Using Evidence for Policy Action on Air Pollution: The Experience from GRAPHS study in Ghana

Kwaku Poku Asante

Kintampo Health Research Centre

15 + years of collaboration

Kwaku Poku Asante
Seth Owusu-Agyei
Kenneth Asayah
Ellen Boamah
Charlotte Tawiah
Charles Zandoh
Kaali Seyram
Francis Agbokey
Theresa Tawiah
Rebecca Dwomoh
Sulemana Watara Abubakari

Darby Jack
Ashlinn Quinn
Daniel Carrion
Carlos Gould
Misbath Daouda
Danielle Medgyesi
Pat Kinney
Robin Whyatt

Alison Lee
Elena Colicino

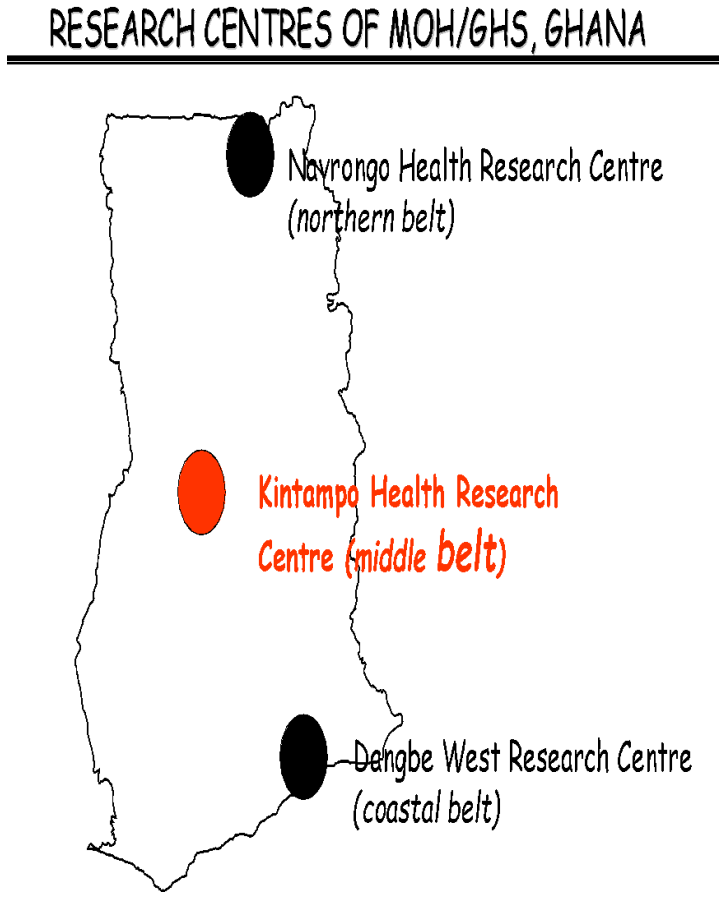
Blair Whylie

Steve Chillrud
Qiang Yang
James Ross

Kelsey Jack
Flavio Malagutti

Kintampo Health Research Centre

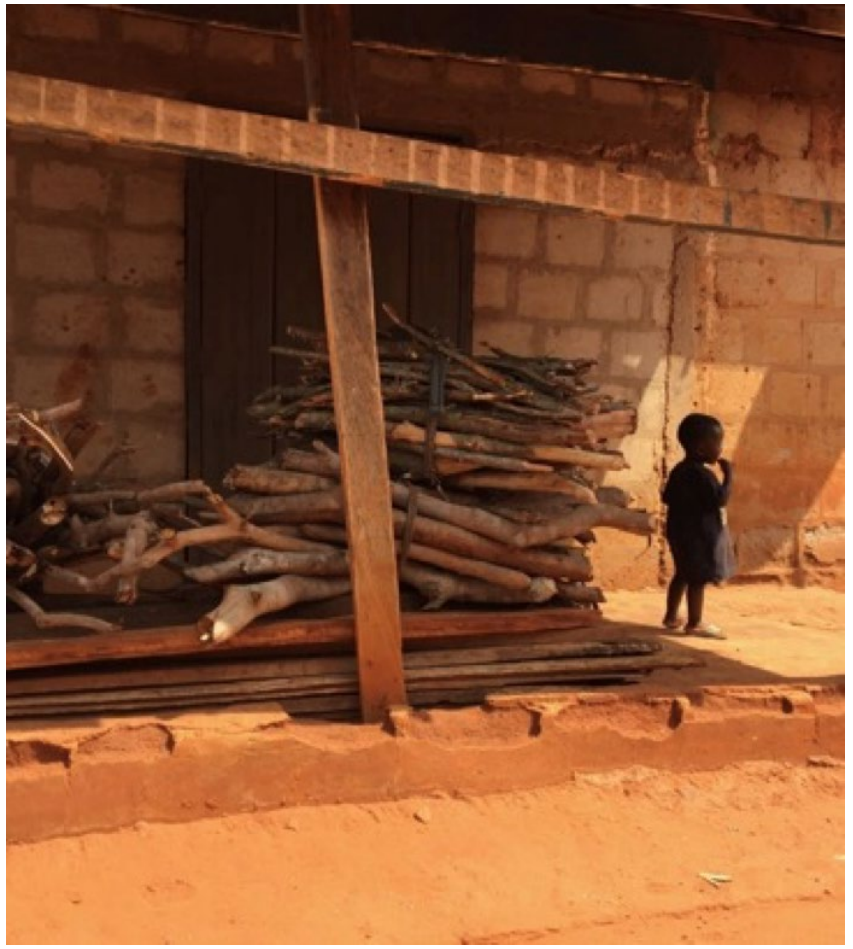
- Established in 1994
- A Ghana Health Service/Ministry of Health institution under the Research and Development Directorate
- Long track record of policy-relevant public health research
- **Core values:** Excellence, Innovation, Inclusiveness, and Accountability,



Context: household air pollution in Ghana

70% of Ghanaians burn solid fuels in open fires for cooking. The costs?

