Does Exposure to Household Air Pollution Affect Infant and Child Health Outcomes? Evidence from India.

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Abstract

Household air pollution is a pressing public health concern in India, given that more than half of the Indian households relying on solid fuel use. Of utmost concern is the impact of household air pollution on child health, with an estimated 4.8 hundred thousand premature deaths annually in India attributable to the use of solid fuel (Balakrishnan et al. 2019). This paper aims to investigate the relationship between child health outcomes such as birth weight, height for age z-score, and the incidence of coughs, and household air pollution resulting from different types of cooking fuel. Through Ordinary Least Square (OLS) linear regressions, both the use of Liquefied Petroleum Gas (LPG) and wood demonstrate a statistically significant decrease in birth weight and height for age z-score, while the magnitude of health impact is greater for burning wood. Meanwhile, educational attainment, urban status, and wealth index all demonstrate a positive and statistically significant association across all health indicators. These findings highlight the need for policies and interventions aimed at reducing household air pollution exposure especially among rural households with lower socio-economic status in India.

I. Introduction

As the second most populous country, India is infamous for its high levels of air pollution, which has been linked to numerous adverse health outcomes. Household air pollution, caused by solid fuels such as wood, charcoal, and coal in developing countries like India, is a major contributor to serious health problems, including respiratory and cardiovascular diseases (Bruce et al. 2000, Saha et al. 2018). Exposure to such biomass smoke is responsible for 59 percent of rural cases and 23 percent of urban cases of tuberculosis in India (Bruce et al. 2000). In addition, air pollution has been associated with reduced birth weight, childhood acute lower respiratory infections, and chronic obstructive pulmonary disease, which all share the global burden as risk factors. Therefore, it is crucial to understand the relationship between household air pollution and maternal and child health outcomes to develop effective interventions and reduce such disease burden.

This research paper aims to investigate the effect of household air pollution on child health in India. The analysis will include a systematic review of published studies to analyze existing case studies on the impact of exposure to household air pollution on child health outcomes through three indicators: birth weight, height for age z-score, and the incidence of coughs. Ordinary Least Square (OLS) regressions then complement the literature review. The regression results present compelling evidence indicating a causal link between the combustion of different cooking fuels and health outcomes. Specifically, the usage of Liquefied Petroleum Gas (LPG) and wood, which are the predominant cooking fuels in India, is found to be associated with a notable decrease in birth weight and height for age z-score. Importantly, findings suggest that the effect of LPG on health outcomes is relatively smaller compared to wood, as reflected by a smaller estimate for LPG. Additionally, educational attainment, urban status, and wealth index exhibit a positive and statistically significant relationship with all health indicators. By producing data-driven evidence of the adverse effects of household air pollution on child health outcomes, this paper aims to inform policy decisions and propose effective solutions to reduce air pollution and improve maternal and child health outcomes in India.

The paper is structured as follows: Section II focuses on the analysis of existing journals. Section III outlines data usage, and Section IV discusses the relevant economic concepts that inform the decision models used in the study. Section V presents the findings, while Section VI addresses any limitations encountered during the study. Finally, Section VII concludes the paper.

II. Literature review

A. Air pollution and infant and child health

a. Outdoor air pollution

Infant health can be profoundly affected by prenatal exposure to outdoor air pollution, particularly with regards to respiratory development. Fuchs et al. (2014) observed elevated respiratory rates among expectant mothers who experienced higher exposure to PM_{10} during the final trimester of pregnancy. This indicates that air pollution during prenatal stages can hinder lung function, potentially contributing to childhood asthma and even infant mortality (deSouza et al. 2021). In a study conducted by deSouza et al. (2021) utilizing data from the 2015-2016 Demographic and Health Survey (DHS) and employing multivariate logistic regressions, significant connections were found between exposure to carbon aerosols, a critical component of $PM_{2.5}$, during the third trimester and the first month of an infant's life, and infant mortality rates in India. These findings are consistent with the research conducted by Saha et al. (2018), which highlighted the detrimental effects of $PM_{2.5}$ penetration through maternal exposure on pulmonary function and pathological changes observed in Indian infants.

