

How health metrics work: health metrics relevant to estimating the impact of black carbon interventions

Empirical evidence and models from household air pollution in Asia

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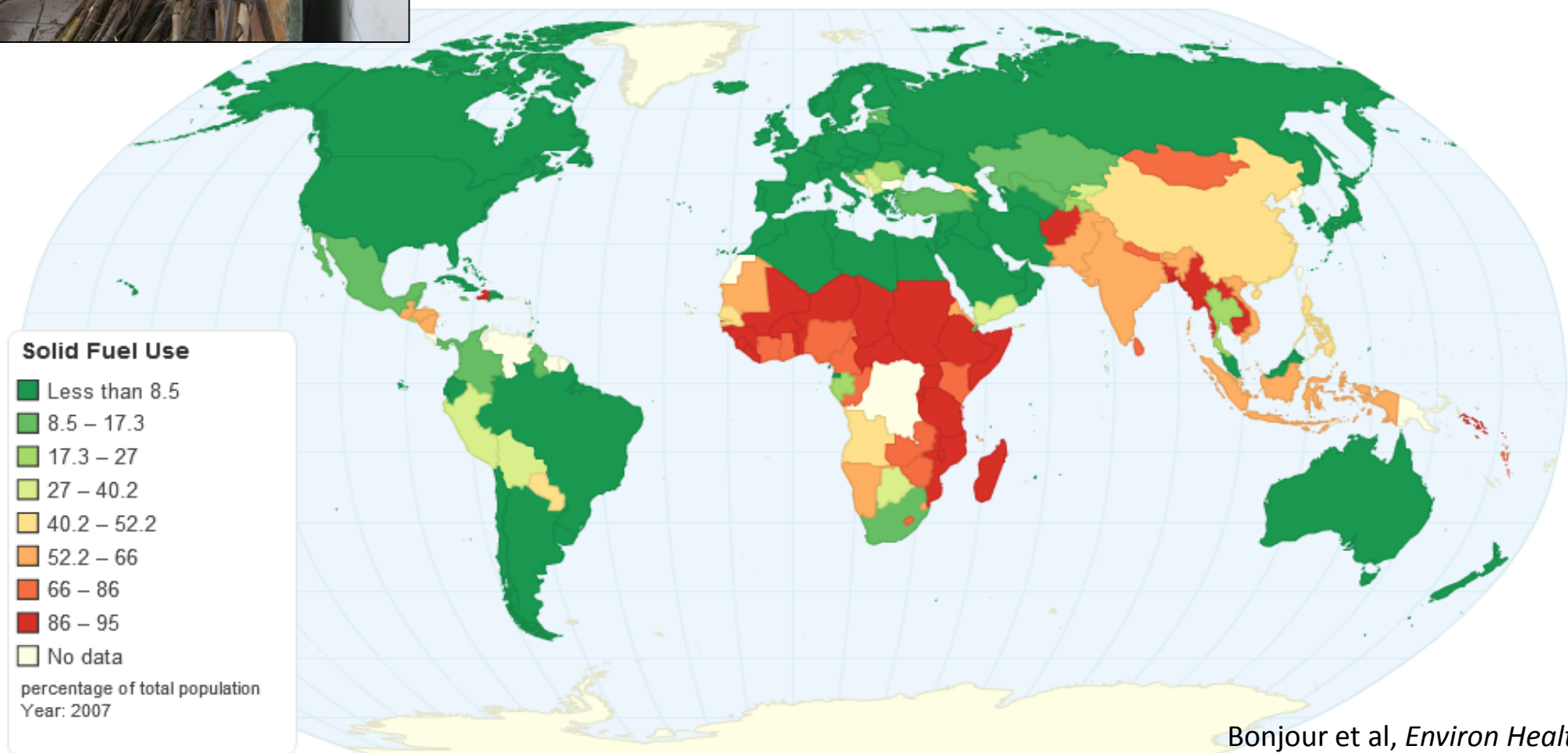
Institute for Health and Social Policy

McGill University, Montreal

CCAC Expert Workshop on Metrics for Evaluating and Reporting on BC and Methane Interventions

March 16, 2017

Population (%) cooking with biomass and coal in 2012



Outline

- ➔ Epidemiologic studies of black carbon exposure and health
 - Evaluating the health impacts of household- or community-level intervention
 - Combining field measurements and models to evaluate the impacts of household energy transitions at larger scales

Personal black carbon exposure & acute changes in blood pressure in Indian women



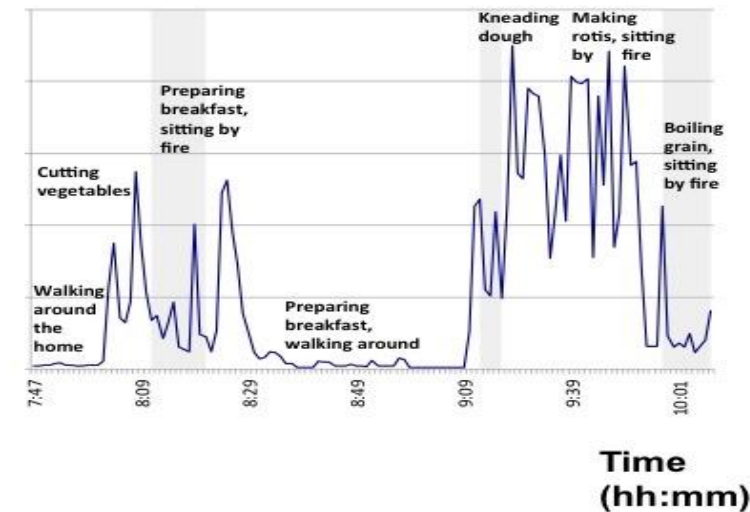
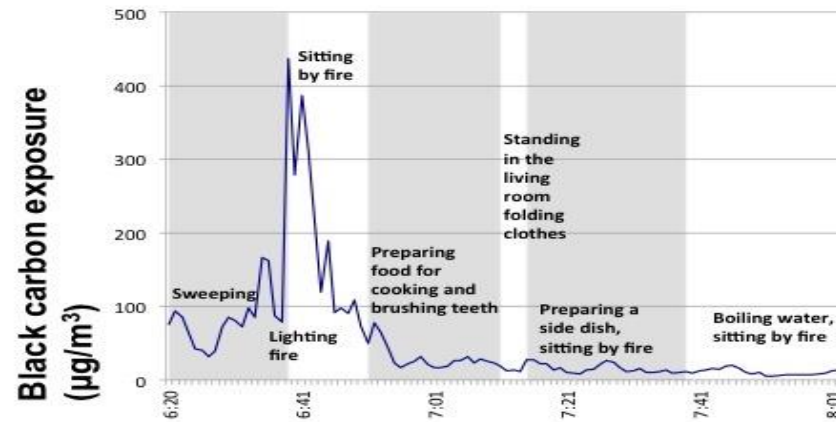
- **Study population:** 45 non-smoking women (mean age=42 y)
- **Exposure:** Real-time exposure to black carbon during cooking in winter and in summer
- **Health Outcome:** Ambulatory systolic and diastolic blood pressure
- **Covariates:** Age, body mass index, socioeconomic status, activity, sodium intake, temperature, time of day, and day of the week

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Activities and exposure to black carbon during cooking

