."
Author(s)	Yoni Heisler, BGR	
AA Location	7-40	
Web address	https://bgr.com/2021/02/26/covid	
Title	Car indoor air pollution - analysis of potential sources	Indoor air quality was assessed in a variety of studies, focusing on particulate matter, endotoxins, and microbiologicals. It was found that particulates, primarily compounds containing aldehydes, calcium, copper, sulfur, and chromium, directed contributed to inflammatory and cardiac responses. Exposure to the bacterial endotoxin B-(1,3)-glucan was also seen, which causes major respiratory responses. The overall indoor air quality can be improved by opening the windows or the correct use of the fans in the AC system.
Author(s)	Journal of Occupational Medicine and Toxicology	
AA Location		
Web address		
Title	Formaldehyde	Formaldehyde is found in many household items like carpets, glues, dyes, upholstery, permanent press clothes, markers, plywood paneling, fiberboard, finishes, and more. It is classified as a possible human carcinogen by the EPA. Acute exposure to formaldehyde can cause burning/tingling sensations in the eyes, nose, and throat, as well as chest tightness and wheezing. Acute and severe exposure can be linked to hypersensitivity, which approximately 10-20% of the US population suffers from. Formaldehyde levels inside of the home can be at irritating levels and proper ventilation can assure levels do not increase or stay at harmful levels.
Author(s)		
AA Location	7-45	
Web address	http://extoxnet.orst.edu/faqs/indo	

Makeup Air		Synopsis
Title	Indoor Air Quality Hazards of New Cars	<p>Volatile Organic Compounds (VOCs) such as formaldehyde, PBDEs, and phthalates, are found in high quantities in motor vehicles. These compounds are known to exacerbate asthma, eye, nose and throat irritation, headache, flu-like symptoms, and skin irritation. Australia's National Health and Medical Research Council set national limits for total VOC count at 500 ug/m³, and any VOC to not exceed 250 ug/m³. However, in new cars, TVOC levels reached as high as 64,000 ug/m³. Multiple studies have shown that the TVOC level decreases exponentially as a car ages, though levels spike when internal temperature increases (like after the car sitting in a hot parking lot). More than 100 VOCs were identified in vehicles tested, some of them causing birth defects, impaired learning, liver toxicity, premature births, and early puberty in laboratory animals under experimental conditions. It is recommended to increase ventilation in the car to diminish high levels of VOCs, such as rolling down the windows, especially during the first six months of new car ownership.</p>
Author(s)	Green Guard	
AA Location	7-46	
Web address		
Title	Bioaerosols in Indoor Environment	<p>Bioaerosols contains microorganisms or the organic derivatives of organisms (such as endotoxins, metabolites, etc) and range from 0.001 to 100 um in size. They are known to possibly pose a health hazard in high concentrations in indoor environments. The levels of bioaerosols are dependent on relative humidity, temperature, outdoor concentration, and air exchange rates (ventilation). The major source of control of levels of bioaerosols lies in the building's heating, ventilation, and air conditioning. Both bacteria and fungi have been found in high counts in the indoor environment from a variety of sources (mostly human activities). Proper cleaning and maintenance procedures and proper ventilation can both play key roles in improving indoor air quality, as well as the use of dehumidifiers and air filters. The study also reviews a variety of different testing measures for collection of air samples and identification of bacteria and fungi.</p>
Author(s)	The Open Environmental & Biological Monitoring Journal	
AA Location	7-47	
Web address		

Makeup Air		Synopsis
Title	Venting on Ventilation presentation	<p>The importance of ventilation in buildings has increased ever since the tightening of a building's envelope became commonplace in construction to conserve energy. Lack of ventilation leads to buildup of indoor pollutants and offices and schools contain around 1000-3000 ppm of CO2. High levels of CO2 are associated with impaired decision-making skills. Better ventilation is also associated with reduced risk of Sick Building Syndrome. No studies have recommended how much outside air should be introduced, but studies have shown that increased ventilation also increases productivity in schools and offices, which adds up to \$37 billion/year (while energy cost is \$0.13 billion). Another estimate for school is a net profit of \$27 million. Overall, ventilation is shown to improve health but does have a high implementation cost. Despite this, long term cost benefits are seen in regards to work productivity and health.</p>
Author(s)	IAQA Conference, Henry Slack	
AA Location	7-48	
Web address		
Title	Formaldehyde	<p>Formaldehyde can be found from multiple sources like building materials, smoking, household items and products, and unvented fuel-burning appliances like a gas stove. Pressed wood products are the primary source of formaldehyde in the home. Exposure to it can cause irritation in the eyes and throat, cause nausea and difficulty breathing and has been known to cause cancer in animals and potentially humans. You can reduce your exposure to formaldehyde in the home by using exterior-grade pressed wood products instead of interior-grade, use dehumidifiers and air-conditioning, and to increase ventilation. These measures are primarily important to make after introducing new products or materials into your home.</p>
Author(s)	EPA	
AA Location	7-49	
Web address	https://www.epa.gov/indoor-air-qu	