In addition to its direct impact on lung development, exposure to air pollution amplifies the risks of preterm birth, decreased birth weight, and compromises the immune system of infants. One analysis of the World Health Organization Global Survey on Maternal and Perinatal Health (Fleischer et al. 2014) employed generalized estimating equation (GEE) to determine the impacts of $PM_{2.5}$ level on lower birth weight and preterm birth among 22 countries. They concluded that higher $PM_{2.5}$ levels in the atmosphere are associated with primarily lower birth weight and preterm birth, both of which are leading risk factors for neonatal mortality in rapidly developing countries such as India (deSouza et al. 2021; Korten et al. 2017; Goyal et al. 2019).

b. Household air pollution

Most people in low-income countries (Pokhrel et al 2010; Lam, et al 2018) use solid fuels and cook inside their house without proper ventilation, producing harmful pollutants that not only affects women fertility but also the physical development of a child. This situation is no different in India, where the use of solid biofuels for residential energy is widespread and has led to 400,000 deaths annually in children under the age of five due to acute lower respiratory infection (Balakrishnan et al. 2019).

Anthropogenic sources such as cooking and heating produce significant amounts of aerosols, and Sehgal et al. (2014) found that 82 percent households in India cook using wood and natural gas in the house, implying great potential for indoor air pollution. Since younger children are spending more time in an indoor environment rather than outdoor environments, they are more likely to be exposed to household wood smoke, elevating the risks for impaired lung functions and chronic obstructive lung disease. The utilization of logistic regression analysis by Padhi et al. (2008) provided insight into the likelihood of respiratory infections in children from households utilizing biomass fuels compared to those using liquified petroleum gas. The results revealed that exposure to cooking smoke from biomass combustion was significantly associated with a decline in lung function and an increased prevalence of doctor-diagnosed asthma. These findings are consistent with a nationwide cross-sectional survey conducted in India by Agrawal (2012), which demonstrated that women residing in households using biomass and solid fuels have a significantly higher risk of asthma compared to those living in urban areas. It is important to note that adults are typically considered to have a stronger immune system than children, and thus, this indirectly aligns with the findings of other literatures (Kankaria, et al. 2014, Padhi et al. 2008) that children in households relying on biomass fuels for cooking are more likely to develop asthma and other respiratory diseases.

B. Other potential factors that contribute to child health outcome

Besides the direct effects of outdoor and indoor air pollution on child respiratory health, this section addresses other potential factors including maternal smoking, maternal educational attainment, and household health insurance status. A meta-analysis conducted by Weitzman et al. (1990) found that maternal smoking of 0.5 packs per day was identified as an independent risk for asthma development and for children's use of asthma medications ($p < 0.05$). Meanwhile, passive maternal smoking has been linked to adverse outcomes in children, including decreased birth weight (Mathai et al. 1992) and potentially lower child height for age in India (Kyu et al. 2009). In particular, Kyu et al. (2009) found that exposure to maternal smoking was associated negatively with child height-for-age in some developing countries in southeast Asia including Cambodia and Nepal. The cultural similarity between India, Cambodia, and Nepal, such as smoking habits, due to their geographical proximity suggests that the findings in these countries could be relevant to India.

In addition to maternal smoking, there is a growing body of evidence demonstrating that maternal education has a positive association with child health outcomes, including access to medicals care , improved nutrition, and immunization coverage (Vikram and Vanneman, 2019). Another study unraveled that children from households with health insurance coverage were less likely to experience financial barriers to healthcare access (Balarajan et al. 2011), which could also contribute to better health outcomes. Overall, these studies highlight the importance of both maternal smoking and health insurance coverage in determining child health outcomes in India.

C. Uniqueness of this study

Several studies have explored the link between air pollution and child health outcomes, with a particular focus on child mortality rates and respiratory issues. However, there is a gap in the literature regarding other important indicators such as birth weight. Moreover, many previous studies failed to consider the influence of maternal smoking on infant lung development. To address these gaps in the literature, my study will consider the influence of household wealth quintiles, maternal smoking, and mother’s education level. My findings provide a more comprehensive understanding of the complex relationship between air pollution and child health and highlight the need for targeted interventions aimed at reducing exposure to air pollution and addressing the socioeconomic and cultural factors that contribute to poor child health outcomes. By filling these gaps in the literature, my study contributes to the broader effort to improve child health outcomes in areas affected by high levels of air pollution.

