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The impact of air pollution on hospital admissions: Evidence from Italy☆

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ABSTRACT

In this paper we study the impact of air pollution on hospital admissions for chronic obstructive pulmonary disease for 103 Italian provinces, over the period from 2004 to 2009. We use information on annual mean concentrations of carbon monoxide, nitrogen dioxide, particulate matter, and ozone measured at monitoring station level to build province-level indicators of pollution. Hence, we estimate a regression model for hospital admissions, where we allow our aggregate measures of pollution to be subject to measurement error and correlated with the error term. We also adopt standard errors for estimates that are robust to serial and spatial correlation in the error term, to allow for temporal persistence and geographical concentration of unobservable risk factors.

We find that higher levels of particulate matter are associated with higher levels of hospitalisation for children, while ozone plays an important role in explaining hospital admissions of the elderly. Other factors that appear to have an effect on hospital admissions for chronic obstructive pulmonary disease are precipitation and provincial unemployment rate.

1. Introduction

Over the past decade, a substantial scientific literature has documented the size and seriousness of the impact of atmospheric pollution on the environment and the health of people. Air pollution in Europe varies substantially over time and across territory. According to the European Environment Agency many air pollutants have decreased substantially over time, resulting in improved air quality across territory. However air quality problems still persist, as air pollutant concentrations have not sufficiently declined, and a large proportion of Europe's population lives in urban areas where emission limits set by the EU National Emission Ceilings Directive are regularly exceeded. A recent report on the quality of air in Europe (Istat, 2010) shows that Italy is ranked as the third most polluted country in Europe, after Bulgaria and Greece, with more than half of the 30 most polluted cities being Italian. In particular, in the year 2008, Turin, Brescia, and Milan recorded the highest levels of overall air pollution in Europe, after the Bulgarian city, Plovdiv. Turin is also the city with the highest concentration of tropospheric ozone, although this has been reducing over time, while Naples is leading for the highest annual concentration of nitrogen dioxide, responsible for acid rains.

Atmospheric pollution threats public health with both short- and long-term effects. The former may include irritation to the eyes, nose and throat, and upper respiratory infections such as bronchitis and pneumonia. Long-term health effects can include chronic respiratory disease, lung cancer, heart disease, and even damage to the brain, nerves, liver, or kidneys. Some groups of the population may be more sensitive to pollutants than are others, such as young children and the elderly, or people with pre-existing health problems. Medical conditions arising from atmospheric pollution can require expensive treatment, leading to high health care costs, lost productivity in the workplace, and human welfare impacts, thus costing billions of dollars each year.

This paper studies the impact of air pollution on hospital admissions in Italy. Specifically, we examine the effects of a range of different pollutants, namely particular matter of size smaller than about 10 μm (PM10), nitrogen dioxide (NO_2), carbon monoxide (CO), and ozone (O_3) on hospital admissions for chronic obstructive respiratory diseases (COPD), for young children and elderly people living in 103 Italian provinces in the period from 2004 to 2009.

Respiratory illnesses are amongst the most common chronic diseases in the world, including chronic illness in younger age, and as a cause of premature mortality, leading to high socio-economic costs. COPD is a disease state characterized by airflow limitation that is not fully reversible, accompanied by progressive lung function decline. Despite advances in therapy, worldwide, COPD is ranked as the sixth leading cause of death in 1990, and it is projected to be the fourth

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leading cause of death worldwide by 2030 (Mathers and Loncar, 2006). In Italy, COPD represents, by number, the third cause of death after circulatory diseases and cancer (Istat, 2009). Although cigarette smoking is considered the major cause of COPD, recent studies have shown that sustained exposure to exhaust fumes from both motor vehicles and industrial plants may cause development or exacerbation of chronic respiratory diseases (Gauderman et al., 2007; Kunzli et al., 2009; Ko and Huy, 2012).

We use information on annual mean concentration of pollutants measured at monitoring station level to build a set of province-level indicators of pollution. Relative to existing literature, one main feature of our work is that we explicitly control for possible measurement errors and endogeneity issues in our provincial measures of pollution. Indeed, pollution readings from monitoring stations may not reflect the exact amount of pollution to which people have been exposed, given that people live at different distances from stations, and they may move across territory. This issue has been identified by a recent literature in economics (e.g. Graff Zivin and Neidell, 2009; Knittel et al., 2011; Moretti and Neidell, 2011; Schlenker and Walker, 2011). In our regression model for COPD, we also allow for possible endogeneity of our pollution indicators. As pointed by Knittel et al. (2011), it is plausible to think that people living in cleaner areas could also be wealthier, have better living conditions, or have access to better health care, thus inducing a correlation between pollution and the error term. To alleviate these endogeneity problems and estimate more accurately the level of pollution within Italian provinces we adopt an instrumental variable approach. As instruments for pollution we include a set of factors that are recognized to be the main drivers of pollution, including both natural sources such as climate conditions, and anthropogenic factors, i.e., generated by human activity, as well as temporal and spatial lags of pollution. We believe that adopting an instrumental variable approach where in the first-stage we use a spatio-temporal model for pollution can help researchers to study more adequately the impact of pollution on hospital admission, ultimately suggesting more reliable policy interventions.

