Supplementary Appendix for Online Publication

Indoor Air Quality, Information, and Socio-Economic Status: Evidence from Delhi

Michael Greenstone, Kenneth Lee, and Harshil Sahai

April 2021

Appendix Note A

I. Identifying the Low SES Sample

As described in Lee et al. (2020) and Baylis et al. (2021), the following approach was taken to create a representative sample of mostly poor, non-migrant individuals living in Delhi. We first consulted the administrative list of *Jhuggie Jhopri Squatter Settlements/Clusters* (or "J.J. clusters") provided by the Delhi Urban Shelter Improvement Board. Prior to sample recruitment, this was the only list of squatter settlements available to the public. Using this list, we randomly selected hundreds of sampling points (i.e., locations where enumerators could begin administering in-person surveys) located around the center of each J.J. cluster, assigning the number of points for each cluster based on its estimated population size. Sampling points that were deemed to no longer be slums or squatter settlements (due to urban development, for example) were ruled out, using a combination of satellite images and in-person checks.

This process produced roughly 300 sampling points (out of roughly 600 total) around which a team of enumerators attempted to recruit individual household respondents for the study. During these interactions, surveyors administered a brief questionnaire, and manually recorded both indoor (i.e., inside the respondent's home) and outdoor (i.e., several meters outside the respondent's home) levels of $PM_{2.5}$ using the KLE monitors described in Section I. In total, indoor and outdoor $PM_{2.5}$ levels were measured for each individual household one to three times, or two times on average. These manual measurements were then matched with the corresponding 15-minute averages reported by the nearest government monitors. In total, there are 5,597 observations of indoor and outdoor $PM_{2.5}$ levels, and corresponding outdoor, ambient $PM_{2.5}$ levels reported by the nearest government monitor, for the low SES households in our data. Note that the low SES air quality measures were captured between October 2018 and March 2019, the winter season prior to data collection in the medium and high SES household sample.

II. Identifying the Medium and High SES Sample

In order to recruit a sample of medium and high SES households in Delhi, we partnered with Indicus Foundation, a research and advocacy organization with longstanding relationships with many of Delhi's Residential Welfare Associations (RWAs), which are non-profit community groups that represent local neighborhoods and are common in many of Delhi's middle- and high-income colonies. Our partner assisted us in identifying a sample of RWAs spread across Delhi, and helped us secure letters of introduction (and authorization) from the President or head of each RWA, which would facilitate our conversations with households as we attempted to enroll them into the study.

In total, we recruited 49 RWAs into the study. These RWAs were then subdivided into 90 neighborhood clusters (which we refer to as, "RWA clusters") prior to any respondent recruitment efforts. When dividing the RWAs into RWA clusters, some basic principles were followed. These included: (1) ensuring that any two clusters were separated by a large road, park, or market (or other non-residential construction); (2) ensuring that all clusters were approximately equal in size; and (3) ensuring that no households that were adjacent or parallel to each other were assigned into different RWA clusters. We also limited our interactions with any RWA members until we had received an official letter of introduction from the RWA head. In some cases, there were requests from local RWA members to include certain households in the study, which were declined.

Due to the rolling nature of Indicus Foundation's RWA identification efforts, not all 90 clusters could be randomly assigned into experimental arms at the same time. Instead, roughly 15 to 20 RWA clusters were randomly assigned into the different groups at the beginning of each of the five month-long study rounds. There were three experimental arms: (1) "Group A" or "No Monitors" (*j*=28), our control group; (2) "Group B" or "Standard Monitors" (*j*=30), which offered a free, month-long trial of a standard KLE monitor, an information intervention on the health impacts of PM2.5, and other pollution-related information; and (3) "Group C" or "Modified Monitors" (*j*=28), which offered a modified version of the KLE monitor that lacked a visible display screen, but was capable of transmitting $PM_{2.5}$ data. An illustration of the study design for the medium and high SES sample is provided in Figure A2.

III. Summarizing Enrollment and Attrition in the Medium and High SES Sample

Table A1 summarizes sample sizes by experimental arm at different study stages. In Stage 0, we report on our success in recruiting urban, medium and high SES households into the study. At this stage, enumerators approached individual households in each RWA to seek the consent of an individual above 18 years of age to conduct the study. In total, 8,877 medium and high SES households were approached for recruitment, out of which the vast majority of (85.5 percent) declined or were unavailable to participate. Roughly 55 percent of households approached at this stage listened to the consent script, which included details about the purpose of the study and the nature of the questions included in the surveys. The remaining 45 percent of households either did not respond to the door bell, or there was no eligible household member present to answer questions.

In Stage I, we report on the number of households that consented to the surveys as well as potentially installing an IAQM, if randomly selected. Consent was requested in two steps. First, households were asked to consent to being surveyed. In total, 2,316 households (26.0 percent of households approached in Stage 0) consented to the baseline survey. Second, at the end of the baseline survey, households were asked to consent to installing an IAQM inside their home, if randomly selected. At this point, the enumerator would show illustrations of the Modified KLE (which lacked the visible display screen). The respondent was told that at the end of the month, an indoor air quality summary report would be provided to the household. Note that enumerators were unaware of the treatment status of each RWA cluster at Stages 0 and I, in order to ensure equal and consistent recruitment efforts across experimental arms. We used illustrations of the modified version of the KLE in order to eliminate any disappointment that might come from being assigned in Group C. In total, 1,284 households (14.5 percent of households approached in Stage 0, and 55.4 percent of households that consented to the baseline survey) consented to potentially installing an IAQM inside their home. Survey data was recorded using ODK on an Android tablet, and this tablet was also used to show respondents the informational video, shown in Figure A2 and described below.

IAQM installations were scheduled to be carried out several days after the baseline survey. This decision was made because, during piloting activities, many households were unwilling to provide the enumerator with more time following the survey. In addition, some households wanted the household head to be present at the time of installation. Many did not remember the Wi-Fi password off-hand.

In Stage II, we report on the number of households in Group B and Group C that were willing and able to pair the IAQM with a local Wi-Fi network on the installation day. During this stage, there was heavy attrition, primarily due to: (1) Wi-Fi connectivity issues, which led to many households being dropped from Group C, in particular, since the modified KLE could only generate useful information if it was paired with Wi-Fi; (2) an unwillingness on the part of households to share their Wi-Fi passwords with enumerators, and concerns about data privacy;

and (3) households changing their mind about installing the IAQM (i.e., revoking consent). In total, 51 and 55 monitors were installed and paired with Wi-Fi in Groups B and C, respectively, and 134 additional monitors were distributed to households in Group B without a Wi-Fi connection.

In Stage III, we report on the number of households that completed the endline survey. In total, 758 households completed both survey rounds. We experienced attrition at this stage due to households either declining to participate in another survey round, or our surveyors being unable to contact respondents, despite multiple phone calls and visits. In Group B, seven of the households that had paired the IAQM with Wi-Fi did not complete the endline survey. In addition, 75 of the households that declined the IAQM did not complete the endline survey.

IV. Identifying the High SES Households

As is shown in Tables A2A to A2C, and Table B1, the 106 households that paired their IAQMs with Wi-Fi are observably more educated and wealthier at baseline. Essentially, these are the "high SES" households in the broader sample of medium and high SES households drawn from the RWA clusters. For example, in Table A2B, we compare the 55 "high SES" Group C households that paired the IAQM with Wi-Fi to the combined Group A and B "medium and high SES" sample. The high SES households are more likely to have graduated college (65.5 percent vs. 39.7 percent), live in households with less members (4.3 vs. 5.1), and are more likely to own a car (60.0 vs. 36.0 percent), an air conditioner (89.1 vs. 53.6 percent), an air purifier (24.1 vs. 4.9 percent), and have Wi-Fi (100 vs. 35.4 percent). As shown in Table A2C, these differences are even greater in comparison to "low SES" households, drawn from the J.J. clusters, in which the likelihood of having graduated college is only 11.0 percent, for instance. Note that the J.J. clusters include some of the poorest neighborhoods in Delhi. In contrast, and as shown in Figure A5, the medium and high SES sample is located in areas that have slightly higher land values than the broader Delhi population.

Table B1 shows that the 51 Wi-Fi connected households in Group B are observably the same as the 55 Wi-Fi connected households in Group C. Hence, throughout this paper, we refer to Wi-Fi connected IAQM respondents as the "high SES" households in our data.

V. Informational Video Component for Group B Households

On the day of installation, Group B households were also shown a five-minute informational video, summarizing: (1) the health impacts of sustained exposure to high levels of air pollution; (2) common sources of indoor air pollution in Delhi; (3) instructions for utilizing the standard KLE monitor; and (4) basic recommendations to reduce personal exposure to air pollution, such as using an indoor HEPA air purifier, sealing cracks in walls and windows, regularly ventilating indoor air by opening and closing doors and windows at certain times of the day, wearing a mask when outside, changing indoor smoking and cooking habits, among others. Screenshots of the video are shown in Figure A3.

