


Key considerations in designing Epidemiological Studies

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ICIMOD HEI Early Career Training
August 2024




What is the motivation for a epidemiological study?

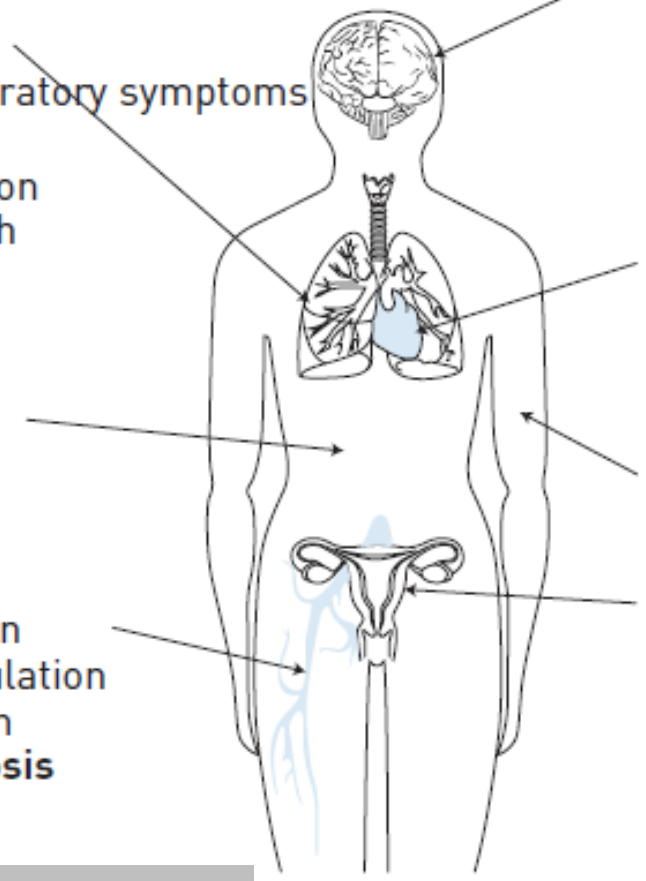
- Initial epidemiological study to include air pollution in a population or geography
- Need to strengthen evidence for strength of association with specific health outcome(s)
- Need to develop exposure-response relationships
- Need to address risk (mis)-perceptions
- Need to inform air quality actions/choice of interventions
- Need to evaluate on-going programs addressing air quality
- **Need to be the saviour of the world !**

Where would you find the best possible summary of the epidemiological evidence?

What are the WHO Air Quality Guidelines

- Based on extensive scientific evidence, the AQGs identify the levels of air quality necessary to **protect public health worldwide.**
- Guideline levels can be used as an **evidence-informed reference** to help decision-makers in setting legally binding standards and goals for air quality management.
- They are an **instrument to design effective measures** to achieve reduction of air pollution, and therefore, to protect human health.

What constitutes an adverse health effect of air pollution: ERS/ATS statement



Respiratory disease mortality
Respiratory disease morbidity
Lung cancer
Pneumonia
Upper and lower respiratory symptoms
Airway inflammation
Decreased lung function
Decreased lung growth

Insulin resistance
Type 2 diabetes
Type 1 diabetes
Bone metabolism

High blood pressure
Endothelial dysfunction
Increased blood coagulation
Systemic inflammation
Deep venous thrombosis

Stroke
Neurological development
Mental health
Neurodegenerative diseases

Cardiovascular disease mortality
Cardiovascular disease morbidity
Myocardial infarction
Arrhythmia
Congestive heart failure
Changes in heart rate variability
ST-segment depression

Skin ageing

Premature birth
Decreased birthweight
Decreased fetal growth
Intrauterine growth retardation
Decreased sperm quality
Pre-eclampsia

Update of the WHO global air quality guidelines: Systematic reviews – An introduction
Román Pérez Velasco* and Dorota Jarosińska **(Env. Intl. 2022)**

Thurston et al . , Eur Respir J 2017

What do the AQGs provide…

Summary of recommended AQG levels and interim targets

Pollutant	Averaging time	IT1	IT2	IT3	IT4	AQG level
$PM_{2.5}$, µg/m³	Annual	35	25	15	*10*	5
$PM_{2.5}$, µg/m³	24-hour[a]	75	50	37.5	*25*	15
PM_{10}, µg/m³	Annual	70	50	30	*20*	15
PM_{10}, µg/m³	24-hour[a]	150	100	75	*50*	45
O_3, µg/m³	Peak season[b]	100	70	–	–	60
O_3, µg/m³	8-hour[a]	160	120	–	–	100
NO_2, µg/m³	Annual	*40*	30	20	–	10
NO_2, µg/m³	24-hour[a]	120	50	–	–	25
SO_2, µg/m³	24-hour[a]	125	50	–	–	40
CO, mg/m³	24-hour[a]	7	–	–	–	4

Air quality guideline levels for both long- and short-term exposure in relation to critical health outcomes.

Interim targets to guide reduction efforts for the achievement of the air quality guideline levels.

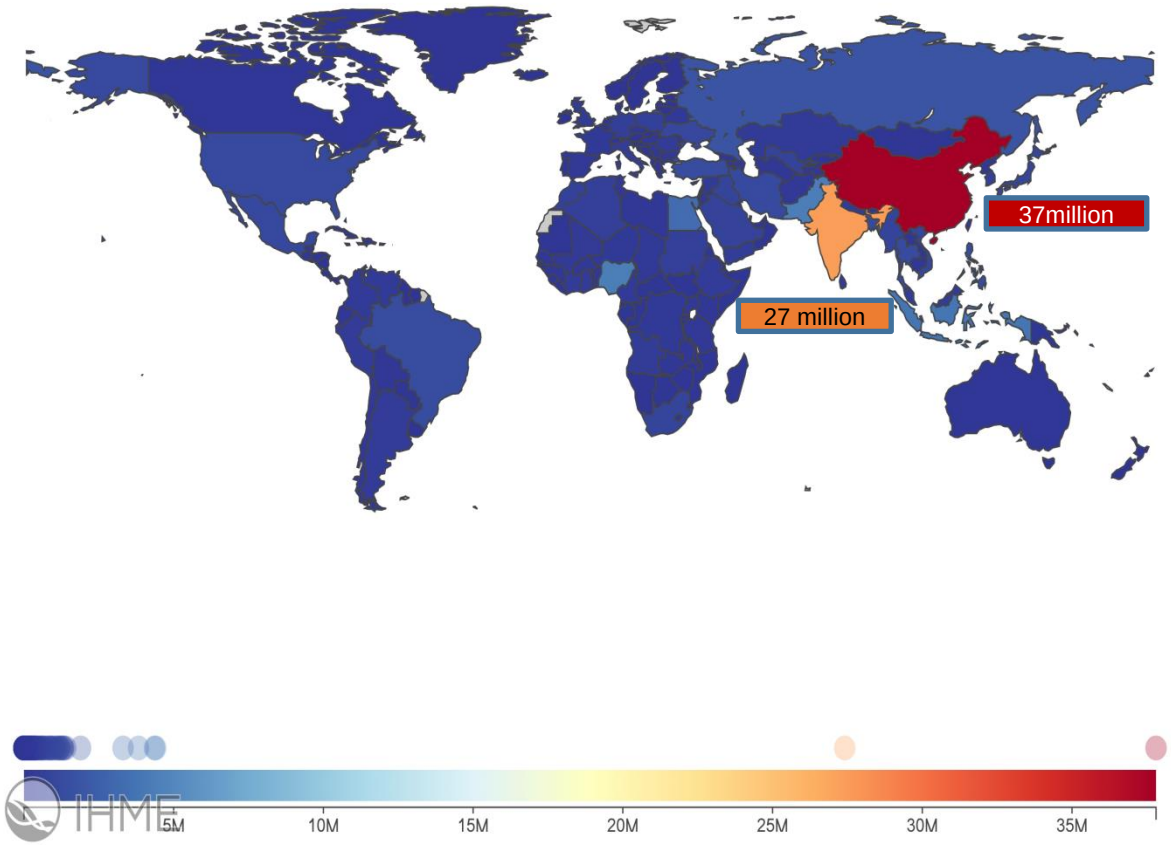
Good practice statements in the management of certain types of particulate matter for which evidence is insufficient to derive quantitative air quality guideline levels, but points to their health relevance.

What do Interim Targets mean?

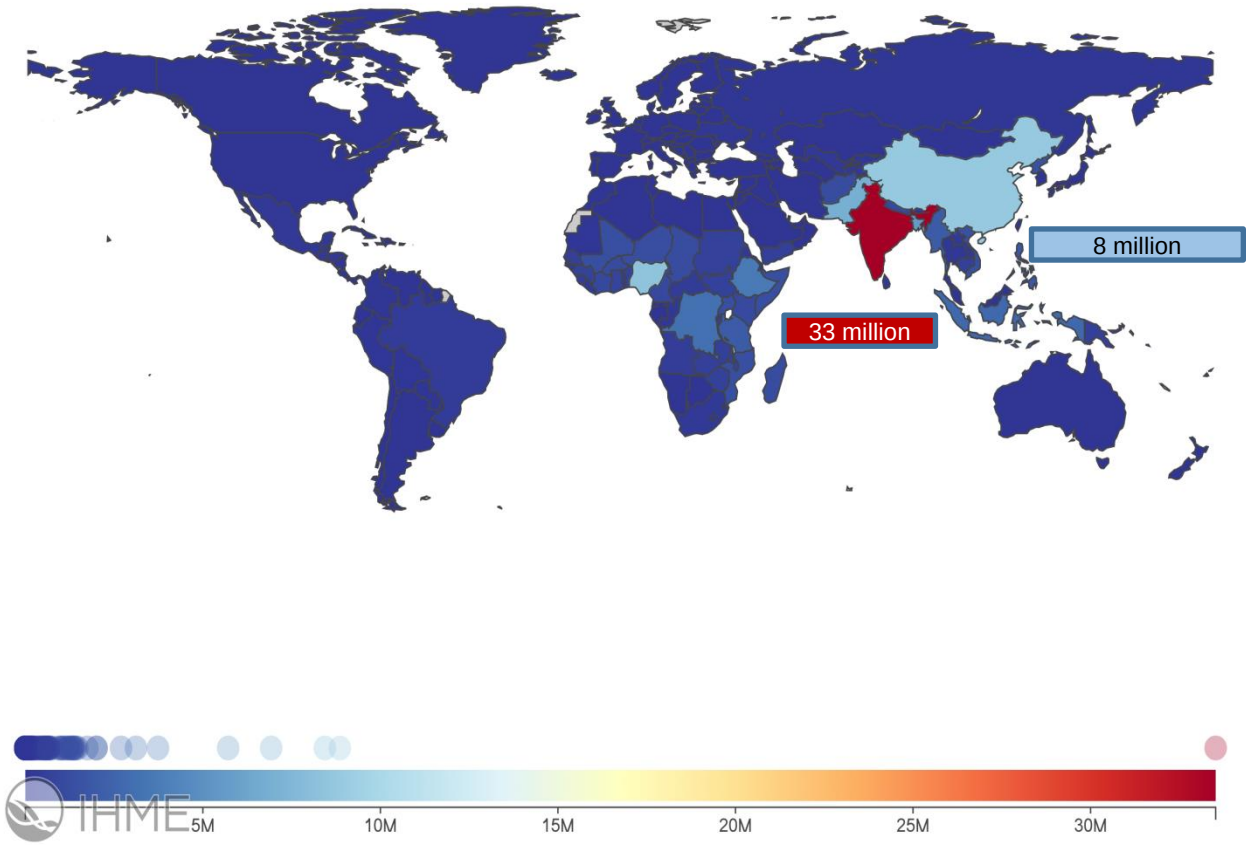
Interim targets to guide continuous improvement of air quality