III. Data

In this research, infant and child health data were collected from the Demographic Health Surveys (DHS) conducted between 2019 and 2021 in India, which are national household surveys that gather comprehensive information about population health. Although the unit of observations is household in DHS, I use individual level data – children under the age of five – for analysis. Three health outcomes were chosen as indicators of infant and child health, including birth weight, height for age z-score, and the incidence of cough accompanied by short rapid breathing in the two weeks before the survey. This study uses the height for age z-score as one indicator of stunted growth, because it reports the deviation between child's height and the median height of a reference population of the same age and sex (DHS codebook).

One thing needs to highlight in the data cleaning process is that I implemented a specific logistic by excluding birth weights exceeding 5 kilograms and any height for age z-scores below -3 or above 3. This decision was based on several factors. Firstly, the average birth weight in India ranges from 2.7 to 3.2 kilograms, according to the World Population Review. In this research, I assumed that birth weights exceeding 5 kilograms are likely to be recall errors. Secondly, considering a normal distribution, the z-score corresponding to a 99.5% confidence level is approximately 2.807. Hence, including observations that deviate from this range by only 0.05% would provide less meaningful insights in the analysis.

One key regressor in the study is the type of cooking fuel used by households. Summary of the data reveals that the most used cooking fuels in the sample are Liquefied Petroleum Gas (LPG) and wood, accounting for 46.7 percent and 42.2 percent of households respectively (*Table A1, appendix*). LPG and wood remained the greatest proportion among children who were reported coughing in the last two weeks (*Figure 1*). *Figure 2 left* demonstrates that households utilizing wood, straw, or grass for cooking fuel exhibit the highest density of children with lower birth weight, with the majority weighing between 2 and 3 kilograms. In contrast, *Figure 2 right* illustrates that households using LPG, one of the most widely used clean fuels in India, report higher birth weights, particularly for infants weighing over 3.5 kilograms. These findings suggest a potential association between household fuel type and infant birth weight. It can be hypothesized that exposure to indoor air pollution caused by the use of solid fuels may result in adverse health outcomes for infants, such as low birth weight. However, further analysis using regression models controlling for potential confounding variables is necessary to establish the causal relationship between cooking fuel and birth weight.

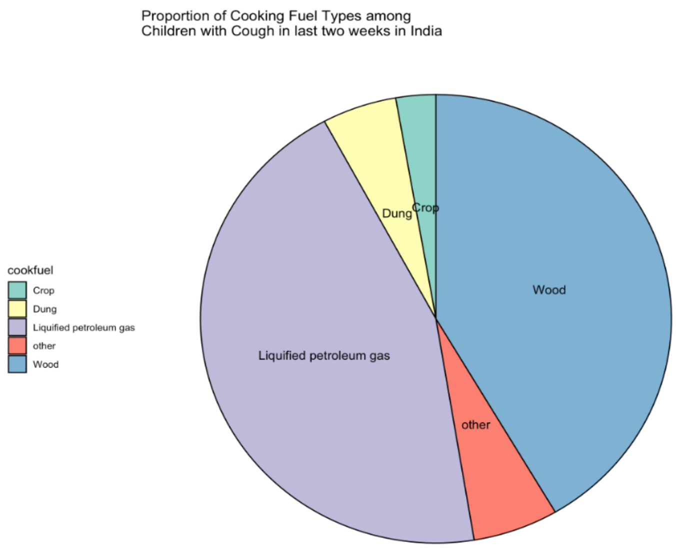

Figure 1. Proportion of cook fuel types among children with cough in the last two weeks.