VI. Subsidized Air Purifier Rental Contract Offers

Immediately after the baseline survey, all Group A (No Monitor) and Group B (Standard Monitor) households were presented with an opportunity to rent an air purifier from SmartAir, an international air purifier manufacturer, at a subsidized and randomly assigned price (*p*) and contract duration (*t*) where:

$$p \in \{399, 799, 1000, 2000\}\ INR$$

and

$$t \in \{2, 4\}\ weeks$$

The air purifier retailed for 8,499 INR, or approximately $116 USD, during the study period. The offer was valid for four weeks and could be availed by visiting the SmartAir website and entering a unique code. The enumerators offered to assist respondents in filling out the online form, if they decided to take up the offer. An example of a subsidized air purifier rental offer is shown in Figure A4.

Over the course of the study, no households accepted any of the subsidized offers. In a follow-up questionnaire, respondents pointed to a number of reasons for this lack of demand, including: (1) They did not think air purifiers were worthwhile (47 percent); (2) They did not receive or understand the procedure to avail the rental offer (20 percent); (3) The contract was too expensive (12 percent); (4) They already owned an air purifier (3 percent); (5) They did not think air pollution was a problem (2 percent); and (6) They did not want to rent the air purifier, but wanted to purchase one (2 percent).

VII. Additional Notes

In Table 2, which reports the impacts of a free, month-long IAQM user trial on medium and high SES households, all regression specifications include the following respondent and household controls, observed at baseline:

- Male (=1)
- Age (years)
- Graduated college (=1)
- Primary cook of the household (=1)
- Number of household members
- Child or senior citizen in house (=1)

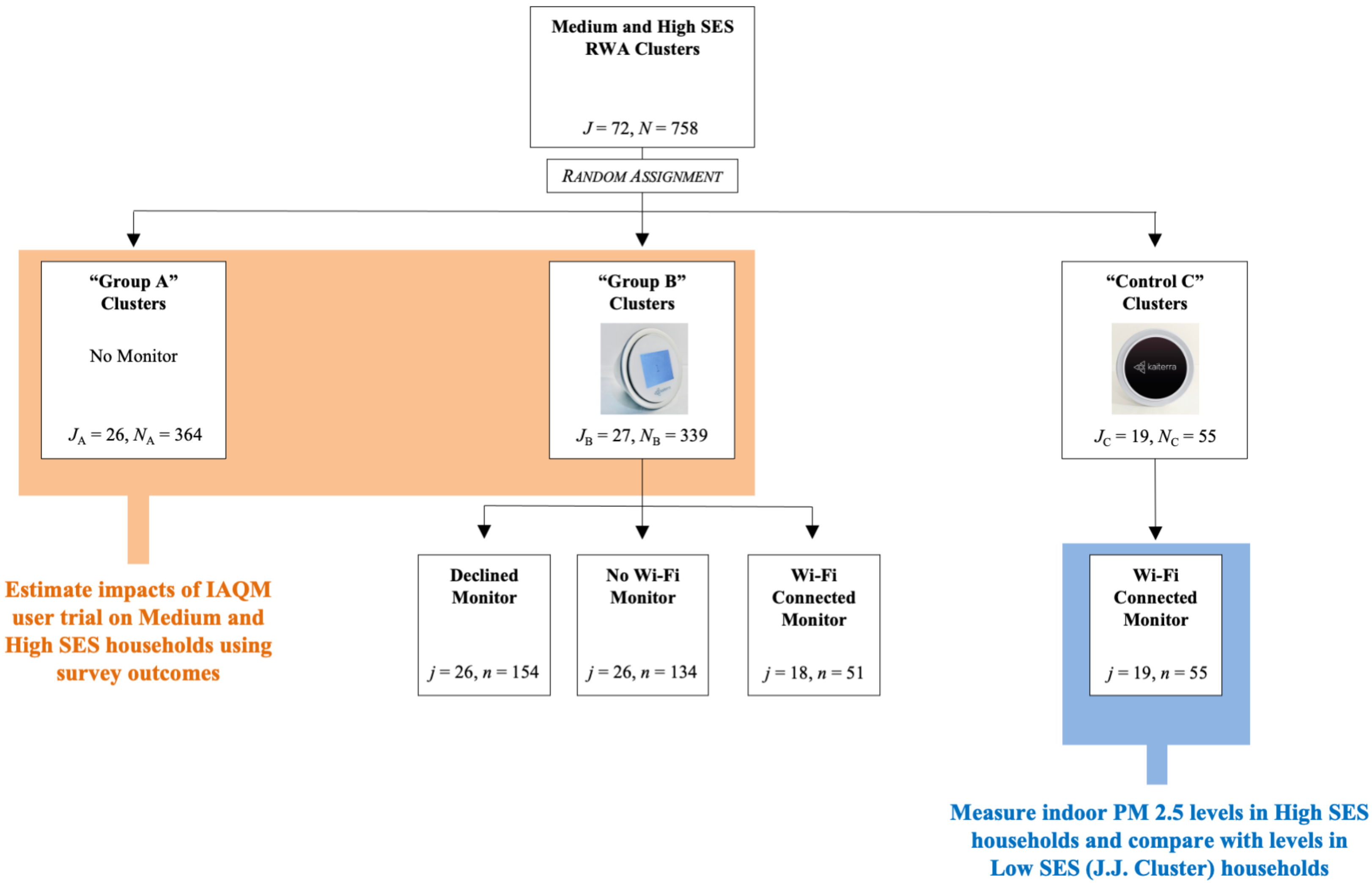
- Owns car (=1)
- Owns air conditioner (=1)
- House has Wi-Fi connection (=1)
- Family owns house (=1)
- Estimated market value of land (USD per square meter)
- Owns air purifier (=1)
- Lit oil lamp, incense, or candle in past week (=1)
- Used mosquito coil in past week (=1)

Figure A1. Indoor air quality monitors (IAQMs)

Panel A—Standard Panel B—Modified

Notes: Panel A presents the standard Kaiterra Laser Egg (KLE), a relatively popular and widely available consumer-grade indoor air quality monitor that retailed for approximately $135 USD during the study period. The standard KLE features a back-lit display communicating real-time $PM_{2.5}$ and PM_{10} concentrations in micrograms per cubic meter ($\mu g/m^3$), or the corresponding Air Quality Index (AQI) levels. When the KLE is switched on and connected to a local Wi-Fi network, it can transmit minute-wise indoor air quality data to a remote server. Panel B presents the modified version of the KLE that measures and transmits indoor $PM_{2.5}$ levels to the remote server, but does not feature a visible and functioning display screen.

Figure A2. Study design for medium and high SES RWA clusters with final sample sizes



Notes: See Table A1 for a summary of enrollment and attrition at various project stages, and Tables A2A to A2D for balance tests across comparison groups. See Appendix B for the results of a related experimental comparison between the Wi-Fi connected high SES households in Groups B and C.

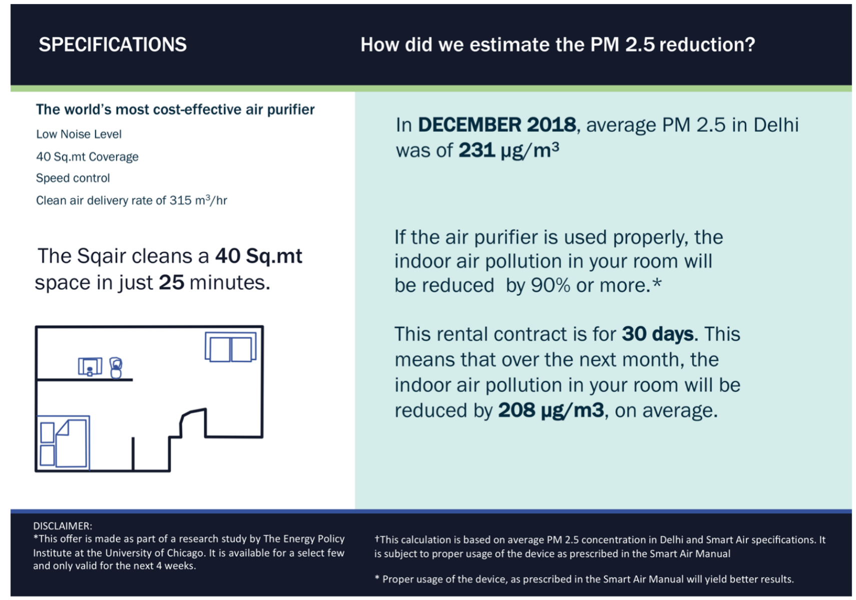
Figure A3. Screenshots of informational video component of Group B (standard monitor) IAQM treatment

Notes: All Group B (standard monitor) RWA cluster respondents were shown a five-minute video summarizing: (1) the health impacts of sustained exposure to high levels of air pollution; (2) common sources of indoor air pollution in Delhi; (3) instructions for utilizing the standard KLE monitor; and (4) basic recommendations to reduce personal exposure to air pollution, such as using an indoor HEPA air purifier, sealing cracks in walls and windows, regularly ventilating indoor air by opening and closing doors and windows at certain times of the day, wearing a mask when outside, changing indoor smoking and cooking habits, among others.

