

Medical News & Perspectives

Air Quality and Brain Health

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In 2020, a panel of international experts added exposure to air pollution late in life to a list of modifiable risk factors for dementia. Although exposure to nitrogen dioxide and fine particulate matter (PM_{2.5}) has been associated with increased risk of dementia, an important question remains: Can air pollution also influence cognitive decline?

It's not that the issue has gone unexamined. Studies examining associations of air pollution with cognitive decline have produced inconsistent results, ranging from significant to weak or no effects. Now, a study published recently in *PLOS Medicine* reports that living in US locations where air quality improved over 10 years was associated with measures suggesting slower cognitive declines among older women.

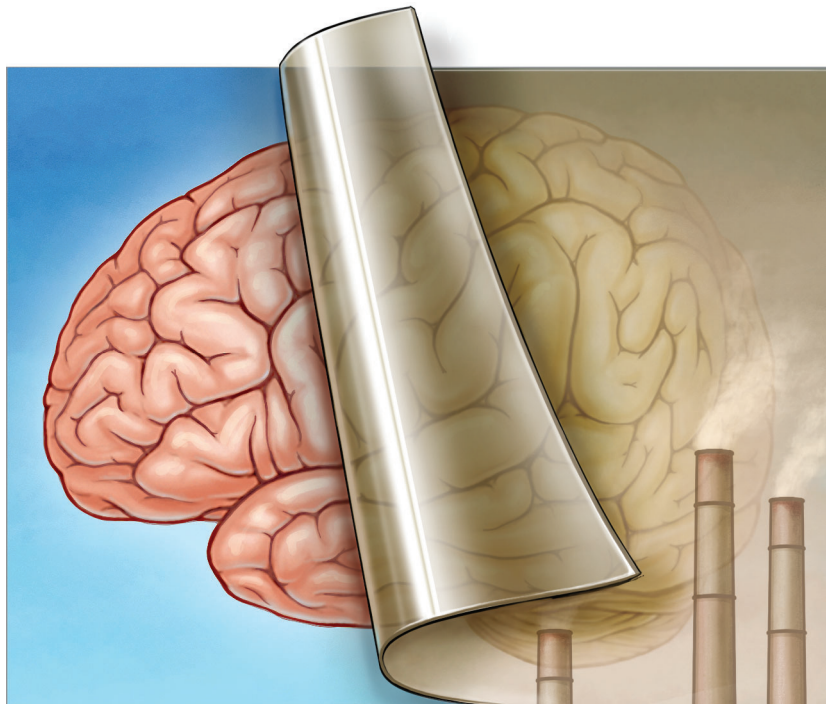
"This is a very important study because it shows that you can do something about keeping cognitive abilities intact longer," Beate Ritz, MD, PhD, professor of epidemiology, environmental health, and neurology at the University of California, Los Angeles Fielding School of Public Health, said in an interview. Ritz studies the effects of air pollution on neurodegenerative and neurodevelopmental disorders but wasn't involved in the *PLOS Medicine* study.

An Environmental Observation

The authors of that study conclude that their observation strengthens the epidemiological evidence of an association between air pollution and cognitive aging and suggests a potential benefit of improved air quality on cognitive health.

"In later life, there are only a handful of modifiable risk factors that can keep the brain free of dementia or other neurodegenerative diseases," senior author Jiu-Chuan Chen, MD, ScD, associate professor of population and public health sciences at USC's Keck School of Medicine, said in an interview.

The study included 2232 women aged 74 to 92 years who participated in the Women's Health Initiative Memory Study-Epidemiology of Cognitive Health Out-



comes (WHIMS-ECHO) study. Most of the participants were non-Hispanic White women, and none had dementia at baseline. The investigators measured participants' general cognitive function and episodic memory annually from 2008 to 2018 via telephone-based screening and testing. They also estimated annual concentrations of PM_{2.5} generated from vehicle exhaust, gases emitted from power plants and steel mills, industrial processes, fuel combustion, and forest fires—and nitrogen dioxide from 1996 to 2012 at each participant's home address.

Women who lived in locations where the air quality had improved over 10 years had test scores for general cognitive status and episodic memory—an important indicator of early Alzheimer disease—that were equivalent to cognitive aging in women up to 1.6 years younger. The investigators reported the estimated associations equivalent to slower declines remained regardless of education level, geographic region, cardiovascular risk factors, and apolipoprotein E ε4 genotype, which is a strong genetic risk factor for dementia.

