Indoor Air Pollution and Health Outcomes: Evidence from India*

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Abstract

Indoor air pollution (IAP) is a leading cause of mortality worldwide, especially in low and lower-middle-income countries where a large population relies on dirty fuels for cooking. Using instrumental variables design and nationally representative survey data from India, this paper examines the health effects of IAP and investigates how medical expenditure for such ailments is influenced. Our results show that solid fuel use for cooking increases the likelihood of suffering from IAP related ailments and spending more days in hospital conditional on being admitted to the hospital for IAP related ailments. The medical expenditure for IAP related ailments also increases. The effects are more pronounced for respondents who report being housemakers and without access to health insurance.

JEL Classifications: I1, J1, O1, Q1, Q3, Q4, Q5
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1 Introduction

Indoor air pollution (IAP) continues to be a leading mortality risk factor globally. The impact of IAP on mortality is more pronounced for low-income countries as large population relies on solid fuel as their primary source of energy in these countries (Murray et al., 2020). The use of such fuels generates IAP due to incomplete combustion when they are used for cooking, lighting, and heating. In addition, women and children who spend most of their time with mothers are more exposed to IAP and thus bear a greater burden of potential harmful health effects of IAP.

There is a large literature examining the effect of IAP on health outcomes in various contexts (Liu et al., 2020). The majority of these works are epidemiological studies and randomized controlled trials that evaluate the health effects of IAP from specific policies that aim to increase the adoption of clean and improvised cooking stoves (Hanna et al., 2016). Specific to the Indian context, little attention has been paid to the health effects of IAP, with the majority of the work focusing on studying the determinants of the adoption of clean fuels for cooking (Basu et al., 2020; Azam, 2023). We aim to fill this gap in the literature and add to a nascent literature examining the health effects of IAP due to solid fuel use by the household as its primary source of energy for cooking.

The use of solid fuel by the household as its primary source of energy for cooking is endogenous due to multiple reasons. First, unobservable characteristics of the household may influence both the fuel choice and health outcomes due to the health behaviors of household members. Second, reverse causality from the health outcome of household members to fuel choice resulting due to the impact of health on income may bias the estimates from OLS estimation. In order to address these endogeneity issues, we rely on an instrumental variables (IV) design where we instrument for households' use of solid fuel as its primary source of energy for cooking by forest cover in the district which the household belongs to (Basu et al., 2020; Biswas and Das, 2022). Greater forest cover makes it easier for households to access firewood as it lowers the time spent on collection.

We use data from a nationally representative survey from India. These data contain information on the type of fuel that a household uses as its primary source of energy for cooking. We also observe all ailments that household members suffered in the last 365 days from the date of the survey, which resulted in the member being admitted to the hospital as

an in-patient. Further, we also observe all acute ailments that members suffered from in the last 15 days from the date of the survey, irrespective of whether the ailment led to hospitalization or not. These data also allow us to control for various individual and household characteristics that affect health outcomes.

The results from our preferred IV specification show that the likelihood that the respondent reports suffering from IAP related ailment in the last 365 days increases by 3.9 percentage points if the household uses solid fuel as its primary source of energy for cooking. Relative to the sample mean, this marginal effect corresponds to an increase of 56.61%. We also examine how being admitted to the hospital for an IAP related ailment impacts the amount of time spent hospitalized. Our point estimates suggest that, on average, a respondent report spending an extra day in the hospital for an IAP related ailment hospitalization relative to a hospitalization that is not IAP related. Our results also suggest that relative to non IAP related ailments, IAP related ailments lead to higher levels of reported medical expenditure.

We also find that the effect is more pronounced for those respondents who report being a housemaker as their usual principal activity and those who belong to a household without access to health insurance. Albeit statistically insignificant, we also find that the effects are more pronounced for female respondents, households in rural areas, and households with lower usual monthly per capita expenditure (MPCE). We also establish the robustness of our results through multiple checks.

With this work, we contribute to multiple strands of literature. We contribute to a large literature examining the impact of solid fuel use on the incidence of various health ailments.[1] Specific to the Indian context, many of these studies do not attempt to address potential endogeneity in solid fuel use by households as its primary source of energy for cooking (Faizan and Thakur, 2019). We add to this literature by trying to uncover consistent causal estimates of solid fuel use on the incidence of various IAP related ailments.

In this regard, our work is very similar to Azam (2023), who use fuel switching between two nationally representative survey waves to document a lower incidence of short-term respiratory ailment by respondents

[1]See Table A1 in Appendix A of Liu et al. (2020) for studies that examine the impacts of cooking fuel choice on human health.

in households that switched from polluting fuels to LPG. Our works differ from theirs in multiple ways. First, we examine the impact of IAP on long-term chronic as well short-term ailments. Second, we are able to document the effect on healthcare utilization as well as medical expenditure for ailments related to IAP. We also add to existing work on the impact of IAP on mortality by examining less severe morbidity (Basu et al., 2020). Finally, we also contribute to a large literature that examines the determinants of clean fuel adoption by examining the impact of continued solid fuel use on health outcomes (Gould and Urpelainen, 2018; Vyas et al., 2021).

The rest of the paper is organized as follows. Section 2 provides a brief description of the background of our setting. Section 3 discusses our data sources and presents descriptive statistics of our analytical sample. In section 4, we discuss our empirical strategy. Section 5 presents the results. Finally, in section 6, we discuss our findings and conclusions.

2 Background

A large part of the population in India relies on solid fuels for cooking. According to the latest available census data, approximately 85% of rural households and only 30% of urban households report using solid fuels for cooking.[2] In addition to directly impacting those who cook with solid fuels, these fuels also impose externalities on other household members and neighbors.

Government agencies recognize the harmful effects of solid fuel use and consequent IAP and have taken multiple steps to reduce the reliance on dirty fuels for cooking and other allied activities. Indian government provides relatively cleaner kerosene at a subsidized rate to Below the Poverty Line (BPL) households. Kerosene is distributed through Public Distribution System (PDS). Supply chain bottlenecks associated with PDS often compel households to continue to rely on solid fuels for cooking (Choudhuri and Desai, 2020). More recently Indian federal government has implemented various schemes in order to promote the adoption of cleaner cooking fuels like LPG. Under one such scheme, subsidized connections, stoves, and regulators are provided to rural households.

Despite a large increase in access to and ownership of LPG, a large frac-

[2]Data from Population and Housing Census 2011, Table HL-10.

tion of rural households continue to use solid fuels for cooking. Existing work highlights the role of income, preferences, and gender inequities in household task allocation as drivers of sustained solid fuel use for cooking by rural households (Gupta et al., 2020). Easy access to solid fuel through proximity to forests and owning agricultural land also contributes to continued reliance on solid fuel as the primary source of energy for cooking.

Use of solid fuel use has been shown to be associated with detrimental health outcomes in India. Existing work documents the harmful health effects of solid fuel use on health outcomes. This negative impact on health due to solid fuel use is more pronounced for women as they are primarily responsible for cooking and related household activities and thus directly exposed to emissions generated from solid fuel use (Gupta, 2019). Balakrishnan et al. (2019) use data from the Global Burden of Disease Study 2017 and show that approximately 0.5 million deaths can be attributed to household air pollution. Using the same data source for an earlier year, Smith (2000) estimate approximately 12-17 million Disability-Adjusted Life-Year due to IAP in India. Using nationally representative household survey data, Bassani et al. (2010) find that solid fuel use is positively associated with early-life mortality, with the effect being more pronounced for girls.

