The effects of fuel-efficient cookstoves on fuel use, particulate matter, and cooking practices: Results from a randomized trial in rural Uganda

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What are the biggest problems in the world?
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- Poverty
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- Climate Change
The Effects of Fuel-Efficient Cookstoves on Use
Millions of Deaths per Year

<table>
<thead>
<tr>
<th>Disease</th>
<th>Deaths per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria</td>
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<tr>
<td>Tuberculosis</td>
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</tr>
<tr>
<td>Child/Mat. Undernutrition</td>
<td>1.40</td>
</tr>
<tr>
<td>HIV/AIDS</td>
<td>1.70</td>
</tr>
<tr>
<td>Household Air Pollution</td>
<td>4.00</td>
</tr>
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</table>
Challenges

• No one wants to buy a stove: adopted at “puzzlingly low rates” (Mobarak et al. 2012, PNAS)

• Purchase rates of 5% and 2% at full price

• Purchase rates of 16% and 7% with 50% discount

• Objectively and unobtrusively measuring stove use is difficult: especially on three stone fires (Ruiz-Mercado et al. 2012)

• Seminal stove use studies had high amounts of direct observation (Ezzatti et al. 2000, Smith-Sivertsen et al. 2009)

• Is there consistent use of the introduced stove?:

  • Declining use (due to poor maintenance) over time (Hanna et al. 2012)

  • Initially declining, but then low levels of consistent use (Pillarisetti et al. 2014)
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How our study addresses these challenges

• No one wants to buy a stove: sell at local market prices, but alter terms of repayment (Levine et al. 2015, Beltramo et al. 2015)

• Cash and Carry: 4%
• Free Trial: 29%
• Time Payments: 26%
• Free Trial and Time Payments: 46%

• Measuring stove use is difficult: Develop new algorithm that works for three stone fires (Simons et al. 2014)

• Detect large Hawthorne effect (3 hour/day increase in efficient stove use, 2 hour/day decrease in three stone fire use, reverts back when observers depart (Simons et al. 2015)

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Study location: Mbarara District, Uganda

The Effects of Fuel-Efficient Cookstoves on Use
Area background

- **Setting:** 2012: Almost all households (97%) cooked on three stone fires in separate cooking hut
  - Agrarian livelihoods including farming *matooke*, potatoes, millet as well as raising livestock
  - Many meals required cooking on two, three stone fires simultaneously (e.g., rice and beans, *matooke* and sauce)

- Introduced Stove: Sold the Envirofit G-3300 wood burning stove
  - Reduces smoke and harmful gasses by up to 80%, reduces biomass fuel use by up to 60%, and reduces cooking time by up to 50%
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Study design

- **Selection**: Upon arriving at new parish, staff displayed Envirofit and offered it for sale at USD$16
  - Anyone could purchase a stove at parish wide meeting
  - Eligible to participate in usage study if used wood as main fuel source, regularly cooked for eight or fewer people, someone generally home each day, and cooking in an enclosed space
  - Buyers that met this criteria were randomly selected into two groups: early buyers and late buyers
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- **Tracking stove usage**: Upon giving consent, two three stone fires per household were fitted with stove usage monitors (SUMs)
  - We tracked 168 households (12 HHs in each of 14 parishes) for six months with SUMs
Study design, continued

- **Delivery of Envirofits**: Staggered delivery in phases 5-6 weeks apart
  - Phase 1: only three stone fires;
  - Phase 2: early buyers get 1st Envirofit;
  - Phase 3: late buyers get 1st Envirofit;
  - Phase 4: both groups get 2nd Envirofit

- Kitchen performance tests (KPTs): Following Bailis et al. (2007) we performed a series of KPTs in each household and recorded:
  - Quantity (kgs) of firewood used daily
  - Levels of household air pollution (PM$_{2.5}$)
  - Self reported cooking diaries (meals cooked per day, people cooked for per day, types of foods cooked each meal, etc.)
  - Three KPTs per household (baseline, midline, endline), each lasting approximately 72 hours
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Analysis

- Convert SUMs readings (Simons et al. 2014): Field staff recorded visual observations (about 2,400 visual observations) of whether a stove was in use (on/off) when they visited homes.
  - Algorithm examined temperature data immediately before and after the 2,400 visual observations of use
  - Algorithm analyzed the data to understand how temperature patterns change at times of observed stove use
  - Predicted cooking behaviors to the wider dataset of 1.7 million temperature readings
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- **Outcomes we analyze:**
  - Stove usage (SUMs data converted to hours per day)
  - Quantity (kgs) of firewood used daily
  - Levels of household air pollution (PM$_{2.5}$)
  - Self reported cooking diaries (meals cooked per day, people cooked for per day, types of foods cooked each meal, etc.)
For each outcome we run a regression:

\[ Y_{ipt} = \alpha_{ip} + b_1 \times \text{midline}_t + b_2 \times \text{endline}_t + \beta_1 (T_i \times \text{midline}_t) + \]

\[ \beta_2 (T_i \times \text{endline}_t) + \varepsilon_{ipt} \]

Where \( Y_{ipt} \) are outcomes of interest for household \( i \) in parish \( p \) during study wave \( t \) (baseline, midline, endline), and
- \( a_{ip} \) are household fixed effects, \( \text{midline}_t \) and \( \text{endline}_t \) are dummies for each study wave, and \( T_i \) is a dummy equaling one if in early buyer group
- \( \varepsilon_{ip} \) is a residual clustered by parish*study-wave but is assumed to be i.i.d within a parish and study-wave
Where we are now, challenges

• **Missing data:**
  • likely that missing data is non-random (SUMs device explodes on stoves used most often)
  • additionally in endline we can’t get correct (PM$_{2.5}$) unless we have ratios of TSF vs. ENV usage when both stovetypes are present in kitchen, working on imputation strategy to try to address this

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- **Working paper in late Spring:**
  - email: ams727@cornell.edu
Thank You