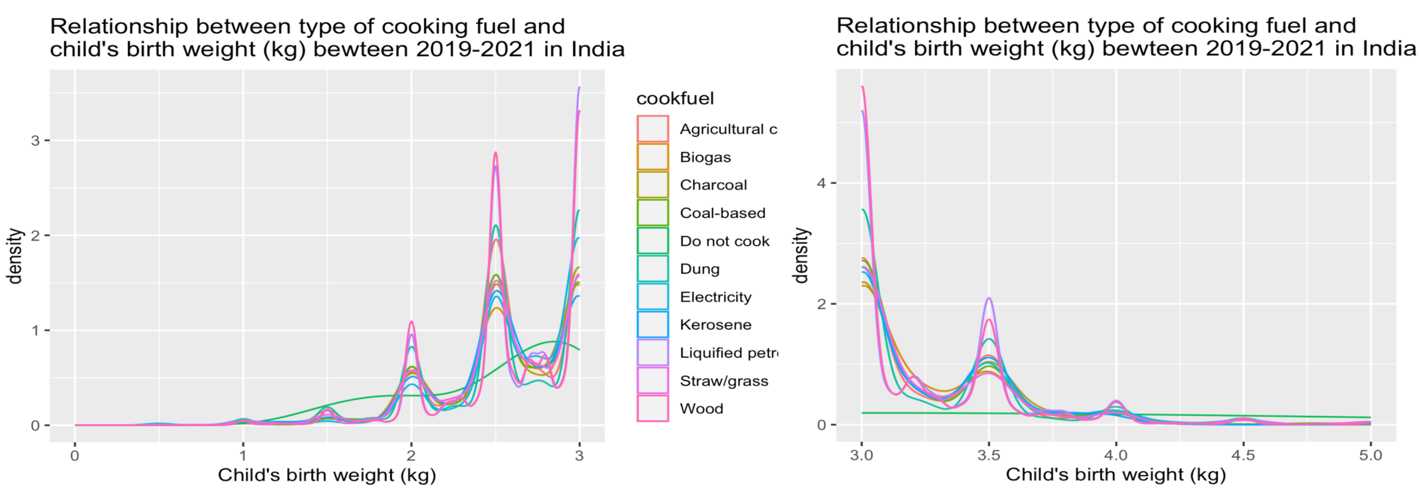

Figure 2. Relationship between type of cook fuel and child's birth weight (kg) between 2019 and 2021 in India.

The resulting sample size consists of over 166, 041 children in India. The DHS data provides additional household-level demographic and socioeconomic variables (*Table A1*). This includes the mother's highest education level, household wealth index quintiles, maternal smoking status, urban status, and health insurance covered status, which we incorporate as controls in my estimation as informed by the previous literature.

IV. Theoretical framework and Methodology

In terms of methodology, we approach both qualitative and quantitative methods to investigate the research question. The qualitative aspect of the study will be based on case studies from other peer-reviewed journal articles. For the quantitative aspect of the study, we employ Ordinary Least Square (OLS) linear regression that estimates the relationship between household air pollution ($X_{i = cookfuel}$) and child health outcomes (denote as Y).

$$Y = \beta_0 + \beta_1 X_i + \varepsilon \quad (1)$$

To address the omitted variable bias and endogeneity threat of the validity of regression coefficients, we incorporate a vector of household-level demographic and socioeconomic variables as controls (denoted as D_i). In addition, we also include fixed effect for geographic location (denoted as G_i). Nonetheless, the results of the study should be interpreted with caution as measurement error and other unobserved factors may also affect the results.

$$Y = \beta_0 + \beta_1 X_i + \beta_2 D_i + \beta_3 G_i + \varepsilon \quad (2)$$

