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### **Supplemental Material**

#### **Prenatal Household Air Pollution Exposure and Childhood Blood Pressure in Rural Ghana**

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**Additional File-** Excel Document

**Table S1. GRAPHS participants enrolled versus not enrolled in longitudinal cohort**

	Not Enrolled (N=717)	Enrolled (N=697)	p value
<b>GRAPHS Study Arm</b>			< 0.01
Control	219 (30.5%)	307 (44.0%)	
Improved Biomass	400 (55.8%)	127 (18.2%)	
Liquefied petroleum gas	98 (13.7%)	263 (37.7%)	
<b>Child Sex</b>			0.38
N-Miss	77	2	
Female	307 (48.0%)	350 (50.4%)	
Male	333 (52.0%)	345 (49.6%)	
<b>Asset Index</b>			0.59
N-Miss	2	0	
Mean (SD)	-0.028 (1.911)	0.028 (1.994)	
Range	-2.879 - 11.388	-3.045 - 13.144	
<b>Secondhand Smoke Exposure</b>			0.08
No	552 (77.0%)	563 (80.8%)	
Yes	165 (23.0%)	134 (19.2%)	
<b>Parity</b>			< 0.01
Mean (SD)	2.44 (2.24)	2.86 (2.15)	
Range	0 - 13	0 - 11	
<b>Maternal Systolic Blood Pressure</b>			0.47
N-Miss	1	0	
Mean (SD)	105.74 (10.61)	105.34 (9.85)	
Range	68 - 154	74 - 138	
<b>Maternal Diastolic Blood Pressure</b>			0.98
N-Miss	2	0	
Mean (SD)	63.26 (8.26)	63.24 (7.73)	
Range	35 - 100	43 - 93	

**Table S2. GRAPHS participants included in longitudinal cohort**

	Control (N=307)	Improved Biomass (N=127)	LPG (N=263)
<b>Child Sex</b>			
N-Miss	1	0	1
Female	162 (52.9%)	55 (43.3%)	133 (50.8%)
Male	144 (47.1%)	72 (56.7%)	129 (49.2%)
<b>Asset Index</b>			
Mean (SD)	0.356 (2.319)	-0.251 (1.602)	-0.218 (1.679)
Range	-2.859 - 13.144	-2.510 - 6.931	-3.045 - 8.432
<b>Secondhand Smoke Exposure</b>			
No	261 (85.0%)	96 (75.6%)	206 (78.3%)
Yes	46 (15.0%)	31 (24.4%)	57 (21.7%)
<b>Ethnicity</b>			
1	63 (20.5%)	18 (14.2%)	26 (9.9%)
2	52 (16.9%)	19 (15.0%)	31 (11.8%)
3	184 (59.9%)	83 (65.4%)	191 (72.6%)
4	8 (2.6%)	7 (5.5%)	15 (5.7%)
<b>Years Education</b>			
Mean (SD)	1.870 (2.015)	2.063 (2.137)	1.578 (1.852)
Range	0.000 - 15.000	0.000 - 6.000	0.000 - 6.000
<b>Parity</b>			
Mean (SD)	2.756 (2.073)	3.315 (2.235)	2.772 (2.172)
Range	0.000 - 11.000	0.000 - 11.000	0.000 - 9.000
<b>Maternal SBP</b>			
Mean (SD)	104.202 (9.592)	104.213 (9.443)	107.213 (10.089)
Range	74.000 - 133.000	84.000 - 132.000	83.000 - 138.000
<b>Maternal DBP</b>			
Mean (SD)	62.508 (7.461)	62.583 (8.060)	64.418 (7.772)
Range	43.000 - 93.000	44.000 - 91.000	44.000 - 88.000

Note: DBP, diastolic blood pressure; LPG, liquified petroleum gas; SBP, systolic blood pressure