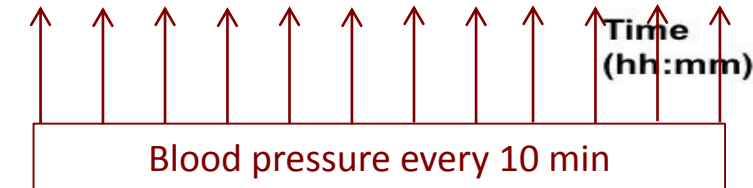
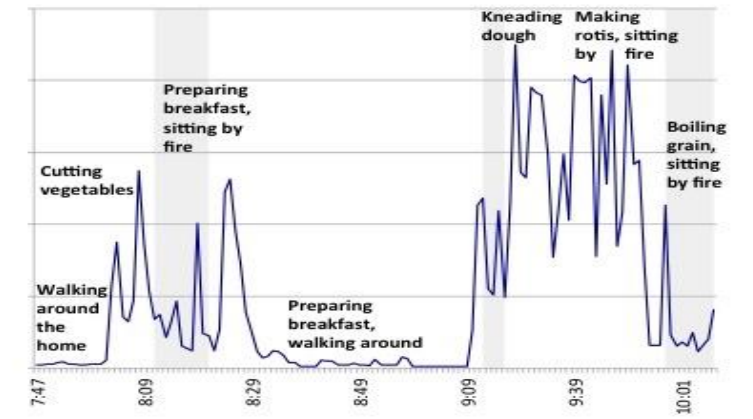
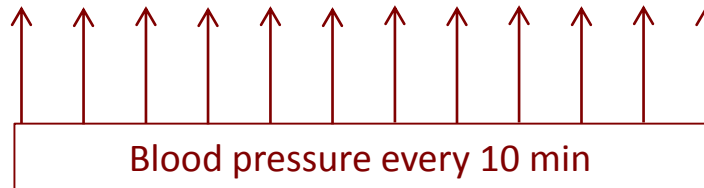
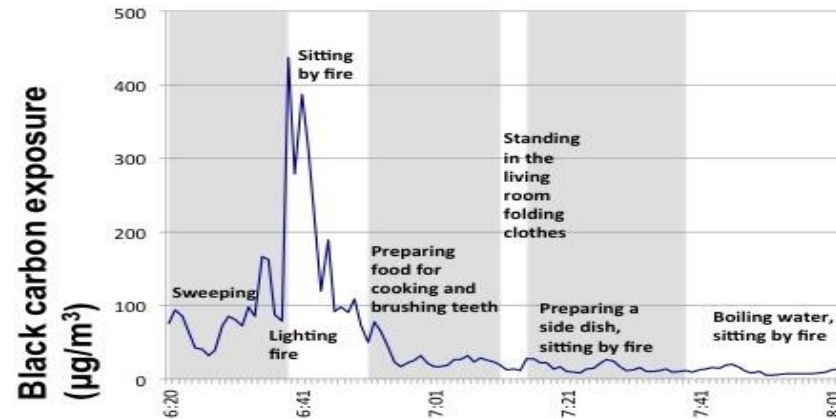


Personal black carbon exposure & acute changes in blood pressure in Indian women

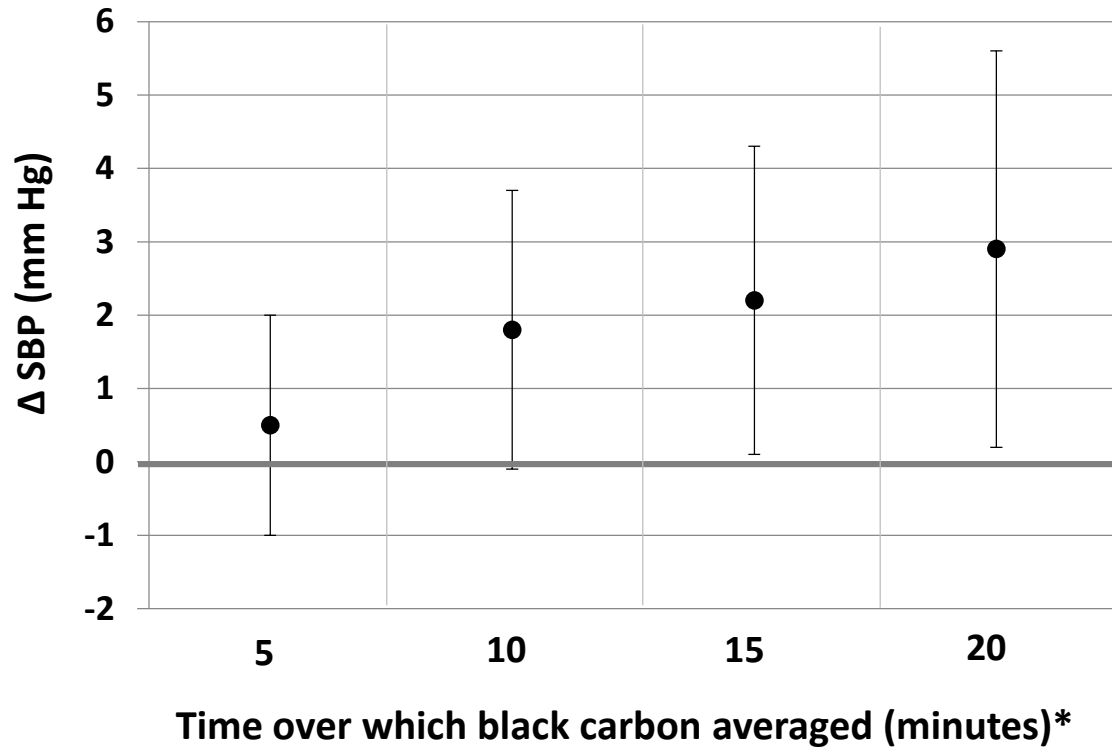


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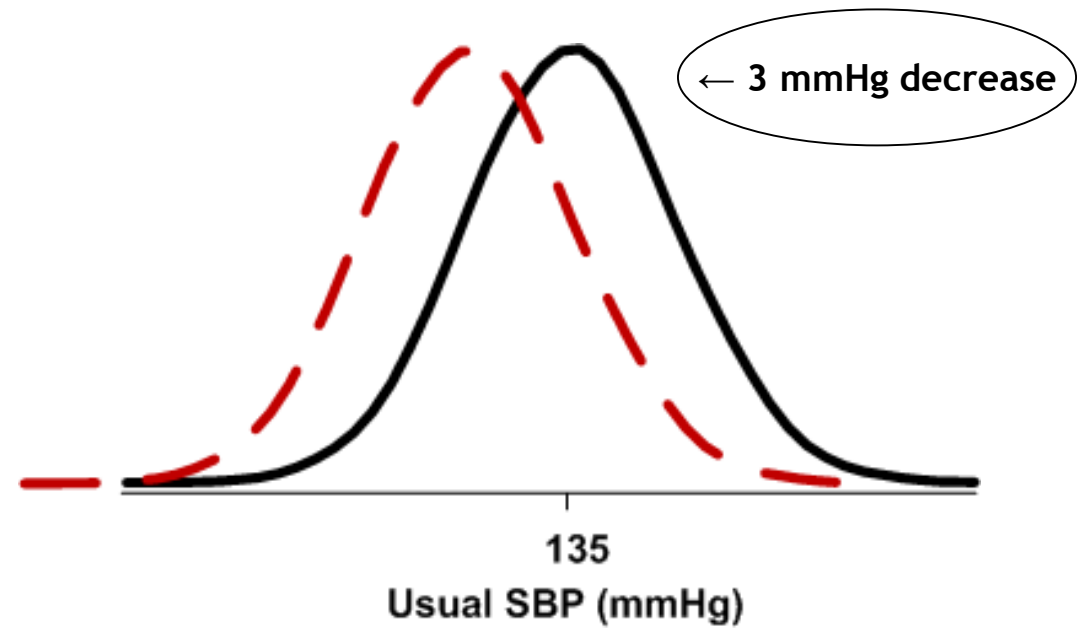


Interquartile range changes in black carbon exposure (~100 $\mu\text{g}/\text{m}^3$) and systolic blood pressure in Indian women during cooking (n=45)



Adjusted for age, temperature, body mass index, socioeconomic status (asset index), time of day, salt intake, heart rate

