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Long-run health consequences of air pollution: Evidence from Indonesia's forest fires of 1997

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ABSTRACT

While many studies in the medical literature documented causal relationships between air pollution and negative health outcomes immediately following exposure, much less is known about the long run health consequences of pollution exposure. Using the 1997 Indonesian forest fires as a natural experiment, we estimate the long term effects of air pollution on health outcomes. We take advantage of the longitudinal nature of the Indonesia Family Life Survey (IFLS), which collects detailed individual data on a multitude of health outcomes, in both 1997 and 2007. We find significant negative effects of pollution, which persist in the long run. Men and the elderly are impacted the most, while children seem to recover almost completely from these early shocks. For the entire population, an extra standard deviation in the pollution level increases the likelihood of a poor general health status by almost 3%.

1. Introduction

There is evidence in the medical literature that air pollution, especially smoke pollution, is damaging to health. Smoke from burning vegetation contains particulate matter that is inhaled and transported into the lungs, causing respiratory problems that can lead to other health issues. This pollution negatively affects especially children and older adults.[1] Exposed children can develop acute respiratory infection, which is a leading cause of infant death (Romieu et al., 2002; Chauhan and Johnston, 2003), while prenatal exposure leads to an increased risk of infant mortality and a series of other health problems for the survivors such as respiratory issues, low birth weight, blood pressure, and even mental health and cognition issues (Lacasana et al., 2005; van Rossem et al., 2015; Peterson et al., 2015). There is ample empirical evidence that better air quality reduces infant mortality (see Chay and Greenstone, 2003a,b; Currie and Neidell, 2005; Bobak and Leon, 1992 or Loomis et al., 1999), and also that prenatal exposure, especially during the third trimester, leads to poor fetal growth (see Berkowitz et al., 2003; Dejmek et al., 1999, or Wang et al., 1997). Although not as seriously affected, adults are not immune however. Pollution can cause respiratory problems (Emmanuel, 2000), difficulties in performing certain physical tasks (Frankenberg et al., 2005), and even higher mortality in older or otherwise unwell adults (Sastry, 2002; Pope et al., 1992). There is, however, much less information on the long-term health consequences of pollution. Most of the studies that establish correlations or causal links between air pollution and health rely on short-run, cross-sectional data. This paper takes advantage of a longitudinal data set from Indonesia that allows us to track individuals 10 years after being exposed to a pollution shock. We are able to quantify the degree of pollution exposure and estimate the impact of pollution on current health, while controlling for the initial health stock and other socio-economic determinants of health.

Observational studies do not permit causal inference; however, the Indonesian case presents us with a "natural experiment" that allows for such attribution. From August to November of

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[1] See Pope (2000) for a review of this medical literature.

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1997, large parts of Indonesia were engulfed in forest fires. Slash-and-burn practices are common in Indonesia as a cheap way of clearing land. Because of the especially dry and windy season caused by El Niño that year, fires started by small farmers and large commercial plantations quickly spread, going out of control until the rainy season started in November. The fires destroyed over 12 million hectares of land and covered much of the country in thick smoke for weeks. The smoke even reached parts of Malaysia and Singapore, with the most extreme level of pollutants reached in September/October. The availability of such natural experiments is ideal in social sciences and the use of natural phenomena as sources of exogenous shocks is widely used (see for instance Skoufias and Vinha, 2012, or Yamamura, 2016).

Beyond the economic and environmental negative effects of these fires, there were clear negative health consequences on the Indonesian population. Jayachandran (2009) estimates 15,600 "missing children" that were never born or died in infancy due to in utero pollution exposure during the Indonesian fires. The adults were not spared these pollution related negative health shocks. Kunii et al. (2002) reports elevated levels of respiratory problems symptoms during the fires, with about 13% of the respondents reporting severe discomfort. Heil (2000) finds an increase of acute health issues caused by the fires even in neighboring countries like Singapore, with the elderly and children being the most susceptible to adverse health outcomes caused by the smog.