**Table S3. GRAPHS participants excluded from longitudinal cohort**

	Control (N=219)	Improved biomass (N=400)	LPG (N=98)	p value
<b>Child sex</b>				0.467
N-Miss	35	27	15	
Female	91 (49.5%)	172 (46.1%)	44 (53.0%)	
Male	93 (50.5%)	201 (53.9%)	39 (47.0%)	
<b>Asset Index</b>				0.357
N-Miss	1	0	1	
Mean (SD)	-0.042 (2.043)	0.039 (1.827)	-0.270 (1.947)	
Range	-2.879 - 11.388	-2.806 - 9.525	-2.686 - 10.034	
<b>Secondhand Smoke Exposure</b>				0.869
0	171 (78.1%)	307 (76.8%)	74 (75.5%)	
1	48 (21.9%)	93 (23.2%)	24 (24.5%)	
<b>Ethnicity</b>				0.014
N-Miss	1	0	1	
1	45 (20.6%)	85 (21.2%)	6 (6.2%)	
2	23 (10.6%)	47 (11.8%)	8 (8.2%)	
3	135 (61.9%)	250 (62.5%)	77 (79.4%)	
4	15 (6.9%)	18 (4.5%)	6 (6.2%)	
<b>Years Education</b>				0.028
N-Miss	1	0	1	
Mean (SD)	2.229 (2.055)	1.975 (1.946)	1.598 (1.748)	
Range	0.000 - 9.000	0.000 - 6.000	0.000 - 6.000	
<b>Parity</b>				< 0.001
Mean (SD)	2.279 (2.142)	2.692 (2.328)	1.765 (1.909)	
Range	0.000 - 9.000	0.000 - 13.000	0.000 - 8.000	
<b>Maternal SBP</b>				0.236
N-Miss	0	1	0	
Mean (SD)	105.671 (10.269)	105.366 (10.764)	107.395 (10.687)	
Range	79.000 - 154.000	68.000 - 145.000	80.000 - 139.000	
<b>Maternal DBP</b>				0.205
N-Miss	1	1	0	
Mean (SD)	63.225 (7.908)	62.942 (8.271)	64.599 (8.918)	
Range	41.000 - 97.000	35.000 - 100.000	40.000 - 99.000	

Note: DBP, diastolic blood pressure; LPG, liquified petroleum gas; SBP, systolic blood pressure

<b>Table S4. Household cooking practices at child age 4 years amongst those enrolled in longitudinal follow up (n=690)</b>				
	Control (n=303)	Improved biomass (n=125)	Liquid petroleum gas (LPG) (n=262)	p-value
<b>Morning Meal</b>				
Open mokyia (stone, mud, clay)	284 (93.7)	119 (95.2)	239 (91.2)	0.27
Coal pot	5 (1.7)	4 (3.2)	10 (3.8)	
Improved wood stove	0	0	0	
LPG	0	0	0	
Did not cook meal	14 (4.6)	2 (0.02)	13 (5)	
<b>Afternoon Meal</b>				
Open mokyia (stone, mud, clay)	129 (42.6)	60 (48)	132 (50.4)	0.02
Coal pot	1 (0.3)	0 (0)	7 (2.7)	
Improved wood stove	0 (0)	0 (0)	0 (0)	
LPG	0 (0)	0 (0)	0 (0)	
Did not cook meal	173 (57.1)	65 (52)	123 (46.9)	
<b>Evening Meal</b>				
Open mokyia (stone, mud, clay)	296 (97.7)	120 (96)	250 (95.4)	0.39
Coal pot	5 (1.7)	4 (3.2)	11 (4.2)	
Improved wood stove	1 (0.3)	1 (0.8)	1 (0.4)	
LPG	0 (0)	0 (0)	0 (0)	
Did not cook meal	1 (0.3)	0 (0)	0 (0)	
<p>At child age 4 visit, children’s mothers were asked, “I want to ask some questions about cooking [morning, afternoon, or evening] meals for the household over the past week. What stove did you use most often to prepare the [morning, afternoon, or evening] meal?”. Categorical responses included: open mokyia (stone/mud/clay); closed mokyia (stone/mud/clay); metal mokyia; sawdust stove; improved wood stove; coal pot; kerosene stove; LPG stove; electric stove; other; NA-no meal cooking. With the exception of LPG, responses that were never answered in the affirmative are not included. Fisher exact test p-values were used to examine the statistical significance of differences in cooking stove by study arm. Of the enrolled children, n=690 completed this questionnaire.</p>				