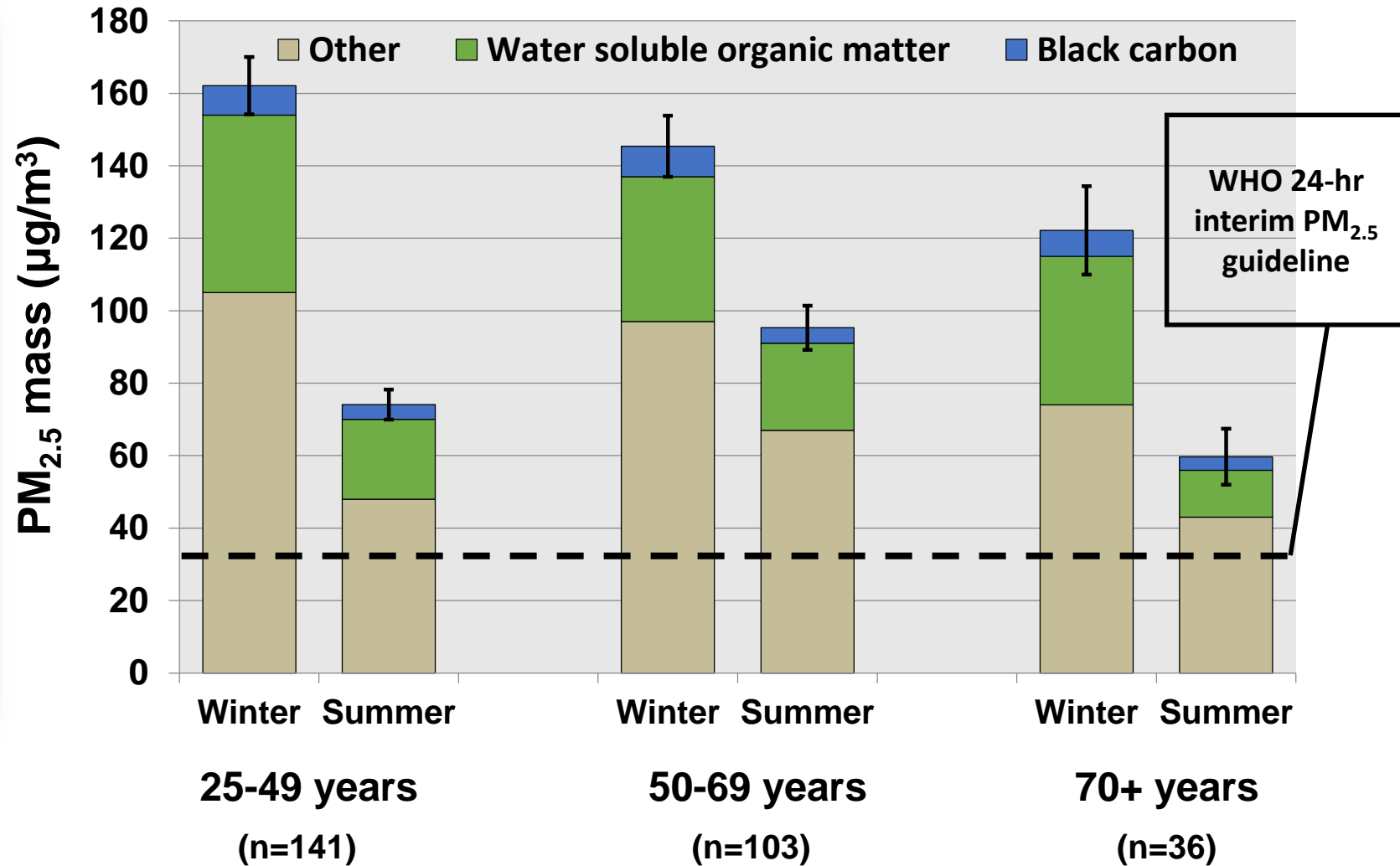
Cardiovascular benefits of population interventions in Asian cohorts



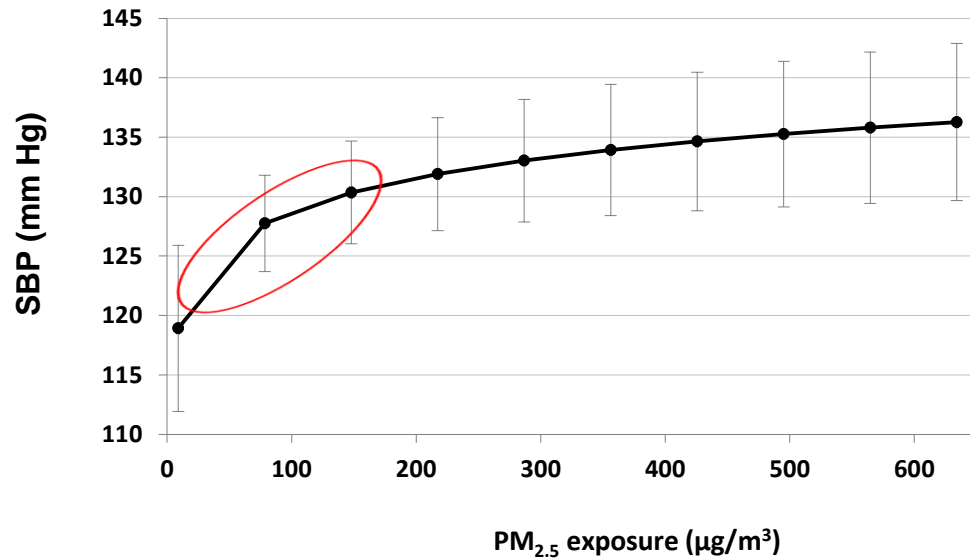
> 8% reduction in stroke

> 10% reduction in coronary heart disease

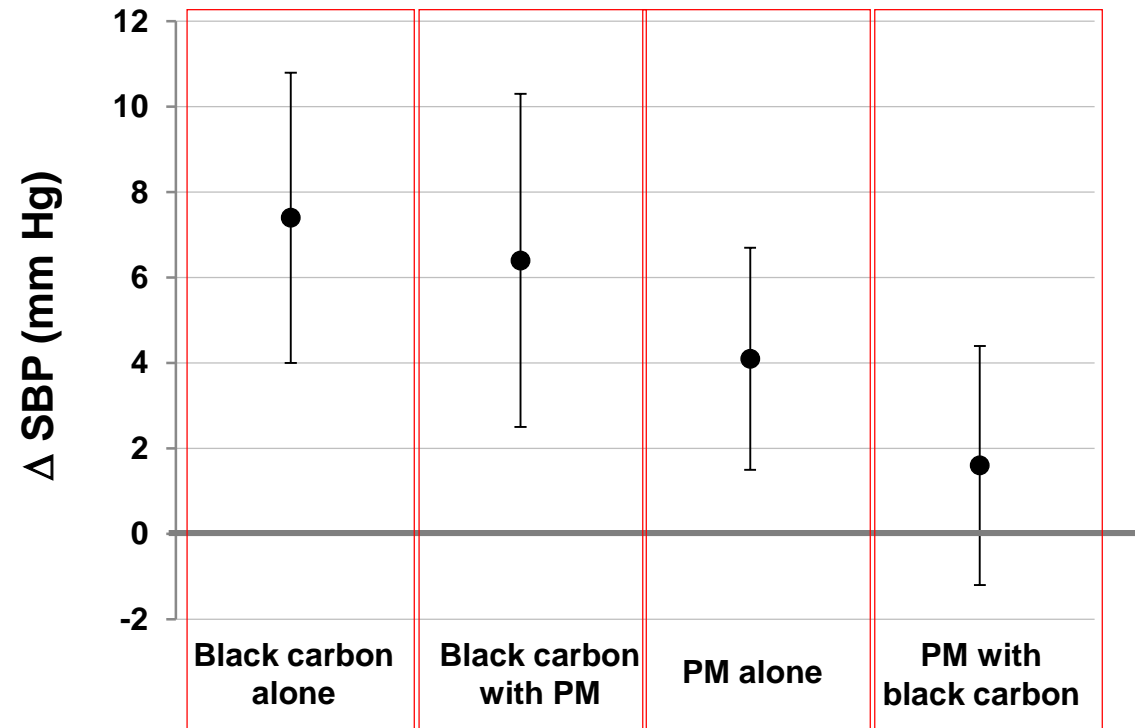
Daily exposure to PM_{2.5} mass and black carbon by age/season in rural Chinese women (n=280)



