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Air pollution and children's respiratory health: A cohort analysis ☆

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ABSTRACT

This paper uses a large database of multiple birth cohorts to study relationships between air pollution exposure and non-infant children's respiratory health outcomes. We observe several years of early-life health treatments for hundreds of thousands of English children. Three distinct research designs account for potential socioeconomic, behavioral, seasonal, and economic confounders. We find that marginal increases in carbon monoxide and ground-level ozone are associated with statistically significant increases in children's contemporaneous respiratory treatments. We also find that carbon monoxide exposure over the previous year has an effect on children's health that goes above and beyond contemporaneous exposure alone.

Introduction

Pollution regulations are controversial, and economists and policymakers continue to debate their efficiency and cost effectiveness. Discussions of the benefits typically focus on health considerations. In principle, controlled clinical experiments could conclusively estimate links between pollution and human health. In practice, however, much of this research is prevented by ethical and other considerations. Relationships between pollution and morbidity or mortality are most often inferred from observational data.

A literature published in epidemiological journals establishes statistical associations between air pollution and human health. Economists have recently contributed new datasets and empirical approaches to study links between pollution and morbidity and mortality. The aim is a more precise estimate of the causal effect of pollution. These latter studies enhance our understanding of the relationships between air quality and health by more completely controlling for potentially confounding unobserved factors.

This paper builds on the recent literature by constructing a rich database of multiple birth cohorts to examine relationships between air pollution exposure and children's morbidity. We focus on children's health for several reasons. Relationships between pollution and health outcomes for non-infant children are understudied and relatively poorly

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understood. Closely related studies often focus on links between pollution and infant mortality or pollution and adult outcomes. Children are also thought to be highly susceptible to damages from pollution. High-risk impacts are likely attributable to ongoing physiological respiratory development, smaller average lung size, and increased activity levels (Committee on Environmental Health, 2004; Gauderman et al., 2000). Pollution effects for children may be long lasting as early-life illness may impede long-term human capital development (Currie, 2009). Finally, economic costs for children's respiratory illnesses are large. The CDC estimates that treatment costs alone amount to several billion dollars annually in the U.S.

Our analysis makes several contributions. First, our dataset is unusually large and detailed. We observe several years of early-life health treatments for hundreds of thousands of children (more than 329,00 children in one sample and 682,000 children in another sample). Second, we assess the health impacts of both contemporaneous pollution exposure and average pollution exposure over the previous year. Studies emphasizing causal effects typically only identify contemporaneous pollution impacts. However, we observe repeated observations for each individual and individuals from multiple birth cohorts, so plausible attribution of some non-contemporaneous impacts is possible. Third, our pollution and weather data are observed at a fine geographic scale. Our geographic unit of analysis – English middle super output areas – average less than 1/3 of the size of the average California zip code. Fourth, we examine data from a universal health care system. This setting offers two advantages: we observe both inpatient treatments and day cases, and we minimize common selection bias concerns that arise due to differences in insurance coverage and ability to pay.

Even with a rich dataset, attributing health outcomes to pollution can be challenging. A household's location is not randomly assigned, so socioeconomic confounders may be correlated with both pollution exposure and health outcomes via mobility and Tiebout sorting. Several determinants of illness may be spuriously correlated with pollution through seasonality. Local trends in economic activity may influence both pollution and health. Our research design seeks to isolate causal impacts. We control for children's age, health at birth measures, seasonality, weather, and national time trends. We identify remaining relationships between pollution and non-infant children's health outcomes in three distinct ways: (1) Analyses include individual-level fixed effects. Identification of a given individual's dose–response relationship comes only from atypical deviations from that individual's own average pollution exposure, over all sample periods. Here, time invariant individual-level confounders like income, race, and persistent differences in local economic conditions will not bias estimates. Tiebout sorting correlated with long-run average differences in pollution will not bias estimates. (2) Analyses include local area-by-year fixed effects. Identification of a given individual's dose–response relationship comes only from atypical within-area deviations from that area's average pollution exposure, for that same year. Confounders cannot bias estimates unless they are correlated with unusual or anomalous pollution levels within an area and a year. Tiebout sorting correlated with neighborhood specific trends in pollution will not bias estimates. (3) Analyses include area-by-age fixed effects. Identification of an average individual's dose–response relationship comes from differences in pollution exposure for children of the same age and living in the same area but born at different times. The intuition is that children living in the same area but born several months to a few years apart are presumed similar and are presumed to have grown up in similar circumstances, but face somewhat different pollution exposures at a given age because they reach that age at a different point in time.

We find that marginal increases in carbon monoxide (CO) and ground-level ozone (O3) are associated with statistically significant increases in children's contemporaneous respiratory treatments. CO results are especially robust. We believe these findings are novel for two reasons. First, non-fatal morbidity impacts of carbon monoxide at common ambient levels remain poorly understood. The EPA's integrated science assessment emphasizes that only a limited number of studies link carbon monoxide and respiratory health, and that the present evidence is merely "suggestive that a causal relationship exists" (USEPA, 2010). Second, associations between criteria pollutants and morbidity outcomes for non-infant children are understudied. Most studies stressing causal effects focus on infant mortality, infant morbidity, and adult mortality.

We also find that CO exposure over the previous year has an incremental effect on children's health that goes above and beyond contemporaneous CO exposure alone. While we do not claim to fully capture the cumulative effects of pollution on children's respiratory health, we do contribute additional evidence on the causal effects of longer-term pollution exposure. These are open questions; the EPA asserts that the "available evidence is inadequate to conclude that a causal relationship exists" between longer-term CO and respiratory morbidity (USEPA, 2010). Our findings suggest that research that focuses only on the acute health impacts of pollution may understate the benefits of pollution reductions.

Background and literature

We study the health impacts of particulate matter (PM10), carbon monoxide (CO), and ozone (O3) concentrations. Particulate matter consists of solids and liquids suspended in the air. Particulates smaller than 10 μm in diameter are designated PM10. Common PM10 sources include construction, on and off road vehicles, fires, and industrial facilities including power plants. Carbon monoxide is a colorless and odorless gas formed when carbon in fuel is incompletely burned. Vehicle emissions are the primary source of ambient carbon monoxide. Ground-level ozone is created from chemical reactions that occur between oxides of nitrogen and volatile organic chemicals in the presence of sunlight and heat. Primary ground-level ozone sources are vehicle emissions, gasoline vapors, and industrial facilities including power plants.