Figure A4. Example of a subsidized air purifier rental contract offer

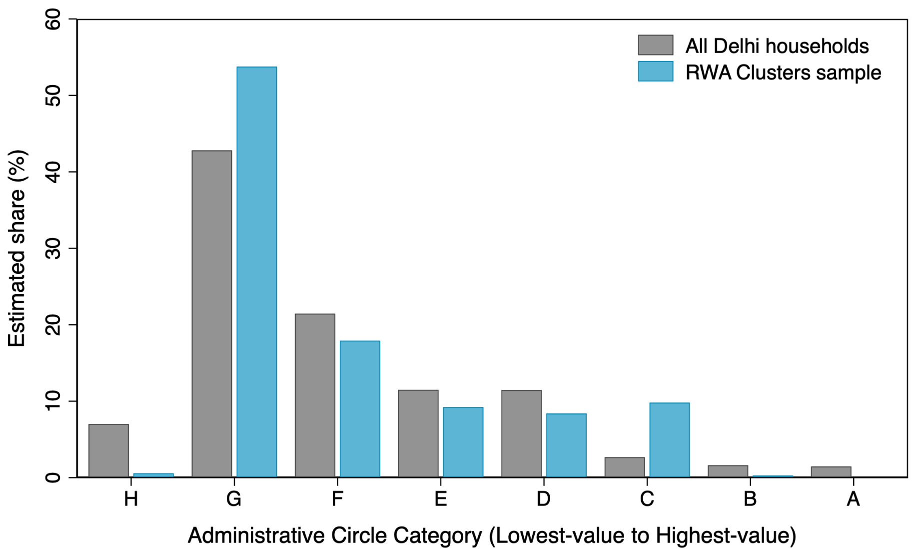
Panel A—Front page

Panel B—Back page



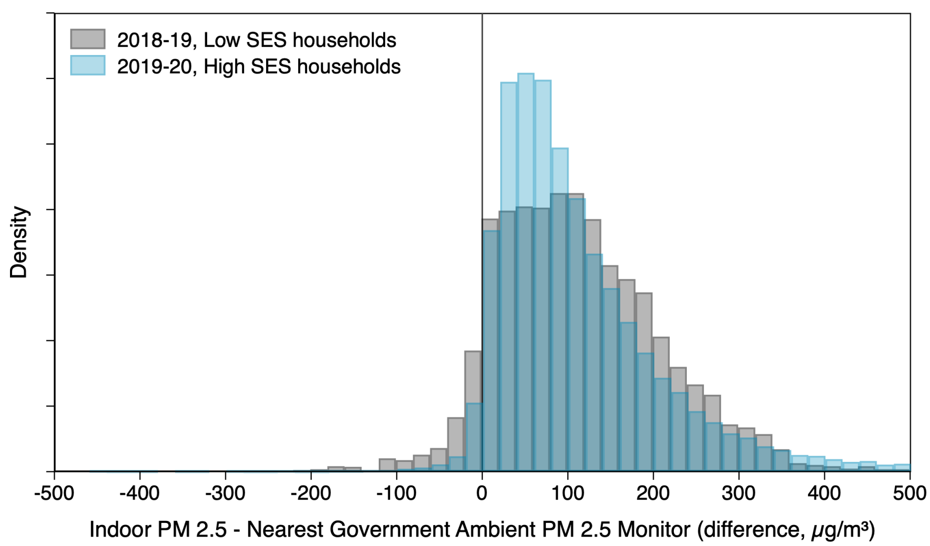
Notes: After the baseline survey, all Group A (no monitor) and Group B (standard monitor) RWA cluster households were presented with an opportunity to rent an air purifier at a subsidized, randomly assigned price ($p \in \{399, 799, 1000, 2000\}$ INR) and contract duration ($t \in \{2, 4\}$ weeks). The air purifier retailed for 8,499 INR, or approximately $116 USD, during the study period. The offer was valid for four weeks. No households accepted the offer. See Appendix Note A for additional details.

Figure A5. Distribution of administrative land values: Medium and high SES RWA clusters sample vs. Delhi



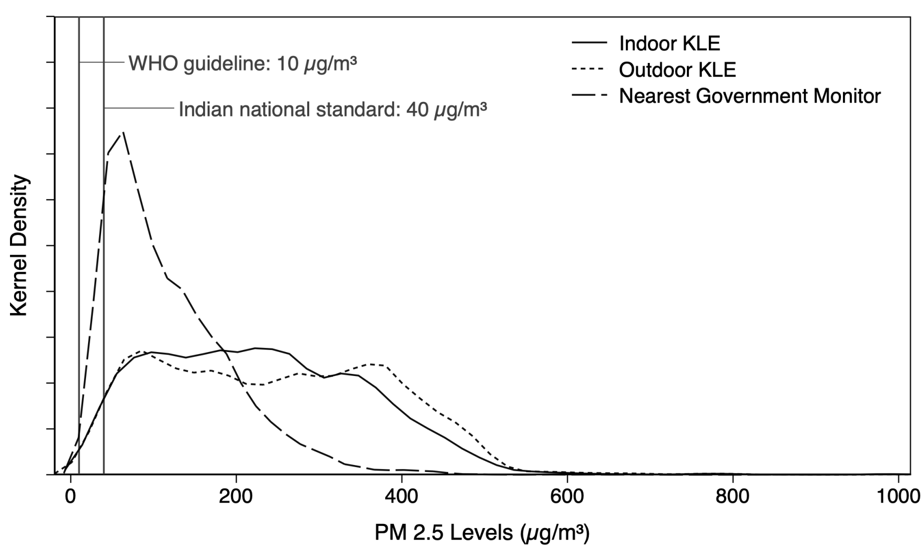
Notes: The Government of the National Capital Territory of Delhi assigns administrative "circle" rates for each locality in Delhi, which can serve as a proxy for relative land values. The term circle rate is used to refer to the minimum land value (INR per square meter) for residential use. There are eight circle categories, ranging from Category A, which corresponds to the highest-valued land in Delhi, to Category H, which corresponds to the lowest-valued land. Based on survey locations, we estimated the approximate distribution of Group A and Group B RWA cluster households, relative to our estimated distribution of all Delhi households.

Figure A6. Indoor - Outdoor, Ambient $PM_{2.5}$ differences in low and high SES households



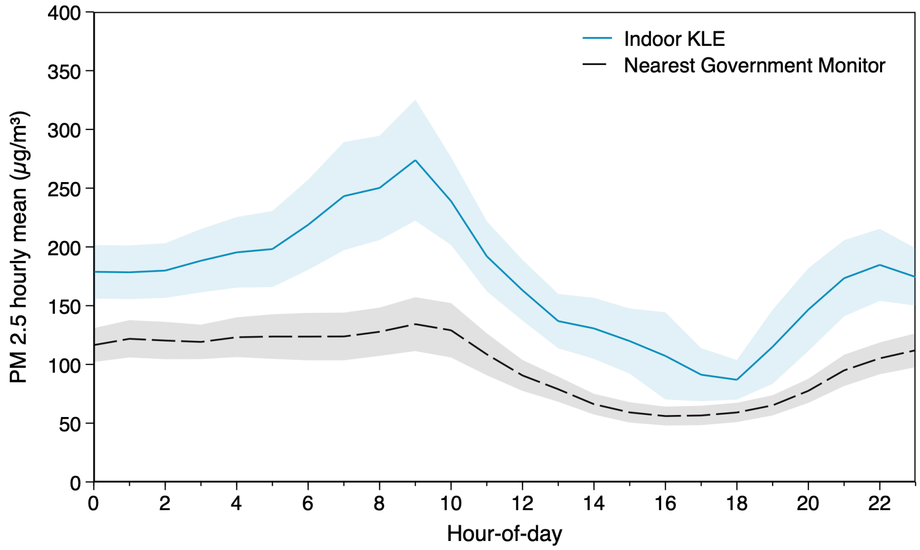
Notes: Indoor PM 2.5 measurements recorded between 9AM and 5PM. High SES households are the Group C, RWA cluster respondents that paired their IAQMs with a local Wi-Fi network. Low SES households are located in the J.J. Clusters across Delhi. Outdoor, ambient $PM_{2.5}$ measurements are from the nearest government monitor. The mean difference is 114.4 and 122.3 $\mu g/m^3$ in the low SES and high SES household samples, respectively.

