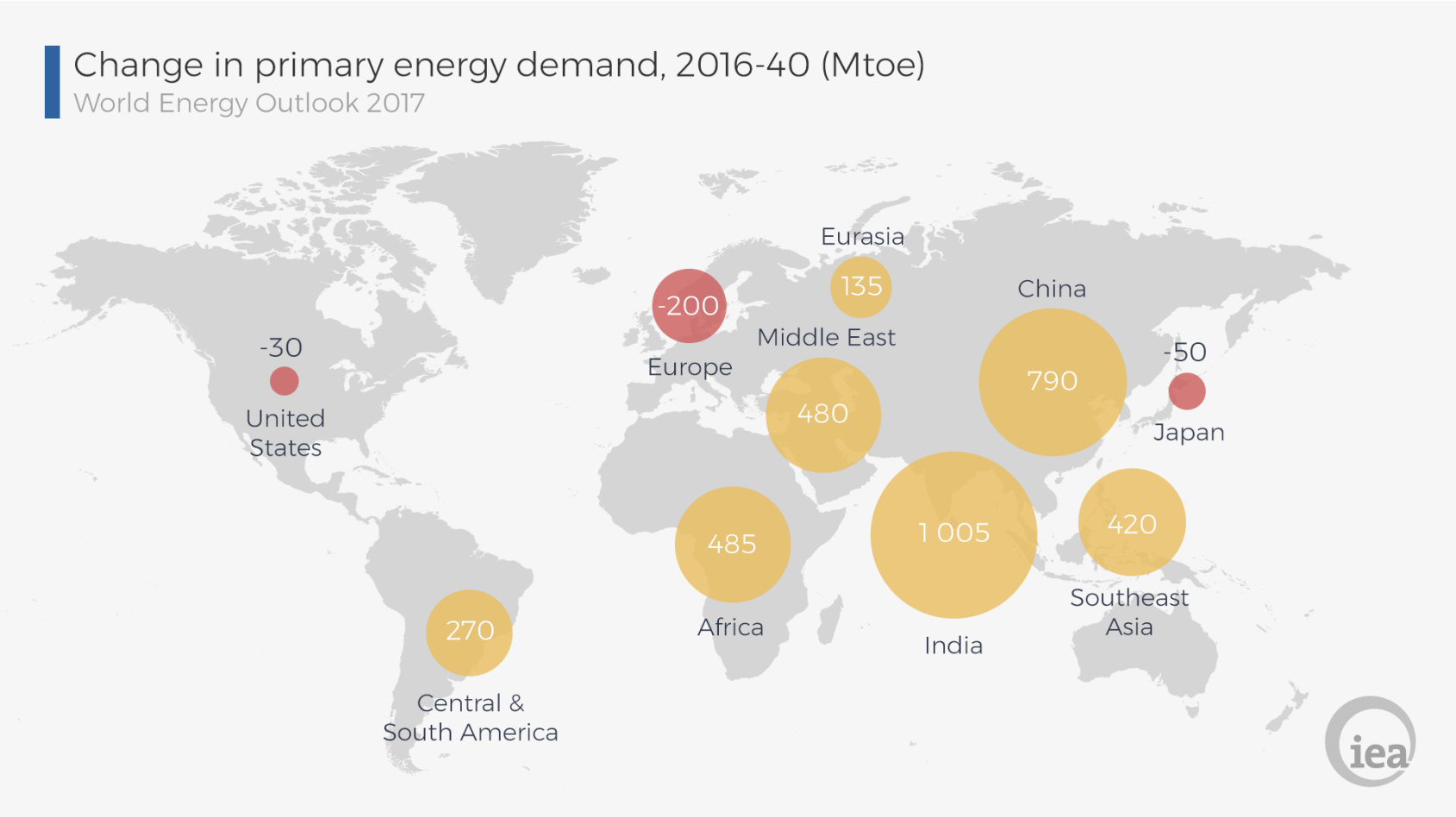
Improved cookstove adoption

Susanna B. Berkouwer[1] (they/them)
Joshua T. Dean[2] (he/him)

[1]The Wharton School, University of Pennsylvania and NBER
[2]The Booth School of Business, University of Chicago

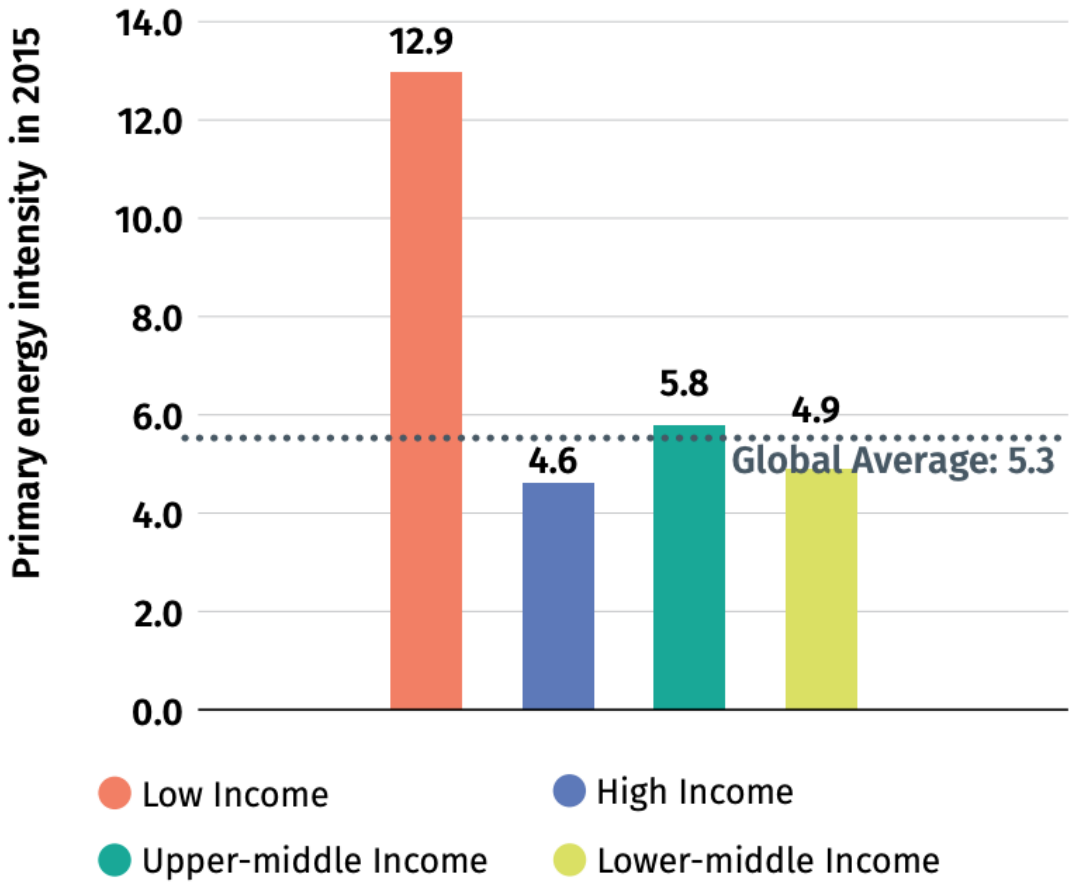
March 2024

Low- and middle-income countries will lead demand growth



Source: International Energy Agency

Energy efficiency uptake slow in low-income countries



Source: Energy Sector Management Assistance Program (ESMAP), International Energy Agency (IEA)

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Expensive

- Energy burden highest among the poor
- Median household earns \$5 per day and spends \$0.70 on charcoal (14%), \$1.15 on energy (22%)

Study setting: Charcoal cookstoves in Nairobi

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- 60% of participants purchase charcoal at least once per day

Kenyan Jiko and Jikokoa

Kenyan Jiko stove

Modern Jikokoa stove

Jikokoa is well-known

Kenyan Jiko and Jikokoa cookstoves

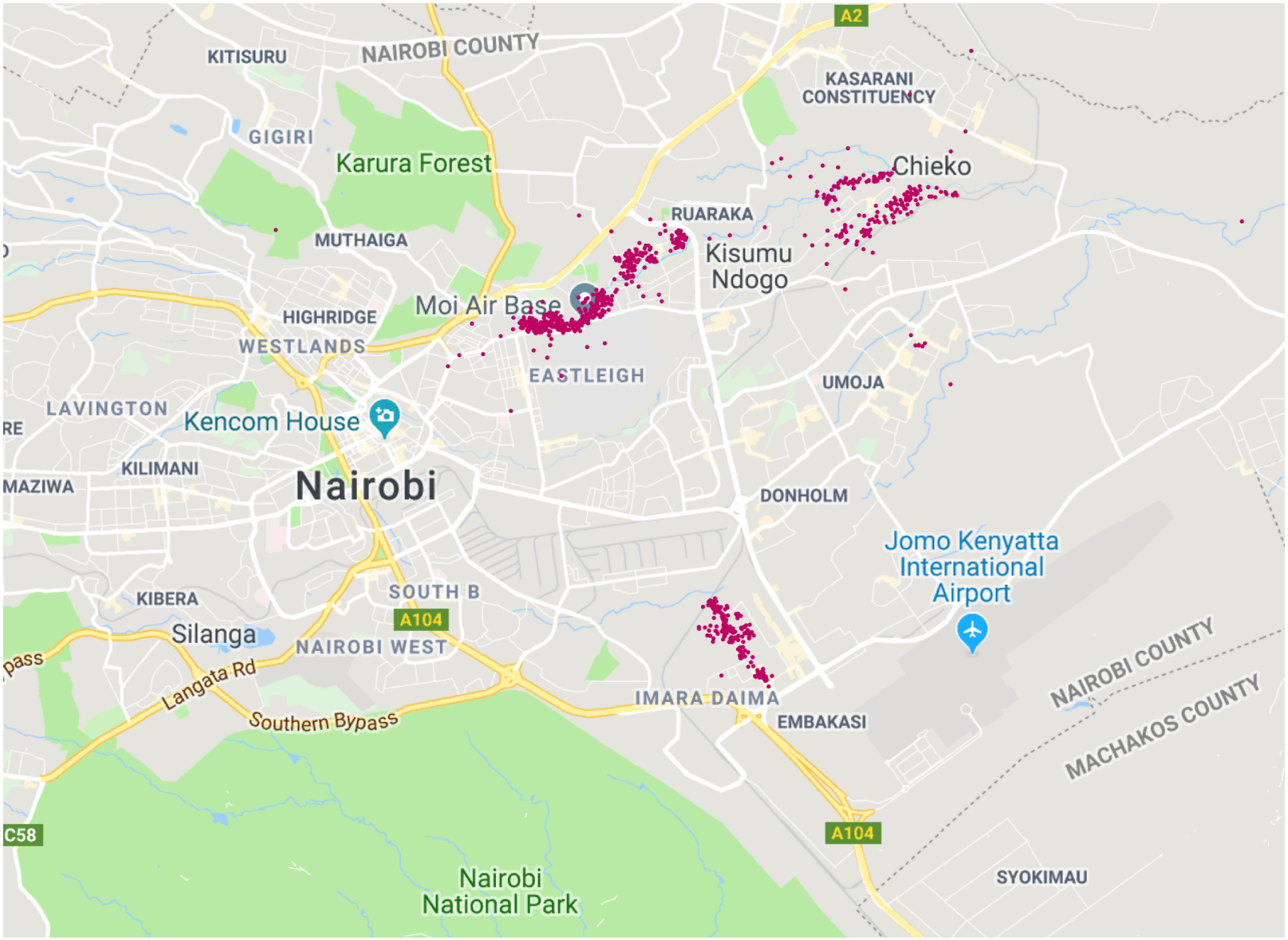
Kenyan Jiko
$2-$5

Jikokoa Stove
$40 (now $30)

- Identical inputs: same charcoal
- Identical usage: almost no learning or behavior change
- Improved insulation materials

RCT with 1,000 households in Nairobi, Kenya

Participants are enrolled at their homes by field officers



Respondents have low incomes, high energy costs

	Mean	SD	25^{th}	50^{th}	75^{th}
Household size	4.73	2.08	3	4	6
Age	37.24	11.83	29	35	44
Female respondent	0.95	0.21	1	1	1
Completed primary education	0.70	0.46	0	1	1
Completed secondary education	0.06	0.24	0	0	0
Respondent income (USD/week)	24.26	25.25	11	21	35
Household income (USD/week)	47.79	39.25	21	35	60
Energy spending (USD/week)	8.60	3.89	6	8	10
Charcoal spending (USD/week)	5.65	2.93	4	5	7
Savings* (USD)	74.59	129.07	1	30	82
Current cookstove price (USD)	3.40	1.34	3	3	4

* *Savings in bank account, mobile money account, or informal group savings*

Today: drawing from two academic studies

- "Credit, attention, and externalities in the adoption of energy efficient technologies by low-income households"
  S. Berkouwer and J. T. Dean. **American Economic Review** (2022). 122(10)1-41.

- "Cooking, health, and daily exposure to pollution spikes"
  S. Berkouwer and J. T. Dean. **NBER Working Paper #31614** (2024).

