Journal of Health Economics 49 (2016) 1–13

Contents lists available at ScienceDirect

Journal of Health Economics

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

You sneeze, you lose
The impact of pollen exposure on cognitive performance during high-stakes high school exams

Simon Søbstad Bensnes *

Department of Economics, Norwegian University of Science and Technology, Høgskoleringen 1, 7491 Trondheim, Norway

ARTICLE INFO

Article history:
Received 3 November 2015
Received in revised form 11 May 2016
Accepted 24 May 2016

JEL classification:
I10
I20
I21

Keywords:
High school
Test scores
Graduation
Pollen
Allergic rhinitis
Hay fever

ABSTRACT

Pollen is known to cause allergic reactions and affect cognitive performance in around 20% of the population. Although pollen season peaks when students take high-stakes exams, the effect of pollen allergies on school performance has received nearly no attention from economists. Using a student fixed effects model and administrative Norwegian data, this paper finds that increasing the ambient pollen levels by one standard deviation at the mean leads to a 2.5% standard deviation decrease in test scores, with potentially larger effects for allergic students. There also appear to be longer-run effects. The findings imply that random increases in pollen counts reduce test scores for allergic students relative to their peers, who consequently will be at a disadvantage when competing for jobs or higher education. This paper contributes to the literature by illuminating the interplay between individual health and human capital accumulation, which in turn can impact long-run economic growth.

1. Introduction

The last few years have seen an increasing interest in the link between individuals' health and productivity. In particular, ambient pollution has been subject to closer scrutiny. Using short-term variations in air pollution, various authors have identified significant effects on labor productivity and supply, and even school absences (e.g., Chang et al., 2014; Hanna and Oliva, 2015; Currie et al., 2009). This study contributes to the literature by examining the causal effect of short-term variations in a non-pollutant that affects health in a manner similar to ambient air pollution. Even though pollen is a natural part of the environment, a relatively large portion of the population is negatively affected by its presence. Understanding the extent to which pollen can harm general productivity through its effect on allergic individuals is helpful in order to assess its detrimental effects. While the study is limited to measuring cognitive performance on high school exams, the findings are likely to be transferable to the labor market, suggesting detrimental effects on productivity across the economy. Unlike many air pollutants, pollen also has a direct negative impact on the general well-being of individuals, further increasing its negative effects and the relevance of this research.

Seasonal allergic rhinitis (SAR), more widely known as hay fever, is a common chronic condition. The prevalence rate varies between countries and regions, with most estimates around 20% for the general population in industrialized countries. SAR is more prevalent among school-aged individuals (Skoner, 2001) and is the most common chronic condition in the pediatric population (Jáuregui et al., 2009). The Norwegian Asthma and Allergy Association estimates that more than 20% of the general population have allergic reactions to pollen, and estimates are even higher for school-aged children, at about 25–30% (Hansen et al., 2013; Hovland et al., 2014; Selnes et al., 2005). Not only is SAR a relatively common condition, but several studies have also shown that its prevalence appears to be increasing (e.g., Åberg, 1989; Linneberg et al., 2000), raising the need for research into its societal costs. While SAR is commonly considered relatively harmless, the medical literature has established strong

I have benefited from comments from Bjarne Strøm, Torberg Falch, Kelly Bedard, Sofie Afseth, Nicholas Sheard, seminar and workshop participants at the University of California, Santa Barbara, the Norwegian University of Science and Technology, the EEA conference in 2015 and two anonymous referees. I am grateful for data access and useful information from Hallvard Ramfjord at the Norwegian Pollen Forecast Services. All errors are my own.

* Corresponding author at: Department of Economics, Norwegian University of Science and Technology, Høgskoleringen 1, 7491 Trondheim, Norway. Tel.: (0047) 735 91 654.

E-mail address: simon.bensnes@ntnu.no (S.S. Bensnes).

http://dx.doi.org/10.1016/j.jhealeco.2016.05.005

negative effects on various measures of cognitive performance and well-being (e.g., Marshall et al., 2000; Kremer et al., 2002). Clinical studies have also shown that medicines commonly used to treat the symptoms of SAR can induce similar, or even stronger, negative effects on cognitive functioning.[1] Significant and unavoidable detrimental effects on cognition suggest that individuals with SAR are at a definite cognitive disadvantage during pollen season, which might have significant effects on productivity. In the education system, this effect might show up as reduced test scores for allergic individuals. Combined with high and rising prevalence rates, the timing of high-stakes exams can significantly affect students' long-run human capital accumulation by distorting the relative ranking of students.

