Extended Abstract

A growing body of evidence supports the link between poor air quality and negative health and human capital outcomes across the world. India, in particular, has seen some of the most alarming levels of air pollution and pollution-related deaths. 14 Indian cities are amongst the 20 most polluted cities in the world in 2017 (WHO 2018) and The Lancet Commission on pollution and health estimated that nearly 30 percent of the global deaths linked to air pollution in 2015 occurred in India (Landrigan *et al.*, 2017). The bulk of the research on air pollution has focused on pollution from industrial sources, vehicular emissions and to some extent, indoor air pollution from household fuel use. However, the pollution and health consequences of crop-residue burning, a commonly used practice by farmers across many developing countries have received much less attention (Lai *et al.*, 2017; Rangel and Vogl, 2017). This study quantifies the impact of such agricultural practices on infant mortality.

Crop-residue burning can result in severe air pollution levels during harvest seasons and such practices are estimated to contribute as much as half of the particulate pollution in some cities in India (Kaskaoutis *et al.*, 2014; Cusworth *et al.*, 2018). The location of these fires is driven by both the prevalence of agricultural technology as well as productivity. The growth of crop-residue burning in India has been linked to the spread of mechanized harvesting (Gupta, 2012). Mechanized harvesting methods leave substantial amounts of crop residue on fields and farmers use controlled burning to quickly get rid of this stubble and prepare the field for the next harvest. These fires are also most common in regions where the productivity gains from the rice-wheat cropping system are high and farmers stand to gain by sowing their next season crop early (Venkataraman *et al.*, 2006). As a result, the location of these fire occurrences may be correlated with economic activity that would also influence human health outcomes. These issues complicate the empirical estimation of the effects of these fires on infant mortality.

In this study, I overcome these identification challenges by isolating the effect of exposure to agricultural fires that occur up-wind of a households' location. The underlying assumption is that particulate emissions from fires are likely to affect air quality conditions downwind, but not upwind of the fire's location. I assemble a novel set of satellite data on

more than 800,000 fire locations, wind conditions, and air quality measures. I combine these data with information on infant births and mortality outcomes from a national scale household survey that includes a rich set of socioeconomic variables, and crucial for my research design, geocoded location information as well. Using these data, I examine the effect of exposure to up-wind agricultural fires on the mortality outcomes for births recorded over a ten-year period (from 2006 – 2016). The identification strategy is similar in spirit to a difference-in-difference approach. I compare the difference in mortality rates for births in locations with high versus low up-wind fires, between harvest versus non-harvest periods over different years.

The main results of this study examine the impact on infant mortality defined as death occurring within the first month of birth. I find that exposure to high levels of fire activity, particularly in the late pregnancy months (a month before birth or the month of birth) increases the mortality rate by 3.17 deaths per 1000 births – an increase of nearly 10 percent relative to the sample mean of 33.09 deaths per 1000 births. Further examining the heterogeneity in the impact across urban and rural areas, I find that the effect is entirely driven by the mortality impact in rural areas while the effect in urban regions is relatively muted. This suggests that urban households may be able to undertake some form of adaptation or safety measures such as staying indoors during pregnancy. They may also have better access to health and maternal care services such as deliveries in hospitals that could mitigate the immediate consequences of air pollution on birth outcomes. These urban-rural disparities are consistent with the findings in the previous literature that document the existence of higher pollution burden on rural residents (Neidell, 2004; MAPS Working Group, 2018).

The results of this paper contribute to the growing literature from the fields of economics, environment, and epidemiology examining the health burden of air pollution. Within economics, the focus has often been on modern, industrial sources of pollution within developed countries owing to the relatively better data availability on air quality measures (Graff Zivin and Neidell, 2013). Recent work has expanded to look at the consequences of air pollution on health, education and labor market outcomes in developing countries as well (Greenstone and Hanna, 2014; Hanna and Oliva, 2015; Bharadwaj *et al.*, 2017). Overall, these studies indicate a significant negative effect on human capital outcomes. But these studies are mostly limited to specific cities and focus on pollution sources that are more common in urban settings and it can be difficult to extend these results to rural populations. There have also been a number of studies that look at the effect of pollution from large-scale fires such as forest wildfires (Sastry, 2002; Jayachandran, 2009; Kim *et al.*, 2017). While these studies shed light on the potential effects of biomass burning, such events studied are usually rare, with extreme levels of pollution. These results may differ from the effects that one would find in response to cyclical exposure to moderate levels of pollution that result from smaller, agricultural fires.

Relative previous studies on air pollution impacts, this study is unique in providing an analysis at a much greater geographic level, encompassing both urban and rural areas in a country; and in examining the effect of a previously ignored, but growing source of pollution from agriculture. I find that seasonal crop-residue burning results in significant human health costs highlighting the need for technological and policy solutions that could reduce the incidence of such agricultural fires.

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