Air Pollution Attributable Disease Burden (GBD 2021)

Ambient particulate matter pollution
Both sexes, All ages, 2021, DALYs

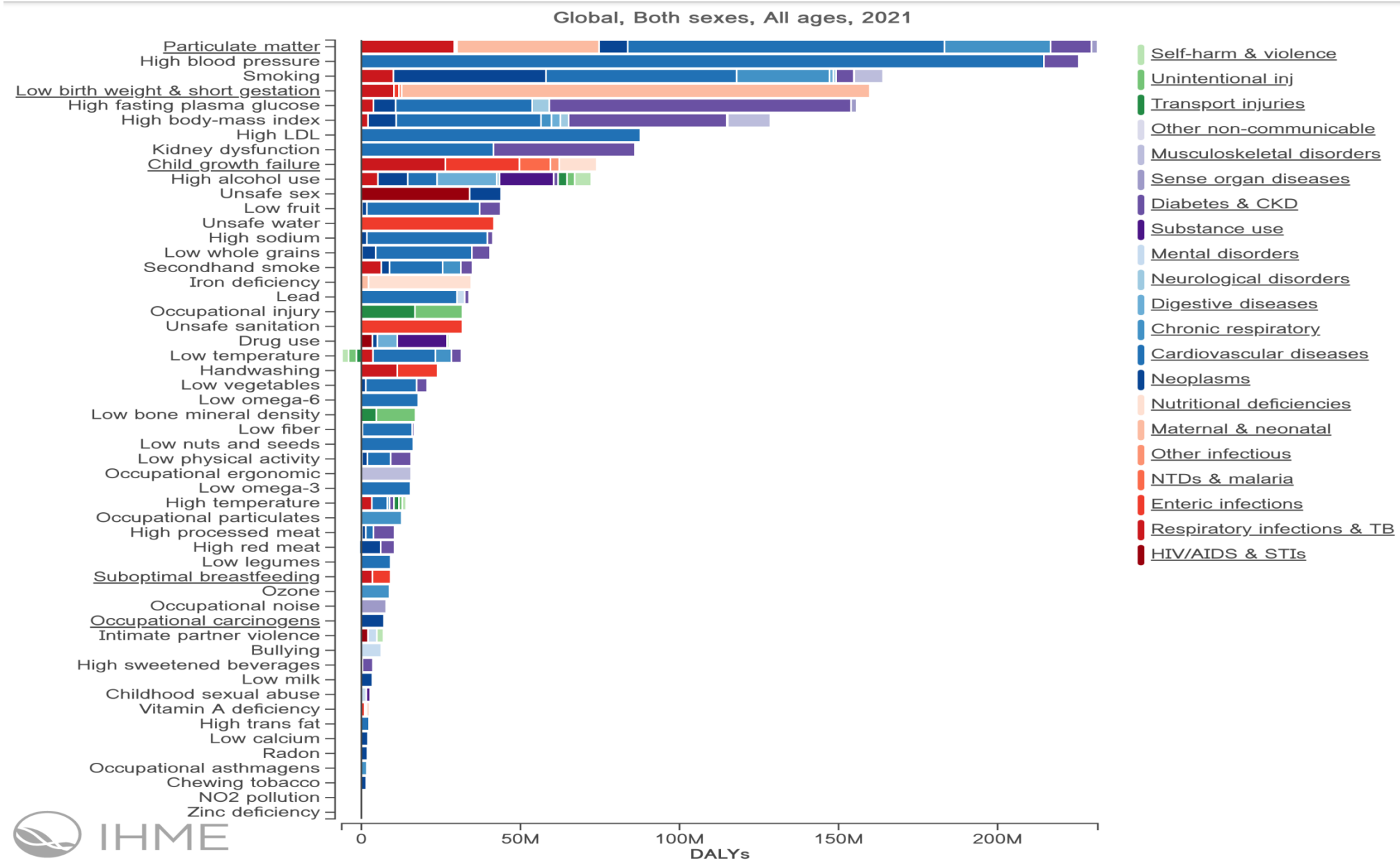


Household air pollution from solid fuels
Both sexes, All ages, 2021, DALYs



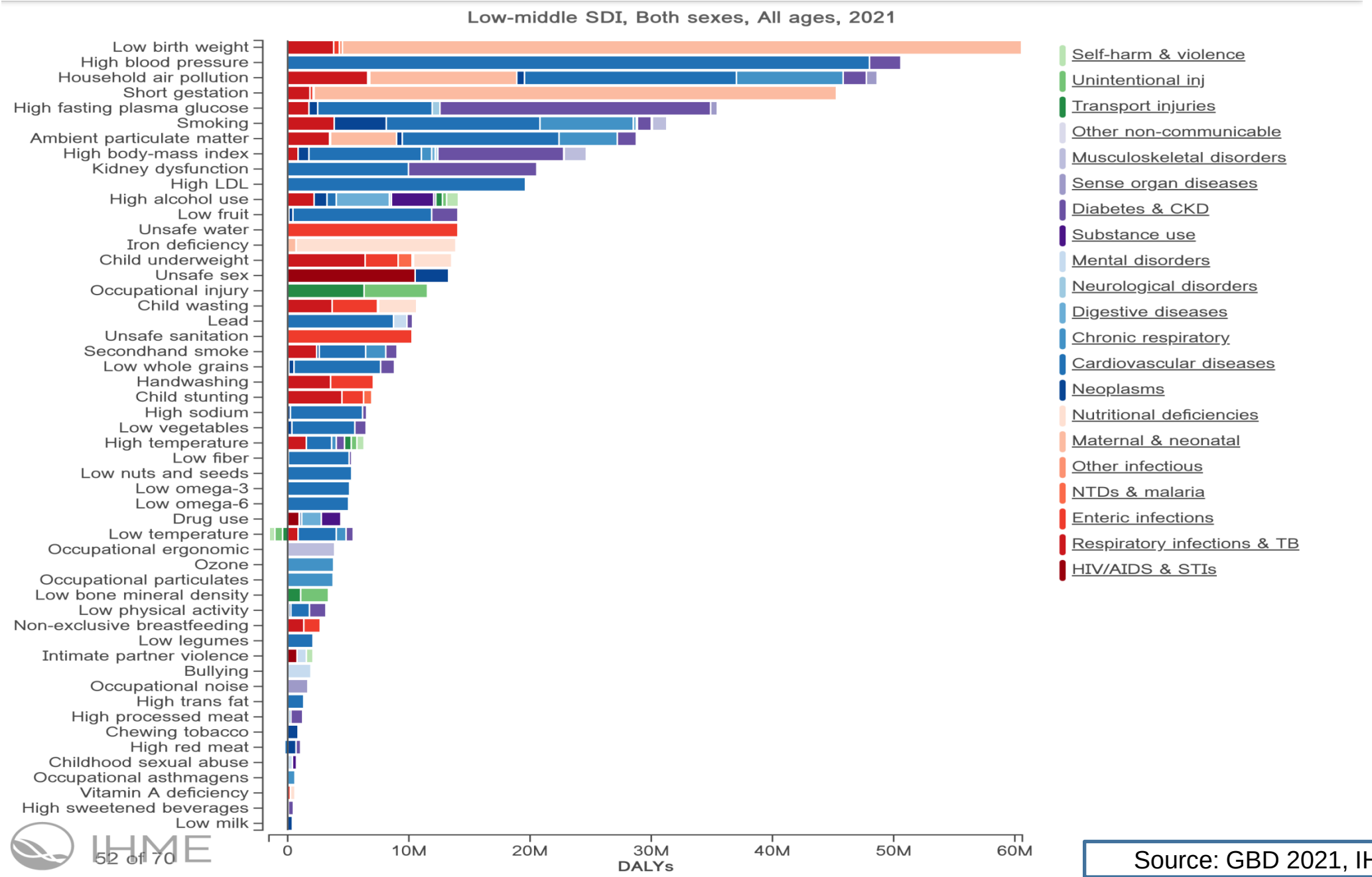
Source: GBD 2021, IHME 2024

Comparative Risk Assessment (GBD 2021)



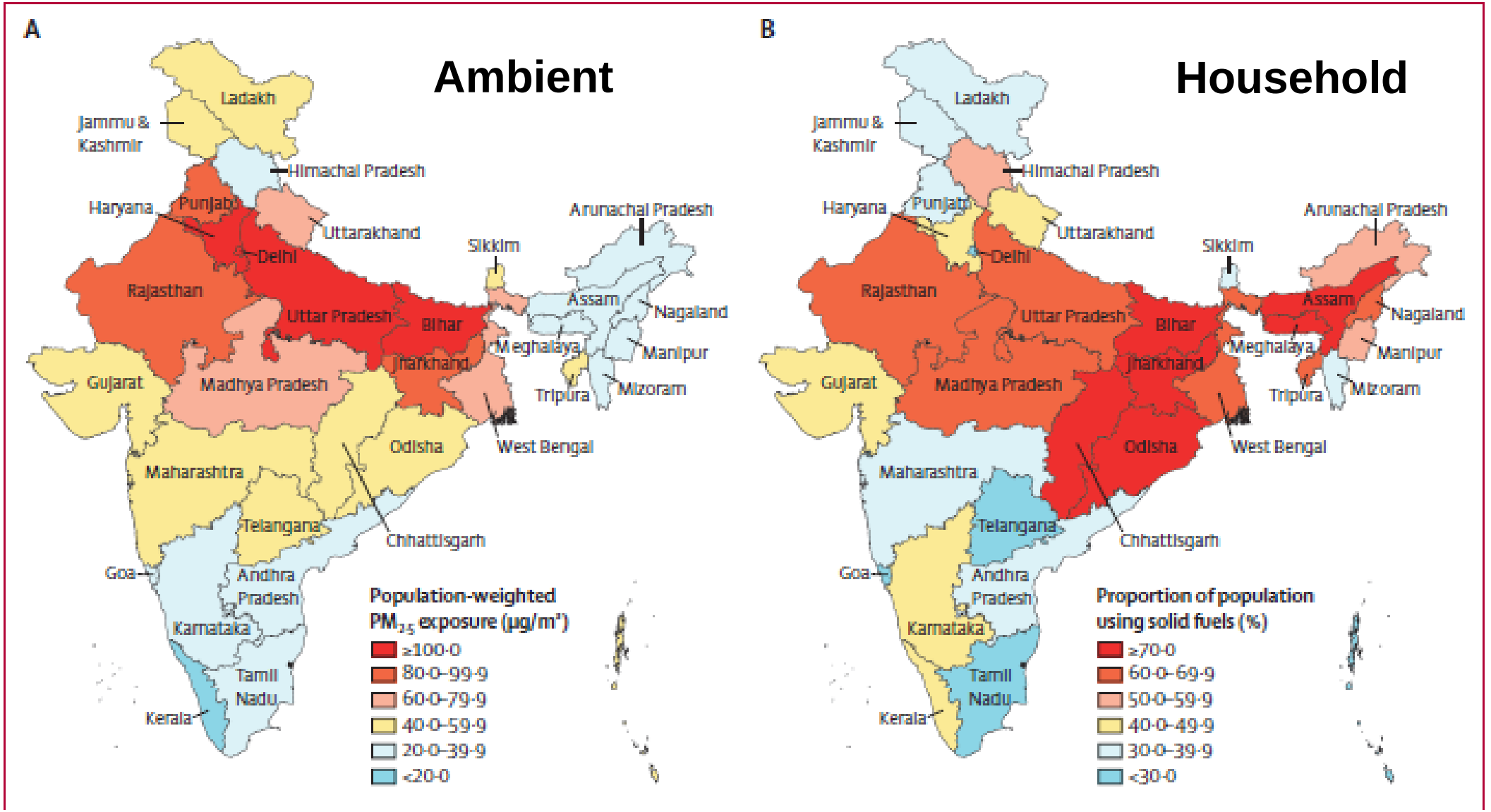
Source: GBD 2021, IHME 2024

Comparative Risk Assessment (GBD 2021)



