Monetary and Non-Monetary Barriers to Accessing Environmental Public Benefit Programs: Evidence from California

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Motivation and research questions

Context

- >90% of Californians breathe unhealthy air at some point each year (CARB, 2026)
- Air purifiers are an effective mitigation strategy
- Take up is low, especially for low-income and pollution burdened households
- How to target these households with a subsidized air purifier program is unclear

Research Questions

1. How do **monetary** (subsidy level) and **non-monetary** (ordeal) costs affect application rates to a public benefits program?
2. Do these effects vary by **household income** and **pollution exposure**?

Experimental design

Setting

- 90,179 California households, sampled from commercial mailing list
- Randomly assigned to one of nine letter treatments
- Rollout Feb-Mar 2026

Design table | Arm details | Sampling | Randomization | Protocol

Treatment arms

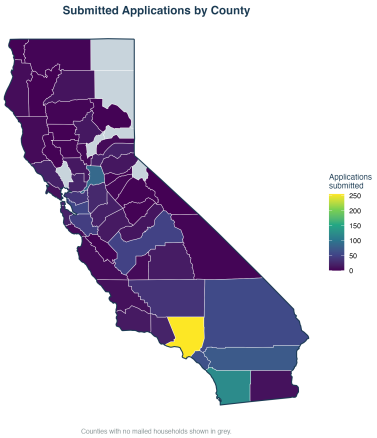
- 0% subsidy
- 50% subsidy
- 75% subsidy
- 95% subsidy
- **100% subsidy (reference)**
- 100% subsidy + time cost
- 100% subsidy + proof of residence
- 100% subsidy + POR + help
- 100% subsidy + AQ info

POR = proof of residence; AQ = air quality.

Descriptive statistics

Treatment arm	*N* mailed	Applied	Rate
0% subsidy	6,575	17	0.26%
50% subsidy	6,590	16	0.24%
75% subsidy	6,579	43	0.65%
95% subsidy	11,293	157	1.39%
100% subsidy	**18,483**	**370**	**2.00%**
100% + time cost	9,194	145	1.58%
100% + proof of res.	13,067	200	1.53%
100% + POR + help	9,203	110	1.20%
100% + AQ info	9,195	175	1.90%
Total	**90,179**	**1,233**	**1.37%**

Bold row = 100% subsidy reference arm (T3).



Regression specifications

ITT:

$$\begin{aligned}\text{Applied}_{ij} = {} & \beta_1 \mathbf{1}(\text{0\% subsidy}) + \beta_2 \mathbf{1}(\text{50\% subsidy}) + \beta_3 \mathbf{1}(\text{75\% subsidy}) + \beta_4 \mathbf{1}(\text{95\% subsidy}) + \\ & \beta_5 \mathbf{1}(\text{100\% subsidy with time cost}) + \beta_6 \mathbf{1}(\text{100\% subsidy + proof of residence}) + \\ & \beta_7 \mathbf{1}(\text{100\% subsidy + proof of residence + help}) + \beta_8 \mathbf{1}(\text{100\% subsidy + AQ info}) + \gamma_j + \varepsilon_{ij}\end{aligned}$$

Regression specifications

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HTE (let $D_i \equiv \mathbf{1}(\text{below 100\% FPL})$)**:**

$$\begin{aligned}\text{Applied}_{ij} = {} & \beta_1 \mathbf{1}(\text{0\% subsidy}) + \beta_2 \mathbf{1}(\text{50\% subsidy}) + \beta_3 \mathbf{1}(\text{75\% subsidy}) + \beta_4 \mathbf{1}(\text{95\% subsidy}) + \\ & \beta_5 \mathbf{1}(\text{100\% subsidy with time cost}) + \beta_6 \mathbf{1}(\text{100\% subsidy + proof of residence}) + \\ & \beta_7 \mathbf{1}(\text{100\% subsidy + proof of residence + help}) + \beta_8 \mathbf{1}(\text{100\% subsidy + AQ info}) + \alpha D_i + \\ & \delta_1 \mathbf{1}(\text{0\% subsidy}) \times D_i + \delta_2 \mathbf{1}(\text{50\% subsidy}) \times D_i + \\ & \delta_3 \mathbf{1}(\text{75\% subsidy}) \times D_i + \delta_4 \mathbf{1}(\text{95\% subsidy}) \times D_i + \\ & \delta_5 \mathbf{1}(\text{100\% subsidy with time cost}) \times D_i + \\ & \delta_6 \mathbf{1}(\text{100\% subsidy + proof of residence}) \times D_i + \\ & \delta_7 \mathbf{1}(\text{100\% subsidy + proof of residence + help}) \times D_i + \\ & \delta_8 \mathbf{1}(\text{100\% subsidy + AQ info}) \times D_i + \gamma_j + \varepsilon_{ij}\end{aligned}$$

γ_j: strata fixed effects. HC1 robust SEs.

