Investigating Health-Relevant Air Pollution Concentration Linkages Across Multiple Seasons During Indoor Cookstove Campaign in Rural India

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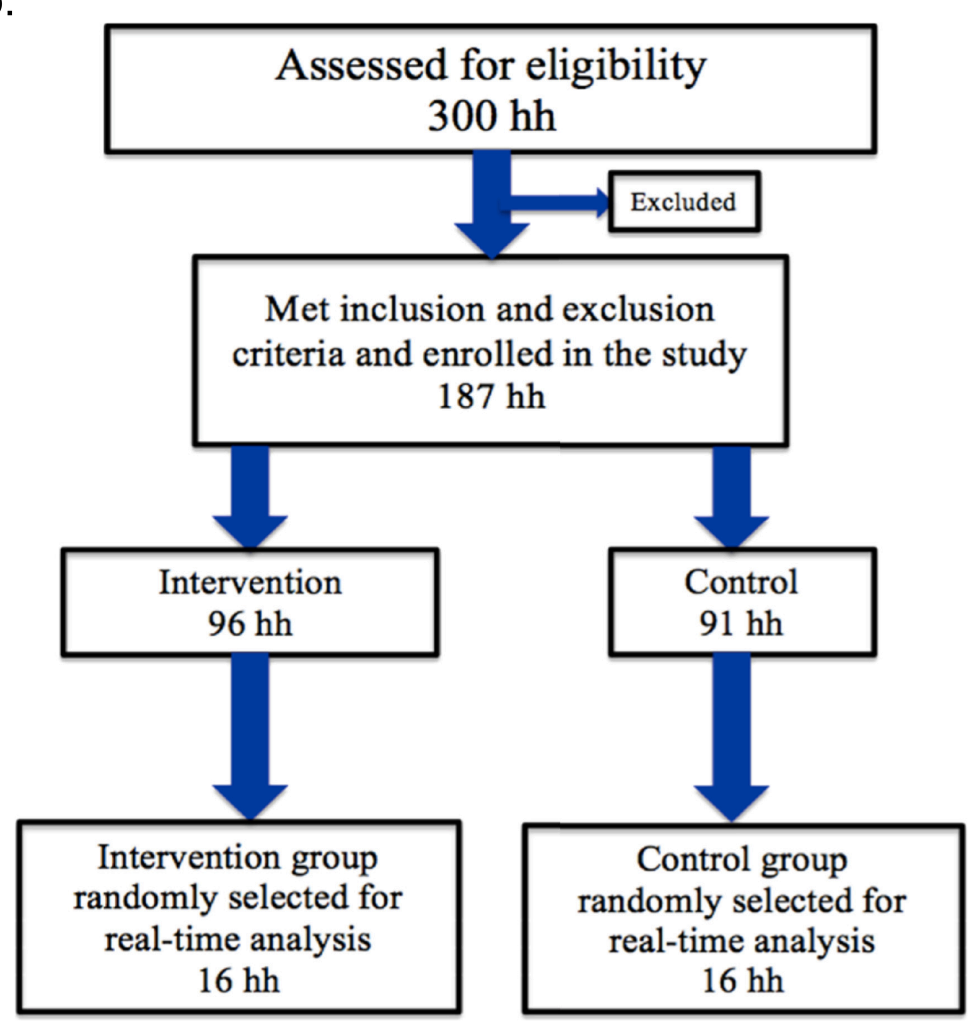
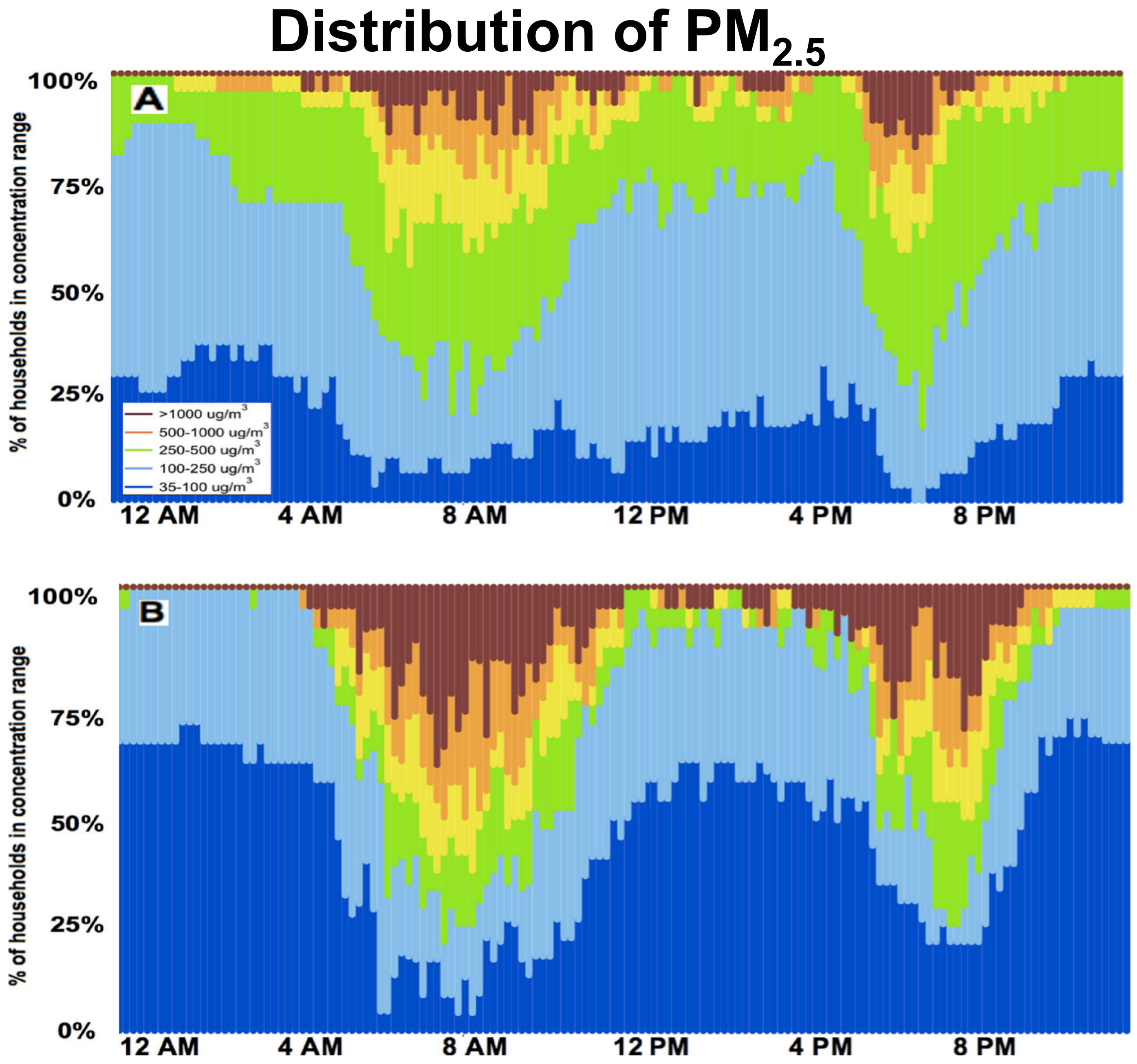
Methods