Figure A7. Indoor, outdoor, and nearest government monitor ambient $PM_{2.5}$ measurements at low SES households



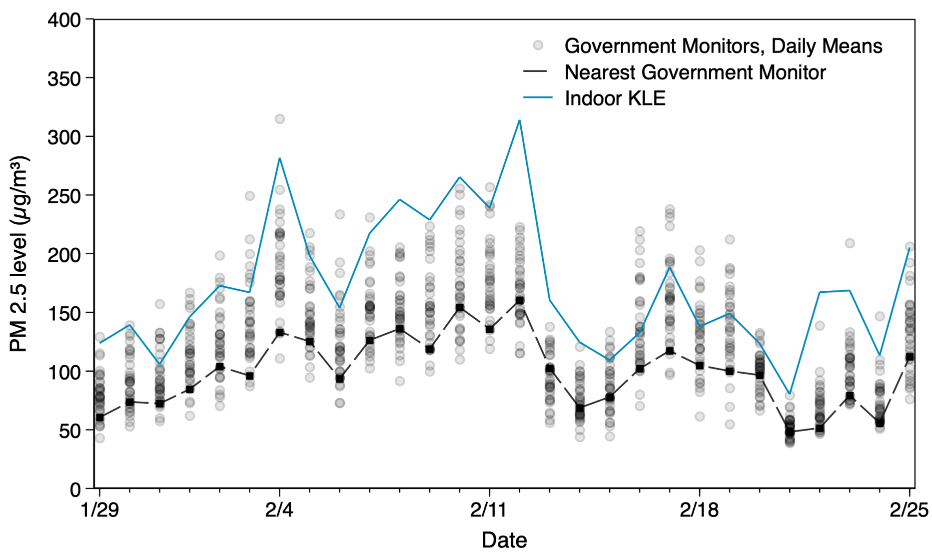
Notes: Indoor and outdoor $PM_{2.5}$ measurements were recorded using a standard KLE monitor. Each measurement is matched to the corresponding ambient $PM_{2.5}$ level from the nearest government monitor. The low SES households are located in the J.J. Clusters across Delhi.

Figure A8A. Indoor $PM_{2.5}$ pattern in a single high SES household in February 2020



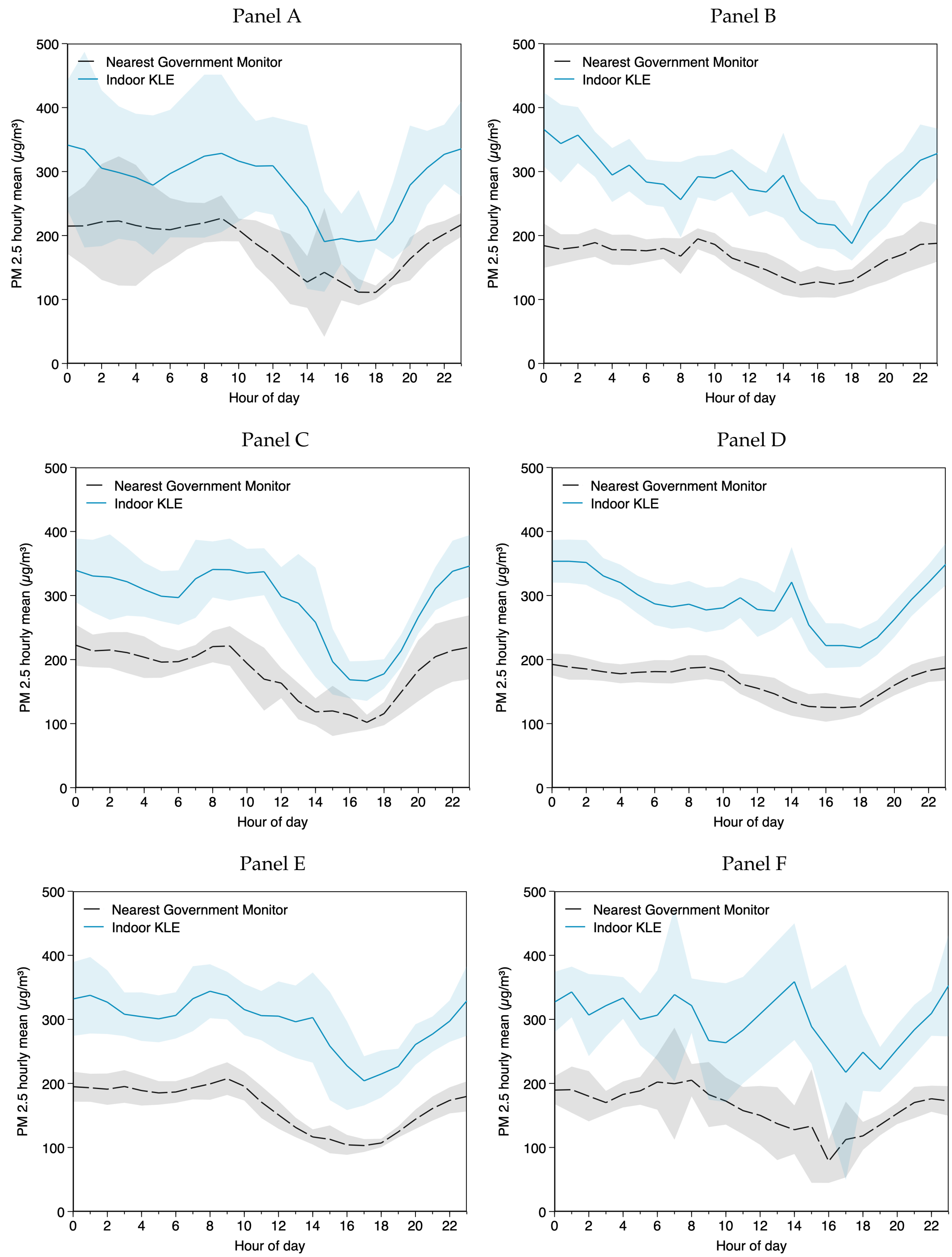
Notes: Daily pattern of indoor $PM_{2.5}$ (solid line) for a single high SES household (Group C, RWA clusters), recorded using a modified KLE monitor between January 29 and February 25, 2020. Ambient $PM_{2.5}$ patterns are plotted using data from the nearest government monitor, which is located 4.2 kilometers away (long-dashed line).

Figure A8B. Intra-city variation in ambient $PM_{2.5}$ measurements from government monitors



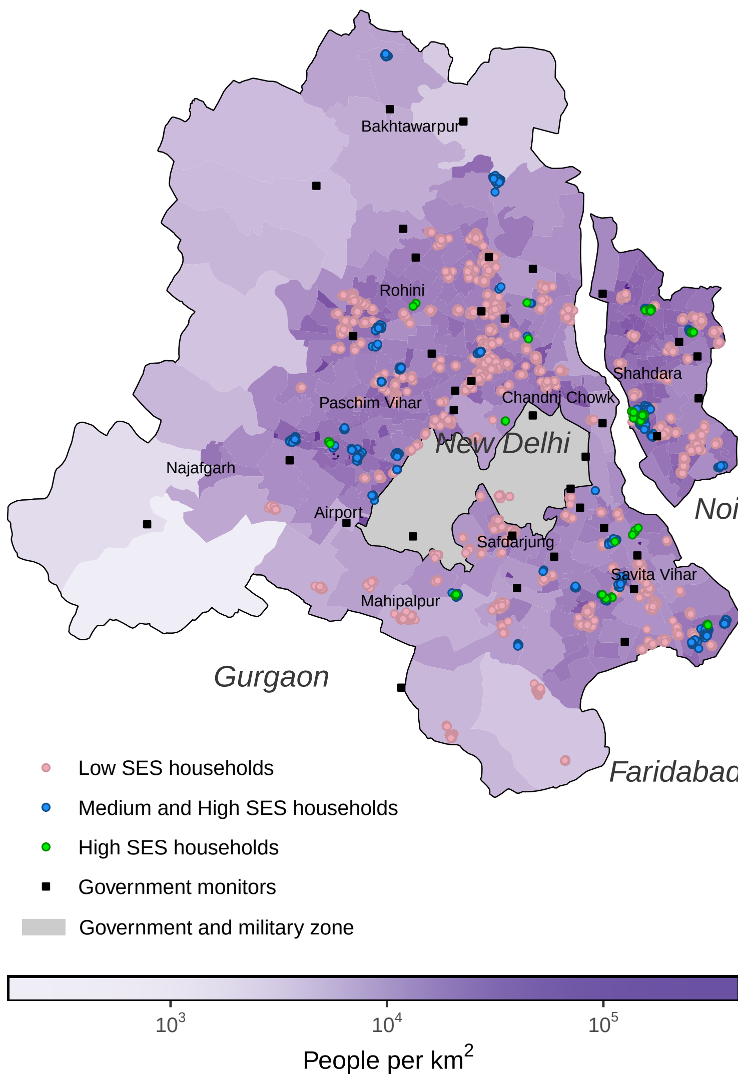
Notes: Daily indoor $PM_{2.5}$ trend (solid blue line) for the single high SES household (Group C, RWA clusters) depicted in Figure A9A is plotted along with daily ambient $PM_{2.5}$ means reported by the government monitors in Delhi (grey dots) as well as the nearest government monitor located 4.2 kilometers away (long-dashed black line). The data was collected between January 29 and February 25, 2020.

Figure A8C—Additional examples of indoor $PM_{2.5}$ patterns in high SES households



Notes: Similar to Figure A8A, we plot patterns of indoor $PM_{2.5}$ for six randomly selected high SES households (Group C, RWA clusters) over their respective month-long treatment periods during the 2019-20 peak pollution period. Ambient $PM_{2.5}$measurements are taken from the nearest government monitors (long-dashed line).

Figure A9—Locations of the low SES, medium and high SES, and high SES samples, and governme



Notes: The low SES households (pink circles) are drawn from the J.J. Clusters administrative list. The medium and high SES households (blue circles) are identified through the RWAs, which are local, non-profit organizations that exist in many of Delhi's middle- and high-income colonies. The high SES households (green circles) are the Group C, RWA cluster respondents that paired their IAQMs with a local Wi-Fi network.