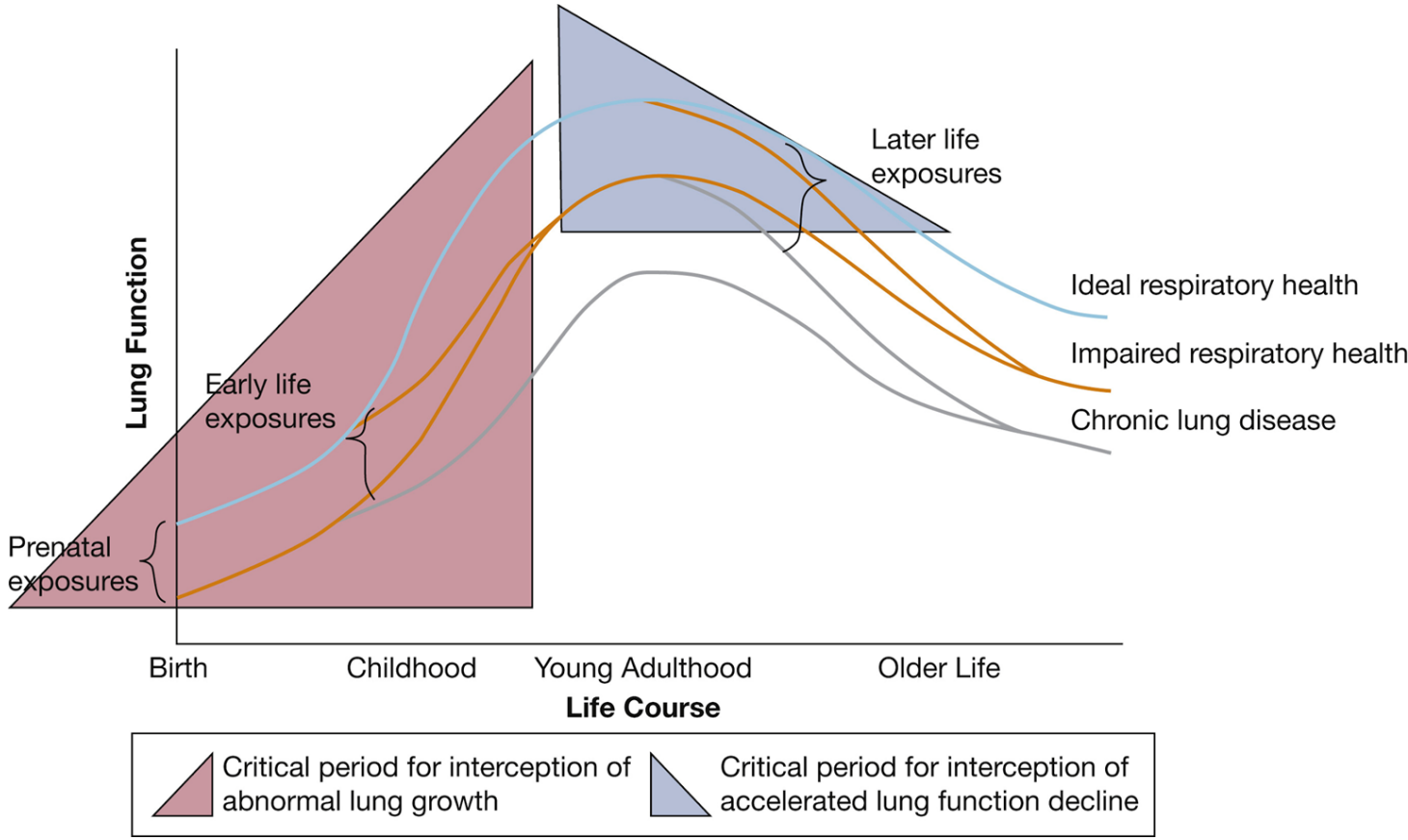
1. **Human exposure to air pollution**. Elevated risk of pneumonia, lung cancer, chronic pulmonary obstructive disease (COPD), and cardiovascular disease; disproportionately affecting women and children.
2. **Deforestation & forest degradation.** Fuelwood harvests that exceed sustainable levels.
3. **Contributions to climate change.** Cookstoves emit CO_2, methane, and black carbon.
4. **Contributions to poverty and gender inequality.** Time burden and physical hardship of collecting fuelwood and cooking over an open fire fall primarily on women and older children.



Key insights from health studies

Lifecourse framework: Fetal and early childhood exposures may shape lifetime health

Growing evidence that antenatal and early childhood air pollution exposures program lifetime cardiovascular, respiratory, and neurocognitive health



Liu and Kalhan *Chest* 2021

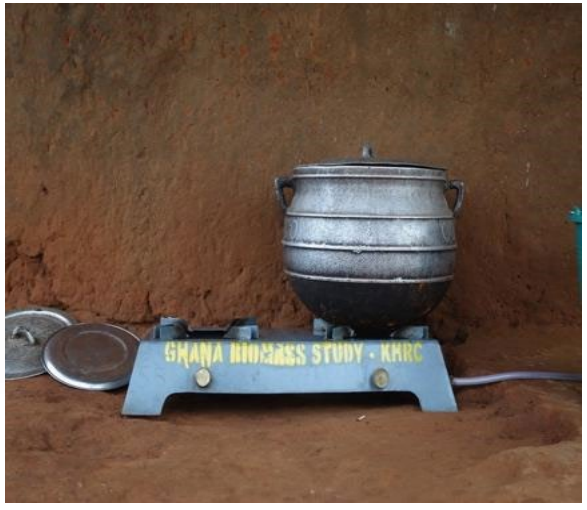
The Ghana Randomized Air Pollution and Health Study (GRAPHS)

Community-level randomized controlled trial of cookstove interventions to reduce HAP

3-stone fire
(Control)

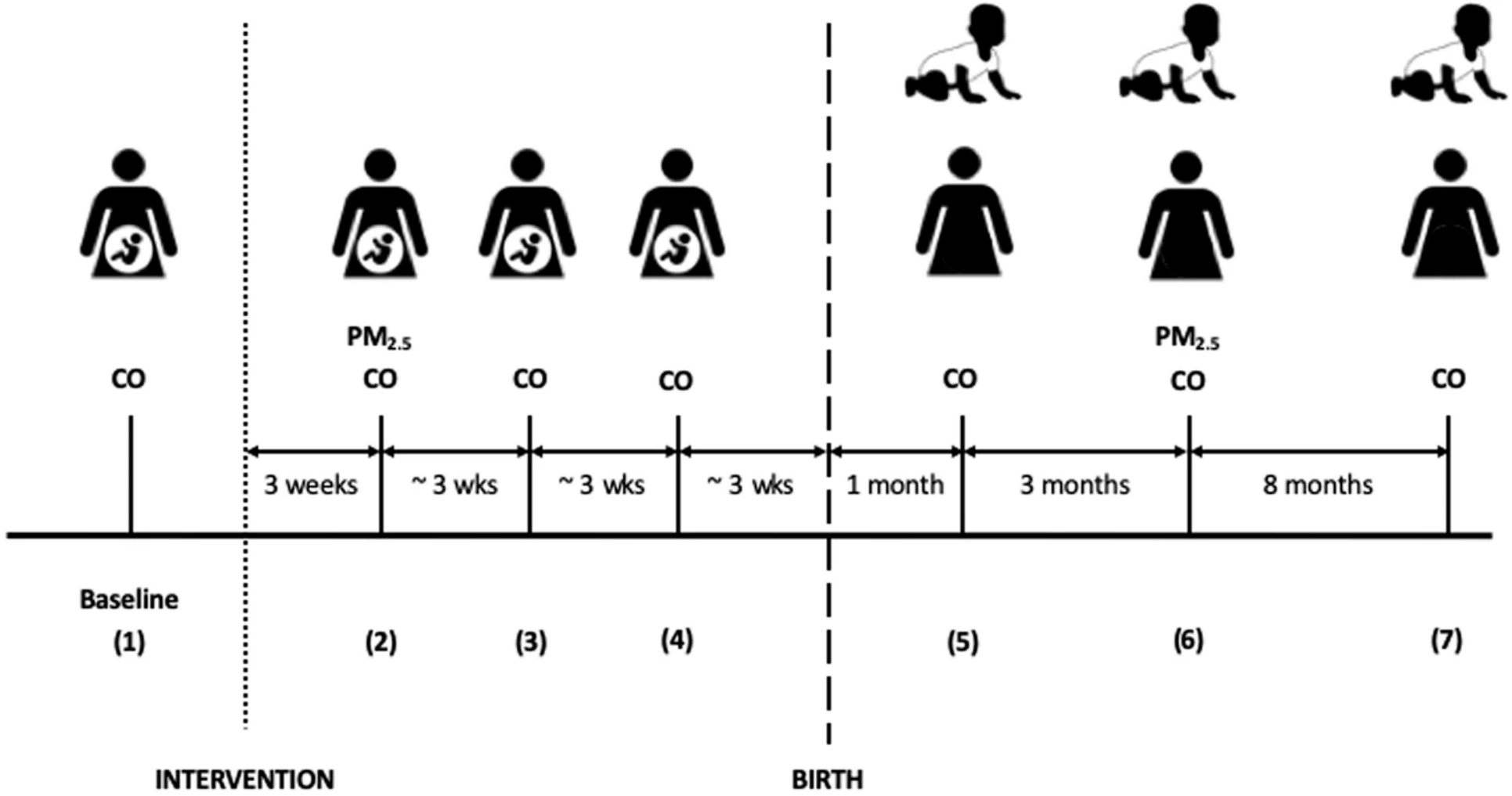
BioLite

LPG (stove + gas)



