Economics of Education Review 56 (2017) 141–151

Contents lists available at ScienceDirect

Economics of Education Review

journal homepage: www.elsevier.com/locate/econedurev

Something in the air? Air quality and children's educational outcomes

Dave E. Marcotte[1]

School of Public Affairs, American University, 4400 Massachusetts Avenue NW, Washington, DC 20016-8070

ARTICLE INFO

Article history:
Received 12 July 2016
Revised 29 November 2016
Accepted 7 December 2016
Available online 14 December 2016

ABSTRACT

Poor air quality has been shown to harm the health and development of children. Research on these relationships has focused almost exclusively on the effects of human-made pollutants, and has not fully distinguished between contemporaneous and long-run effects. This paper contributes on both of these fronts. Merging data on ambient levels of human-made pollutants and plant pollen with detailed panel data of children beginning kindergarten in 2010, I study the relationship between poor air quality on achievement in early grades. I also provide tentative estimates of the effects of air quality in the first years of life on school-readiness. I find that students score between 1 to 2 percent lower on math and reading scores on days with high levels of pollen or fine airborne particulate matter, and that asthmatic students score about 10 percent lower on days with high levels of ozone. I find suggestive evidence that poor air quality during early childhood negatively affects school readiness.

Economists have done a substantial amount of research linking poor air quality to health and developmental outcomes for children. This research has mostly been limited to pollution emitted as a consequence of human activity and has focused either on long-run effects due to pre- and neo-natal exposure, or on the contemporaneous impacts of ambient pollution on acute health episodes or cognitive performance later in life. In this paper, I contribute to this literature in two ways. First, I incorporate a natural threat to air quality in the form of plant pollen. Pollen is potentially important because it contributes to the level of fine particulate matter in the air, and unlike other forms of particulate matter pollen has known effects on non-pulmonary aspects of human health including cognitive functioning via allergies. Second, using data on air quality over long periods, I estimate effects of exposure to air pollution and pollen early in life on school readiness, and the effects of exposure while in school on achievement. To both of these ends, I make use of child level panel data to confront the substantial and well established empirical problems inherent in estimating air quality impacts: Tiebout sorting which threatens validity for establishing long-term effects and avoidance behavior in the short run is likely related to other factors that are beneficial for child development (Neidell, 2009).

To estimate effects of poor air quality on children's academic outcomes I combine data on daily ambient pollution and pollen levels in nearly 20 counties throughout the United States collected by the U.S. Environmental Protection Agency and the National Allergens Bureau. I merge these data on air quality with rich longitudinal data on young children from the restricted-use Early Childhood Longitudinal Survey – Kindergarten (ECLS-K) panel data. In addition to collecting data on child, family, and school characteristics, the ECLS-K administers batteries of cognitive tests to children. These batteries provide measures of early childhood problem solving and measures of math and reading skills. Further, the date on which ECLS-K students are tested is recorded, so that I can know the ambient levels of pollution and pollen when students were tested as well as the period leading up to the test.

