



# Cooking That Kills: Cleaner Energy, Indoor Air Pollution, and Health

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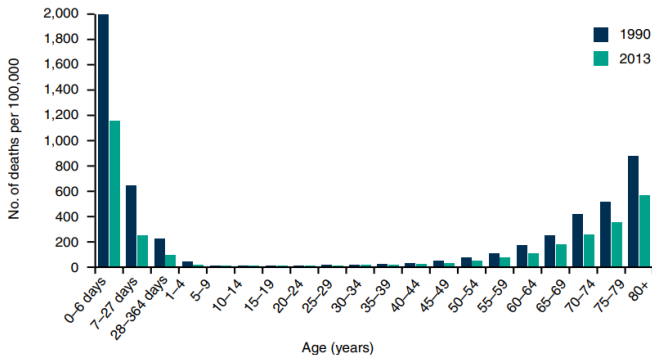
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# Cooking fuel and fine particulates



# The Cost of Household Air Pollution

**FIGURE 2.15 Deaths per 100,000 People by Age Group, 1990 and 2013**



Sources: World Bank and IHME, using data from IHME, GBD 2013.

Source: World Bank (2016)

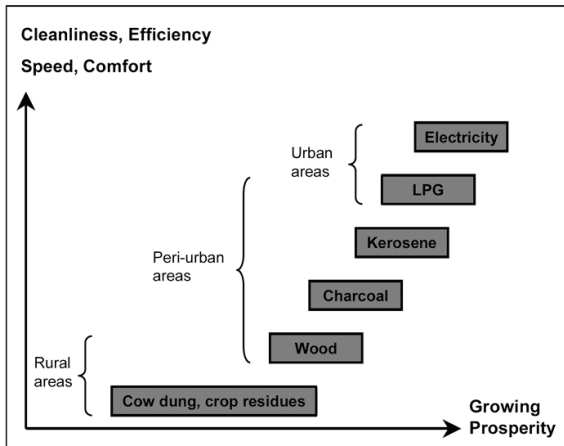
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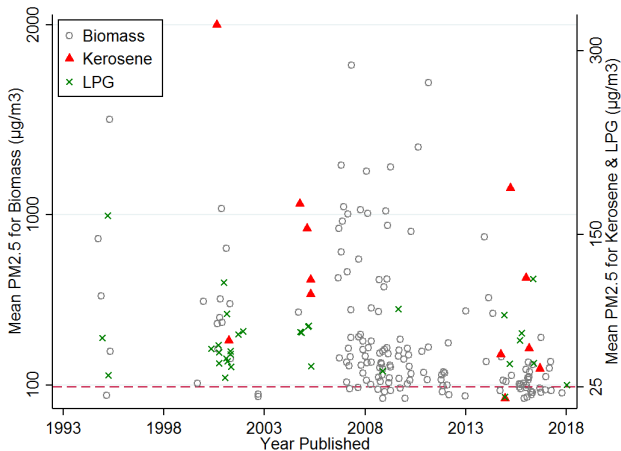
# The Dirtiest and The Cleanest



Source: [Fatmi \(2017\)](#)



# Cooking fuel and fine particulates



Source: Author's compilation from various exposure studies.

- Estimate causal effects of fuel switching on health.
- Focus on infants.
- Avoid measurement errors in individual exposure.

- The program lead to 113 infant deaths averted from 9,464 live births.

## Results preview

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- Reduction to pollutant exposure is likely to be the main mechanism.

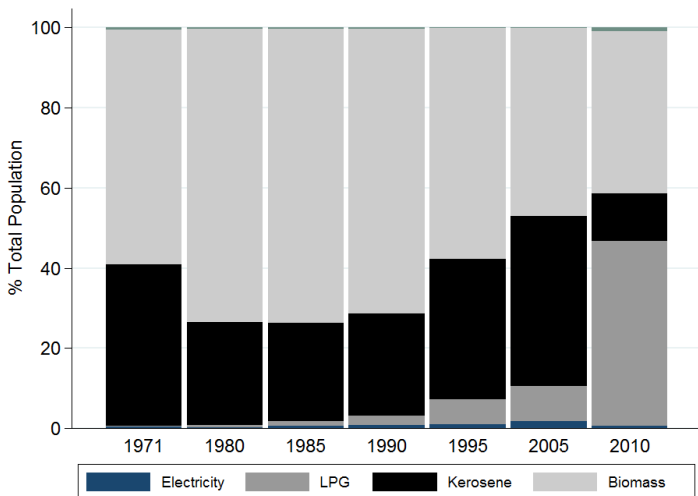
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- Reduction to pollutant exposure is likely to be the main mechanism.
- Prenatal exposure seems to be the leading biological mechanism.
- The magnitude is comparable with [Arceo et al. \(2016\)](#).

