

Clean Energy Access: Gender Disparity, Health and Labor Supply

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Energy-Gender-Health-Labor Nexus

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2. Women spend a considerably higher amount of time on unpaid housework and care than men, hence less time in market work.

Energy-Gender-Health-Labor Nexus

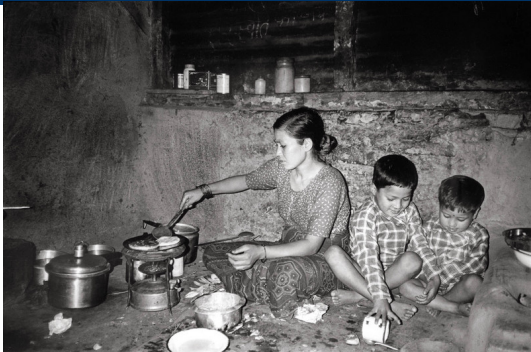
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- How access to energy can help filling this gap?
1. Lower time-burden through modern appliances ([Greenwood et al., 2005](#)).
 2. Reduces health-burden through clean technology: by making women/children sick less often

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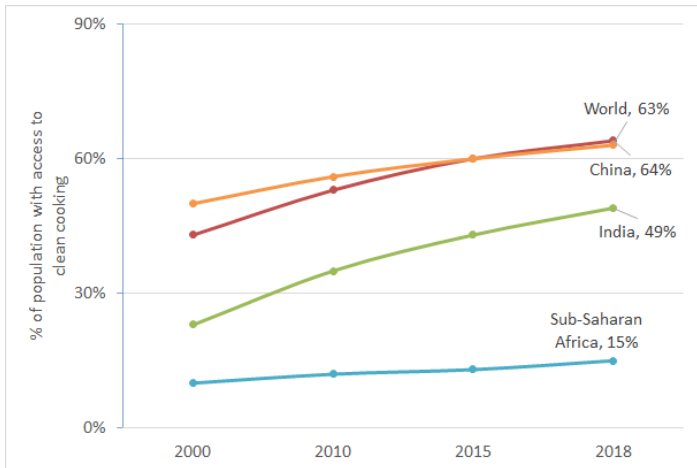
"How does having access to clean energy reduce gender disparity in health? How does it influence labor outcomes?"

Cooking Technology

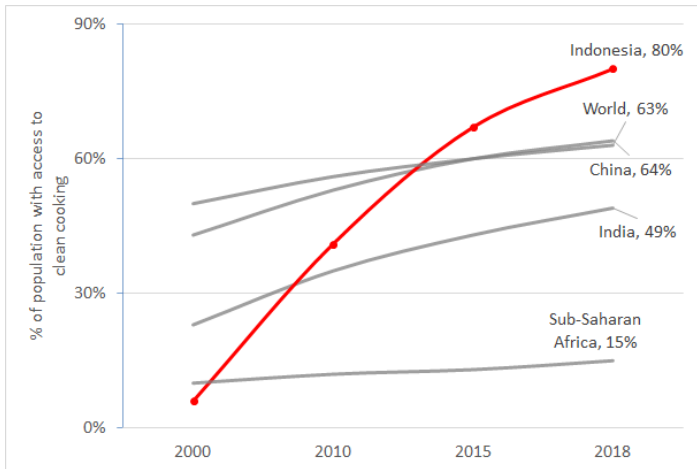


1. 40% of people globally is without access to modern and clean cooking
2. Indoor air pollution is associated with four million deaths annually (WHO). Health and time burden on women as the primary user.
3. Worldwide interest on policy to improve adoption on clean energy

Countries' Clean Cooking Initiatives



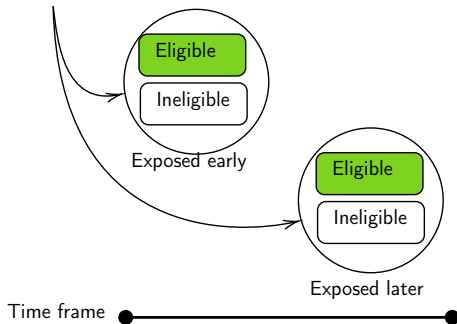
Intervention in Indonesia as a Policy Experiment