There are also important effects of pollution on economic outcomes. If pollution affects childhood health and childhood health affects human capital accumulation, then exposure to pollution creates life-long socio-economic handicaps. Currie et al. (2014) review the two strands of literature dealing with establishing causality between pollution and early-childhood health, and then between early-childhood health and human capital outcomes later in life. However, most of the literature focuses on the short-run effects of pollution on children and not much was done on the long run consequences for adults. Ferrie et al. (2012) present some evidence about the long run consequences of water lead pollution on cognitive ability and we are aware of only two other concurrent efforts that look at the medium and long term effects of air pollution, which coincidentally focus on the same Indonesian forest fires case. Banerjee (2016) and Rosales and Triyana (2015) use the same exogenous shock of pollution to study the effects of early life exposure to human capital formation. Both studies differ from ours in that they only focus on in utero and early life exposure, consider a smaller set of health outcomes, and make use of different methodologies. Their results are also not in agreement. Banerjee (2016) finds significant effects on cognition and insignificant effects on height and lung capacity, while Rosales and Triyana (2015) finds significant effects on height and lung capacity, but no effects on cognition.

This paper uses the 1997 Indonesian forest fires as an exogenous shock of pollution, and studies its long term consequences on the health of survivors, both children and adults, 10 years after the event. We focus on both subjective and objective health measures, and differentiate between sexes and age groups. Overall, we find significant negative effects of pollution in all our health measures. The impact of pollution is higher for men and the elderly population. Somewhat surprisingly, children seem to be less affected than the elderly, which shows that in spite of the higher short-term impact on young children, they manage to recover the best from early health issues caused by pollution. In particular, our result on the effects of pollution on lung capacity for children mitigates the apparently contradicting results from the two concurrent studies mentioned earlier. While Rosales and Triyana (2015) found significant effects of pollution on the lung capacity of young children that persist in the medium-run, Banerjee (2016) found no such effects in the long-run, which our study confirms. This is consistent with a recovery and catching up hypothesis. We are unable to analyze their other results, since lung capacity is the only common outcome between our study and theirs.

2. Data and methodology

Our primary data source is the Indonesian Family Life Survey (IFLS), which is a longitudinal socio-economic survey that tracks and surveys a sample of households representative for about 83% of the Indonesian Population. The approximately 17% of the Indonesian population living in the outer provinces were not surveyed for cost purposes (Frankenberg et al., 2005). There are currently four waves of IFLS, fielded in 1993, 1997, 2000, and 2007. The survey collects demographic and socio-economic data on individual households' family members and also community level indicators such as local infrastructure. The IFLS does a particularly good job in tracking households from one wave to another and has been intensively used as a data source in socio-economic research (see for instance Kim, 2015; Sohn, 2015a, 2015b) including for studying the same phenomenon of air pollution (for instance in Jayachandran, 2009 or Kunii et al., 2002). Since our main goal is to measure the long run consequences of air pollution caused by the 1997 fires, it is crucial to have the same households monitored in both 1997 and 10 years later in 2007.

We collect subjective and objective health measures for more than fifteen thousand respondents in the IFLS that we could track between 1997 and 2007. Depending on the health measure studied, the sample sizes differ, since some health measures are only collected after a certain age. The health measures we focus on are the respondent's lung capacity, hemoglobin level, general health status (GHS) and the number of difficulties with activities of daily living (ADL). To control for initial health stock, we collected these health measures in both 1997 and 2007. The 2007 health measure represents the dependent variable, while the 1997 health measure is used as a control for individual health stock. With respect to the age cutoffs for each individual health measure, lung capacity is only collected for individuals that are at least 9 years old, hemoglobin is measured for everyone older than 1, GHS is collected for all age groups, and ADL is only collected for individuals over 40.

Our first two health measures are objective outcomes: lung capacity and hemoglobin. Lung capacity points to impairments of the respiratory system, which is immediately affected by air pollution. While some studies have shown long-term damage to lungs stemming from extended exposure to pollution (e.g. Hwang et al., 2015) we know of no studies that look at the long-term impact of a single pollution event. Lung capacity is measured in IFLS for all respondents over 9 years old, using the Personal Best Peak Flow Meter. Lung capacity was measured three times for each respondent and the average of these measurements is used in the analysis. Blood hemoglobin is a health measure for anemia, but hemoglobin counts can also be affected by infections. Hemoglobin counts were measured in the IFLS using the Hemocue meter, which uses a small drop of blood obtained from pricking the respondents' finger. Because hemoglobin levels are measured for all respondents over 1 year old, as opposed to all respondents over 9 years old as was the case with lung capacity, the sample size is some three thousand observations larger for these estimation. Hemoglobin reflects the sufficiency of blood (or iron in the blood) through the body. The ingestion of particulate matter inflicts numerous tiny