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Rising Above the Smoke: How Does Clean Energy Impact Child Development in India?

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This study uses data from India's 2019 Time Use Survey to explore how access to clean energy (such as fuel and electricity) influences children's time use across genders. Results show that clean energy access leads to children spending less time on unpaid household chores and more time on learning and personal development. Additionally, the gender gap in these activities decreases when families have clean energy, a trend supported by evidence from the government's PMUY scheme.

I. Introduction

This paper investigates the impact of access to clean lighting and clean fuel on children's total developmental activities - encompassing unpaid domestic work, educational pursuits, and self-development in India, through a time use perspective.

Clean energy sources considered include electricity, LPG, natural gas, biogas, solar energy, and advanced stoves. The adoption of energy-efficient technologies can mitigate emissions, reduce energy expenditure, and enhance household welfare, particularly within low- and middle-income countries (Berkouwer & Dean, 2022). These objectives correspond with Sustainable Development Goal (SDG)¹ 7, which targets universal energy access by 2030. As of 2022, 91% of the global population had electricity access; however, since 2021, population growth has outstripped progress, leaving an estimated 10 million people without electricity. Additionally, approximately 2.1 billion people worldwide remain dependent on polluting fuels for cooking (IEA et al., 2023). In India specifically, NFHS-5 data indicates that about 47% of rural households and 6.5% of urban households primarily use firewood for cooking (Dhamija, 2023), presenting significant health and educational challenges that further compound existing inequalities.

Energy poverty yields critical short- and long-term consequences for children's learning, employment prospects, and health. Numerous studies highlight detrimental effects such as hazardous indoor air quality impacting respiratory health (Maji et al., 2021), reductions in both the quantity and quality of productive hours (Verma & Imelda, 2023),

negative educational impacts—including diminished school attendance (Biswas & Das, 2022; O'Brien et al., 2021)—impaired cognitive skills (Nsenkyire et al., 2023), and lower academic achievement (Wang & Du, 2024). Further, children in affected households often experience poorer physical and mental health outcomes (Oliveras et al., 2021) and reduced subjective well-being (O'Driscoll et al., 2024; Zhang et al., 2021). Despite this, empirical research examining the intermediate role of time poverty remains limited. This study addresses this gap by analyzing gendered patterns of time use in relation to child development.

In developing contexts, time is a vital resource, particularly given the greater prevalence of non-market economic activity undertaken by women and children (Donath, 2000). Like other resources, time may be distributed unequally, often resulting in time poverty among specific groups. Since consumption relies on a combination of time (home production) and income (market production), investigating time poverty is essential for comprehending the effects of anti-poverty initiatives (Gammage, 2010).

This research utilizes the 2019 Indian Time Use Survey (ITUS (2019)) to examine children aged 5 -17 in households with access to clean energy, leveraging the government's clean fuel initiative, Prime Minister Ujjwala Yojana (PMUY) - to assess time allocation changes among eligible households' children across key developmental activities. Findings reveal a substantial reduction in time devoted to unpaid domestic chores, accompanied by increased engagement in learning and self-development, attributable to the implementation of clean energy solutions.

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¹ [THE 17 GOALS | Sustainable Development](#)

By elucidating the implications of energy poverty for time poverty, an often-underexplored dimension of multi-dimensional poverty in India - this study contributes to the existing literature. By centering the analysis on policy impacts on children, it underscores the necessity of recognizing children as active participants in, rather than passive recipients of, policy interventions.

II. Data and Methodology

A. Data

We analyse the first nationally representative ITUS (2019), which was designed to measure the allocation of time by the population across various paid and unpaid activities. Respondents provided details about their activities during the 24 hours preceding the interview, organised into 48 time slots, each lasting 30 minutes. The activities were classified according to the International Classification of Activities for Time Use Statistics, 2016, ensuring comparability across different countries. The novelty of the TUS dataset lies in the fact that it is the only available survey technique for collecting detailed information on economic activities existing both within and outside the production boundary, as well as on non-delegable personal activities outside the general production boundary.

