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Supplemental Material

Household Air Pollution Concentrations after Liquefied Petroleum Gas Interventions in Rural Peru: Findings from a One-Year Randomized Controlled Trial Followed by a One-Year Pragmatic Crossover Trial

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SUPPLEMENTARY TABLES AND FIGURES

Table S1. CONSORT checklist of information to include when reporting a randomized trial assessing nonpharmacologic treatments*

Section/Topic Item	Checklist item no.	CONSORT item	Extension for NPT trials
Title and abstract			
	1a	Identification as a randomized trial in the title	DONE
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	<i>Refer to CONSORT extension for abstracts for NPT trials</i> DONE
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	DONE
	2b	Specific objectives or hypotheses	DONE
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	When applicable, how care providers were allocated to each trial group DONE
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	DONE
Participants	4a	Eligibility criteria for participants	When applicable, eligibility criteria for centers and for <i>care providers</i> DONE
	4b	Settings and locations where the data were collected	DONE
Interventions†	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	Precise details of both the experimental treatment and comparator DONE
	5a		Description of the different components of the interventions and, when applicable, description of the procedure for tailoring the interventions to individual participants. DONE

Section/Topic Item	Checklist item no.	CONSORT item	Extension for NPT trials
	5b		Details <i>of whether and</i> how the interventions were standardized. DONE
	5c.		Details <i>of whether and</i> how adherence of care providers to the protocol was assessed or enhanced N/A
	5d		<i>Details of whether and how adherence of participants to interventions was assessed or enhanced</i> DONE
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	DONE
	6b	Any changes to trial outcomes after the trial commenced, with reasons	DONE
Sample size	7a	How sample size was determined	When applicable, details of whether and how the clustering by care providers or centers was addressed DONE
	7b	When applicable, explanation of any interim analyses and stopping guidelines	N/A (no changes in trial outcomes)
Randomization:			
- Sequence generation	8a	Method used to generate the random allocation sequence	DONE
	8b	Type of randomization; details of any restriction (such as blocking and block size)	DONE
- Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	DONE

Section/Topic Item	Checklist item no.	CONSORT item	Extension for NPT trials
- Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	DONE
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	If done, who was blinded after assignment to interventions (e.g., participants, care providers, <i>those administering co-interventions</i> , those assessing outcomes) and how DONE
	11b	If relevant, description of the similarity of interventions	N/A
	11c		<i>If blinding was not possible, description of any attempts to limit bias</i> DONE
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	DONE When applicable, details of whether and how the clustering by care providers or centers was addressed: N/A
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	N/A (no sub-analyses done)
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analyzed for the primary outcome	DONE The number of care providers or centers performing the intervention in each group and the number of patients treated by each care provider or in each center: N/A
	13b	For each group, losses and exclusions after randomization, together with reasons	DONE
	13c		<i>For each group, the delay between randomization and the initiation of the intervention</i> DONE
	new		Details of the experimental treatment and comparator as they were implemented DONE

Section/Topic Item	Checklist item no.	CONSORT item	Extension for NPT trials
Recruitment	14a	Dates defining the periods of recruitment and follow-up	DONE
	14b	Why the trial ended or was stopped	N/A
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	DONE When applicable, a description of care providers (case volume, qualification, expertise, etc.) and centers (volume) in each group. N/A
Numbers analyzed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	DONE
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	DONE
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	DONE
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	N/A
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	DONE
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	DONE In addition, take into account the choice of the comparator, lack of or partial blinding, and unequal expertise of care providers or centers in each group
Generalizability	21	Generalizability (external validity, applicability) of the trial findings	DONE Generalizability (external validity) of the trial findings according to the intervention, comparators, patients, and care providers and centers involved in the trial

Section/Topic Item	Checklist item no.	CONSORT item	Extension for NPT trials
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	DONE
Other information			
Registration	23	Registration number and name of trial registry	DONE
Protocol	24	Where the full trial protocol can be accessed, if available	DONE
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	DONE

**Additions or modifications to the 2010 CONSORT checklist. CONSORT = Consolidated Standards of Reporting Trials*

†The items 5, 5a, 5b, 5c, 5d are consistent with the Template for Intervention Description and Replication (TIDieR) checklist