Overview of This Paper

- Provide new evidence on the impact of clean cooking on adults' health and labor outcomes and potential mechanisms

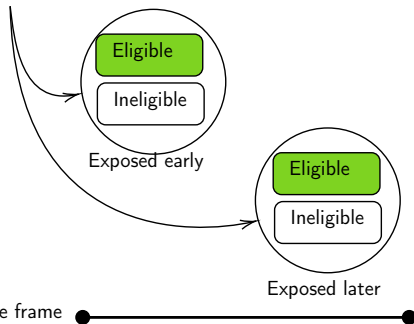
Program goal: Distribute to two-thirds of total population in 5 years



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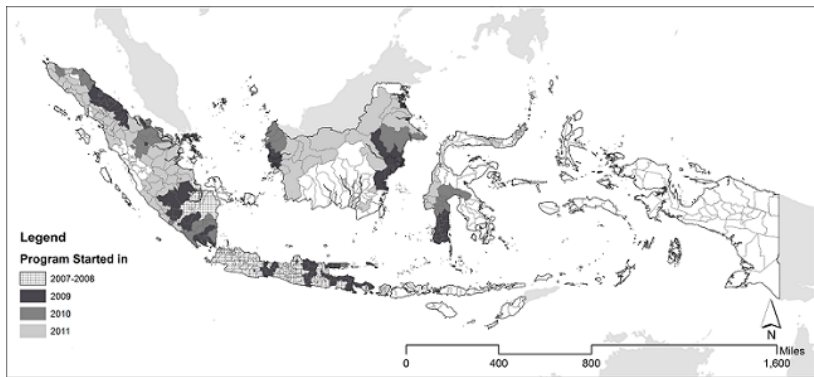
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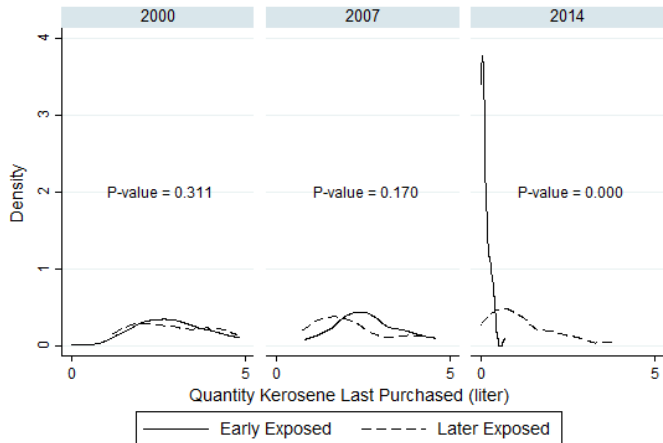
- Identification: program timing is unrelated to individual or regional characteristics
- Focus on the expansion period [▶ Imelda, 2020](#)

Administrative data on the program between 2007-2014



Districts by the implementation year (2007-2014).

Early vs Later Exposed



Graphs by year

Kerosene Purchased at Baseline Year

Preview of Results

Health impact:

- Health improvements particularly among **women**
- Those who spend more time at home, experience greater health impact
 - ▣ Main channel: pollution

Labor impact:

- increase work hours among **women** who benefit from the health impact
 - ▣ Main channel: health
- increase in work hours among **men** in households where women enjoyed the health impact
 - ▣ Channel: substitution and complementarity

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Take away: clean energy can reduce health disparity, and also improve labor outcomes not only for women but also for men.

Contributions

- First evidence that document the wide spillover effects of an energy policy on health and labor outcomes within households.
 - ▣ The key mechanism is that the access to cleaner energy improves labor outcomes by reducing the health-burden on women.
- Using individual panel data over 14 years to provide causal estimates of the impact of clean energy intervention on adults (Pitt et al., 2006; Silwal and McKay, 2015; Cesur et al., 2016; Imelda, 2020).
- More broadly, “missing adult women” in developing countries (Sen, 1990; Klasen and Wink, 2002; Anderson and Ray, 2010).