- Cookstove randomized control trial (RCT) in rural India: households randomly assigned to receive ("intervention") or not receive ("controls") the intervention cookstove.
- Real-time measurement of CO, BC, and $PM_{2.5}$
- 24h-averaged, fixed window (05:00–09:00 and 18:30–21:00), and variable window (150% of a household's 02:00 background baseline) definitions of cooking employed.
- Two seasons: pre-intervention baseline (September 2, 2011–December 10, 2011; "S1"); a post-intervention follow-up (March 11, 2012–August 1, 2012; "S2").
- "Intervention" = replacing traditional open fire with a new hearth and two chulika stoves. "Mixed" = both intervention and traditional stoves used. "Intent to treat" = intervention plus mixed group.



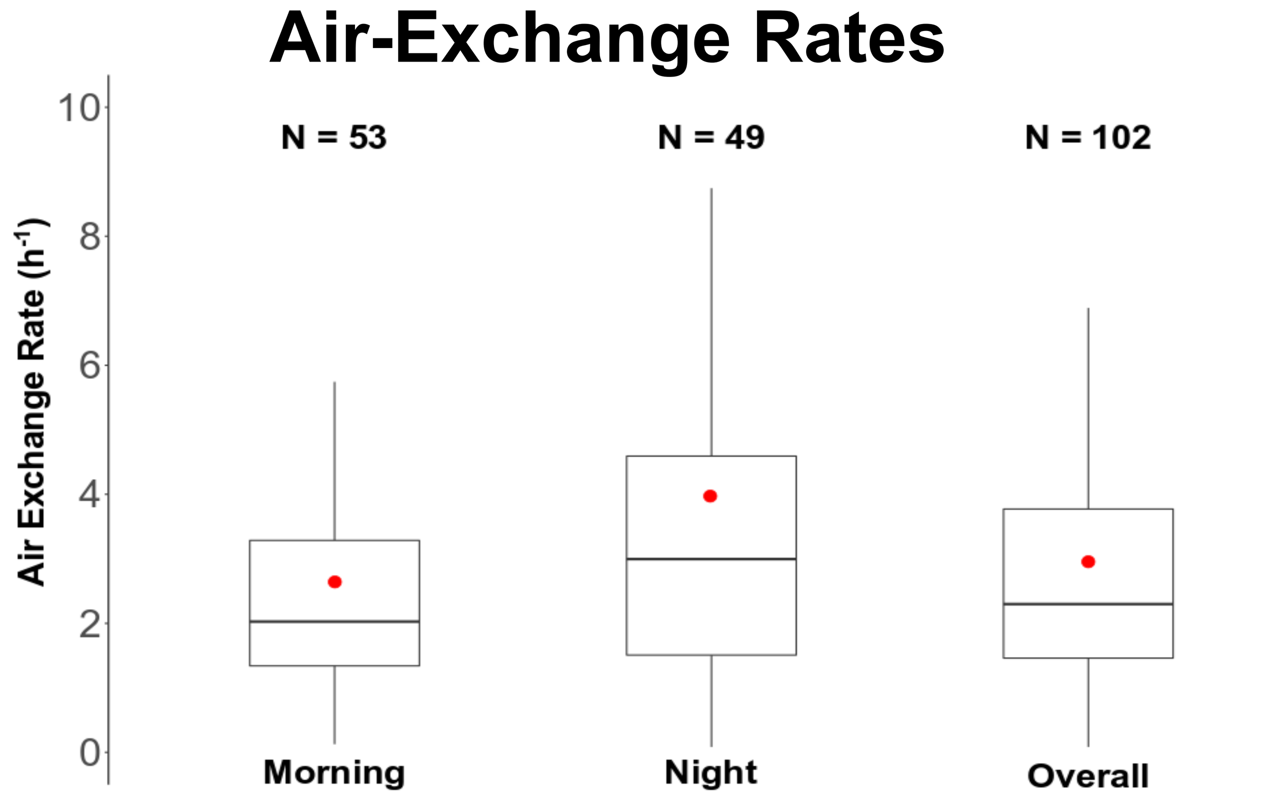
Household (hh) eligibility and exclusion based on parallel assignment study design. **32 hh selected for real-time analysis.**

Seasonal and Diurnal Distribution of $PM_{2.5}$



Midday concentrations were generally higher during S1 (A) than during S2 (B). During cooking, **the percent of events with concentrations higher than 1000 µg/m³ was lower during S1 than during S2 (7% vs. 13%)**.

