Climate Change, Pollution and Infant Mortality: Evidence from Temperature Shocks and Crop Residue Burning in India

Introduction

Recent literature examining the impact of climate change on human capital outcomes has increasingly found that prenatal exposure to weather shocks, particularly temperature stress, have a detrimental effect on infant mortality as well as later life outcomes. Complementary research in the field of environmental economics has also found evidence of similar negative effects due to *in utero* exposure to particulate pollution. In both cases, the effect sizes are larger in developing countries compared to the developed world. While these two factors have been looked at separately in isolation, there is limited evidence on the interaction of exposure to pollution and temperature shocks. This question is particularly significant in the context of developing countries such as India which are exposed to high climate variability risks as well as some of the highest levels of pollution.

Data on long-term trends in temperature and mortality in India shows that the probability of heat waves has increased nearly 2.5 times (compared to half-a-century ago) and the risk heat-related mortality events increased by more than 140 percent[1]. Concurrently, a recent assessment by the Lancet Commission on Pollution and Health finds that of the 9 million estimated pollution-linked deaths globally in 2015, 2.5 million deaths occurred in India alone[2].

In this study we examine the role of temperature and pollution separately as well as the interaction of these factors on infant mortality (deaths within first year after birth) in India. To do so we combine data on child births and deaths from a large survey of nearly five million households with satellite based measures of temperature and pollution. In addition, a key contributor to particulate matter pollution (PM2.5) in India is the practice of crop residue burning. Farmers burn the remnants of their harvest to clear fields in time to plant the next season's crop. This is most commonly practiced in the areas dominated by rice-wheat cropping system in the Northern Gangetic Plains. We exploit the seasonality of crop residue burning activities along with the spatial variation in the location of crop residue fires to construct an exogenous measure of prenatal exposure to pollution.

Data

Infant mortality: We use survey reported measures of child births and deaths from the Annual Health Survey (AHS), implemented by the Office of the Registrar General of India and the fourth round of the District Level Household Survey (DLHS-4). The AHS sample consists of nearly 4.3 million households, across 284 districts in eight of the poorest states in India, with data collected between 2010 - 2013. The DLHS-4 sample covers 350,000 households across all remaining districts of the country and was implemented during the same period[3]. Both survey samples are representative at the district level and use similar

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[1] Mazdiyasni, O., AghaKouchak, A., Davis, S. J., Madadgar, S., Mehran, A., Ragno, E., Niknejad, M. (2017). Increasing probability of mortality during Indian heat waves. Science Advances, 3(6), e1700066. https://doi.org/10.1126/sciadv.1700066

[2] https://www.reuters.com/article/us-global-pollution-health/india-tops-global-pollution-deaths-of-9-million-a-year-study-idUSKBN1CO39P

[3] Our analysis examines sensitivity of the results from combining both samples as well as separately for each survey to avoid errors due to larger sample sizes in poorer districts in the AHS survey.

questionnaires. The survey instruments emphasize variables pertaining to women's reproductive health along with basic household characteristics. We use the self-reported births history for married women in the sample to construct data for birth month and year of each child and month and year of death, in case the child died. To limit recall errors, the sample is limited to birth history in the five years prior to the survey.

Temperature and Pollution: We assemble multiple sources of satellite data to construct a district-level panel for temperature and pollution measures spanning the period 2005 – 2014 (matching the timing of births in the household survey data). We retrieve gridded daily temperature data from the NCEP/NCAR Reanalysis as well as the long-term monthly means. Pollution level is proxied through the aerosol optical depth (AOD) measures from MODIS-Terra. District level measures are constructed by calculating weighted means of the grid values within a 200-kilometer distance from the district centroid. The resulting measures are daily temperature and monthly mean of AOD for each district. In addition, we also use satellite data (MODIS/Terra Active Fire Product) to construct indicators of crop-residue burning activity – measured by number of fire pixels observed in each 1-degree grid cell, over each month. Finally, we also use DMSP-OLS annual Nighttime Light Intensity data as proxy to control for changes in level of industrial activity in each district.

Empirical Strategy

We estimate a model of the following form:

$$M_{idqy} = \beta_0 + \sum_{k=1}^{4} \beta_k\,(ADD\ over\ 30\ C)_k + \sum_{k=1}^{4} \gamma_k (AODD)_k + \sum_{k=1}^{4} (\delta_k\,(ADD\ over\ 30\ C)_k * (AODD)_k + X_{idqy}\boldsymbol{\rho} + \boldsymbol{\tau_{dq}} + \boldsymbol{\alpha}_{\mathrm{y}}$$

Where M is mortality outcome for child born in district d, in quarter q, year y; ADD is Accumulated Degree Days over 30 C during trimester k (with k = 1 i=being the first three months of birth); AODD is average aerosol optical depth in trimester k interacted with the weighted-distance of the district to five nearest grids with bio-mass fires in them (with pixel-counts of fires in each grid as weights); X is a vector of household controls and lagged intensity of annual nighttime light intensity for the district, followed by district-quarter fixed effects and year fixed effects. The AODD pollution measure overcomes potential selection due to sorting of households – for instance, poorer households may be more likely to reside in areas close to industrial activity due to labor market factors, and this would result in an overestimate of the pollution impact.

Results and Discussion

Preliminary results indicate a significant, negative direct effect of temperature shocks in rural areas in the final trimester during pregnancy but not in other periods, and no effect in urban areas on infant mortality. The direct effect of pollution is significant and negative during the final trimester of pregnancy and during the first three months of birth in both rural and urban areas - though the effect is stronger in rural areas. Finally, the interaction of pollution and heat stress is significant and negative during all four periods in rural areas, but coefficients for urban areas are not significant. The direct effects found here are consistent with existing results in the literatures. The key contribution of this paper is to highlight the heightened risk that the interaction of pollution and climate change implies, particularly for the poorer and more vulnerable sections of the population.