Access to formal healthcare is widespread in India. Existing work documents major reliance on the private sector for outpatient care services. There are, however, large regional disparities in access to care (Ghosh, 2014). While the relatively less affluent population relies on the public sector for outpatient care, the continued reliance of higher-income households on the private sector for outpatient care has widened disparities in access, and quality of care received (Dwivedi and Pradhan, 2020; Mohanan et al., 2016). Across income distribution, there has been a declining trend of public health facility usage for inpatient care. This is partly due to perceived low-quality care delivered in these facilities (Das and Hammer, 2014).

3 Data

The ideal data to examine the impact of IAP on health outcomes will contain information on IAP exposure along with information on health outcomes like ailments, hospital admissions, and medical expenditure on treatment. While these data do not exist, for our empirical analysis, we combine multiple data sources to causally identify the impact of IAP on

health outcomes. In this section, we describe each of these data sources and also present descriptive statistics for our analytical sample.

3.1 NSS Data

Our main data comes from 75^{th} round of NSS (NSS, 2019). This round surveyed a random sample of households from rural and urban areas of each district in India. NSS follows a two-stage random sampling method wherein rural villages and urban wards are randomly selected in the first stage. Households are then randomly sampled from each first-stage unit.

This round collected information on the detailed demographics of the sampled households. Detailed information was collected on the morbidity and mortality of household members. For morbidity, information on hospitalization in the last 365 days is collected. Further, information on acute ailments in the last 15 days for each household member is collected.

Treatment received for each ailment, irrespective of whether it resulted in hospitalization or not, is also collected. The survey also collects information on out-of-pocket expenditures. Detailed information on the deceased household members in the last 365 days is also available.

Importantly, the survey also contains information on the primary source of energy for cooking used by the household. Using this information, we are able to categorize households into using solid fuel or not.[3] In Figure 1, we show the proportion of households using various fuels as the primary source of energy for cooking. We note that there is significant variation in the types of fuels that households use as the primary source of energy for cooking.

3.2 Other Data

In addition to NSS data, we also use data from The Socioeconomic High-resolution Rural-Urban Geographic Dataset on India (SHRUG) (Asher et al., 2021). We use SHRUG to extract data on district-level forest cover. Forest cover is constructed using high-resolution satellite data and a machine learning model. These models allow for better distinctions between forests and plantations.

[3]Household is assigned to using solid fuel as the primary source of energy for cooking if it reports using firewood and chips or dung cake or coke/coal or charcoal.

We use raw SHRUG data which contains information on the total forest cover for each district and normalize it with the information on the number of cells for the district to arrive at the average forest cover for the district. Since NSS data correspond to districts from the 2013 Economic Census, we use the information on these district identifiers to construct district-level forest cover.

In Figure 2, we present forest cover for two years during which the households were interviewed in the survey. We conclude from this figure that there is significant across and within district variation in forest cover for these two years. As we detail in section 4, we use district-level forest cover measure to construct our instrumental variable.

We also use data from CAMS EAC4 to construct an annual measure of ambient air pollution at the district-level. These data are derived from satellites and provide comprehensive and continuous information on air pollution. We use data on the particulate matter which is less than two and one half microns or less in width, PM2.5. Using Population and Housing Census 2011 district shapefiles, we construct a weighted average of PM2.5 concentration where the extent of overlap with the district polygon weights each grid.

We present summary statistics for our analytical sample in Table 1. We report summary statistics for variables that we use in our empirical specifications. We point out a few statistics from the table. First, on average, three percent of respondents report having suffered any IAP-related ailment in the last 365 days.[4] Second, despite the strong push by the central government to incentivize households to adopt clean cooking fuels, roughly 40% of the households report using solid fuels as their primary source of energy for cooking.

Third, our summary statistics show that a large number of households do not have access to proper sanitation facilities, as documented by a lack of access to a private latrine and piped water. Finally, we highlight almost equal sex distribution for our analytical sample.

[4]Indoor air pollution (IAP) related ailments include hypertension, heart disease, acute upper respiratory infections, cough, asthma, mental retardation, mental disorders, headache, seizures or known epilepsy, weakness in limb muscles and difficulty in movements, stroke, memory related ailments, discomfort or pain in the eye, burns, back or body aches, and anemia.

4 Empirical Strategy

In order to causally identify the effect of IAP on health outcomes, we estimate a fixed-effects specification. Our main specification is as follows.

$$y_i = \beta SolidFuel_{h(i)} + \mathbf{X}_i\boldsymbol{\gamma} + \mathbf{X}_h\boldsymbol{\delta} + State_{h(i)} + Month_{date(h(i))} \times Year_{date(h(i))} + \epsilon_i \quad (1)$$

In equation (1), y_i is the outcome of interest for respondent i. $SolidFuel_{h(i)}$ is an indicator for whether the household h to which respondent i belongs uses solid fuel as a primary source of energy for cooking or not. $\mathbf{X}_i$ is a vector of individual controls. This vector contains the age of the respondent and an indicator for whether the respondent is female or not. $\mathbf{X}_h$ is a vector of household controls. This vector contains the number of household members who have completed at least primary schooling, the size of the household, an indicator for whether the household has access to a private latrine, an indicator for whether the household has access to piped drinking water, categorical variable for the religion of household with Hinduism as the omitted category, and an indicator for whether the household is an upper caste household or not.

In equation (1), we also control for a few fixed-effects. Specifically, we control for state fixed-effects, $State_{h(i)}$. These account for all time-invariant state characteristics that are common to all households in the state. We also control time fixed-effects to account for temporal shocks to the outcome, which are common to all households in the country. These are depicted as $Month_{date(h(i))} \times Year_{date(h(i))}$ in equation (1), where $date\,(h\,(i))$ is the date on which household h was interviewed. ϵ_i is idiosyncratic error term.

Our coefficient of interest in equation (1) is β. This gives the marginal effect of a household using solid fuel as the primary source of energy for cooking on the outcome of interest. Ordinary Least Squares (OLS) estimation of equation (1) is likely to be plagued with endogeneity issues. This could be due to reverse causality as poor health may reduce household income which may force it to use dirtier fuels that are cheaper. There may also be some omitted variables that our specification is not able to account for. For instance, the unobserved intra-household bargaining power of women may determine household fuel choice for cooking and also the health outcomes of children.

To assuage endogeneity concerns, we implement an instrumental variables (IV) research design. We instrument for household's use of solid

fuel as the primary source of energy for cooking using the information on district-level forest cover. As we show in Figure 1, firewood is the largest share of fuel for households that do not use clean fuels for cooking. As larger forest cover provides easy and cheap access to firewood, households may be incentivized to use it as the cooking fuel of their choice (Bhatt and Sachan, 2004; Biswas and Das, 2022; Gould et al., 2020).