Air-Exchange Rates

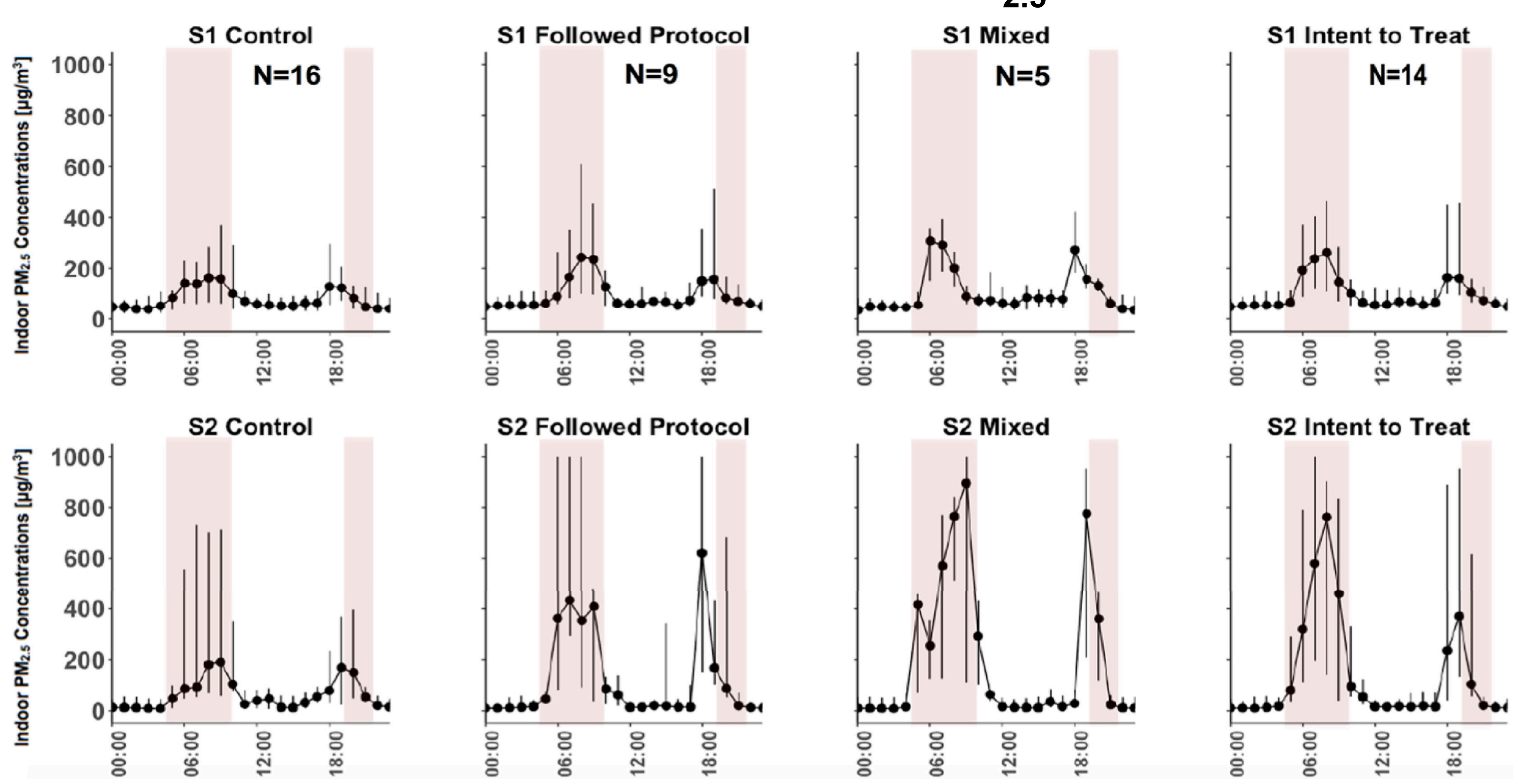


Median AER was 2.5 h^{-1} (mean: 3.4 h^{-1}, IQR: 1.5–3.9 h^{-1}). Median AER was **52% higher in the evenings than the mornings** (3.2 vs. 2.1 h^{-1}, $p < 0.003$; IQR: 1.5–6.0 h^{-1} vs. 1.4–3.3 h^{-1}). Differences between S1 and S2 were small and not statistically significant.