V. Results – Impact of Household Air pollution on Child Health Outcome

Table 1 presents the findings regarding the impact of different cook fuel types on the incidence of cough, birth weight, and height for age z-score, as a measure of household air pollution. To assess these health indicators, we initially conducted OLS regressions, followed by the inclusion of geographic fixed effects and a comprehensive set of demographic and socioeconomic control variables. Comparing to the reference level of electricity, the use of LPG for cooking showed a statistically significant decrease of 0.037 kilograms in birth weight (column 3) and a decrease of 0.0228 units in the height for age z-score (column 5). Burning wood, on the other hand, exhibited a more substantial impact, resulting in an average decrease of 0.102 kilograms in birth weight and 0.378 units in the height for age z-score. The relatively smaller decrease in birth weight and height-for-age z-score associated with LPG suggests that LPG is indeed a cleaner fuel compared to wood and other biomass commonly used in India (Gould & Urpelainen, 2018). This is attributed to the complete combustion of LPG, resulting in lower emissions of carbon monoxide and hydrocarbons. However, it is important to note that even though LPG is considered cleaner, it still has adverse health impacts on children under the age of 5 because of the negative sign of the estimates. In relation to the incidence of cough (column 1), the OLS regression did not reveal any statistically significant differences between LPG and wood, the two primary fuel sources. However, statistically significant associations were observed among other fuel types. This suggests the possibility that other factors, not captured in the current analysis, may be influencing the incidence of cough in relation to LPG and wood usage. Overall, these initial results show that using all type of cook fuels have a negative impact on birth weight and height for age z-score.

Upon inclusion of control variables and geographic fixed effects, the estimates for all three indicators experienced changes in magnitude, while the sign remained unchanged. This consistency in sign aligns with intuition, as the use of electricity for cooking generates fewer emissions compared to all other types of fuels. On average, households using LPG show a statistically significant decrease of 0.044 unit in the height-for-age z-score compared to those using electricity, after accounting for control variables. Similarly, households using wood display a decrease of 0.021 kilograms in birth weight, holding the control variables constant. The results imply that the selection of cooking fuel distinct implications for a child's malnutrition and stunting, which refers to impaired growth and development and increased susceptibility to respiratory diseases.

Table 2A **(***Appendix*) reveals an important finding: children exposed to passive maternal smoke are 20 percent more likely to report coughing in the last two weeks (column 1). However, no statistically significant associations are observed between passive maternal smoke exposure and birth weight or height. This lack of significance may be attributed to the skewed distribution in the incidence of cough, rendering it a less reliable indicator of health outcomes in this study.

Besides maternal smoking status, the results reveal that educational attainment, urban status, and wealth index collectively demonstrate a positive and statistically significant association across all three health indicators (*Table 2A*). Specifically, mothers with higher education levels tend to have children with an average increase of 0.06 kilograms in birth weight and 0.01 unit in height-for-age z-score compared to those with a secondary education or lower (*Table 2A*). It is evident that higher education levels often associated with better access to healthcare services and increased awareness of healthy lifestyle choices. This way, mothers with higher education levels may be equipped with better decision-making skills, allowing them to make informed choices regarding the health of their children.

Living in urban areas, which also typically offer improved access to nutrition and healthcare, is associated with a statistically significant increase in birth weight by 0.0131 kilograms and height-for-age z-score by 0.048 unit compared to rural areas (*Table 2A*). Interestingly, urban households also experience a significant increase of 0.008 in the incidence of cough (*Table 2A*). This could potentially be attributed to the higher levels of outdoor air pollution prevalent in urban areas due to proximity to industries, factories, and automobile emissions.

Moreover, the analysis demonstrates a notable trend in the magnitude of effects for birth weight and height-for-age z-score across different quintiles of the wealth index, ranging from the poorest to the richest households. On average, households categorized under the richest wealth index exhibit the lowest likelihood of cough incidence and the highest birth weight and height-for-age z-score. These findings emphasize the significance of the wealth index as a crucial indicator for child health, indicating that higher economic status is associated with improved health outcomes for children.