Table S2. Number and percent of cumulative PM and BC samples below the detection limit in rural Peru (n=180 participants)

Visit ^a	Control group - Biomass cookstove		Intervention group - LPG stove	
	N	Percent	N	Percent
Kitchen PM_{2.5}				
Baseline	2	2	6	7
3	13	14	64	71
6	13	14	52	58
12	8	9	31	35
18	33	37	41	47
24	40	47	40	47
Personal PM_{2.5}				
Baseline	16	18	18	20
3	28	31	59	66
6	19	21	39	43
12	16	18	37	42
18	53	59	51	58
24	49	57	48	56
Kitchen BC				
Baseline	3	3	3	3
3	11	12	76	84
6	13	14	67	74
12	6	7	66	74
18	79	88	48	55
24	81	94	51	59
Personal BC				
Baseline	15	17	10	11
3	29	32	85	94
6	27	30	83	92
12	18	20	78	89
18	85	94	60	68
24	81	94	66	77

a. Visits: Baseline and 3-, 6-, 12-, 18-, and 24-months. PM_{2.5}: fine particulate matter; BC: black carbon. The limit of detection for PM_{2.5} was 20 µg/filter for the first six months of the study and 9.8 µg/filter for the remainder of 2.5 years of the study. The LOD for BC was 1.4 µg/filter.

Table S3. Percent of CO direct-reading measurements below the instrument detection limit during most common cooking times of the day in rural Peru (5 AM to 9:30 AM and 6 PM to 7 PM)

Visit ^a	Control group - Biomass cookstove						Intervention group - LPG stove					
	N	Mean	SD	Median	25th pct	75th pct	N	Mean	SD	Median	25th pct	75th pct
Kitchen CO												
Baseline	85	30.6	23.2	25.9	12.4	43.4	87	31.9	21.5	30.2	16.7	40.8
3	84	33.9	24.5	30.1	14.4	47.5	83	65.4	29.2	73.1	45.7	90.7
6	86	33.3	22.9	29.8	19.1	45.4	82	57.8	27.4	62.9	36.9	80.2
12	86	33.4	23.3	30.9	14.8	46.7	78	56.3	29.7	61.5	31.6	80.7
18	84	60.2	29.9	64.3	38.7	83.0	80	47.3	31.2	45.9	17.1	76.0
24	81	62.3	23.8	61.6	46.5	82.1	79	44.7	28.8	38.2	23.1	69.9
Personal CO												
Baseline	81	55.7	27.4	63.0	39.3	74.7	80	57.0	23.4	58.7	38.9	74.0
3	80	64.2	25.2	69.5	48.3	83.5	80	75.3	24.6	85.1	62.5	95.0
6	84	55.0	27.4	61.6	31.7	80.1	80	84.4	17.4	89.8	80.5	95.3
12	83	61.5	22.8	62.3	43.4	79.2	83	81.3	19.8	90.4	70.4	98.3
18	79	81.9	20.4	90.2	70.3	97.3	83	75.0	23.0	83.4	70.5	1.5
24	74	82.1	19.5	87.7	76.4	97.1	77	75.7	24.0	85.0	69.5	1.6

a. Visits: Baseline and 3-, 6-, 12-, 18-, and 24-months. CO: carbon monoxide; SD: standard deviation; pct: percentile; N: represents non missing samples in each timepoint; the limit of detection for the direct-reading CO monitors: 1 ppm.

Table S4. Household air pollution exposure summary statistics for all follow-up visits comparing maximum hourly means of control and intervention groups in rural Peru ^a

