

# Scientists Find Evidence of Link Between Outdoor Ozone and Building-Related Health Symptoms

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Air filters used in the ventilation systems of some building may play a role in the prevalence of building-related symptoms (BRS), which is more commonly known as sick building syndrome.

A team of researchers at the U.S. Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) has found evidence that the prevalence of building-related symptoms (BRS) increases with increasing outdoor concentrations of the pollutant ozone. They have also discovered that the type of air filter that some buildings use in their ventilation systems may also play a role in the prevalence of BRS.

BRS, more commonly known as sick building syndrome, is a set of health symptoms reported by office workers which improve when they leave the work environment. The symptoms can include irritation of the eyes, nose, throat, respiratory tract, and skin, as well as headache and fatigue.

This is the first epidemiological evidence from a field study of a link between ambient ozone levels and BRS. It is also the first field evidence linking

BRS to a specific filtration technology used in large buildings.

The study was conducted by Michael Apte, Ian Buchanan, Mark Mendell, and Anna Mirer of Berkeley Lab's Environmental Energy Technologies Division in collaboration with the U.S. Environmental Protection Agency (EPA), which collected the data.

Results originated from the team's analysis of data from an EPA study called BASE (Building Assessment Survey and Evaluation), in which 100 U.S. office buildings were studied for one week each in either the summer or winter between 1994 and 1998. That study included surveys of office workers and their self-reported health conditions, weather and workplace data, and environmental conditions in and around the buildings.

(No data on indoor or outdoor ozone levels was collected during the EPA's BASE study. Ozone data used in this analysis was obtained from the historical records of ambient air quality monitoring stations near the BASE buildings during the same time periods as the BASE buildings were studied.)

According to Apte, "Based on patterns of associations between building-related symptoms and certain volatile organic compounds indoors, we hypothesized that increasing levels of outdoor ozone would lead to higher prevalence of building-related symptoms among the occupants within a building."

Their analysis of the BASE data shows that the prevalence of upper respiratory symptoms in a building increases linearly with increasing concentration of outdoor ozone. It also shows that the indoor concentrations of formaldehyde, acetaldehyde, and organic acids including

pentanal, hexanal and nonanal increased with increasing outdoor ozone. All of these are known sensory irritants, and formaldehyde is a known carcinogen.

From a long history of previous studies in the laboratory, scientists know that ozone can cause ill health in humans—this is why it is regulated as an outdoor pollutant. More recent lab studies have also proven that ozone reacts with organic molecules typically found indoors to produce short-lived chemicals that are irritating, and may be toxic or carcinogenic if a human is chronically exposed to them. For example, formaldehyde and acetaldehyde are produced when ozone reacts with commonly found organic chemicals; both are irritants.

Lab studies suggest that these chemicals may have a large impact on indoor air quality. However, until the current study, there has been no direct field evidence of a correlation between outdoor ozone and a health condition inside a building.

In a second paper, the researchers report on how different types of building air filters can affect the prevalence of BRS symptoms. Data from a subset of buildings in the BASE study showed strong statistical connections between a certain type of air filter and increased BRS. Air filters are made of different types of materials, including polyester/synthetic fibers, fiberglass, natural filters made of cotton or cellulose, or natural-synthetic blends. Their purpose is to remove particles and other contaminants from the building's air.

The team found that the combination of higher outdoor ozone levels and the use of a polyester or other synthetic filter correlates with a statistically significant increase in the prevalence of BRS compared to other types of air filters. This filter showed a significant association with lower and upper respiratory symptoms, cough, sore eyes, fatigue, and headache.

By contrast, far fewer symptoms were reported in buildings with high ozone and fiberglass filters, or in situations where the building used polyester/synthetic filters and the outdoor air had lower ozone concentrations.

The research suggests that replacing the polyester/synthetic filter could have a major positive impact, reducing BRS prevalence by up to 75 percent in buildings with high outdoor ozone concentrations, and by up to 39 percent in lower ozone environments. "The study estimated that removing both risk factors—higher ozone in outdoor air and polyester/synthetic filters—could reduce BRS by 26 to 62 percent," says Apte.

Apte notes that the results of both studies require further verification. "This research is a first step, and it needs to be replicated in other studies with a statistical design specifically to address the ozone-symptom association and with accurate information on filters and ozone levels. The strongest studies would involve controlled interventions on these two factors," he says.

"However, if future research confirms these results, then we may have a path toward reducing building-related symptoms as well as illness caused by chronic exposure to ozone in the indoor environment, through the use of ozone removal technologies in ventilation systems."

Two papers describing the results will be published in the journal *Indoor Air* — "Outdoor Ozone and Building Related Symptoms in the BASE Study," by M. Apte, I. Buchanan, and M. Mendell, and "Air Filter Materials, Outdoor Ozone and Building-Related Syndrome in the BASE Study," by I. Buchanan, M. Mendell, A. Mirer, and M. Apte. The work was funded by the Centers for Disease Control—National Institute for Occupational Safety and Health.

Source: Berkeley Lab

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