E-mail address: marcotte@american.edu

[1] I have benefitted from suggestions and conversations with Jason Fletcher, Glen Waddell, Jonathan Smith, Paco Martorell, Ben Hansen, Olivier Deschenes, and seminar participants at American University, the universities of Oregon and California Davis, IZA Bonn, the 3rd IZA Workshop on the Labor Market Effects of Environmental Policies in Berlin and the 2016 Spring NBER Health Economics meeting. I received research assistance from Cheryl Camillo. I am grateful to Jerome Schultz and the American Academy of Allergy, Asthma & Immunology for sharing some of the data employed here. Further, I wish to thank the following for collecting and sharing air quality data: Jeffrey Adelglass (Dallas), N.J. Amar (Allergy and Asthma Center, Waco TX), Sheila Amar (Allergy and Asthma Center, Austin TX), Leonard Bielory (STARx Allergy and Asthma Center, Springfield NJ), Walter Brummond (Allergy and Asthma Centers (Milwaukee), Mathew S. Bowdish (William Storms Allergy Clinic, Colorado Springs), Robert Bush (UW Medical School, Madison), Theodore Chu (San Jose), Stanley Fineman (Atlanta Allergy and Asthma Clinic), Linda Ford (Asthma and Allergy Center, Bellevue NE), Philip Gallagher (Allergy and Asthma Assoc. of NW PA), Duane Harris (Intermountain Allergy and Asthma Clinic, Salt Lake City), Tony Huynh (City of Houston, TX), Neil Kao (Allergic Disease and Asthma Center, Greenville SC), Joseph Leija (Melrose Park, IL), Fred Lewis (Olean, NY),Jonathan Matz and David Golden (Baltimore), Michael Miller (Allergy Asthma and Immunology, Knoxville), Jay Portnoy (Children's Mercy Hospital, Kansas City), Donald Pullver (Allergy Asthma and Immunology of Rochester, NY), Christopher Randolph (Waterbury, CT), Robert Reid (Banck Clinical Research Center, San Diego), Guy Robinson (Fordham College, New York), Andy Roth (RAPCA, Dayton, OH), David Skoner (Allegheny General Hospital, Pittsburgh), Raj Srinivasan (Vancouver (WA) Clinic), Frank Virant, Northwest Asthma and Allergy Center, Seattle), Wayne Wilhelm (St. Louis County Health Department).

http://dx.doi.org/10.1016/j.econedurev.2016.12.003
0272-7757/

In the remainder of this paper I describe recent findings on the impact of air quality on child health, and describe the empirical challenges inherent in identifying these effects. I then employ a standard human capital model common to the health literature to illustrate the pathways through which poor air quality could affect children's performance in school,[2] and derive testable hypotheses. I next describe the data and empirical models used to address these questions about short and long-run effects of exposure. Because I have panel data, inference principally comes from variation in within-student exposure to threats to air quality. However, since school readiness is measured by tests administered at a point in time, for that outcome I exploit variation in exposure due to month of birth for matriculating kindergartners within each school setting. Further, because the relationship between air quality and weather is well established, I illustrate the importance of controlling for weather conditions.

This paper contributes to an emerging literature on the role of air quality and the development and academic achievement of children. Understanding the implications of air quality on educational achievement is vital for assessing the full costs of human made pollution, as well as estimating the benefits and implications of policies to limit exposure to threats to air quality or limit the affects of exposure. These include policies to treat acute symptoms of affected children, such as subsidies for asthma or allergy treatments. More broadly this literature is beginning to shed light on the role of indoor air quality in schools on student achievement (Stafford, 2015). Better understanding how environmental threats to air quality affect outcomes within schools is relevant for understanding if air conditioning and other aspects of the conditions of schools shape trends in achievement, both in the aggregate and for students in resource-poor districts.

1. Background

Research on the human health consequences of poor air quality has paid special attention to effects on children. This attention is warranted because children are at elevated risk for harm, and because costs are borne over a long time horizon for children relative to adults. Children are more susceptible to harm, in part, because physiologic development *in utero* and early infancy is especially rapid - so any factors inhibiting this process can disrupt normal development (Gluckman, Hanson, Cooper, & Thornburg, 2008; U.S. EPA, 2013; and Currie, Joshua, Jamie, & Neidell, 2014). Further, children are more likely to be exposed to ambient pollutants since they spend more time out of doors than adults and are more active (Schwartz, 2004; U.S. EPA, 2013).