Roadmap

1. Program details
2. Data and empirical strategy
3. Main results on health and plausible mechanism
4. Main results on labor outcomes and plausible mechanism
5. Robustness
6. Conclusion and policy implication

1. Kerosene to LPG Fuel Conversion Program

- Nationwide energy program, started in 2007, with ambitious goal to convert 50 million of households to use **LPG** within five years.
- The main purpose of the program was to reduce **the cost in subsidizing kerosene**.
- Eligible if the households have not used LPG before the program.
- Steps:
 1. distribution of a **free starter kit** (a stove and a cylinder)
 2. **subsidy** on the LPG refill.
 3. **restriction** on kerosene quantity.

Kerosene Vs. LPG

Fine particulates from burning LPG are about **46–76%** lower than particulates from burning kerosene ([Imelda, 2020](#)).



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Conceptual framework for labor supply

- When women (and their children) are less likely to be sick, they have options to increase their work hours and to participate in market work (Cai, 2010; Stabridis and van Gameren, 2018).
- Many reasons why clean energy access may not increase labor supply
 - ▣ health impact is not large enough to influence labor supply
 - ▣ individual preference on leisure
 - ▣ limited opportunities to participate in the market work

2. Data

- Administrative data on the program between 2007-2014
 - Yearly data for LPG roll-out at district level
 - Early exposed districts—program roll-out in 2009, 2010
 - Later exposed districts—program roll-out beyond 2010.
 - Refined into several dummies (0-2, 3-4, 5-6 years of exposure)

2. Data

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- Indonesian Family Life Survey (2000, 2007, 2014)
 - longitudinal data that track the same individual over 14 years. Low rate of attrition (Thomas et al., 2012).
 - 2007 is the baseline year.
 - Eligible households = those who never use LPG at baseline years.
 - Households that are ineligible are used for placebo check.

Difference-in-differences event study style

$$Y_{idt} = \beta_1 \text{EarlyExposure} \times \text{Post} + \beta_2 \text{EarlyExposure} \times \text{Pre} \\ + \gamma_t + \delta_d + \theta X_{idt} + \epsilon_{idt}$$

- where i, r, t denote individual, region and year of survey respectively.
- Post (Pre) is the dummy variables for 2014 (2000), and 0 for 2007—the baseline year.
- γ_t and δ_d are the time and district fixed effects; X_{idt} is a set of individual controls at year 2007; ϵ_{irt} cluster at district level.
- β_1 captures the intent-to-treat effect due to longer exposure to the program.

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- **Outcome variables:** lung capacity (Silwal and McKay, 2015; Rosales-Rueda and Triyana, 2019), and work hours
- **Parallel-trend assumption:** individuals in the two groups should be trending similarly pre program (β_2).

Measuring lung capacity



Advantage of using lung capacity as proxy for health: (1) strong predictor for mortality for elderly; (2) reliable measure; (3) not easily influenced by contemporaneous factors.

Summary Statistic at Baseline (2007)

	(1)		(2)	
	Early Exposed Mean	Std. Dev.	Later Exposed Mean	Std. Dev.
<i>Demographic</i>				
Age(yrs)	43.03	15.20	41.64	15.40
Ever Married (%)	0.83	0.38	0.79	0.41
No school (%)	0.13	0.34	0.10	0.30
Primary/Middle School (%)	0.47	0.50	0.41	0.49
High School (%)	0.34	0.47	0.40	0.49
Electricity (%)	0.95	0.21	0.94	0.23
Refrigerator (%)	0.62	0.85	0.69	0.91
Television (%)	0.77	0.42	0.72	0.45
Per-capita Income (USD)	153.16	230.51	175.36	216.01
<i>Cooking Fuel Used</i>				
Gas (%)	0.10	0.30	0.09	0.29
Kerosene (%)	0.34	0.47	0.45	0.50
Firewood (%)	0.54	0.50	0.45	0.50
<i>Health and Labor Outcomes</i>				
Lung capacity (Litres/Minute)	329.20	113.00	337.78	107.65
Employed (%)	0.77	0.42	0.73	0.45
No. of hours worked per month	189.66	101.39	198.15	102.03
Participation in Agriculture (%)	0.45	0.50	0.44	0.50
Help in Household Work (%)	0.59	0.49	0.58	0.49
<i>N</i>	3815		2255	

Parallel Trend Test: Main Outcome Variables (β_2)