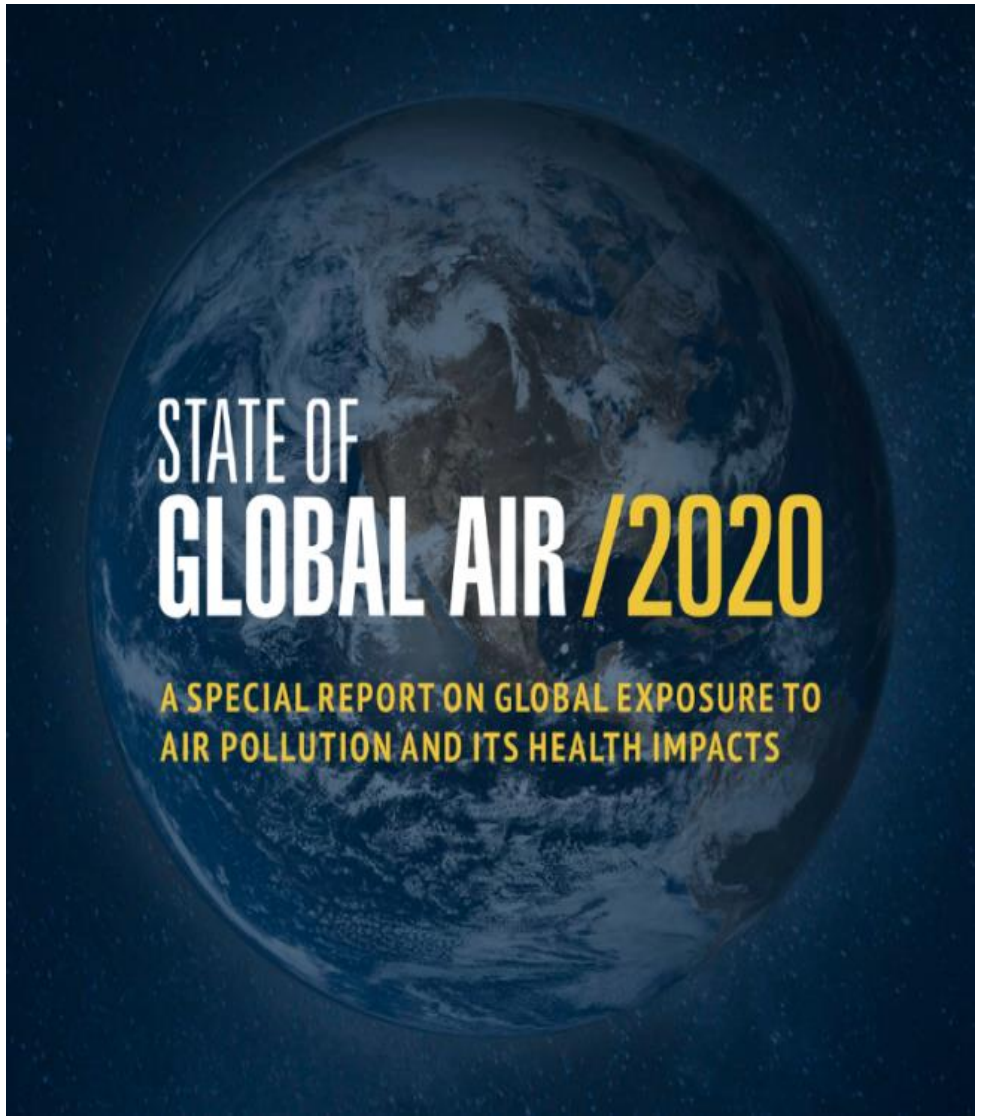
Source: GBD 2021, IHME 2024

Exposures to ambient and household air pollution at sub-national scales



India SLDBI Collaborators ***Lancet 2021***, Balakrishnan et al. ***Lancet Planetary Health*** 2019

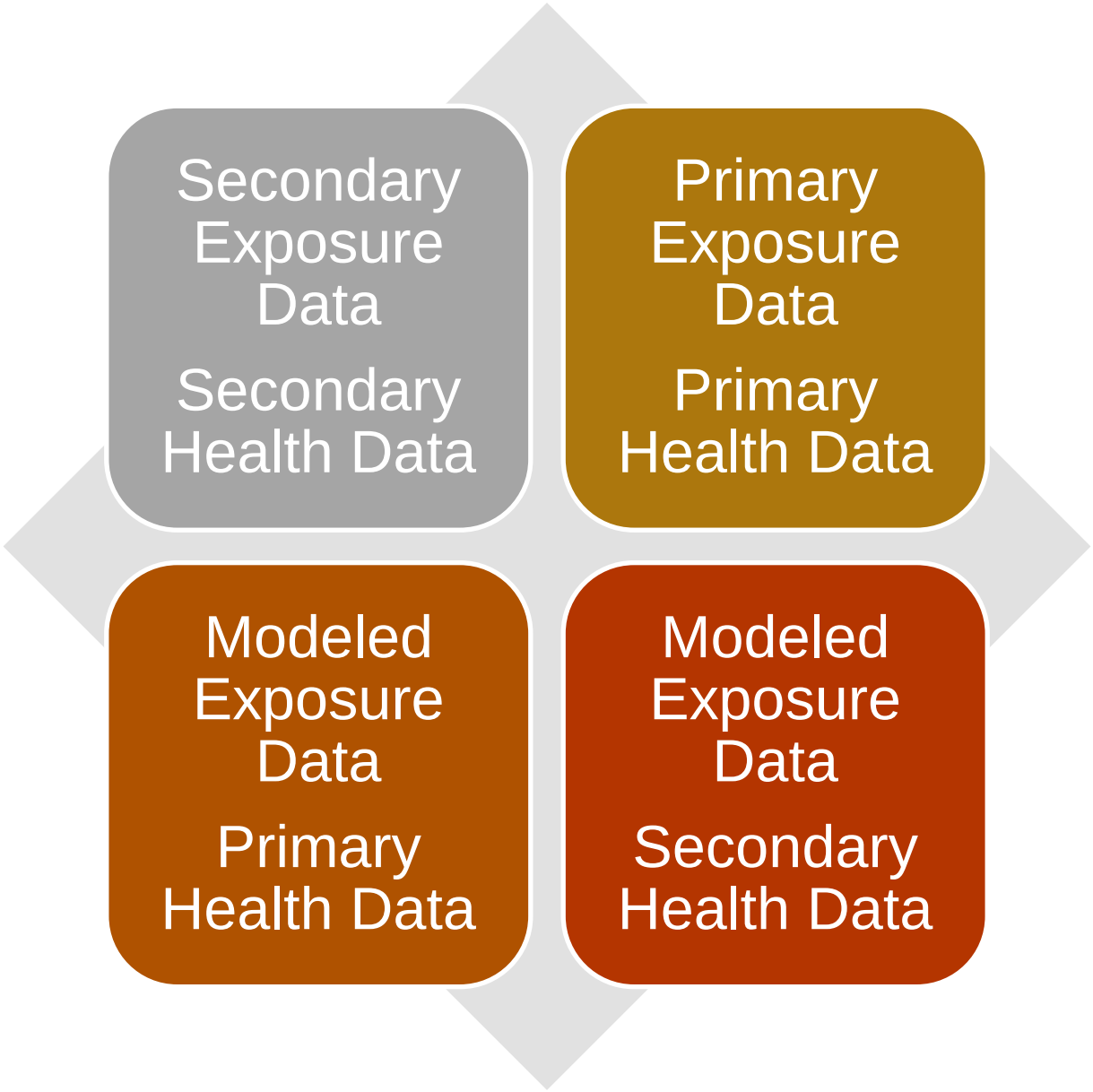
State of Global Air Series



https://capherindia.org/spatial-bibliography

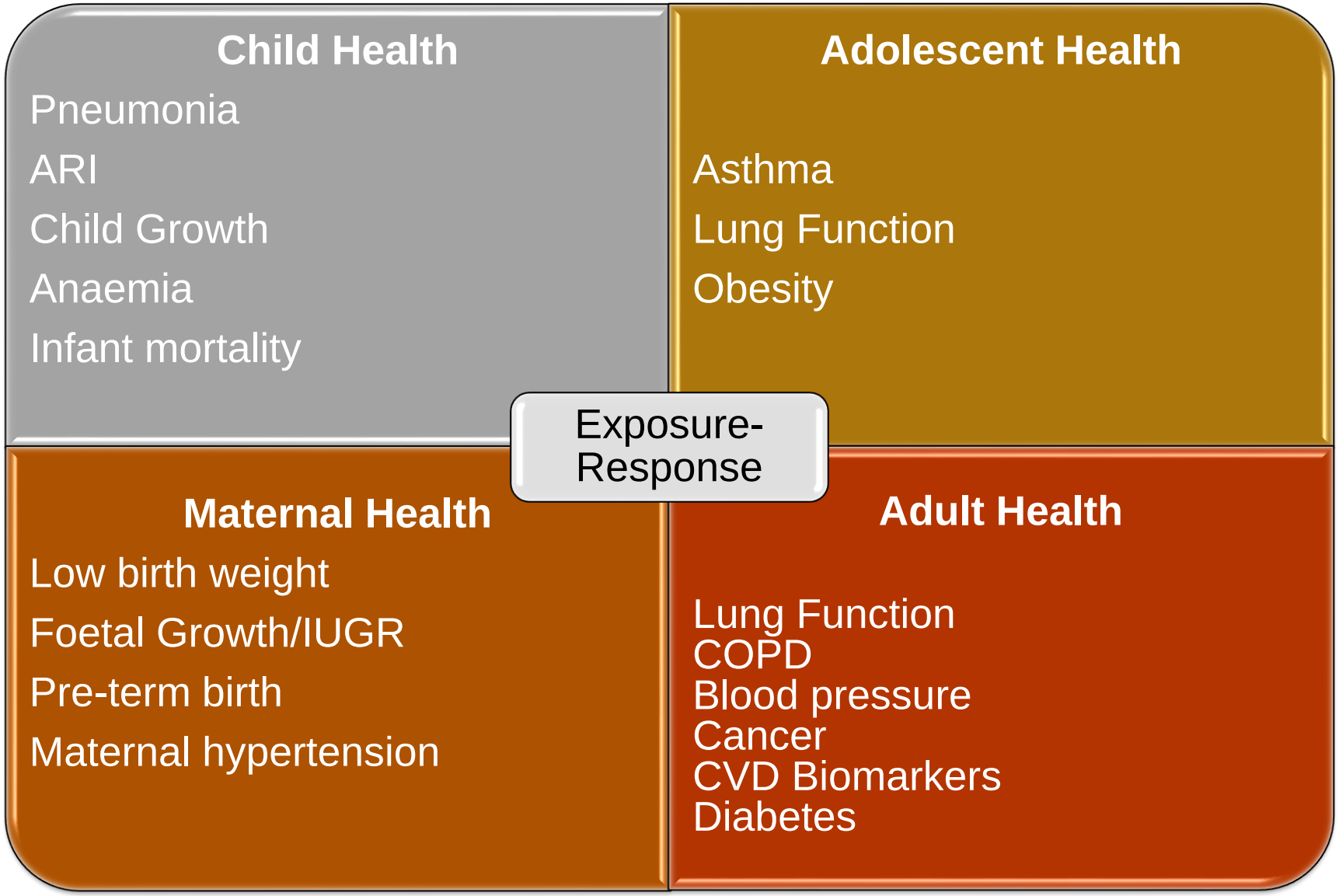
What considerations have been used in recent large scale HAP and AAP related epidemiological studies in India ?