Table A1. Medium and high SES household sample sizes by experimental arm, including clusters (J) and households (N)

		Impacts of an IAQM user trial in medium and high SES households						*Measuring indoor $PM_{2.5}$ in high SES households*			
		Group A: No Monitor			Group B: Standard Monitor			Group C: Modified Monitor			
Study stage		J	N	%	J	N	%	J	N	%	Balance table(s)
0.	Contacted for study recruitment	32	3,248	–	28	3,130	–	30	2,499	–	–
I.	Consented to surveys and IAQM installation	28	539	100	27	421	100	26	324	100	Tables A2D, B1
II.	Installed and paired IAQM with Wi-Fi	–	–		18	51	12.1	19	55	17.0	Table B1
	Installed IAQM without Wi-Fi	–	–		26	134	31.8		–	–	–
	Declined IAQM	–	–		26	236	56.1		–	–	–
III.	Completed study	26	364	67.5	27	339	80.5	19	55	17.0	Tables A2B, A2D, B1

Note: In Stage 0, we attempted to recruit 8,877 households in 90 RWA clusters. In Stage I, 1,284 households (14.5%) consented to being surveyed and installing an IAQM, if randomly selected. Enumerators were unaware of the treatment status of each cluster during recruitment. In Stage II, installations were carried out several days after the baseline survey. In Group A, 185 households (43.9% of Stage I households) accepted the monitor, out of which only 51 were successfully paired with a local Wi-Fi network (12.1% of Stage I households). In Group C, only 55 households were successfully paired with a local Wi-Fi network (17.0% of Stage I households). In Group B, seven Stage II households that installed and paired the IAQM with Wi-Fi and 75 Stage II households that declined the IAQM did not complete the endline survey. In Stage III, 703 households in Groups A and B completed the study (67.5% and 80.5% of Stage I households in Groups A and B, respectively). See Appendix Note A for additional details.

Table A2A. Differences in household characteristics at baseline—Low, medium and high, and high SES household samples

	Low SES Households (*J.J. clusters*)	Medium and High SES Households (*Groups A & B RWA clusters*)	High SES Households (*Group C RWA clusters*)
	(1)	(2)	(3)
Panel A: Respondent characteristics			
Male (%)	45.6	34.7	41.8
Age (years)	36.8	43.0	49.4
Never enrolled in school (%)	24.1	6.4	0
Graduated college (%)	11.0	39.7	65.5
Home-maker (%)	40.0	50.4	47.3
Domestic worker (%)	3.5	0	0
Skilled labour (%)	5.4	2.0	0
Salaried employee (%)	7.6	10.5	10.9
Business owner (%)	4.8	13.7	16.4
Income past week (USD)	27.39	–	–
Panel B: Household characteristics			
Number of household members	6.9	6.6	4.3
Owns air conditioner (%)	10.7	53.6	89.1
Owns air purifier (%)	1.8	4.9	24.1
Uses LPG as primary cooking fuel (%)	96.5	100	98.2
Distance to nearest gov't monitor (km)	2.2	3.4	2.5
House has Wi-Fi connection (%)	–	35.4	100.0
Sample size	3,002	703	55

Notes: Columns 1, 2, and 3 report sample means for low SES, medium and high SES, and high SES households, respectively. Low SES households are located in the J.J. clusters across Delhi and were surveyed between 2018-19. Medium and high SES households are the Group A and B, RWA clusters respondents that completed the study and were surveyed between 2019-20. High SES households are the Group C, RWA clusters respondents that paired their IAQMs with a local Wi-Fi network.

Table A2B. Differences in household characteristics at baseline—Medium and high SES vs. High SES households

	Medium and High SES Households (*Groups A & B*) (1)	High SES Households (*Group C*) (2)	*p*-value of difference (3)
Panel A: Respondent characteristics			
Male (%)	34.7	41.8	0.29
Age (years)	43.0	49.4	0.01
Graduated college (%)	39.7	65.5	< 0.01
Salaried employee (%)	10.5	10.9	0.93
Business owner (%)	13.7	16.4	0.58
Primary cook of the household (%)	61.5	58.2	0.63
Panel B: Household characteristics			
Number of household members	5.1	4.3	0.01
Child or senior citizen in house (%)	67.7	58.2	0.15
Family owns house	27.1	23.6	0.58
Owns car (%)	36.0	60.0	< 0.01
Owns air conditioner (%)	53.6	89.1	< 0.01
Owns air purifier (%)	4.9	24.1	< 0.01
Elevator in building (%)	2.5	14.0	< 0.01
Security guard in building (%)	10.9	39.5	< 0.01
Uses LPG as primary cooking fuel (%)	100.0	98.2	< 0.01
Distance to gov't monitor (km)	3.4	2.5	< 0.01
House has Wi-Fi connection (%)	35.4	100.0	< 0.01
Sample size	703	55	

Notes: Columns 1 and 2 report sample means for medium and high SES households (combining Groups A and B) and high SES households (Group C), respectively. The high SES households are the Group C, RWA clusters respondents that paired their IAQMs with a local Wi-Fi network. Column 3 reports *p*-values of the differences in the means.

Table A2C. Differences in household characteristics at baseline—Low SES vs. High SES households

	Low SES Households (*J.J. clusters*) (1)	High SES Households (*RWA clusters*) (2)	*p*-value of difference (3)
Panel A: Respondent characteristics			
Male (%)	45.6	41.8	0.58
Age (years)	36.8	49.4	< 0.01
Never enrolled in school (%)	24.1	0.0	< 0.01
Graduated college (%)	11.0	65.5	< 0.01
Home-maker (%)	40.0	47.3	0.28
Domestic worker (%)	3.5	0.0	0.16
Skilled labour (%)	5.4	0.0	0.08
Salaried employee (%)	7.6	10.9	0.37
Business owner (%)	4.8	16.4	< 0.01
Income past week (USD)	27.39	–	–
Panel B: Household characteristics			
Number of household members	6.9	4.3	0.08
Owns air conditioner (%)	10.7	89.1	< 0.01
Owns air purifier (%)	1.8	23.6	< 0.01
Uses LPG as primary cooking fuel (%)	96.5	98.2	0.51
Distance to nearest gov't monitor (km)	2.2	2.5	0.15
House has Wi-Fi connection (%)	–	100	–
Sample size	3,002	55	

Notes: Columns 1 and 2 report sample means for low SES and high SES households, respectively. High SES households are the Group C, RWA clusters respondents that paired their IAQMs with a local Wi-Fi network. Low SES households are located in the J.J. Clusters across Delhi. Column 3 reports *p*-values of the differences in the means.

Table A2D. Differences in household characteristics at baseline—Group A vs. Group B Medium and high SES households, at Stages I and III

	Medium and high SES households sample					
	Sample at Stage I			Sample at Stage III		
	Group A (Control) (1)	Group B (Treatment) (2)	*p*-value of difference (3)	Group A (Control) (4)	Group B (Treatment) (5)	*p*-value of difference (6)
Panel A: Respondent characteristics						
Male (%)	31.9	37.1	0.10	31.9	37.8	0.10
Age (years)	43.0	43.0	0.99	42.5	43.5	0.41
Graduated college (%)	38.6	44.2	0.08	36.0	43.7	0.04
Salaried employee(%)	9.6	12.9	0.12	8.8	12.4	0.12
Business owner(%)	12.4	12.6	0.93	14.0	13.3	0.79
Primary cook of the household (%)	63.8	60.6	0.30	62.6	60.2	0.50
Panel B: Household characteristics						
Number of household members	5.0	5.1	0.51	5.0	5.1	0.60
Child or senior citizen in house (%)	69.4	67.5	0.52	68.1	67.3	0.80
Family owns house (%)	26.3	29.4	0.30	26.4	27.8	0.67
Owns car (%)	37.8	37.8	1.00	35.4	36.7	0.73
Owns air conditioner (%)	57.0	52.4	0.16	55.2	51.9	0.38
Owns air purifier (%)	7.1	6.4	0.67	4.4	5.3	0.59
Elevator in building (%)	1.4	2.4	0.29	2.0	2.9	0.49
Security guard in building (%)	9.9	14.0	0.07	10.2	11.7	0.56
Uses LPG as primary cooking fuel (%)	99.6	100.0	0.21	100.0	100.0	–
Distance to gov't monitor (km)	2.8	3.8	< 0.01	2.9	3.9	< 0.01
House has Wi-Fi connection (%)	40.6	35.0	0.08	37.7	32.8	0.18
Sample size	539	421		364	339	

Notes: Columns 1 and 4 report sample means for Group A, RWA clusters households, and columns 2 and 5 for Group B, RWA clusters households. Columns 3 and 6 report *p*-values of the differences in the Group A and B means for the sample at each stage of the study.