Restricting our analysis to children aged 6–17, the sample comprises 87,668 individuals (54.53% boys, 45.47% girls). Urban residents account for 34.57%, while rural residents make up 65.43%. Clean energy is used for cooking by 61.77% of households and for lighting by 95.13%. In terms of time use, boys spend 7.04, 359, and 1,037 minutes per day, respectively, on unpaid domestic services, learning, and self-development activities. In comparison, girls spend 43.56, 354.26, and 1,014 minutes per day, respectively, on the same activities.

B. Methodology

We estimate the following models for three different activities:

$$Y_{is}^j = \beta_0 + \beta_1 \text{clean_fuel}_{is} + \beta_2 X_{is} + \mu_s + u_{is} \quad (1)$$

$$Y_{is}^j = \gamma_0 + \gamma_1 \text{clean_light}_{is} + \gamma_3 X_{is} + \eta_s + u_{is} \quad (2)$$

Here, Y_{is} is the time spent on j^{th} activity vis-a-vis unpaid domestic services, learning activities² and self-development activities³ by the i^{th} child in the s^{th} state. The dummy variables of interest are clean_fuel_{is} and clean_light_{is} that takes the value one if the household has access to clean fuel for cooking (LPG, Gobar gas, or natural gas) and clean electricity (Solar, wind, and others), respectively, and 0 otherwise. X_{is} are individual and household-specific characteris-

tics. η_s and μ_s are the vector of state-level fixed effects and error terms, respectively.

Launched in 2016, the government's flagship program, Pradhan Mantri Ujjwala Yojana (PMUY)⁴, has significantly expanded LPG coverage, achieving a 105.4% increase as of 2023. We analyze time allocation among children in eligible households and compare them with those in households without access to clean fuel. Eligibility requires an adult woman from a poor (BPL) household without an LPG connection, where BPL status is determined by factors such as consumption expenditure below Rs. 10,000, SC/ST classification, kutchra housing, or landholding of less than five acres, among others.

III. Results

For a preliminary analysis of gender-specific effects on children's time use, we interacted gender with clean fuel and electricity (Table 1). On average, girls in households with clean energy allocate significantly less time to domestic services and more time to learning and self-development activities than boys.

Next, we introduced PMUY eligibility conditions and performed a sub-sample analysis. Table 2 reveals a gender-differentiated pattern of time use: girls generally spend more time on unpaid domestic services and less on self-care than boys. However, this gap diminishes in households with clean fuel compared to those with alternate cooking fuel. Notably, in clean fuel households, there is no significant gender difference in learning time, unlike households using alternate fuel, where girls spend less time than boys. This trend persists in impoverished households (meeting all eligibility criteria) and aligns with previous literature (Choudhuri & Desai, 2021; Frempong et al., 2021; Karmaker et al., 2022). In households with monthly expenditures below Rs. 10,000, SC/ST status, kutchra housing, and land size less than 5 acres, girls spend 58.09 minutes more on unpaid domestic services with clean fuel, compared to 62.80 minutes more with alternate fuel. This could be a result of reduced fuel collection and cooking time (Afridi et al., 2023) and improved behavioral changes in women's choices of fuel use (Selvam et al., 2022).

The findings of this study can be corroborated in future research with a panel data structure, allowing for more nuanced analysis. Additionally, while we addressed within-household differences by using a household fixed effects strategy, the issue of endogeneity could persist due to self-selection bias and time-invariant factors correlated with both clean fuel adoption and children's time use.

² formal education, homework, additional non-formal courses

³ cultural activities, leisure pursuits, social interaction and communication, religious practices, engagement with mass media, sports activities, self-care, and personal maintenance.

⁴ [PMUY : Home](#)

Table 1. Interaction effect of gender with clean fuel and clean light

Variables	(1) unpaid domestic services	(2) learning time	(3) total self- development time	(4) unpaid domestic services	(5) learning time	(6) total self- development time
female	47.48*** (1.035)	-5.335* (2.854)	-30.41*** (2.628)	53.47*** (2.986)	-16.30** (7.729)	-20.70*** (6.851)
Clean fuel	-0.0672 (0.532)	5.450** (2.668)	4.807* (2.566)	NA	NA	NA
Female # clean fuel	-18.89*** (1.204)	8.438** (3.645)	6.546* (3.421)	NA	NA	NA
clean light	NA	NA	NA	3.610*** (0.958)	7.779 (5.404)	-1.713 (5.016)
Female # clean light	NA	NA	NA	-18.06*** (3.038)	16.84** (7.938)	-6.216 (7.065)
State FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
Constant	23.58*** (5.263)	187.3*** (17.58)	1,133*** (15.73)	19.57*** (5.428)	183.5*** (18.25)	1,138*** (16.37)
Observations	87,609	87,609	87,609	87,609	87,609	87,609
R-squared	0.181	0.073	0.060	0.175	0.073	0.060