## Existing studies

- Ambient air pollution and health (Arceo et al., 2016; Jayachandran, 2009; Tanaka, 2015; Cesur et al., 2016; Greenstone and Hanna, 2014; Chay and Greenstone, 2003)
- Epidemiological studies on indoor air pollution and health (Spengler and Sexton, 1983; Saksena et al., 2003; Smith et al., 2011; Hanna et al., 2016; Jeuland et al., 2015)
- Technology adoption, indoor air pollution, and health (Hanna et al., 2016; Jeuland et al., 2015; Barron and Torero, 2017; Duflo et al., 2008; Hanna and Oliva, 2015; Imelda, 2018a)

# Primary cooking fuel in Indonesia



Notes: Census 1971-2010.



# Kerosene to LPG Conversion Program

- Purpose: reduce the cost of subsidizing kerosene.

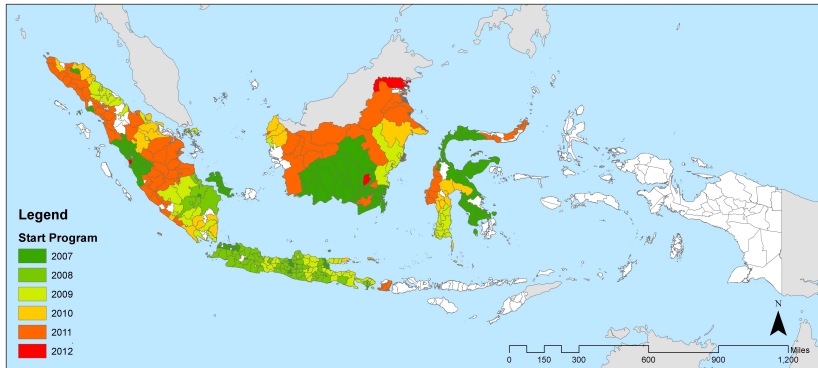
# Kerosene to LPG Conversion Program

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- Effectiveness.

# Kerosene to LPG Conversion Program

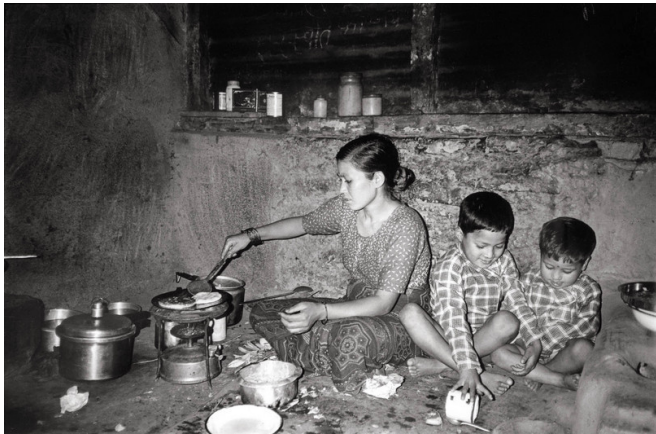
- Purpose: reduce the cost of subsidizing kerosene.
- Effectiveness.
- One of the first successful program.

