Motivation
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Data
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Result
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## Does Fuel-Switching Improve Health?
## Evidence from Liquid Petroleum Gas Subsidy Program

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# Emission is bad for health

- Short term and longterm effect
- children and adults
- Indoor air pollution (IAP) vs outdoor air pollution.

## Wood

## Kerosene

## Liquid Petroleum Gas (LPG)
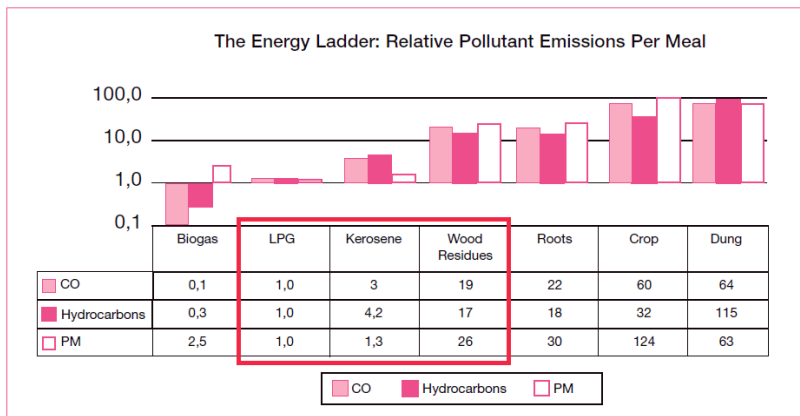
# Relative Pollutant Emission per Meal



The Energy Ladder: Relative Pollutant Emissions Per Meal

|  | Biogas | LPG | Kerosene | Wood Residues | Roots | Crop | Dung |
|---|---|---|---|---|---|---|---|
| CO | 0,1 | 1,0 | 3 | 19 | 22 | 60 | 64 |
| Hydrocarbons | 0,3 | 1,0 | 4,2 | 17 | 18 | 32 | 115 |
| PM | 2,5 | 1,0 | 1,3 | 26 | 30 | 124 | 63 |

CO    Hydrocarbons    PM

*Figure 9. Health-damaging pollutants per unit energy delivered: ratio of emissions to LPG (data from (Smith, Uma et al. 2000a)). Note the use of a log scale in the figure. The values are shown as grams per megajoule of energy delivered to the cooking pot (g/MJ-d).*

Source: Kirk Smith, Uma et al. 2000

Question: Does fuel switching induced by the program improve
health outcomes?

Contribution:

- addressing endogeneity problem in fuel-switching through plausibly exogenous shifter.

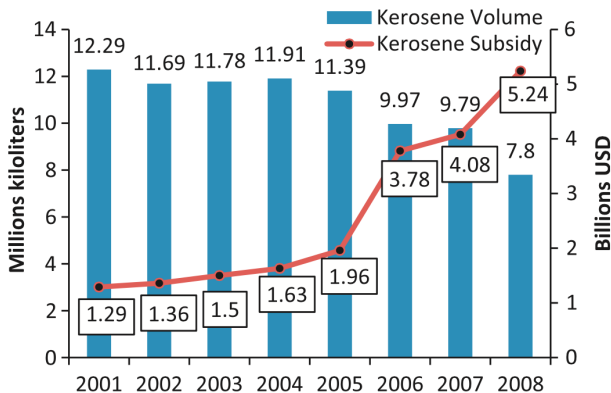- the first that investigates health outcomes associated with this policy.

# Kerosene Subsidy



**Fig. 2.** Subsidized kerosene volume and its subsidy, years 2001–2008.
*Source*: Pertamina analysis.

Source: Budya & Arofat 2012

## Liquid Petroleum Gas (LPG)

**Start:** May 2007 in Indonesia.
**Purpose:** reduce kerosene subsidies, improve energy efficiency (**1 lt** kerosene $\approx$ **0.4 kg** LPG), improve the environment.

## LPG Conversion Program

- Pilot Project in big cities
- Target: 50 million LPG distributed
- Mechanism: offer subsidized price
    - Price of LPG **US$ 0.45/kg**
    - Price of kerosene **US$0.28/lt**
    - No subsidy for other types of LPG
    - Limit kerosene supply

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# Conversion Milestone
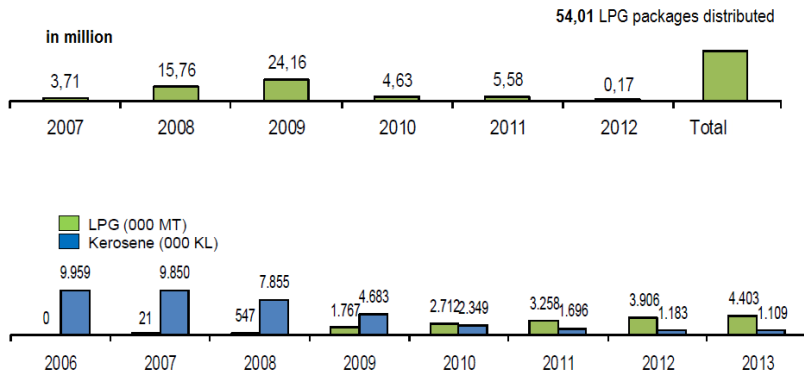


Source: Pertamina, 2014

Data

Indonesian Demographic and Health Survey 2002, 2007, 2012.