Assessing feasibility for choice of study designs

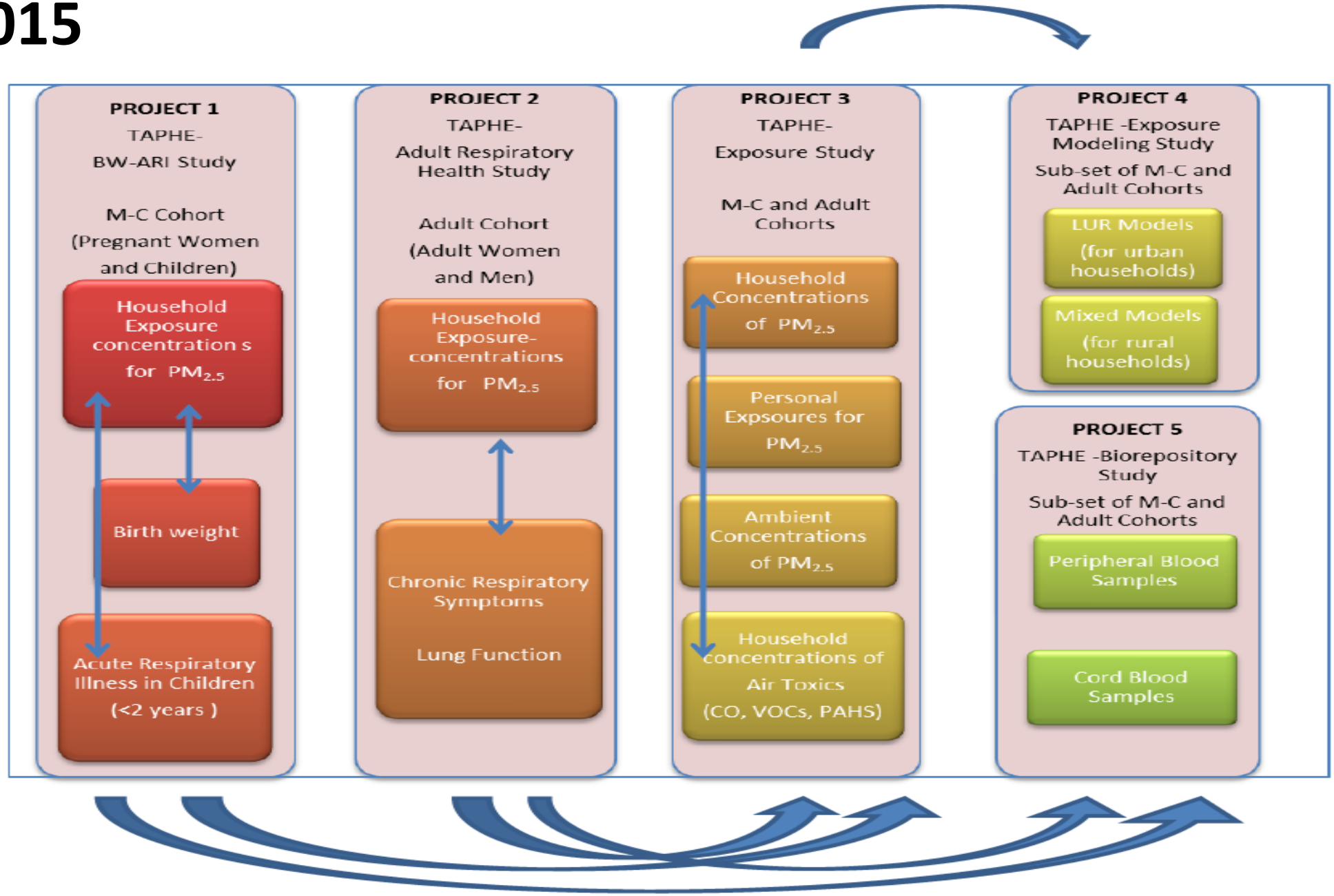


Assessing feasibility for study execution

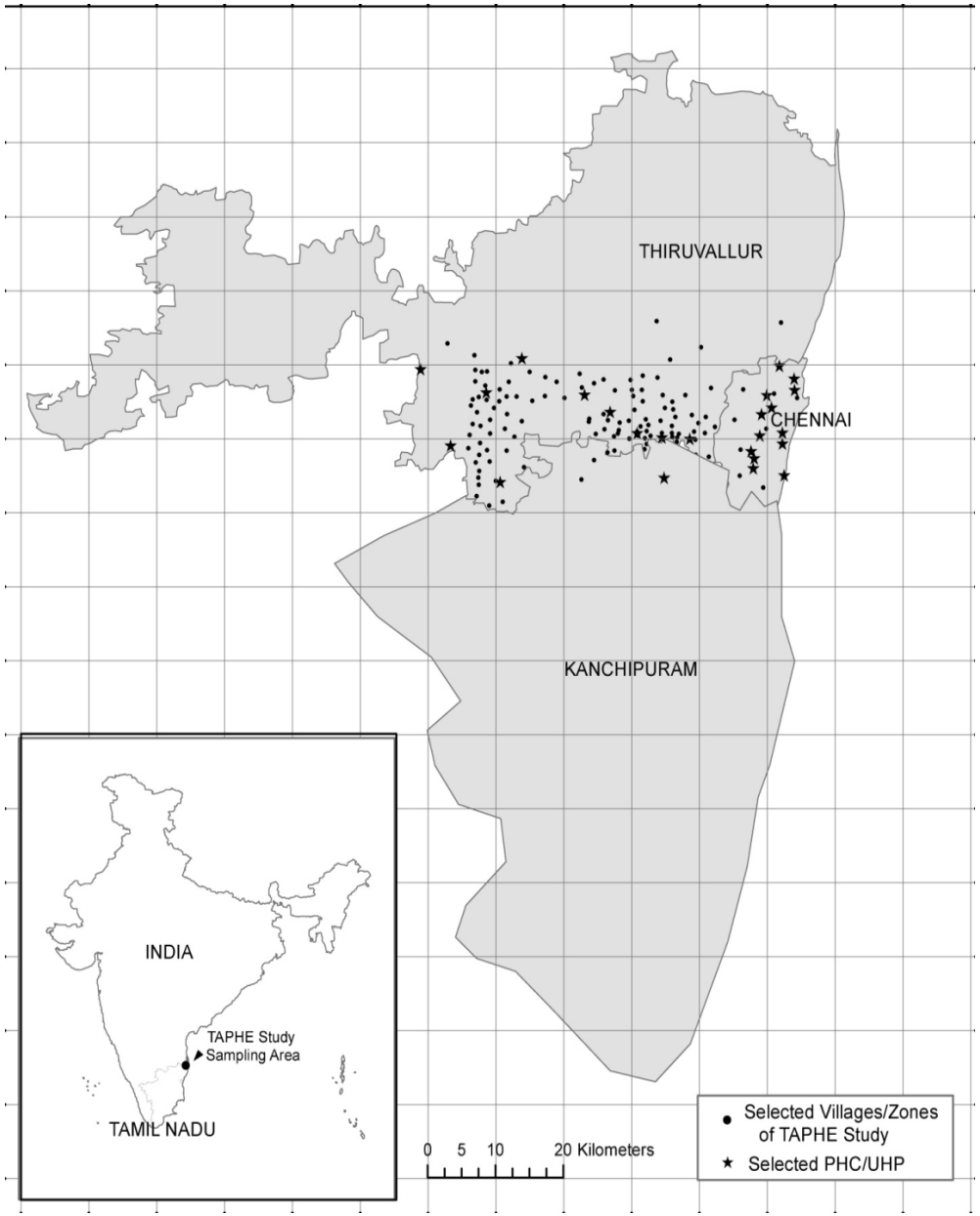
Addressing health impacts of national relevance in rural-urban populations



