

Air Pollution and Learning

A. Patrick Behrer, Joshua Goodman, J. Parker Goyer, R. Jisung Park

POLICY ISSUE

Nearly everyone breathes polluted air. Ninety-nine percent of the world's population lives in places that exceed the World Health Organization's recommended levels of ambient particulate matter. Exposure is also uneven: in the United States, lower-income communities and communities of color have long experienced more exposure to polluted air than their counterparts. Poor air quality is typically treated as a health issue and environmental concern, but it can also have detrimental effects on learning through its interference with cognition, physical well-being, and normal school operations, potentially exacerbating educational inequality. Prior research shows that air pollution diminishes student performance on the day of an exam, raising further questions about the effects of sustained exposure over time. A new study uses national, student-level data to examine how exposure to polluted air over the course of a school year affects student learning, when that exposure matters most, and which students bear the greatest cost.

STUDY DATA & FINDINGS

The authors used College Board data on nearly 10 million students at roughly 25,000 U.S. high schools who took the PSAT at least twice between 2007 and 2016. They paired these scores with daily estimates of the amount of fine ambient particulate matter around each school, calculating the number of days in the year before each PSAT exam that were moderately or heavily polluted. Because many students take the PSAT more than once, the authors were able to compare the same student's scores across exams preceded by "cleaner" and "dirtier" years with respect to the number of polluted days. This allowed them to separate the effects of pollution exposure from other factors specific to each student, such as academic ability, family background, and school environment. They also separated the effects of pollution from local changes that might directly affect learning, such as a new factory or an economic downturn, by focusing on changes in air quality driven by smoke from distant wildfires.

KEY FINDINGS

Air pollution exposure measurably slows learning

- 1 year of air pollution exposure leads to PSAT scores decreasing by 14-19% of typical annual growth
- Moderate pollution matters more than heavy pollution
- Pollution on school days matters more than summer pollution

Air pollution exposure widens achievement gaps

- Effects are 3 times larger in socioeconomically disadvantaged schools
- Effects are large for Black & Hispanic students, not observed for White & Asian students

The authors found:

A year of pollution exposure measurably slows learning, lowering PSAT scores by 14–19 percent of typical annual score growth. That is comparable to the amount of learning lost from roughly 5–10 additional days of absence during a school year.

The harm comes from routine, moderate pollution rather than extreme events. The average student experiences more than 100 moderately polluted days per year, at air quality levels generally considered safe according to EPA standards. Each additional day of exposure to moderate air pollution leads to a small but statistically significant decrease in PSAT scores, whereas heavy pollution days do not appear to have a clear impact on test performance.

Pollution during the school year, not the summer, drives the effect. The authors found that each moderately polluted school day contributed to measurable decreases in PSAT scores, while pollution during the summer showed no clear effects. This finding suggests that the negative impact of sustained air pollution exposure is more likely driven by disruptions to classroom instruction and short-term interference with cognitive processes such as attention and memory than by long-term health effects alone.

Exposure to air pollution widens achievement gaps. Effects are three times larger in socioeconomically disadvantaged schools than in schools with more resources. And air pollution is most harmful to Black and Hispanic students. The effects of moderately and heavily polluted school days are large and statistically significant for Black and Hispanic students but not observable for White and Asian students at all. This is true even though these groups differ only modestly in their exposure to pollution, with Black and Hispanic students experiencing about 8 more moderate pollution days and 3 more heavy pollution days than their White and Asian peers. In other words, the same exposure does more damage to disadvantaged students, compounding educational disparities substantially.

POLICY IMPLICATIONS

Education effects are rarely counted in the costs and benefits of air quality regulation, and these findings suggest they merit a place in that analysis. However, the findings also demonstrate that poor air quality is an education policy and leadership concern in addition to a public health and environmental issue. State, district, and school leaders have a role to play in reducing harm for students exposed to air pollution, particularly those who face the highest costs of this exposure.

School building investments are one practical lever for mitigating the negative learning effects of air pollution. Because these effects are concentrated during the school year, the air quality inside school buildings matters. Prior research finds large test score gains from HVAC upgrades, particularly in disadvantaged schools, and the current study's findings suggest that cleaner air could explain part of those gains. States and districts weighing facilities investments should consider air filtration, ventilation, and monitoring tools as high priorities in these decisions. Furthermore, district air quality protocols often focus on extreme events, such as closing schools or canceling outdoor activities during heavy wildfire smoke. But the negative test score effects documented in this study are shown to accumulate over many moderately polluted days that are unlikely to trigger a procedural response. School systems can support their long-term facilities investments with the knowledge that ordinary polluted days deserve attention alongside air quality emergencies.

Finally, addressing unequal harm requires more than just addressing unequal exposure. The authors found that Black and Hispanic students are exposed to only somewhat more days of air pollution than White and Asian students but experience greater negative effects on their learning for each day of exposure. This suggests that efforts focused only on reducing exposure will fall short of addressing the deeper mechanisms at play. Although we don't yet know why sensitivity to air pollution differs for different groups, we know that mitigation resources are most needed in schools serving students with the greatest risk of experiencing harm.

ADDITIONAL RESOURCES

Park, R. J., Goodman, J., Hurwitz, M., & Smith, J. (2020). Heat and learning. *American Economic Journal: Economic Policy*, 12(2), 306–339. Using the same PSAT retaker design, this study finds that hotter school days reduce learning, while weekend and summer temperatures have little impact.

The EPA's Indoor Air Quality Tools for Schools: This resource hub helps schools develop and sustain indoor air quality (IAQ) management programs.

The Sustainable Built Environment Lab at Boston University: BU-SBEL researches IAQ in schools, including in Boston Public Schools, the first school district in the country to install and share IAQ data from thousands of classroom monitors.

SUGGESTED CITATION

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wheelockpolicycenter.org

wheelockpolicy@bu.edu



Boston University Wheelock College of Education & Human Development
Wheelock Educational Policy Center