<b>Table S5. Associations between GRAPHS stove intervention arm and age 4 blood pressure z-score, as compared to control</b>			
	<b>Intention-to-Treat Models</b>		
	N	Improved biomass	Liquified Petroleum Gas
Systolic blood pressure (SBP)	669	-0.02 (-0.24, 0.20)	-0.13 (-0.29, 0.04)
Diastolic blood pressure (DBP)	669	-0.02 (-0.24, 0.20)	-0.20 (-0.36, -0.03)
<b>Female</b>			
SBP	339	-0.04 (-0.31, 0.23)	-0.23 (-0.46, -0.01)
DBP	339	0.03 (-0.30, 0.35)	-0.27 (-0.49, -0.04)
<b>Male</b>			
SBP	330	-0.02 (-0.35, 0.31)	-0.02 (-0.27, 0.22)
DBP	330	-0.05 (-0.35, 0.25)	-0.12 (-0.35, 0.12)
Cluster-robust generalized linear regression models.			

**Table S6. Exposure distribution by study arm for longitudinal cohort participants**

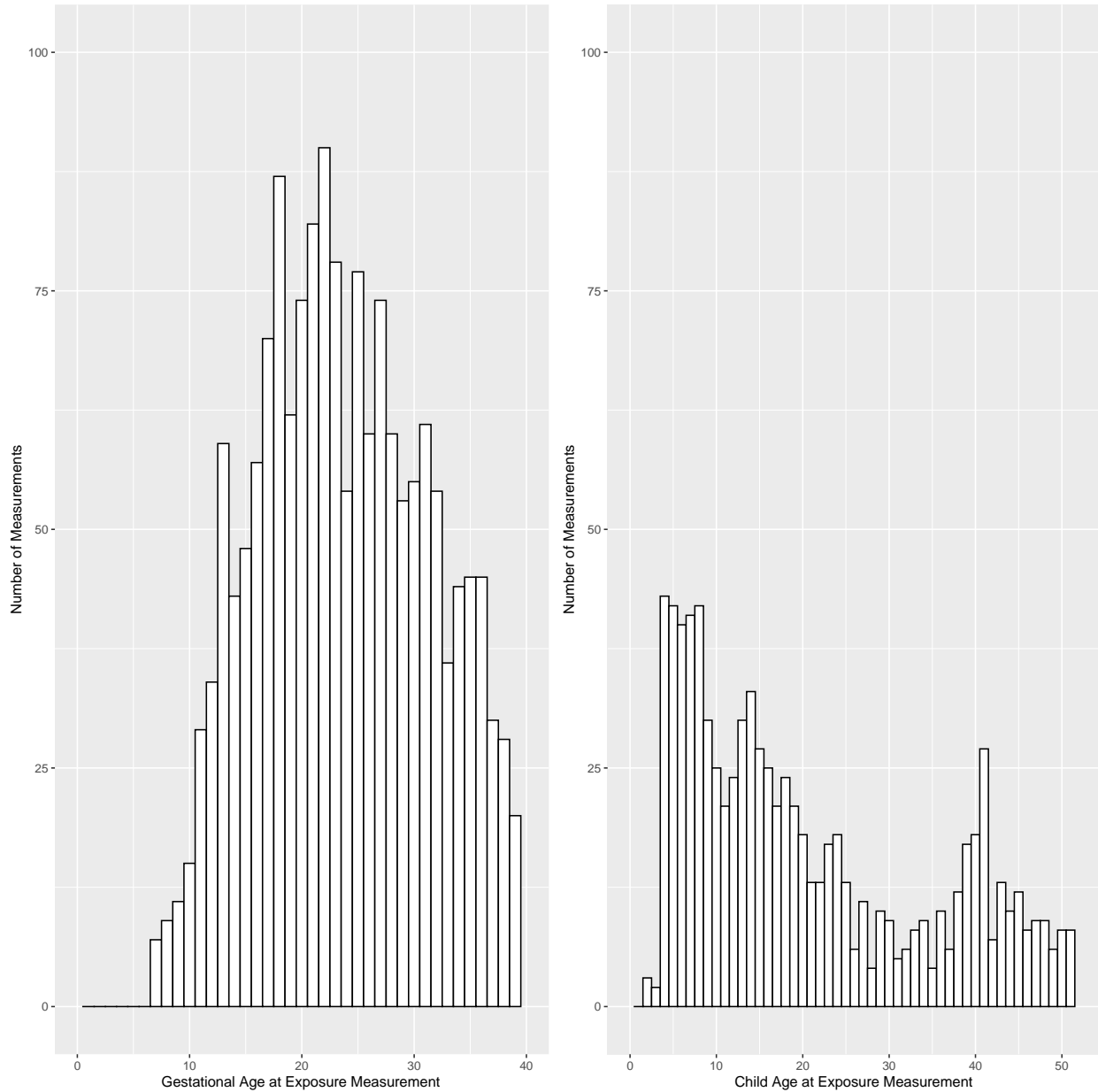
	Control (N = 290)	Improved biomass (N = 124)	LPG (N = 255)
Maternal prenatal 48-hour CO Average <sup>†</sup> , ppm – median, IQR	1.09 (0.62, 1.92)	1.03 (0.48, 1.96)	0.89 (0.46, 1.57)