Table: Summary Statistics

| Variable | Before Program | | | | | After Program | | | | |
| | Obs | Mean | Std. Dev. | Min | Max | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|---|---|---|---|
| Household characteristics | | | | | | | | | | |
| Cooking-Fuel | | | | | | | | | | |
|   LPG | 33,716 | 0.10 | 0.30 | 0 | 1 | 17,332 | 0.43 | 0.50 | 0 | 1 |
|   kerosene | 33,716 | 0.38 | 0.49 | 0 | 1 | 17,332 | 0.16 | 0.37 | 0 | 1 |
|   wood | 33,716 | 0.51 | 0.50 | 0 | 1 | 17,332 | 0.41 | 0.49 | 0 | 1 |
| | | | | | | | | | | |
| Location | | | | | | | | | | |
|   urban | 33,716 | 0.39 | 0.49 | 0 | 1 | 17,332 | 0.45 | 0.50 | 0 | 1 |
|   rural | 33,716 | 0.61 | 0.49 | 0 | 1 | 17,332 | 0.55 | 0.50 | 0 | 1 |
| | | | | | | | | | | |
| wealth | 33,716 | -0.09 | 1.02 | -2.41 | 2.68 | 17,332 | -0.06 | 1.04 | -2.75 | 3.16 |
| livingchild | 33,716 | 2.52 | 1.57 | 0 | 13 | 17,332 | 2.37 | 1.50 | 0 | 13 |
| working | 33,628 | 0.45 | 0.50 | 0 | 1 | 17,324 | 0.49 | 0.50 | 0 | 1 |
| HH member | 33,716 | 5.56 | 2.19 | 1 | 20 | 17,332 | 5.54 | 2.28 | 1 | 31 |
| mother age | 33,716 | 29.48 | 6.36 | 15 | 49 | 17,332 | 30.02 | 6.44 | 15 | 49 |
| years of school | 33,716 | 1.55 | 0.69 | 0 | 9 | 17,332 | 1.76 | 0.72 | 0 | 3 |
| smoke last 24hr | 33,702 | 0.07 | 0.80 | 0 | 32 | 17,283 | 0.14 | 1.40 | 0 | 48 |

# Treated and Control Groups

Treatment group= treated region * intervention time
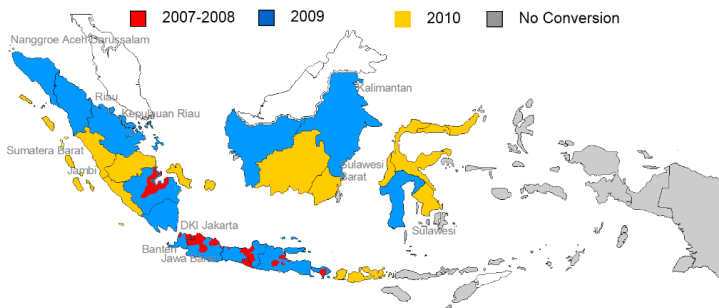


Source: Pertamina, 2014

# Evidence of fuel-switching

Figure: Predicted Probability of each cooking fuel choice compare to wood as baseline
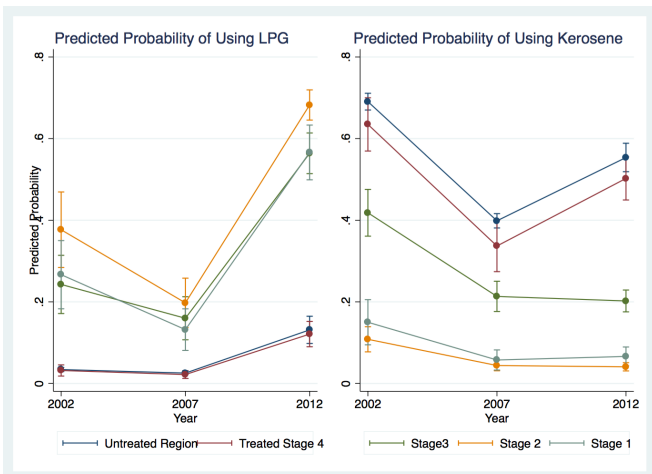
Difference-in-difference and Matching

$Pr[Y_{irt} = 1] = \beta_1 Reg_{rt} + \beta_2 Prog_{rt} + \beta_3 Reg_{irt} * Prog_{rt} + \beta_4 X_{irt} + \epsilon_{irt}$

Where:

$i$ represents child in every household (singleton only), $r$ represents region, $t$ represent years. $X_{irt}$ represents relevant child's controls (i.e. wealth index, education, household size, number of cigarettes in the last 24 hours, rural/urban, mother's age).