	Lung Capacity		Hours Worked Per Month	
	(1)	(2)	(3)	(4)
	Women	Men	Women (Housekeeper)	Men (Housekeeper HH)
EarlyExposure \times Pre	10.13 (7.25)	1.03 (9.10)	17.30 (19.26)	11.12 (14.41)
Control Mean	283.3	410.9	152.4	211.1
Observations	7782	6049	879	1718

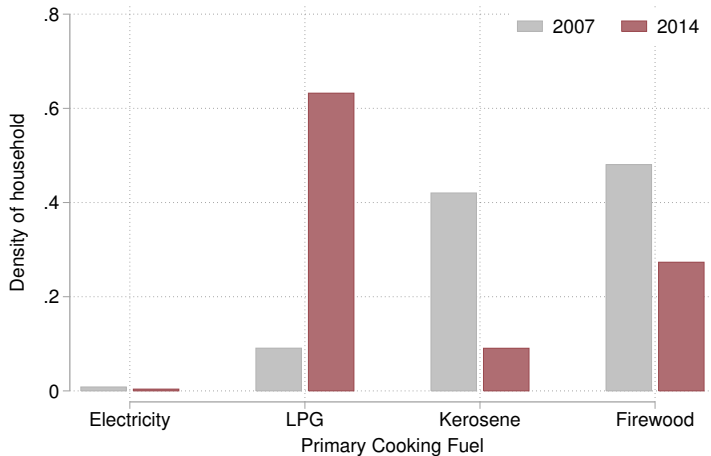
Parallel Trend Test: Other Health Measures (β_2)

	(1) Anemia	(2) Diabetes	(3) Self report Health	(4) Weight	(5) Cough
EarlyExposure \times Pre	0.01 (0.00)	-0.00 (0.00)	0.03 (0.03)	0.46 (0.34)	0.00 (0.03)
Control Mean	0.013	0.006	0.776	53.128	0.359
Observations	18269	18269	18270	18244	17284

Parallel Trend Test: Other Characteristics (β_2)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Education	Log PC Income	Electricity	Refrigerator	TV	Toilet	Water in/out
EarlyExposure \times Pre	0.00 (0.01)	0.04 (0.08)	-0.01 (0.03)	0.04 (0.07)	-0.02 (0.04)	0.03 (0.04)	0.05 (0.04)
Control Mean	0.894	4.429	0.949	0.584	0.752	0.703	0.465
Observations	18270	16552	18270	18270	18270	18270	18270

Take-ups



Primary cooking fuel based on Indonesian Family Life Survey 2007 and 2014.

Suggestive Evidence: Fuel Choice and Health

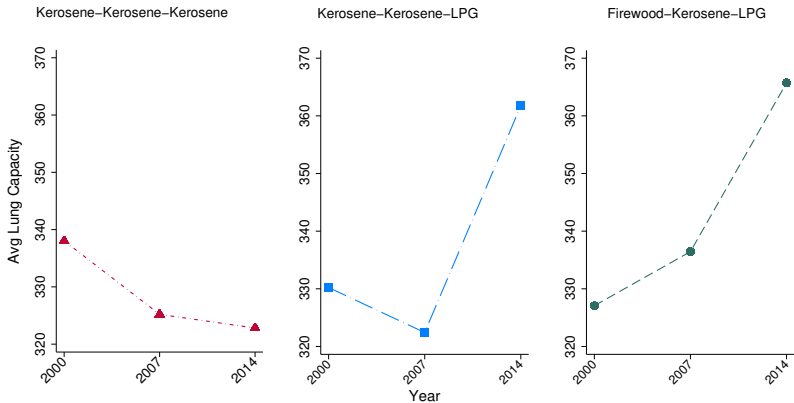


Figure 1: Average Lung Capacity Over Time

Is there any gender disparity in health?