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Accounts for stacking

Today

Background

Study design

Financial savings

Climate

Barriers to adoption

Long-run impacts: 2022-2023 (3.5 years later)

Pollution impacts

Health impacts

We cross-randomize credit and attention treatments

- Each cell contains number of respondents
- Pre-analysis plan filed with AEA RCT Registry ex-ante

		Credit Control	**Credit Treatment**	
			Weekly Deadlines	Monthly Deadlines
Attention Control		96	98	98
Attention Treatment	Energy Savings	96	97	96
	Energy Savings – Costs	145	146	146

Credit: Control and Treatment groups

- **Control:** Pay (subsidized) price today, receive stove today

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- **Treatment:** Receive stove today, pay within 3 months
  1. Pay by 12 weekly deadlines
  2. Pay by 3 monthly deadlines
- If respondents miss deadlines:
  - SMS reminders
  - After 1 week, reclaim the stove
- Repayment: respondents have paid 80% on average
- Interest rate of 1.16% per month, 14.8% per year (*M-Shwari rate, excluding fees*)

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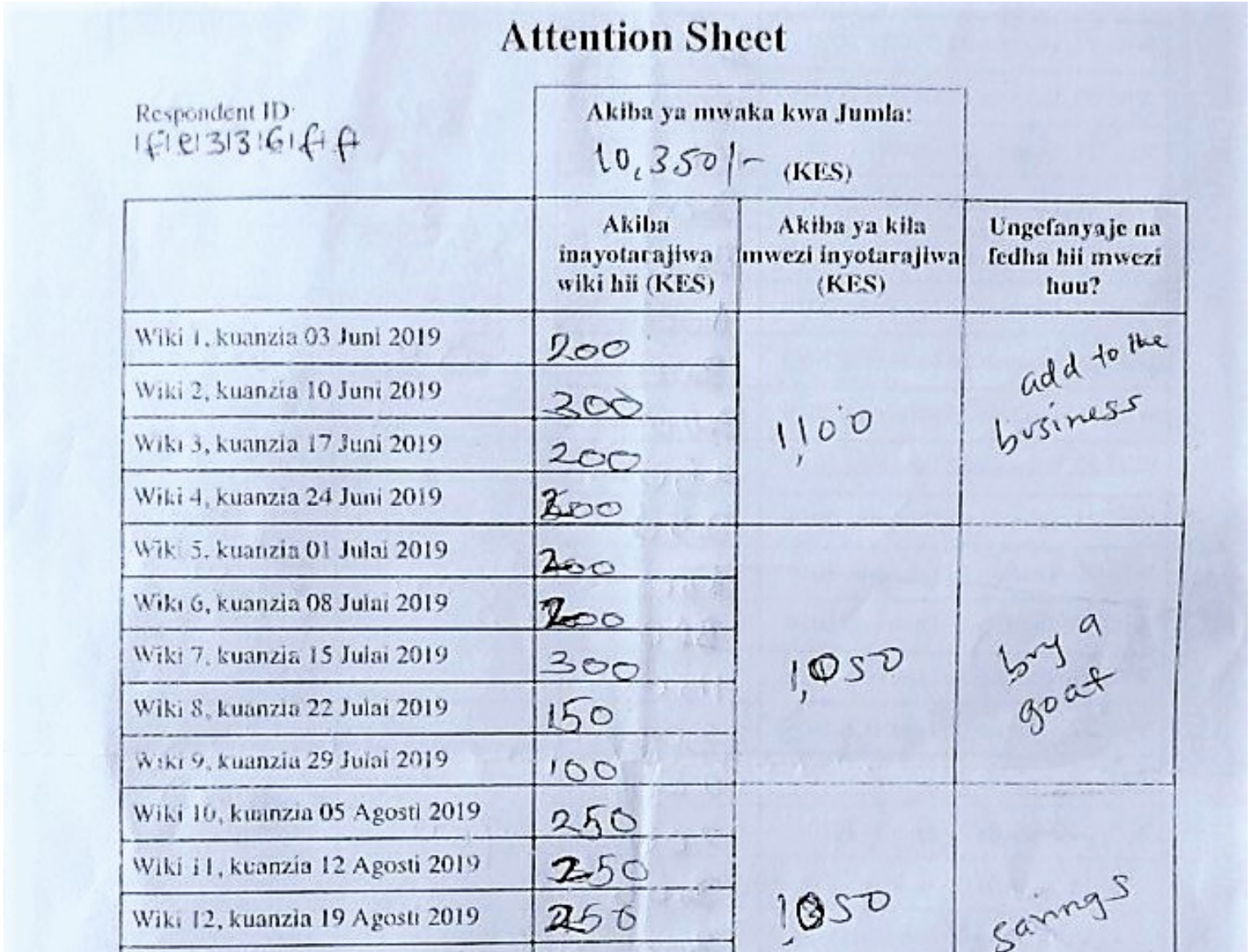
- All respondents receive basic information: 50% savings

Treatment: Attention to energy savings

12 months of money and utility (100 KSH ≈ 1 USD)



Attention Sheet

Respondent ID: 1f1e313161f1f

Akiba ya mwaka kwa Jumla: 10,350/- (KES)

	Akiba inayotarajiwa wiki hii (KES)	Akiba ya kila mwezi inyotarajiwa (KES)	Ungefanyaje na fedha hii mwezi huu?
Wiki 1, kuanzia 03 Juni 2019	200	1,100	add to the business
Wiki 2, kuanzia 10 Juni 2019	300		
Wiki 3, kuanzia 17 Juni 2019	200		
Wiki 4, kuanzia 24 Juni 2019	400		
Wiki 5, kuanzia 01 Julai 2019	200	1,050	buy a goat
Wiki 6, kuanzia 08 Julai 2019	200		
Wiki 7, kuanzia 15 Julai 2019	300		
Wiki 8, kuanzia 22 Julai 2019	150		
Wiki 9, kuanzia 29 Julai 2019	100		
Wiki 10, kuanzia 05 Agosti 2019	250	1,050	savings
Wiki 11, kuanzia 12 Agosti 2019	250		
Wiki 12, kuanzia 19 Agosti 2019	250		

Treatment: Attention to energy savings

If the price of the cookstove is USD 38 would you want to buy it?

You would need to pay USD 3 per week for the next 12 weeks.

JUNE
Week 1: You would save USD 2
Week 2: You would save USD 3
Week 3: You would save USD 2.50
Week 4: You would save USD 4

JULY
Week 5: You would save USD 2
Week 6: You would save USD 2
Week 7: You would save USD 4
Week 8: You would save USD 5
Week 9: You would save USD 4

AUGUST
Week 10: You would save USD 2.50

Treatment: Attention to energy savings and costs

If the price of the cookstove is USD 38 would you want to buy it?

You would need to pay USD 3 per week for the next 12 weeks.

JUNE
Week 1: You would pay USD 1 (USD 2 – USD 3)
Week 2: You would save USD 0 (USD 3 – USD 3)
Week 3: You would pay USD 0.50 (USD 2.50 – USD 3)
Week 4: You would save USD 1 (USD 4 – USD 3)

JULY
Week 5: You would pay USD 1 (USD 2 – USD 3)
Week 6: You would pay USD 1 (USD 2 – USD 3)
Week 7: You would save USD 1 (USD 4 – USD 3)
Week 8: You would save USD 2 (USD 5 – USD 3)
Week 9: You would save USD 1 (USD 4 – USD 3)

AUGUST
Week 10: You would pay 0.50 (USD 2.50 – USD 3)

Implementation Timeline

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2. Implement attention and/or credit treatments

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Revealing random price:

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      - Pay P_i: incentive compatible

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    This generates random variation in adoption.

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   This generates random variation in adoption.
4. Recurring SMS survey (every 3 days) on charcoal spending

Implementation Timeline

3 visits scheduled 1 month apart:

Visit 1

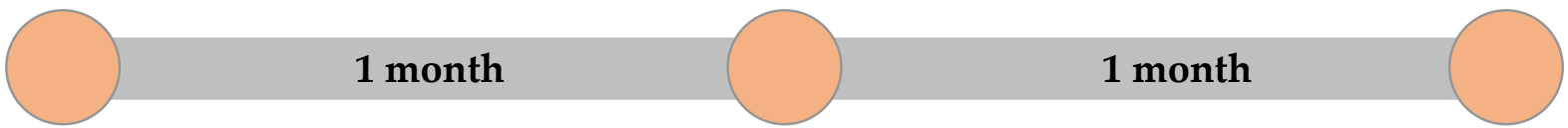
- Enrollment survey

Visit 2

- Random treatments
- BDM WTP elicitation
- Stove transaction

Visit 3

- Endline survey



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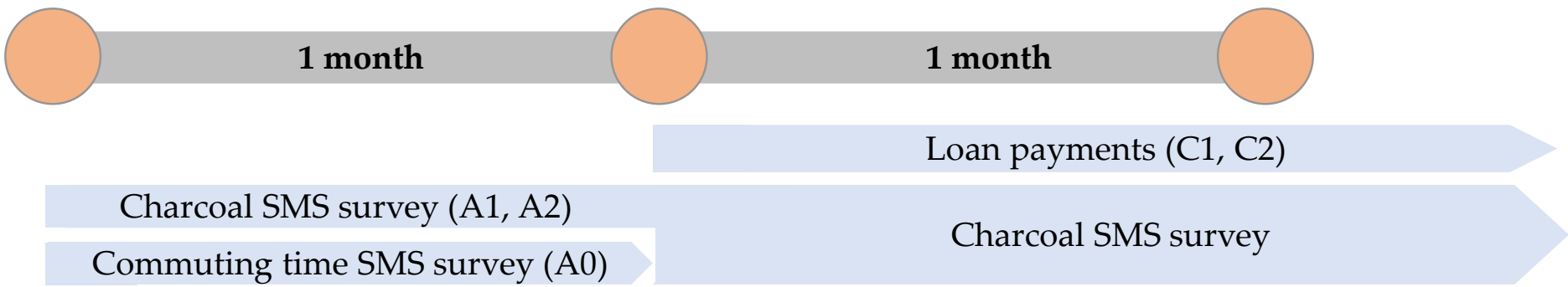

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Long-run impacts: 2022-2023 (3.5 years later)

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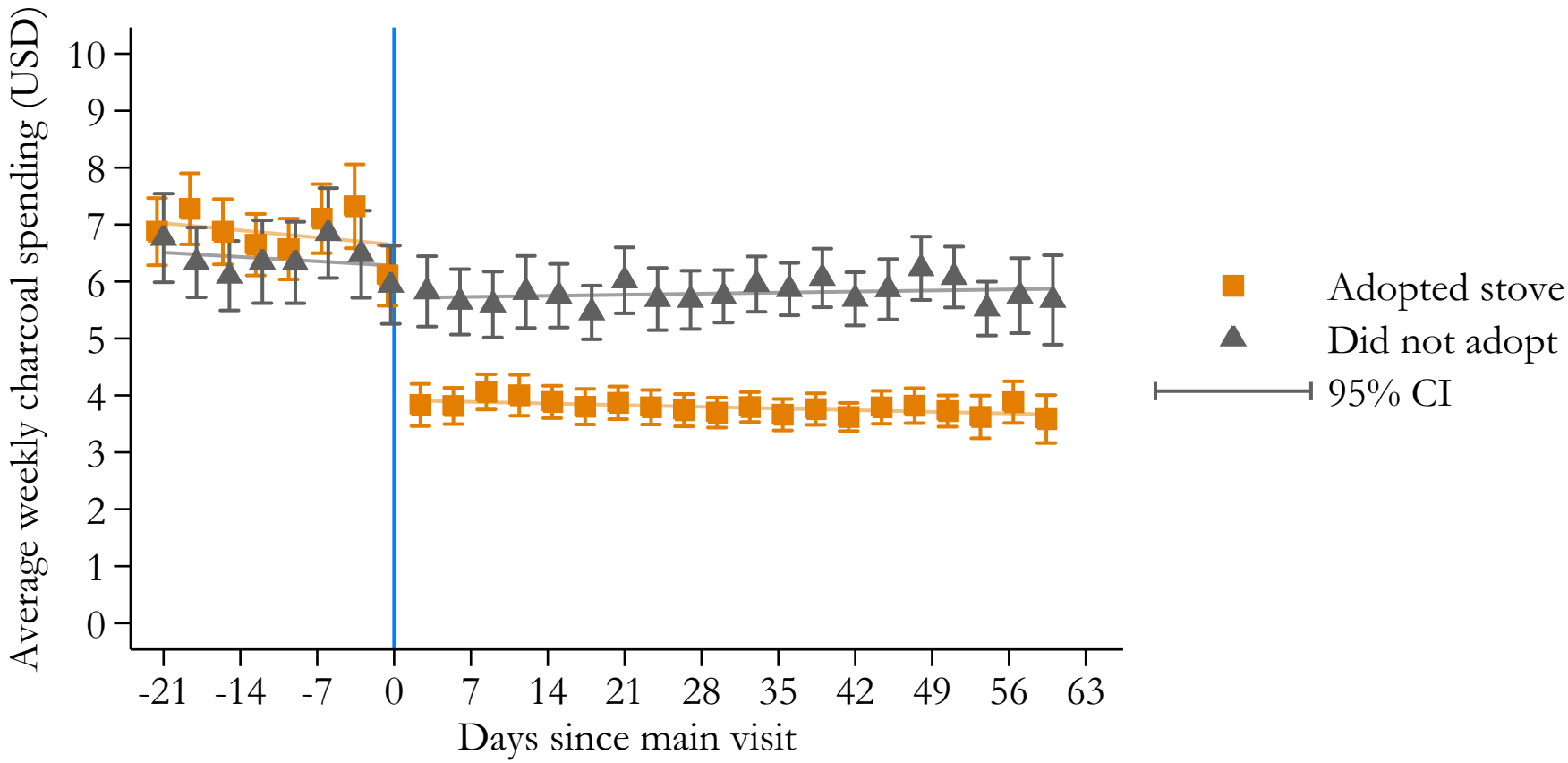
Health impacts

Stove reduces charcoal use by $2.28 per week (40%)



- Weekly charcoal spending from SMS survey
- Effects are instant and stable over time
- Low variability

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Instrumental Variables: instrument for improved stove ownership with randomly assigned price (can also use credit treatment)

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	OLS	First Stage	IV Estimate	
	USD	Bought Stove	USD	IHS(USD)
BDM Price (USD)	0.002	-0.029***		
	(0.013)	(0.001)		
WTP (USD)	-0.003	0.024***	-0.004	-0.001
	(0.010)	(0.001)	(0.011)	(0.003)
Bought Cookstove (=1)	-1.943***		-2.244***	-0.487***
	(0.295)		(0.295)	(0.071)
Observations	7852	913	7852	7852
Control Mean	5.719		4.964	2.155
Socioeconomic controls	Yes	Yes	Yes	Yes
Data Source	SMSes	Midline	SMSes	SMSes
F-statistic:		183.28		

SE in parentheses. $^{*} \leq 0.10, ^{**} \leq .05, ^{***} \leq .01$. Socioeconomic controls include baseline savings, income, risk aversion, credit constrainedness, number of adults and children. Errors clustered by respondent. Errors in SMS regressions clustered by respondent.