Household air pollution and blood pressure in Chinese women



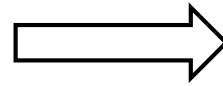
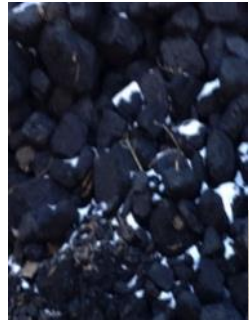
Associations of PM_{2.5} mass and black carbon exposure (1 log-µg/m³) and blood pressure in older women (n=280)



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- Epidemiologic studies of black carbon exposure and health
- ➔ Health metrics and study designs for evaluating household- and community-level interventions
- Combining field measurements (emissions + exposures) and models (air quality + health exposure-response) to evaluate the impacts of household energy transitions at larger scales

Replacement of solid fuel stoves with cleaner-burning stoves and fuels



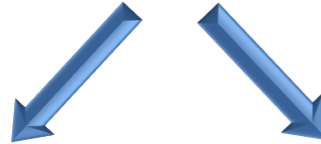
Design, development, and testing of improved energy packages



Baseline / post-intervention measurements of air pollution and health indicators



Laboratory analysis of air pollution samples & biomarker samples



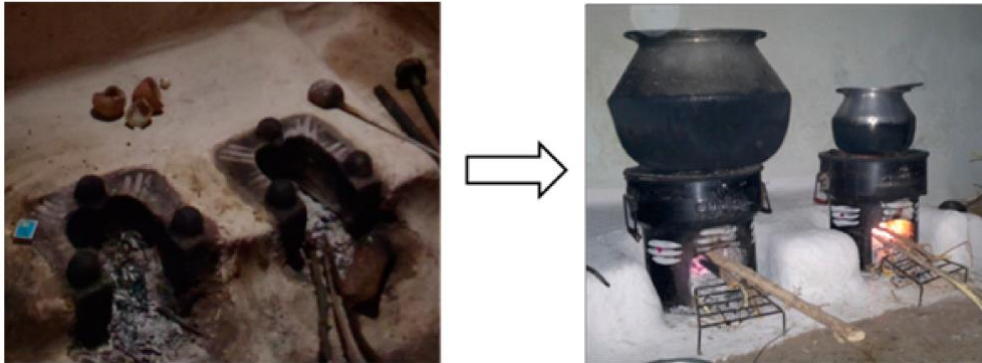
Changes in air pollution emissions, household concentrations and human exposures

Health impacts, e.g.,:

- Birth outcomes
- Pneumonia in infants and young children
- Childhood cognitive impacts
- Subclinical cardiovascular outcomes



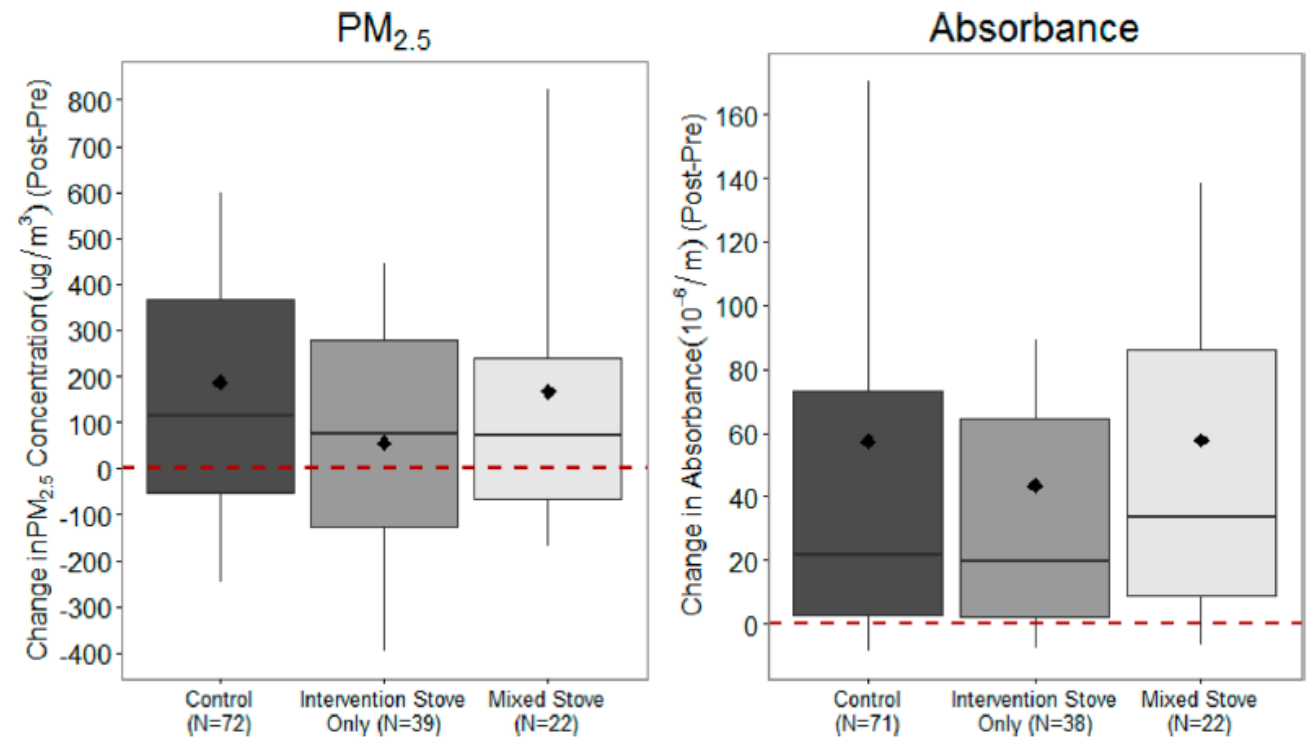
Change in black carbon concentrations from a carbon-finance approved cookstove intervention in India



Absorbance-to-mass ratio (m^2/g);
mean (95% CI)

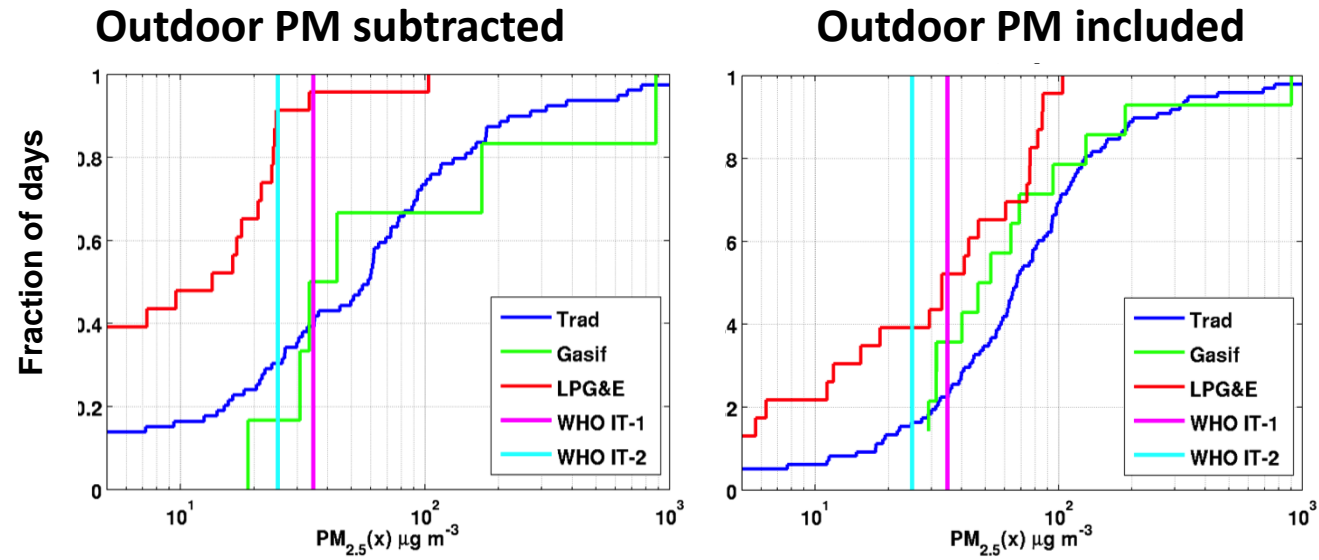
- Control: 0.15 (0.10–0.24)
- Intervention: 0.20 (0.14–0.31)
- Mixed stove: 0.18 (0.13–0.31)