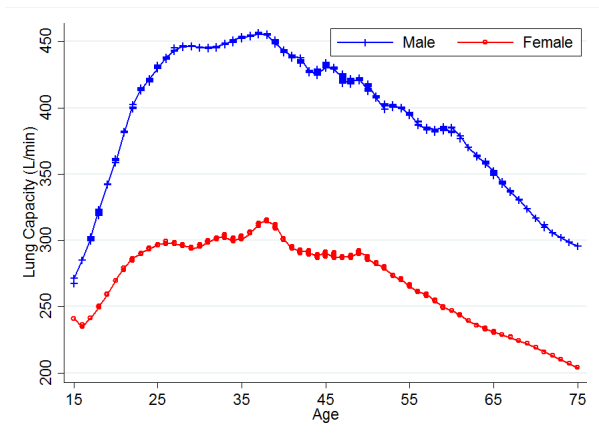
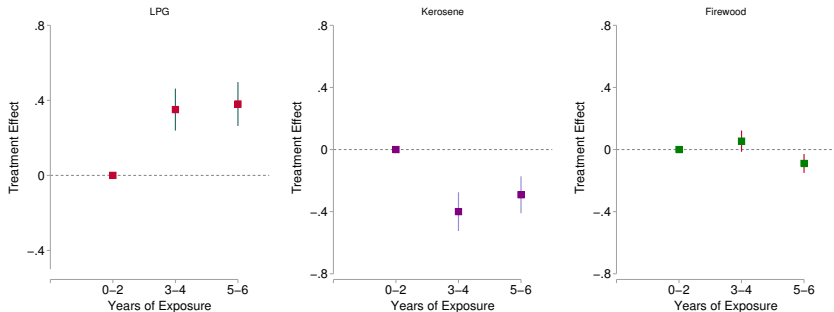


Figure 2: Lung Capacity by Gender at Baseline

Fuel Switching by Duration of the Program

First stage: Program Impacts on Fuel Choice



- Years of exposure 0-2 years, 3-4 years, 5-6 years, are those individuals who received LPG after 2014, 2013-2014, 2011-2012, 2009-2010, respectively.

4. Results: Program Impact on Health

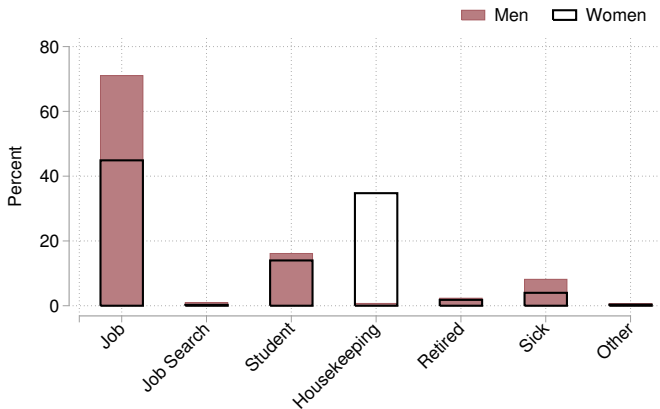
Longer exposure to clean energy access leads to higher lung capacity

	Women				Men			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EarlyExposure × Post	11.34** (5.501)	11.34** (5.502)	11.34** (5.542)	11.34** (5.500)	1.940 (6.043)	1.940 (6.044)	1.940 (6.100)	1.940 (6.042)
Control Mean	283	283	283	283	411	411	411	411
Observations	7782	7782	7782	7782	6049	6049	6049	6049
Rural-Urban FE	✓	✓			✓	✓		
Individual Controls		✓	✓			✓	✓	
District FE			✓				✓	
Individual FE				✓				✓

Magnitude: women who are exposed earlier experienced improvements in the lung capacity (4%) than those who are exposed later.

□ ≈ if a regular smoker quits smoking for 10 years.

Disparity in housework activities and time spent at home



Survey Question in 2007 asked: **primary** activity during the past week.

Impact on lung capacity among women who most likely spent their time indoors

	Women			
	(1)	(2)	(3)	(4)
EarlyExposure \times Post	6.91 (5.42)	6.91 (5.42)	6.91 (5.46)	6.91 (5.42)
EarlyExposure \times Post \times Housekeeper	11.89** (5.67)	11.89** (5.67)	11.89** (5.71)	11.89** (5.67)
Control Mean	283	283	283	283
Observations	7782	7782	7782	7782
Rural-Urban FE	✓	✓		
Individual Controls		✓	✓	
District FE			✓	
Individual FE				✓