We weigh KG ash output from 1 month of charcoal use

Stove reduces charcoal ash output by 40%

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Bought Cookstove (=1)		-2.244***	-0.487***	-0.479***
		(0.295)	(0.071)	(0.083)
Observations	913	7852	7852	796
Control Mean		4.964	2.155	1.545
Socioeconomic controls	Yes	Yes	Yes	Yes
Data Source	Midline	SMSes	SMSes	Buckets

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- Regression estimate of 1.5–2% of ratio *Charcoal*:*Ash* matches chemistry

Savings persist after one year

Phone survey in September 2020 (14 months after adoption):

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	(0.295)		(0.295)	(0.071)	(0.461)	(0.085)
Observations	7852	913	7852	7852	866	866
Control Mean	5.719		4.964	2.155	5.403	2.178
Socioeconomic controls	Yes	Yes	Yes	Yes	Yes	Yes
Data Source	SMSes	Midline	SMSes	SMSes	1 Year EL	1 Year EL
F-statistic:		183.28				

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Incorporating the $40 cost of the stove:

- Internal Rate of Return (IRR): **300% per year**

These savings are large

Authors	Year	Country	Annual IRR
Berkouwer and Dean	2019	Kenya	300%
Energy Efficiency			
Allcott and Greenstone	2017	USA	-4%
Fowlie, Greenstone, Wolfram	2018	USA	-10%–0.21%
Davis, Martinez, Taboada	2018	Mexico	*less than* -8%

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Authors	Year	Country	Annual IRR
Berkouwer and Dean	2019	Kenya	300%
Firms			
Bigsten, Isaksson, Soderbom, et al.	2000	Africa	10–35%
McKenzie and Woodruff	2006	Mexico	36–180%
McKenzie and Woodruff	2008	Mexico	240–396%
De Mel, McKenzie, Woodruff	2008	Sri Lanka	55–63%
Kremer, Lee, Robinson	2013	Kenya	113%
Fafchamps, McKenzie, Quinn, Woodruff	2014	Ghana	180%
Banerjee and Duflo	2014	India	105%
Blattman, Fiala, Martinez	2014	Uganda	30–50%
Agriculture			
Udry and Anagol	2006	Ghana	30–50%
Duflo, Kremer, Robinson	2008	Kenya	52–85%
Education			
Bigsten, Isaksson, Soderbom, et al.	2000	Africa	1–5%
Duflo	2001	Indonesia	8.8–12%
Other			
Baird, Hicks, Kremer, Miguel	2016	Kenya	32%
Haushofer, Shapiro	2016	Kenya	15%
Blattman, Green, Jamison, et al.	2016	Uganda	8–24%

Today

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- Study design
- Financial savings
- Climate
- Barriers to adoption
- Long-run impacts: 2022-2023 (3.5 years later)
- Pollution impacts
- Health impacts

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- No crowding in/out of other cooking technologies

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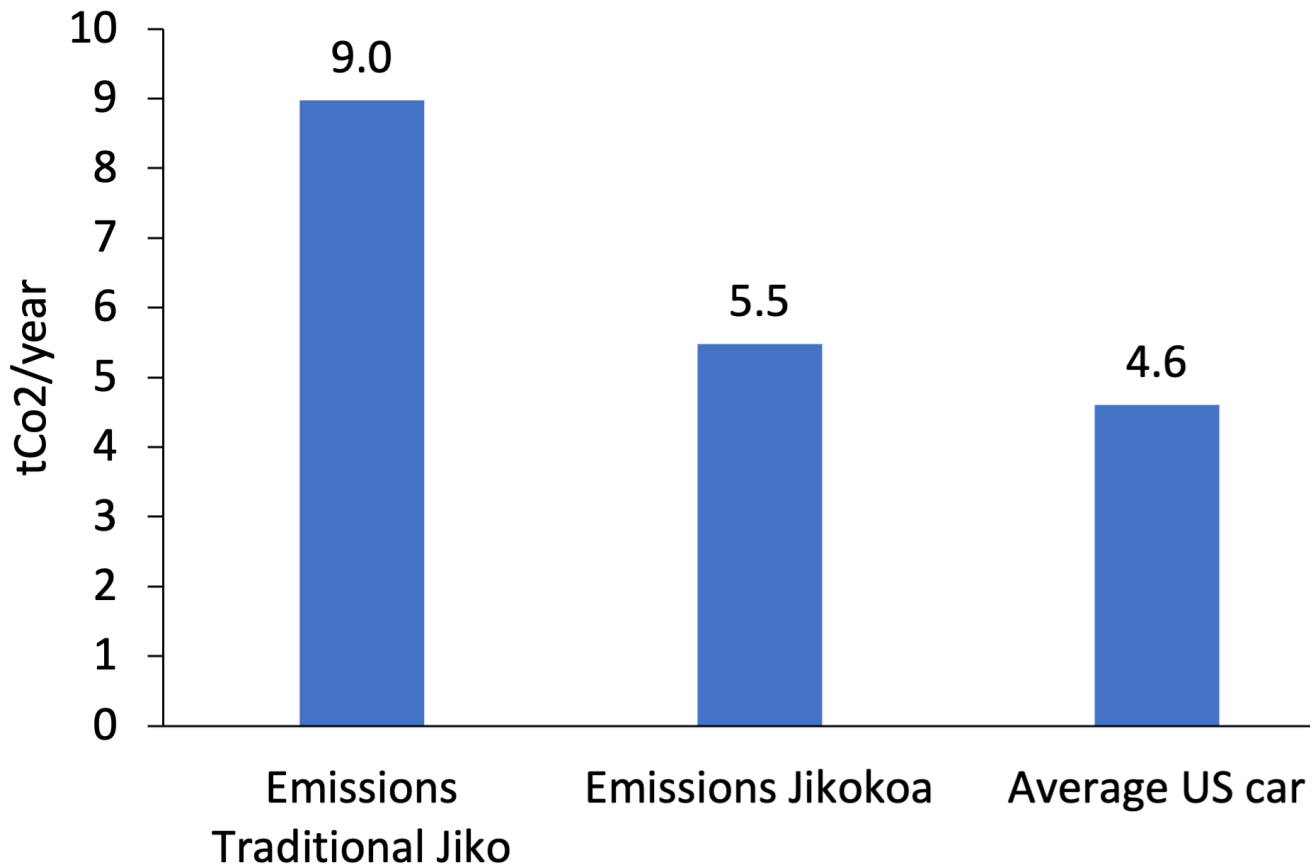
Additionality:

- Low subsidy group ($13-15): 37% adopted
- High subsidy group ($28-30): 77% adopted
- $6,150 in subsidies incentivized 358 stove-years

Abatement cost: $5–10 per tCO_2e

These are cost-effective emissions reductions

This \$40 investment yields a roughly equivalent annual tCO_2e reduction as adoption of a \$40,000 EV:

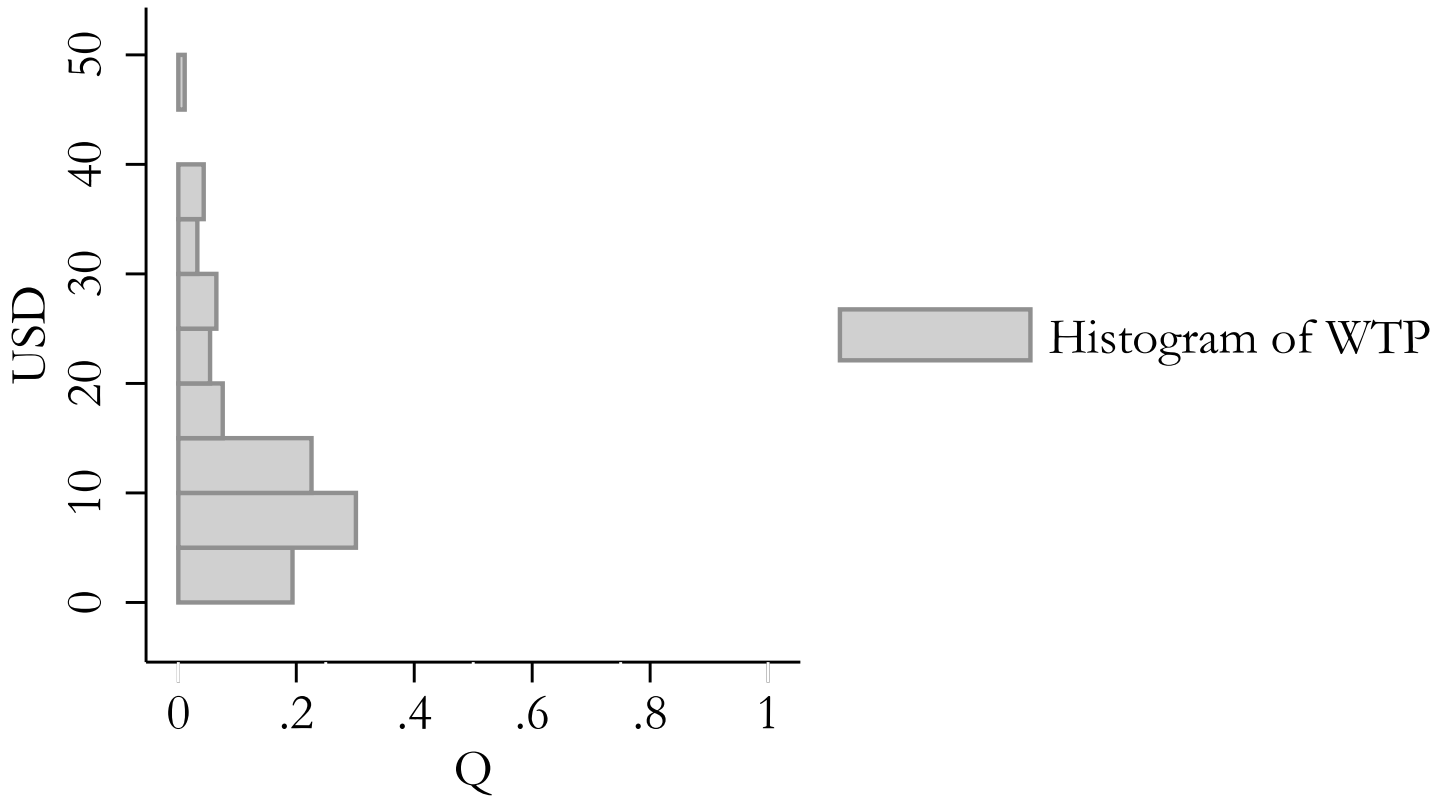


(Source: Arvid Viaene)

Today

Adoption still low:

WTP for pure control group (no attention, no credit):



- Control group WTP: Average \$12, median \$10

Adoption still low: Demand curve from BDM

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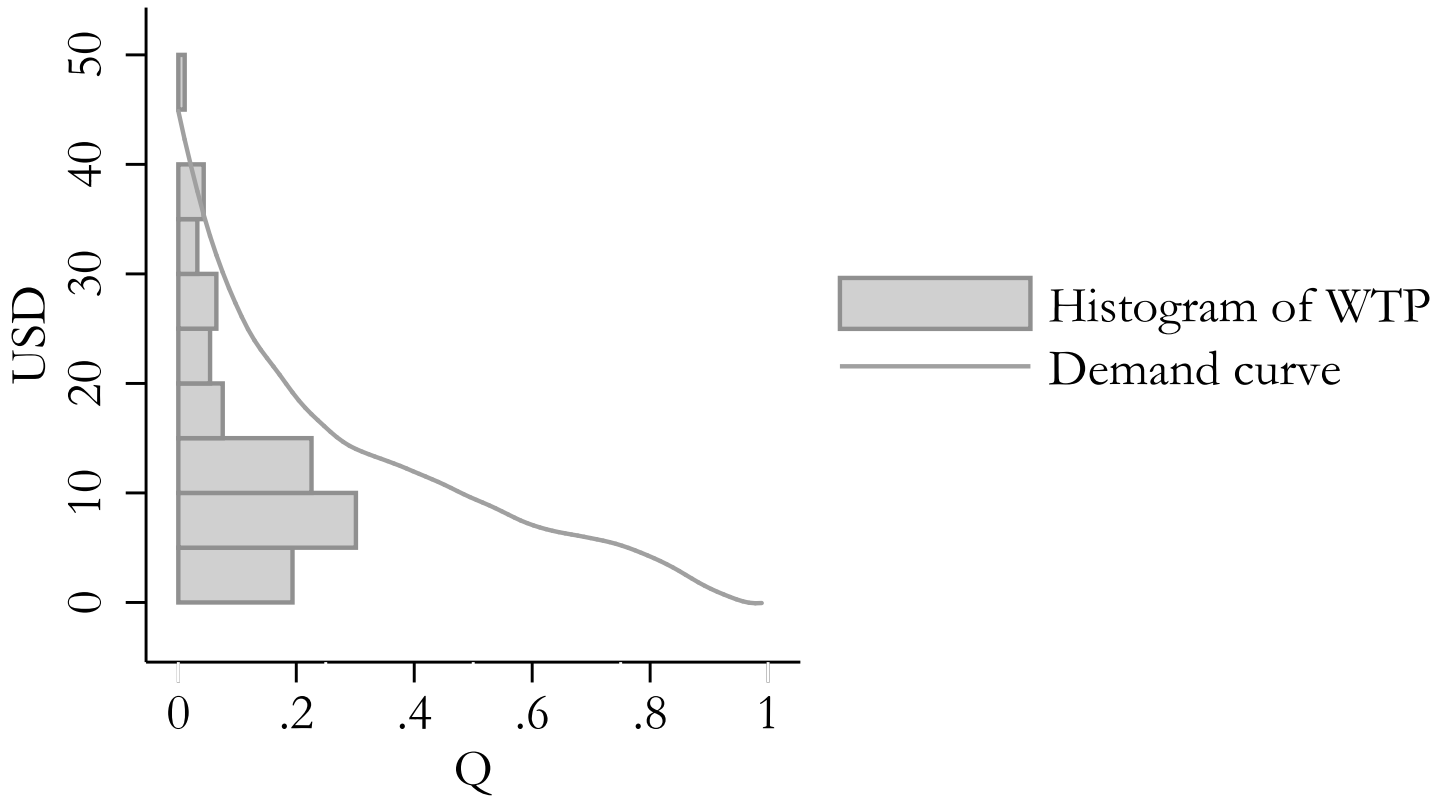