N	277	115	241
Child postnatal 48-hour CO Average <sup>‡</sup> , ppm – median, IQR	0.66 (0.30, 1.28)	0.62 (0.21, 1.34)	0.50 (0.24, 0.91)
N	241	93	206
Maternal prenatal 48-hour PM <sub>2.5</sub> <sup>°</sup> , microgram/m <sup>3</sup> – median, IQR	75.5 (46.8, 104.8)	56.9 (38.7, 81.1)	42.5 (29.6, 70.7)
N	178	73	117
Maternal postnatal 48-hour PM <sub>2.5</sub> <sup>°</sup> , microgram/m <sup>3</sup> – median, IQR	58.5 (40.3, 87.2)	62.3 (37.6, 89.3)	47.6 (33.3, 63.5)
N	176	76	107
Child age 4 24-hour PM <sub>2.5</sub> , microgram/m <sup>3</sup> – median, IQR	61.0 (38.1, 90.6)	68.1 (41.0, 95.7)	45.7 (29.6, 73.8)
N	194	88	191

<sup>†</sup>Prenatal maternal personal CO exposure was measured in parts per million at four points. Prenatal average CO exposures include pre-intervention and post-intervention exposure measurements.

<sup>‡</sup>Postnatal child personal CO exposure was measured in parts per million at three points.