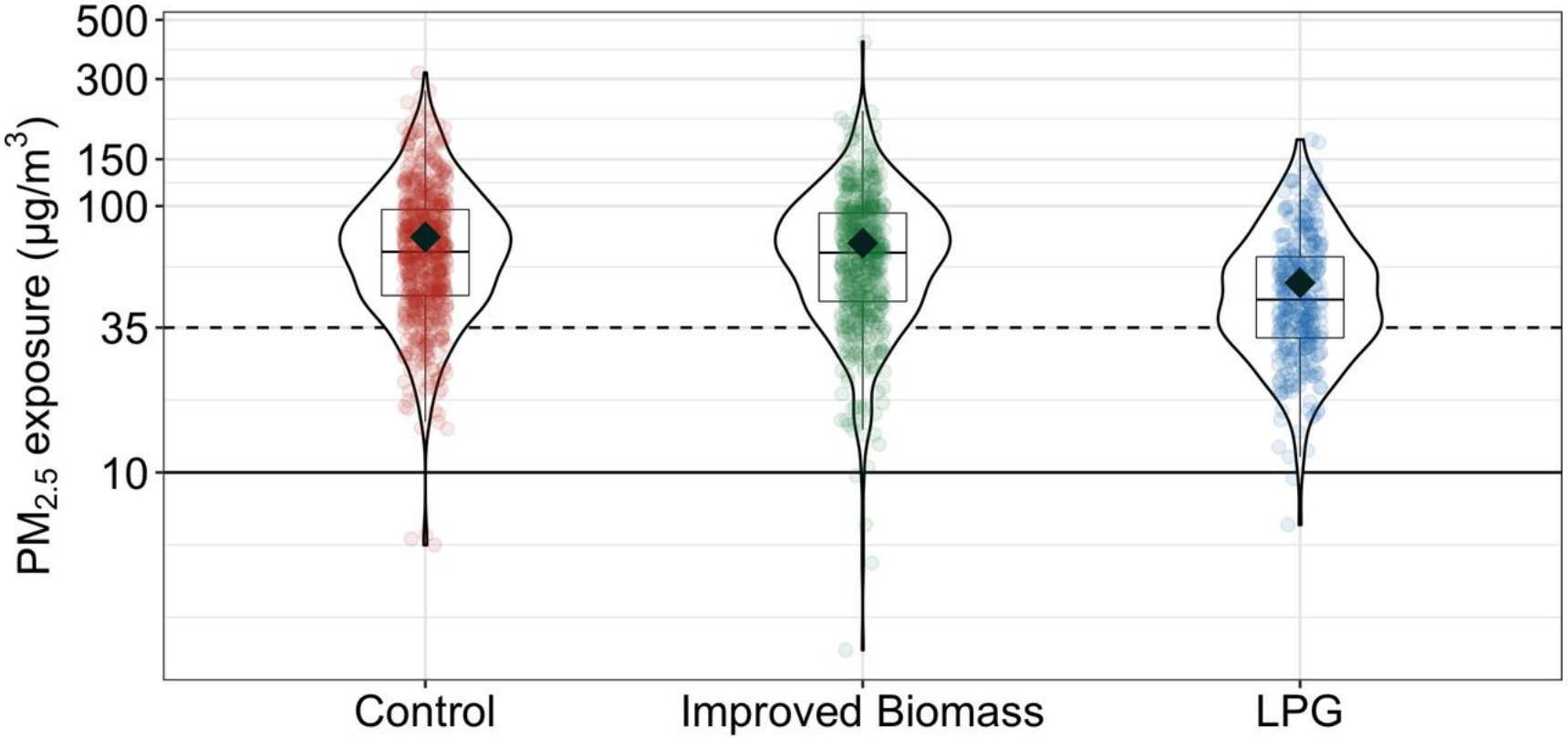
	Clusters	Births	Enrollment
BioLite	13	455	525
Control	13	455	525
LPG	9	315	365
total	*35*	*1225*	*1415*

Personal air pollution exposure monitoring in GRAPHS



Chillrud et al 2021

Intervention had smaller than expected effect

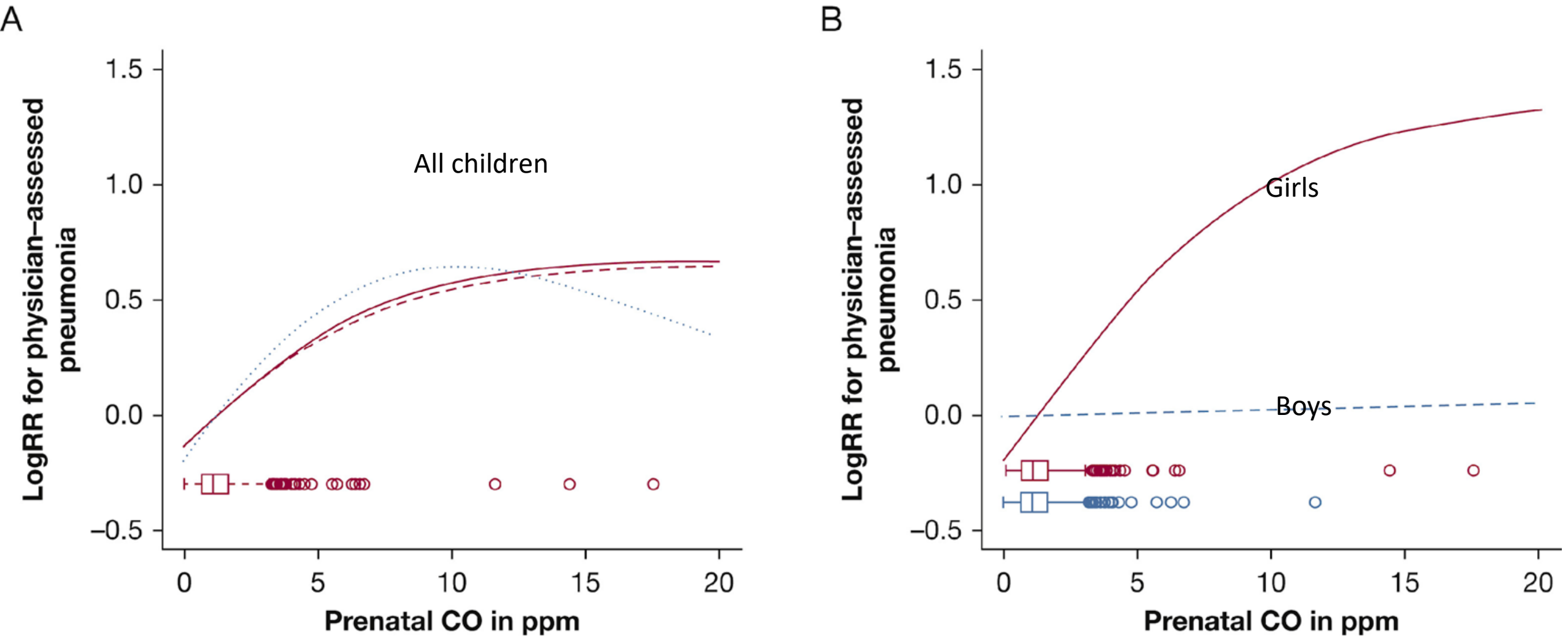


	Control	Improved Biomass	LPG
Participants	356	321	202
Estimates	578	504	297
Mean ± SD	77±44	73±41	52±28
Median (IQR)	67 (46-96)	67 (44-94)	44 (32-64)