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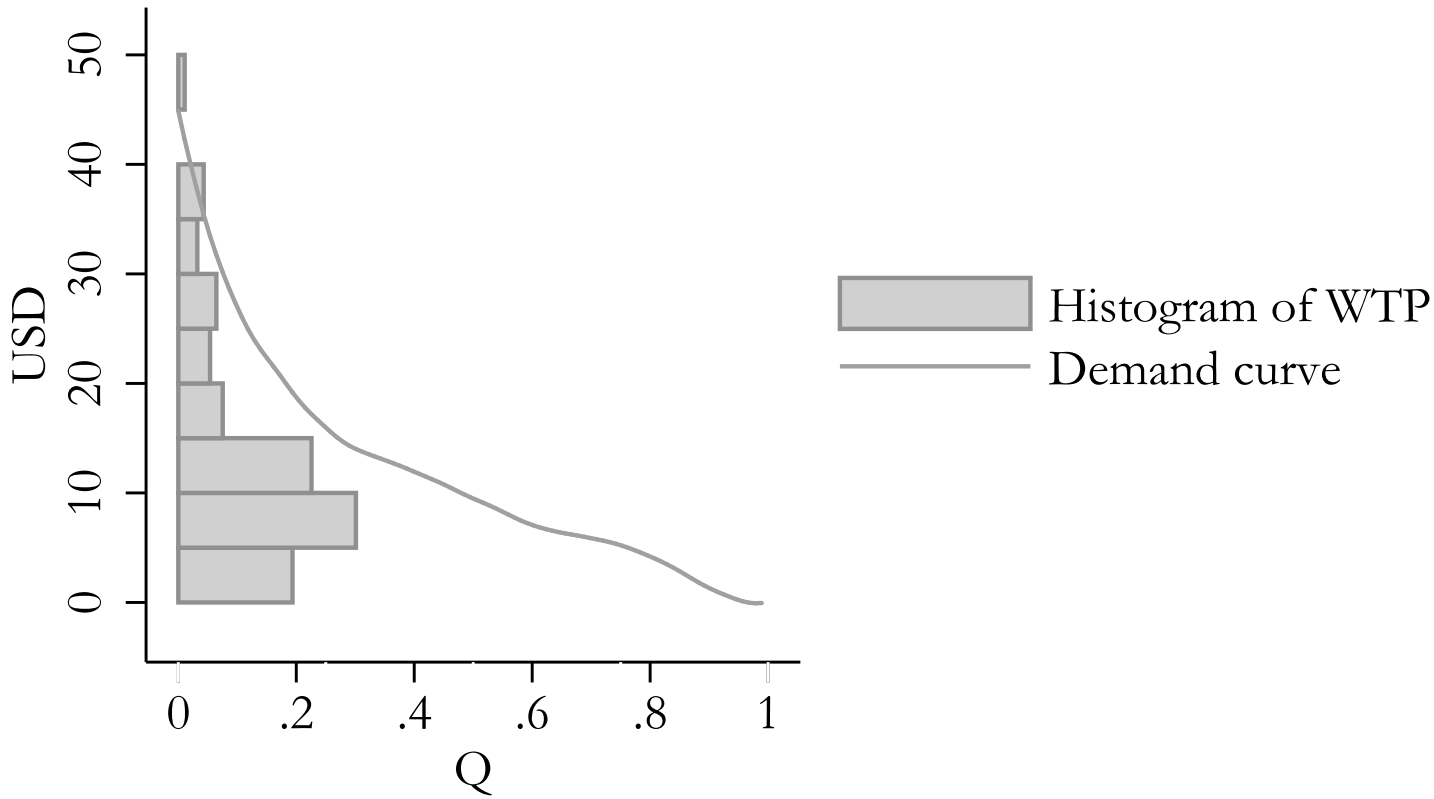
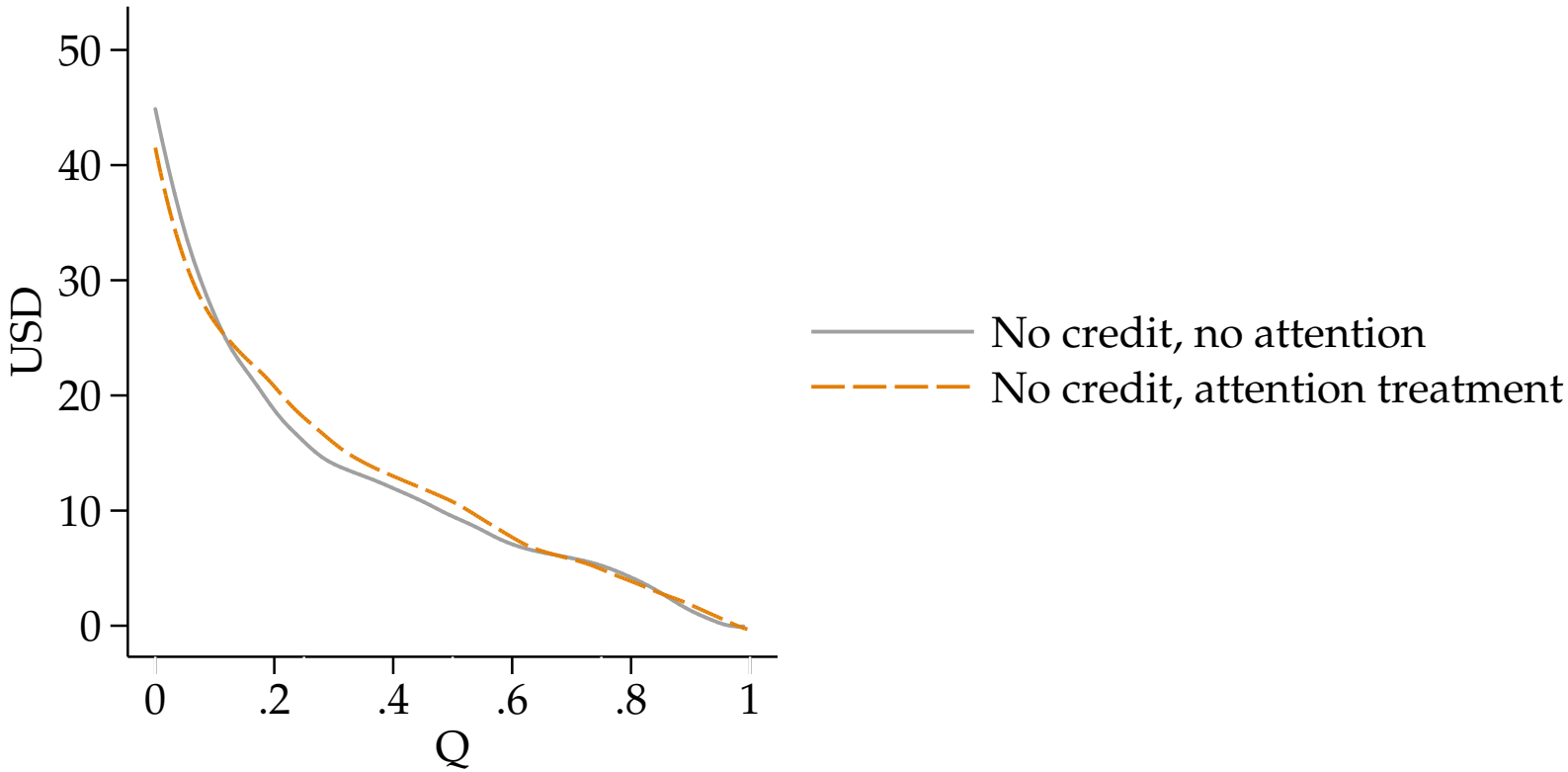


- Control group WTP: Average \$12, median \$10
- Implied discount factor $\delta = 0.88$ per *week* ($\delta = 0.001$ per *year*)

No evidence of inattention to energy savings



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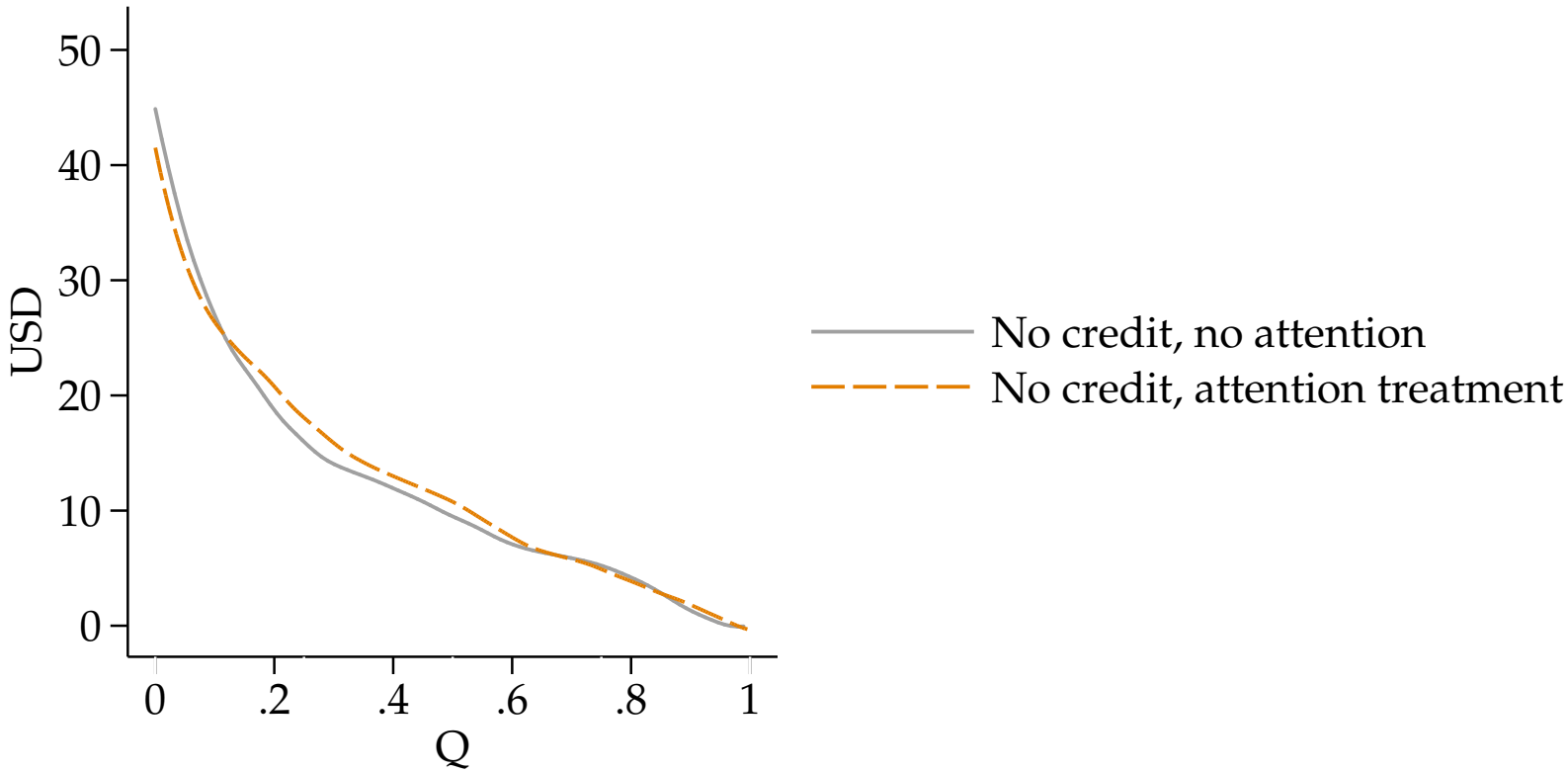
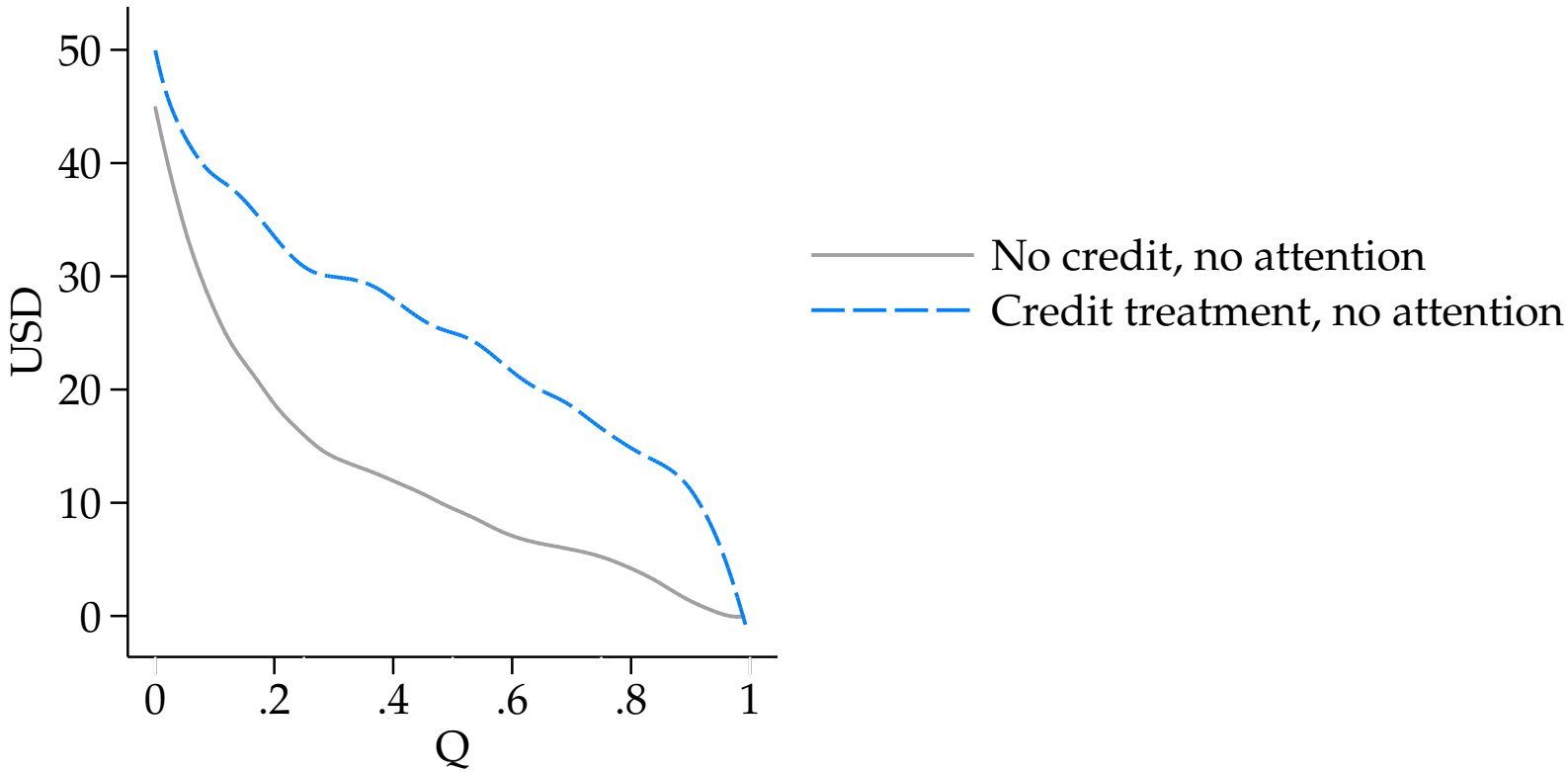