Change in PM_{2.5} and black carbon concentrations by stove use group from pre- to post-intervention



Cumulative distribution of daily indoor PM_{2.5} concentrations in rural China with different stove interventions (n=389 days in 202 homes)

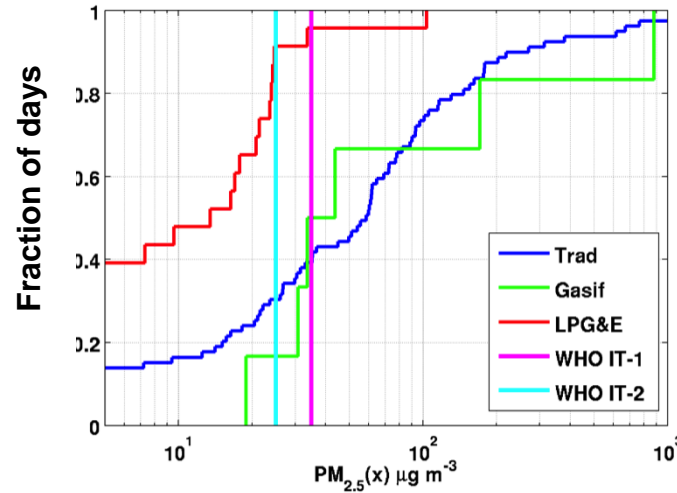
SUMMER



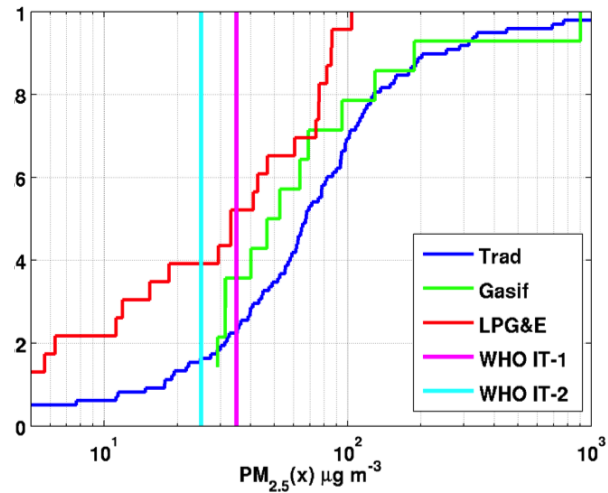
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SUMMER

Outdoor PM subtracted

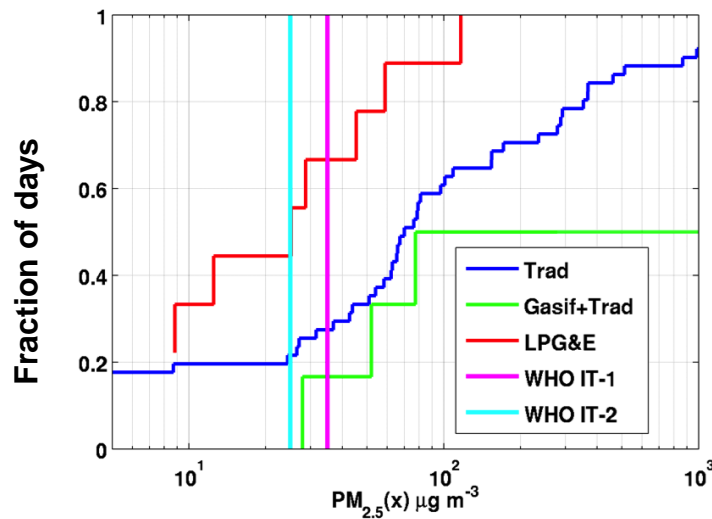


Outdoor PM included

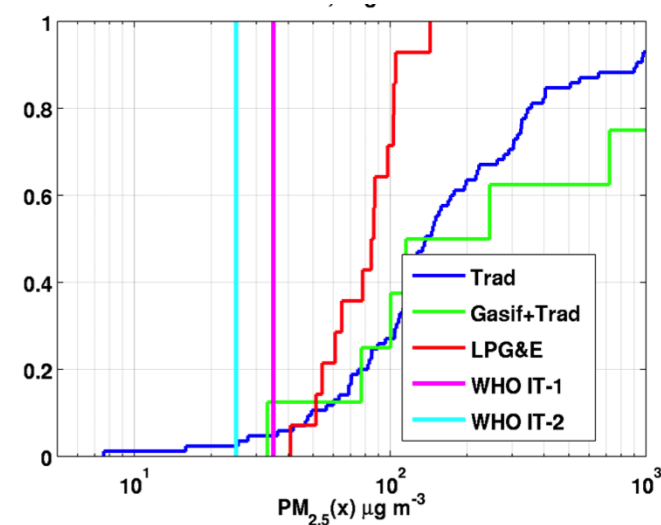


WINTER

Outdoor PM subtracted



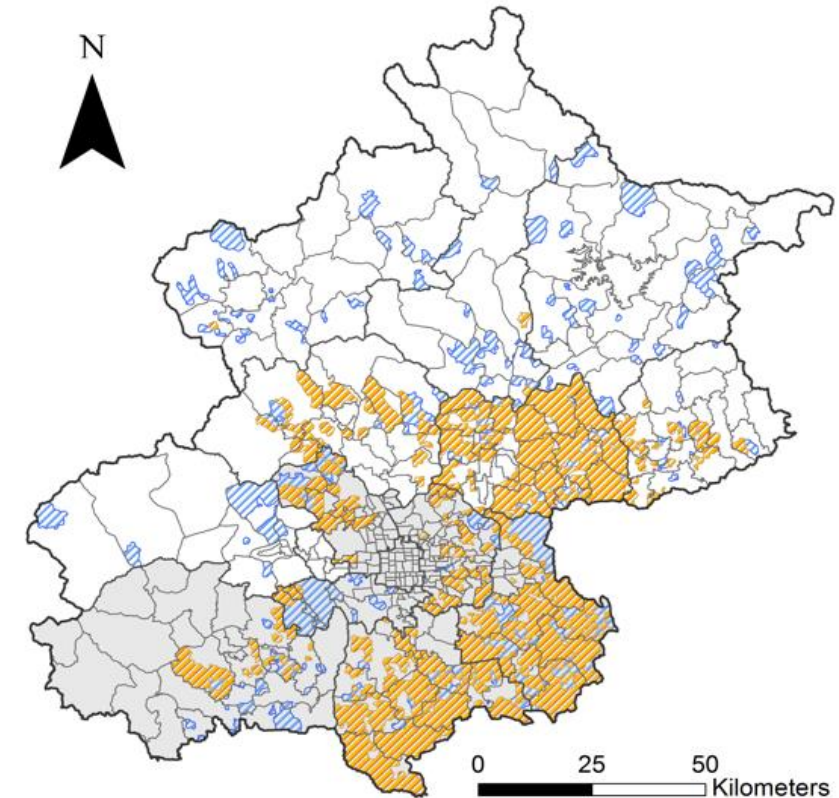
Outdoor PM included







Leveraging natural experiments for policy and program evaluation: Coal-to-electricity programs in peri-urban Beijing

1. How much does the program reduce coal burning?
2. What is the average adoption of the new technologies?
3. Does the program impact air pollution and health?