Table A3. Predictors of indoor PM 2.5 (logged) in low SES households

	(1)	(2)	(3)
Ambient PM 2.5 (logged)	0.61***	0.40***	0.40***
	(0.03)	(0.03)	(0.03)
Income last week (000s INR)	0.01***	0.01**	0.01
	(0.00)	(0.00)	(0.00)
Hour-of-day, Day-of-week, Month FEs	No	Yes	Yes
Additional controls	No	No	Yes
Observations	2,440	2,438	2,424
R^2	0.39	0.46	0.47

Notes: Indoor PM 2.5 measurements taken using a standard KLE inside low SES respondent homes. Robust standard errors clustered by J.J. cluster sampling point in parantheses. Asterisks indicate coefficient statistical significance level (2-tailed): * $P < 0.10$; ** $P < 0.05$; *** $P < 0.01$.

Table A4. Impacts of a free, month-long IAQM user trial on medium and high SES households

	Control Mean (1)	ITT Effect (2)	TOT Effect (3)	FDR q-val (4)
Panel A: Primary outcomes				
Experienced KLE monitor (%)	0	54.3***	-	-
	[0]	(4.4)		
Accepted subsidized air purifier rental offer (%)	0	0	0	–
	[0]	(0)	(0)	
Panel B: Secondary outcomes				
Own air purifier (%)	5.2	-0.4	-0.7	0.727
	[22.3]	(0.5)	(0.9)	
Sealed gaps in home in past month (%)	4.7	-0.9	-1.6	0.777
	[21.2]	(2.0)	(3.6)	
Closed doors, windows due to outdoor air (%)	82.4	0.4	0.8	0.866
	[38.1]	(2.7)	(4.9)	
Lit oil lamp, incense, or candle in past week (%)	69.8	4.4	8.3	0.635
	[46.0]	(3.9)	(7.1)	
Air pollution awareness index	0	0.20	0.30*	0.383
	[1]	(0.11)	(0.19)	
Very or extremely concerned (%)	61.7	4.2	7.7	0.635
	[48.7]	(4.1)	(7.7)	
Read air pollution news recently (%)	55.8	-6.1*	-11.3*	0.383
	[49.8]	(3.1)	(5.9)	
Used pollution mask in past week (%)	15.9	-1.2	-2.3	0.777
	[36.6]	(3.1)	(5.6)	
Range of regression sample sizes		604 - 693		

Notes:Column 1 reports mean values in Group A (no monitor) with standard deviations in brackets. Column 2 reports coefficients from separate ITT regressions in which the dependent variable (e.g., "Own air purifier (%)") is regressed on a treatment variable indicating whether or not the household was randomly assigned into Group B (standard monitor). Column 3 reports coefficients from separate TOT (IV) regressions in which the treatment indicator ("Accepted IAQM user trial") is instrumented with the treatment variable. All specifications include respondent and household controls, as well as a survey round fixed effect. Column 4 reports the FDR-adjusted q-values associated with the coefficient estimates in column 23 Robust standard errors clustered at the RWA clusters-level in parantheses. Asterisks indicate coefficient statistical significance level (2-tailed): * $P < 0.10$; ** $P < 0.05$; *** $P < 0.01$.

Table A5. Feedback from IAQM households in Group B, RWA clusters

	(%)
Panel A: Observed by enumerator at endline survey	
Monitor was not in use	53.5
Panel B: Reported by respondent at endline survey	
Switched off monitor	39.9
Turned away monitor from use	27.9
Alarmed by monitor readings	43.1
User experience was Extremely good	32.4
Would recommend monitor to peers	61.5

Notes: Based on endline survey data collected from Group B (standard monitor) households that took up the free, month-long user trial.

Appendix Note B

I. The Impacts of a Visible Display Screen

The RWA clusters were randomly assigned across three experimental arms: Group A (No Monitors); Group B (Standard Monitors); and Group C (Modified Monitors). The objective of the study was to examine two experimental comparisons. In the first comparison, which is described in the main text of this article, we evaluate the impact of a free, one-month user trial of a standard KLE monitor on endline survey outcomes, by exploiting random assignment of RWA clusters across Group A and Group B.

In the second intended comparison, which is illustrated in Figure B1 and is the subject of this appendix note, we attempt to evaluate the impact of a visible display screen (Standard Monitor) on indoor $PM_{2.5}$ levels and endline survey outcomes, by exploiting random assignment of RWA clusters across Group B and Group C, which offered households a modified version of the KLE that lacked a visible and functioning display screen.

II. Sampling Issues

Despite random assignment across RWA clusters, we obtained experimental arms that were not balanced along observable household characteristics at baseline, using the sample of households that initially enrolled into the study (i.e., the Stage I households that consented to being surveyed and potentially installing an IAQM, if randomly assigned).[1] In Table B1, we summarize characteristics at baseline for Group B and Group C households. As shown in columns 1 to 3, the sample at Stage I does not appear to be balanced. Group C respondents

[1] See Table A1 for a summary of sample sizes by experimental arm at various study stages.

(*n*=324) are more likely to have graduated from college (51.7 vs. 44.2 percent), and live in households that own cars (51.6 vs. 37.8 percent), air conditioners (74.6 vs. 52.4 percent), and air purifiers (11.6 vs. 6.4 percent), and have a Wi-Fi connections (59.0 vs. 35.0 percent).

Recall that the Group C and Group B experimental comparison required households to not only install an IAQM inside their home, but to also pair the device with a Wi-Fi network. Due to this technical and economic requirement, there was heavy attrition in this comparison sample. The initial (Stage I) sample sizes were reduced from 421 and 324 households in Groups B and C, respectively, to 51 and 55 Wi-Fi connected households in Groups B and C, respectively, by Stage II. There were a number of reasons for these declines, including: (1) the household lacked a local Wi-Fi network connection; (2) the household was unwilling or unable to share the Wi-Fi password with the survey enumerator at the time of installation (e.g., the household member who knew the password could not be reached); and (3) the household was concerned about privacy and what data the device might measure and transmit (e.g., some respondents were concerned the device would record and transmit audio).

In total, 106 households installed and paired the IAQM with a local Wi-Fi network, transmitting nearly two million, minute-level indoor $PM_{2.5}$ measurements to the remote server, over the five rounds of the study. Out of these 106 households, 93 completed the endline survey (Stage III). In Table B1, columns 4 to 6, we compare differences in household characteristics at baseline for these 93 households. Despite the imbalance we observe in columns 1 and 2, we do not detect statistically significant differences in columns 4 and 5. In other words, the two smaller subsets of Wi-Fi connected households appear to be roughly the same. Note that more broadly, households that were willing and able to pair the IAQM with a local Wi-Fi network are better educated and wealthier on average than the typical RWA clusters household we survey, as well as the low SES households in the J.J. clusters sample.

III. Estimating Impacts on Indoor PM 2.5

Due to the sampling issues described above, the following data and results must be interpreted with caution. To assess the effect of the visible display screen on indoor $PM_{2.5}$, we utilize the high-frequency data generated by the IAQMs to estimate the effect of a randomly assigned visible display screen on average indoor $PM_{2.5}$ levels. In Tables B2A and B2C, we report the results of estimating regressions of the following form:

$$y_{it} = b_0 + b_1 T_i + b_2 PM_{it} + b_3 D_{it} + X_i^{'} \Lambda + \delta_t + \delta_r + \varepsilon_{it}$$

where y_{it} represents the outcome of interest for household i in the 15-minute interval period t (the outcome of interest is Indoor $PM_{2.5}$ (logged) in Tables B2A and B2B, and Data Availability (%) in Tables B2C and B2D); T_i is a binary variable indicating whether household i was randomly assigned into the visible display treatment (Group C); PM_{it} is ambient $PM_{2.5}$ (logged) in period t based on the nearest government monitor to household i; D_{it} is the number of days after installation (rounded down); X_i is a vector of household characteristics at baseline; δ_t are time fixed effects for month-of-year, day-of-month, and hour-of-day; δ_r is a survey round fixed effect; and standard errors are clustered at the neighborhood level. In Tables B2B and B2D, we report the results of specifications which include interaction terms between T and key variables of interest, such as PM and D.

The vector X_i includes the following variables observed at baseline: Male (=1); Age (years); Graduated college (=1); Primary cook of the household (=1); Number of household members; Child or senior citizen in house (=1); Owns car (=1); Owns air conditioner (=1);

Family owns house (=1); Estimated market value of land (USD per square meter); Owns air purifier (=1); Lit oil lamp, incense, or candle in past week (=1); Used mosquito coil in past week (=1).

In Table B2A, column 5, we show that when controlling for time fixed effects and household controls, a randomly assigned visible display screen leads to an 8.6 percent decline (*t*-stat = 1.93) in average indoor $PM_{2.5}$. In Table B2B, we show that the reduction in indoor PM 2.5 is not differentially greater the longer a user interacts with the IAQM (the estimated coefficient on $D \times T$ is zero) or in more polluted periods (the estimated coefficient on $PM \times T$ is zero). There is suggestive evidence, however, that the treatment effect is greater for households that own air purifiers (column 4), although this effect is not statistically significant.

In Table B2C, we estimate the effect of the visible display screen on data availability, which captures whether or not the IAQM was switched on and in use in any given time interval. The treatment effect on data availability is -11.2 percentage points (*t*-stat: 1.76, column 4) when excluding household controls, and-5.1 percentage points (t-stat = 0.67, column 5) when including household controls.