Follow-up visit (months) ^a	Control group - Biomass cookstove				Intervention group - LPG stove				p-value ^c
	N ^b	Mean (SD)	Median (25 th , 75 th)	GM (GDS)	N ^b	Mean (SD)	Median (25 th , 75 th pct)	GM (GDS)	
Kitchen PM_{2.5}									
Baseline	89	10010 (6830)	9750 (3890, 14080)	7280 (3)	89	9410 (6280)	8920 (4590, 13390)	6710 (3)	0.587
3	88	8470 (6940)	6660 (2840, 12790)	5230 (3)	90	770 (851)	538 (233, 911)	486 (3)	<0.001
6	89	9740 (8830)	7830 (3590, 13920)	5570 (4)	90	588 (719)	331 (187, 734)	346 (3)	<0.001
12	89	10600 (8430)	9040 (4040, 14650)	6810 (3)	89	867 (1640)	262 (79, 818)	252 (5)	<0.001
18	90	1253 (3099)	311 (101, 695)	324 (5)	88	3717 (4869)	839 (273, 5814)	1149 (5)	<0.001
24	86	782 (2177)	189 (109, 448)	228 (4)	86	4738 (10144)	814 (358, 6356)	1246 (6)	<0.001
Personal PM_{2.5}									
Baseline	90	2080 (2570)	1390 (820, 2090)	1330 (3)	89	1950 (1790)	1500 (760, 2340)	1370 (2)	0.813
3	88	1680 (2620)	970 (460, 1880)	920 (3)	90	280 (366)	150 (84, 313)	163 (3)	<0.001
6	90	1940 (2810)	1180 (490, 2300)	980 (4)	89	365 (897)	140 (59, 299)	138 (4)	<0.001
12	90	1900 (2120)	1180 (610, 2530)	1120 (3)	88	291 (544)	92 (43, 325)	120 (4)	<0.001
18	90	246 (376)	105 (50, 249)	112 (3)	88	763 (1485)	265 (106, 724)	285 (4)	<0.001
24	86	265 (458)	85 (43, 257)	112 (3)	85	623 (781)	316 (135, 745)	293 (4)	<0.001
Kitchen CO									
Baseline	85	306 (168)	311 (195, 412)	248 (2)	87	296 (156)	306 (165, 403)	223 (3)	0.465
3	84	308 (182)	340 (160, 415)	218 (3)	82	37.1 (40.2)	20.7 (5.3, 57)	15.9 (4.8)	<0.001
6	86	328 (189)	360 (210, 426)	238 (3)	82	47.3 (51.5)	31.3 (14.6, 55.1)	26.3 (3.5)	<0.001
12	86	331 (193)	360 (183, 439)	238 (3)	78	72.8 (116.1)	46.6 (18.1, 79.1)	32.7 (4.4)	<0.001
18	84	59.1 (97.9)	39.9 (8.5, 72.9)	24.2 (4.8)	80	165.3 (162.5)	87.1 (25.6, 335.3)	68.6 (5.4)	<0.001
24	81	64.6 (86)	40.9 (9.5, 75.9)	27.1 (4.7)	79	171.6 (169.7)	66.3 (36.3, 337.4)	80.2 (4.3)	<0.001
Personal CO									
Baseline	81	61.6 (78.2)	33.1 (17.9, 65.7)	32 (3.4)	80	85.1 (107)	38.2 (19.5, 84.1)	43.7 (3.3)	0.104
3	80	60.3 (72.9)	37.2 (18.2, 73)	32.1 (3.5)	80	16.2 (17)	9.3 (4.6, 23.1)	9.4 (3.1)	<0.001
6	84	64.8 (79.7)	42.6 (22.2, 76.5)	37.3 (3.1)	80	11.9 (15.3)	6.1 (3.2, 12.8)	6.6 (3)	<0.001
12	81	83.3 (96.7)	42.5 (22.1, 109)	43.8 (3.4)	81	19.2 (26)	9.6 (3.6, 26.7)	9.1 (3.7)	<0.001
18	78	18.1 (22.7)	7.4 (2.9, 29.8)	8.3 (3.9)	83	43.1 (74.4)	13.3 (3.5, 45.9)	13.1 (5.4)	0.060
24	74	18.4 (36.2)	7.8 (2.9, 17.9)	7.4 (3.8)	77	43.7 (72.8)	14.8 (5, 45.8)	14.8 (4.9)	0.005

a. During the second year (follow-up visits:18- and 24 months) the control participants received the LPG stove intervention and vouchers for one year supply of free fuel and intervention participants stopped receiving free fuel but kept the LPG stove.

b. N: represents non missing samples in each timepoint; GM: geometric mean; GSD: geometric standard deviation; PM_{2.5}: fine particulate matter; CO: carbon monoxide; BC: black carbon.

c. P-values obtained using Student t-test on the log transformed exposure concentrations comparing intervention and control groups. BC consisted of time weighted integrated samples therefore hourly maximums were not evaluated for this pollutant. Samples < LOD were replaced by LOD/sqrt(2): 7 and 1 μg for PM_{2.5} and BC gravimetric integrated samples, respectively; and 0.7 ppm for direct reading CO measurements