The Tamil Nadu Air Pollution and Health Effects (TAPHE) Study 2010-2015



Distribution of Participants in the TAPHE-Birth Weight Study



Enrolled:1285 pregnant women

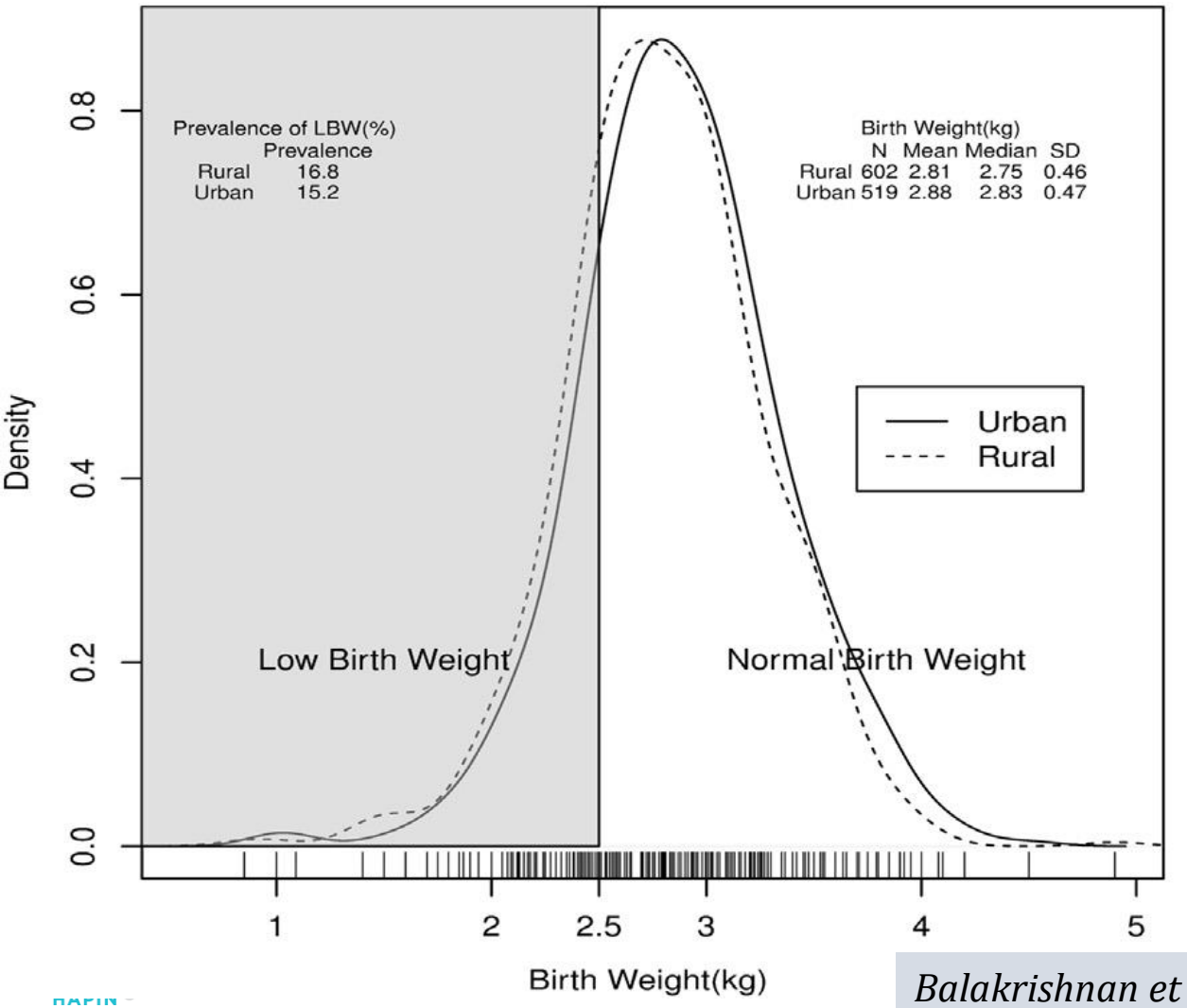
Complete Follow Up Until Birth (including exposure measures) : 1121 of 1152 live births

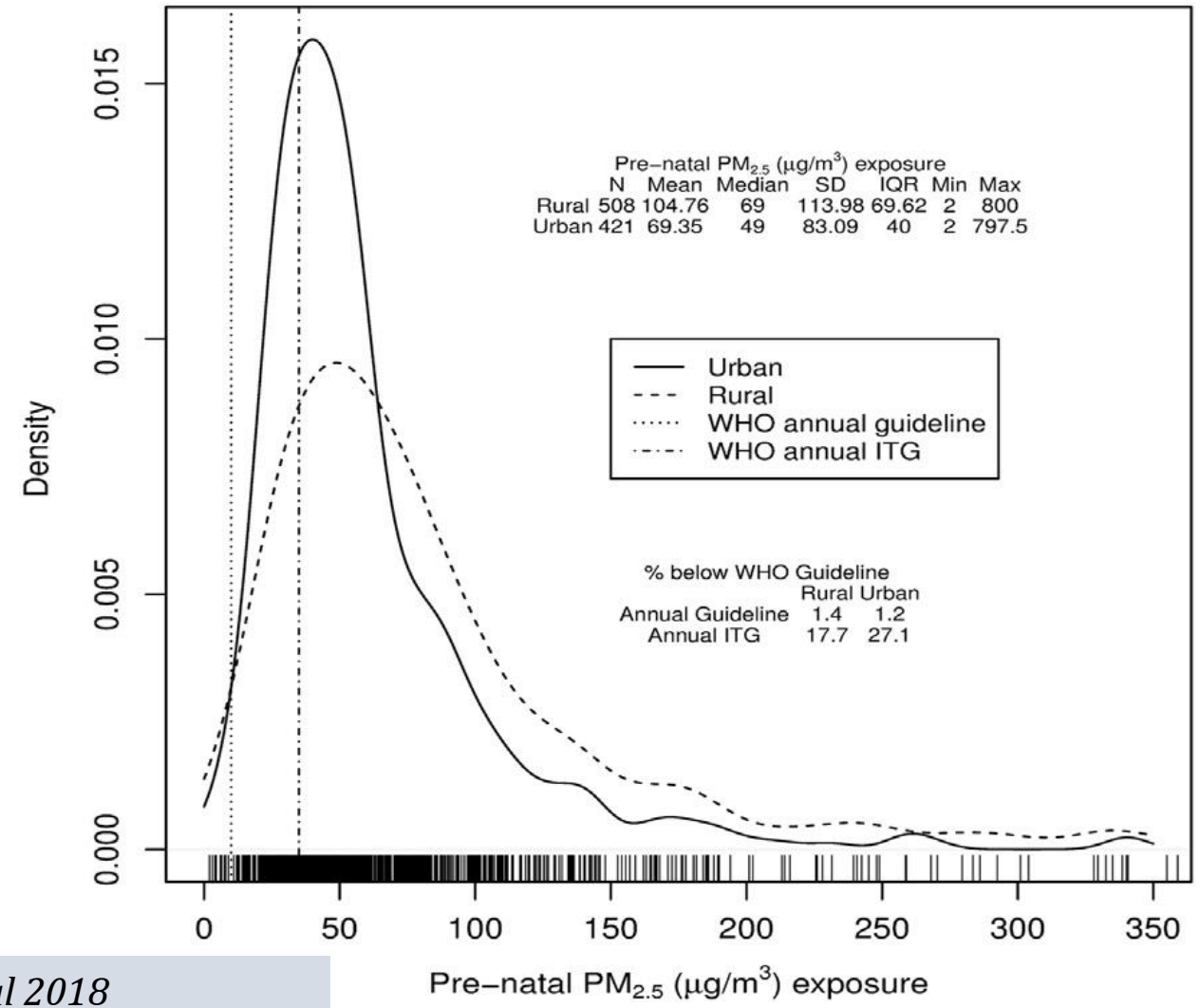
Rural 602 (drawn from 110 villages of Thiruvallur District)

Urban 519 (drawn from 10 municipal zones of Chennai)

Balakrishnan et al 2015

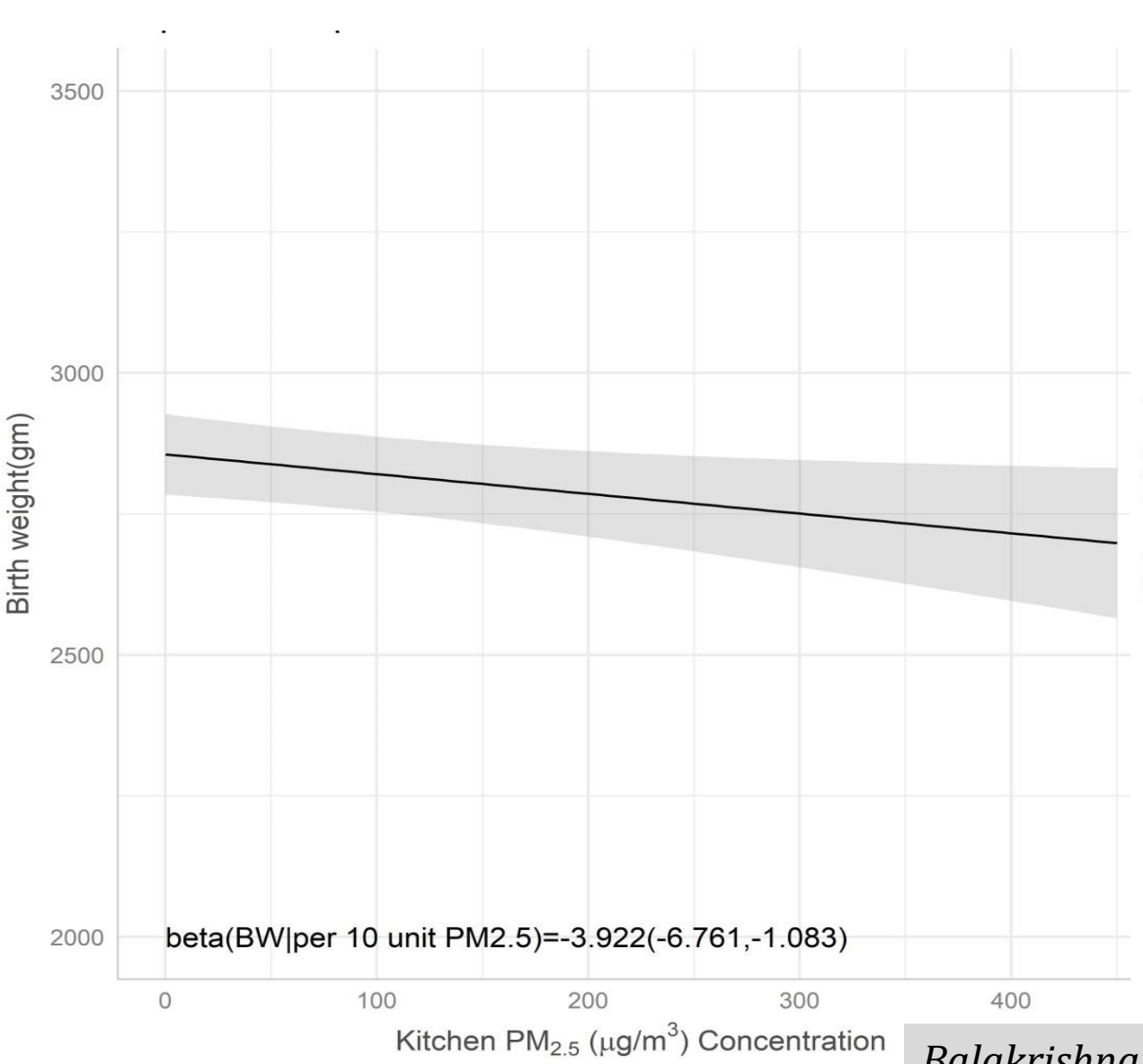
Distribution of birthweight and pregnancy period kitchen $PM_{2.5}$ concentrations in the TAPHE cohort

