

What the Air You Breathe May Be Doing to Your Brain

Increasing evidence shows exposure to fine particulate matter not only damages lungs and hearts but is also associated with dementia.

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For years, the two patients had come to the Penn Memory Center at the University of Pennsylvania, where doctors and researchers follow people with cognitive impairment as they age, as well as a group with normal cognition.

Both patients, a man and a woman, had agreed to donate their brains after they died for further research. “An amazing gift,” said Edward Lee, the neuropathologist who directs the [brain bank](#) at the university’s Perelman School of Medicine. “They were both very dedicated to helping us understand Alzheimer’s disease.”

The man, who died at 83 with dementia, had lived in the Center City neighborhood of Philadelphia with hired caregivers. The autopsy showed large amounts of amyloid plaques and tau tangles, the proteins associated with Alzheimer’s disease, spreading through his brain.

Researchers also found infarcts, small spots of damaged tissue, indicating that he had suffered several strokes.

By contrast, the woman, who was 84 when she died of brain cancer, “had barely any Alzheimer’s pathology,” Lee said. “We had tested her year after year, and she had no cognitive issues at all.”

The man had lived a few blocks from Interstate 676, which slices through downtown Philadelphia. The woman had lived a few miles away in the suburb of Gladwyne, Pennsylvania, surrounded by woods and a country club.

The amount of air pollution she was exposed to — specifically, the level of fine particulate matter called PM2.5 — was less than half that of his exposure. Was it a coincidence that he had developed severe Alzheimer’s while she had remained cognitively normal?

With increasing evidence that chronic exposure to PM2.5, a neurotoxin, not only damages lungs and hearts but is also associated with dementia, probably not.

“The quality of the air you live in affects your cognition,” said Lee, the senior author of a recent [article in JAMA Neurology](#), one of several large studies in the past few months to demonstrate an association between PM2.5 and dementia.

Scientists have been tracking the connection for at least a decade. In 2020, the influential Lancet Commission [added air pollution](#) to its list of modifiable risk factors for dementia, along with common problems like hearing loss, diabetes, smoking, and high blood pressure.

Yet such findings are emerging when the federal government is dismantling efforts by previous administrations to continue reducing air pollution by shifting from fossil fuels to renewable energy sources.

“‘Drill, baby, drill’ is totally the wrong approach,” said John Balmes, a spokesperson for the American Lung Association who researches the effects of air pollution on health at the University of California-San Francisco.

“All these actions are going to decrease air quality and lead to increasing mortality and illness, dementia being one of those outcomes,” Balmes said, referring to recent environmental moves by the White House.

Many factors contribute to dementia, of course. But the role of particulates — microscopic solids or droplets in the air — is drawing closer scrutiny.

Particulates arise from many sources: emissions from power plants and home heating, factory fumes, motor vehicle exhaust, and, increasingly, wildfire smoke.

Of the several particulate sizes, PM2.5 “seems to be the most damaging to human health,” Lee said, because it is among the smallest. Easily inhaled, the particles enter the bloodstream and circulate through the body; they can also travel directly from the nose to the brain.

The research at the University of Pennsylvania, the largest autopsy study to date of people with dementia, included more than 600 brains donated over two decades.

Previous research on pollution and dementia mostly relied on epidemiological studies to establish an association. Now, “we’re linking what we actually see in the brain with exposure to pollutants,” Lee said, adding, “We’re able to do a deeper dive.”

The study participants had undergone years of cognitive testing at Penn Memory. With an environmental database, the researchers were able to calculate their PM2.5 exposure based on their home addresses.

The scientists also devised a matrix to measure how severely Alzheimer’s and other dementias had damaged donors’ brains.

Lee’s team concluded that “the higher the exposure to PM2.5, the greater the extent of

Alzheimer's disease," he said. The odds of more severe Alzheimer's pathology at autopsy were almost 20% greater among donors who had lived where PM2.5 levels were high.

Another research team recently [reported a connection](#) between PM2.5 exposure and Lewy body dementia, which includes dementia related to Parkinson's disease. Generally considered the second most common type after Alzheimer's, Lewy body accounts for an estimated 5% to 15% of dementia cases.

In what the researchers believe is the largest epidemiological study to date of pollution and dementia, they analyzed records from more than 56 million beneficiaries with traditional Medicare from 2000 to 2014, comparing their initial hospitalizations for neurodegenerative diseases with their exposure to PM2.5 by ZIP codes.

"Chronic PM2.5 exposure was linked to hospitalization for Lewy body dementia," said Xiao Wu, an author of the study and a biostatistician at the Mailman School of Public Health at Columbia University.

After controlling for socioeconomic and other differences, the researchers found that the rate of Lewy body hospitalizations was 12% higher in U.S. counties with the worst concentrations of PM2.5 than in those with the lowest.

To help verify their findings, the researchers nasally administered PM2.5 to laboratory mice, which after 10 months showed "clear dementia-like deficits," senior author Xiaobo Mao, a neuroscientist at the Johns Hopkins School of Medicine, wrote in an email.

The mice got lost in mazes that they had previously dashed through. They had earlier built nests quickly and compactly; now their efforts were sloppy, disorganized. At autopsy, Mao said, their brains had atrophied and contained accumulations of the protein associated with Lewy bodies in human brains, called alpha-synuclein.

A [third analysis](#), published this summer in The Lancet, included 32 studies conducted in Europe, North America, Asia, and Australia. It also found "a dementia diagnosis to be significantly associated with long-term exposure to PM2.5" and to certain other pollutants.

Whether so-called ambient air pollution — the outdoor kind — increases dementia because of inflammation or other physiological causes awaits the next round of research.

Although air pollution has declined in the United States over two decades, scientists are calling for still stronger policies to promote cleaner air. "People argue that air quality is expensive," Lee said. "So is dementia care."

President Donald Trump, however, reentered office vowing to increase [the extraction and use of fossil fuels](#) and to block the transition to renewable energy. His administration [has rescinded tax incentives](#) for solar installations and electric vehicles, Balmes noted, adding, "They're encouraging continuing to burn coal for power generation."

The administration has [halted new offshore wind farms](#), announced [oil and gas drilling](#) in the Arctic National Wildlife Refuge in Alaska, and moved to stop [California's plan](#) to transition to electric cars by 2035. (The state has challenged that action in court.)

"If policy goes in the opposite direction, with more air pollution, that's a big health risk for older adults," Wu said.

Last year, under the Biden administration, the Environmental Protection Agency [set tougher annual standards](#) for PM2.5, noting that "the available scientific evidence and technical information indicate that the current standards may not be adequate to protect public health and welfare, as required by the Clean Air Act."

In March, the EPA's [new chairman announced](#) that the agency would be "revisiting" those stricter standards.

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