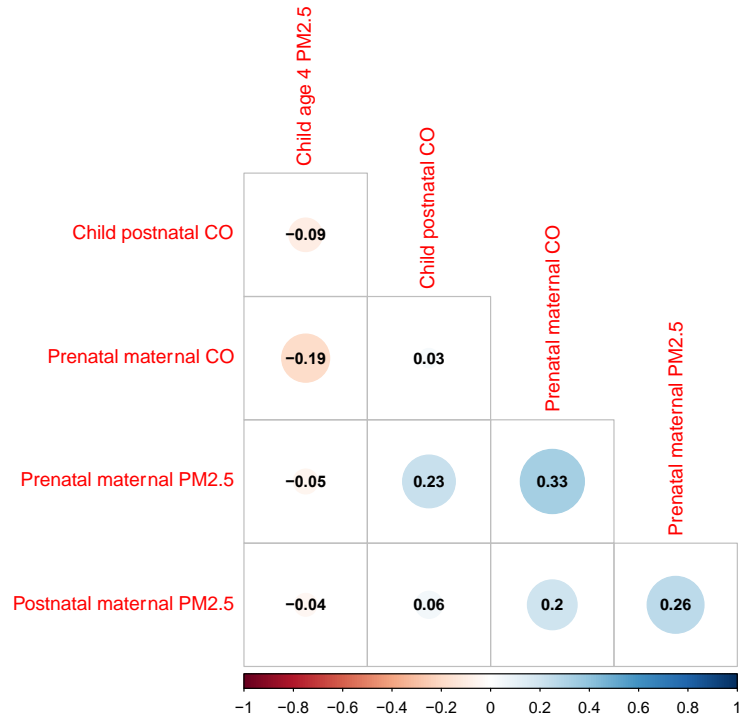
<sup>°</sup>Prenatal and postnatal maternal PM<sub>2.5</sub> exposure measurements were performed once in each time point. CO, carbon monoxide; DBP, diastolic blood pressure; IQR, interquartile range; LPG, liquified petroleum gas; PM<sub>2.5</sub>, fine particulate matter; SBP, systolic blood pressure