TABLE 1 THE IMPACT OF AIR POLLUTION ON CHILD HEALTH OUTCOME

Dependent variable	Incidence of Cough		Birth Weight		Height for Age z-score	
	(1)	(2)	(3)	(4)	(5)	(6)
Cook fuel						
LPG	0.020	-0.010	-0.0372***	-0.017	-0.228***	-0.0444**
	(-0.0151)	(-0.0158)	(-0.0133)	(-0.0134)	(-0.0227)	(-0.021)
Coal	0.108***	0.0689***	-0.144***	-0.0563***	-0.504***	-0.0847***
	(-0.0259)	(-0.0265)	(-0.0204)	(-0.0206)	(-0.0301)	(-0.0287)
Charcoal	0.107***	0.0465*	-0.0659***	-0.010	-0.467***	-0.0724**
	(-0.0253)	(-0.0255)	(-0.0201)	(-0.0199)	(-0.0299)	(-0.0281)
Wood	0.013	-0.023	-0.102***	-0.021	-0.378***	-0.021
	(-0.0151)	(-0.0159)	(-0.0133)	(-0.0135)	(-0.0227)	(-0.0211)
Straw	0.151***	0.0655**	-0.134***	-0.0510**	-0.492***	0.009
	(-0.0248)	(-0.0257)	(-0.0194)	(-0.0198)	(-0.0295)	(-0.0281)
Crop	0.146***	0.0737***	-0.144***	-0.0507***	-0.361***	-0.017
	(-0.0208)	(-0.0216)	(-0.0167)	(-0.017)	(-0.0268)	(-0.0254)
Animal dung	0.0469***	0.001	-0.116***	-0.0327**	-0.463***	-0.029
	(-0.017)	(-0.018)	(-0.0148)	(-0.0152)	(-0.0241)	(-0.0228)
Smoke status	No	Yes	No	Yes	No	Yes
Insurance	No	Yes	No	Yes	No	Yes
Education	No	Yes	No	Yes	No	Yes
Urban	No	Yes	No	Yes	No	Yes
Wealth index	No	Yes	No	Yes	No	Yes
State fixed effects	No	Yes	No	Yes	No	Yes
Constant	0.236***	0.138***	2.894***	2.782***	-1.405***	-1.327***
	(-0.0149)	(-0.0166)	(-0.0131)	(-0.0149)	(-0.0225)	(-0.0235)
Observations	161,463	161,463	166,041	166,041	166,041	166,041
R-squared	0.001	0.015	0.004	0.043	0.013	0.097

Notes: Table presents estimates of equation (1) where the dependent variable is reported health indicator for children under the age of 5. Columns 1-2 report results for cough, columns 3-4 report results for birth weight, and columns 5-6 for height for age z-score. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 1. The impact of household air pollution on child health outcome.

VI. Limitations

The paper reveals statistically significant relationship between household air pollution and birth weight and height for age z-score. Nevertheless, there are several limitations that should be considered when interpreting the findings. Firstly, the DHS survey relies on mothers' self-perception, which introduces the potential for recall error and subjectivity in reporting their children's respiratory symptoms and birth weight. This impacts the accuracy of the data by leading to misclassification or underreporting of the health indicators employed in my analysis. Meanwhile, the high proportion (99.8 percent) of observations reporting no occurrence of coughing in the DHS dataset restricted the ability to fully explore the relationship between cough incidence and household air pollution through cooking fuel types due to its skewness. Despite the inclusion of control variables, no statistically significant associations were observed between cough and LPG and wood (columns 1 & 2).

In addition to the skewed distribution of cough incidence, relying solely on cough incidence as an indicator for respiratory diseases in children has its limitations, because this occurrence of cough encompasses various situations, including temporary illnesses such as the common cold, which should not be classified as long-term respiratory diseases like asthma. Therefore, it is essential for future studies to utilize datasets that capture specific health variables such as cough frequency on a weekly base or the usage of asthma medication. Access to such comprehensive data would contribute to a deeper understanding of the child respiratory health status and provide more accurate insights.

Another limitation of my study is the omission of an important factor in the OLS regression analysis: outdoor air pollution. Due to the limited study period and data access, we were unable to incorporate data on outdoor air pollution. Although the available outdoor air pollution data covers air particulates and air quality index between 2017 and 2021 on a city-level basis, the DHS dataset distinguishes data only by state. To this end, a potential future step would involve categorizing each city within a state described in the DHS data and merging the outdoor air pollution dataset with the DHS data. This integration would introduce another regressor, namely the air quality index, serving as an indicator for outdoor air pollution. Such an approach would yield valuable insights into the association between air pollution and children's respiratory health.