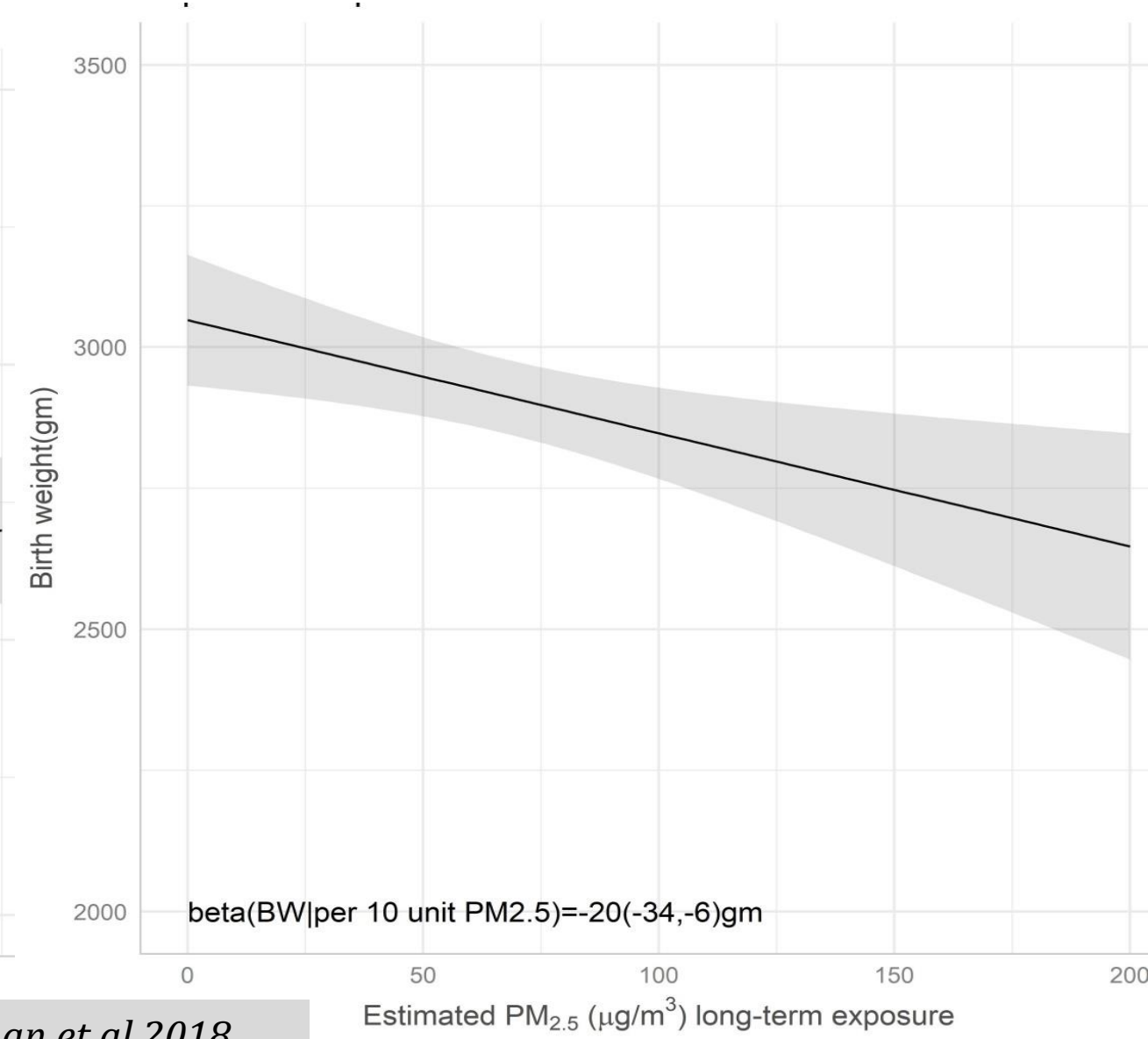




Balakrishnan et al 2018

Exposure response based on short-term measures vs. mixed model estimates

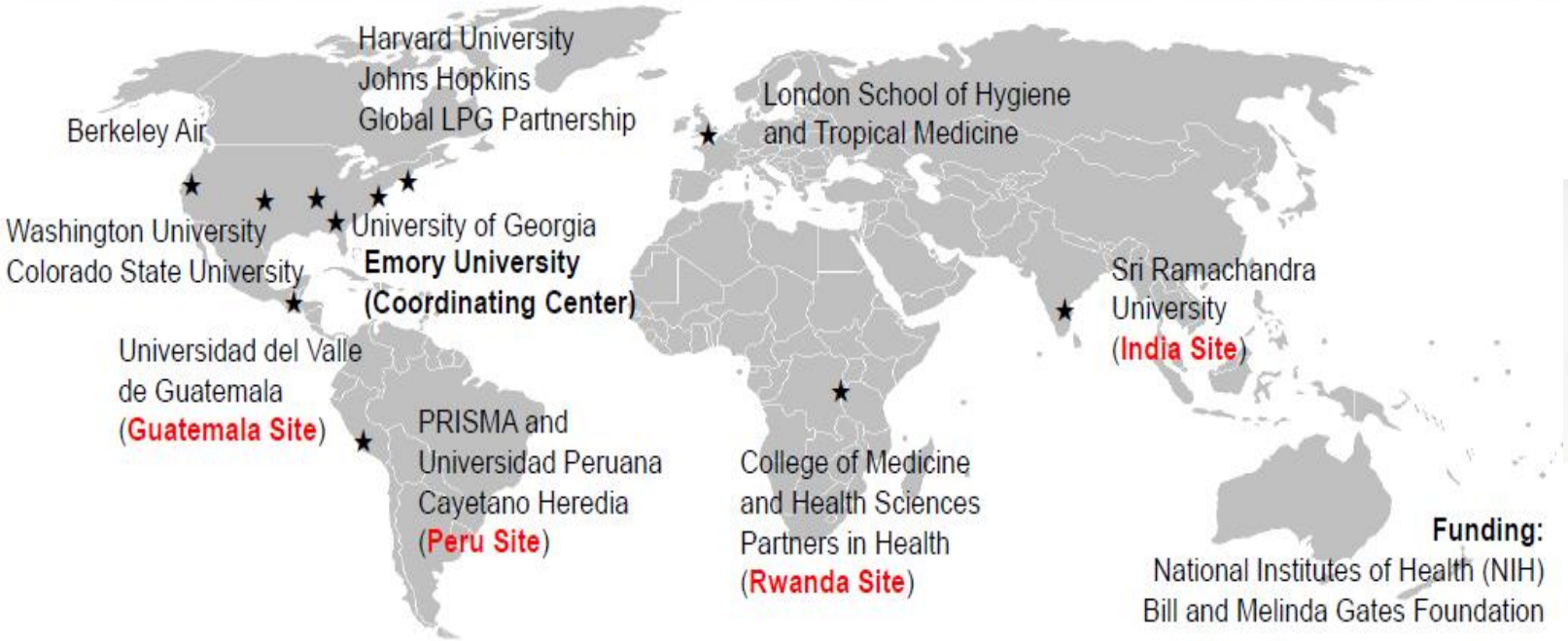




Balakrishnan et al 2018

HAPIN: Scaling multi-pollutant, longitudinal HAP and stove-use monitoring within multi-country RCTs (2016-2022)

The Household Air Pollution Intervention Network (HAPIN)

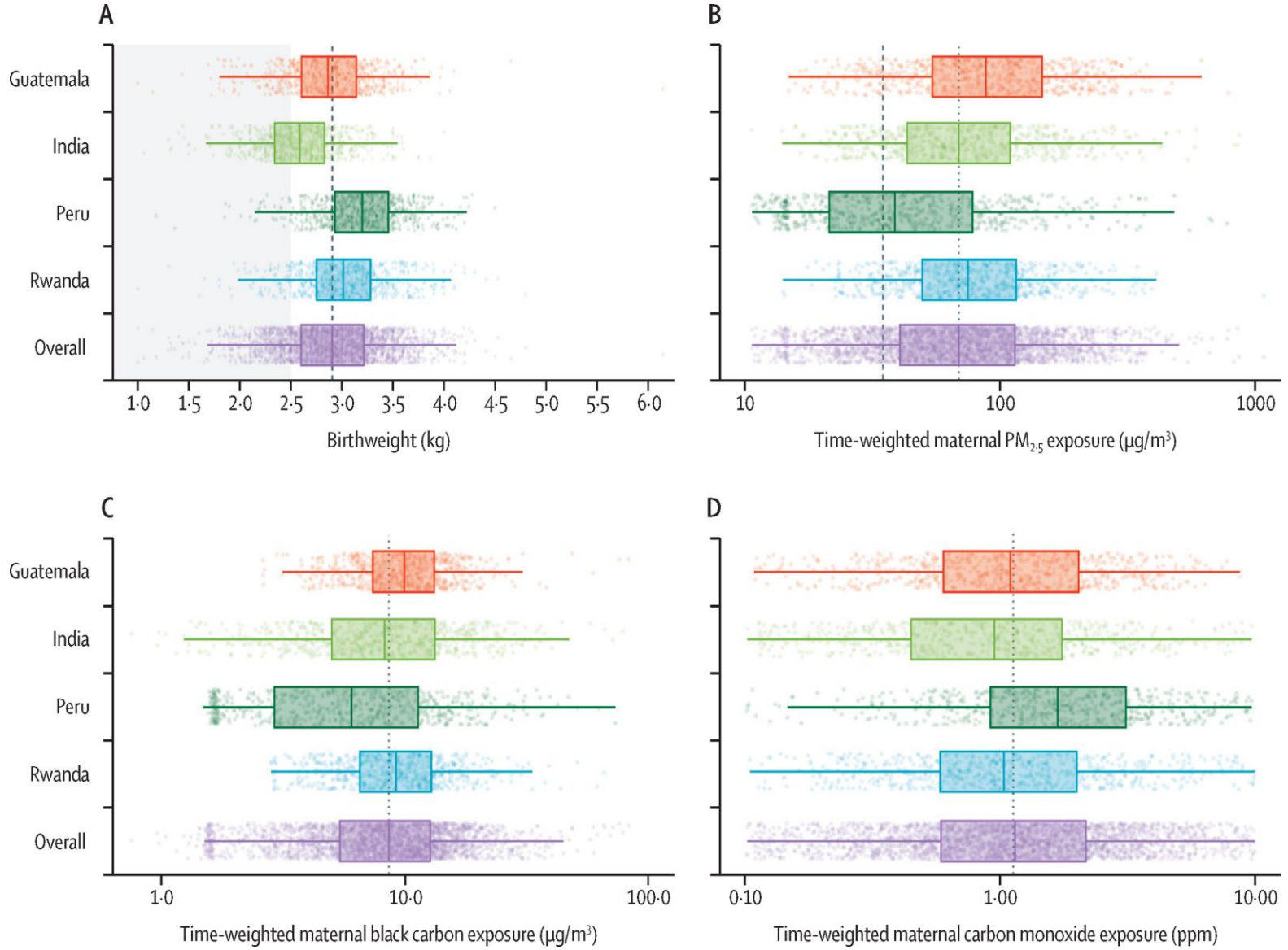


Funding:
National Institutes of Health (NIH)
Bill and Melinda Gates Foundation

LPG intervention → Birth weight; Child severe pneumonia; Child linear growth/stunting; Adult blood pressure

