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Allergy test: Seasonal allergens and performance in school

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ABSTRACT

Seasonal pollen allergies affect approximately 1 in 5 school age children. Clinical research has established that these allergies result in large and consistent decrements in cognitive functioning, problem solving ability and speed, focus and energy. However, compared to air pollution, the impact of pollen and seasonal allergies on achievement in schools has received less attention from economists. Here, I use data on daily pollen counts merged with school district data to assess whether variation in the airborne pollen that induces seasonal allergies is associated with performance on state reading and math assessments. I find substantial and robust effects: A one standard deviation in ambient pollen levels reduces the percent of 3rd graders passing ELA assessments by between 0.2 and 0.3 standard deviations, and math assessments by between about 0.3 and 0.4 standard deviations. I discuss the empirical limitations as well as policy implications of this reduced-form estimate of pollen levels in a community setting.

The effect of airborne allergens on the cognitive functioning of allergy sufferers has been the subject of much attention among medical researchers. Numerous clinical studies identify effects on fatigue, mood, focus, the speed and accuracy of problem solving and reasoning.[1] There is also a substantial body of research on the effects of common treatments for allergens on many of these same outcomes.[2] Indeed, the advantages of newer generation treatments are their more limited side effects.[3] However, the impacts of seasonal allergies in community-based settings have not received as much attention from economists. There is a fair amount of research on the direct and indirect costs of allergic rhinitis in the clinical and health services literatures. Reed et al. (2004) provide a comprehensive summary of this work, and make clear the external and internal validity limitations of this research.

Related to the topic of the current paper, economists have done a substantial amount of research linking exposure to air pollution on child health outcomes, development and human capital accumulation. Air pollution is a combination of solids and gasses suspended in the air that can harm human health.[4] Much of the focus is on pollution emitted as a consequence of human activity. But, natural sources like dust and pollen also contribute to the level of fine particulate matter in the air. In general, air pollution can affect cognitive performance of children in two ways: Prolonged exposure, especially early in life, can harm development; and exposure to high levels of pollution may have immediate effects on health and thereby limit performance on cognitively demanding tasks. While it is difficult to sort out these two mechanisms, research on pollution has identified impacts of in-utero and neo-natal exposure on birthweight and early developmental markers (Currie and Neidell, 2005). Pollen is unlikely to have these effects in part because pollen allergies do not typically develop in infancy, with age of onset usually around 8–10 years of age overall, and with a mean age of onset of 3 in one study of children developing allergies and asthma before the age of 10 (Masuda et al. (2008)). Research on pollen has focused on the effects of SAR on cognitive functioning due principally from immediate changes in levels of neurotransmitters that affect somnolence, mental alertness, problem solving ability and mood. Naturally, inhibited cognitive functioning during allergy season might have long-run effects on human capital accumulation, but the immediate effect of allergy

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[1] I review this evidence below.

[2] See Bender (2005) for a review of the literature on both allergy symptoms and treatments.

[3] For example, so-called third-generation antihistamines such as fexofenadine and desloratadine are marketed for their fewer side effects impeding daily functioning.

[4] U.S. Environmental Protection Agency: http://www.epa.gov/airquality/urbanair/.

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symptoms in clinical settings are decrements in performance on cognitive tasks.

In this paper, I examine whether variation in the airborne pollen that induces SAR is associated with poorer performance on reading and math tests given to students in elementary and middle school. I merge data on daily pollen counts at 16 reporting stations around the country to data on test performance on mandatory state assessments and student characteristics from school districts within 10 miles of these reporting stations. Students in grades 3 through 8 are tested every year in each of these districts. Math and reading assessments are given during different weeks (and sometimes different months). Further, assessment dates differ by grade in many districts. So the merged data set provides information on the performance of students in a particular grade on a subject test in each district by year, along with measures of ambient pollen levels, as well as characteristics of the school and student body.

Using these combined data, I identify the impact of exposure to allergens on test performance by making use of this variation in testing dates across districts, subjects and grades, along with the fact that the timing and volume of seasonal allergen peaks vary over time and space. This sets up a clear natural experiment whereby we can assess the direct effect of seasonal allergens on performance on state tests. Further, because I know daily pollen counts, as well as the dates on which tests were taken, I am able to estimate contemporaneous as well as leading and (lag effects) of pollen levels on math and reading achievement. Later, I discuss the relevance of this design compared to those involving student-level randomization. Here, it is important to recognize the current design is relevant for understanding aggregate impacts. In school settings, these aggregate measures are widely used, and form the basis of accountability systems in education.