4. Results: Program Impact on Health (β_1)

- Reduced gender disparity on **health**: increase in lung capacity among women (4%) and no effects on men
- No effects on other health measures (cough, weight, hypertension, self-reported health)
- Channels:
 1. Pollution (impact on lung, concentration on housekeepers, driven by those who were exposed longer)
 2. Expenditure (reduce 2% or 2 USD monthly expenditure)
 3. Income, assets, education level (undetected changes) [▶ table](#)
 4. Local economic growth (no impact on ineligible households living in the same district) [▶ table](#)

Program Impact on Other Outcomes

	Other Health Outcomes				Non-Health Outcomes		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Cough	Self Reported Health	Weight	Hypertension	Education	Per Capita Income	House has electricity
EarlyExposure \times Post	-0.03 (0.04)	0.02 (0.02)	0.38 (0.28)	0.01 (0.01)	0.01 (0.01)	-13.51 (30.01)	-0.00 (0.02)
Control Mean	0.35	0.82	53.90	0.02	0.92	206.88	0.96
Observations	13505	13505	13505	13505	14169	12924	14169

Program Impact on Other Outcomes

	Non-Health Outcomes				Placebo Impact	
	(8)	(9)	(10)	(11)	(12)	(13)
	Own a Refrigerator	Own a TV	Toilet Inside house	Water Source Inside House	Lung (All)	Lung (Housekeeper)
EarlyExposure × Post	-0.02 (0.05)	-0.01 (0.03)	-0.00 (0.03)	-0.00 (0.06)		
Placebo Sample					-1.69 (7.71)	3.39 (14.91)
Control Mean	0.72	0.79	0.74	0.49	300.42	297.91
Observations	14169	14169	14169	14169	872	294

Program Impact on Labor Outcomes

- There are many factors that can influence labor outcomes.
- We hypothesize that (if any) labor outcome impact should be concentrated among individuals who enjoyed the benefits from the program.
- We introduce two additional indicators for "if individuals are more likely to be benefited from the program"
 1. Housekeeper at baseline (for women)
 2. Households where there is at least one women did housekeeping at baseline (for men)

Heterogenous Impact on Work Hours (β_1)

Subsample: individuals that are more likely to be benefited from the program

PANEL A : HOUSEKEEPER/ BELONG TO HOUSEKEEPER HOUSEHOLD								
	Women				Men			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EarlyExposure \times Post	31.69* (17.35)	31.28* (17.35)	31.61* (18.43)	28.36 (18.24)	28.46*** (10.61)	28.53*** (10.62)	28.57*** (10.88)	29.28*** (10.73)
Control Mean	152	152	152	152	211	211	211	211
Observations	879	879	879	879	1718	1718	1718	1718
Rural-Urban FE	✓	✓			✓	✓		
Individual Controls		✓	✓			✓	✓	
District FE			✓				✓	
Individual FE				✓				✓

Heterogenous Impact on Work Hours (β_1)

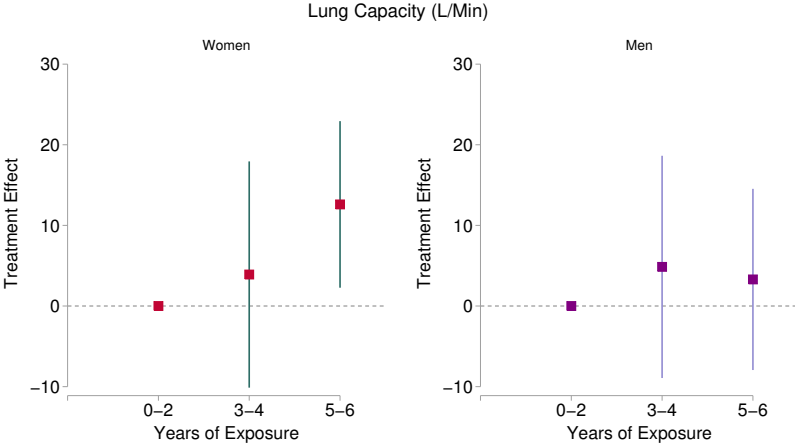
The remaining sample (individuals that are less likely to be benefited from the program)