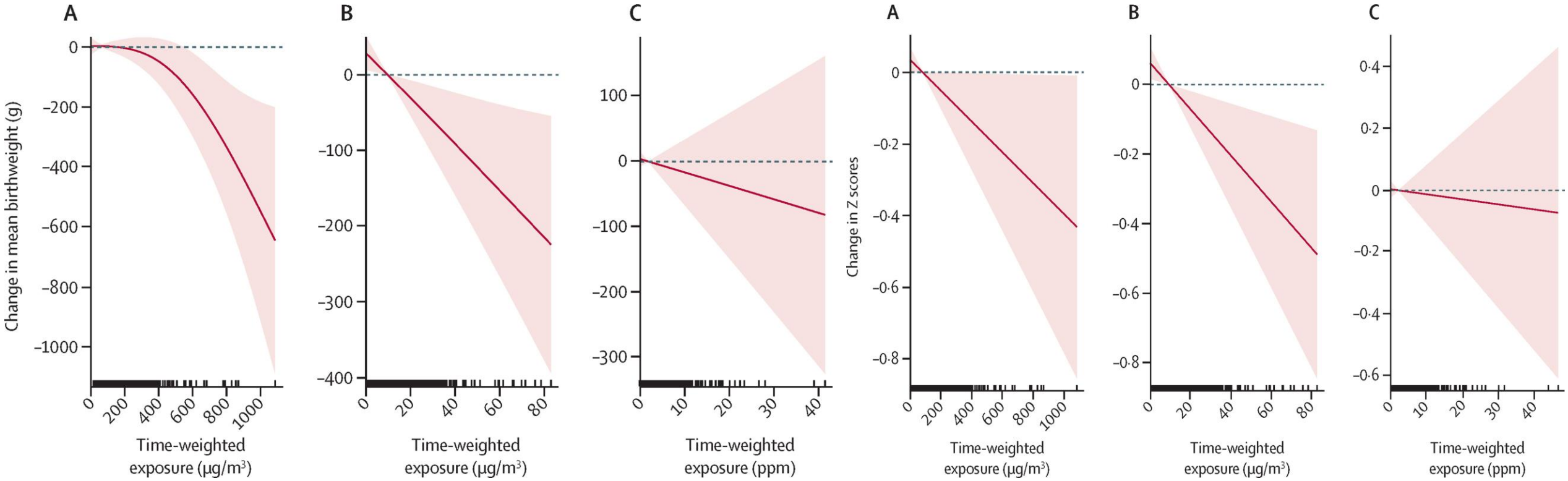
Ambient PM:
E-Sampler
and Purple
Air monitors

Distribution of birthweight and personal exposures in the HAPIN Trial



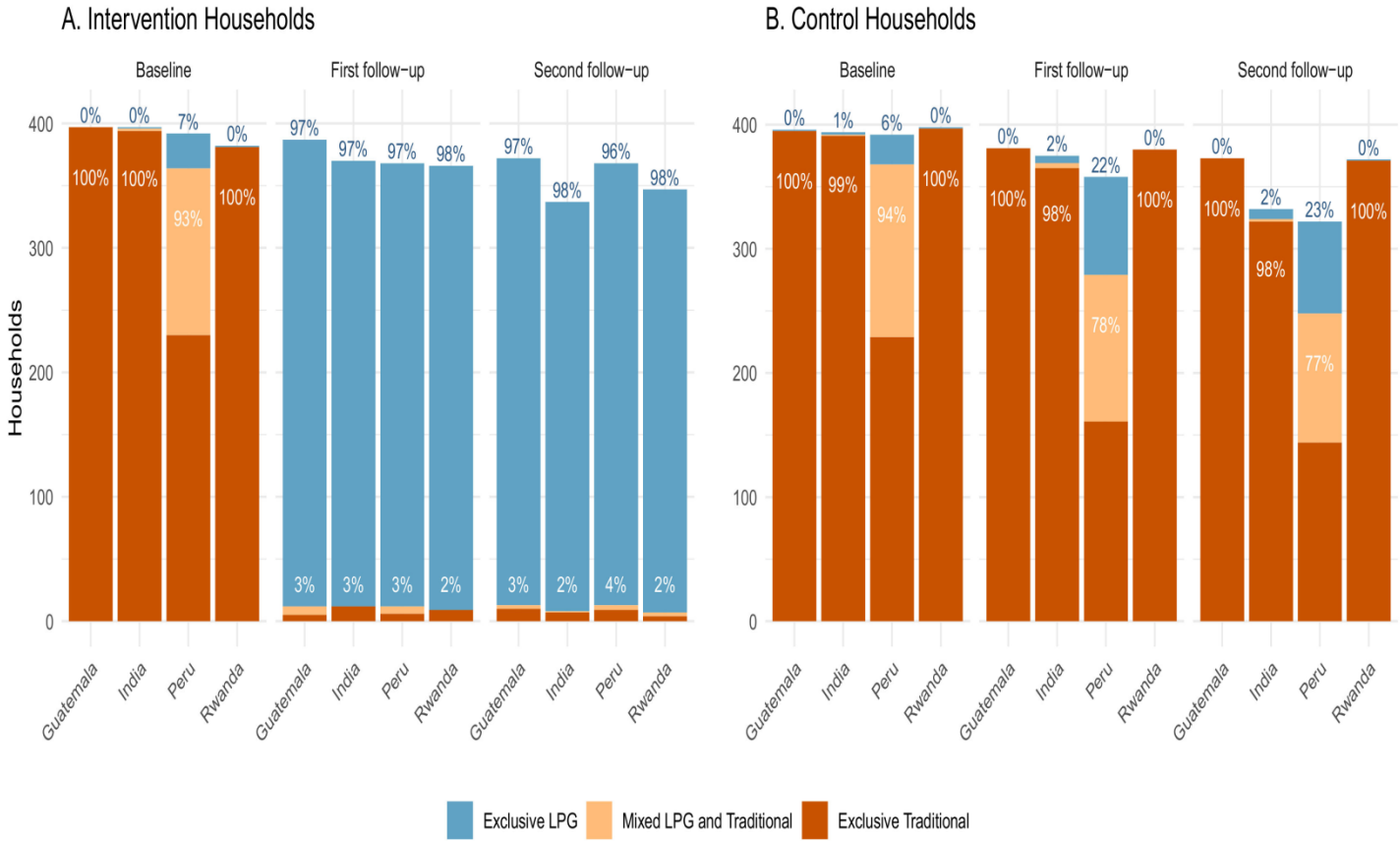
Balakrishnan et al. , ***Lancet Planetary Health*** 2023

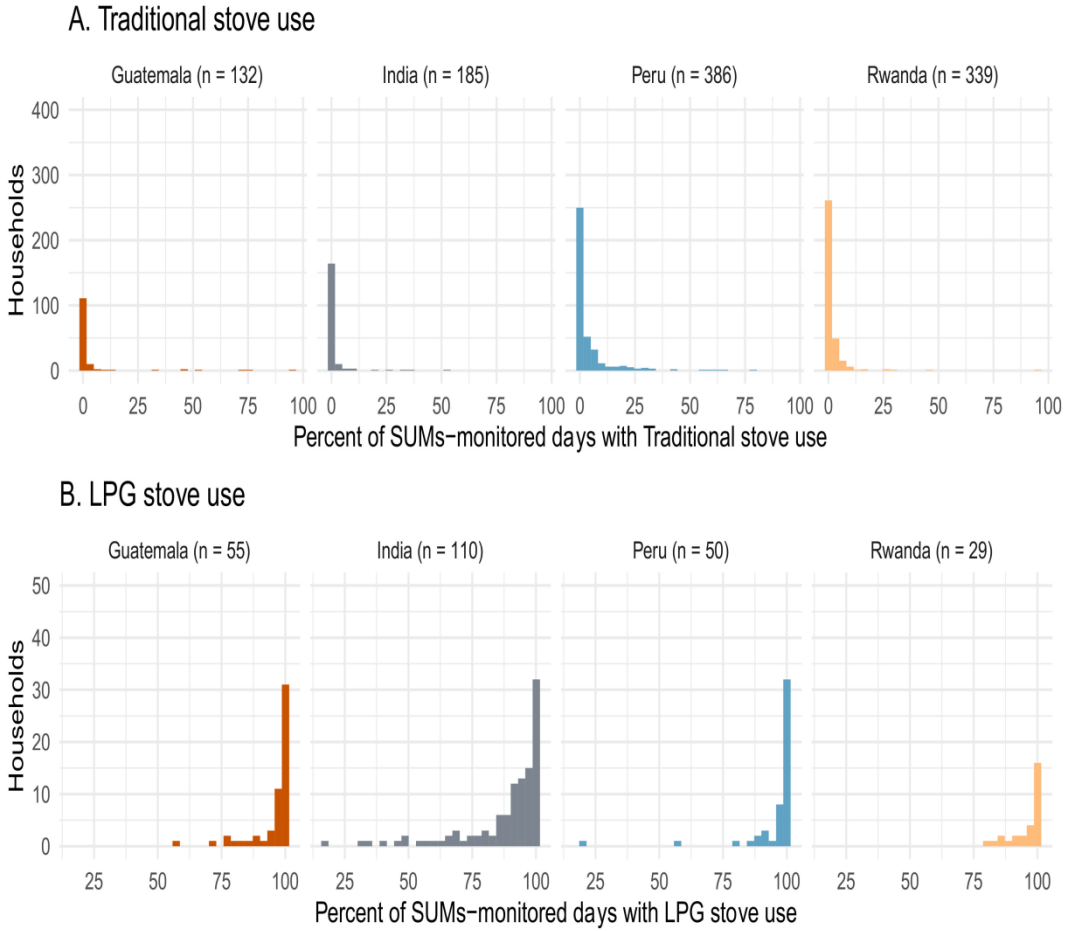
Household air pollution and birthweight- Results from the HAPIN Trial