Table S5. Percent of time PM_{2.5} personal monitors were worn by study participants during typical morning and evening cooking times in rural Peru

Visit ^a	N	During typical morning cooking times day 1					During typical evening cooking times day 1					During typical morning cooking times day 2					During typical evening cooking times day 2				
		Mean	Median	25th pct	75th pct	p-value	Mean	Median	25th pct	75th pct	p-value	Mean	Median	25th pct	75th pct	p-value	Mean	Median	25th pct	75th pct	p-value
Baseline Intervention	89	86.5	100.0	84.8	100		67.5	95.1	35.5	100		56.2	63.0	36.3	80		62.8	91.8	13.2	100	
Baseline Control	90	87.5	100.0	95.4	100	0.56	68.2	88.7	25.7	100	0.57	63.6	70.6	47.4	86	0.07	70.6	100.0	25.6	100	0.16
Month 3 Intervention	90	77.5	98.2	59.5	100		60.2	91.2	12.7	100		47.5	52.9	13.9	72		61.9	85.5	12.5	100	
Month 3 Control	88	80.3	97.6	70.3	100	0.69	61.5	88.3	8.5	100	0.62	50.3	55.7	17.9	76	0.51	63.1	88.4	15.6	100	0.53
Month 6 Intervention	89	84.6	100.0	79.8	100		59.8	88.1	14.1	100		46.5	57.4	9.3	74		60.3	84.2	10.4	100	
Month 6 Control	90	79.9	97.2	68.1	100	0.19	55.3	62.5	7.5	100	0.47	48.5	57.3	11.1	77	0.55	56.0	67.2	5.0	100	0.34
Month 12 Intervention	88	73.3	94.4	43.6	100		58.8	77.3	6.3	100		43.4	53.1	5.9	73		60.7	85.1	5.5	100	
Month 12 Control	90	85.3	98.7	79.9	100	0.07	59.0	77.5	1.7	100	0.998	50.0	65.6	13.8	76	0.13	60.7	87.0	10.5	100	0.60
Month 18 Intervention	87	73.7	99.2	43.6	100		56.9	68.3	12.5	100		41.2	44.1	8.3	67		45.2	20.9	0.3	100	
Month 18 Control	90	83.3	100.0	69.5	100	0.30	58.3	65.5	14.3	100	0.760	49.6	64.3	13.9	79	0.06	61.6	79.4	19.2	100	0.02
Month 24 Intervention	85	76.2	100.0	55.6	100		56.3	70.9	3.1	100		43.6	46.5	14.6	66		52.9	57.4	0.0	100	
Month 24 Control	85	81.0	100.0	75.7	100	0.70	55.7	66.3	10.3	100	0.57	52.2	64.5	14.1	78	0.03	53.1	50.7	8.5	100	0.51
All samples	1061	81	100	70	100		60	83	13	100		49	58	15	76		59	80	11	100	

a. pct: percentile; N: represents non missing samples in each timepoint; PM_{2.5}: fine particulate matter. P-values obtained using the Wilcoxon rank-sum test to compare the intervention group and control group in each follow-up visit. Typical cooking times defined as: morning: 4 AM to 9 AM and evening: 5 PM to 7 PM.

Table S6. Time trends of pollutant concentration over time using daily means in rural Peru

Exposure ^a	Year 1				Year 2			
	Control		Intervention		Control		Intervention	
	Slope	p-value	Slope	p-value	Slope	p-value	Slope	p-value
Kitchen PM _{2.5}	1.022	0.09	0.896	<0.001	0.950	0.03	0.996	0.89
Personal PM _{2.5}	1.023	0.11	0.967	0.004	1.001	0.97	0.994	0.74
Kitchen BC	1.014	0.31	0.877	<0.001	0.980	0.23	0.964	0.20
Personal BC	1.025	0.08	0.965	<0.001	1.003	0.73	0.971	0.13
Kitchen CO	1.003	0.82	1.056	<0.001	0.996	0.88	1.036	0.20
Personal CO	1.011	0.47	1.003	0.84	0.997	0.92	0.990	0.66

a. Generalized estimating equation models were used using the log transformed pollutant concentrations and study time visit (in months) as a continuous variable. The slopes indicate the time trends (e.g. if slope <1, pollutant concentrations decreased over time) evaluated within intervention group. PM_{2.5}: fine particulate matter; CO: carbon monoxide; BC: black carbon. Daily mean metric used is defined as the mean of the two consecutive 24-hr average concentrations, where available.