## Balancing Test

Table: Balancing Test

| | Mean | | | t test | | V(T)/V(C) |
|---|---|---|---|---|---|---|
| Variable | Treated | Control | %bias | t | p>\| t \| | |
| momage | 29.33 | 29.339 | -0.1 | -0.09 | 0.932 | 1.02 |
| wealth | .21577 | .21523 | 0.1 | 0.04 | 0.971 | 1.01 |
| highschool | 1.812 | 1.8121 | -0.0 | -0.01 | 0.991 | 1.00 |
| hhmem | 5.4236 | 5.4214 | 0.1 | 0.07 | 0.947 | 1.01 |
| Urban | 1.4736 | 1.4736 | 0.0 | -0.00 | 1.000 | 1.00 |

## Probit Results

Table: Treatment effects with survival rate as outcome

| Survival Rate | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Exclude 2012 | | Full sample | | DID 1 | | Placebo | DID 2 | | Placebo |
| lpg/natural gas | 0.1283 | 0.1305 | 0.0810 | 0.0584 | | | | | | |
| | (0.0719) | (0.0731) | (0.0436) | (0.0459) | | | | | | |
| kerosene | -0.0256 | -0.0139 | -0.0205 | -0.0123 | | | | | | |
| | (0.0398) | (0.0407) | (0.0329) | (0.0342) | | | | | | |
| **Program** | | | | | 0.2445*** | 0.3722*** | | | | |
| | | | | | (0.0738) | (0.0922) | | | | |
| ProgramPlacebo | | | | | | | -0.1362 | | | |
| | | | | | | | (0.1888) | | | |
| **ProgramDuration** | | | | | | | | -0.0029 | -0.0058 | |
| | | | | | | | | (0.0032) | (0.0045) | |
| ProgDurPlacebo | | | | | | | | | | 0.0002 |
| | | | | | | | | | | (0.0057) |
| Region Fixed Effects | | Y | | Y | | Y | Y | | Y | Y |
| MonthYear Fixed Effects | | Y | | Y | | Y | Y | | Y | Y |
| N | 33,138 | 33,668 | 50,171 | 50,171 | 13,410 | 13,326 | 26728 | 40910 | 40910 | 26728 |
| Pseudo R-squared | 0.0625 | 0.0893 | 0.0668 | 0.0876 | 0.0709 | 0.0859 | 0.0872 | 0.071 | 0.0859 | 0.0872 |

Standard errors in parentheses, clustered by household.
* p<0.05    ** p<0.01   *** p<0.001"

# Survival Rate Predicted Probability



Predicted Survival Rate
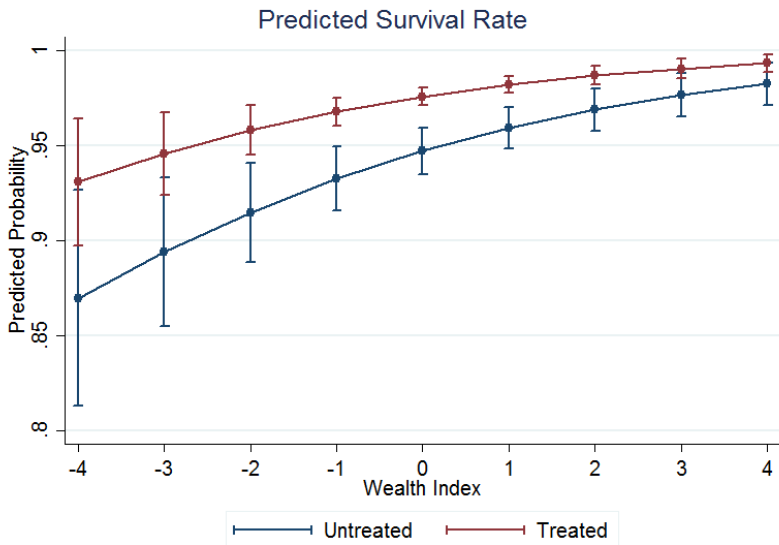
## Treatment Effects

### Table: Treatment Effects

|                 | MarginalEff | SE     | N      |
|-----------------|-------------|--------|--------|
| SurvivalRate    | 0.0281***   | 0.0076 | 13,326 |
| Stillbirth      | -0.0311**   | 0.0099 | 14,830 |
| Low Birthweight | 0.0061      | 0.0133 | 15,402 |
| ARI             | 0.0107      | 0.0127 | 15,239 |

Standard errors cluster by household

\* $p < 0.05$, \*\* $p < 0.01$, \*\*\* $p < 0.001$

ARI: Acute Respiratory Infection

Conclusion

- By switching to LPG, household gets higher survival rate by 2.8% and lower probability of stillbirth by 3.1%.
- No evidence of improvement in Acute Respiratory Infection symptoms and lower birth weight.
- Switching to a cleaner cooking fuel is likely to be more beneficial during prenatal period.