This paper explores the effect of pollen on cognition by combining rich administrative data from the Norwegian high school system in the years 2008–2011 with daily pollen counts from measurement stations across the country. The data contain information on numerous observable student characteristics in addition to exam grades for each course, and which school each student attended. The student data and the location of exams are merged to exam dates from the Ministry of Education and data on pollen counts collected by the Norwegian Pollen Forecast Services. Taking advantage of the resulting panel structure in the data, I found it is possible to implement a student fixed effects model, allowing an identification strategy that relies on variation in the pollen count between tests on different dates for the same student. The advantage of this approach is that it removes potential unobserved correlation between student performance and pollen exposure, a potential source of bias in previous studies. The main results show that a one standard deviation increase in pollen counts relative to the mean decreases the average student's score by about 2.5% of a standard deviation. Assuming that non-allergic students are unaffected by pollen proliferation levels, the treatment effect is likely to be larger for allergic students. Using estimates for the prevalence rate of SAR among 16-year-old Norwegians, the results suggest that the effect for allergic students is about 10% of a standard deviation. The results imply that random exposure to pollen can have a substantial effect on the exam grade for students with SAR.

Further, I use the available information on student background to explore heterogeneous effects. When the effect of pollen proliferation is allowed to depend on student background, the results are consistent with the patterns in the prevalence rates found in the medical literature, lending support to the validity of the reduced-form estimations used in this paper. Lastly, I find that being exposed to higher pollen count levels across all exams appears to affect the higher education choices of graduating students, suggesting longer-run effects.

The contributions of this paper are twofold. First, this paper estimates the effect of pollen proliferation on cognitive abilities in a non-experimental setting, taking into account student sorting across regions with different proliferation levels. It is likely that pollen has an effect on cognition in other settings as well, and therefore could potentially affect labor productivity across the economy. Second, the estimations show that random exposure to pollen during examinations reduces test scores for the average student. Affected students are therefore ranked worse relative to unaffected peers, regardless of true ability. As students who apply for university compete on exam scores, the enrollment decisions of universities might be suboptimal. Consequently, random variation in the timing of pollen proliferation can harm workforce productivity through its effect on grades and on the composition of students enrolled in higher education. It may be possible to offset this effect somewhat by increasing efforts in diagnosing and optimizing treatment.

The rest of the paper is organized as follows. First, relevant findings on the effect of pollen on cognitive performance, as well as related literature, are presented in Section 2. Section 3 presents the institutional background, while Section 4 presents the data and empirical strategy. Main results are presented in Section 5, while robustness tests and heterogeneous effects are analyzed in Section 6. Longer-run estimates are presented in Section 7. Section 8 summarizes and concludes.

2. Seasonal allergic rhinitis and related literature

2.1. Seasonal allergic rhinitis: epidemiology and effects on cognition

Pollen grains are produced as part of plants' reproduction cycle and are spread by wind or insects from plant to plant. The grains are small and easily inhaled by humans. In a person with seasonal allergic rhinitis (SAR), the immune system will produce antibodies, including histamine and cytokines, to fight the perceived threat from the pollen grains. The antibodies will in turn cause an inflammatory state in the airways, causing symptoms including itching, sneezing, congested airways, and rhinorrhea (Greiner et al., 2012). In addition to the more visible allergic reactions, SAR can also affect cognitive ability and fatigue, both indirectly through reduced quality of sleep (Craig et al., 2004; Santos et al., 2006) and directly, as the antibodies themselves have a detrimental effect on cognitive ability (McAfoose and Baune, 2009; Tashiro et al., 2002). Several laboratory studies have confirmed a link between reduced cognitive function and SAR. Marshall et al. (2000) found that patients clinically diagnosed with SAR had impaired cognitive functioning under tests taken during the pollen season compared to tests taken outside the pollen season. Randomizing ragweed pollen exposure on adults with a history of SAR, Wilken et al. (2002) found that allergic individuals who were exposed to pollen performed worse on a number of cognitive measures, including longer response times, reduced working memory, and computation. A similar result was also found by Marshall and Colon (1993). While SAR is associated with reduced cognition under certain conditions, it is important to note that treatment of the symptoms has similar effects. Vuurman et al. (1993) found that, when exposed to pollen, children with SAR were cognitively outperformed by other children regardless of whether they received medication or not, although newer generations of antihistamines had smaller negative effects than either placebos or older generations. It therefore seems likely that students with the condition will suffer irrespective of medication use, although optimal usage may dampen the effects.

SAR is a very common condition, with an estimated 400 million people affected globally (Greiner et al., 2012). The incidence of the condition varies between countries, but is generally higher in industrialized countries.[2] While some of the variation in prevalence rates between countries can be explained by differences in climatic and demographic factors, lifestyle also plays a major role. Comparing children born in the former East and West Germany, Krämer et al. (2010) found that the convergence in lifestyles coincided with a convergence in the prevalence of SAR. The fact that lifestyle is so strongly linked to prevalence rates is interesting, as it suggests that the condition might be even more common in the

[1] Although older generations of antihistamine treatments generally have the strongest side effects, newer generation drug treatments also have been shown to have some negative effects on cognition (e.g., Vuurman et al., 1993; Jáuregui et al., 2009).

[2] In addition to a large variation in estimated prevalence across countries, estimates within countries are very uncertain and depend on how prevalence is measured. As one might expect, self-reported numbers are generally much higher than what is clinically documented, but many people who are allergic are not themselves aware of it (Greiner et al., 2012). The connection between socio-economic background and SAR is discussed and explored in Section 6.