PANEL B : NON-HOUSEKEEPER/ DOES NOT BELONG TO HOUSEKEEPER HOUSEHOLD								
	Women				Men			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EarlyExposure \times Post	-4.206 (8.147)	-4.233 (8.147)	-3.920 (8.240)	-6.199 (8.302)	10.77 (10.23)	10.74 (10.21)	10.61 (10.40)	7.854 (10.28)
Control Mean	181	181	181	181	211	211	211	211
Observations	3475	3475	3475	3475	3228	3228	3228	3228
Rural-Urban FE	✓	✓			✓	✓		
Individual Controls		✓	✓			✓	✓	
District FE			✓				✓	
Individual FE				✓				✓

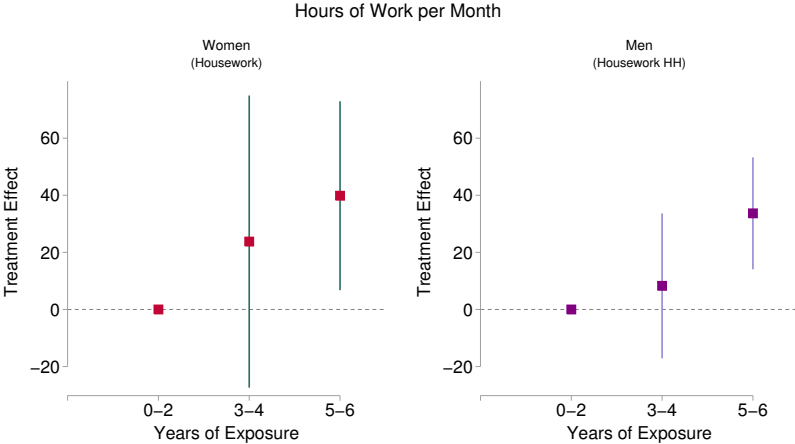
5. Results: Program Impact on Labor Outcomes

	PANEL A : WOMEN	
	Hours Worked Per Month	Work Status
	(1)	(2)
EarlyExposure \times Post \times Houskeeper	37.03** (18.17)	0.173** (0.0830)
Control Mean	175.62	0.25
Observations	4352	2227

Program Impact on Health by Duration



Program Impact on Work Hours by Duration



5. Results: Program Impact on Women's Sector

	Women(Housekeeper)			
Baseline Sector of Women	(1) Agriculture	(2) Manufacturing	(3) Social Service	(4) Retail
EarlyExposure × Post	30.82* (16.61)	20.02 (36.43)	-15.36 (73.35)	39.35 (49.48)
Control Mean	148.428	144.767	147.587	168.201
Observations	498	90	93	198

5. Results: Program Impact on Labor Outcomes

The results on labor supply will be focused on households that are likely affected by the program:

- ▣ Increase in work hours of **women** who were housekeepers at baseline.
- ▣ Increase in work hours of **men** who were in households where there is at least one women did housekeeping primarily at baseline.

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- ▣ Channels:
 - Health (driven by households with positive health shocks, concentration on households with kids)
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 - Local job opportunity (no changes on ineligible households.)
- ▣ **Spillover effects**: increase in work hours of **men**.
Channels: substitution and complementarity

Substitution

Women can act as a **substitute** for **men**'s housekeeping efforts (columns 1-3). Subsequently, the program increases **men**'s propensity to have **secondary job** as men are likely to have some spare time from less unpaid housework activities (columns 4-6).

	Help in Housework			Secondary Job		
	(1)	(2)	(3)	(4)	(5)	(6)
	All men	Men in Houskpr HH	Men in Non-Houskpr HH	All men	Men in Houskpr HH	Men in Non-Houskpr HH
EarlyExposure × Post	-0.09* (0.05)	-0.16*** (0.06)	-0.05 (0.06)	0.08* (0.05)	0.13** (0.05)	0.06 (0.06)
Control Mean	0.246	0.228	0.256	0.353	0.325	0.368
Observations	4106	1466	2640	5202	1810	3392

Complementarity

It is likely easier for **women** to pick up the slack or act as a complement for **men** when there were both in the **same sector** at baseline—proxy for similar skills.

