Lead Exposure and Academic Performance

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Children today are exposed to numerous environmental toxins, and a large body of research indicates that these toxins can substantially damage their health and development. One particularly insidious toxin, lead, has been aggressively targeted by U.S. public policy. How has society benefited from the public health efforts on lead? More specifically, can we see improvements in children's cognitive performance as a consequence of their lessened exposure?[1]

Lead and Policy

Although lead is extremely useful in improving the performance of paint, gasoline, and plumbing, it is also dangerous. Extensive evidence indicates that even moderate exposure in childhood can have long-lasting adverse effects on an individual's neurological development, behavior, and cognitive performance.[2] Happily, lead is one of the great success stories of environmental and public health policy. At the national level, it was removed from paint and gasoline in the 1970s, yielding broad reductions in lead levels across all ages and demographic groups.[3] At the state level, public health campaigns have systematically reduced exposure for children in many places.

Massachusetts has been at the forefront of these efforts. Since the 1970s, the Massachusetts Childhood Lead Poisoning Prevention Program (CLPPP) has overseen the mandatory lead screening of all children under the age of 6, the provision of appropriate medical and environmental services to affected families, and the implementation of policies aimed at eliminating sources of lead exposure. These endeavors have drastically reduced levels among Massachusetts children, so that in recent years less than 1 percent of screened children have exhibited elevated lead levels.

Given what we know about the levels at which lead affects child development, it is likely that the low and moderate levels that were common in the 1990s in Massachusetts would have impaired children's cognitive performance. Accordingly, it is plausible that lead policy had measurable effects on academic performance as children born in the 1990s grew up in the 2000s.

Less Lead, Better Scores

Using data from Massachusetts in the past two decades, I studied the link between lead exposure in early childhood and academic performance in elementary school. The dataset was constructed from blood-lead data collected by the CLPPP and test-score data collected by the Massachusetts Department of Elementary and Secondary Education. The sample included nearly all children who were born between 1991 and 2000 in Massachusetts and who attended public elementary schools in the state between 2000 and 2009. The approximately 700,000 children were grouped into school-cohort groups by the elementary school they attended (out of approximately 1,200 in the state) and by their age cohort. Measures of each group's early-childhood lead were constructed from measurements of individuals' blood lead. Measures of each group's elementary-school academic achievement were constructed from individuals' scores on the Massachusetts Comprehensive Assessment System (MCAS) in the third and fourth grades.[4] The data included numerous controls for characteristics of the schools and communities.

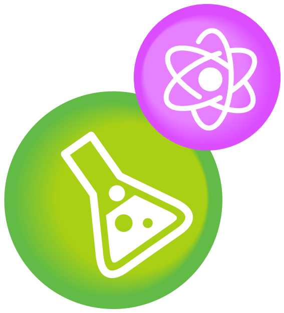
Can we see improvements in children's cognitive performance as a consequence of lessened lead exposure?

The results support the hypothesis that childhood lead exposure adversely affects academic performance and that policies targeting lead had substantial benefits. First, there is a strong cross-sectional relationship between early-childhood lead levels and elementary-school test scores. Towns where children have higher lead levels tend to have lower MCAS scores. Moreover, a comparison of relative changes over time reveals that, for the most part, schools whose student population experienced larger decreases in lead exposure in the 1990s also experienced larger increases in MCAS scores in the 2000s.

Since characteristics of towns or schools could be driving some of these relationships, it is important to control for factors such as school spending, the share of low-income students, the town's per capita income, and its demographic composition. Panel data analysis that included such controls also yielded strong results: the share of a group with elevated blood lead had a statistically significant positive effect on the share of that group scoring unsatisfactory on the MCAS in both English Language Arts and Mathematics.