Our first-stage specification is as follows.

$$\begin{aligned} SolidFuel_{h(i)} = \alpha + \zeta ForestCover_{d(h(i))} + \mathbf{X}_i\boldsymbol{\gamma} + \mathbf{X}_h\boldsymbol{\delta} \\ + State_{h(i)} + Month_{date(h(i))} \times Year_{date(h(i))} + \eta_i \end{aligned} \tag{2}$$

In equation (3), $ForestCover_{d(h(i))}$ is the percent of district d to which household h belongs that is classified as forest. Our second-stage specification is as follows.

$$\begin{aligned} y_i = \alpha + \beta \hat{SolidFuel}_{h(i)} + \mathbf{X}_i\boldsymbol{\gamma} + \mathbf{X}_h\boldsymbol{\delta} \\ + State_{h(i)} + Month_{date(h(i))} \times Year_{date(h(i))} + \theta_i \end{aligned} \tag{3}$$

In equation (3), $\hat{SolidFuel}_{h(i)}$ is the predicted solid fuel use by the household as the primary source of energy for cooking. In both equations (2) and (3), the rest of the variables are the same as that in equation (1).

We use district-level forest cover information from SHRUG. We detail how we construct this measure in section 3. In Figure 3, we present the correlation between district-level forest cover and whether the household uses solid fuel as the primary source of energy for cooking. We note that these estimates suggest that higher forest cover increases the likelihood that household uses solid fuel as the primary source of energy for cooking.

Our IV design is motivated by existing work that uses forest cover as an instrument for household fuel choice after conditioning for other variables and fixed-effects (Basu et al., 2020; Biswas and Das, 2022). In order for the instrument to be valid, the assumption is that instrument affects the outcome of interest only through its effect on the choice of solid fuel as the primary source of energy for cooking by the household. While this assumption is inherently untestable, we provide several tests in section 5 to lend credence to instrument validity.

5 Results

In this section, we present and discuss our results. We start by discussing results from our main specifications in equation (1) to (3). We present point estimates from these specifications in Table 2. In the first column, we present point estimates from estimating equation (1), where we ignore the endogeneity of solid fuel use by the household as its primary source of energy for cooking. The point estimates show that the use of solid fuel by the household increases the likelihood of the respondent reporting suffering from IAP related ailment in the last 365 days.

In the second column, we present point estimates from our IV research design. In these specifications, we instrument for solid fuel use by the household with the district-level forest cover.[5] The point estimates show that the use of solid fuel use by the household as its primary source of energy for cooking increases the likelihood of the respondent reporting suffering from IAP related ailment in the last 365 days. Relative to the first column, the point estimates are larger. Specifically, the use of solid fuel by the household increases the likelihood that the respondent reports suffering from IAP related ailment in the last 365 days by 3.9 percentage points. Relative to the sample mean, this marginal effect corresponds to an increase of 56.61%.

In the next column, we replace the dependent variable in our specification with the number of days spent in the hospital.[6] The dependent variable takes a value of zero if the respondent does not report any hospitalization and a value of one otherwise. With this specification, we aim to study how solid fuel as the primary source of energy for cooking by household impacts the likelihood that the respondent report having any time hospitalized. Our point estimates are statistically insignificant but indicate a very small decline in the probability of respondents being hospitalized.

In column (4), we restrict the sample to those respondents who report

[5]We highlight that we have missing information on forest cover for a few districts. Therefore, the sample size drops in moving from the first to the second column. We later present point estimates from a specification where we replace missing forest cover values with zero.

[6]We impute the number of days spent in the hospital as zero for those respondents who do not repeat hospitalization either as an in-patient of a medical institution in the last 365 days or for acute ailments.

spending any time hospitalized.[7] We slightly alter our main specification by replacing the variable of interest from whether the household uses solid fuel as the primary source of energy for cooking or not to whether the hospitalization was due to IAP related ailment or not. The dependent variable for this specification is the same as that for the specification in the previous column. Our aim is to study whether being admitted to the hospital for IAP related ailment affect the amount of time respondent report having spent in the hospital relative to non IAP related ailment. Our point estimates suggest that, on average, a respondent report spending an extra day in the hospital for an IAP related ailment hospitalization relative to a hospitalization that is not IAP related. This result indicates that hospitalizations that are driven by IAP related ailment are more intensive as far as days spent in the hospital are concerned.

In the next two columns, we turn our attention to examining the impacts on medical expenditure for treatment. In column (5), we estimate our main specification but replace the dependent variable with the amount spent on medical treatment for the treatment of an ailment that the respondent report suffering in the last 365 days.[8] Point estimates from this specification suggest that medical expenditure goes down if the household that the respondent belongs to reports using solid fuel as the primary source of energy for cooking. Since the incidence of any ailment in the last 365 days is rare and not all treatment results in out-of-pocket expenditure by the patient, this result is not surprising. As households that use solid fuel as the primary source of energy for cooking are also more likely to have lower levels of income and wealth, they are unlikely to spend money on treatment except for severe medical conditions. This may also lead to lower levels of medical expenditure for these households, as indicated by our point estimates.

In the last column, we look at how the incidence of an IAP related ailment affects medical expenditure for treatment relative to the incidence of a non IAP related ailment. To operationalize this, we replace the variable of interest in our main specification with whether the reported ailment is IAP related or not. The dependent variable of interest is the same as that in

[7]Since this specification is conditional on hospitalization, the sample size drops considerably relative to the main specification.

[8]We impute medical expenditure for those respondents who do not report suffering an ailment in the last 365 days as zero. All medical expenditures are reported in thousands of Indian rupees.

the previous column. Our results suggest that relative to non IAP related ailments, IAP related ailments lead to higher levels of reported medical expenditure. This finding, although suggestive, lends further credence to our results from column (4), as IAP related ailment is more intensive and exerts a financial burden on households. Overall, results in Table 2 indicate solid fuel use as the primary source of energy for cooking leads to a higher incidence of IAP related ailments and hospitalizations for such ailments, increases the number of days spent in hospital along with an increase in medical expenditure for treatment of these ailments.

We next turn to establish the robustness of our main results. We present results from these exercises in Table 3. In the first two columns of the table, we repeat point estimates from our main specifications for both OLS and IV estimations. In the third and fourth columns, we present point estimates from specifications where we alter the fixed-effects in the specification. Specifically, we replace state and year-month fixed-effects with state-year and month fixed-effects. With this specification, we allow annual shocks to vary by the state while also accounting for short-term temporal shocks through month fixed-effects that are common to all households. The point estimates in these two columns are very similar to point estimates from our main specification. This helps us conclude that our main result is not sensitive to specific fixed-effects that we employ in our main specification.

In the next column, we alter district-level forest cover, which is used to construct our instrument. We use lagged district-level forest cover as the instrument for whether the household uses solid fuel as its primary source of energy for cooking. The point estimates from this empirical specification are close to point estimates from our main specifications. This establishes the robustness of our results to the exact definition of the instrument we use.

In the next two columns, we examine the validity of our instrumental variable design. In column (6), we alter our IV specification by replacing the dependent variable with whether the respondent reports being female or not. If the instrument is valid, we do not expect it to affect the likelihood of the respondent being a female. The point estimates suggest that our instrument does not affect the likelihood of the respondent being female. This provides evidence towards the validity of our instrument. In the next column, we use the earliest available forest cover at district-level as the instrumental variable. With this specification, we aim to show that only contemporaneous forest cover impacts households' choice of solid

fuel as the primary source of energy for cooking. The point estimates in this column lend credence to instrument validity as we do not find any statistically significant effect of early forest cover on a household's adoption of solid fuel as its primary source of energy for cooking.