Table S7. Percent of daily mean samples below World Health Organization interim targets ($\mu\text{g}/\text{m}^3$) for $\text{PM}_{2.5}$ by intervention group in rural Peru (n=180 participants)

Visit ^a	Control group - Biomass cookstove				Intervention group - LPG stove			
	<35	<37.5	<50	<75	<35	<37.5	<50	<75
Kitchen $\text{PM}_{2.5}$								
Baseline	2%	2%	2%	3%	1%	1%	1%	3%
3	1%	1%	1%	6%	22%	23%	29%	61%
6	0%	0%	1%	13%	37%	38%	46%	89%
12	0%	0%	1%	10%	70%	72%	79%	86%
18	76%	79%	85%	90%	16%	16%	17%	50%
24	92%	92%	92%	92%	16%	16%	16%	44%
Personal $\text{PM}_{2.5}$								
Baseline	19%	20%	31%	57%	24%	26%	36%	49%
3	38%	38%	44%	69%	89%	89%	94%	98%
6	30%	31%	43%	61%	78%	80%	87%	91%
12	26%	27%	38%	58%	80%	82%	87%	93%
18	91%	92%	95%	99%	74%	76%	81%	87%
24	83%	88%	96%	96%	71%	75%	82%	86%

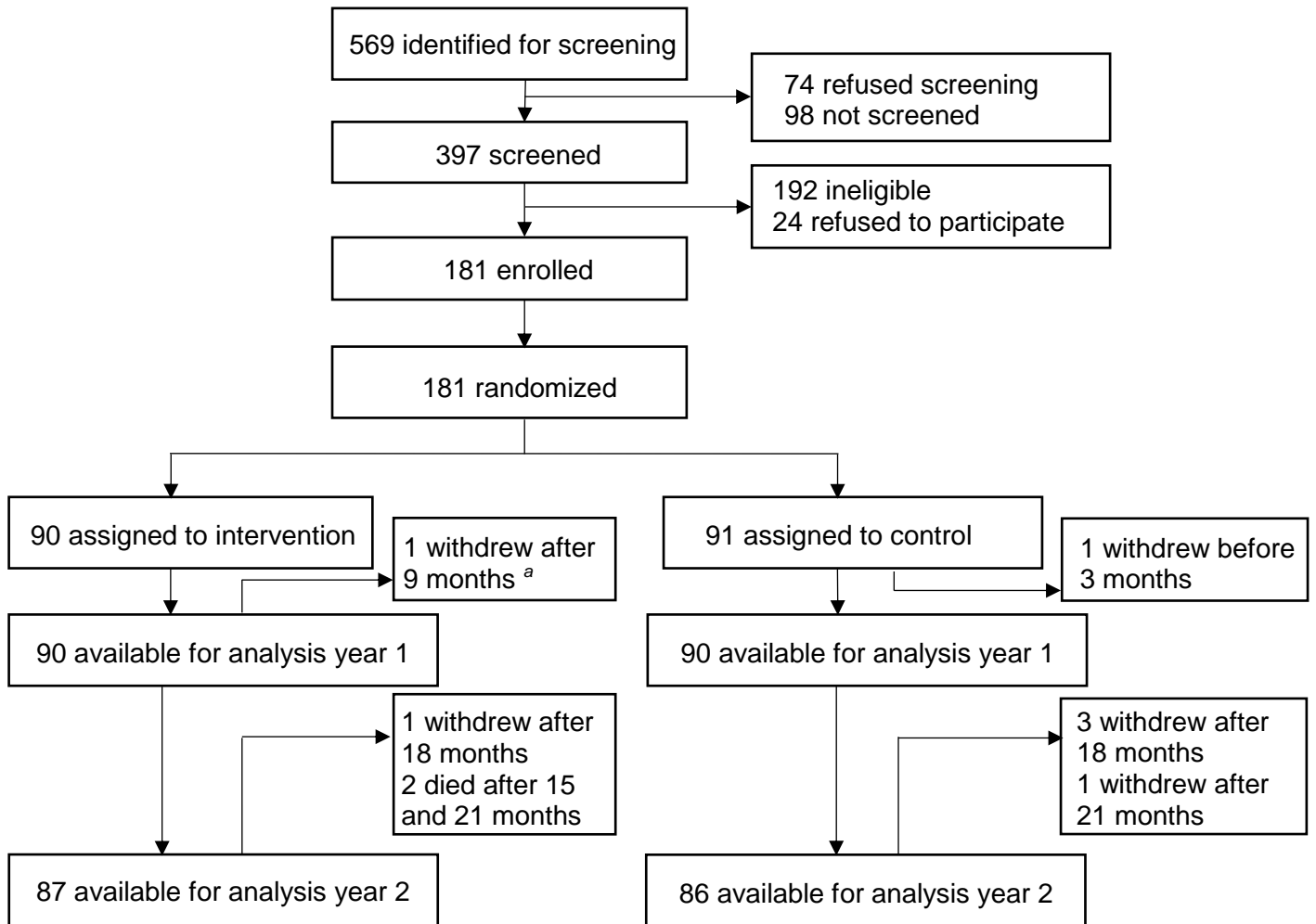
a. Visits: Baseline and 3-, 6-, 12-, 18-, and 24-months of follow up; $\text{PM}_{2.5}$: fine particulate matter. Daily mean metric used is defined as the mean of the two consecutive 24-hr average concentrations, where available.