VII. Conclusion

In conclusion, the analysis conducted in this paper sheds light on the significant relationship between household air pollution and child health outcomes including birth weight, height-for-age z-scores, and incidence of cough. Results suggests a significant decline in birth weight and height for age z-score in relation to the predominant use of LPG and wood as cooking fuels in India. The findings regarding the smaller estimates of health outcomes associated with LPG compared to wood contribute to the growing body of literature highlighting the popularity of LPG as a cleaner cooking fuel in India. However, due to factors such as prices, limited supply, and accessibility, such popularity of LPG or other gaseous fuels is not a viable option for the majority of India's population (Balakrishnan et al. 2019). According to Gould and Urpelainen (2018), detailed survey of LPG use in rural India highlights the fact that only 4 percent of LPG-using households use the fuel exclusively by 2015, as fuel costs are a critical obstacle to widespread adoption. Recognizing these challenges in accessing LPG in rural India, the Government of India initiated the Pradhan Mantri Ujjwala Yokana (PMUY) program in 2016. This initiative aims to alleviate the public health burden of household air pollution by offering subsidies and loans for adopting an LPG connection, which includes a gas stove, cylinder, regulator, and a hose pipe (Mani et al. 2020). These important policy efforts are made to mitigate household air pollution in India and have successfully enabled 95 percent of Indian households to have access to LPG by 2020.

Based on the current developments and policy environment in India, one potential policy implication should continue to prioritize the promotion of clean cooking fuels, such as LPG or electric stoves through not only subsidies but also establishing distribution networks. The latter approach aims to increase the number of LPG distribution centers and explores innovative delivery mechanisms to reach remote or underserved communities. Meanwhile, launching awareness and behavioral change programs can help raise awareness about the harmful effects of air pollution and the benefits of using clean cooking fuels. Through targeted messaging and community engagement initiatives, such programs encourage household to transition to cleaner fuels and adopt cleaner cooking practices.

Moving forward, further analysis of the research question could involve categorizing each city within a state in the DHS data and merging the outdoor air pollution dataset with the DHS data. This way, I could examine the effects of outdoor air pollution on child respiratory health. It would also be beneficial to assess the effectiveness of specific interventions or policy measures in mitigating the impact of air pollution and explore the socioeconomic disparities in exposure and vulnerability to indoor and outdoor air pollution. Lastly, my study would benefit from employing spatial analysis or time series analysis techniques to explore the potential spatial or temporal patterns in the air pollution data, allowing for a more nuanced examination of the relationship between child respiratory health and air pollution.

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Appendix

Table of Summary Statistics

Variable	Obs	Mean	Std. dev.	Min	Max
cough					
no	161,463	0.998	0.040	0	1
yes	161,463	0.002	0.040	0	1
birth weight	166,041	2.822	0.554	0.5	5
height for age	166,041	-1.715	0.811	-3	3
cook fuel					
electricity	166,041	0.011	0.106	0	1
lpg	166,041	0.467	0.499	0	1
biogas	166,041	0.003	0.059	0	1
kerosene	166,041	0.004	0.063	0	1
coal	166,041	0.008	0.089	0	1
charcoal	166,041	0.009	0.092	0	1
wood	166,041	0.422	0.494	0	1
straw	166,041	0.010	0.099	0	1
crop	166,041	0.018	0.134	0	1
animal dung	166,041	0.046	0.209	0	1
no cooking	166,041	0.000	0.009	0	1
other	166,041	0.001	0.030	0	1
education					
no education	166,041	0.188	0.391	0	1
primary	166,041	0.120	0.325	0	1
secondary	166,041	0.540	0.498	0	1
higher	166,041	0.152	0.359	0	1
wealth index					
poorest	166,041	0.229	0.420	0	1
poorer	166,041	0.226	0.418	0	1
middle	166,041	0.205	0.404	0	1
richer	166,041	0.188	0.390	0	1
richest	166,041	0.153	0.360	0	1
smoke status					
no	166,041	0.998	0.040	0	1
yes	166,041	0.002	0.040	0	1
urban					
urban	166,041	0.217	0.412	0	1
rural	166,041	0.783	0.412	0	1
insurance					
no	166,041	0.712	0.453	0	1
yes	166,041	0.288	0.453	0	1
state					
jammu	166,041	0.029	0.168	0	1
himachal	166,041	0.013	0.113	0	1
chandigarh	166,041	0.001	0.029	0	1

Notes: The unit of observation for three health outcomes variables are individual children below age 5, while the rest are household level demographic and socio-economic status. The data describes the entire country of India. The data is retrieved from Demographic Health Survey (2019 - 2021).

