Medical Xpress

Even 'safe' air pollution levels can harm the developing brain, study finds

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Air pollution is known to contribute to disease, which is why regulators such as the Environmental Protection Agency (EPA) set limits on emissions. But mounting evidence suggests that even pollution levels long thought to be safe can increase the risk of health problems, including in the brain.

Now, research from the Keck School of Medicine of USC has shown that even levels of certain pollutants considered safe by the EPA are linked to changes in brain function over time. The study, just published in the journal *Environment International*, used brain scan data from more than 9,000 participants in the Adolescent Brain Cognitive Development (ABCD) study, the largest-ever nationwide study of youth brain health. Children exposed to more pollutants showed changes in connectivity between various brain regions. In some areas, they had more connections than normal; in other areas, they had fewer.

"A deviation in any direction from a normal trajectory of brain development—whether brain networks are too connected or not connected enough—could be harmful down the line," said Devyn L. Cotter, MSc, a doctoral candidate in neuroscience at the Keck School of Medicine and first author of the study.

Communication between regions of the brain help us navigate virtually every moment of our day, from the way we take in information about our surroundings to how we think and feel. Many of those critical connections develop between the ages of 9 and 12 and can influence whether children experience normal or atypical cognitive and emotional development.

"Air quality across America, even though 'safe' by EPA standards, is contributing to changes in brain networks during this critical time, which may reflect an early biomarker for increased risk for cognitive and emotional problems later in life," said Megan M. Herting, Ph.D., associate professor of population and public health sciences at the Keck School of Medicine and the study's senior author.

Changes in brain connectivity

To explore the link between air pollution and brain development, Herting, Cotter and their colleagues analyzed functional MRI scans from 9,497 participants in the ABCD study. Baseline brain scans were collected from children, ages 9 to 10, and a subset of children had follow-up scans collected two years later, allowing researchers to observe how brain connectivity changed over time. In particular, they analyzed the salience, frontoparietal and default-mode brain networks, as well as the amygdala and hippocampus—key regions of the brain known to be involved in emotion, learning, memory and other complex functions.

Next, the researchers used EPA and other data to map air quality at each child's residence, including levels of fine particulate matter ($PM_{2.5}$), nitrogen dioxide (NO_2) and ground-level ozone (O_3). They then used advanced statistical tools to investigate how air pollution levels relate to changes in brain connectivity over time. In other words: are young brains developing differently when they are exposed to more pollution?

Greater exposure to $PM_{2.5}$ was linked to relative increases in functional connectivity between regions, while more exposure to NO_2predicted relative decreases in connectedness. Exposure to higher levels of O_3 was associated with greater connections within the brain's cortex, but fewer connections between the cortex and other regions, such as the amygdala and hippocampus.

To rule out other factors that could explain differences in brain development, the researchers controlled for sex, race/ethnicity, parental education level, household income, urban versus rural location and seasonality, as air pollution varies across winter and summer months.

Tightening air quality rules

The findings could prompt regulators to consider brain health, in addition to lung and cardiometabolic heath, when they set or adjust recommendations for air quality. While the EPA proposed strengthening standards for $PM_{2.5}$ earlier this year, guidelines for annual NO_2 have not changed since they were first set in 1971.

"On average, air pollution levels are fairly low in the U.S., but we're still seeing significant effects on the brain," Cotter said. "That's something policymakers should take into account when they're thinking about whether to tighten the current standards."

Cotter, Herting and their colleagues aim to look more closely at the chemical makeup of pollutants to determine how and why they cause harm in the brain, which could help further refine regulations. They also plan to continue using data from the ABCD study to analyze brain health over time.

"Long term, does this lead to risk for psychopathology that continues to ramp up during mid- to late- adolescence? How does this affect people's trajectory of mental health?" Herting said.

More information: Devyn L. Cotter et al, Effects of ambient fine particulates, nitrogen dioxide, and ozone on maturation of functional brain networks across early adolescence, *Environment International* (2023). DOI: 10.1016/j.envint.2023.108001

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