And main outcomes (birth weight, pneumonia) were null

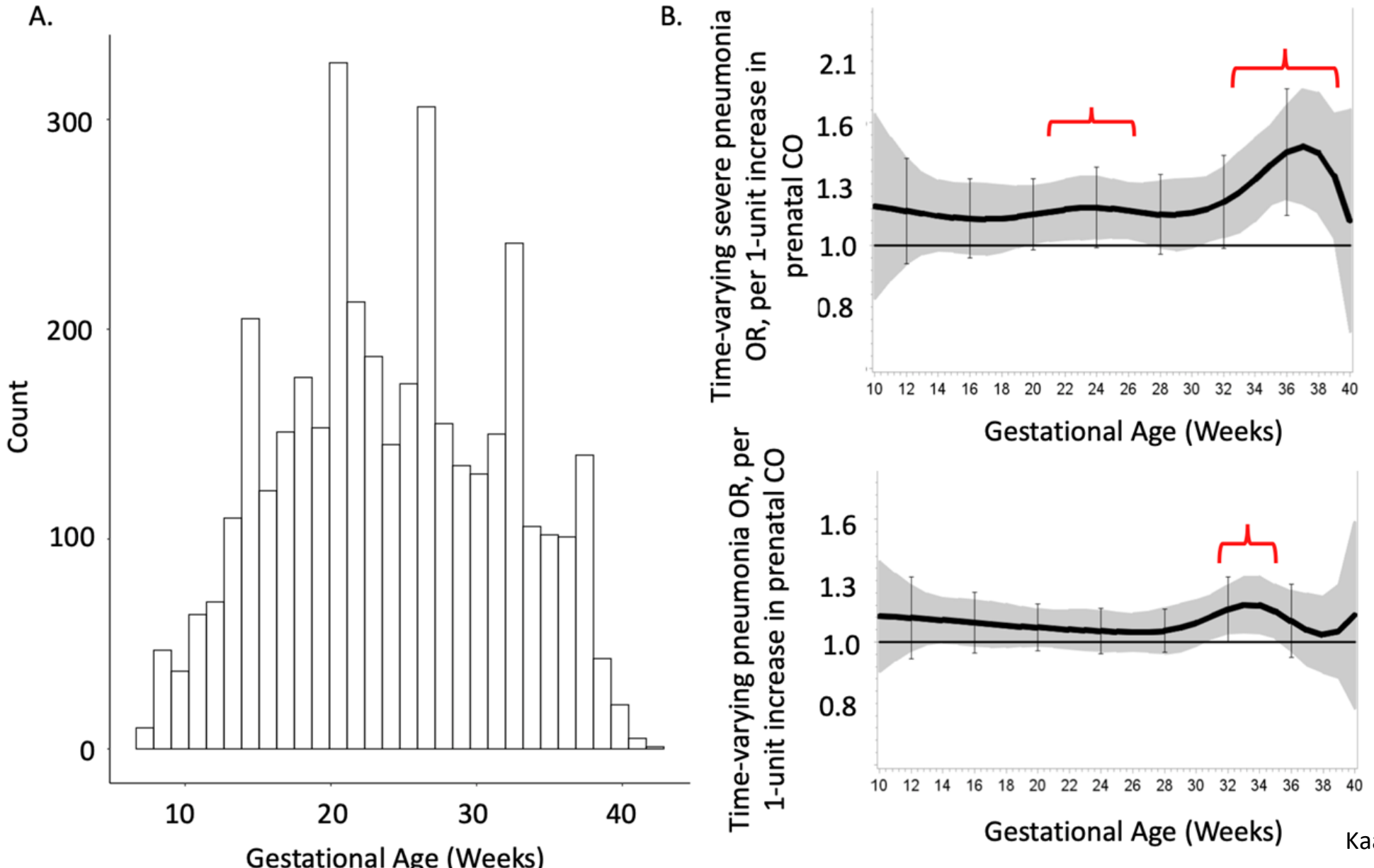
Jack et al 2021

Clear exposure response relationships for pneumonia, and effect was almost entirely in girls