In Table B2D, we show that data availability is not differentially lower for treatment households in more polluted periods (the estimated coefficient on $PM \times T$ is zero) (e.g., the user switches off the monitor when pollution is high), which could have potentially explained the negative effect of the visible display screen on indoor $PM_{2.5}$. At the same time, data availability is differentially lower as more time elapses following installation (the estimated coefficient on $D \times T$ is -0.48; *t*-stat = 1.07). These results suggest that the informational content of real-time $PM_{2.5}$ information may decrease as households become accustomed to the general air quality environment inside their homes. Alternatively, in a highly polluted environment like Delhi, households may experience information fatigue from being repeatedly reminded of the same extremely high levels of indoor PM 2.5 inside their homes.

III. Estimating Impacts on Survey Outcomes

What would explain the reduction in average indoor $PM_{2.5}$ for households that experienced an IAQM with a visible display screen? Using survey data, we can estimate treatment effects using regression specifications of the following form:

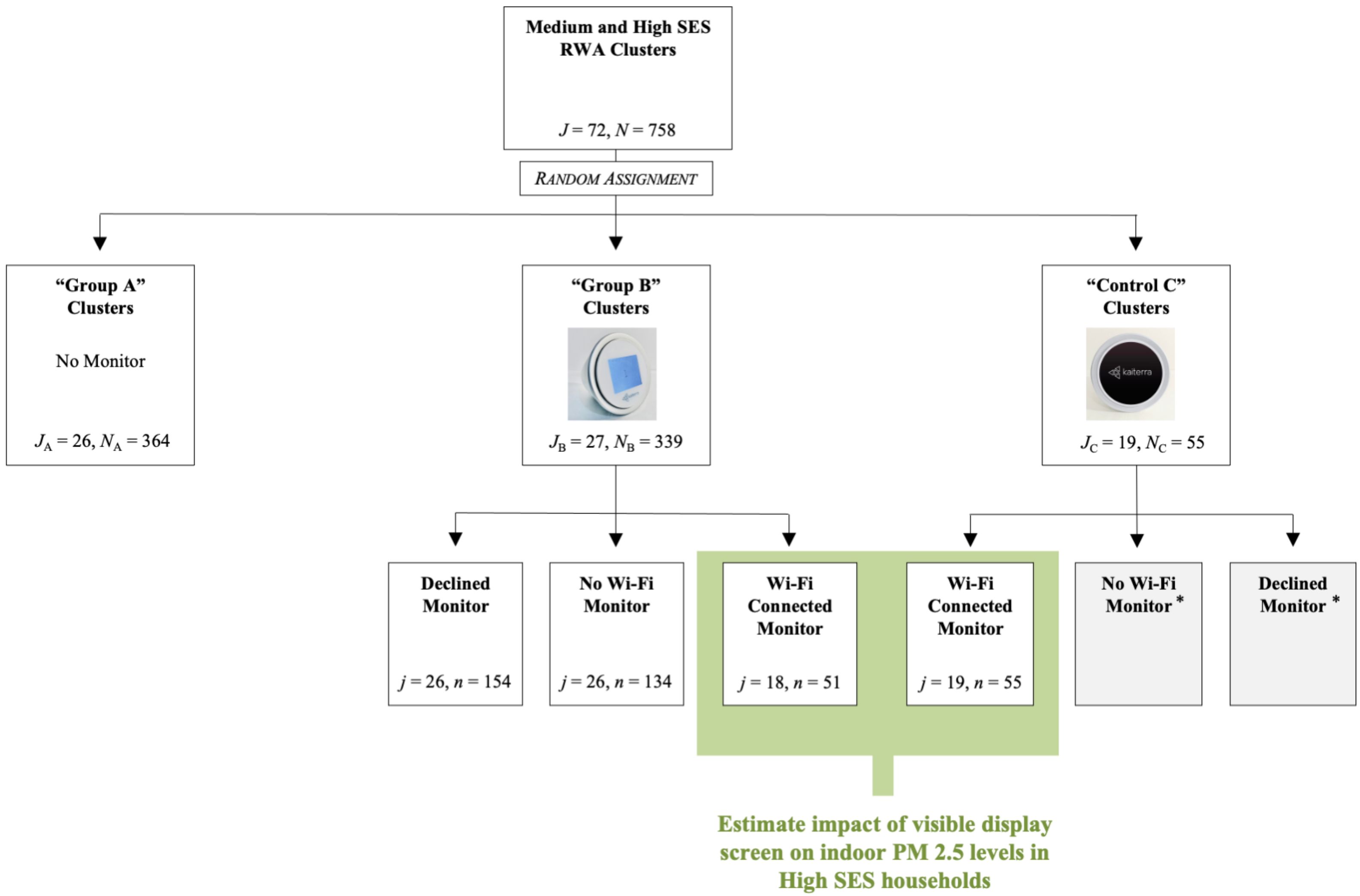
$$y_i = \beta_0 + \beta_1 T_i + X_i^{'}\Lambda + \delta_r + \varepsilon_i$$

where y_i represents the various outcomes of interest; T_i is a binary variable indicating household assignment into Group C (Standard Monitor); X_i is a vector of household-level characteristics at baseline; δ_r is a survey round fixed effect; and standard errors are clustered at the RWA cluster level. The vector X_i includes the following variables observed at baseline: Male (=1); Age (years); Graduated college (=1); Primary cook of the household (=1); Number of household members; Child or senior citizen in house (=1); Owns car (=1); Owns air conditioner (=1); Family owns house (=1); Estimated market value of land (USD per square meter); Owns air purifier (=1); Lit oil lamp, incense, or candle in past week (=1); Used mosquito coil in past week (=1).

In Table B3, we summarize the estimated β_1 coefficients on a number of defensive actions and air pollution awareness outcomes, including whether or not the household owned an air purifier at endline. Similar to the results in Table 2, the visible display screen treatment did not increase ownership of air purifiers. However, there is a large treatment effect on whether or not the household ventilated due to the outdoor air in the past week (specifically, by closing doors and windows) (22.8 percentage point increase; *t*-stat = 2.09) and whether or not the respondent used a pollution mask in the past week (9.0 percentage point increase; *t*-stat = 2.20).

Given the sampling issues described above, all of the results summarized in this appendix note must be interpreted with caution. However, the results point to a few possibilities and areas for further research. For instance, in this setting and among this particular group of high SES, Wi-Fi connected households, the regression results suggest that people may respond to high-frequency information about indoor air pollution by adopting low-cost behavioral changes to reduce indoor $PM_{2.5}$ exposure, but their willingness to pay for clean air is low. Alternatively, these results may suggest that different kinds of information, such as information reminding users of the impacts of $PM_{2.5}$ exposure on health, could prove to be more effective in inducing defensive behaviors and actions than the flashing $PM_{2.5}$ numbers on an IAQM screen.

Figure B1. Study design for medium and high SES RWA Clusters with final sample sizes



Notes: In an associated experimental comparison, we estimated the impact of a visible display screen on endline survey outcomes and indoor $PM_{2.5}$ measurements by comparing the subset of Group B, RWA clusters households that paired their IAQMs with Wi-Fi with the Group C, RWA clusters households that also paired their IAQMs with Wi-Fi. Based on education and household assets, these are the High SES households in our data. In the combined sample, there are 106 households that transmitted nearly two million minute-wise indoor $PM_{2.5}$ measurements to the remote server, out of which 93 households completed the endline survey.

Table B1. Differences in household characteristics at baseline—Group B vs. Group C, RWA clusters households at Stages I and III

	Medium and High SES households in RWA Clusters					
	Sample at Stage I (i.e., *Medium and high SES households*)			Sample at Stage III (i.e., *High SES households (with Wi-Fi)*)		
	Group C (Control) (1)	Group B (Treatment) (2)	*p*-value of difference (3)	Group C (Control) (4)	Group B (Treatment) (5)	*p*-value of difference (6)
Panel A: Respondent characteristics						
Male (%)	31.2	37.1	0.09	42.9	50.0	0.50
Age (years)	47.5	43.0	< 0.01	49.4	52.4	0.42
Graduated college (%)	51.7	44.2	0.04	61.2	56.8	0.67
Salaried employee(%)	9.0	12.9	0.09	10.2	14.0	0.59
Business owner(%)	12.0	12.6	0.81	18.4	16.3	0.79
Primary cook of the household (%)	62.0	60.6	0.68	59.2	43.2	0.13
Panel B: Household characteristics						
Number of household members	4.7	5.1	0.04	4.4	4.4	0.92
Child or senior citizen in house (%)	71.3	67.5	0.26	61.2	70.5	0.35
Family owns house (%)	22.5	29.4	0.04	24.5	23.3	0.89
Owns car (%)	51.6	37.8	< 0.01	61.2	79.5	0.06
Owns air conditioner (%)	74.6	52.4	< 0.01	89.8	95.5	0.31
Owns air purifier (%)	11.6	6.4	0.01	18.8	18.2	0.94
Elevator in building (%)	5.8	2.4	0.02	10.8	4.0	0.34
Security guard in building (%)	17.8	14.0	0.19	37.8	44.0	0.63
Uses LPG as primary cooking fuel (%)	99.4	100.0	0.11	98.0	100.0	0.35
Distance to gov't monitor (km)	2.6	3.8	< 0.01	2.5	3.0	0.04
House has Wi-Fi connection (%)	59.0	35.0	< 0.01	100.0	100.0	–
Sample size	324	421		49	44	

Notes: Columns 1 to 3 compare sample means between Group C and Group B households, based on the initial sample that consented to the study (Stage I). At this stage, the sample consisted of a combination of medium and high SES households. Columns 4 to 6 compare sample means between the subset of Group C and Group B households that connected their IAQMs to Wi-Fi, and are the subject of this experimental comparison. At this stage, the 93 households that transmitted data to the remote server and completed the endline survey, were high SES households, with higher rates of education and asset ownership.