In the next column, we show that our main results are not altered by imputing forest cover values for districts that have missing forest cover information. Specifically, for districts where we are unable to obtain information on forest cover, we replace missing values with zeroes. We present results from estimating our main specifications with this change in column (7). Our point estimates suggest that our main results are not sensitive to non-random missing observations for district-level forest cover. In the next two columns, we change our definition of whether the household uses solid fuel as the primary source of energy for cooking or not. Specifically, a household is assigned to using solid fuel as the primary source of energy for cooking if it reports using firewood and chips as its primary source of energy for cooking. The results from these specifications suggest that our main finding is not sensitive to the assignment of households using solid fuel as the primary source of energy for cooking. Finally, in the last column, we establish the robustness of our main result to controlling for ambient air pollution levels.

In Table 4, we present results from our heterogeneity analysis.[9] In the first two columns, we replace our dependent variable with an indicator for whether anyone in the household reported suffering an IAP related ailment in the last 365 days. We note that these specifications are estimated at the household-level. Our OLS and IV estimates show that household using solid fuel as the primary source of energy for cooking increases the likelihood that household has at least one member that reported suffering an IAP related ailment in the last 365 days.

In the next two columns, we replace the dependent variable in our main specification with an indicator for whether the respondent reported suffering any ailment in the last 365 days. The point estimates in these two columns suggest that the use of solid fuel as the primary source of energy for cooking does not affect the likelihood of the respondent suffering any ailment in the last 365 days. In the next two columns, we interact our

[9]We present results from subsample analysis as additional heterogeneity analysis. The results from these estimations are presented in Table **??**. In what follows, we discuss results in Table 4 as subsample analysis does not permit us to conduct a test of equality of point estimates for different subgroups.

variable of interest, an indicator for whether the household uses solid fuel as the primary source of energy for cooking, with an indicator for whether the respondent is female (Cui et al., 2021).

The point estimates from our preferred IV specification suggest that the effect of solid fuel use by the household as its primary source of energy for cooking does not exert a differential effect by sex of respondent on the likelihood of respondent reporting suffering an IAP related ailment in the last 365 days. In a similar specification in the next two columns, we interact our variable of interest with an indicator for whether the household is in a rural area. The point estimates from this specification suggest that the effect of solid fuel use by the household as its primary source of energy for cooking on the likelihood of respondent reporting suffering an IAP related ailment in the last 365 days does not differentially differ by whether the household is in a rural area.

In the next two columns, we interact our variable of interest with an indicator for whether the household has medical insurance or not. The point estimates from this specification suggest that solid fuel use by the household as its primary source of energy for cooking exerts a differential effect on the likelihood of respondent reporting suffering an IAP related ailment in the last 365 days by whether the household has medical insurance. Specifically, a household having medical insurance reduces the likelihood that the respondent reports suffering an IAP related ailment in the last 365 days relative to a respondent from a household without access to medical insurance.

We next explore the heterogeneity of our main effect with the level of MPCE in the next two columns.[10] We interact our variable of interest with MPCE. Our preferred IV specification suggests that higher levels of MPCE lead to a lower likelihood of respondents reporting suffering an IAP related ailment in the last 365 days, albeit this differential effect is not statistically significant.

We next turn to examine the heterogeneity of our main effect with whether the respondent reports being a housemaker or not. A respondent who reports being a housemaker is more likely to be directly exposed to the air pollution produced due to households' use of solid fuel for cooking.

[10]We point out that the MPCE is the usual expenditure for the household. Therefore, we do not believe that this is likely endogenous to a household's use of solid fuel as its primary source of energy for cooking.

We, therefore, expect those respondents who report being a housemaker to be more likely to report suffering an IAP related ailment. Point estimates from our preferred IV specification lend credence to our hypothesis as we find a statistically significant differential impact of the respondent being a housemaker on the likelihood of them reporting suffering an IAP related ailment.

Finally, in the last two columns, we show that the likelihood of respondents reporting suffering an IAP related ailment is not differentially affected by solid fuel use for cooking if they belong to a household that has a vulnerable age member or not.[11] Given increased healthcare contact for households with a member in a vulnerable age group, it is plausible that respondents are more aware of IAP related ailments and thus report more ailments if they belong to a household with a vulnerable member. On the other hand, a vulnerable age member of the household may make it adopt better ventilation techniques which might reduce the negative health effects of IAP. Against this backdrop, the statistically insignificant effect is not entirely surprising.

6 Discussion and Conclusion

Using nationally representative data from India, we examine how solid fuel use affects health outcomes. We rely on an instrumental variables design to uncover the causal effect of solid fuel use on these outcomes. We use district-level forest cover as an instrument for households' fuel choices. Our results show that the use of solid fuel for cooking increases the likelihood that respondent reports having suffered IAP related ailment in the last 365 days. Specifically, the use of solid fuel by the household increases the likelihood that the respondent reports suffering from IAP related ailment in the last 365 days by 3.9 percentage points. Relative to the sample mean, this marginal effect corresponds to an increase of 56.61%.

We also find that respondent report having spent more days in the hospital, conditional on being admitted to the hospital, for IAP related ailments relative to non-IAP related ailments. Further, the medical expenditure for IAP related ailments also increases. Our results show that the effects are

[11] A household is classified as having a vulnerable age group member if any member of the household is aged less than six or over 60.

more pronounced for respondents who report being housemakers and without access to health insurance. Albeit statistically insignificant, our results show that the effects are more pronounced for females, those who reside in rural areas, those with lower levels of monthly per capita expenditure, and those who belong to a household with at least one member in the vulnerable age group. We also establish the robustness of our results through multiple checks.

We compare our point estimates to existing work examining the health effects of IAP. Using nationally representative survey data from India, Basu et al. (2020) find that the use of solid fuel for cooking increases under-five mortality by 4.9 percentage points. This effect is greater but very similar to our point estimate for morbidity. Using fuel switching between two waves of nationally representative panel data, Azam (2023) find that the use of clean cooking fuel by the household decreases the incidence of cough by three percentage points. This effect is also very similar to our point estimate. We, therefore, conclude that our point estimate on ailment incidence is very similar to existing work.

While we uncover consistent estimates of solid fuel use as the primary source of energy for cooking by the household on various health outcomes, our work has some limitations. First, we are unable to longitudinally follow individuals limiting our ability to study long-term health outcomes. Second, we are unable to obtain direct measures of IAP. Third, we only see the extensive margin of health impact through the self-reporting of respondents suffering an IAP related ailment. Fourth, we are unable to get information on repeat hospital encounters for the same ailment. We hope future work addresses these and other limitations of our work.