Makeup Air		Synopsis
Title	The Inside Story: A Guide to Indoor Air Quality	<p>This guide was written by the EPA and US Consumer Product Safety Commission. A large amount of scientific evidence has shown that indoor air is more polluted than outdoor air, as well as shown that on average we spend 90% of our time indoors. This increase in indoor pollutants are from indoor sources that emit gases or particles into the air along with improper (or no) ventilation present in the building. It is recommended to improve indoor air quality by removing the sources of pollution, increasing ventilation, and installing air cleaners and dehumidifiers. Some of these indoor air pollutants include particulate matter which comes from a plethora of various household items and activities (cleaning and cosmetic products, pressed wood, biological particulates, cooking, pesticides, radon, asbestos, smoking, combustion from stoves, candles, etc). All of these indoor pollutants are associated with multiple health risks that are either acute in nature or can pose lifelong health risks. Some of these adverse health effects include irritation of the eyes, nose, and throat, headaches, dizziness, fatigue, lung cancer, asthma, various other cancers, visual disorders, memory impairment, allergic rhinitis, hypersensitivity pneumonitis, and more. Secondhand smoke alone accounts for 150,000-300,000 lower respiratory infections in children under 18 months old, as well as worsening asthma conditions in 200,000-1,000,000 children and 3,000 lung cancer deaths per year. To successfully reduce the concentration of indoor pollutants in your home, it is recommended to have adequate ventilation of outdoor air, keep humidity levels below 50% and reduce sources of contaminants. Overall, poor indoor air quality can be attributed to the indoor pollution sources, inadequate ventilation systems, and poorly designed buildings.</p>
Author(s)	Consumer Product Safety Commission	
AA Location	8-A	
Web address	https://www.cpsc.gov/Safety-Educ	
Title	WHO: Air Pollution and Health	<p>The World Health Organization has attributed air pollution (indoor and outdoor) to sometimes fatal respiratory and heart disease, stroke, cancer, and other adverse health effects. Globally, air pollution is the biggest environmental killer, killing 1 in every 8 people. A total of 7 million deaths are linked to air pollution per year.</p>
Author(s)	WHO	
AA Location	8-B	
Web address	https://www.who.int/phe/health_t	
Title	Restaurants, AC, coronavirus	<p>The fear of the spread of coronavirus through HVAC systems has become a concern, particularly in public spaces like restaurants. Ventilation and air filtration are two parts of an HVAC system that helps control the spread of the virus. The ASHARE recommends increased ventilation with outside air to reduce risk.</p>
Author(s)	Washington Post	
AA Location	8-B	
Web address	https://www.washingtonpost.com/	

Makeup Air		Synopsis
Title	Reducing Indoor Air Pollution	<p>In 1987, the EPA ranked indoor air pollution as the fourth lead cancer risk among the 13 environmental problems assessed. This is concerning since in another study it was found that California residents spend 87% of their time indoors. Indoor air pollution is often higher than outdoor air pollution due to high concentrations of pollutants like formaldehyde and chloroform that accumulate indoors. Indoor air pollution can have acute effects such as eye and throat irritation to chronic effects such as respiratory disease and cancer. Minimizing or preventing indoor air pollution can be done through adequate ventilation with outdoor air.</p>
Author(s)	CA Air Resources Board	
AA Location	1-25	
Web address		
Title	Economic, Environmental, and Health Implication of Enhanced Ventilation in Office Buildings	<p>The economic and environmental cost of implementing better ventilation into office buildings was assessed. It was found that doubling the ventilation rate from the minimum set by the American Society of Heating, Refrigeration, and Air-Conditioning Engineers increased office worker performance by 8%, or \$6,500 dollars per year. It also reduced absenteeism and improved health of the employees. The cost of doubling the ventilation was less than \$40 dollars per year per person. When also implementing an energy recovery ventilation system, the environmental impact was the equivalent of 0.03 cars per building, a quite negligible value).</p>
Author(s)	International Journal of Environmental Research and Public Health	
AA Location	3-7	
Web address		
Title	Researchers uncover indoor pollution hazards	<p>Washington State University researchers found high levels of pollutants in the home like formaldehyde and at times mercury. These indoor air pollutants come from building materials, furniture, household chemicals, and cooking. As temperatures rise, levels of pollutants also rise. One proposition to help reduce indoor air pollutant levels is to use green building materials.</p>
Author(s)	Washington State University	
AA Location	4-20	
Web address		
Title	Volatile Organic Compounds in Commonly Used Products	<p>VOCs can come from common household objects like furniture, building material, furnishings, carpets, cleaning/air fresheners, fuel products, cosmetics, and more. It is recommended to provide good ventilation in your home when using these products or bringing in new furniture or carpet. Acute exposure to VOCs can cause headache, dizziness, light-headedness, drowsiness, nausea, eye and respiratory irritation. Chronic exposure in lab animals can cause cancer, and affect the liver, kidney, and nervous system.</p>
Author(s)	NY Department of Health	
AA Location	VOC-16	
Web address		