Note: The analysis includes the following covariates: child's gender, current age, age squared divided by 100, household size, rural status, typical monthly household consumption expenditure (in INR), upper caste status, religion, and state fixed effects. Robust standard errors are reported in parentheses. ***, **, and * denotes statistical significance at 1%, 5%, and 10% levels, respectively.

IV. Conclusion

Using India's Time Use Survey 2019, this study examines the effect of clean energy on children's time use, contributing to the literature on time use, gender division of labor, and energy poverty effects. The study indicates that children in households with access to clean energy reduce time on unpaid domestic chores, allowing for greater focus on educational and self-development activities. Employing PMUY eligibility criteria, the study suggests clean cooking fuel promotes gender equity in children's time use. While technology adoption (like the PMUY scheme) reduces the time for unpaid domestic services, it may not fully challenge traditional gender roles. It is one piece of a broader puzzle with positive spillovers into children's lives. Future studies could investigate the causal impact of clean energy on children's time use.

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Data and replication statement

The data on NSSO's TUS, 2019 is available on <https://mospi.gov.in/time-use-survey-0> and supplementary material is available on request.

Table 2. Policy implications (PMUY) on the children belonging to the households fulfilling the eligibility criteria

Panel A: subsample of households with consumption expenditure<10000						
variables	(1) Domestic service time: clean fuel	(2) Domestic service time: alternate fuel	(3) Learning time: clean fuel	(4) Learning time: alternate fuel	(5) self-care time: clean fuel	(6) self-care time: alternate fuel
female	39.80*** (1.917)	56.80*** (2.954)	1.202 (2.640)	-13.72*** (3.402)	-28.19*** (2.405)	-31.07*** (3.555)
observations	19,048	19,372	19,048	19,372	19,048	19,372
r-squared	0.552	0.580	0.863	0.825	0.851	0.799
Panel B: subsample of households belonging to scheduled caste/ scheduled tribe						
female	41.38*** (2.108)	57.60*** (3.931)	4.686 (3.406)	-19.43*** (4.724)	-31.96*** (3.550)	-31.95*** (5.956)
observations	9,579	10,198	9,579	10,198	9,579	10,198
r-squared	0.564	0.573	0.856	0.834	0.849	0.796
Panel C: subsample of households residing in kuccha house or no dwelling						
female	40.66*** (5.278)	59.86*** (5.007)	5.972 (7.688)	-15.58** (6.530)	-28.49*** (6.875)	-36.83*** (6.525)
observations	2,448	5,631	2,448	5,631	2,448	5,631
r-squared	0.556	0.583	0.828	0.820	0.852	0.794
Panel D: subsample of households with land size<5 acres (<2.02 hectares)						
female	34.58*** (1.477)	54.97*** (2.774)	0.0950 (2.061)	-12.99*** (3.155)	-22.90*** (1.972)	-30.10*** (3.310)
observations	32,544	21,860	32,544	21,860	32,544	21,860
r-squared	0.553	0.571	0.862	0.820	0.848	0.798
Panel E: subsample of households living in abject poverty (fulfilling the above mentioned all 4 criteria)						
female	58.09*** (11.23)	62.80*** (5.764)	-8.238 (11.08)	-31.56*** (11.42)	-27.13** (12.14)	-28.52*** (9.846)
observations	680	2,506	680	2,506	680	2,506
r-squared	0.549	0.565	0.839	0.822	0.862	0.798

Note: In columns 1, 3, and 5, the subsample is limited to the households with access to clean cooking fuel, and columns 2, 4, and 6 are limited to the regression with subsamples limited to the households with access to alternate cooking fuel arrangements. All the regressions include controls from age, age squared/100, household fixed effects, and robust standard errors reported in parentheses are clustered at the district level. ***, **, and * denotes statistical significance at 1%, 5%, and 10% levels, respectively.



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