Association between Traffic-Related Air Pollution in Schools and Cognitive Development in Primary School Children: A Prospective Cohort Study

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Abstract

Background

Air pollution is a suspected developmental neurotoxicant. Many schools are located in close proximity to busy roads, and traffic air pollution peaks when children are at school. We aimed to assess whether exposure of children in primary school to traffic-related air pollutants is associated with impaired cognitive development.

Methods and Findings

We conducted a prospective study of children (n = 2,715, aged 7 to 10 y) from 39 schools in Barcelona (Catalonia, Spain) exposed to high and low traffic-related air pollution, paired by school socioeconomic index; children were tested four times (i.e., to assess the 12-mo developmental trajectories) via computerized tests (n = 10,112). Chronic traffic air pollution (elemental carbon [EC], nitrogen dioxide [NO2], and ultrafine particle number [UFP; 10–700 nm]) was measured twice during 1-wk campaigns both in the courtyard (outdoor) and inside

the classroom (indoor) simultaneously in each school pair. Cognitive development was assessed with the *n*-back and the attentional network tests, in particular, working memory (two-back detectability), superior working memory (three-back detectability), and inattentiveness (hit reaction time standard error). Linear mixed effects models were adjusted for age, sex, maternal education, socioeconomic status, and air pollution exposure at home.

Children from highly polluted schools had a smaller growth in cognitive development than children from the paired lowly polluted schools, both in crude and adjusted models (e.g., 7.4% [95% CI 5.6%–8.8%] versus 11.5% [95% CI 8.9%–12.5%] improvement in working memory, $p = 0.0024$). Cogently, children attending schools with higher levels of EC, NO2, and UFP both indoors and outdoors experienced substantially smaller growth in all the cognitive measurements; for example, a change from the first to the fourth quartile in indoor EC reduced the gain in working memory by 13.0% (95% CI 4.2%–23.1%). Residual confounding for social class could not be discarded completely; however, the associations remained in stratified analyses (e.g., for type of school or high-/low-polluted area) and after additional adjustments (e.g., for commuting, educational quality, or smoking at home), contradicting a potential residual confounding explanation.

Conclusions

Children attending schools with higher traffic-related air pollution had a smaller improvement in cognitive development.

Editors' Summary

Background

Human brain development is a complex and lengthy process. During pregnancy, the basic structures of the brain are formed, and the neural circuits that will eventually control movement, speech, memory, and other cognitive (thinking) functions, as well as the function of many organs, begin to be established. By the time of birth, the brain is about a quarter of its adult size, and the neural circuits that control vital bodily functions such as breathing are well developed. By contrast, the cerebral cortex—the brain region that is involved in thought and action—is poorly developed. Much of the development of the cerebral cortex happens during the first two years of life. For example, babies usually learn to crawl at about nine months. Other aspects of brain function take longer to develop. Thus, the cognitive functions that are essential for learning undergo considerable development between the ages of 6 and 10 years, and further brain changes occur during adolescence.

Why Was This Study Done?

Exposure to the air pollutants produced by the combustion of fossil fuels by vehicles during pregnancy or infancy has been associated with delays in cognitive development. Moreover, experiments in animals suggest that traffic-related air pollution is a developmental neurotoxicant—a factor that disrupts brain development. However, although many schools are located next to busy roads and although traffic-related air pollution levels peak during school hours, it is not known whether exposure of school-age children to traffic-related air pollutants impairs their cognitive development and thus their ability to learn. Here, in a prospective cohort study (the BREATHE study), the researchers assess whether exposure of

children aged 7–10 years to traffic-related air pollutants in schools in Barcelona, Spain, is associated with impaired cognitive development. A prospective cohort study is an observational investigation that studies groups (cohorts) of individuals who differ with respect to a specific factor to determine how exposure to this factor affects specific outcomes.

What Did the Researchers Do and Find?

The researchers used computerized tests to measure the development of working memory (the system that holds multiple pieces of transitory information in the mind where they can be manipulated), superior working memory (working memory that involves continuous updating of the working memory buffer), and attentiveness every three months over a 12-month period in 2,715 primary school children attending 39 schools exposed to high or low levels of traffic-related air pollution and paired by socioeconomic index. That is, the researchers compared three cognitive development outcomes in the children attending each school where exposure to air pollution was high with the same outcomes in children attending a school with a similar socioeconomic index where exposure to pollution was low; school pairing was undertaken to avoid "confounding" by social class, a factor that is known to affect cognitive development. Statistical analyses of these data indicated that the increase in cognitive development over time among children attending highly polluted schools was less than that among children attending paired lowly polluted schools, even after adjusting for additional factors that affect cognitive development. Thus, for example, there was an 11.5% 12-month increase in working memory at the lowly polluted schools but only a 7.4% 12-month increase in working memory at the highly polluted schools. Other analyses indicated that children attending schools with higher levels of traffic-related air pollutants in either the courtyard or in the classroom experienced a substantially smaller increase over the 12-month study in all three cognitive measurements than those attending schools with lower levels of pollutants.

What Do These Findings Mean?

These findings suggest that, compared with attendance at schools exposed to low levels of traffic-related air pollution, attendance at schools exposed to high levels of traffic-related air pollution is associated with a smaller increase in cognitive development over a 12-month period among 7- to 10-year-old children in Barcelona. The accuracy of these findings may be limited by residual confounding. That is, the children attending schools where traffic-related pollution is high might have shared other unknown characteristics that affected their cognitive development. Importantly, these findings do not prove that traffic-related air pollution causes impairment of cognitive development. Rather, they suggest that the developing brain may be vulnerable to traffic-related air pollution well into middle childhood, a conclusion that has implications for the design of air pollution regulations and for the location of new schools.