# Variation over time across districts



Source: Pertamina, 2014

# Kerosene





# Empirical strategy

- DID
- IV
- mother fixed effects

$$\text{LPG Intensity}_{rt} = \frac{\sum \text{LPG packages}_{rt}}{\text{Population}_{rt=2010}} \quad (1)$$



$$Pr(y_{irt} = 1) = c + \alpha_r + \beta_t + \theta Treatment_{irt} + \epsilon_{irt} \quad (2)$$

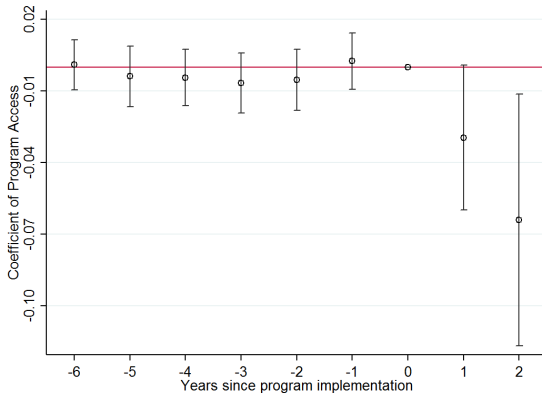
- where  $y_{irt}$  takes the value of 1 if the infant  $i$  in region  $r$  at time  $t$  died and 0 otherwise.
- $\alpha_r$  and  $\beta_t$  are district and year of birth fixed effects
- $Treatment_{irt}$  is either:
  - ▣ (1) program exposure: a dummy indicating if child  $i$  is born after the program roll-out or
  - ▣ (2) program access: a continuous measure of program intensity in district  $r$  at time  $t$ .

$$Pr(LPG_{irt} = 1) = c + \alpha_r + \beta_t + \rho Program_{rt} + \epsilon_{irt} \quad (3)$$

$$Pr(y_{irt} = 1) = c + \eta LP\hat{G}_{irt} + \epsilon_{irt} \quad (4)$$

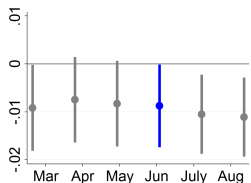
- Indonesian Demographic and Health Survey 2002, 2007, 2012);
- Administrative data on the program

# Event Study Plot

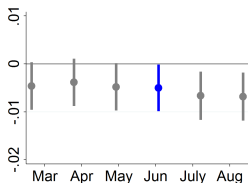


Notes: This figure plots the program access coefficient by years prior to the program implementation. Each coefficient represents the mean difference between the treatment group and the control group.

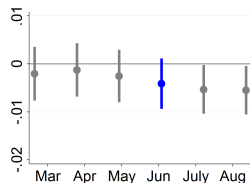
# Program Impact on Other Birth Outcomes



(a) Infant mortality



(b) Within one day mortality



(c) Birth weight (<1500 g)

# Program effect on infant mortality-DID results

Variables	Infant mortality					
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A.						
Program exposure (1/0)	-0.018*** (0.004)	-0.016*** (0.004)	-0.011** (0.004)	-0.010** (0.004)	-0.011*** (0.004)	-0.012* (0.006)
Panel B.						
Program access	-0.046*** (0.014)	-0.041*** (0.014)	-0.030** (0.014)	-0.030** (0.015)	-0.031** (0.015)	-0.021 (0.018)
Observations	35,297	35,297	35,297	35,297	35,297	35,297
R-squared	0.001	0.035	0.051	0.055	0.058	0.083
Year FE	Y	Y	Y	Y	Y	Y
Birth Characteristics	X	Y	Y	Y	Y	Y
District FE	X	X	Y	Y	Y	Y
Full control	X	X	X	Y	Y	Y
Full control X Post	X	X	X	X	Y	Y
District Trends	X	X	X	X	X	Y
Total Households	28,994	28,994	28,994	28,994	28,994	28,994

# Program effect on infant mortality-IV results

	Infant mortality within				Birth weight		
	1 year (1)	1 day (2)	30 days (3)	1 to 11 months (4)	<1500 g (5)	2500 - 3500 g (6)	2500 - 3500 g (7)
Panel A. Treatment group: targeted 2007-2011							
Cooking with LPG	-0.015*** (0.005)	-0.006* (0.003)	0.001 (0.003)	-0.006* (0.003)	-0.001 (0.003)	-0.027*** (0.010)	0.097*** (0.014)
Observations	45,343	45,343	45,343	45,343	35,400	35,400	35,400
R-squared	0.040	0.021	0.011	0.013	0.031	0.043	0.018
IV F-stat	25.53	25.53	25.53	25.53	20.66	20.66	20.66
Year FE	Y	Y	Y	Y	Y	Y	Y
Birth Characteristics	Y	Y	Y	Y	Y	Y	Y
District FE	Y	Y	Y	Y	Y	Y	Y
Full control	Y	Y	Y	Y	Y	Y	Y
Full control X Post	N	N	N	N	N	N	N