Makeup Air		Synopsis
Title	Indoor Volatile Organic Compounds and Health	<p>Though there is not enough sufficient evidence to draw direct conclusions, there have been reports of indoor exposure to VOCs causing respiratory symptoms, headaches, and fatigue. 3 out of the 4 studies reviewed found direct links between asthma and allergies to higher concentrations of VOCs indoors. They have also been found to cause cancer in laboratory animals in high concentrations. Benzene and formaldehyde, two examples of a VOC, are suspected to be a human carcinogen as well. Though there is limiting evidence, there is enough to warrant precautions for VOCs in the indoor environment. One way to manage their levels is to increase ventilation in the building.</p>
Author(s)	IAQ Science	
AA Location	VOC-17	
Web address		
Title	Indoor Residential chemical emission as risk factors for respiratory and allergic effects in children: a review	<p>The following VOCs were linked to the follow health effects in children: 1. Six studies linked formaldehyde to diagnosis of asthma, chronic and acute respiratory conditions, wheezing, lower airway inflammation. 2. Two studies linked aromatic compounds to diagnosis of asthma and pulmonary infections. 3. phthalate esters in dust were linked to asthma diagnosis. 4. Five studies linked recent painting, redecoration, and new furniture to wheezing at 1 year old and recurrent wheezing, pulmonary infection, asthma history, and obstructive bronchitis. 5. Six studies linked plastic containing materials (PVC, wall/floor/textiles) to wheezing, bronchial obstruction, recurrent wheeze, upper respiratory symptoms, and two studies linking low ventilation plus exposure to plastic containing materials to bronchial obstruction.</p>
Author(s)	Indoor Air	
AA Location	VOC-18	
Web address		
Title	Cost Effectiveness of Improving Indoor Environments to Increase Productivity	<p>The estimated work performance and economic benefit from improving ventilation rates and temperature was evaluated for the average office worker with a salary of \$100K. It was found that the optimal temperature was 71 degree Fahrenheit and with each improvement in degree of temperature, there was an annual economic benefit between \$55-430 dollars per person. The highest benefit was going from 76 to 75 degrees or 67 to 68 degrees. When the ventilation rate was doubled, there was a max of \$1400 dollars per worker in economic benefit. The benefit-cost ratio (dividing by energy, maintenance, equipment) of going from 13 cfm to 20 cfm per person was 9.4, and 7.0 when going from 13 to 40 cfm. Overall, there is significant economic benefit from improving temperature and ventilation rates in the indoor environment due to increased worker productivity.</p>
Author(s)	EPA, DOE	
AA Location	econ-2	
Web address	https://iaqscience.lbl.gov/performance	

Makeup Air		Synopsis
Title	Providing Better Indoor Environmental Quality Brings Economic Benefits	<p>Overall, there are significant advantages to improving indoor air quality in regards to temperature control and ventilation. Benefit-cost ratios are as high as 80 and \$700 dollars per year per person. Multiple studies evaluating student performance under different temperatures and ventilation rates was also investigated. It was found that there is decrease in performance of reading and math skills with decreased ventilation and an increase in these skills with increased ventilation.</p> <p>Environmental tobacco smoke (ETS) is rampant and at the time of the study in 2000, 64.7 million smokers exposed non-smokers to ETS every day. This caused the following preventable health costs of being exposed to ETS: \$1300-\$11,000 per smoker for death, \$4-\$13/smoker for asthma induction, \$0.26-\$0.65/smoker for days of asthma exacerbation, \$1.30-\$2.63/smoker in bronchitis/pneumonia hospitalizations, \$0.13-\$0.28/smoker for acute bronchitis/pneumonia, and \$5.87-\$16.80/smoker for all morbidity. Overall, just death alone costs between \$85 billion and \$730 billion dollars per year due to ETS.</p>
Author(s)	Proceedings of Clima 2007 Wellbeing Indoors	
AA Location	econ-1	
Web address		
Title	Rethinking ventilation: A benefit-cost analysis of carbon-offset increased outdoor air provision	<p>It was found that by increasing ventilation rates, the carbon offset from the increased energy usage is negligible and that economic benefits in increased worker productivity far exceeded the energy costs. It was found that with a 400% increase in ventilation rate cause a \$5.13/m²/year increase in energy costs.</p>
Author(s)	Building and Environment	
AA Location	econ-5	
Web address		
Title	Perceptions in the US building industry of the benefits and costs of improving indoor air quality	<p>The estimated cost of increasing ventilation from 20 to 40 cfm/occupant and a MERV filter upgrade from a 6 to an 11 costed \$10-\$21/occupant. When the building industry was surveyed, a majority of people thought the average cost would be \$75/person and that the willingness to pay was \$15/person. This highlights the misinformation in the building industry on the importance and cost of indoor air quality, but remains hopeful as the willingness to pay is within the range of the total cost of increasing ventilation and upgrading to higher efficiency filters.</p>
Author(s)	Indoor Air	
AA Location	econ-6	
Web address		