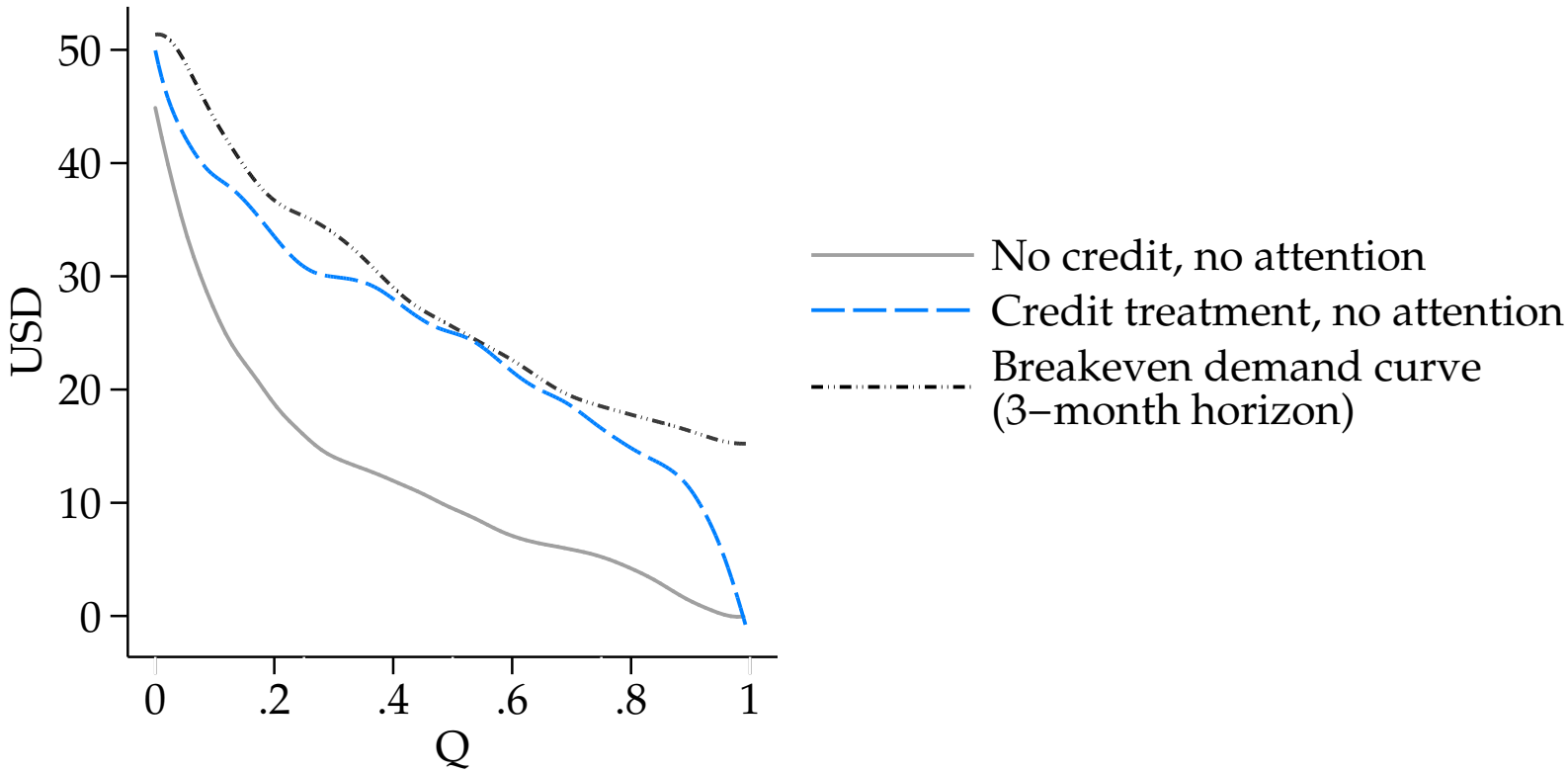
- Nudges, behavioral interventions may not increase energy efficiency
- **Departs from:** Allcott and Taubinsky (2015); Allcott and Wozny (2014); Gillingham et al. (2019); Jessoe and Rapson (2014)

Access to credit doubles WTP



- Credit increases WTP by \$13 (95% CI: [11.2, 14.0])
- 104% relative to control

Access to credit doubles WTP



- Credit increases WTP by \$13 (95% CI: [11.2, 14.0])
- 104% relative to control
- Credit *alone* closes reaches breakeven point over the loan period
- Adopters use weekly savings to pay for stove

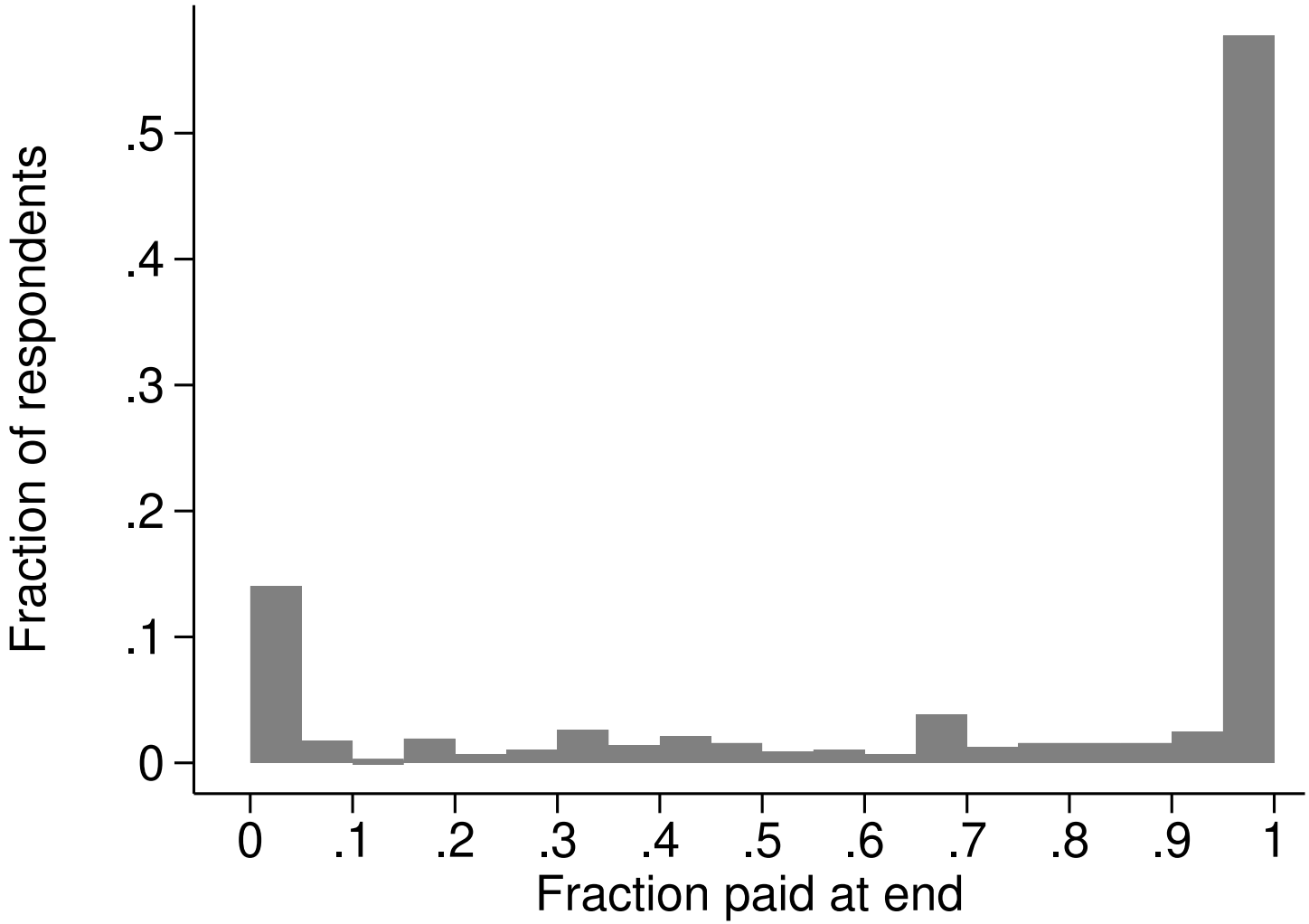
Large economic cost of credit market frictions

- Udry and Agamol (2006), Banerjee and Duflo (2005), Banerjee, Karlan, Zinman (2015), Pitt and Khandker (1998), De Mel, McKenzie, Woodruff (2008)

Large economic cost of credit market frictions

- Udry and Agamol (2006), Banerjee and Duflo (2005), Banerjee, Karlan, Zinman (2015), Pitt and Khandker (1998), De Mel, McKenzie, Woodruff (2008)
- Technology is homogeneous; well-known as a high quality product
- Households can't invest even with 300% annual returns: high interest rates are not the primary barrier
- Other credit frictions are important: quantity constraints, time constraints, high cost of default