Table S8. Correlation coefficients for household air pollution concentrations for different pollutants, different exposures and intraclass correlations between consecutive sampling days for year one follow-up visits 3-, 6- and 12-months in rural Peru (n=180 participants)

Variables compared ^a	Spearman correlation coefficient	Number of pairs
Comparing pollutants		
Kitchen CO vs PM _{2.5} control group	0.90	241
Kitchen CO vs PM _{2.5} LPG intervention group	0.05	223
Kitchen TWA PM _{2.5} vs BC control group	0.76	265
Kitchen TWA PM _{2.5} vs BC LPG intervention group	0.80	267
Personal CO vs PM _{2.5} control group	0.36	216
Personal CO vs PM _{2.5} LPG intervention group	0.15	210
Personal TWA PM _{2.5} vs BC control group	0.78	267
Personal TWA PM _{2.5} vs BC LPG intervention group	0.35	266
Comparing kitchen area and personal exposures		
Kitchen PM _{2.5} vs Personal PM _{2.5} control group	0.48	248
Kitchen PM _{2.5} vs Personal PM _{2.5} LPG intervention group	0.36	245
Kitchen BC vs Personal BC control group	0.50	248
Kitchen BC vs Personal BC LPG intervention group	0.71	245
Kitchen CO vs Personal CO control group	0.32	224
Kitchen CO vs Personal CO LPG intervention group	0.26	207
Comparing consecutive days: day 1 vs day 2		
Variables compared	Intraclass correlation coefficient	Number of pairs
Kitchen CO control group	0.77	253
Kitchen CO LPG intervention group	0.84	232
Kitchen PM _{2.5} control group	0.54	259
Kitchen PM _{2.5} LPG intervention group	0.57	259
Personal CO control group	0.67	234
Personal CO LPG intervention group	0.76	231
Personal PM _{2.5} control group	0.36	254
Personal PM _{2.5} LPG intervention group	0.50	253

a. PM_{2.5}: fine particulate matter; CO: carbon monoxide; BC: black carbon. Intraclass correlation coefficients (ICCs) represent the ratio of the between-consecutive-day variance to the total sample variance of measurements in a one-way random-effects model.

Figure S1. Screening, randomization and follow-up diagram in rural Peru



a. Data from baseline, and months-3 and -6 follow up visits was collected for the participant that withdrew and was included in the analysis, only data from month-12 follow up was missing.

