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Air pollution, avoidance behaviour and children's respiratory health: Evidence from England

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ABSTRACT

Despite progress in air pollution control, concerns remain over the health impact of poor air quality. Governments increasingly issue air quality information to enable vulnerable groups to avoid exposure. Avoidance behaviour potentially biases estimates of the health effects of air pollutants. But avoidance behaviour imposes a cost on individuals and therefore may not be taken in all circumstances. This paper exploits panel data at the English local authority level to estimate the relationship between children's daily hospital emergency admissions for respiratory diseases and common air pollutants, while allowing for avoidance behaviour in response to air pollution warnings. A 1% increase in nitrogen dioxide or ozone concentrations increases hospital admissions by 0.1%. For the subset of asthma admissions – where avoidance is less costly – there is evidence of avoidance behaviour. Ignoring avoidance behaviour, however, does not result in statistically significant underestimation of the health effect of air pollution.

1. Introduction

Although air quality in the UK has improved greatly since the Great Smog of London in 1952, a recent report by the House of Commons Environmental Audit Committee (2010) concluded that "poor air quality probably causes more mortality and morbidity than passive smoking, road traffic accidents or obesity". Children are especially vulnerable to air pollution exposure because of their developing lungs and immature immune systems and because they spend more time outdoors (World Health Organization – European Centre for Environment and Health, 2005) and respiratory disease is one of the leading causes of hospitalisation of children. This paper examines the effect of air pollution on hospital emergency admissions for respiratory diseases in children.

The UK government, in common with other governments, provides daily air pollution forecasts that are freely available via the internet, a Freephone telephone service and Teletext as well as with the weather forecast in newspapers, on TV and radio. We therefore expect individuals susceptible to air pollution, such as asthmatics, to avoid exposure to raised levels of air pollution. If avoidance behaviour exists, estimates of the health effects of air pollution will be biased. The reason is that the standard approach in the literature is to approximate air pollution exposure by measurements taken at fixed-site outdoor monitors. Therefore, avoidance behaviour could cause mismeasurement of air pollution exposure. For example, if people stay indoors on a high air pollution day and consequently actual exposure is very low, we might observe a reduction in hospital admissions, which results in underestimation of the effect of air pollution on hospital admissions. On the other hand, avoidance behaviour, such as staying indoors, imposes a cost on individuals that might exceed the perceived gains. This paper investigates whether ignoring avoidance behaviour leads to bias in the estimates of the negative effects of pollution on children's health.

I exploit a large panel data set in which the unit of analysis is the primary unit of local government in the United Kingdom (known as a local authority). For these units, I have compiled daily data on hospital emergency admissions of children aged 5–19 years, two criteria pollutants – nitrogen dioxide and ozone – and air pollution warnings, the latter to measure avoidance behaviour. The data

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cover 89 local authorities in England for 2003–2007, containing 45% of the 9.5 million children aged 5–19 in England. My research design exploits daily variations in air pollution levels, which are mainly caused by random changes in atmospheric conditions and pollutant emissions. The high frequency of my data and the large panel dimension mean I can control for national year-week effects, which capture trends, seasonal effects and epidemics that are national in scope, and local authority-year-quarter effects to control for changes in hospital practices or economic activity, which might be correlated with pollution levels, at the local level. I also control for daily variations in weather and smog conditions and allow for delayed effects of air pollution exposure. Given this rich set of controls, the deviations in pollutant concentrations are likely to be exogenous to omitted factors and my estimation design recovers the causal effects of the pollutants.

I complement this national study with a study of visits to an outdoor attraction (a zoo) by two groups of parents and children. For one of these groups, members, avoidance is less costly, allowing me to test whether avoidance behaviour is more likely when the cost is low.

My findings suggest that both nitrogen dioxide and ozone at the relatively low levels experienced in England lead to respiratory hospital admissions in children. A 10% increase in nitrogen dioxide or ozone increases the rate of hospital emergency admissions for all respiratory diseases and symptoms in children aged 5–19 years by around 1%. I find evidence of avoidance behaviour for the subset of hospital admissions for asthma. For asthmatics the cost of avoidance is low, because a sufficient response to air pollution warnings is adjusting the dose of their reliever medicine and making sure they carry their inhaler. The direct effect of an air pollution warning is an 8% reduction in asthma admissions. Ignoring avoidance behaviour, however, does not result in statistically significant underestimation of the effects of nitrogen dioxide and ozone.