The authors of the article acknowledged that their study was susceptible to limitations that are characteristic of observational studies.

Mounting Evidence

Other articles, published around the same time as the *PLOS Medicine* study, also detail associations of improved air quality and cognitive health.

A study in *The Lancet Healthy Longevity* of 2812 individuals reported a smaller decline in scores on a test measuring global cognitive function among older adults in areas of China where the government set air quality improvement targets than for a control group in regions without targeted air pollution reduction.

Similarly, a study in *Alzheimer's & Dementia* among 7051 adults aged 65 years or older living in Bordeaux, Dijon, or Montpellier in France showed that observed and hypothetical PM_{2.5} reduction was associated with reduced risk of dementia.

Another study Chen coauthored examining the WHIMS-ECHO data and published

in *PNAS* found that living in locations with the greatest reductions in PM_{2.5} and nitrogen dioxide was associated with lower risk of dementia.

And, a 2020 study published in *The Lancet Planetary Health* examined data for all fee-for-service Medicare beneficiaries and found an association between long-term exposure to PM_{2.5} and an increased risk of first hospital admission for Parkinson disease, Alzheimer disease, and other dementias—including at levels deemed safe by the US Environmental Protection Agency (EPA). Women, White individuals, and urban populations were particularly susceptible, the study showed.

Brains and Air Pollution

Three prevailing hypotheses suggest how air pollutants create havoc in aging brains, Chen said. One is that ultrafine particulate matter can bypass the blood-brain barrier and cause direct damage by activating the microglia and causing loss of neurons, he explained. Another hypothesis involves neuroimmune cross-talk. "Particles in the lungs or bloodstream might alert the immune system and trigger inflammation in the brain," he noted. Swallowed particles might also perturb the gut microbiome, which, in turn, disrupts the brain. A third hypothesis is that air pollution causes cerebrovascular damage, which then contributes to the development and progression of Alzheimer disease neuropathology.

Room for Improvement

Although US air pollution levels have dropped by 70% since President Richard Nixon signed the Clean Air Act in 1970, some of the gains have recently eroded. "Between 2017 and 2021...air pollution regulations were relaxed," pediatrician and epidemiologist Philip Landrigan, MD, MSc, director of Program for Global Public Health and the Common Good at Boston College, said during an interview.

The EPA establishes national air quality standards for 6 pollutants to safeguard the health of vulnerable populations such as children, elderly individuals, and people with asthma. The current US standard for PM_{2.5} is an annual average of 12.0 µg/m³.

In an August 2020 editorial published in the *New England Journal of Medicine*, members of the EPA Clean Air Scientific Advisory Committee Particulate Matter Review Panel said the risk of premature deaths from long-term exposure at existing PM_{2.5} levels was "unacceptably high." The experts estimated that under the current standard, from 13 500 to 52 100 people in the US prematurely die annually from air pollution. They advised an annual standard of 8 to 10 µg/m³, but the EPA announced in December 2020 that it wouldn't change the existing PM_{2.5} standards.

In September 2021, the World Health Organization (WHO) set even more stringent air quality guidelines, noting that for PM_{2.5} "no threshold has been identified below which no damage to health is ob-

served." The WHO's recommended annual exposure limit to PM_{2.5} is 5 µg/m³.

Lifestyle Modifications

As clinicians advise their patients on lifestyle modifications that can reduce the risk of disease, air pollution exposure should enter into conversations with older patients and those with heart disease, diabetes, or lung disease, Landrigan said.

He and other experts recommend avoiding travel times and routes with traffic congestion and walking, jogging, or bicycling along sparsely trafficked roads. In addition, they noted, it's advisable to minimize outdoor exercise when air pollution levels are high or exercise indoors instead. When possible, people also should use air conditioning on high pollution days. Updates on local air quality are available through the EPA site <https://airnow.gov>.

However, clinicians can do more than offer advice to help patients protect themselves from air pollution. "Physicians and health care providers can act together as a powerful social conscience in this country and persuade political leadership to take action to protect people's health by ending pollution," Landrigan said. "When doctors and nurses speak with a collective voice, it's a voice that gets heard." ■

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