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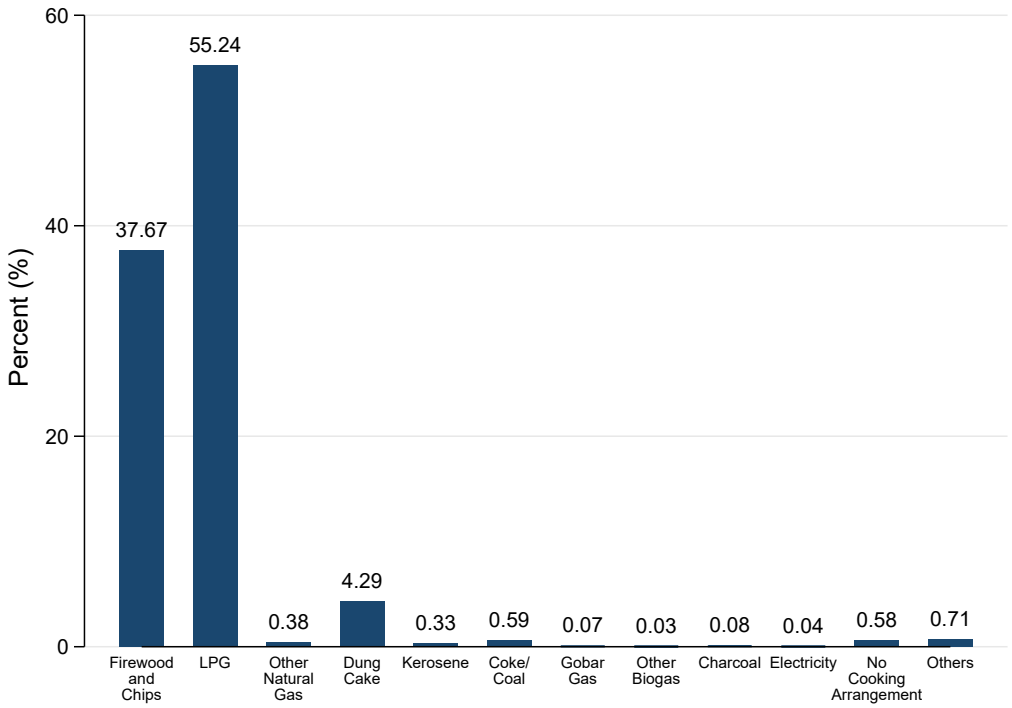
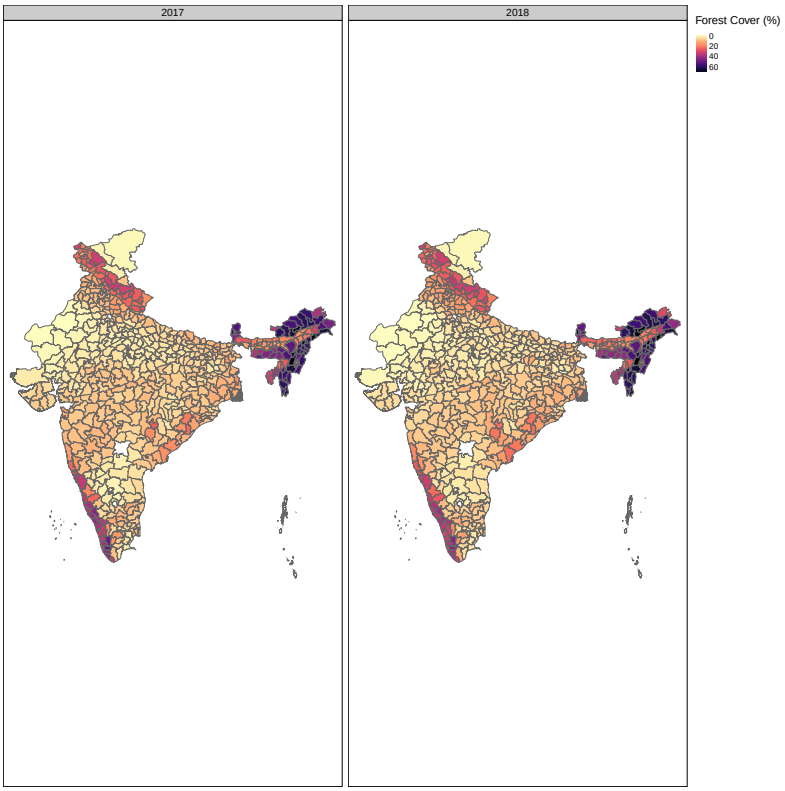
Figure 1: Proportion of Households Using Different Fuel Types



Note: Data from NSS 75th round. Survey weights are used to account for complex survey design.

Figure 2: District Forest Cover (%)



Note: District level forest cover for 2017 and 2018. Data comes from The Socioeconomic High-resolution Rural-Urban Geographic Dataset on India (SHRUG) (Asher et al., 2021). Each sub-figure shows average forest cover in the district and uses 2011 Population and Housing Census district shapefiles.

Figure 3: First-stage

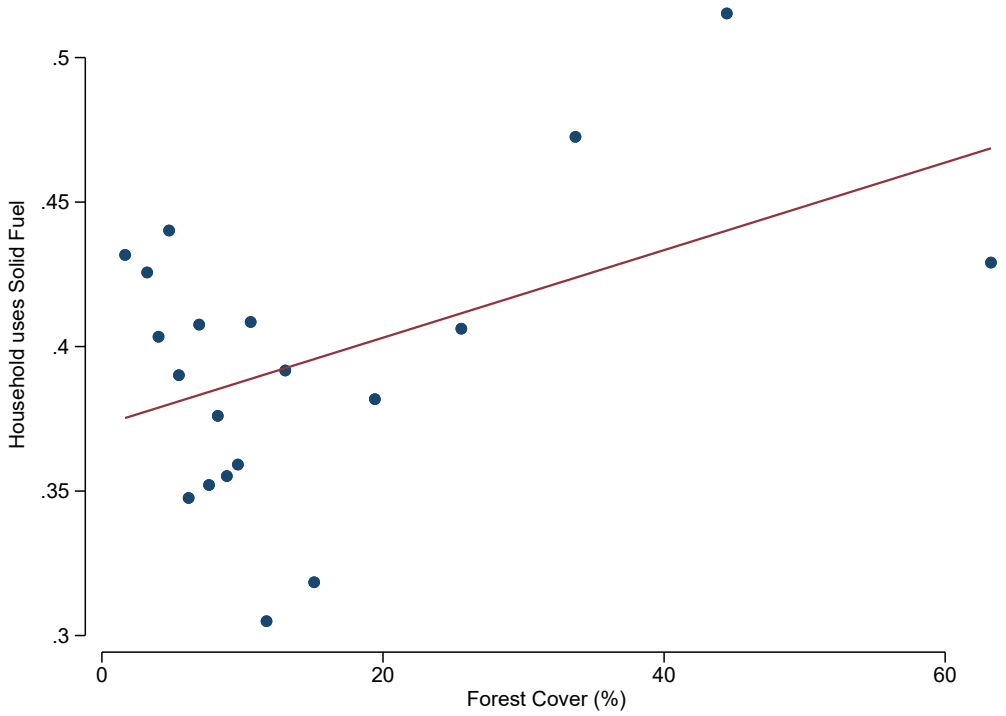


Table 1: Summary Statistics

	N	Mean	SD	Min	Max
Individual Controls					
IAP Ailment	555,352	0.039	0.194	0.00	1.00
Age (Years)	557,212	29.322	18.830	0.00	115.00
Female	555,315	0.483	0.500	0.00	1.00
Household Controls					
Household uses Solid Fuel	557,210	0.426	0.495	0.00	1.00
Primary Completed Adults	556,652	2.305	1.647	0.00	19.00
Household Size	557,212	5.353	2.330	1.00	31.00
Access to Private Laterine	557,212	0.661	0.473	0.00	1.00
Access to Piped Water	557,212	0.417	0.493	0.00	1.00
Upper Caste	557,212	0.264	0.441	0.00	1.00
District-Level Controls					
Forest Cover (%)	506,574	10.226	8.883	0.00	75.98
PM2.5 $(\mu g/m^3)$	432,706	96.598	49.520	4.82	242.18