Indeed, the impact of poor air quality has been found to effect health *in utero* and in early childhood. Exploiting variation in air pollution due to the implementation of the Clean Air Acts and the recession of the early 1980 s, Chay and Greenstone (2003a and b, respectively) report substantial and significant decreases in child mortality due to reduction in airborne particulate matter. Beyond effects on mortality, there is good evidence that ambient pollution affects child health via birth weight. Currie, Neidell, and Schmieder (2009) illustrate that variation in exposure to carbon monoxide among pregnant women affects birth weight for their children. Birth weight is a well-known indicator of myriad long-term developmental outcomes. For example, using administrative data on birth and school records in Florida and identifying off of birth weight differences between twins, Figlio, Guryan, Karbownik, and Roth (2014) find that birth weight effects on cognitive performance in school are "essentially constant through the school career…" of children. Bharadwaj et al (2014) find evidence that in utero exposure to carbon monoxide in Santiago Chile is associated with lower 4th grade test scores. Two studies linking exposure to air pollution to lower performance on high school tests (Sanders, 2012) and earnings in adulthood (Isen, Rossin-Slater, and Walker, 2014) provide further reduced form evidence consistent with this developmental effect of exposure to air pollution early in life.

Research on a contemporaneous link between levels of air pollution and children's health has made clear that poor air quality is a trigger for acute episodes of respiratory problems, including asthma. For example, Ransom and Pope (1995) provide early evidence of poor air quality due to industrial activity on hospitalization among children for pulmonary conditions, making use of a natural experiment due to the closing and re-opening of a steel mill in Utah. Similar findings come from studies of oil refinery closures in France (Lavaine & Neidell, 2013) and airport traffic in California (Schlenker & Walker, 2016).

The relationship between ambient air quality and cognitive performance is less clear. The impact of air pollution on cognitive ability is mainly thought to operate through development in early childhood (e.g. Currie, 2009). However, pollution can affect cognition because small particulate matter can penetrate the lungs and inhibit the flow of oxygen into the bloodstream and hence the brain (Lavy, Ebenstein, & Roth, 2014). While the importance of this link has yet to be established, it is clear that high levels of pollutants can cause breathing problems and asthma attacks and thereby inhibit performance. For example, Graff Ziven and Neidell (2013) and Chang, Zivin, Gross, and Neidell (2014) illustrate that poor air quality lowers productivity of piece rate daily farm workers and produce packers, respectively. Two studies most relevant to this paper are, Lavy et al. (2014) and Stafford (2015). Lavy and his colleagues illustrate that high levels of fine particulate pollution have a negative effect on performance of Israeli high school students on exams that determine admission to selective post-secondary schools.[3] Stafford (2015) examines performance on Texas's standardized math and reading tests before and after school renovations that improve indoor air quality and finds substantial improvements in test scores following renovations to remediate mold or improve ventilation.

There is a clearer link to cognitive functioning from levels of ambient pollen, as opposed to air quality more generally. Pollen induces seasonal allergies in approximately 15 to 20 percent of the population (Meltzer et al., 2012).[4] The allergic reaction is due to the combination of antibodies that target allergens with receptor cells, releasing chemicals to combat the perceived threat. These chemicals include histamine and cytokines that cause inflammation of tissue and increased secretion of mucous membrane (Janeway, Travers, & Walport, 2001). These are the common symptoms of seasonal allergic rhinitis (SAR) including nasal congestion, watery eyes, and irritated throat. These chemicals and their attendant symptoms can also affect levels of fatigue, cognitive function, and mood. The most obvious mechanism through which an allergic

[2] The seminal work on this area is by Grossman (1972). For relevant extensions and discussion of this context, see Currie et al. (2014).

[3] A distinct but related literature in development economics has established a link between extreme weather events in utero and early childhood on health and education outcomes in developing countries in Africa and Asia. The mechanisms at play are thought to include fetal origins, malnutrition, and increased exposure to indoor pollution from heating and cooking during cold/wet weather. See for example, Alderman et al (2006); Groppo and Kraehnert (2016); and Deuchert and Felfe (2015).

[4] Estimating the prevalence seasonal allergies is difficult because many sufferers do not seek treatment, and a confirmed diagnosis requires a skin test (NIAID, 2012). The estimate from the National Health Interview Survey is that 7.3 percent of Americans have been diagnosed by a physician with hay fever in the 12 months prior to interview while the Agency for Health Care and Quality estimates that prevalence ranges between 10 and 30 percent. By all accounts, prevalence is higher among children than adults, with some estimates as high as 40 percent. There is also evidence that prevalence is rising (Linneberg et al., 2000).