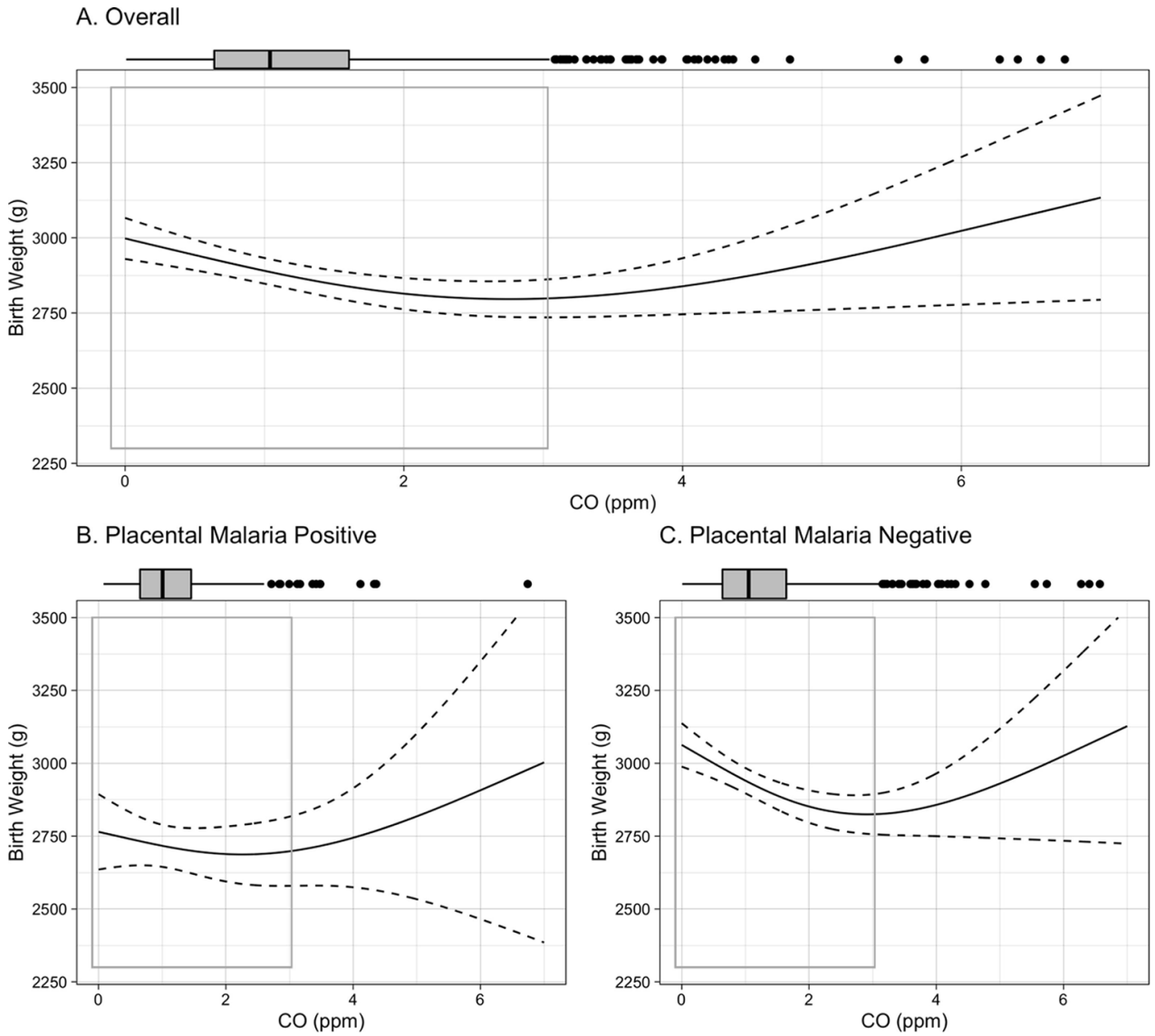
Kinney et al 2021

Key exposures for pneumonia appear to be late in pregnancy



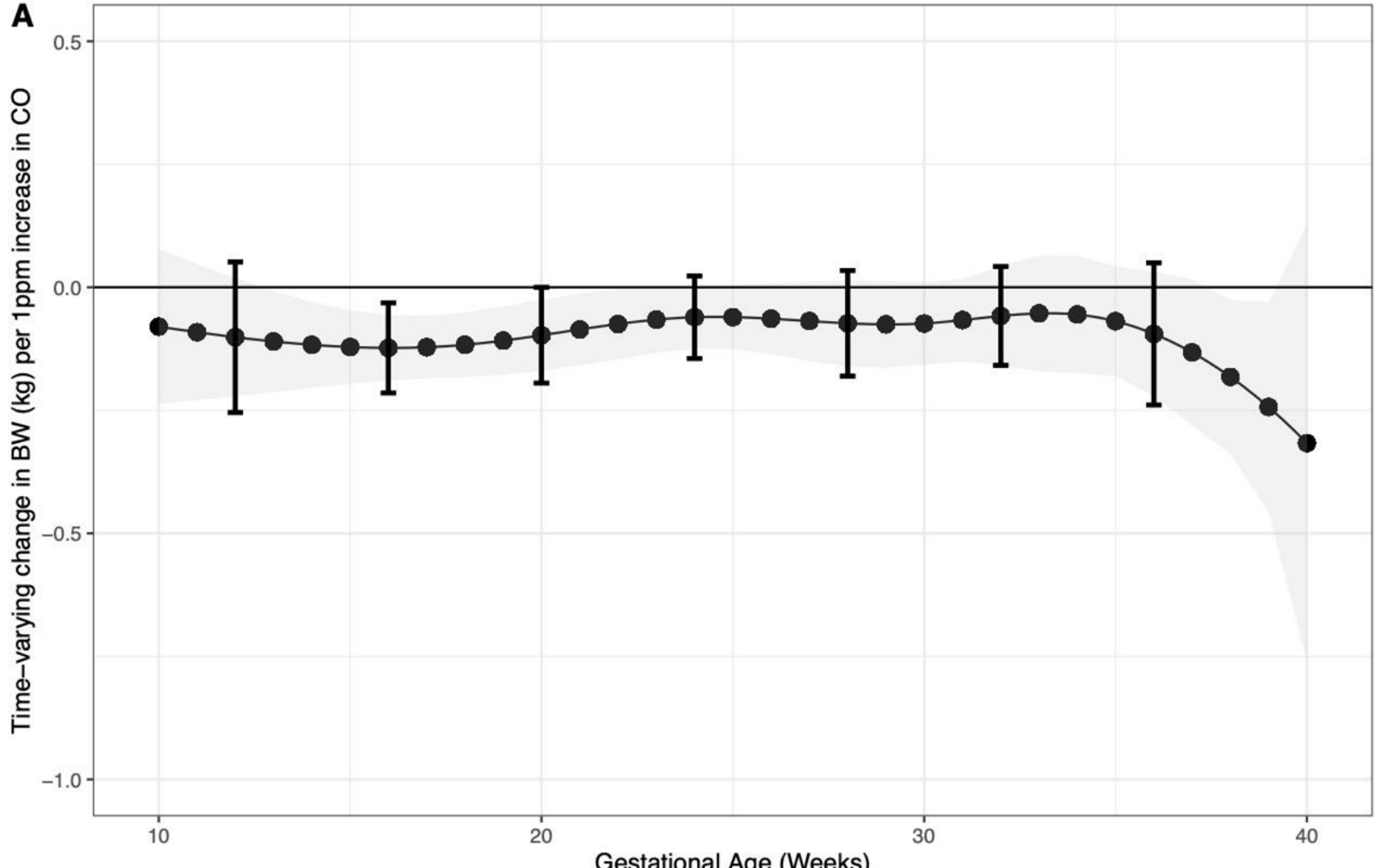
Kaali et al, in manuscript

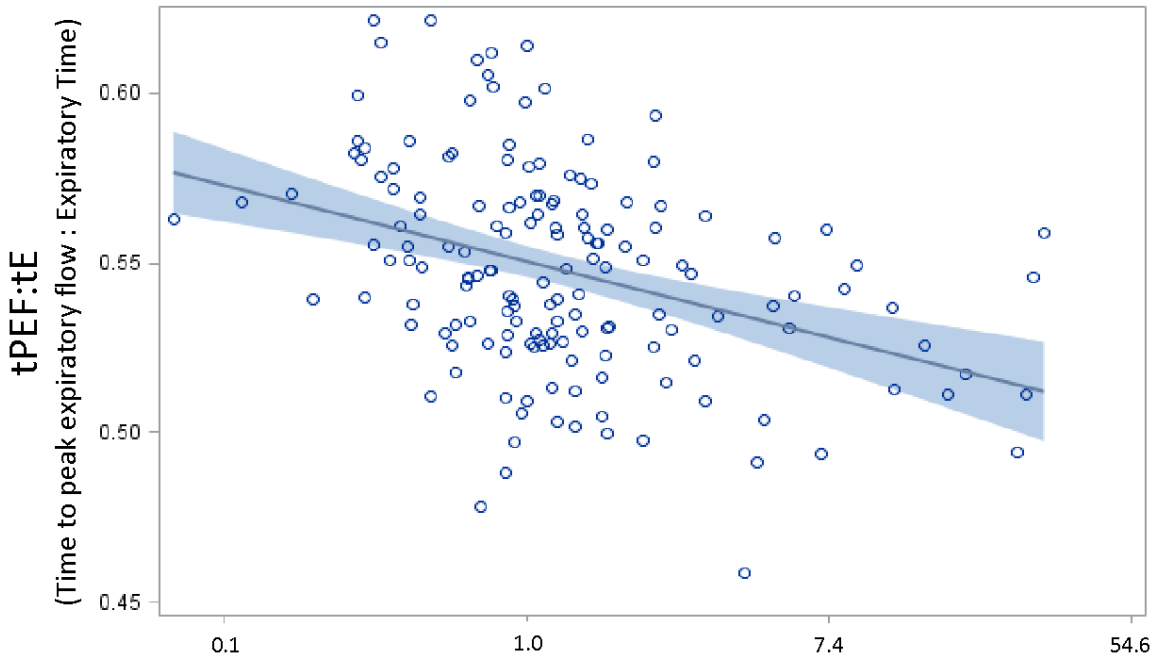
Clear exposure response relationship for birth weight, with smaller effects in mothers with placental malaria