Notes: Indoor air pollution (IAP) related ailments include hypertension, heart disease, acute upper respiratory infections, cough, asthma, mental retardation, mental disorders, headache, seizures or known epilepsy, weakness in limb muscles and difficulty in movements, stroke, memory related ailments, discomfort or pain in the eye, burns, back or body aches, and anemia. Household is assigned to using solid fuel as the primary source of energy for cooking if it reports using firewood and chips or dung cake or coke/coal or charcoal. The number of household members with at least primary education includes only those who are 18 years or older. A household is assigned as having access to a private latrine if it reports having access to a latrine with exclusive use. Household is assigned as having access to piped water if it reports having access to piped water dwelling/premises/yard or outside. The sample contains data from NSS 75th round, CAMS EAC4, and The Socioeconomic High-resolution Rural-Urban Geographic Dataset on India (SHRUG) (Asher et al. (2021)). Survey weights are used to account for complex survey design.

Table 2: Effect of Indoor Air Pollution on Health Outcomes – Main Effect

	(1) OLS IAP Ailment	(2) IV IAP Ailment	(3) IV Days in Hospital	(4) OLS Days in Hospital	(5) IV Medical Expenditure	(6) OLS Medical Expenditure
Household uses Solid Fuel=1	0.00148	0.03906	-0.00731		-6.13494	
	(0.00082)*	(0.01444)***	(0.02078)		(1.28027)***	
IAP Ailment=1				1.11057		17.73009
				(0.07987)***		(0.34504)***
Individual Controls						
Age (years)	0.00108	0.00106	0.00217	0.03906	0.09622	0.08106
	(0.00002)***	(0.00002)***	(0.00003)***	(0.00183)***	(0.00205)***	(0.00179)***
Female=1	0.00056	0.00116	0.09721	-1.72189	0.26302	0.32205
	(0.00068)	(0.00071)	(0.00100)***	(0.07507)***	(0.06396)***	(0.05995)***
Household Controls						
Primary Completed Adults	-0.00118	0.00134	-0.00128	0.03802	-0.15157	0.30429
	(0.00023)***	(0.00100)	(0.00143)	(0.02344)	(0.08923)*	(0.01709)***
Household Size	-0.00669	-0.00787	-0.01287	0.03060	-0.17708	-0.30203
	(0.00016)***	(0.00055)***	(0.00079)***	(0.01667)*	(0.04798)***	(0.01183)***
Access to Private Latrine=1	0.00109	0.00889	-0.00224	-0.31717	-0.52340	0.67596
	(0.00084)	(0.00300)***	(0.00430)	(0.07822)***	(0.26014)**	(0.06065)***
Access to Piped Water=1	0.00348	0.01211	-0.00057	0.03283	-1.05691	0.15349
	(0.00081)***	(0.00315)***	(0.00452)	(0.07207)	(0.29209)***	(0.07132)**
Islam	0.00496	0.00638	0.00211	-0.30735	-0.62477	-0.48133
	(0.00105)***	(0.00125)***	(0.00172)	(0.08571)***	(0.09810)***	(0.07917)***
Other Religion	0.00076	-0.00157	-0.00242	-0.20087	0.58342	0.25518
	(0.00159)	(0.00189)	(0.00259)	(0.14376)	(0.21760)***	(0.15983)
Upper Caste=1	0.00226	0.00703	-0.00067	-0.01591	0.49470	1.35524
	(0.00085)***	(0.00206)***	(0.00296)	(0.07271)	(0.18619)***	(0.07681)***
State FE	✓	✓	✓	✓	✓	✓
Year × Month FE	✓	✓	✓	✓	✓	✓
Dep. Var. Mean	0.069	0.069	0.154	6.015	3.425	3.425
KP F-Statistic		1562.237	1562.237		1552.107	
N	554,627	504,416	504,416	85,321	503,963	554,115

Notes: Heteroskedasticity robust standard errors in parentheses. (* p<.10 ** p<.05 *** p<.01). Each observation in all columns is at the respondent level. The dependent variable in first two columns is an indicator for whether the respondent suffered any indoor air pollution (IAP) related ailment in last 365 days or not. The dependent variable in the third column is number of days spent in hospital. The dependent variable in the fourth column is number of days spent in hospital for medical treatment received as in-patient of a medical institution during the last 365 days. The dependent variable in the fifth and sixth column is medical expenditure in thousands of rupees. IAP related ailments include hypertension, heart disease, acute upper respiratory infections, cough, asthma, mental retardation, mental disorders, headache, seizures or known epilepsy, weakness in limb muscles and difficulty in movements, stroke, memory related ailments, discomfort or pain in the eye, burns, back or body aches, and anaemia. Household is assigned to using solid fuel as primary source of energy for cooking if it reports using firewood and chips or dung cake or coke/coal or charcoal. The sample contains data from NSS 75th round and The Socioeconomic High-resolution Rural-Urban Geographic Dataset on India (SHRUG) (Asher et al. (2021)).