→ All require measurement in homes and communities inside and outside the program boundaries



Legend

	Heat pump subsidy after 2017		Beijing Municipality
	Heat pump subsidy by 2017		District Boundaries
	Coal Banned in 2016		Township Boundaries

Household and community-level intervention evaluation

- Advantages

- Direct evaluation of health impacts associated with ongoing interventions or policies
- Can facilitate evaluation of exposure-response relationships
- Able to evaluate important intervention-related metrics like adoption, use, and breakage rates to inform the feasibility of scale-up

- Challenges

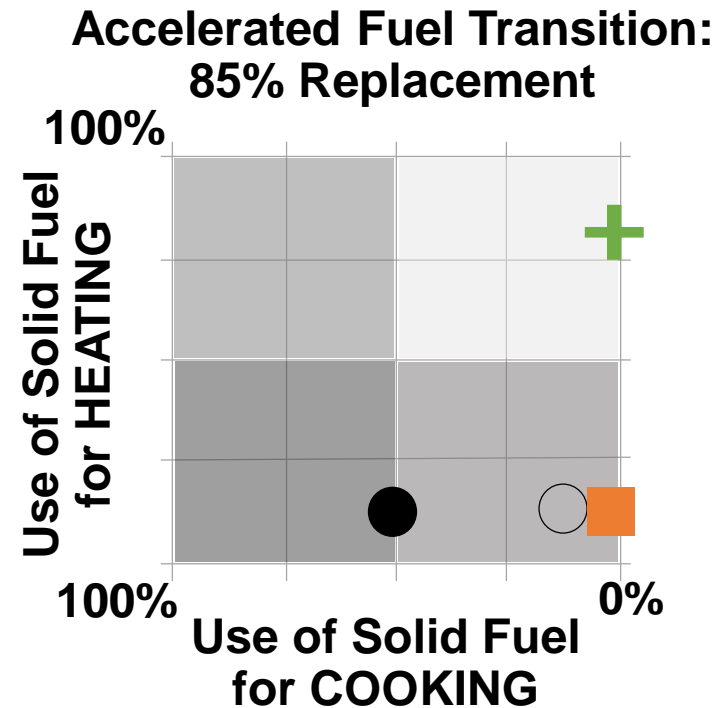
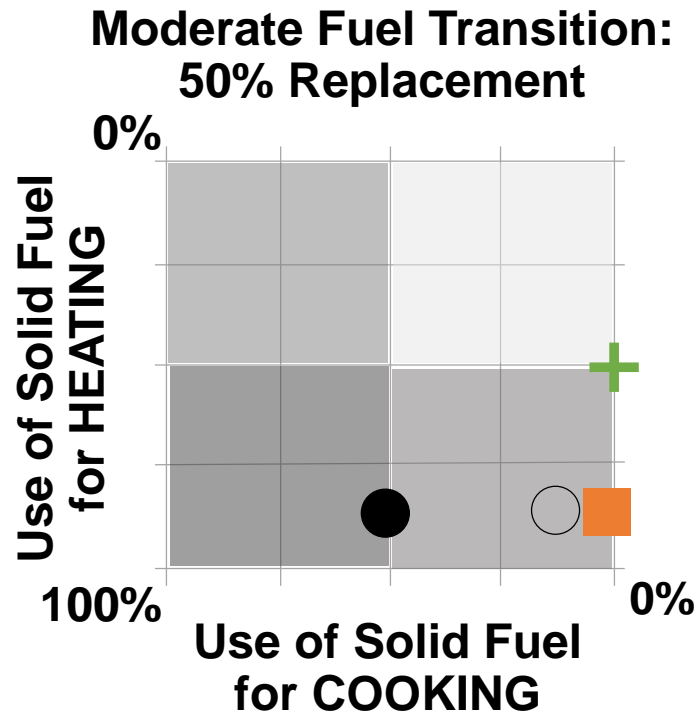
- Larger scale evaluation is difficult due to exposure assessment
- Usually limited to shorter-term or acute health outcomes
- Expensive and time intensive to evaluate
- Evaluation of policies or government programs may be politically sensitive

Outline

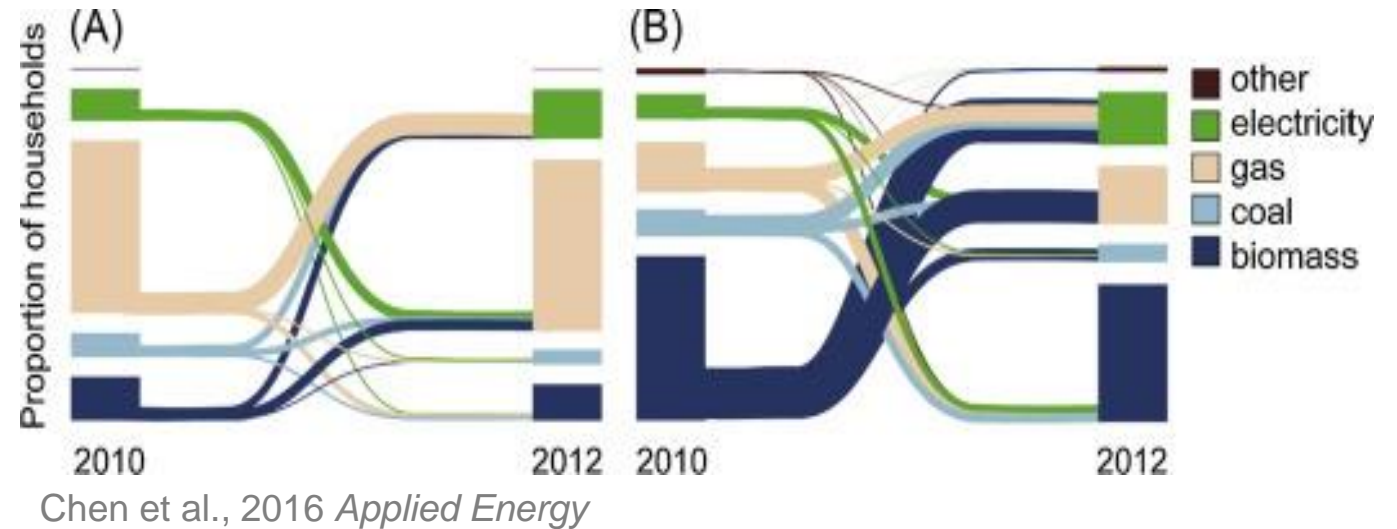
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Estimating policy impact: development of household energy use transition scenarios for China

- Baseline
- Business as Usual (transition to clean cooking fuel)
- Reduce use of solid fuel for cooking
- + Reduce use of solid fuel for heating