# Program effect on infant mortality-Mother FE results

	Infant death		Mortality within 1 day		Weight: <1500 g	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A.						
Program exposure (1/0)	-0.007 (0.006)	-0.018* (0.010)	-0.005 (0.003)	-0.007 (0.005)	-0.006* (0.004)	-0.013 (0.015)
Observations	25,730	25,730	25,730	25,730	7,227	7,227
R-squared	0.062	0.431	0.036	0.422	0.145	0.838
Panel B.						
Lag program access	-0.010 (0.021)	-0.045 (0.038)	-0.020** (0.008)	-0.022 (0.019)	-0.024* (0.013)	-0.077 (0.073)
Observations	25,730	25,730	25,730	25,730	7,227	7,227
R-squared	0.062	0.431	0.036	0.422	0.145	0.838
District FE	Y	Y	Y	Y	Y	Y
Mother FE	N	Y	N	Y	N	Y
Total Households	10,277	10,277	10,277	10,277	5,730	5,730



# Mechanism

Dependent Variable:	Post		Targeted (2009-2011) X Post	
	Coef. (1)	SE (2)	Coef. (3)	SE (4)
Cooking with LPG	0.061***	(0.016)	0.361***	(0.023)
Cooking with kerosene	0.041**	(0.017)	-0.350***	(0.026)
Cooking with wood	-0.101***	(0.017)	-0.017	(0.023)
Mother's age at birth	0.432***	(0.154)	0.044	(0.196)
First birth	0.020**	(0.010)	0.013	(0.013)
Child born in the last 5 years	-0.068***	(0.017)	0.005	(0.021)
Antenatal visits	0.710***	(0.146)	0.170	(0.179)
Number of household member	0.045	(0.080)	-0.107	(0.091)
Has TV	0.211***	(0.016)	-0.010	(0.021)
Has fridge	0.189***	(0.017)	0.020	(0.021)
Has clean water for drinking	0.190***	(0.022)	0.010	(0.028)
Visited health facility last 12 months	0.095***	(0.021)	-0.003	(0.026)

- Consumption channel. Changes in the expenses are small, 2% from total monthly expenditure ([Imelda, 2018b](#))

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- Changes in behavior is less likely (i.e., lack of awareness, or stacking fuels is not possible).

- Matching (Coarsened Exact Matching ([Blackwell et al., 2009](#)))
- First year excluded
- Household clustering
- Time-varying district characteristics
- Month-year fixed effects
- Placebo treatment

- A one-percentage point increase in the intensity of LPG distributed would cause the infant mortality rate to decrease by 3.7 percentage points, or 1.2 infants per 1,000 live births.

# Appendix

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## Appendix

# Thank you!

Comments? Questions?

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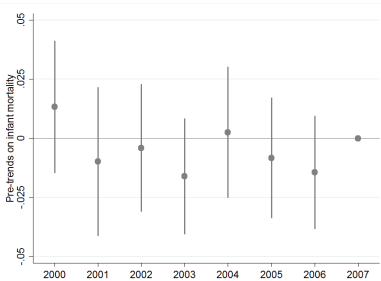


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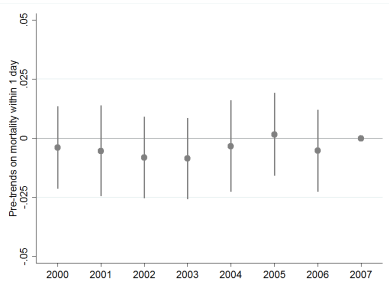
## Appendix



Figure 1: Pre-trends in infant mortality



(a) Infant mortality



(b) Within one day mortality

Notes: This figure plots the interaction between late targeted (2009-2011) and year of birth for children born in earlier years. All regressions include year and district fixed effects. The year 2007 is the reference category. Early targeted districts (2007-2008) are excluded.

Source: IDHS 2002 and 2007.