Table 1 Summary Statistics of all variables in the sample.

TABLE 2 THE IMPACT OF AIR POLLUTION ON CHILD HEALTH OUTCOME

Dependent variable	Incidence of Cough		Birth Weight		Height for Age z-score	
	(1)	(2)	(3)	(4)	(5)	(6)
Cook fuel						
LPG	0.020	-0.010	-0.0372***	-0.017	-0.228***	-0.0444**
	(-0.0151)	(-0.0158)	(-0.0133)	(-0.0134)	(-0.0227)	(-0.021)
Coal	0.108***	0.0689***	-0.144***	-0.0563***	-0.504***	-0.0847***
	(-0.0259)	(-0.0265)	(-0.0204)	(-0.0206)	(-0.0301)	(-0.0287)
Charcoal	0.107***	0.0465*	-0.0659***	-0.010	-0.467***	-0.0724**
	(-0.0253)	(-0.0255)	(-0.0201)	(-0.0199)	(-0.0299)	(-0.0281)
Wood	0.013	-0.023	-0.102***	-0.021	-0.378***	-0.021
	(-0.0151)	(-0.0159)	(-0.0133)	(-0.0135)	(-0.0227)	(-0.0211)
Straw	0.151***	0.0655**	-0.134***	-0.0510**	-0.492***	0.009
	(-0.0248)	(-0.0257)	(-0.0194)	(-0.0198)	(-0.0295)	(-0.0281)
Crop	0.146***	0.0737***	-0.144***	-0.0507***	-0.361***	-0.017
	(-0.0208)	(-0.0216)	(-0.0167)	(-0.017)	(-0.0268)	(-0.0254)
Animal dung	0.0469***	0.001	-0.116***	-0.0327**	-0.463***	-0.029
	(-0.017)	(-0.018)	(-0.0148)	(-0.0152)	(-0.0241)	(-0.0228)
Smoke status						
Yes	No	0.200***	No	-0.004	No	-0.018
		(-0.0519)		(-0.0357)		(-0.0405)
Education						
Primary		0.044***		-0.004		0.001
		(-0.006)		(-0.005)		(-0.007)
Secondary	No	0.0567***	No	0.0161***	No	0.0452***
		(-0.00475)		(-0.004)		(-0.005)
Higher		0.0412***		0.0718***		0.144***
		(-0.007)		(-0.005)		(-0.008)
Urban						
Yes	No	0.008*	No	0.0131***	No	0.048***
		(-0.005)		(-0.004)		(-0.006)
Wealth index						
Middle		-0.0125**		0.0689***		0.140***
	No	(-0.006)	No	(-0.005)	No	(-0.007)
Richest		-0.0361***		0.125***		0.325***
		(-0.008)		(-0.007)		(-0.009)
Insurance	No	Yes	No	Yes	No	Yes
State fixed effects	No	Yes	No	Yes	No	Yes
Constant	0.236***	0.138***	2.894***	2.782***	-1.405***	-1.327***
	-0.0149	-0.0166	-0.0131	-0.0149	-0.0225	-0.0235
Observations	161,415	161,415	165,992	165,992	165,992	165,992
R-squared	0.001	0.015	0.004	0.043	0.013	0.097

Notes: Table presents estimates of equation (1) where the dependent variable is reported health indicator for children under the age of 5. Columns 1-2 report results for cough, columns 3-4 report results for birth weight, and columns 5-6 for height for age z-score. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 2 Regression results of household air pollution on child health outcomes.