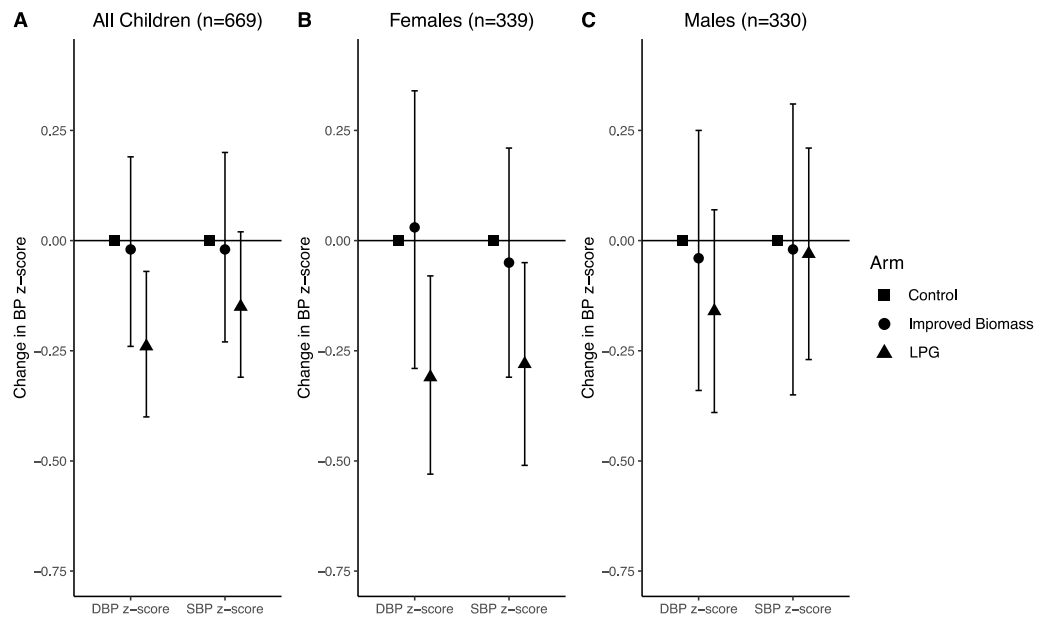




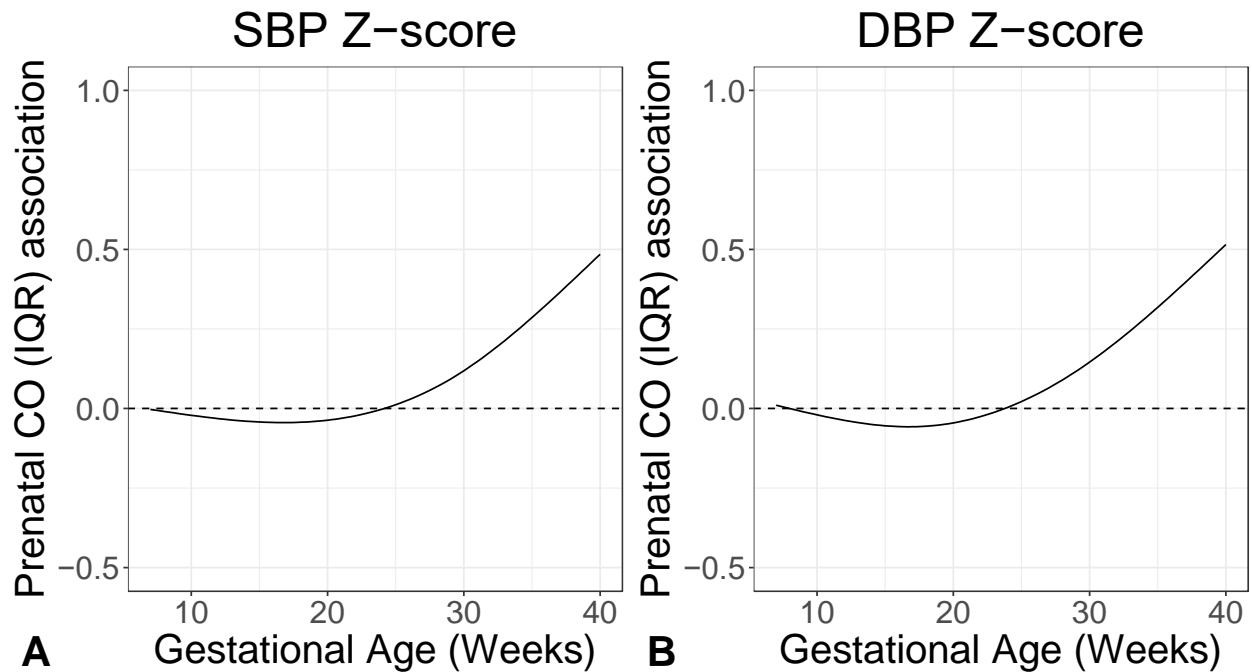
**Figure S1. Counts of carbon monoxide (CO) measurements A) over pregnancy by gestational age in weeks; and B) over first year of life by child age in weeks.** This figure shows the number of valid, personal CO measurements per week gestation for the entire cohort over each time period, demonstrating multiple measures at each week of gestation or childhood except in early gestation and infancy. Numeric data can be found in Excel Table S5.

**Figure S2. Correlation matrix of carbon monoxide (CO) and fine particulate matter (PM<sub>2.5</sub>) exposures at different timepoints.**