In the fully controlled specification, a 1 percentage point increase in the share of children with lead above the Center for Disease Control's level of concern (a technical measurement of 10 µg/dL, 10 micrograms per deciliter) was associated with an increase of 0.2 percentage points in the share of that group getting an unsatisfactory score. For higher lead levels, the effects were larger: a 1 percentage point increase in the share with lead above 20 µg/dL was associated with a 1 percentage point increase in the share of that group scoring unsatisfactoryily. Thus in a group of 100 children, the movement of one child's lead level past the 20 µg/dL mark causes one child's performance level to fall below satisfactory. So school cohorts that include more children with elevated blood lead in early childhood also include more children who score unsatisfactory, even removing the influence of other determinants that might be associated with lead levels.

To understand what this means for Massachusetts, I performed several straightforward simulations.[5] The exercises indicated that public health policy was responsible for modestly reducing unsatisfactory test



performance statewide. In the 1990s, policy reduced the share of Massachusetts children with blood lead levels above 10 µg/dL from 11 percent to 3 percent. That decline is estimated to be responsible for a 2 percentage point decline in the share of children scoring unsatisfactory on the MCAS. When considered relative to the fact that approximately one-third of children score unsatisfactory in any given year, this amounts to an approximate 5 percent reduction in unsatisfactory performance. That reduction is equivalent to the performance improvement that would have been associated with an across-the-board increase in income per capita of $1,000-$2,000.

Moreover, simulations that separate communities by income indicated that lead policy also was responsible for reducing achievement gaps between low-income and middle-income communities. That can be seen by comparing the effects of lead policy with the effects of tax or spending policy that would increase family income in low-income communities. To achieve—without the 1990s decline in lead—the same "time path" of test-score performance that was seen over the sample period, per capita income would have had to go up by 15 percent for low-income communities. By closing the lead gap, lead policy achieved test-score improvements similar to what would be achieved by closing one-fifth of the income gap between low- and middle-income communities.

Policy Lessons

Studying lead and academic performance in a state that has significantly reduced children's blood lead levels has confirmed that lead does adversely affect academic performance and that the societal impact of aggressive public health policy is significant. Furthermore, the benefits appear to be a bargain. Annual government spending on lead policy in Massachusetts is currently less than $5 million—several orders of magnitude smaller than annual government spending on education in Massachusetts. The results suggest that public health policy not only has been effective in improving academic outcomes and reducing inequality, but also has been relatively frugal. Continuing research will employ individual-level data to identify these effects better and will employ a more comprehensive benefit-cost analysis of lead policy in the context of broader social policy.

One lesson to take from the research is that policymakers concerned with improving academic outcomes may want to broaden their view, looking beyond traditional education policies to consider other environmental and public health policies that can dramatically alter children's cognitive and social development. A growing body of research has yielded diverse evidence that early-childhood influences and events can have long-lasting effects on individual outcomes.[6] By focusing additional efforts on actionable early-life influences, policymakers may be able to take advantage of early high-yield interventions.

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Endnotes

1. Jessica W. Reyes, "Childhood Lead and Academic Performance in Massachusetts" (New England Public Policy Center Working Paper 11-2, Boston, July 2011).
2. David C. Bellinger, "Very Low Lead Exposures and Children's Neurodevelopment," *Current Opinions in Pediatrics* 20, no. 2 (2008): http://www.ncbi.nlm.nih.gov/pubmed/18332714.
3. Blood lead concentrations are measured in micrograms per deciliter, or µg/dL. The U.S. Centers for Disease Control and Prevention has set 10 µg/dL as the "level of concern." However, the current consensus in the public health community is that no level of lead is safe. There are proposals to lower the level of concern to as low as 2 µg/dL.
4. It was not possible to link individual children over time, so the lead profile of a school-cohort group is drawn from lead measures of children in that school area and age cohort, while the test-score profile of the group is drawn from test scores of children in that school and age cohort. If children move or attend other schools, there will be some slippage between these groups. Such slippage will most likely attenuate any measured effects of lead on performance.
5. The regression results were applied to time trends in the variables of interest.
6. Douglas Almond and Janet Currie, "Human Capital Development before Age Five" (National Bureau of Economic Research Working Paper 15827, Cambridge, 2010).