Table B2A. Impact of visible display screen on indoor $PM_{2.5}$ (logged) for high SES households

	(1)	(2)	(3)	(4)	(5)
Visible display screen (=1)	-0.17**	-0.09*	-0.09*	-0.08*	-0.09*
	(0.06)	(0.05)	(0.05)	(0.05)	(0.04)
Ambient PM 2.5 (logged)	0.83***	0.81***	0.81***	0.63***	0.65***
	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)
Days after installation	-0.00	-0.00	-0.00	-0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
Respondent is male (=1)					-0.00
					(0.04)
Age of respondent (years)					-0.00**
					(0.00)
Graduated college (=1)					-0.02
					(0.05)
Respondent is primary cook (=1)					0.05
					(0.04)
Number of household members					-0.02**
					(0.01)
Child or senior citizen at home (=1)					0.04
					(0.03)
Owns car (=1)					-0.00
					(0.03)
Owns air conditioner (=1)					-0.10
					(0.06)
Owns air purifier (=1)					-0.05
					(0.04)
Est. market value of land (USD/sq. mtr.)					-0.00
					(0.00)
Lit incense, lamp, candle in past week (=1)					0.01
					(0.04)
Lit mosquito coil in past week (=1)					0.07*
					(0.04)
Round FE	No	Yes	Yes	Yes	Yes
Hour of week FE	No	No	Yes	Yes	Yes
Day of year FE	No	No	No	Yes	Yes
Mean indoor PM 2.5 ($\mu g/m^3$)	261.6	261.6	261.6	261.6	261.6
Monitors	106	106	106	106	106
Observations	149,395	149,395	149,395	149,395	149,395
R^2	0.68	0.69	0.70	0.73	0.74

Notes: Average indoor $PM_{2.5}$ is summarized at 15-minute intervals. Robust standard errors clustered by RWA clusters are in parantheses. Asterisks indicate coefficient statistical significance level (2-tailed): * $P < 0.10$; ** $P < 0.05$; *** $P < 0.01$.

Table B2B. Impact of visible display screen on indoor $PM_{2.5}$ (logged) (with interactions) for high SES households

	(1)	(2)	(3)	(4)
T: Visible display screen (=1)	-0.09*	-0.07	-0.29**	-0.07*
	(0.05)	(0.05)	(0.14)	(0.04)
Ambient PM 2.5 (logged)	0.65***	0.65***	0.63***	0.65***
	(0.02)	(0.02)	(0.03)	(0.02)
Days after installation	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Owns air purifier (=1)	-0.06	-0.06	-0.06	-0.03
	(0.05)	(0.05)	(0.05)	(0.04)
Days after treatment × T		-0.00		
		(0.00)		
Ambient PM 2.5 (logged) × Treatment			0.04	
			(0.03)	
Owns air purifier (=1) × T				-0.07
				(0.12)
Mean indoor PM 2.5 (μg/m³)	261.6	261.6	261.6	261.6
Monitors	106	106	106	106
Observations	149,395	149,395	149,395	149,395
R^2	0.74	0.74	0.74	0.74

Notes: Average indoor PM 2.5 is summarized at 15-minute intervals. Robust standard errors clustered by RWA Clusters are in parantheses. All specifications include round, hour of week, and day of year fixed effects, and household controls. Column 1 reports the same results shown inTable B2A, column 5. Asterisks indicate coefficient statistical significance level (2-tailed): * $P < 0.10$; ** $P < 0.05$; *** $P < 0.01$.

Table B2C. Impact of visible display screen on data availability (%) for high SES households

	(1)	(2)	(3)	(4)	(5)
Visible display screen (=1)	-7.5	-11.5*	-11.5*	-11.2*	-5.1
	(6.4)	(6.5)	(6.5)	(6.4)	(7.6)
Ambient PM 2.5 (logged)	-2.1	0.1	0.3	2.6	1.6
	(2.1)	(1.6)	(1.7)	(2.4)	(2.3)
Days after installation	-0.8***	-0.8***	-0.8***	-1.0	-1.1
	(0.2)	(0.2)	(0.2)	(1.0)	(1.1)
Respondent is male (=1)					0.5
					(6.8)
Age of respondent (years)					0.2
					(0.2)
Graduated college (=1)					11.3*
					(6.0)
Respondent is primary cook (=1)					19.1***
					(6.7)
Number of household members					-0.3
					(1.7)
Child or senior citizen at home (=1)					3.5
					(5.6)
Owns car (=1)					-9.6
					(7.0)
Owns air conditioner (=1)					11.2
					(11.4)
Owns air purifier (=1)					2.5
					(9.0)
Est. market value of land (USD/sq. mtr.)					0.0*
					(0.0)
Lit incense, lamp, candle in past week (=1)					-9.5
					(5.8)
Lit mosquito coil in past week (=1)					-4.8
					(9.0)
Round FE	No	Yes	Yes	Yes	Yes
Hour of week FE	No	No	Yes	Yes	Yes
Day of year FE	No	No	No	Yes	Yes
Mean data availability (%)	54.0	54.0	54.0	54.0	54.0
Monitors	106	106	106	106	106
Observations	276,445	276,445	276,445	276,444	276,444
R^2	0.02	0.04	0.04	0.07	0.12

Notes: Data availability is summarized at 15-minute intervals. Robust standard errors clustered by RWA clusters are in parantheses. Asterisks indicate coefficient statistical significance level (2-tailed): * $P < 0.10$; ** $P < 0.05$; *** $P < 0.01$.

Table B2D. Impact of visible display screen on data availability (%) (with interactions) for high SES households

	(1)	(2)	(3)	(4)
T: Visible display screen (=1)	-7.51	2.00	14.19	-5.33
	(6.41)	(8.78)	(16.86)	(8.37)
Ambient PM 2.5 (logged)	-2.08	1.58	3.49	1.60
	(2.13)	(2.43)	(2.94)	(2.39)
Days after installation	-0.83***	-0.83	-1.12	-1.10
	(0.25)	(1.06)	(1.07)	(1.00)
Owns air purifier at baseline (=1)		2.68	2.66	1.96
		(8.95)	(8.93)	(9.05)
Days after treatment × T		-0.48		
		(0.45)		
Ambient PM 2.5 (logged) × T			-3.97	
			(3.46)	
Owns air purifier (=1) × T				1.81
				(17.66)
Mean data availability (%)	54.0	54.0	54.0	54.0
Monitors	106	106	106	106
Observations	276,445	276,444	276,444	276,444
R^2	0.02	0.12	0.12	0.12

Notes: Data availability is summarized at 15-minute intervals. Robust standard errors clustered by RWA Clusters are in parantheses. All specifications include round, hour of week, and day of year fixed effects, and household controls. Column 1 reports the same results shown inTable B2C, column 5. Asterisks indicate coefficient statistical significance level (2-tailed): * $P < 0.10$; ** $P < 0.05$; *** $P < 0.01$.

Table B3. Impacts of a visible display screen on high SES households

	Control Mean (1)	Treatment Effect (2)	FDR q-val (3)
Own air purifier (%)	18.4	0	0.028
	[39.1]	(0)	
Sealed gaps in home in past month (%)	0	0	-
	[0]	-	
Ventilated due to outdoor air in past week (%)	56.3	22.8**	0.104
	[50.1]	(10.9)	
Lit oil lamp, incense, or candle in past week(%)	70.9	-5.1	0.717
	[45.9]	(9.9)	
Air pollution awareness index	0	-0.40	0.280
	[1]	(0.2)	
Very or extremely concerned (%)	63.3	-8.0	0.514
	[48.7]	(8.8)	
Read air pollution news recently (%)	52.1	1.2	0.897
	[50.5]	(9.3)	
Used pollution mask in past week(%)	4.8	9.0**	0.104
	[20.2]	(4.1)	
Range of regression sample sizes	81 - 91		

Notes: Column 1 reports mean values in Group C, RWA clusters high SES households with standard deviations in brackets. Column 2 reports coefficients from separate ITT regressions in which the dependent variable (e.g., "Own air purifier (%)") is regressed on a treatment variable indicating whether or not the high SES (Wi-Fi connected) household was randomly assigned into Group B (i.e., assigned a standard KLE monitor). All specifications include household and respondent covariates, as well as a survey round fixed effect. Column 3 reports the FDR-adjusted q-values associated with the coefficient estimates in column 2. Robust standard errors clustered at the RWA clusters-level are in parantheses. Asterisks indicate coefficient statistical significance level (2-tailed): * $P < 0.10$; ** $P < 0.05$; *** $P < 0.01$.