Repayment rates: good but still too low



Today

Background

Study design

Financial savings

Climate

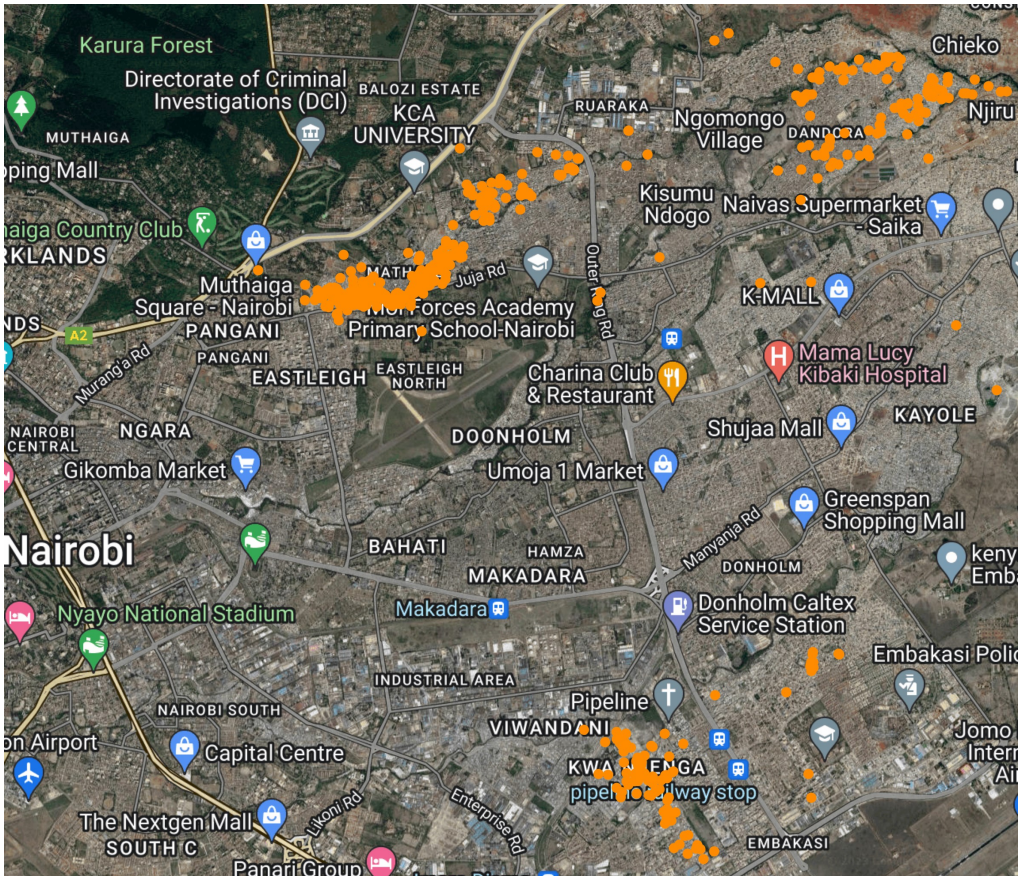
Barriers to adoption

Long-run impacts: 2022-2023 (3.5 years later)

Pollution impacts

Health impacts

Follow-up population: 702 households (74%)



- 639 still reside in primary study areas
- 10 respondents reside elsewhere in Nairobi
- 53 respondents reside elsewhere in Kenya

Jikokoa ownership is persistent

	Control Mean	TE of 2019 Jikokoa Ownership	N
Owns other wood/charcoal stove in 2022	0.88	-0.54***	702
	[0.33]	(0.05)	
Owns Jikokoa in 2022	0.10	0.74***	702
	[0.31]	(0.04)	
Owns LPG stove in 2022	0.57	0.05	702
	[0.50]	(0.06)	
Owns bio-ethanol stove in 2022	0.15	0.01	702
	[0.36]	(0.04)	
Owns electric stove in 2022	0.00	0.02*	702
	[0.06]	(0.01)	

Reduction in charcoal expenditures persist

	(1) 2022	(2) 2019
Own Jikokoa	-1.50***	-1.12***
	(0.47)	(0.35)
Own Jikokoa (Urban)		
Own Jikokoa (Rural)		
Rural	-1.05***	-1.08***
	(0.36)	(0.38)
Control Mean	3.84	3.65
Weak IV F-Statistic	64.22	217.30
Observations	702	702

Regressions use the randomly assigned subsidy, offer of credit and their interaction as instruments for Jikokoa adoption

Reduction in charcoal expenditures persist – concentrated in urban areas

	(1) 2022	(2) 2019	(3) 2022	(4) 2019
Own Jikokoa	-1.50***	-1.12***		
	(0.47)	(0.35)		
Own Jikokoa (Urban)			-1.64***	-1.20***
			(0.51)	(0.37)
Own Jikokoa (Rural)			-0.45	-0.40
			(1.05)	(0.98)
Rural	-1.05***	-1.08***	-1.74**	-1.58*
	(0.36)	(0.38)	(0.85)	(0.82)
Control Mean	3.84	3.65	3.84	3.65
Weak IV F-Statistic	64.22	217.30	26.75	96.17
Observations	702	702	702	702

Regressions use the randomly assigned subsidy, offer of credit and their interaction as instruments for Jikokoa adoption

Impacts on socio-economic well-being

	Control Mean	Treatment Effect	N
Has formal bank account (=1)	0.13	0.11	702
	[0.34]	(0.07)	
Total savings (USD)	53.64	-8.63	701
	[86.62]	(19.88)	
... in mobile banking (USD)	5.85	-0.22	702
	[12.29]	(2.05)	
... in SACCO payout (USD)	40.25	-15.30	701
	[64.75]	(13.97)	
... in formal banking (USD)	7.63	6.81	702
	[34.99]	(8.69)	
People in network who adopted Jikokoa	0.78	1.13***	702
	[2.04]	(0.40)	
... neighbors	0.28	0.56***	702
	[0.82]	(0.16)	
... family members	0.20	0.21	702
	[0.69]	(0.13)	
... friends	0.20	0.22*	702
	[0.69]	(0.13)	
... other people	0.10	0.14	702
	[0.45]	(0.10)	

Adoption does not affect cooking behavior

	Minutes per day	Cooking (=1)		Cooking indoors (=1)	
	(1)	(2)	(3)	(4)	(5)
Own Jikokoa	4.131	0.013	0.014	-0.026	-0.065
	(9.025)	(0.010)	(0.010)	(0.047)	(0.061)
Control Mean	137.013	0.101	0.101	0.889	0.872
HOD FE	N/A	N/A	Yes	N/A	Yes
Weak IV F-Stat	51	51	69	46	47
Observations	697	697	31887	649	3068

Today

Background

Study design

Financial savings

Climate

Barriers to adoption

Long-run impacts: 2022-2023 (3.5 years later)

Pollution impacts

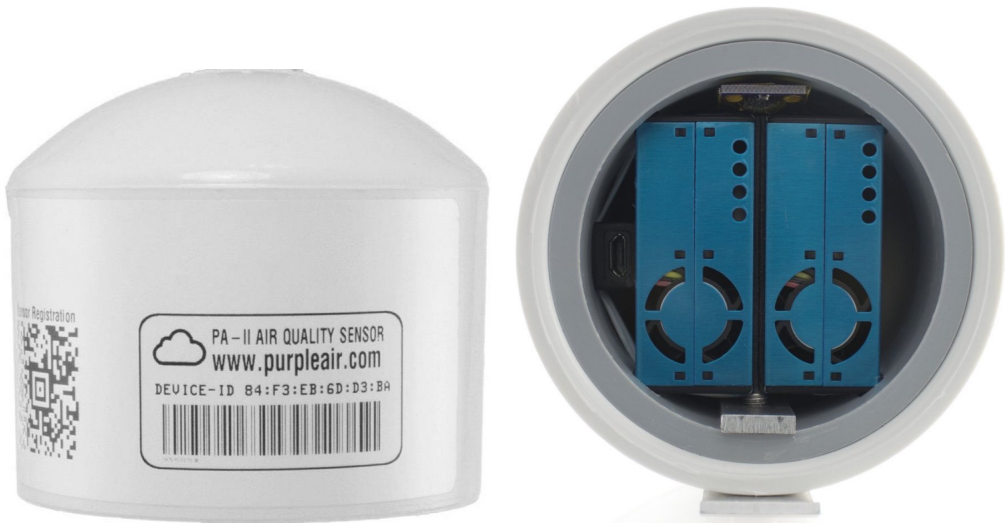
Health impacts

Air pollution

Particulate Matter (PM)

- Purple Air device
- One reading every 2 minutes
- Calibrated using Ward et al. (AGU 2021)

PM1.0: Any particles $< 1.0\mu m$ *diameter*
PM2.5: Any particles $< 2.5\mu m$ *diameter*



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PM1.0: Any particles $< 1.0\mu m$ *diameter*
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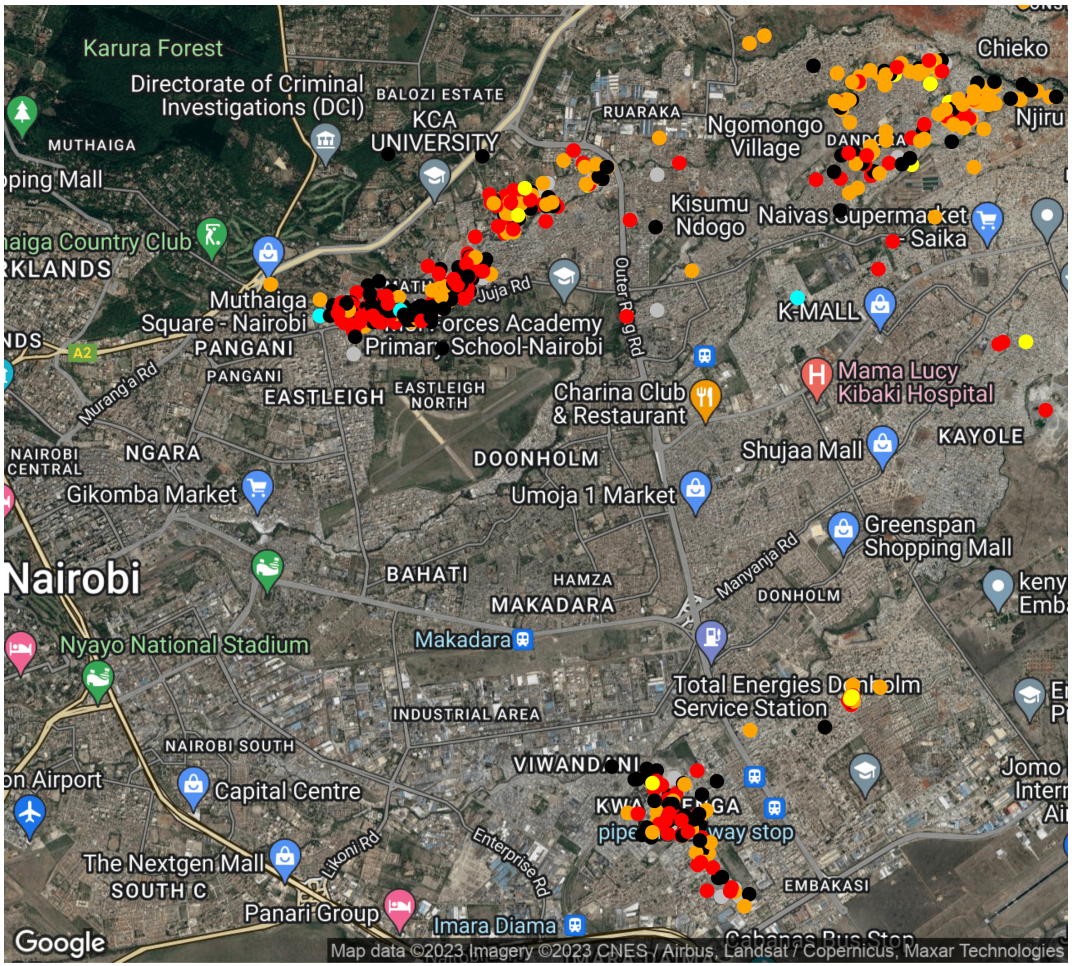
Carbon Monoxide (CO)

- Lascar Electronics device
- One reading every minute
- Calibrated every 2 months

Air pollution measurements

- Methodology and design developed by Berkeley Air Johnson et al 2021
- Best practices Chillrud et al 2021; Burrowes 2019; Gordon et al 2014; Gould et al 2022
- Each backpack contains 2 devices and a battery
- Dropped off during visit 1, picked up ∼48 hours later

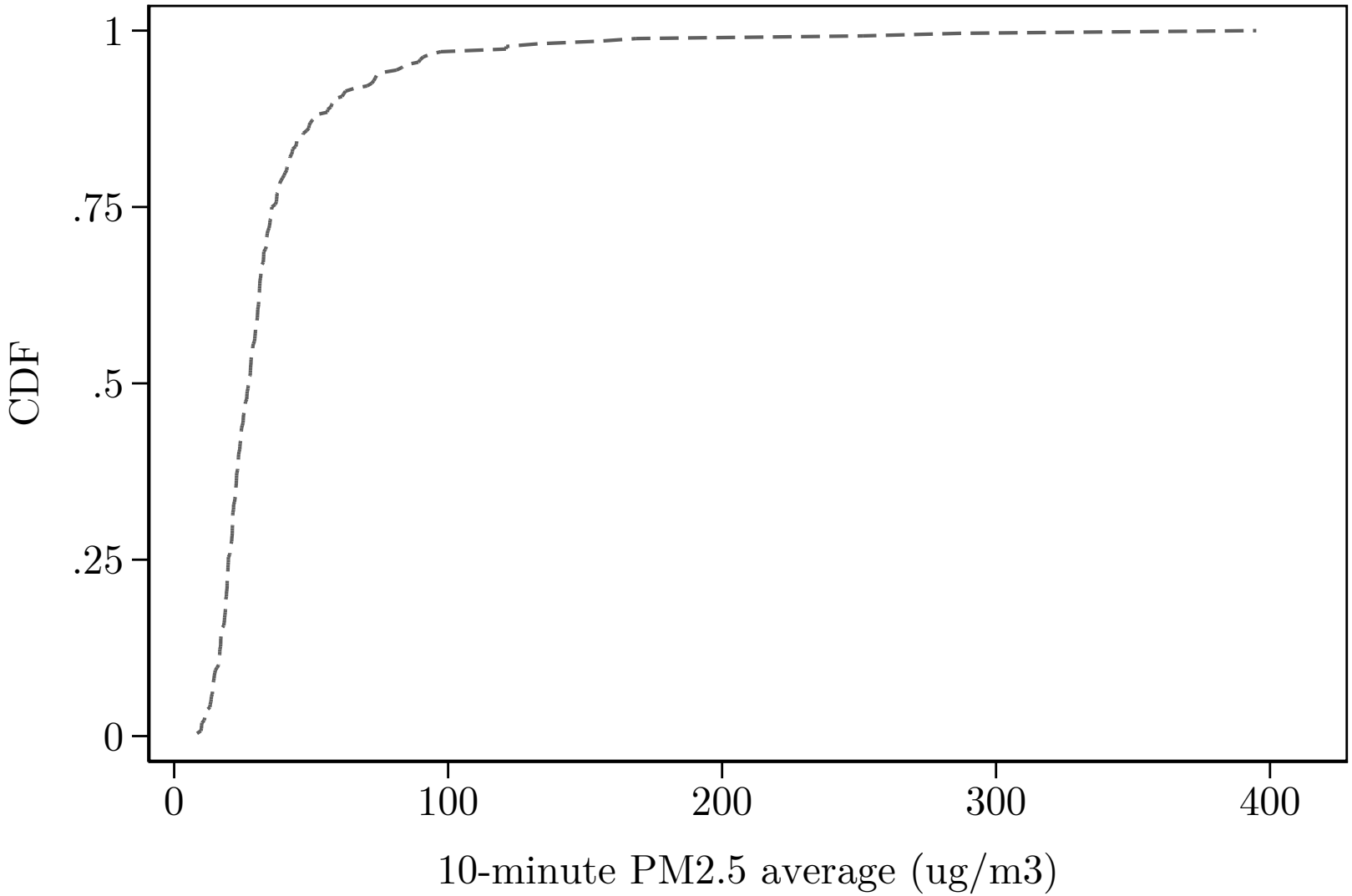
Average PM2.5 concentrations far exceed WHO guidelines