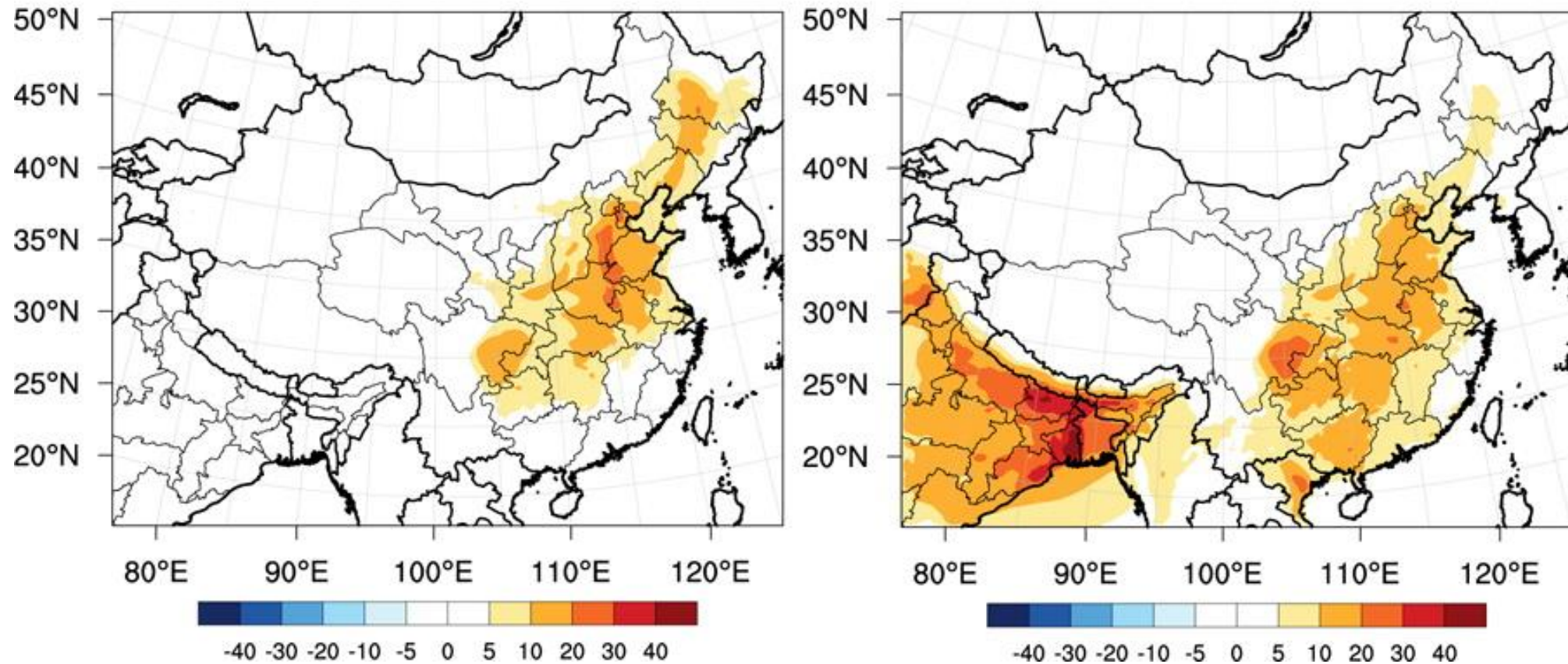
Estimate changes in solid fuel use associated with scenarios



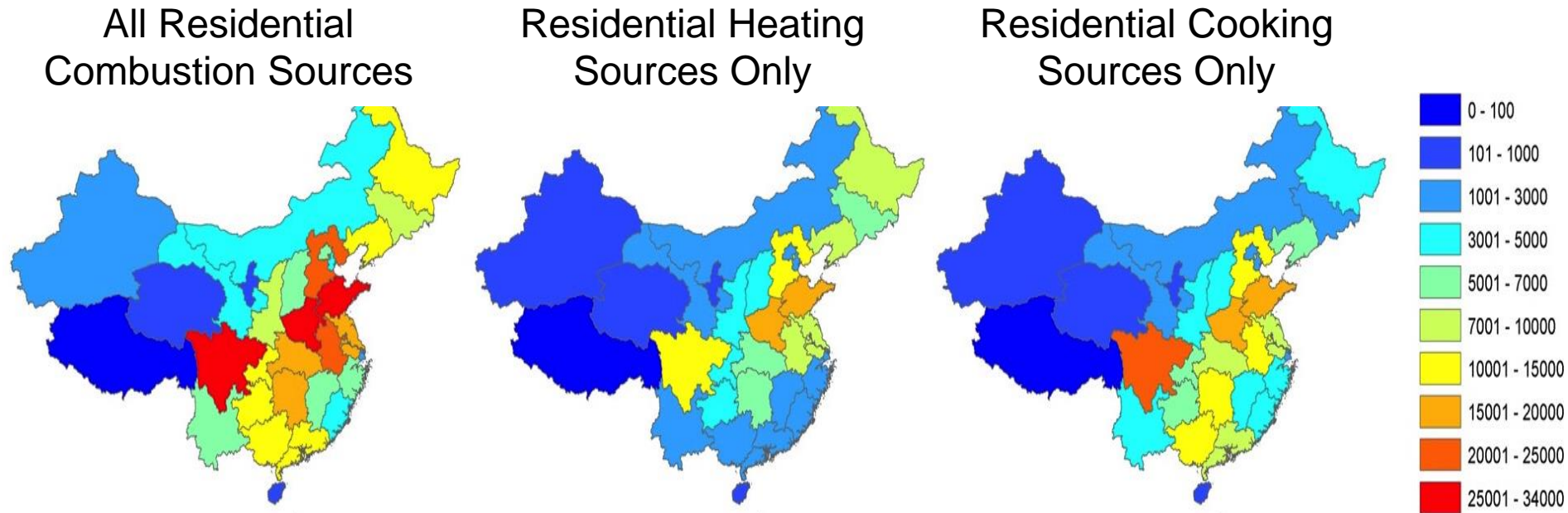
- Baseline
- Business as Usual (transition to clean cooking fuel naturally reaches 90% by 2030)
- Eliminate use of solid fuel (biomass and coal) for cooking: transition to LPG + electricity
- + Reduce use of solid fuel for space heating
 - (a) 85% or (b) 50% of coal for space heating replaced by electricity
 - (b) 85% of (c) 50% of biomass for space heating replaced by electricity
 - (c) 50% of coal and biomass for space heating replaced by biomass pellets

Baseline: estimated ambient PM_{2.5} attributable to household solid fuel combustion in China

Ambient PM_{2.5} [$\mu\text{g m}^{-3}$] due to heating (left) and cooking (right) emissions.



Baseline: Impact of ambient PM_{2.5} from household cooking and heating with solid fuel on premature mortality in China

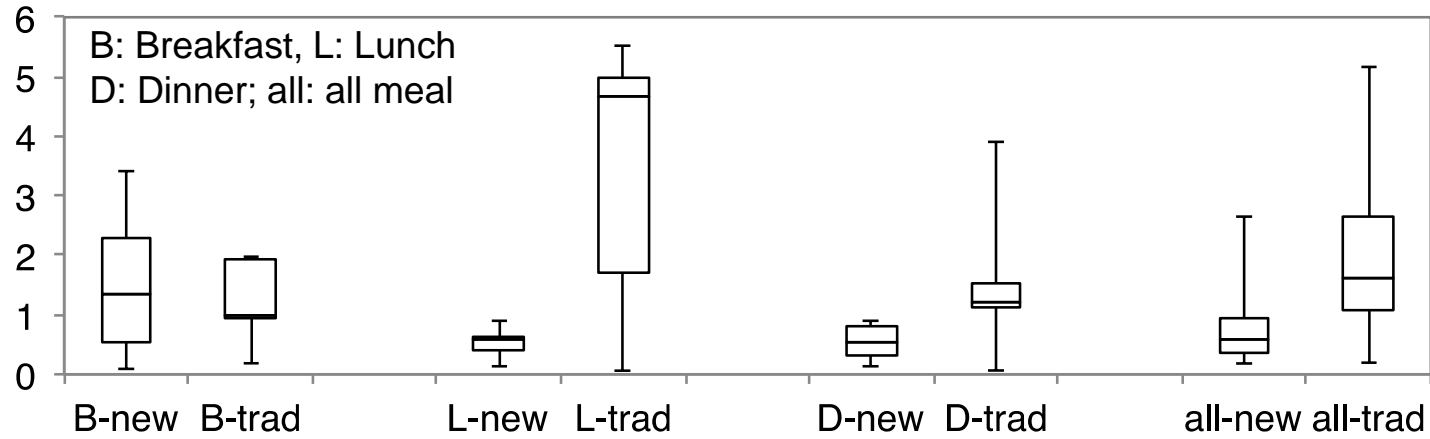


- 341,000 (95% confidence interval: 306,000–370,000)
 - 159,000 (95% CI: 142,000–172,000) from heating emissions
 - 182,000 (95% CI: 163,000–197,000) from cooking emissions