Background and Motivation

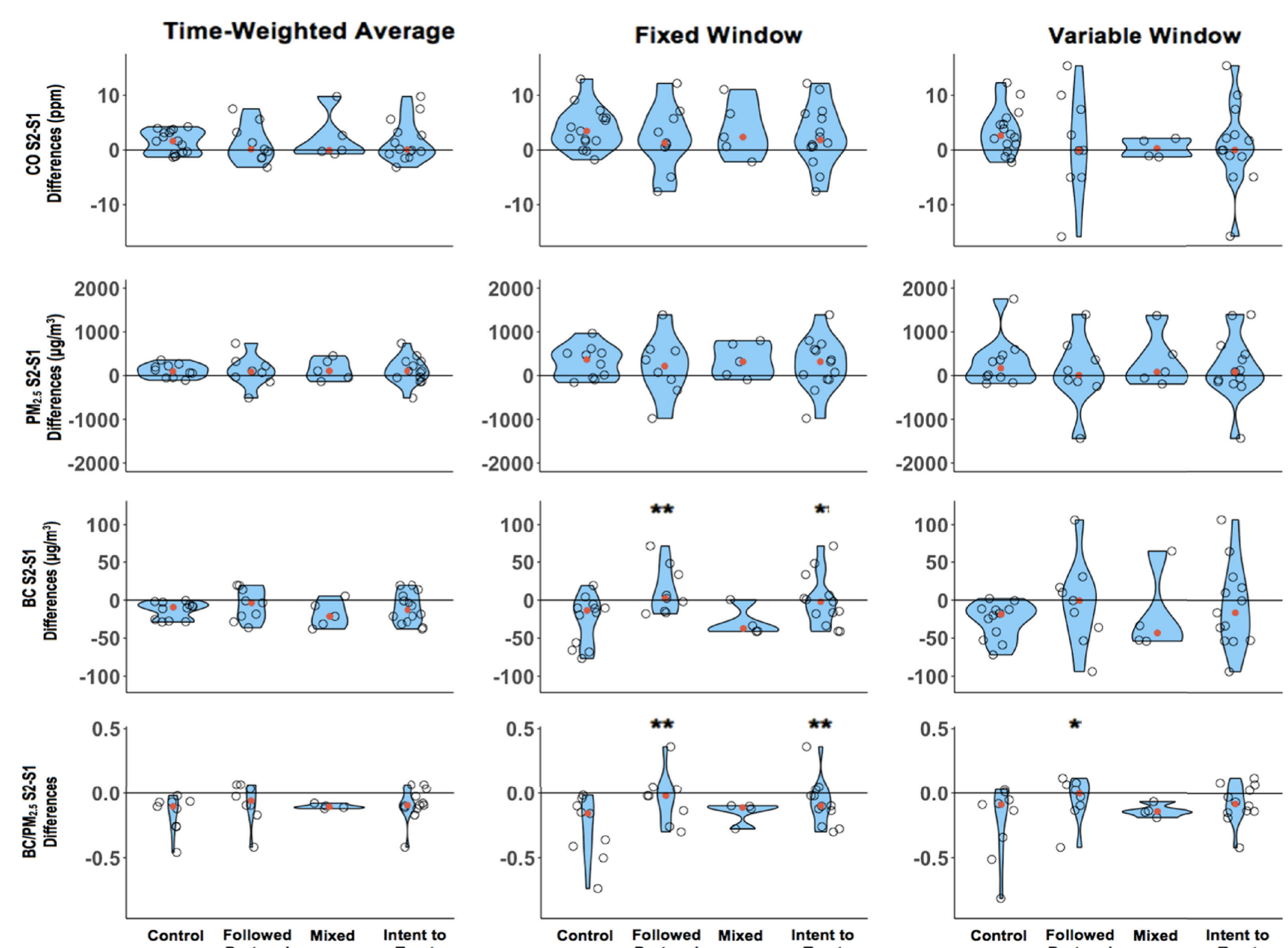
- Combustion of solid fuel in traditional stoves affects human health and the environment [1]. The resulting household air pollution is associated with adverse health impacts in adults and children [2].
- Our study was CDM approved & conducted in a rural village in the Koppal district of northern Karnataka, a state with a population of ~1.2 million people that covers 7190 square kilometers.
- Approximately 35% of Koppal residents are day-wage laborers earning less than one dollar per day; an estimated 99% of Koppal households use traditional stoves (indoor, open fires) to cook food and heat bath water [3].

Diurnal Trends of $PM_{2.5}$



Indoor concentrations of $PM_{2.5}$ generally **peaked in the morning and evening around cooking events (shaded regions)**. Average concentrations during non-cooking hours for both seasons (S1: 58 and S2: 18 µg/m³) were relatively constant within that season (pooled coefficient of variability for S1 and S2: 47%).

Effectiveness of Evaluation



Intervention cookstoves yielded **statistically significant increase in BC** concentrations (by 39 µg/m3, p<0.05) and **$BC/PM_{2.5}$** (by 0.25, p<0.05) during cooking-relevant hours-of-day relative to controls. Median CO and $PM_{2.5}$ concentrations decreased, though not statistically significant.

Conclusions

- The CDM-approved intervention stove improved some but not all aspects of air quality.
- During cooking-relevant hours-of-day, in intervention households relative to controls, median concentrations decreased for CO (by 1.5 ppm, p=0.28) and $PM_{2.5}$ (by 148 µg/m³, p=0.46) but increased for BC (by 39 µg/m³, p<0.05) & for the ratio of $BC/PM_{2.5}$ (by 0.25, p<0.05).
- We measured a mean AER of 3.4 h^{-1} (median = 2.5; IQR = 1.5–3.9; range = 0.08–12.7 h^{-1}), which is consistent with literature.
- The smaller sample size real-time monitoring (n=32) may prevent establishing statistical significance that may otherwise be viable with a larger dataset of time-integrated equipment.

Text and figures in full can be found in **Kelp, M.M., et al., Real-time indoor measurement of health and climate-relevant air pollution concentrations during a carbon-finance-approved cookstove intervention in rural India. Development Engineering, 2018. 3: p. 125-132.**

References

[1] Venkataraman et al., 2005, doi: 10.1126/science.1104359
[2] Dherani et al., 2008, doi: 10.2471/BLT.07.044529
[3] Fair Climate Network, 2012, Baseline Information: Koppal Taluk

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