PM2.5 ($\mu g/m^3$):

- 0 – 5
- 5 – 10
- 10 – 15
- 15 – 25
- 25 – 35
- 35+

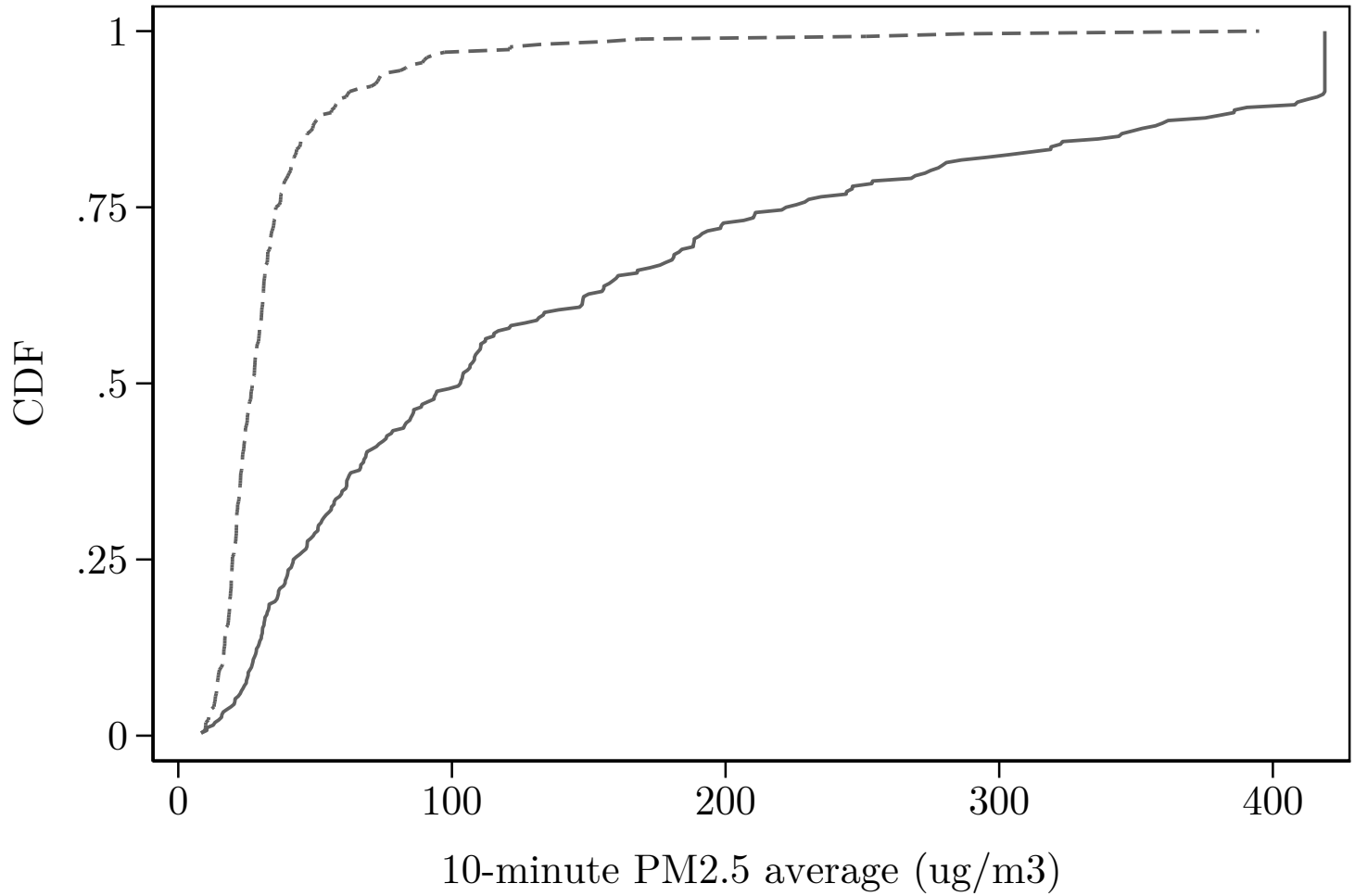
Each respondent's median 10-minute PM2.5:



$35 \mu g/m^3 =$ AQI 100

Each respondent's 99th percentile of 10-minute PM2.5:

(99th percentile is approx. 15 minutes per day)

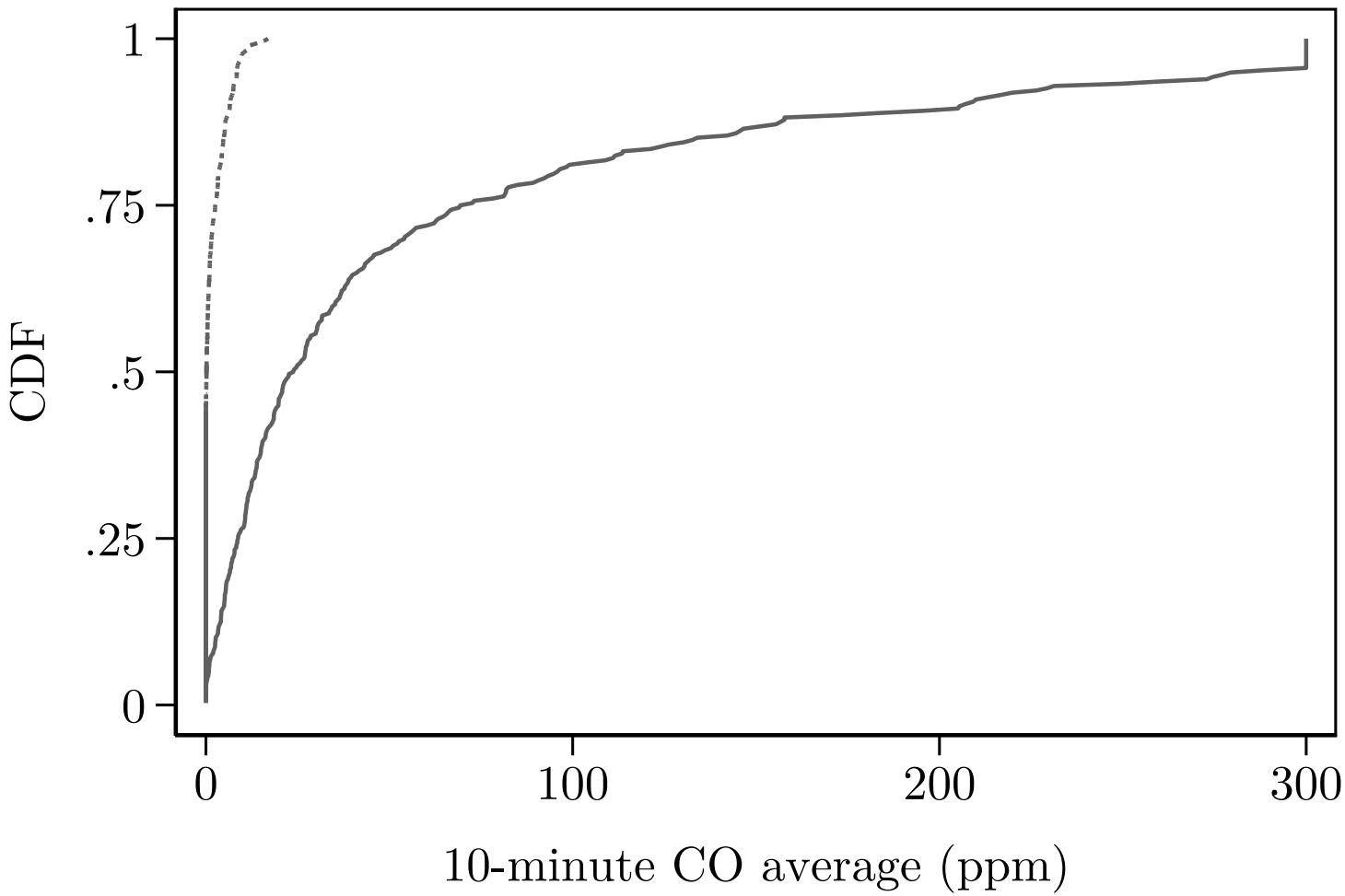


$100\mu g/m^3$ = AQI 174
$200\mu g/m^3$ = AQI 250

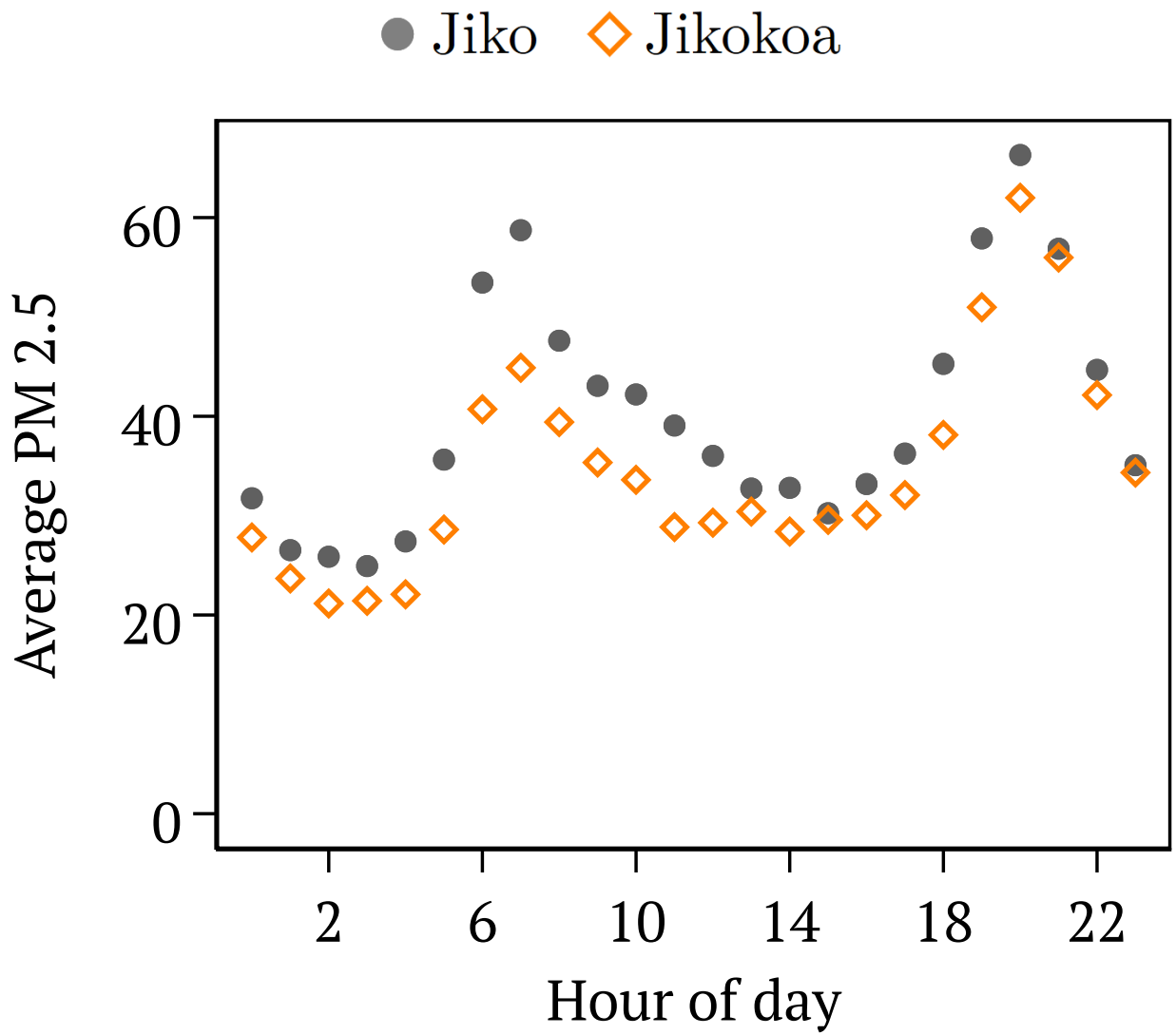
50th & 99th percentile of 10-minute CO average:

>10ppm: "Significant increase in heart disease deaths and hospital admissions for congestive heart failure"

>100ppm: "Headache, tiredness, dizziness, nausea, damage to hearts and brains within 2–5 hours" (EPA)



Jikokoa adoption and hourly average PM2.5 exposure



Cooking increases PM2.5 by $125 \mu g/m^3$

Panel A) All hours

	Median	Mean	Max Hour	99th
Own Jikokoa	0.1	-0.8	-16.4	-8.3
	(1.7)	(3.4)	(19.0)	(23.0)
Control Mean	25.2	37.8	153.3	200.3
Weak IV F-Statistic	53	53	53	53
Observations	651	651	651	651

Panel B) Hours when self-reporting cooking

	Median	Mean	Max Hour	99th
Own Jikokoa	-11.0**	-16.6***	-31.0**	-52.0**
	(5.2)	(6.4)	(15.4)	(22.5)
Control Mean	35.9	49.7	92.6	150.3
Weak IV F-Statistic	48	48	48	48
Observations	598	598	595	598

Adoption reduces peak emissions by $52\mu g/m^3$ (42%)

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	(1.7)	(3.4)	(19.0)	(23.0)
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Observations	598	598	595	598

No detectable change in daily average

- –0.8$\mu g/m^3$ is around 2%
- 95% CI: -7.5, 5.9 $\mu g/m^3$

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How big of an effect could private fuel switching have on **average** exposure?