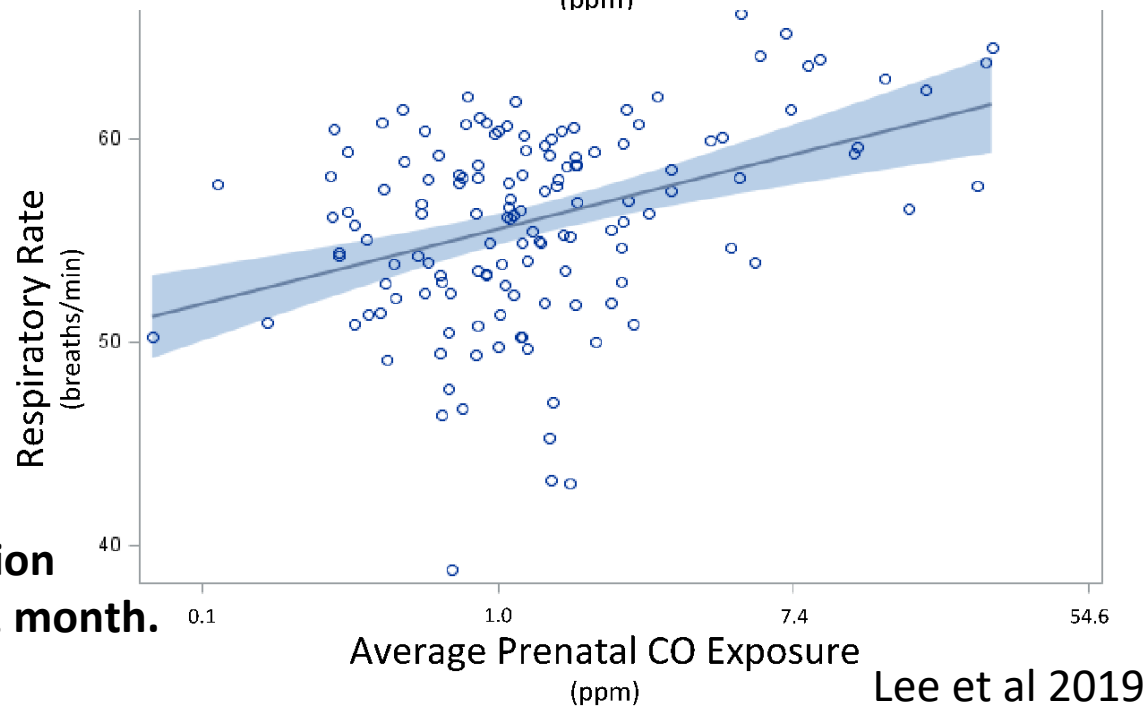


Quinn et al 2021

Key exposures for birthweight appear to be earlier in pregnancy



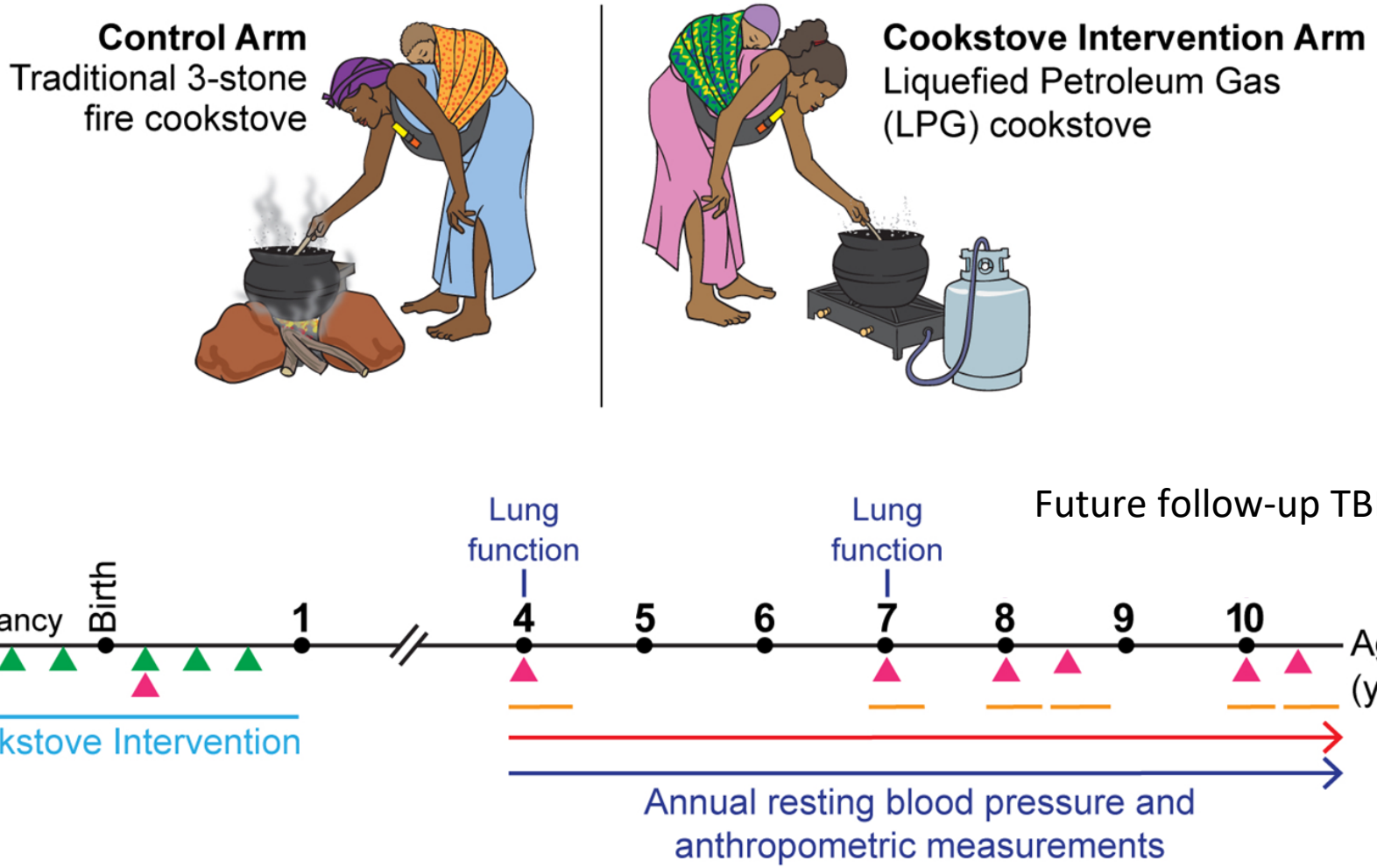




Elevated prenatal CO exposure is associated with increased respiration rate and impaired lung function (expiratory flow dynamics) at age 1 month.

Lee et al 2019

Ongoing follow-up of the GRAPHS Cohort



Growth trajectories: Higher HAP exposures associated with reduced growth over infancy

Prenatal HAP exposure to CO (and PM2.5) increased risk for

- Lower length
- Lower length-for-age z score
- Stunting

CO PM2.5

	OR	95% CI
Length	1.17	(1.01; 1.35)
Length-for-age z score	1.15	(1.01; 1.32)
Stunting	1.25	(1.08; 1.45)

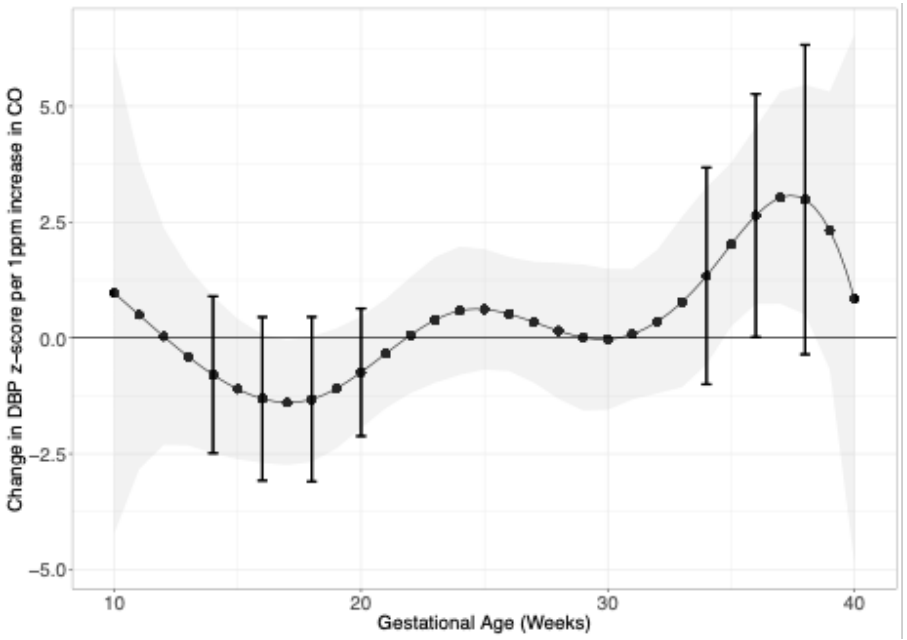
Postnatal HAP exposure to CO and PM2.5 increased risk for

- Smaller head circumference
- Smaller mid-upper arm circumference
- Lower weight-for-length z score