Table 3: Effect of Indoor Air Pollution on Health Outcomes – Robustness Checks

	(1) OLS Baseline	(2) IV Baseline	(3) OLS Alternate FE	(4) IV Alternate FE	(5) IV Alternate Forest Cover	(6) OLS Female	(7) IV Early Forest Cover	(8) IV Full Forest Cover	(9) OLS Alternate Solid Fuel	(10) IV Alternate Solid Fuel	(11) IV Air Pollution
Household uses Solid Fuel=1	0.00148	0.03906	0.00154	0.03453	0.03062		0.00832	0.03598	0.00070	0.03910	0.05755
	(0.00082)*	(0.01444)***	(0.00082)*	(0.01423)**	(0.01494)**		(0.01240)	(0.01355)***	(0.00082)	(0.01445)***	(0.02345)**
Individual Controls											
Age (years)	0.00108	0.00106	0.00108	0.00106	0.00106	0.00026	0.00107	0.00108	0.00108	0.00106	0.00101
	(0.00002)***	(0.00002)***	(0.00002)***	(0.00002)***	(0.00002)***	(0.00004)***	(0.00002)***	(0.00002)***	(0.00002)***	(0.00002)***	(0.00002)***
Female=1	0.00056	0.00116	0.00056	0.00114	0.00113		0.00104	0.00068	0.00056	0.00114	0.00045
	(0.00068)	(0.00071)	(0.00068)	(0.00071)	(0.00071)		(0.00070)	(0.00068)	(0.00068)	(0.00071)	(0.00077)
Household Controls											
Primary Completed Adults	-0.00118	0.00134	-0.00118	0.00103	0.00077	-0.01125	-0.00072	0.00109	-0.00123	0.00110	0.00275
	(0.00023)***	(0.00100)	(0.00023)***	(0.00099)	(0.00103)	(0.00051)***	(0.00087)	(0.00092)	(0.00023)***	(0.00092)	(0.00161)*
Household Size	-0.00669	-0.00787	-0.00669	-0.00771	-0.00756	0.00682	-0.00675	-0.00793	-0.00665	-0.00767	-0.00864
	(0.00016)***	(0.00055)***	(0.00016)***	(0.00055)***	(0.00057)***	(0.00035)***	(0.00048)***	(0.00051)***	(0.00016)***	(0.00048)***	(0.00086)***
Access to Private Latrine=1	0.00109	0.00889	0.00109	0.00797	0.00721	0.00698	0.00279	0.00773	0.00093	0.00815	0.01308
	(0.00084)	(0.00300)***	(0.00084)	(0.00296)***	(0.00309)**	(0.00172)***	(0.00261)	(0.00274)***	(0.00084)	(0.00274)***	(0.00495)***
Access to Piped Water=1	0.00348	0.01211	0.00347	0.01118	0.01033	0.00597	0.00562	0.01035	0.00332	0.01187	0.01705
	(0.00081)***	(0.00315)***	(0.00081)***	(0.00312)***	(0.00325)***	(0.00164)***	(0.00273)**	(0.00280)***	(0.00081)***	(0.00306)***	(0.00549)***
Islam	0.00496	0.00638	0.00500	0.00621	0.00602	-0.01038	0.00507	0.00643	0.00491	0.00575	0.00746
	(0.00105)***	(0.00125)***	(0.00105)***	(0.00124)***	(0.00126)***	(0.00216)***	(0.00121)***	(0.00120)***	(0.00104)***	(0.00115)***	(0.00161)***
Other Religion	0.00076	-0.00157	0.00081	-0.00121	-0.00109	-0.00164	0.00018	-0.00117	0.00081	-0.00174	-0.00388
	(0.00159)	(0.00189)	(0.00159)	(0.00187)	(0.00190)	(0.00326)	(0.00183)	(0.00180)	(0.00159)	(0.00192)	(0.00266)
Upper Caste=1	0.00226	0.00703	0.00226	0.00643	0.00593	0.00830	0.00304	0.00652	0.00215	0.00647	0.00919
	(0.00085)***	(0.00206)***	(0.00085)***	(0.00204)***	(0.00213)***	(0.00173)***	(0.00183)*	(0.00187)***	(0.00085)**	(0.00188)***	(0.00308)***
Forest Cover (%)						0.00009					
						(0.00012)					
State FE	✓	✓			✓	✓	✓	✓	✓	✓	✓
State × Year FE			✓	✓							
Year × Month FE	✓	✓			✓	✓	✓	✓	✓	✓	✓
Month FE			✓	✓							
Dep. Var. Mean	0.069	0.069	0.069	0.069	0.069	0.490	0.069	0.069	0.069	0.069	0.069
KP F-Statistic		1562.237		1604.762	1460.767		2088.238	1835.169		1577.401	602.665
N	554,627	504,416	554,627	504,416	504,416	504,418	504,416	554,627	554,627	504,416	430,840

Notes: Heteroskedasticity robust standard errors in parentheses. (* p<.10 ** p<.05 *** p<.01). Each observation in all columns is at the respondent level. The dependent variable in each column except column (6) is an indicator for whether the respondent suffered any indoor air pollution (IAP) related ailment in last 365 days or not. The dependent variable in column (6) is an indicator for whether the respondent is a female or not. IAP related ailments include hypertension, heart disease, acute upper respiratory infections, cough, asthma, mental retardation, mental disorders, headache, seizures or known epilepsy, weakness in limb muscles and difficulty in movements, stroke, memory related ailments, discomfort or pain in the eye, burns, back or body aches, and anaemia. Household is assigned to using solid fuel as primary source of energy for cooking if it reports using firewood and chips or dung cake or coke/coal or charcoal. Lagged forest cover is used as instrument in the last two columns. In column (11), we also control for ambient air pollution using data from CAMS EAC4. The sample contains data from NSS 75th round and The Socioeconomic High-resolution Rural-Urban Geographic Dataset on India (SHRUG) (Asher et al. (2021)).