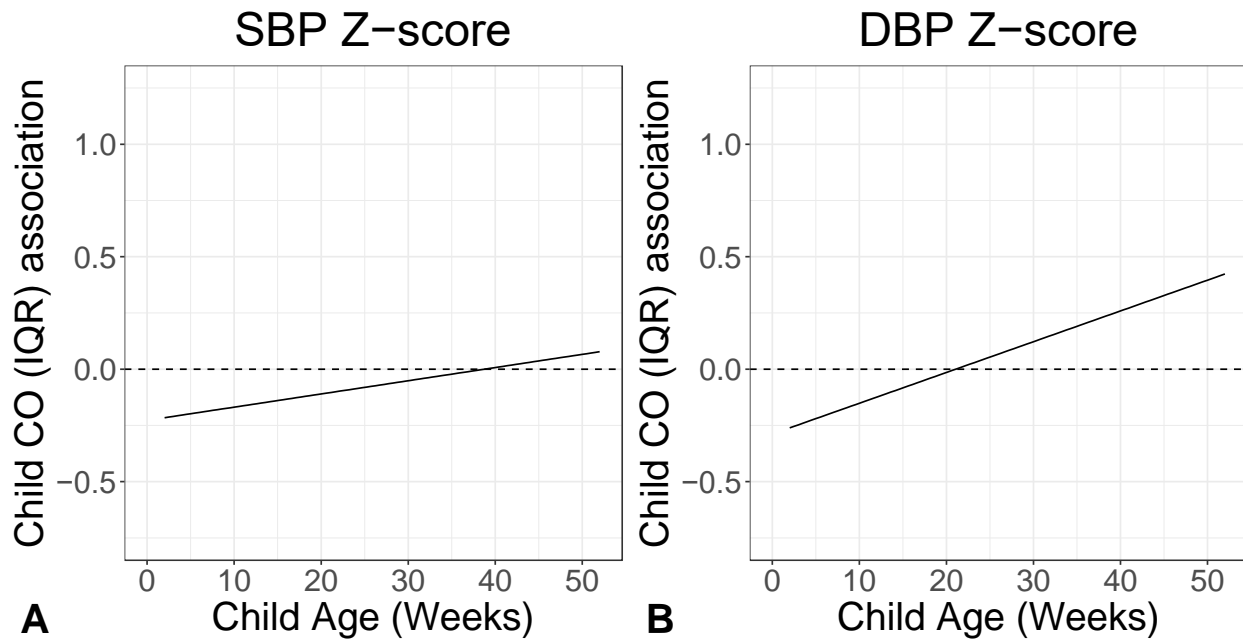




**Figure S3. Intention to treat analyses with sensitivity adjustment for maternal blood pressure (BP).** This figure shows the intention-to-treat associations between GRAPHs stove intervention arm and SBP and DBP z-scores at age 4, using cluster-robust generalized linear regression models adjusted for maternal BP. In GRAPHs, pregnant women were randomized to open fire (control), liquified petroleum gas (LPG), or improved biomass stoves which were supported over pregnancy and through the index child's first year of life. Resting systolic BP (SBP) and diastolic BP (DBP) were measured at child age 4 years, 3 years after support for the intervention ended. Data for this figure can be found in Excel Table S6.



**Figure S4. Time-varying associations between prenatal household air pollution exposure, as represented by personal carbon monoxide (CO), and resting A) systolic blood pressure (SBP) and B) diastolic blood pressure (DBP) z-scores at age 4 years.** The multivariable model 2 (n=1212 observations from n=464 children) adjusted for child sex and BMI; maternal ethnicity, secondhand tobacco smoke exposure and enrollment BP; and household asset index with additional adjustment for child age 4 fine particulate matter (PM<sub>2.5</sub>) exposure. It also included inverse probability weights to account for the age four PM<sub>2.5</sub> exposure measurements available in only a subset. The Y-axis represents the time-varying association between blood pressure z-score and an interquartile (IQR) increase in CO exposure; the X-axis depicts gestational age in weeks. The solid line shows the predicted estimate and the shaded area represents the 95% confidence interval. A sensitive window is identified when the confidence intervals do not include zero. Numeric data for this figure can be found in Excel Table S7.



**Figure S5. Time-varying associations between child household air pollution exposure, as represented by personal carbon monoxide (CO), and resting A) systolic blood pressure (SBP) and B) diastolic blood pressure (DBP) z-scores at age 4 years.** The multivariable model 2 (n=618 observations from n=382 children) adjusted for child sex and BMI; maternal ethnicity, secondhand tobacco smoke exposure, average prenatal CO exposure and enrollment BP; and household asset index with additional adjustment for child age 4 fine particulate matter (PM<sub>2.5</sub>) exposure. It also included inverse probability weights to account for the age four PM<sub>2.5</sub> exposure measurements available in only a subset. The Y-axis represents the time-varying association between blood pressure z-score and an interquartile (IQR) increase in CO exposure; the X-axis depicts gestational age in weeks. The solid line shows the predicted estimate and the shaded area represents the 95% confidence interval. A sensitive window is identified when the confidence intervals do not include zero. Numeric data for this figure can be found in Excel Table S8.