Results 1: Application rates

1. Demand slopes down; ordeal costs deter applicants

	Submitted
0% subsidy	-0.017***
	(0.001)
50% subsidy	-0.018***
	(0.001)
75% subsidy	-0.013***
	(0.001)
95% subsidy	-0.006***
	(0.002)
100% subsidy + time cost	-0.004**
	(0.002)
100% subsidy + proof of residence	-0.005***
	(0.001)
100% subsidy + POR + help	-0.008***
	(0.002)
100% subsidy + AQ info	-0.001
	(0.002)
Ref. group mean (100% subsidy)	0.020
N	90179
R^2	0.0063

* p < 0.1, ** p < 0.05, *** p < 0.01

1a: Demand slopes downward

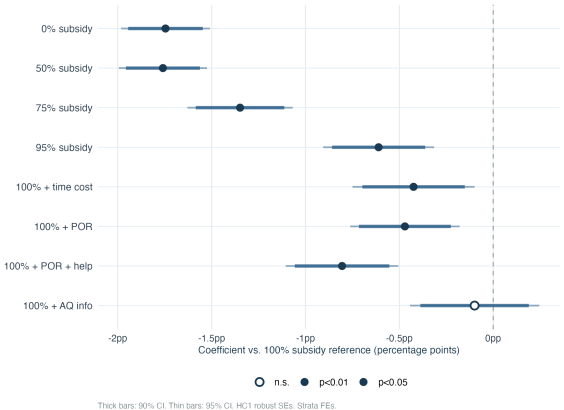
- 0% subsidy: −1.7ppt (85%) vs. T3
- 50% subsidy: −1.8ppt (90%)
- 75% subsidy: −1.3ppt (65%)
- 95% subsidy: −0.6ppt (30%)

1b: Ordeal costs deter applicants

- Time cost: −0.4ppt (20%)
- Proof of res.: −0.5ppt (25%)
- POR + help: −0.8ppt (40%)

OLS ITT. Effects relative to T3 (100% subsidy) mean (2.0%). HC1 SEs. Strata FEs. $N = 90{,}179$.

1. Demand slopes down; ordeal costs deter applicants



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1b: Ordeal costs deter applicants

- Time cost: −0.4ppt (20%)
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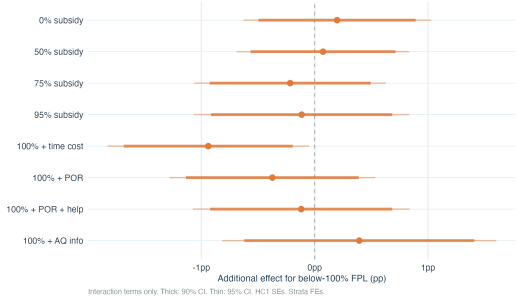
- POR + help: −0.8ppt (40%)

OLS ITT. Effects relative to T3 (100% subsidy) mean (2.0%). HC1 SEs. Strata FEs. $N = 90{,}179$.

Results 2: Heterogeneous effects

3. Effects vary by income and pollution exposure

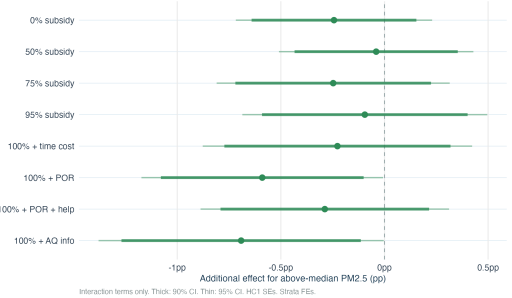
3a: By federal poverty level (<100% FPL)



T4 (time cost): −1.2ppt for below-100% FPL vs. −0.3ppt for above-100% FPL.

▸ HTE PM2.5 table ▸ HTE FPL (<100%) table

3b: By PM2.5 exposure (above median)



T5 (proof of res.): −0.8ppt for above-median PM2.5 vs. −0.2ppt for below-median PM2.5.