The closest antecedent to my paper is Neidell (2009), who investigates the effect of ozone on hospital admissions for asthma in Southern California in the 1990s. Neidell exploits daily variation in air pollution within 22 source receptor areas in a fixed effects regression with year-month dummies. He controls for avoidance behaviour by including a smog alert dummy variable in his specification and finds evidence suggestive of avoidance behaviour in response to smog alerts. He also examines data on visits to outdoor attractions, for example Los Angeles Zoo, and finds that attendance is lower on days when smog alerts are announced. Attendance at the zoo drops more sharply for members, for whom as local residents the cost of avoidance are lower, and for children and the elderly, for whom the benefits of avoidance are higher.

In addition to studying a different country and time period, my study setting is very different from Southern California, where – due to a long history of high ozone levels and smog – people are likely to be aware of the health effects of air pollution. In England, ozone levels rarely exceed limit values and there is little awareness of the implications of poor air quality (Defra, 2007). I also go beyond Neidell's research in several key aspects. First, I show that avoidance behaviour is different across subsets of respiratory disease. I compare the effect of air pollution warnings on hospital admissions for asthma, where the costs of avoidance are low, to admissions for acute respiratory infections, where the costs of avoidance are higher. I complement this analysis with a comparison of the behaviour of two groups with different avoidance costs by analysing the response of members and day visitors to Bristol Zoo to air pollution warnings. Pollution warnings reduce visits by members, who tend to be local residents, but have no effect on the number of day visitors, for whom reorganising a zoo visit or obtaining information about local air quality is probably more costly. Second, I implement a stronger identification strategy. My specification allows unobserved differences between areas to evolve at a quarterly rate by including year-quarter fixed effects. Additionally, I include year-week rather than year-month dummies to control for seasonal cycles and influenza epidemics. I present a robustness test that replaces the year-quarter fixed effects with year-month fixed effects. Third, my sample is large and covers approximately 45% of the total population of 50 million in diverse locations, ranging from old mining and steel towns in the north to affluent areas in London and the South East. The scope of Neidell's study is limited to 22 of the 38 source receptor areas within the South Coast Air Quality Management District, whose total area is about 28,000 km^2 compared to 130,000 km^2 of England.

This paper is also connected to a large epidemiological literature. I discuss the epidemiological approach and the related economics literature in the next section. I then present the details of my estimation strategy in Section 3. Section 4 provides an overview of the extensive data I have brought together from various administrative sources. Main results and a simple cost-benefit analysis of the air pollution forecast are in Section 5. Section 6 shows the robustness of the results to specification changes, presents a falsification test that uses digestive diseases as a placebo outcome and extends the analysis by examining interaction effects and spatial heterogeneity. Section 7 provides direct evidence of avoidance behaviour in visitor data from Bristol Zoo. The discussion in Section 8 compares the size of my estimates to earlier studies before concluding the paper.

2. Related literature

Epidemiologists studying the relationship between air pollution and hospital admissions traditionally examine time series for a single city. For example, de Leon et al. (1996) analyse data for London in 1987–1992 and Atkinson et al. (1999) extend this analysis for the period 1992–1994. Anderson et al. (2001) conduct a study in the West Midlands conurbation in England for the period 1994–1996. Fusco et al. (2001) report an association between air pollutants and respiratory hospital admissions in Rome, Italy, for the period 1995–1997. Examples of non-European studies are Burnett et al. (1994), who investigate admissions to Ontario hospitals, and Petroeschevsky et al. (2001), who analyse data for Brisbane, Australia. The less common multi-city studies such as the "Air Pollution and Health: A European Approach" (APHEA) project estimate pollutant effects for each city with city-specific models. In a second stage, they derive pooled regression coefficients. Sunyer et al. (1997) investigate the relationship between air pollution and children's asthma admissions in Helsinki, London and Paris. They compute a combined estimate across cities by taking the weighted average of the city-specific coefficients using inverse variance weights.

These studies focus on achieving a good statistical fit. For example, they control for trends and seasonal cycles through sinusoidal terms or smooth functions of calendar time. They include smooth functions of meteorological variables where the degrees of freedom are chosen to minimise an information criterion. Most estimate single-pollutant models, which might cause omitted variable bias. They choose the most significant pollutant lag (see, for example, the APHEA protocol (Katsouyanni et al., 1996)), which amplifies the problems associated with pre-test estimation. None of the epidemiological studies model behavioural changes in response to air quality information.

The aforementioned paper by Neidell (2009) is one example of the approaches taken by economists in an attempt to overcome the endogeneity issues of many epidemiological studies. The seminal