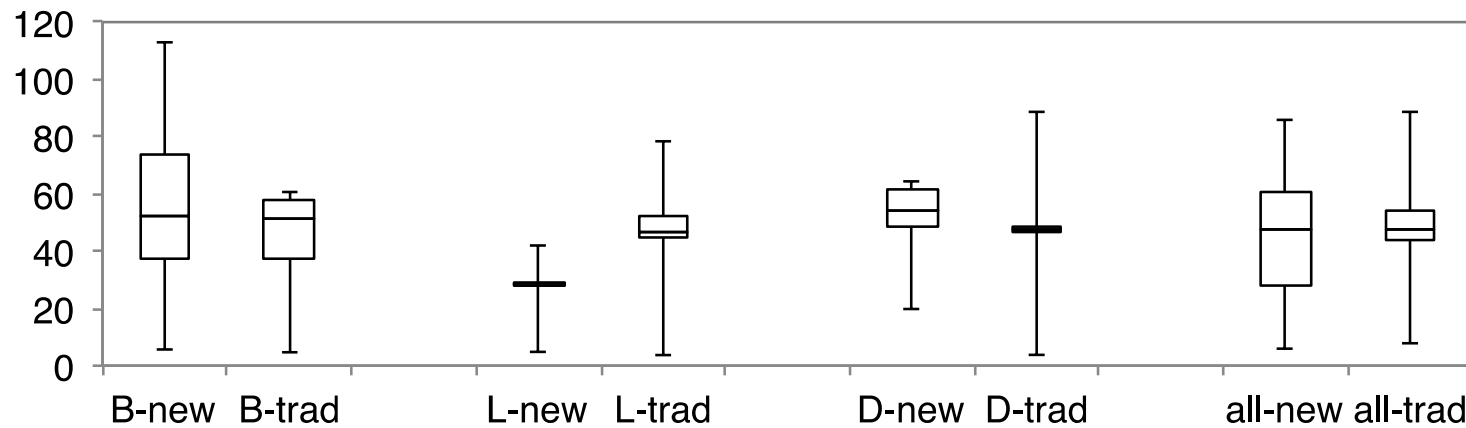
Ambient air quality: changes in emissions factors and air quality associated with intervention scenarios

Emission Factors (g/kg-fuel) for biomass pellets under conditions of actual use in the Tibetan Plateau

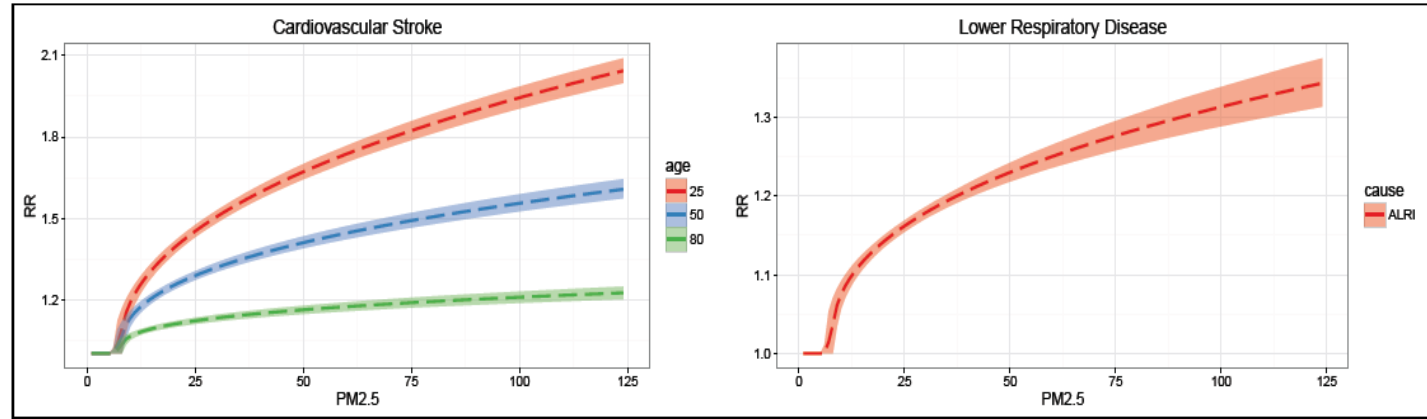
PM_{2.5}



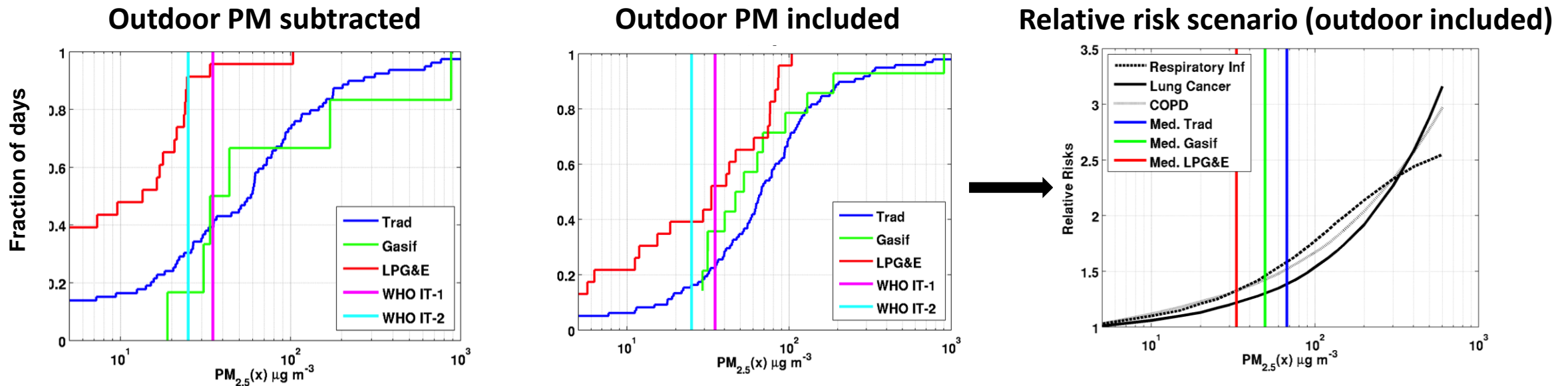
CO



Household air pollution: Integrating measurements of indoor PM with different interventions into exposure-response models (n=389 days from 202 homes)



Burnett et al. *Environ Health Perspect*, 2014



Combining field measurements and models

- Advantages
 - Facilitates comparison of health impacts and related costs of different interventions and policies; absolute benefits and impact on inequities
 - Can be used inform and/or motivate policy and program action
 - Less 'risky' than prospective evaluation of an intervention or policy
- Challenges
 - Baseline data and other model inputs may be absent or unreliable
 - Accounting for factors known to influence the choice of household energy sources and energy use behaviors is difficult
 - Personal preferences and behaviors
 - Macroeconomic factors, e.g., fuel prices and their variability
 - Infrastructure, e.g., reliability of supply

Key policy impacts

- Black carbon from household solid fuel combustion may be a directly useful metric for both health and climate impacts
- Selection of appropriate health metrics varies by study design, level of intervention, and goal of evaluation (i.e., exposure-response versus policy evaluation)
- Health metrics are (relatively) straightforward; primary challenge is input of valid air pollution exposure metrics

Key study investigators and institutions

McGill University

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NCAR

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Michael Brauer
Aaron Cohen

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- Baumgartner J, Zhang, YX, Schauer JJ, Huang W, Wang YQ, Ezzati M. (2014) Proximity to highways and black carbon from cookstoves as a risk factor for higher blood pressure in rural China. *Proceedings of the National Academy of Sciences (PNAS)*, 111: 13229-13234

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