Conclusion

- Application form length and document requirements significantly affect who applies.
- Ordeal costs deter applicants disproportionately deter target applicants.
- Policy implication: Reducing administrative burden improves uptake and equity, particularly for the most disadvantaged households.

QR code to my website

mspitzerbrooks.github.io

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Thanks!

Appendix: Experimental design table

0% subsidy	50% subsidy	75% subsidy	95% subsidy	100% subsidy	Time cost	Proof of residence	App. info	AQ + health info
✓								
	✓							
		✓						
			✓					
				✓				
				✓	✓			
				✓		✓		
				✓		✓	✓	
				✓				✓

Notes: Each row is a treatment arm; checkmarks indicate features included. "X% subsidy": subsidy rate on offer, plus free shipping. "Time cost": longer application form (∼15 min vs. ∼5 min). "Proof of residence": applicants must upload an address document. "App. info": letter includes application process details and a helpline link. "AQ + health info": letter includes EPA AQI data for the applicant's county. T3 = reference arm.

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Appendix: Treatment arms

- 0% subsidy

Appendix: Treatment arms

- 0% subsidy
- 50% subsidy

Appendix: Treatment arms

- 0% subsidy
- 50% subsidy
- 75% subsidy

Appendix: Treatment arms

- 0% subsidy
- 50% subsidy
- 75% subsidy
- 95% subsidy

Appendix: Treatment arms

- 0% subsidy
- 50% subsidy
- 75% subsidy
- 95% subsidy
- 100% subsidy **(reference)**

Appendix: Treatment arms

- 0% subsidy
- 50% subsidy
- 75% subsidy
- 95% subsidy
- 100% subsidy **(reference)**
- 100% subsidy + time cost (longer form, $\sim$15 min vs. $\sim$5 min)

Appendix: Treatment arms

- 0% subsidy
- 50% subsidy
- 75% subsidy
- 95% subsidy
- 100% subsidy **(reference)**
- 100% subsidy + time cost (longer form, $\sim$15 min vs. $\sim$5 min)
- 100% subsidy + proof of residence

Appendix: Treatment arms

- 0% subsidy
- 50% subsidy
- 75% subsidy
- 95% subsidy
- 100% subsidy **(reference)**
- 100% subsidy + time cost (longer form, ∼15 min vs. ∼5 min)
- 100% subsidy + proof of residence
- 100% subsidy + proof of residence + help

"You will be asked to provide proof of residence at this address. We accept any pictures of bills (such as utility or phone) and other official documents with your name and address. For additional assistance or questions, go to pcair.ucdavis.edu/instructions."

Appendix: Treatment arms

- 0% subsidy
- 50% subsidy
- 75% subsidy
- 95% subsidy
- 100% subsidy **(reference)**
- 100% subsidy + time cost (longer form, ∼15 min vs. ∼5 min)
- 100% subsidy + proof of residence
- 100% subsidy + proof of residence + help
- 100% subsidy + AQ info

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Appendix: Sampling

- Sample drawn from commercial mailing list of $\sim$12 million California residents
- List provides address, binned income estimates, demographics, GPS coordinates
- Linked to CalEnviroScreen 5.0 via Census Tract for annual average PM2.5
- Sampling procedure:
  1. Randomly sample within income-bin $\times$ PM2.5 decile strata
  2. Oversample low-income households ($<$ \$75k) at 2$\times$ the probability

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Appendix: Randomization

- Households randomly assigned to treatment within income-bin $\times$ PM2.5 decile strata
- 9 treatment arms; unequal arm sizes by design
- Unequal sizes for two reasons:
  1. More observations in the reference arm (T3) improves power (Muralidharan et al. 2025)
  2. Number of pre-specified hypotheses differs across pairwise comparisons
- Randomization unit: household. SEs are HC1 heteroskedasticity-robust (not clustered)

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Appendix: Experimental protocol

1. Participant receives letter in the mail
2. If they choose to apply, they visit the program website
3. Fill out Qualtrics application form (first entry: unique personal code)
4. After the application window, a random subset of applicants receives an air purifier

Data collected:

- *All* households: income bins, PM2.5, demographics (mailing list)
- *Applicants only*: continuous self-reported income, detailed demographics, health conditions (Qualtrics)

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Appendix: Application rate by county (top 10)

County	N mailed	Applied	Rate
Colusa	36	2	5.56%
Inyo	46	2	4.35%
Calaveras	84	3	3.57%
Plumas	34	1	2.94%
Yolo	453	13	2.87%
El Dorado	431	12	2.78%
Madera	423	11	2.60%
Imperial	359	9	2.51%
Mendocino	206	5	2.43%
Butte	547	13	2.38%

Ranked by application rate. Rate = submitted / mailed. Counties with small samples ($N < 100$ mailed) have noisy rates.