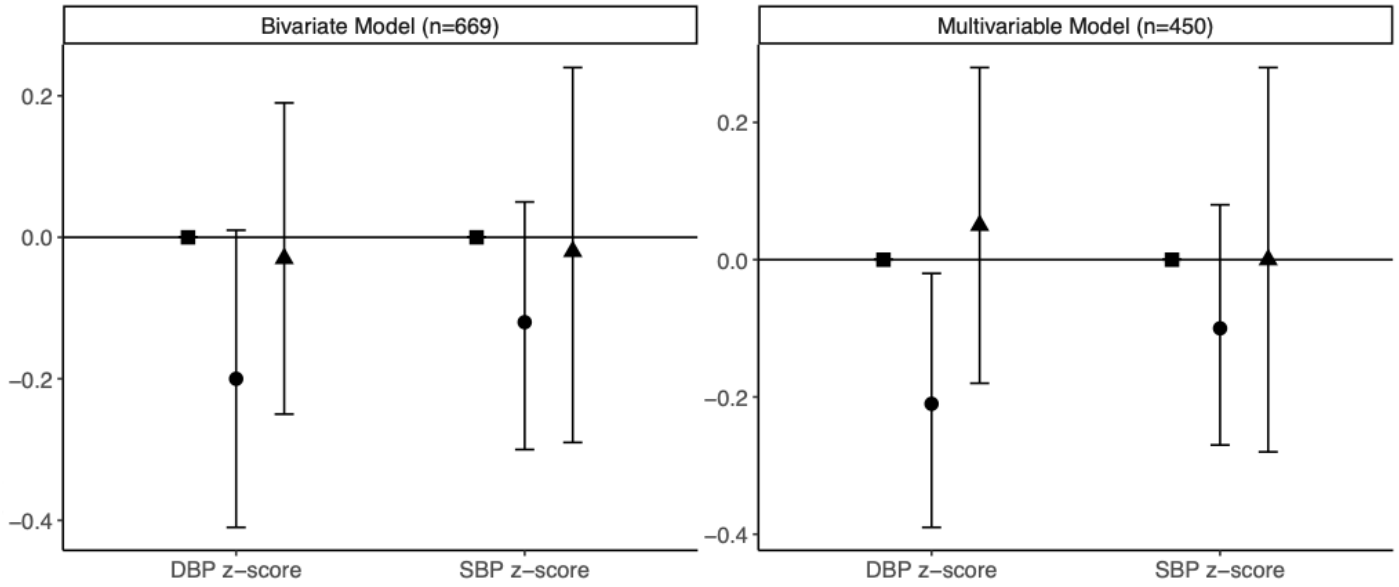
	OR	95% CI
Head circumference	1.09	(1.04; 1.13)
Mid-upper arm circumference	1.07	(1.00; 1.14)
Weight-for-length z score	1.09	(1.01; 1.19)

Boamah-Kaali, 2021

Cardiovascular health: Higher HAP exposures associated with higher blood pressure at age 4



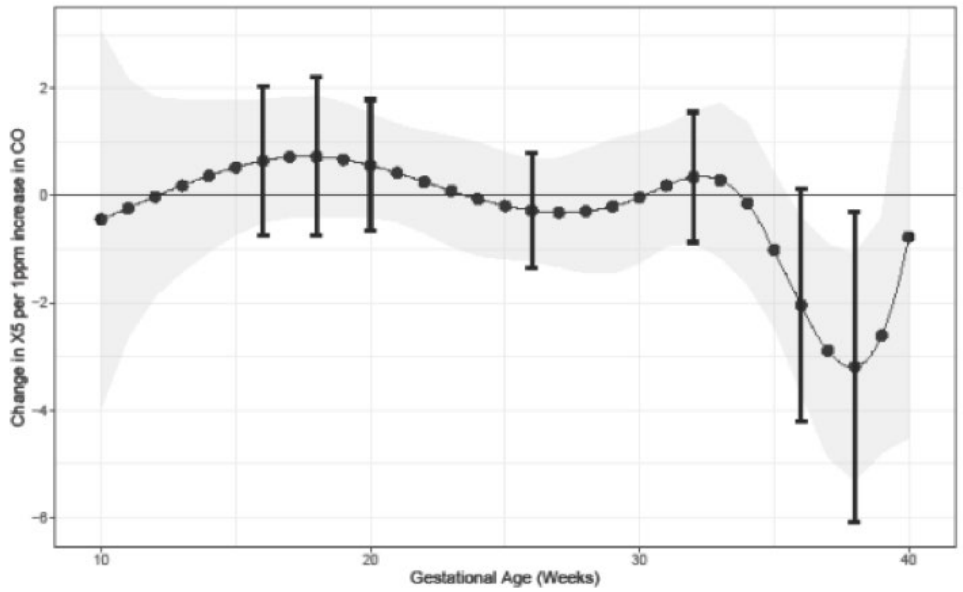
Higher CO exposure from 35-40 weeks of gestation associated with higher age four diastolic BP

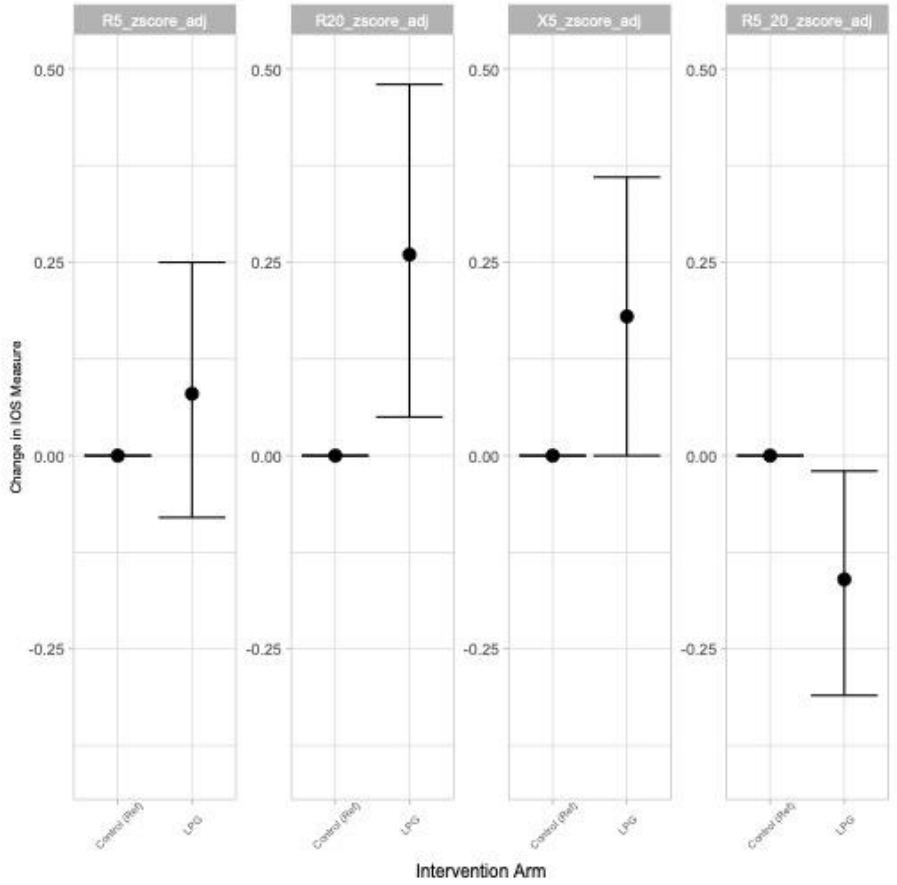


Age four diastolic BP z-score lower amongst children born in the LPG arm

Daouda et al, in manuscript

Lung function: Higher prenatal HAP exposure associated with impaired lung function at age 4





- Reactance at 5 Hz (X5): Indicator of the lung's ability to expand
- Higher CO exposures from 35-40 weeks of gestation associated with impaired lung function (top figure)
- Higher age 4 lung function among children born in the LPG arm (right figure)

Agyapong et al, in manuscript

Key Takeaways

Bottom line

- Evidence of impacts of HAP on children's lung function, growth, and blood pressure.
- Analyses underway also find effects for nasal and gut microbiome.