Table 4: Effect of Indoor Air Pollution on Health Outcomes – Heterogenous Effect

	(1) OLS HH	(2) IV HH	(3) OLS Any ailment	(4) IV Any ailment	(5) OLS Females	(6) IV Females	(7) OLS Rural	(8) IV Rural	(9) OLS Insurance	(10) IV Insurance	(11) OLS MPCE	(12) IV MPCE	(13) OLS Housemaker	(14) IV Housemaker	(15) OLS Vulnerable	(16) IV Vulnerable
Household uses Solid Fuel=1	0.01036	0.15613	-0.00293	-0.02995	-0.00042	0.02886	0.00527	0.00791	0.00173	0.04728	-0.00512	0.08823	-0.00020	0.01957	-0.00223	0.02627
	(0.00331)***	(0.06073)**	(0.00123)**	(0.02188)	(0.00105)	(0.02001)	(0.00188)***	(0.06415)	(0.00098)*	(0.01728)***	(0.00144)***	(0.02680)***	(0.00091)	(0.01630)	(0.00135)**	(0.02094)
Household uses Solid Fuel=1 × Female=1					0.00390	0.01835										
					(0.00138)***	(0.02804)										
Household uses Solid Fuel=1 × Rural=1							-0.00163	0.05375								
							(0.00203)	(0.06483)								
Household uses Solid Fuel=1 × Household has Insurance Coverage=1									-0.00036	-0.05956						
									(0.00344)	(0.01606)***						
Household uses Solid Fuel=1 × Household MPCE											0.00080	-0.00433				
											(0.00011)***	(0.00363)				
Household uses Solid Fuel=1 × Member is a Housemaker=1													0.00630	0.08680		
													(0.00159)***	(0.03232)***		
Household uses Solid Fuel=1 × Household has at least one vulnerable age member=1															0.00702	0.02036
															(0.00151)***	(0.02780)
Individual Controls																
Age (years)			0.00185	0.00183	0.00108	0.00106	0.00108	0.00106	0.00107	0.00105	0.00108	0.00106	0.00123	0.00122	0.00108	0.00107
			(0.00003)***	(0.00003)***	(0.00002)***	(0.00002)***	(0.00002)***	(0.00002)***	(0.00002)***	(0.00003)***	(0.00002)***	(0.00002)***	(0.00002)***	(0.00002)***	(0.00002)***	(0.00002)***
Female=1			0.09907	0.09936	-0.00088	-0.00611	0.00055	0.00117	0.00095	0.00167	0.00055	0.00100	0.01305	0.01448	0.00097	0.00155
			(0.00102)***	(0.00106)***	(0.00087)	(0.01113)	(0.00068)	(0.00071)*	(0.00079)	(0.00083)**	(0.00068)	(0.00072)	(0.00087)***	(0.00094)***	(0.00068)	(0.00071)**
Member is a Housemaker=1													-0.02705	-0.05867		
													(0.00120)***	(0.01255)***		
Household Controls																
Primary Completed Adults	0.00730	0.01839	-0.00132	-0.00316	-0.00117	0.00134	-0.00140	0.00061	-0.00142	0.00134	-0.00163	0.00039	-0.00084	0.00180	-0.00140	0.00124
	(0.00115)***	(0.00473)***	(0.00036)***	(0.00151)**	(0.00023)***	(0.00100)	(0.00024)***	(0.00107)	(0.00028)***	(0.00113)	(0.00024)***	(0.00115)	(0.00023)***	(0.00100)*	(0.00023)***	(0.00106)
Household Size	0.00344	-0.00280	-0.01422	-0.01305	-0.00669	-0.00787	-0.00655	-0.00734	-0.00644	-0.00763	-0.00737	-0.00739	-0.00682	-0.00804	-0.00568	-0.00697
	(0.00079)***	(0.00272)	(0.00024)***	(0.00084)***	(0.00016)***	(0.00055)***	(0.00016)***	(0.00067)***	(0.00019)***	(0.00062)***	(0.00017)***	(0.00201)***	(0.00016)***	(0.00055)***	(0.00016)***	(0.00058)***
Access to Private Latrine=1	0.01459	0.04216	-0.01264	-0.00727	0.00110	0.00886	0.00077	0.00816	0.00022	0.00963	0.00025	0.00974	0.00111	0.00953	0.00119	0.00912
	(0.00330)***	(0.01195)***	(0.00127)**	(0.00454)	(0.00084)	(0.00300)***	(0.00084)	(0.00315)***	(0.00101)	(0.00362)***	(0.00084)	(0.00286)***	(0.00084)	(0.00301)***	(0.00084)	(0.00307)***
Access to Piped Water=1	0.01093	0.04463	0.00119	-0.00380	0.00348	0.01204	0.00232	0.00849	0.00403	0.01343	0.00305	0.01204	0.00335	0.01268	0.00337	0.01208
	(0.00320)***	(0.01307)***	(0.00120)	(0.00477)	(0.00081)***	(0.00315)***	(0.00083)***	(0.00245)***	(0.00095)***	(0.00366)***	(0.00081)***	(0.00373)***	(0.00081)***	(0.00316)***	(0.00081)***	(0.00319)***
Islam	0.01499	0.01886	0.00544	0.00430	0.00495	0.00636	0.00424	0.00471	0.00632	0.00822	0.00531	0.00701	0.00589	0.00712	0.00433	0.00589
	(0.00439)***	(0.00491)***	(0.00154)***	(0.00185)**	(0.00105)***	(0.00125)***	(0.00105)***	(0.00119)***	(0.00122)***	(0.00146)***	(0.00105)***	(0.00155)***	(0.00105)***	(0.00125)***	(0.00105)***	(0.00128)***
Other Religion	-0.00028	-0.00955	0.00129	0.00239	0.00076	-0.00155	0.00125	-0.00011	-0.00020	-0.00214	0.00066	-0.00254	0.00057	-0.00174	0.00086	-0.00136
	(0.00592)	(0.00720)	(0.00234)	(0.00277)	(0.00159)	(0.00189)	(0.00159)	(0.00170)	(0.00193)	(0.00226)	(0.00159)	(0.00191)	(0.00159)	(0.00189)	(0.00159)	(0.00189)
Upper Caste=1	0.01093	0.02901	-0.00231	-0.00552	0.00225	0.00699	0.00185	0.00522	0.00227	0.00690	0.00100	0.00485	0.00199	0.00730	0.00272	0.00751
	(0.00333)***	(0.00888)***	(0.00125)*	(0.00312)*	(0.00085)***	(0.00207)***	(0.00085)**	(0.00270)*	(0.00099)**	(0.00227)***	(0.00086)	(0.00205)**	(0.00085)**	(0.00208)***	(0.00085)***	(0.00209)***
Rural=1							-0.00620	-0.03359								
							(0.00092)***	(0.01143)***								
Household has Insurance Coverage=1									0.00888	0.02375						
									(0.00171)***	(0.00445)***						
Household MPCE											0.00037	0.00151				
											(0.00005)***	(0.00032)***				
Household has at least one vulnerable age member=1															-0.01738	-0.02182
															(0.00097)***	(0.01087)**
State FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year × Month FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dep. Var. Mean	0.298	0.298	0.180	0.180	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069
KP F-Statistic		302.139		1562.237		550.910		98.775		549.953		51.991		221.127		517.996
N	113,257	101,753	554,627	504,416	554,627	504,416	554,627	504,416	409,724	368,716	554,627	504,416	554,627	504,416	554,627	504,416

Notes: Heteroskedasticity robust standard errors in parentheses. (* p<.10 ** p<.05 *** p<.01). Each observation in all columns except first two columns is at the respondent level. Each observation in first two columns is at the household level. The dependent variable in all columns except first two columns is an indicator for whether the respondent suffered any indoor air pollution (IAP) related ailment in last 365 days or not. The dependent variable in first two columns is whether any household member reported having suffered any IAP related ailment in last 365 days or not. IAP related ailments include hypertension, heart disease, acute upper respiratory infections, cough, asthma, mental retardation, mental disorders, headache, seizures or known epilepsy, weakness in limb muscles and difficulty in movements, stroke, memory related ailments, discomfort or pain in the eye, burns, back or body aches, and anaemia. Household is assigned to using solid fuel as primary source of energy for cooking if it reports using firewood and chips or dung cake or coke/coal or charcoal. Household is assigned to rural area using NSS sector codes. Household is assigned to having access to insurance if it reported having paid any insurance premium in last 365 days or not. Respondent is assigned to being a housemaker if it reported having usual principal activity status as "attended domestic duties". The sample contains data from NSS 75th round and The Socioeconomic High-resolution Rural-Urban Geographic Dataset on India (SHRUG) (Asher et al. (2021)).

Table 5: Effect of Indoor Air Pollution on Health Outcomes – First-stage

	(1) OLS Use Solid Fuel for Cooking
Forest Cover (%)	0.00417
	(0.00011)***
Individual Controls	
Age (years)	0.00011
	(0.00003)***
Female=1	-0.00376
	(0.00118)***
Household Controls	
Primary Completed Adults	-0.06731
	(0.00044)***
Household Size	0.03675
	(0.00030)***
Access to Private Latrine=1	-0.19948
	(0.00153)***
Access to Piped Water=1	-0.20981
	(0.00139)***
Islam	-0.04191
	(0.00186)***
Other Religion	0.03391
	(0.00260)***
Upper Caste=1	-0.12801
	(0.00143)***
Dep. Var. Mean	0.371
N	504,416

Notes: Heteroskedasticity robust standard errors in parentheses. (* p<.10 ** p<.05 *** p<.01). Each observation in all columns is at the respondent level. The dependent variable is an indicator for whether the household uses solid fuel as the primary source of energy for cooking. Empirical specification also controls for state and year-month fixed-effects. Household is assigned to using solid fuel as primary source of energy for cooking if it reports using firewood and chips or dung cake or coke/coal or charcoal. The sample contains data from NSS 75th round and The Socioeconomic High-resolution Rural-Urban Geographic Dataset on India (SHRUG) (Asher et al. (2021)).