	Agriculture Area Cultivated			Number of Crops (Variety)		
	(1) All HH	(2) Both in Agriculture	(3) Both NOT in Agriculture	(4) All HH	(5) Both in Agriculture	(6) Both NOT in Agriculture
EarlyExposure × Post	0.25** (0.12)	0.60* (0.31)	0.11 (0.15)	0.36* (0.21)	0.63 (0.39)	0.23 (0.21)
Control Mean	0.748	1.045	0.624	1.416	1.489	1.386
Observations	1821	535	1286	1818	534	1284

- Coarsened Exact Matching ▶ CEM
 - Direction as well as magnitude of the impact is consistent with earlier results
- Poverty Alleviation Program ▶ PAP
 - No systematic correlation of PAP with the timing and the eligibility for the clean cooking program
- Sample Restrictions ▶ SR
 - Impact is not highly sensitive to relaxing or restricting to various samples

Conclusion

- Access to clean cooking improves **women's** health and women's labor outcomes.
- Although **men** accrued small or zero health benefits relative to women, they also increased their working hours.
- Clean energy can benefited not only **women** but also **men**, ignoring these spillover effects underestimates the benefit of clean energy access.
- Access to clean energy can not only support the 7th UN Sustainable goal (SDG7) but also help to achieve gender equality (SDG5), good health and well-being (SDG3).

Thank you!

Comments? Questions?

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Draft (<https://sites.google.com/a/hawaii.edu/imelda/research>)

ENERGYECOLAB

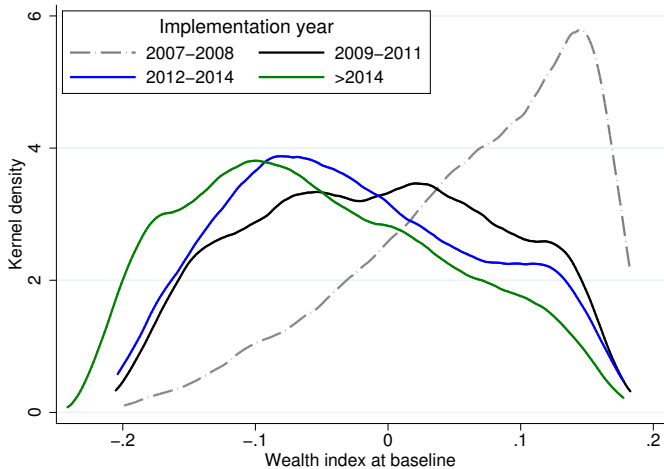


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Expansion periods



Wealth Index

Focus on expansion periods, following [Imelda \(2020\)](#) [▶ Back](#)

Labor impact concentrated on household with positive health impact

PANEL A : WOMEN (Housekeeper)			
	Mean Change in HH Lung Capacity		Placebo Impact
	(1) Mean $\Delta > 0$	(2) Mean $\Delta \leq 0$	(3) All
EarlyExposure \times Post	44.81** (21.05)	21.55 (27.32)	6.92 (75.54)
Control Mean	153	155	158
Observations	964	429	104
PANEL B : MEN			
	Mean Change in HH Lung Capacity		Placebo Impact
	(1) Mean $\Delta > 0$	(2) Mean $\Delta \leq 0$	(3) All
EarlyExposure \times Post	22.82*** (8.79)	-2.32 (12.35)	-8.79 (16.36)
Control Mean	212	204	201
Observations	3656	1547	515
Sample		Eligible	Ineligible

The gap persists

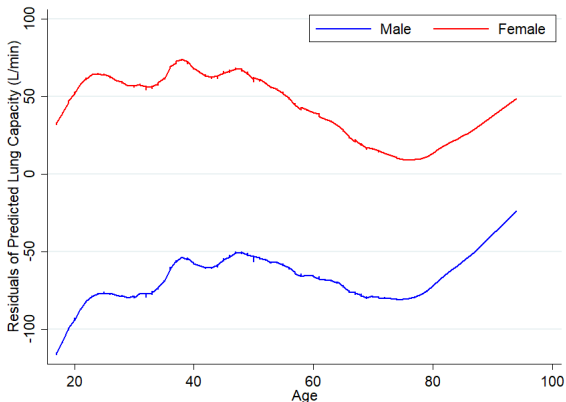


Figure 3: Residuals of predicted lung capacity conditional on age and height