The remainder of the paper is organized as follows. Section 2 provides a review of the literature on the effects of pollution on mortality rate and hospital admissions. Section 3 introduces our econometric specification and outlines our estimation strategy. Section 4 describes the data, while Section 5 comments on the empirical findings. Section 6 concludes.

2. Background literature

Over the past decade, a wide scientific literature has been documenting the size and seriousness of the impact of atmospheric pollution on the health of people. Most of these studies have focused on the effect of air pollutants on health outcomes, using data at the city, county or region level to test for the effects of prolonged exposure to air pollution, trying to identify which are the most dangerous pollutants and which segment of the population is more at risk.

Early works on the link between urban air pollution and chronic respiratory illness have been carried by Portney and Mullahy (1986, 1990), for the US. Results showed a positive relationship between ozone concentrations and sickness. Samakovlis et al. (2005) investigated the relationship between air pollution and respiratory diseases in Sweden. In particular they find that NO_2 may increase risk for asthma, bronchitis and hay fever nasal problems. Jerrett et al. (2005) studied the health effects of chronic air pollution exposure within industrial cities. Their results suggested that chronic air pollution exposure significantly increases the risk of premature cardiorespiratory and cancer mortalities. Subsequent studies have also found significant associations between ozone (Belle et al., 2005) and nitrogen dioxide (Nafstad et al., 2004) on higher mortality rates. More recently, Currie et al. (2009) explored the impact of air pollutants on infant health, measured by birth weight, gestation and mortality, in New Jersey in 1990s. The paper combined information about mother's residential location from birth certificates with information on air quality monitors. They showed negative effects of exposure to carbon monoxide on children heath, both during the pregnancy and after birth, even in areas at low levels of pollution. Agarwal et al. (2010) studied the effect of exposure to a set of toxic pollutants from manufacturing facilities on county-level infant and foetal mortality rates in the United States between 1989 and 2002. They showed a significant adverse effect of toxic air pollution concentrations on infant mortality rates.

So far, few studies have focused on the effects of air pollution on hospital admissions. Neidell (2004) studied the influence of air pollution on child hospitalisations for asthma in California. Results showed that, among the pollutants considered in the analysis, only carbon monoxide has a significant effect on hospital admissions for children, with a greater effect for children of lower socio-economic status. Dominici et al. (2006) described a short-term increase in hospital admission rates associated with PM2.5 for American Medicare enrollees, in the period between 1999 and 2002. Jayaraman and Nidhi (2008) suggested that air pollution levels in Delhi, specifically of O_3, NO_2 and PM10 have a significant impact on human health in terms of an increase (24%, 13% and 3%, respectively) in respiratory diseases related hospital visits. Namdeo et al. (2011) demonstrated association of short-term variation in pollution and health outcomes in the northern part of the UK. They founded that PM10 and O_3 are positively associated with respiratory hospital admissions in the elderly. Rava et al. (2011) showed that proximity to wood industries is associated with a higher risk of hospitalisation for respiratory diseases and respiratory symptoms in children.

A recent related literature has emphasized that the majority of the works we have reviewed may suffer for a problem of measurement errors, thus leading to a bias in the estimates. It is likely that people have a different exposure to the amount of pollution detected from the monitoring stations. Indeed, people live at different distances from these stations, with some residing close while others far apart. Further, some people may be more mobile than others, also because of avoidance behaviour (Graff Zivin and Neidell, 2009). In other words, a mismatch is likely to exist between the amount of pollution detected and the exposure of the population to such pollution. Lleras-Muney (2010) finds that estimates are very sensitive to the technique used to impute pollution at aggregate level, and that the measurement error is not normally distributed, making the direction of the bias on estimates ambiguous. To deal with this issue, a number of works have adopted the instrumental variables (IV) approach. Chay and Greenstone (2003b) use a natural experiment to look at the relationship between pollution and infant mortality rate. The authors use the Clean Air Act of 1970 as an instrument to estimate effect of pollution on the infant mortality rate. Moretti and Neidell (2011), using zip code for the years 1993–2000, study the relationship between ozone and infant mortality rate in California (US). To alleviate possible bias resulting from the measurement error, they adopt an IV approach, using timing of port of Los Angeles traffic and distance to the port as instruments for ozone concentrations. The authors conclude that estimated effects of ozone on health are large, and that simple correlations are significantly biased by unobserved avoidance behavior and/or measurement error. Knittel et al. (2011) argue that ordinary least squares (OLS) yields inconsistent estimates of the impact of pollution on health outcomes not only because of measurement errors but also for other broader endogeneity issues. According to the author, people living in cleaner areas could also be wealthier, have better living conditions, or have access to better health care, thus inducing a correlation between pollution and the error term. Further, changes in local economic activity may be correlated with both pollution and health. Regional growth will tend to increase pollution levels, but may also be correlated with increases in income levels and/or health care access, thus tending to bias OLS estimates. Hence, Knittel et al. (2011) adopt an IV approach to investigate the relationship between traffic, weather, pollution, and infant outcomes