

WORKSPACES

Research: Stale Office Air Is Making You Less Productive

by Joseph G. Allen

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How often do you consider the air quality in your office and how it affects employees and their productivity? Chances are it's not often.

There is a tendency to assume that, as long as commonly used standards for air quality are met, it won't be an issue. But these standards aren't very high. One common international standard that governs how much air is brought in from outside, "Ventilation for Acceptable Indoor Quality," does not even purport to assure "healthy" air quality.

In the 1970s, efforts to conserve energy in the U.S. included tightening up buildings and reducing ventilation rates so buildings didn't have to bring as much fresh air inside. This inadvertently led to a buildup of indoor pollutants and the birth of a phenomenon known as "sick building syndrome," a set of symptoms such as eye irritation, headaches, coughing, and chest tightness that is still an issue today.

Study after study has shown that the amount of ventilation, or fresh outdoor air brought inside, is a critical determinant of health. Good ventilation has been shown to reduce sick building syndrome symptoms, cut absenteeism, and even reduce infectious disease transmission.

Given these studies tying air quality to health, we wanted to see whether improved ventilation affects cognitive function, an indicator of worker productivity. Specifically, does better air influence a worker's ability to process information, make strategic decisions, and respond to crises?

With my colleagues Jack Spengler and Piers MacNaughton, at Harvard University, and collaborators Suresh Santanam at Syracuse University and Usha Satish at SUNY Upstate Medical, I investigated this question. In the first phase of our study, we enrolled 24 "knowledge workers" – managers, architects, and designers – to spend six days, over a two-week period, in a highly controlled work environment at the Syracuse Center of Excellence. Each day we asked them to show up at this location and do their normal work routine from 9 AM to 5 PM. Meanwhile, without their knowledge, we changed the air quality conditions of their workspaces from a conventional environment, which merely met minimally acceptable standards, to an optimized one.

For the optimized environment, we increased the amount of outdoor air brought in to the space (i.e., the ventilation rate), doubling what is required under the "acceptable indoor air" standard, a condition that most buildings can achieve. We also changed the level of volatile organic compounds (VOCs) in the space by controlling the number of common materials that emit these chemicals – e.g., surface cleaners, dry erase markers, dry cleaned clothing, and building materials. We exposed

the workers to a typical and a low VOC concentration. Last, we tested three levels of carbon dioxide (CO₂) in the air: low levels (600 parts per million) that result from high ventilation rates, a typical level seen in many offices (950 ppm), and higher levels that are commonly encountered in U.S. schools (1400 ppm).

We held everything else constant. At the end of each day, we tested the workers' decision-making performance using a standardized cognitive function test that researchers have used for decades.

We found that breathing better air led to significantly better decision-making performance among our participants. We saw higher test scores across nine cognitive function domains when workers were exposed to increased ventilation rates, lower levels of chemicals, and lower carbon dioxide. The results showed the biggest improvements in areas that tested how workers used information to make strategic decisions and how they plan, stay prepared, and strategize during crises. These are exactly the skills needed to be productive in the knowledge economy.

We conducted this as a double-blind study to limit the potential for bias. Just as participants were kept blind to the changing conditions of their workplaces, the scientists who analyzed the cognitive function data were kept blind to the conditions. In addition, we controlled for differences among the participants and measured each individual's performance against their own baseline. We didn't care if one person was smarter than another; we were interested in how people compared against themselves. To be sure there was no learning effect (if people scored better after taking the test a few times) and no bias was introduced (if our blinding didn't work), we repeated one of the exposure conditions (high ventilation, low VOCs, low CO₂) on the first and last day, nine days apart. Our results were consistent, indicating that there were no learning effects and that the blinding was effective.

In the second phase of the study, we moved from the lab to the real world to test for additional factors beyond ventilation, VOCs, and CO₂ that might influence cognitive function. We enrolled more than 100 knowledge workers in 10 buildings across the United States, six of which had achieved "green certification." (Although "green" implies lower energy use and perhaps lower ventilation rates, many buildings do both quite well.) We measured the indoor air quality in each of these buildings and tested workers' cognitive function.

Controlling for factors such as salary, type of work, building owner/tenant, and geographic location, we found that workers in buildings that were green certified scored higher on the tests. In addition to the air quality, we saw that temperature had an effect on workers. When they worked under a standard comfortable temperature and humidity range, they performed better on the tests of decision making, independent of which building they were in.

What should leaders and building managers take away from these findings? The short answer is that better air quality in your office can facilitate better cognitive performance among your employees. Of course, these are just two studies, but they are wholly consistent with 30 years of science on the benefits of higher ventilation rates.

In most buildings, managers can take action immediately. The first step is to look at your air quality indicators and see whether there's room to improve. While cost may be a concern, it turns out that the cost of improving air quality through higher ventilation rates are far lower than is widely believed. (One study found that building managers tend to overestimate energy costs by a factor of two to 10.)

We modeled costs under four different types of ventilation systems in U.S. cities that occupy different climate zones and have varying energy sources. Our estimates show that the cost of doubling ventilation rates would be less than \$40 per person per year. In most cities, it's even lower. When energy-efficient ventilation systems are used, the cost would be \$1-\$10 per person per year.

We also benchmarked the cognitive function scores from our study to the thousands of people who have taken the test in other settings, and we paired the percentile increase in scores to salary data from the Bureau of Labor Statistics. (We used salary data as a proxy for productivity and selected data for knowledge workers, the same population as in our study.) We estimated that the productivity benefits from doubling the ventilation rates are \$6,500 per person per year. This does not include the other potential health benefits, such as reduced sick building syndrome and absenteeism.

Ultimately, managers would be wise to routinely incorporate health impacts into all of their cost-benefit calculations. When health is accounted for, the costs for enhancing the indoor environment can be properly weighed against the health and productivity benefits. For example, an executive

will clearly see that an enhanced facilities budget will reduce human resource costs. This makes buildings, in essence, a human resource tool.

In addition to managing VOCs, ventilation rates, and temperature, managers can consider other critical aspects of the indoor environment that influence health and productivity, such as lighting and noise.

This research adds empirical evidence to a long-recognized phenomenon. Ben Franklin once professed, “I am persuaded that no common air from without is so unwholesome as the air within a close room that has been often breathed and not changed.” We’ve all struggled to concentrate in a conference room that is stuffy and warm. When a window or door is opened and fresh air comes in, it breathes life into the room. Businesses would benefit from recognizing this and taking action to optimize their air quality for employees’ health and productivity.

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3 COMMENTS**Gavin Wilkinson** 18 days ago

It's great to see this studied. Quantifying is a step towards getting past the uncertainties, of wondering whether it's just you. Occasionally I work in an office that feels really groggy when it is too cold to open the window and it's busy, people remark on it. I've recently been testing my home but yet to get on to the office. Certainly the bedroom is much better for having the door or window open. There are actually some graphs showing it in this, slightly tongue in cheek, video <https://youtu.be/EP4VpWg01tw>

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