The first task of the paper is to describe the biological mechanisms through which pollen affects SAR and its subsequent symptoms. In doing so, I summarize clinical evidence on the cognitive effects of SAR. I then describe the data and the empirical framework. I follow this with descriptive statistics and graphical analyses of joint variation in ambient pollen and test performance, along with the main empirical results. In the final section, I discuss results and their limitations, and consider their value both for understanding the effect of pollen on community level measures of cognitive performance, as well as for understanding inter-temporal variation in educational assessment systems.

1. Background

Seasonal allergic rhinitis (SAR) is the term clinicians use to refer to pollen allergies, often referred to as hay fever.[5] Pollen is a fine powder, comprised of grains produced by plants as part of the reproduction cycle (NIAID, 2012). Many trees and grasses produce large quantities of pollen and rely on the wind to spread it from one plant to another for reproduction. SAR is a reaction induced in the bodies of some people to these pollen grains that are otherwise not harmful to humans (NIAID, 2012). 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 mucus membrane (Janeway et al., 2001). These are the common symptoms of SAR including nasal congestion, watery eyes, and irritated throat.

These chemicals and symptoms can also affect levels of fatigue, cognitive function, and mood. The most obvious mechanism through which an allergic response to allergens affects cognitive function is through effects on sleep. A very common problem suffered by allergy sufferers is interrupted sleep and daytime somnolence (Santos et al., 2006). Cytokines as well as histamines are involved in brain function, affecting cognition, and memory (McAfoose and Baune, 2009; Tashiro et al., 2002). Additionally, cytokines appear to affect mood, and have been linked to mood disorders, such as major depression (Kronfol and Remick, 2000; Dowlati et al., 2009).

While SAR is a chronic condition, the task of estimating its prevalence in the population 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% of Americans have been diagnosed by a physician with hay fever in the 12 months prior to interview.[6] Meltzer et al. (2012) estimate the prevalence of SAR in the community at 16%, while the Agency for Health Care and Quality estimates that prevalence ranges between 10 and 30%. By all accounts, prevalence is higher among children than adults, with some estimates as high as 40%. There is also evidence that prevalence is rising (Linneberg et al., 2000).

Perhaps because of its chronicity and generally mild symptoms, SAR has not received much attention from economists studying the consequences of disease. The exception to this is in the area of estimating direct and indirect costs of illness. Much of this work is analytic, deriving estimates of direct costs by estimating medication and physician costs from National Health Accounts data, and indirect costs by surveying allergy sufferers to ask how much productivity in the workplace is inhibited by symptoms (Malone et al., 1997; Gallup Organization Inc., 1989). A review of this literature by Reed et al. (2004) makes clear that empirical, observational estimates of the effects of SAR on day to day functioning of sufferers is scarce.

There is a sizeable literature in medicine on the effects of SAR on functioning. Much of this work is based on clinical lab research, comparing subjects with a history of SAR in various settings. For example, Wilken et al. (2002) randomly divided subjects with SAR into a group exposed to pollen and a control group, and found that exposed subjects scored lower on measures of computation and reasoning ability, and had longer response times and more difficulty with attention. Marshall et al. (2000) find similar patterns for subjects with SAR when comparing tests administered during allergy season to those administered when pollen levels were essentially zero. Regardless of the design for establishing the treatment–control comparison, clinical studies overwhelmingly find lower measured cognitive processing abilities and speed among symptomatic SAR subjects (e.g., Bender, 2005; Druce, 2000; Marshall and Colon, 1993; Fineman, 2002). It also appears that typical medical treatments do not offer much protection from fatigue and decrements in cognitive functioning (Bender, 2005; Kay, 2000).

The only evidence of which I am aware of the effects of SAR on school children in a community setting comes from a case-control study of nearly 2000 British teenagers. Walker et al. (2007) compare students in one region of the UK who had a history of SAR with students with no such history as they sat for the General Certificate of Secondary Education (GCSE) exams, which are used to determine post-secondary placement. Importantly, practice CGSE exams are administered in winter when pollen counts are negligible, and then the actual exams in June, a period of high grass pollen in the region. The authors used a type of difference in difference analysis by comparing practice scores to final exam scores,

[5] While SAR is commonly called hay fever, fever is not a symptom. However, fever can occur due an infection in the sinuses, a common complication of SAR.

[6] http://www.cdc.gov/nchs/data/series/sr_10/sr10_256.pdf.