These all support the hypothesis that in utero and early life HAP exposures set the stage for lifelong health.

Distributed lag models suggest that impacts are concentrated in mid to late pregnancy (though this needs to be confirmed).

Key insights from policy studies

Ghana policy context

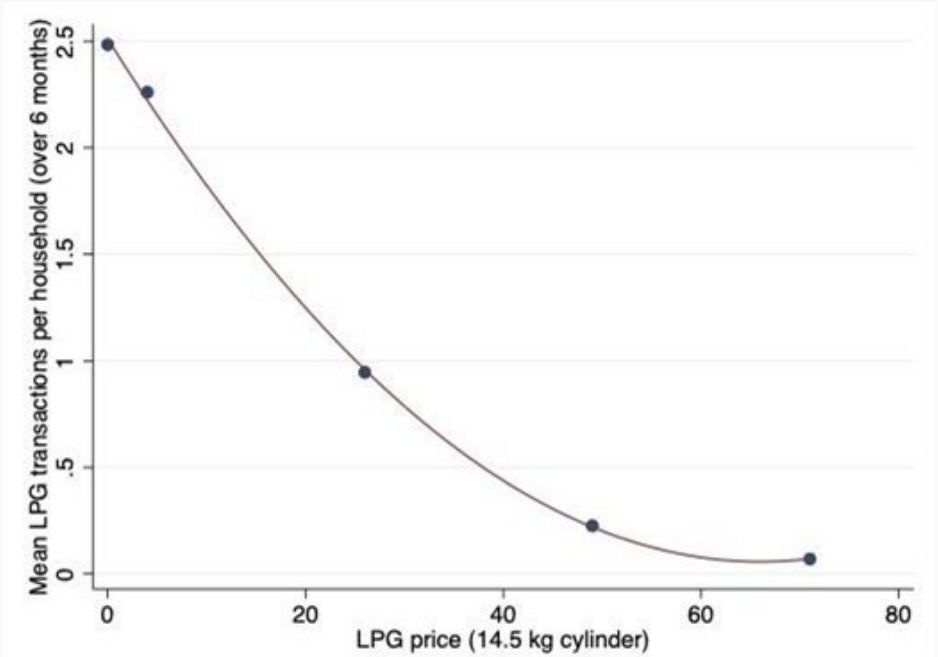
- Ministry of Energy introduced a National LPG Promotion Policy (NLPGPP) in 2017
- NLPGPP overall goal is ensuring that at least 50% of Ghanaians have access to safe, clean and environmentally-friendly LPG for increased domestic, commercial and industrial usage by 2030.
- A major policy shift in the NLPGPP was the introduction of Cylinder Recirculation Model (CRM) to accelerate the rate of uptake of LPG for cooking.
- Piloting has started and National Petroleum Authority is entrusted to roll out CRM over 5 years.

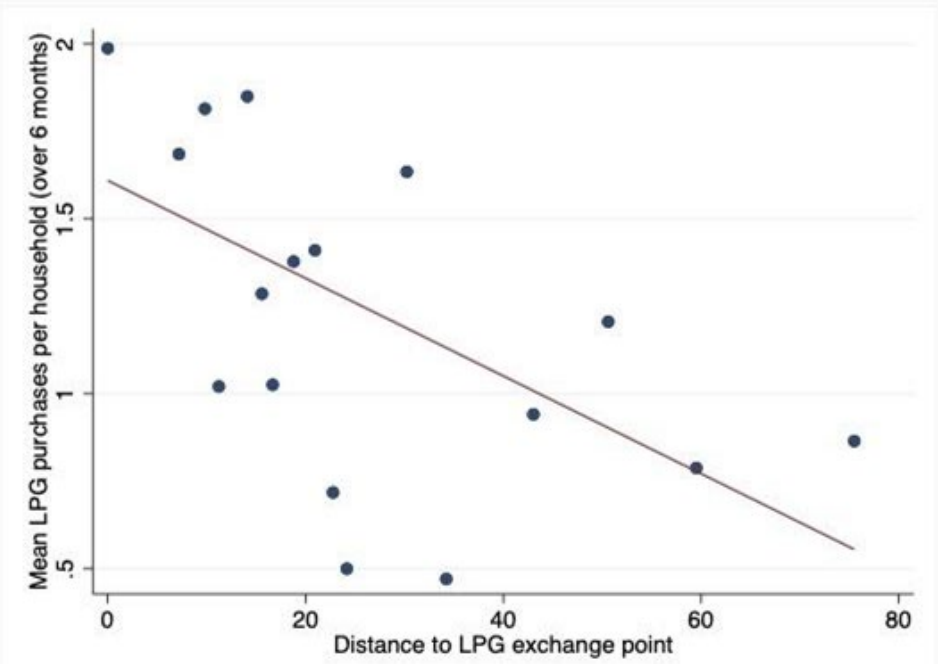
Rural LPG Program evaluation

- Program evaluation study focused on Ghana Ministry of Energy program to distribute LPG stoves to rural households
- Very low uptake of LPG over time - only 9% of participants refilled 3+ times
- Barriers: cost, distance

Abdulai et al 2018

Randomized variation in price and distance to cylinder exchange shows that rural consumers are





Enhancing LPG Adoption in Ghana (ELAG)

- Cluster-randomized factorial trial tracking effectiveness of home delivery of LPG and health education
- Participants of GRAPHS from Control or BioLite arms; 1-year follow-up

Table 3. Comparison of median and interquartile range of stove use (in minutes) by arm of study in the last six months of the observation period. *p* values produced from Wilcox rank sum tests. $n = 778$.

	Arm	Median (IQR)	*p* Value
Results without imputation	Control	120 (10–430)	Reference
	Education	160 (0–480)	0.668
	Delivery	0 (0–90)	<0.001
	Dual	0 (0–110)	<0.001
Results with Imputation	Control	320 (170–560)	Reference
	Education	380 (280–670)	<0.001
	Delivery	600 (470–750)	<0.001
	Dual	580 (460–680)	<0.001

- Evidence of improved knowledge and attitudes with educational interventions, *no evidence of meaningful changes to sustained use*

(Carrion et al., *Sustainability*, 2021)

Columbia World Projects – new effort in Ghana

Five years, two phases: Assess-Design-Test

- Incorporate evidence-based behavior change approaches to support adoption and sustained use of clean fuels.
- Develop a stack of clean energy technologies that can (hopefully) fully displace traditional open fires – match technologies to needs. Focus on energy services.
- Transition entire communities towards clean alternatives.
- Identify broader energy system changes that support and sustain household and community level transitions.
- Collaborative model – coproduce with Government of Ghana partners and with partner communities.

Constructing a clean cookstove stack in Ghana

Putting the pieces together – integrating health and policy research to support clean energy transitions

What have we learned?

- Multifaceted evidence of harm to child health, with potential implications for health throughout the life-course --
  - This suggests that early life fuel switching may have disproportionately large benefit.
  - Distributed lag models suggest that early switching during pregnancy is critical
- However, Individual level fuel switching have a significant but small impact on exposure – we thus hypothesize that community-scale interventions are key to really reducing exposure. (Nevertheless, household-level clean fuels affect age 4 blood pressure and lung function)
- Very steep rural demand curve for clean fuels implies that subsidies are likely to be necessary in rural areas
- Parity of charcoal and LPG expenditures suggests a place to focus
- An important teaming and learning process … hard disagreement based on mutual respect, converging on health impact and capacity building and equitable academic benefits

And where do we go from here?

Thank you!

- Study participants and policy stakeholders
- NIH (P30-ES009089, R01-ES019547, R01-ES026991, R01-ES024489, R21-TW010957, Clean Cooking ISN)
- GHS/MoH
- NPA/MoE/EC
- Columbia Global Health Initiative
- Columbia World Projects
- USAID
- GACC (now CCA)
- Thrasher Research Fund
- JPAL (MIT)
- WEE-DiFine (BRAC)