

Executive Summary for Policymakers Heat Stress, Climate Change, and Educational Attainment

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Overview

The human body and brain are highly sensitive to heat stress. Emerging scientific research suggests that climate change, in addition to its effects on sea-level rise and crop yields, may also affect society through the *direct* physiological impacts of heat stress on human health and labor productivity.

This study finds that increased heat exposure from climate change may significantly affect educational outcomes as well. Using data from New York City public schools from 1998-2011, and statistical analyses that approximate natural experiments, it suggests that students who took their high school exit exams on hot days tended to do significantly worse, such that the same student taking an exam on a 90°F day would have a 12.3% higher likelihood of failing relative to a more suitable 72°F day.

Background

NYC has the largest public school district in the United States, with over 1 million students. It is also one of the most racially and socio-economically diverse, with a student body that is 40% Latino, 31% African American, and 14% Asian. Many students are economically disadvantaged, with nearly 80% of students qualifying for federally subsidized school lunch.

Each June, students are required to take a series of high stakes exams called Regents exams, which determine diploma eligibility and can affect college admissions.

This study uses historical data from over 4 million Regents exam records from 947 NYC public schools, and weather data from NCDC to compare student outcomes across days and school years with varying degrees of heat exposure. For instance, by comparing the exam scores of the same student on different days – one exam may be taken on a 75°F day, another on an 85°F day, with no opportunity to reschedule – the author is able to assess the causal impact of hot weather on student performance.

Key Findings

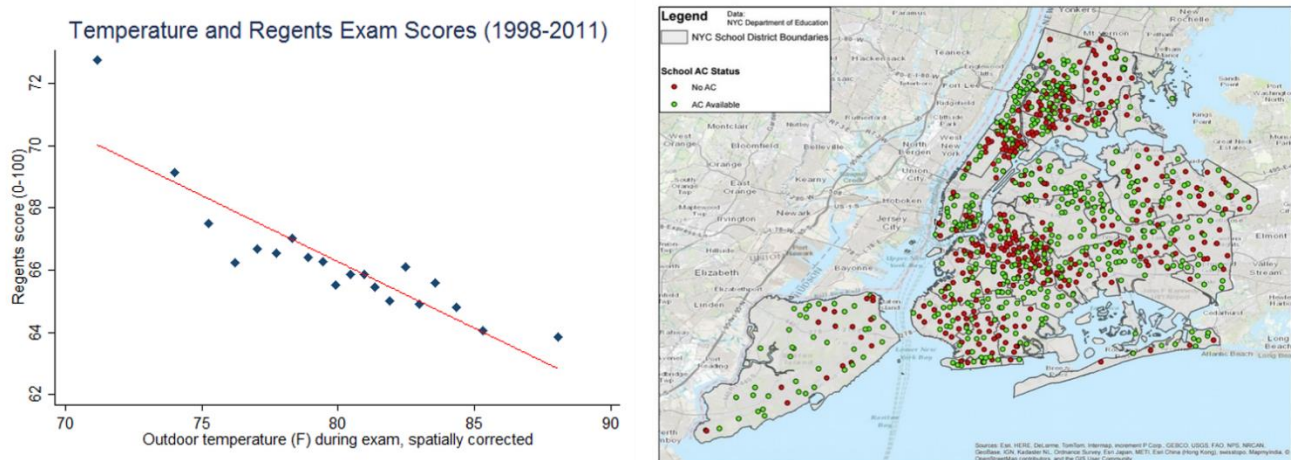
1. **Heat stress during exams reduces student performance.** Students who take their high school exit (Regents) exams on a 90°F day score -4.5% per exam, and face a 10.5% lower likelihood of passing any given subject. This effect is on par with roughly 1/4 of the Black-White test score gap.
2. **Heat exposure during the school year can disrupt learning.** Students who experience more hot days during the school year tend to do worse on end-of-year Regents exams. A year with 5 additional hot days (above 80°F) can reduce performance by 7% of a standard deviation, an effect similar in size to reversing the gains from having a one standard deviation better teacher for one grade, which has been shown in other studies to result in lifetime economic benefits from higher wages of approximately \$37,000 per student, or \$925,000 per classroom.
3. **Teachers and administrators may be constrained in how they respond to heat-related student impacts.** The study finds that, prior to grading reforms that prohibited NYC high school teachers from grading their own students' Regents exams, teachers may have compensated for students who “have a bad test day” due to heat by manipulating the grades of students who score just below the passing cutoff (e.g. 65 out of 100). While it is unclear whether teachers were aware of the fact that heat caused the lower scores, the findings suggest that teachers engaged in more grade

manipulation after hotter exam takes, and that grading reforms in 2011 may have inadvertently removed a form of protection from climate-related impacts that had applied disproportionately to Black and Hispanic students.

4. **Many US public school districts lack adequate air conditioning.** Fewer than 62% of NYC public school buildings had any air conditioning equipment as of 2012. Over a third of those that do have AC were reported as having defective components. While systematic accounts of school air conditioning penetration are lacking, publicly available data suggests that fewer than 60% of Baltimore public schools and 30% of Boston public schools have air conditioning.
5. **Low-SES students are likely to be hardest hit from climate change.** This is due in part to lack of adaptive resources – lower income households are less likely to own or use air conditioning equipment – as well as the fact that, in many urban public school districts, summer school is mandatory for low-performing (predominately Black and Hispanic) students.

Conclusions

Consistent with existing studies on heat stress and human task performance, this study finds that hot temperature in the classroom affects student performance considerably – in ways that can have substantial and lasting economic consequences. Given relatively low levels of air conditioning in many urban public school districts, the rapid onset of global warming, and the well-documented links between educational attainment and economic opportunity, this study suggests that the economic benefit of emissions reductions may be larger than previously thought.



Notes: The figure in the left presents a binned scatterplot of Regents scores and exam-time temperature, by percentile of the realized exam-time temperature distribution. Blue line is estimated relationship between temperature and test score, controlling for average differences across subjects, average differences across years, and exam-day precipitation and humidity (N=4,509,095; each dot represents approximately 220,000 exam observations). The figure on the right provides a map of New York City public schools, with green dots representing schools that had any air conditioning equipment as of 2012, and red dots representing schools that did not, according to the NY School Construction Authority.

About the author: Jisung Park is a PhD Candidate in the economics department at Harvard University, where he specializes in environmental economics, labor economics, and public finance. A native of Lawrence, Kansas, and Seoul, Korea, Jisung received his undergraduate education in economics and political science from Columbia University ('09), and attended Masters programs in Environmental Management ('10) and Development Economics ('11) at Oxford University on a Rhodes Scholarship (New York, 2009).

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