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Appendix: Sample characteristics

Variable	N	Mean	SD	Min	Median	Max
Full sample (mailed, $N = 90,179$)						
PM2.5 ($\mu g/m^3$, CES 5.0)	90,179	9.56	1.52	6.09	9.40	13.36
Income <$75k (0/1)	90,179	0.660	0.474	0.000	1.000	1.000
Submitted applicants ($N = 1,233$)						
PM2.5 ($\mu g/m^3$, CES 5.0)	1,233	9.43	1.44	6.19	9.27	12.69
Income <$75k (0/1)	1,233	0.602	0.490	0.000	1.000	1.000
Self-reported income ($)	1,058	109694	105212	10000	80000	1000000
Log self-reported income	1,058	11.280	0.814	9.210	11.290	13.816

PM2.5: census-tract mean (CES 5.0, with wildfire). Income < $75k: binary from mailer income bins. Applicant sample = submitted applications.

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Appendix: Arc elasticity of demand

Segment	P (from)	P (to)	Rate (from)	Rate (to)	Arc elasticity
50% → 75% subsidy	\$75	\$37	0.2%	0.7%	-1.35
75% → 95% subsidy	\$37	\$7	0.7%	1.4%	-0.53
95% → 100% subsidy†	\$7	\$0	1.4%	2.0%	-0.18

† Midpoint price = \$3.50 (near zero); elasticity magnitude reflects near-zero price floor.

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Appendix: HTE by PM2.5 exposure

	Submitted
0% subsidy	-0.016***
	(0.002)
50% subsidy	-0.017***
	(0.002)
75% subsidy	-0.012***
	(0.002)
95% subsidy	-0.006***
	(0.002)
100% subsidy + time cost	-0.003
	(0.002)
100% subsidy + proof of residence	-0.002
	(0.002)
100% subsidy + POR + help	-0.007***
	(0.002)
100% subsidy + AQ info	0.002
	(0.003)
Above-median PM2.5	0.001
	(0.004)
0% subsidy × above-med PM2.5	-0.002
	(0.002)
50% subsidy × above-med PM2.5	0.000
	(0.002)
75% subsidy × above-med PM2.5	-0.002
	(0.003)
95% subsidy × above-med PM2.5	-0.001
	(0.003)
100% + time cost × above-med PM2.5	-0.002
	(0.003)
100% + POR × above-med PM2.5	-0.006**
	(0.003)
100% + POR + help × above-med PM2.5	-0.003
	(0.003)
100% + AQ info × above-med PM2.5	-0.007**
	(0.004)
Ref. group mean (100% subsidy)	0.020
N	90179
R^2	0.0064

* p < 0.1, ** p < 0.05, *** p < 0.01

Outcome: Submitted. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$. HC1 SEs. Reference: T3.

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Appendix: HTE by income (<100% FPL)

	Strata FEs
0% subsidy	-0.018***
	(0.001)
50% subsidy	-0.018***
	(0.001)
75% subsidy	-0.013***
	(0.002)
95% subsidy	-0.006***
	(0.002)
100% subsidy + time cost	-0.003*
	(0.002)
100% subsidy + proof of residence	-0.004***
	(0.002)
100% subsidy + POR + help	-0.006***
	(0.002)
100% subsidy + AQ info	-0.001
	(0.002)
Below 100% FPL	-0.003
	(0.006)
0% subsidy × below 100% FPL	0.002
	(0.004)
50% subsidy × below 100% FPL	0.001
	(0.004)
75% subsidy × below 100% FPL	-0.002
	(0.004)
95% subsidy × below 100% FPL	-0.001
	(0.005)
100% + time cost × below 100% FPL	-0.009**
	(0.005)
100% + POR × below 100% FPL	-0.004
	(0.005)
100% + POR + help × below 100% FPL	-0.001
	(0.005)
100% + AQ info × below 100% FPL	0.004
	(0.006)
Ref. group mean (100% subsidy)	0.020
N	90179
R^2	0.0064

* p < 0.1, ** p < 0.05, *** p < 0.01

Strata FEs. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$. HC1 SEs. Reference: T3.

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