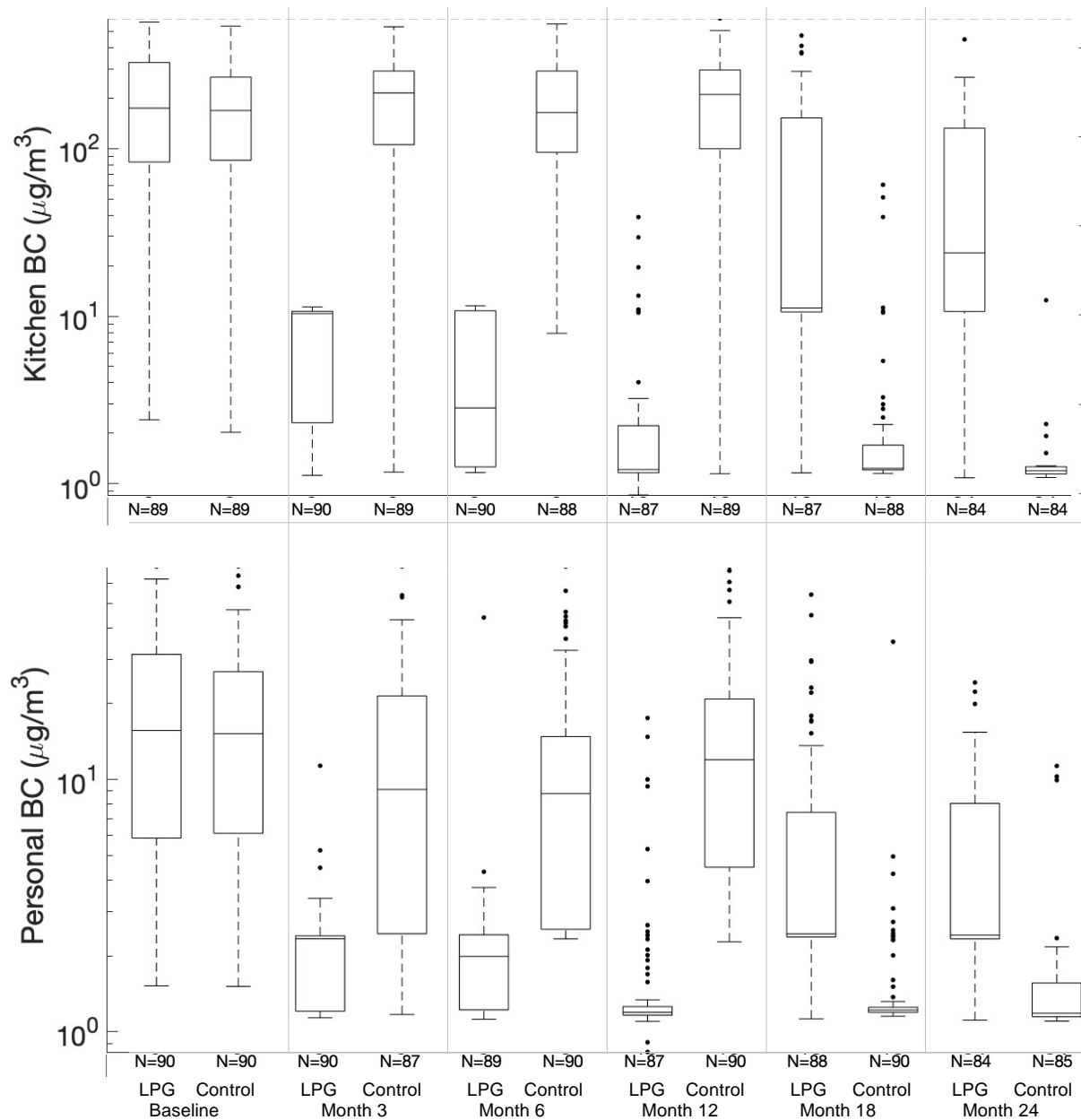


Figure S2. Black carbon box plots of 48-hr mean kitchen area and personal exposure concentrations at each follow-up visit (baseline, 3-, 6-, 12-, 18-, and 24-months) for LPG stove intervention participants (LPG) and control participants (Control). During the second year (follow-up visits:18- and 24 months) the control participants received the LPG stove intervention and vouchers for one year supply of free fuel and intervention participants stopped receiving free fuel but kept the LPG stove. Interquartile ranges of the box plots represent the 25th and the 75th percentiles of the daily means for each group; the middle line of the box represents the 50th percentile. Numeric data is provided in Table 2.