- Respondents cook for 9% of the day (2 hours) on average
- Average PM2.5 is $38 \mu g/m^3$ (AQI: 100)
  - $52 \mu g/m^3$ when cooking
  - $36 \mu g/m^3$ when not cooking
- Even if treatment consisted of a perfectly clean stove, then treatment would still only reduce average exposure by $1.9 \mu g/m^3$ (4%)

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  - $36\mu g/m^3$ when not cooking
- Even if treatment consisted of a perfectly clean stove, then treatment would still only reduce average exposure by $1.9\mu g/m^3$ (4%)
- **In rural areas:**
  - Background is $9\mu g/m^3$ (Pope et al, 2018)
  - Suppose cooking twice as long
  - **28%** reduction in aggregate exposure

Today

Background

Study design

Financial savings

Climate

Barriers to adoption

Long-run impacts: 2022-2023 (3.5 years later)

Pollution impacts

Health impacts

Can clean cooking technologies improve health?

1. Many of the RCTs focus on **adoption** without measuring health impacts
   - Bensch et al. (2015), Bensch and Peters (2019), Chowdhury et al. (2019), Levine et al. (2018), Miller and Mobarak (2013), Mobarak et al. (2012), and Pattanayak et al. (2019).
   - Berkouwer and Dean (2022)

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2. Much existing evidence is **correlational**. Lancet Global Health (2020) reviews 437 papers: **6** were RCTS (3 from 1 RCT)
   - RESPIRE (2011); HAPIN (2022)

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3. We find **9** RCTs that estimate the causal impact of improved stove adoption on air pollution concentrations and health
   - Only **one** RCT in an urban location (sample of pregnant women) CHEST (2015)
   - **None** measure non-kitchen exposure

Clinical health outcomes

Following methodology from public health Tielsch et al., 2016; Smith-Sivertsen et al., 2009; Checkley et al., 2021

1. **Blood pressure** using a sphygmomanometer
   - Following procedures set out by CDC NHANES (2019)
   - Average of 3 measurements of systolic and diastolic BP
   - Respondent to sit on a chair, straight back, feet flat on the floor, etc.
2. **Blood oxygen saturation** using pulse oximeter

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3. **Child anthropometrics**
   - Weight
   - Height
   - Arm circumference

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   - Respondent to sit on a chair, straight back, feet flat on the floor, etc.
2. **Blood oxygen saturation** using pulse oximeter
3. **Child anthropometrics**
   - Weight
   - Height
   - Arm circumference
4. **Have you been diagnosed by a medical professional with...**
   - Asthma, pneumonia, COPD, hypertension, diabetes, TB, COVID, etc.
5. **Pneumonia diagnosis** using UNICEF MICS6 (2020) methodology

Self-reported health outcomes

Following methodology from public health Tielsch et al., 2016; Smith-Sivertsen et al., 2009; Checkley et al., 2021

In the past two weeks, have you experienced...
(split defined in pre-analysis plan)

- **Self-reported respiratory symptoms:** Headache, fatigue, cough, runny nose, sore throat, etc.
- **Self-reported non-respiratory symptoms:** Fever, stomach pain, malaria, worms, myalgia, etc.

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- **Self-reported non-respiratory symptoms:** Fever, stomach pain, malaria, worms, myalgia, etc.

Child outcomes: ask parents about any symptoms or diagnoses in children under 10

A 0.24SD reduction in self-reported respiratory symptoms

- Split pre-specified in analysis plan

	Control Mean	Treatment Effect	N
Health symptoms index (z-score)	0.00	-0.15	702
	[1.00]	(0.16)	
Number of health symptoms	2.78	-0.72*	702
	[2.93]	(0.42)	
Non-respiratory health symptom index	-0.00	-0.03	702
	[1.00]	(0.19)	
Number of non-respiratory health symptoms	1.09	-0.24	702
	[1.54]	(0.25)	
Respiratory health symptom index	-0.00	-0.24*	702
	[1.00]	(0.13)	
Number of respiratory health symptoms	1.70	-0.48**	702
	[1.76]	(0.23)	

Reductions in sore throat, headache, cough, fatigue

	Control Mean	Treatment Effect	N
Respiratory health symptom index	-0.00	-0.24*	702
	[1.00]	(0.13)	
Number of respiratory health symptoms	1.70	-0.48**	702
	[1.76]	(0.23)	
Persistent cough	0.24	-0.09	702
	[0.43]	(0.07)	
Always feeling tired	0.30	-0.07	702
	[0.46]	(0.07)	
Breathlessness at night	0.08	-0.01	702
	[0.27]	(0.04)	
Frequent diarrhea	0.02	-0.02	702
	[0.15]	(0.03)	
Difficulty breathing / Chest tightness	0.07	-0.01	702
	[0.26]	(0.04)	
Runny nose	0.23	-0.05	702
	[0.42]	(0.07)	
Sore throat	0.16	-0.12*	702
	[0.37]	(0.06)	
Headache	0.52	-0.12	702
	[0.50]	(0.08)	
Wheezing	0.03	0.01	702
	[0.17]	(0.03)	
Persistent mucus problems	0.04	-0.01	702
	[0.19]	(0.02)	

No detectable impact on clinical health outcomes

	Control Mean	Treatment Effect	N
Blood oxygen	96.61	0.31	696
	[2.53]	(0.37)	
Average systolic blood pressure	122.16	0.49	696
	[18.97]	(3.30)	
Average diastolic blood pressure	81.32	0.58	696
	[11.73]	(2.15)	
Hypertension: Stage 1 or higher (>130/80)	0.51	0.02	696
	[0.50]	(0.09)	
Hypertension: Stage 2 or higher (>140/90)	0.27	-0.02	696
	[0.44]	(0.08)	

No detectable impact on clinical health outcomes

- We can rule out a 0.14 SD or greater reduction in health diagnoses
- We can rule out a 6 mmHg or greater reduction in systolic BP
- Smoking acutely increases systolic BP by 20 mmHg (Cohen and Townsend, 2009); limited evidence on long-term impact on BP
- Comparing our cardiovascular impacts with the medical literature we can reject a 12% or greater decrease in major cardiovascular events

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- We can rule out a 6 mmHg or greater reduction in systolic BP
- Smoking acutely increases systolic BP by 20 mmHg (Cohen and Townsend, 2009); limited evidence on long-term impact on BP
- Comparing our cardiovascular impacts with the medical literature we can reject a 12% or greater decrease in major cardiovascular events
- No heterogeneity by baseline health, beliefs about health, age, WTP, or background pollution

No impact on diagnoses by healthcare professionals

	Control Mean	Treatment Effect	N
Number of health diagnoses	0.30	0.13	702
	[0.58]	(0.09)	
Asthma	0.01	-0.01	702
	[0.08]	(0.01)	
Pneumonia	0.13	0.02	702
	[0.34]	(0.05)	
Chronic Pulmonary Disease	0.00	0.01	702
	[0.06]	(0.01)	
Tuberculosis	0.01	0.02	702
	[0.08]	(0.01)	
COVID	0.01	-0.01	702
	[0.08]	(0.01)	
Other lung disease	0.01	-0.01	702
	[0.08]	(0.01)	
Stroke or cardiovascular disease	0.01	-0.00	702
	[0.08]	(0.01)	
Diabetes	0.02	-0.00	702
	[0.14]	(0.02)	
Other	0.04	0.01	702
	[0.19]	(0.03)	

No impact on children's outcomes (ages <10, <5)

	Control Mean	Treatment Effect	N
Child weight (kg)	17.73	-1.02	224
	[7.57]	(1.80)	
Child height (cm)	98.59	6.02	199
	[31.07]	(6.08)	
Child arm circumference (cm)	16.37	1.24	220
	[7.26]	(1.41)	
Number of child health symptoms	1.19	0.34	343
	[1.50]	(0.40)	
Child health symptom index	0.00	0.32	343
	[1.00]	(0.29)	
Fever	0.18	-0.01	343
	[0.38]	(0.09)	
Vomiting	0.10	-0.01	343
	[0.30]	(0.06)	
Cough	0.40	0.03	343
	[0.49]	(0.12)	
Diarrhea	0.10	0.00	343
	[0.30]	(0.07)	
Breathlessness	0.04	0.08	343
	[0.19]	(0.06)	
Persistent headache	0.08	0.05	343
	[0.27]	(0.05)	
Very bad cough	0.25	0.10	343
	[0.43]	(0.09)	
Pneumonia - DHS	0.03	0.03	343
	[0.18]	(0.05)	

No impact on health expenditures

	Control Mean	Treatment Effect	N
Non-hospital health expenditures (USD)	4.34	0.80	702
	[7.64]	(1.07)	
Hospital visits in past 30 days	0.33	-0.01	702
	[0.57]	(0.09)	
Hospital visit expenditures (USD)	3.39	1.03	702
	[11.17]	(1.48)	

No impact on cognitive function

	Control Mean	Treatment Effect	N
Cognitive index	-0.00	-0.01	587
	[1.00]	(0.15)	
Working memory (Corsi)	-0.00	-0.48**	305
	[1.00]	(0.22)	
Attention (d2)	0.00	-0.09	564
	[1.00]	(0.15)	
Inhibitory control (HF - % correct)	-0.00	0.18	516
	[1.00]	(0.16)	
Inhibitory control (HF - reaction time)	0.00	0.14	516
	[1.00]	(0.19)	

Sample size here is smaller due to technical issues with the tablets. Since the order of follow-up surveys was randomized, it is unlikely that this biased the results.

Evidence against measurement error, experimenter demand

Evidence against measurement error, experimenter demand

1. Medical diagnoses correlate with blood pressure

	Mean	Blood Pressure	N
	(1)	(2)	(4)
Health diagnoses index	-0.00	0.11***	696
	[1.00]	(0.04)	
Number of health diagnoses	0.28	0.06***	696
	[0.55]	(0.02)	

Evidence against measurement error, experimenter demand

1. Medical diagnoses correlate with blood pressure
2. Impact on **respiratory** but not **non-respiratory** symptoms

	Control Mean	Treatment Effect	N
Non-respiratory health symptom index	-0.00	-0.03	702
	[1.00]	(0.19)	
Number of non-respiratory health symptoms	1.09	-0.24	702
	[1.54]	(0.25)	
Respiratory health symptom index	-0.00	-0.24*	702
	[1.00]	(0.13)	
Number of respiratory health symptoms	1.70	-0.48**	702
	[1.76]	(0.23)	

Evidence against measurement error, experimenter demand

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3. No difference by size of subsidy (25% to 90%)

	Respiratory			Non-respiratory		
	(1)	(2)	(3)	(4)	(5)	(6)
Owns Jikokoa	-0.45***	-0.29	-0.30	-0.39***	-0.40	-0.38
	(0.12)	(0.28)	(0.28)	(0.11)	(0.26)	(0.27)
Price (10 USD)	-0.00	0.05	0.05	-0.06	-0.07	-0.06
	(0.07)	(0.11)	(0.11)	(0.06)	(0.10)	(0.10)
Owns Jikokoa		-0.09	-0.09		0.00	0.01
X Price (10 USD)		(0.14)	(0.14)		(0.13)	(0.13)
WTP (10 USD)			0.02			-0.02
			(0.05)			(0.05)

Evidence against measurement error, experimenter demand

1. Medical diagnoses correlate with blood pressure
2. Impact on **respiratory** but not **non-respiratory** symptoms
3. No difference by size of subsidy (25% to 90%)
4. Health—max pollution correlation persists among **non-adopters**

	Mean	Mean Pollution in SD	Median Pollution in SD	Max Hourly Pollution in SD	Hours Above $100\mu g/m^3$	N
	(1)	(2)	(3)	(4)	(5)	(6)
Health symptoms index	0.02	-0.00	0.03	0.09	-0.00	291
	[1.02]	(0.06)	(0.07)	(0.07)	(0.04)	
Number of symptoms	2.82	0.01	0.10	0.33*	0.01	291
	[2.96]	(0.18)	(0.19)	(0.19)	(0.10)	

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Thank you!

sberkou@wharton.upenn.edu
joshua.dean@chicagobooth.edu