Balakrishnan et al. , ***Lancet Planetary Health*** 2023

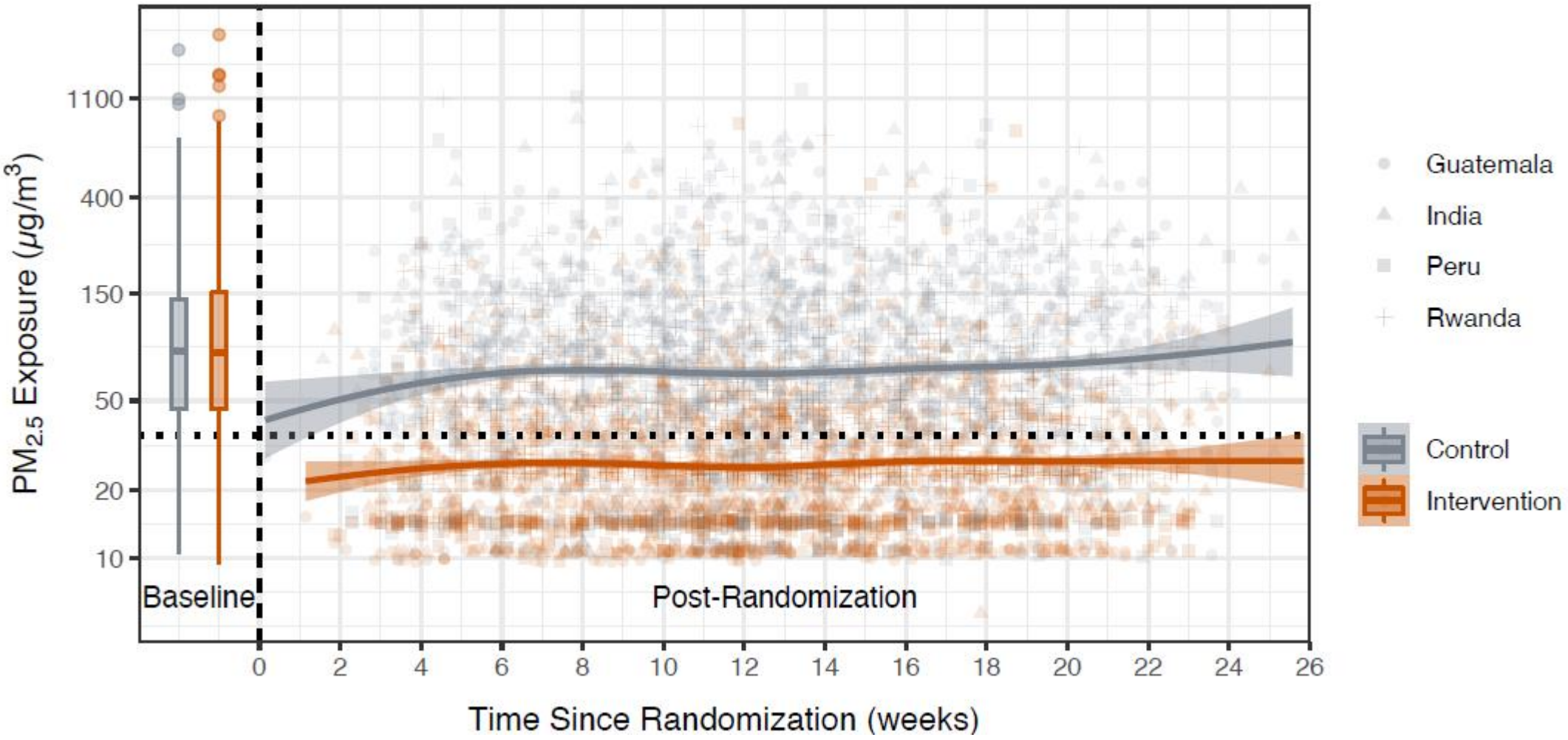
Intervention assessment in the HAPIN Trial: Fidelity and Adherence





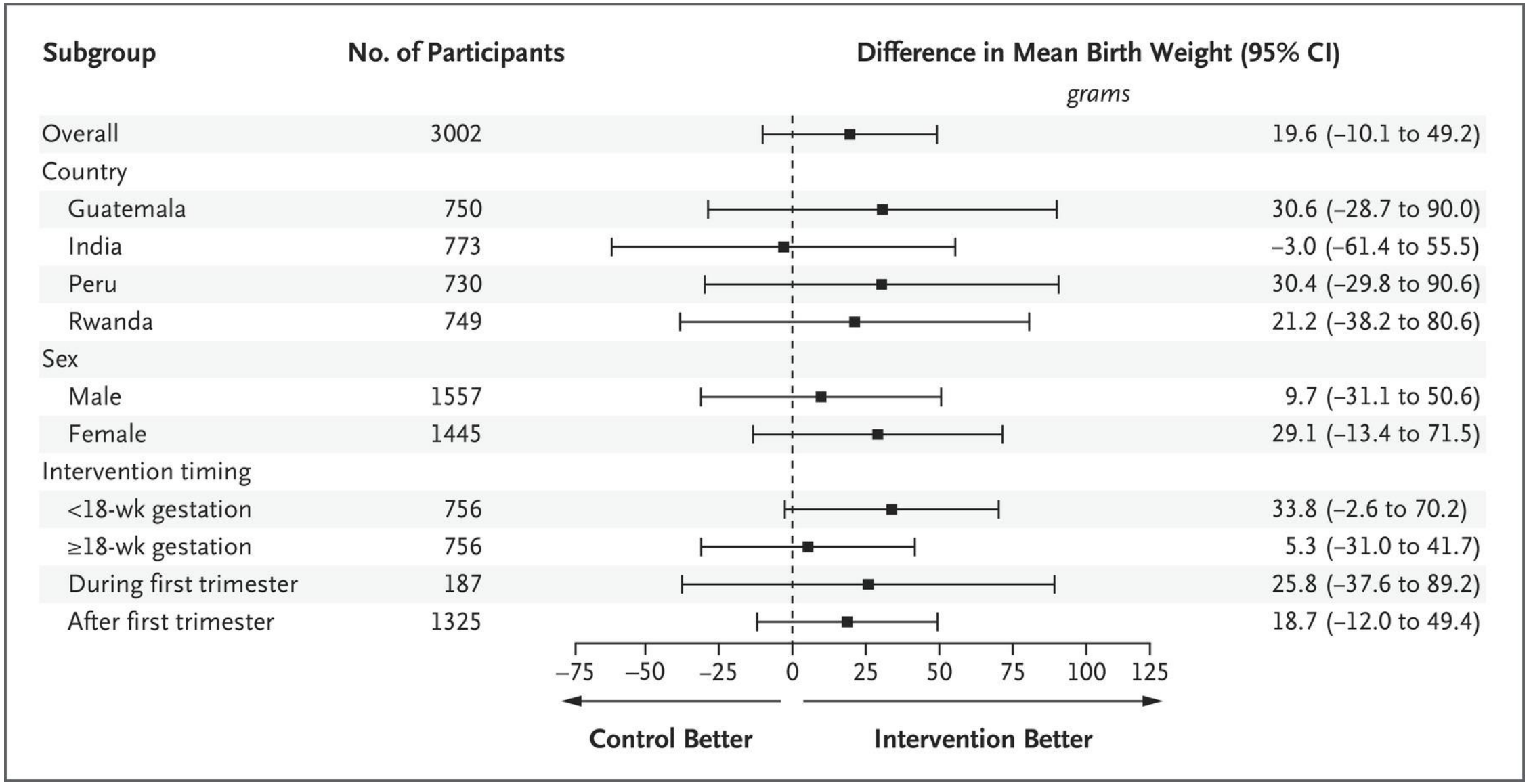
Quinn et al IJERPH 2022

Intervention assessment: WHO-ITG attainment via exclusive LPG Use



Johnson et al EHP 2022

Results from ITT Analyses for Birthweight in the HAPIN Trial



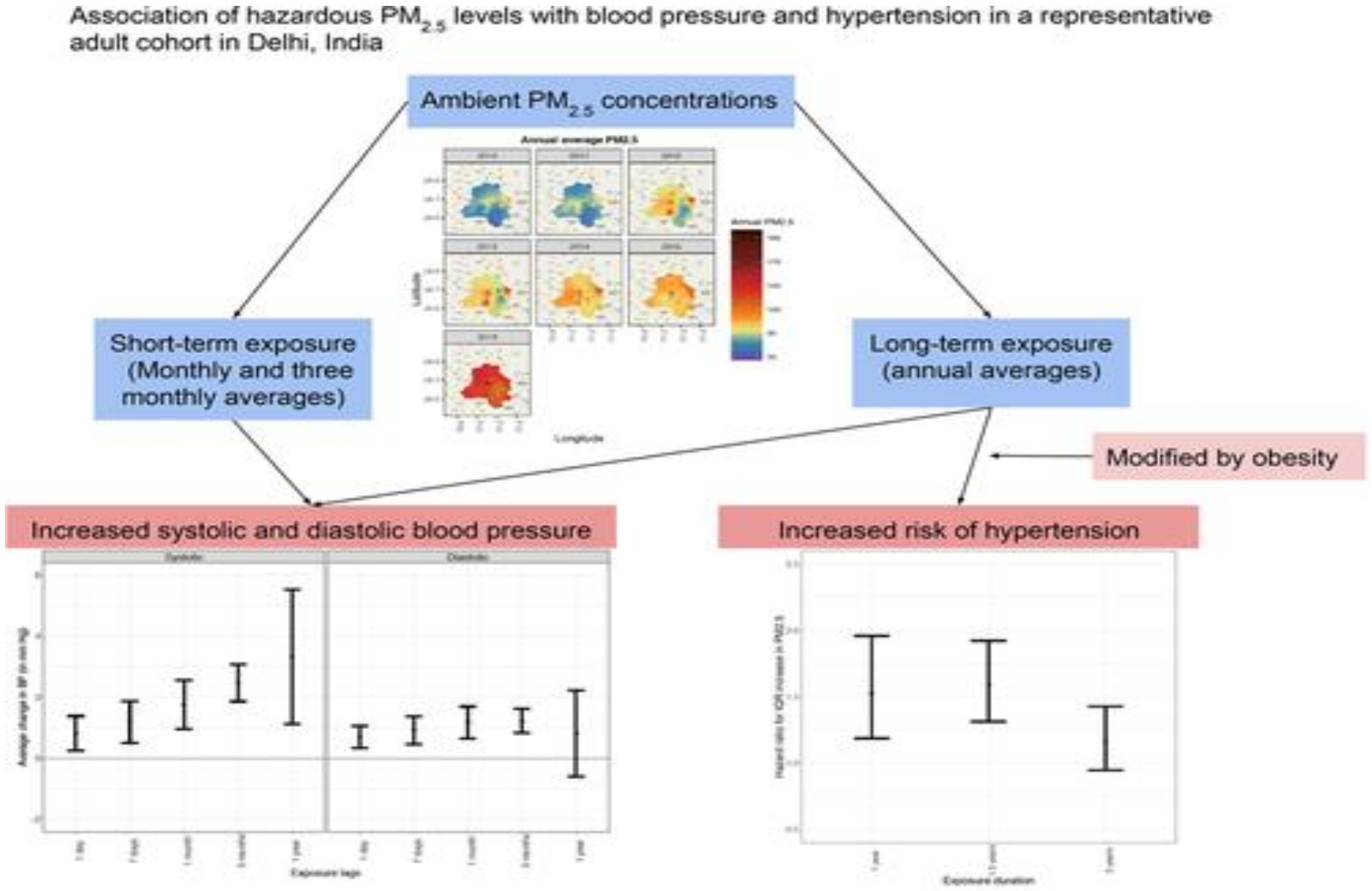
Clasen, et al **NEJM**, 2022

What did we learn from TAPHE and HAPIN?

- Written study protocols and frequently reinforced trainings are key
- Ethical considerations are of paramount importance
- Near real time data uploads (via electronic data capture) to cloud based data servers are the most cost-efficient ways of maintaining data quality and security
- Project staff are family! Invest early on converting project staff to PhD students.
- PIs should know how to sing and dance as well as communicate with policy makers and journal reviewers
- Biostatisticians with a feel for environmental epidemiology are a rare commodity. Find one, keep forever!
- RCTs can be heart-breaking
- Observational (E-R) studies can provide powerful arguments for furthering air quality actions

Cardiovascular Health Effects of Air Pollution : CARRS Cohort

(*PHFI,HARVARD University*)



Dorairaj Prabhakaran. Hypertension. Exposure to Particulate Matter Is Associated With Elevated Blood Pressure and Incident Hypertension in Urban India, Volume: 76, Issue: 4, Pages: 1289-1298, DOI: (10.1161/HYPERTENSIONAHA.120.15373)

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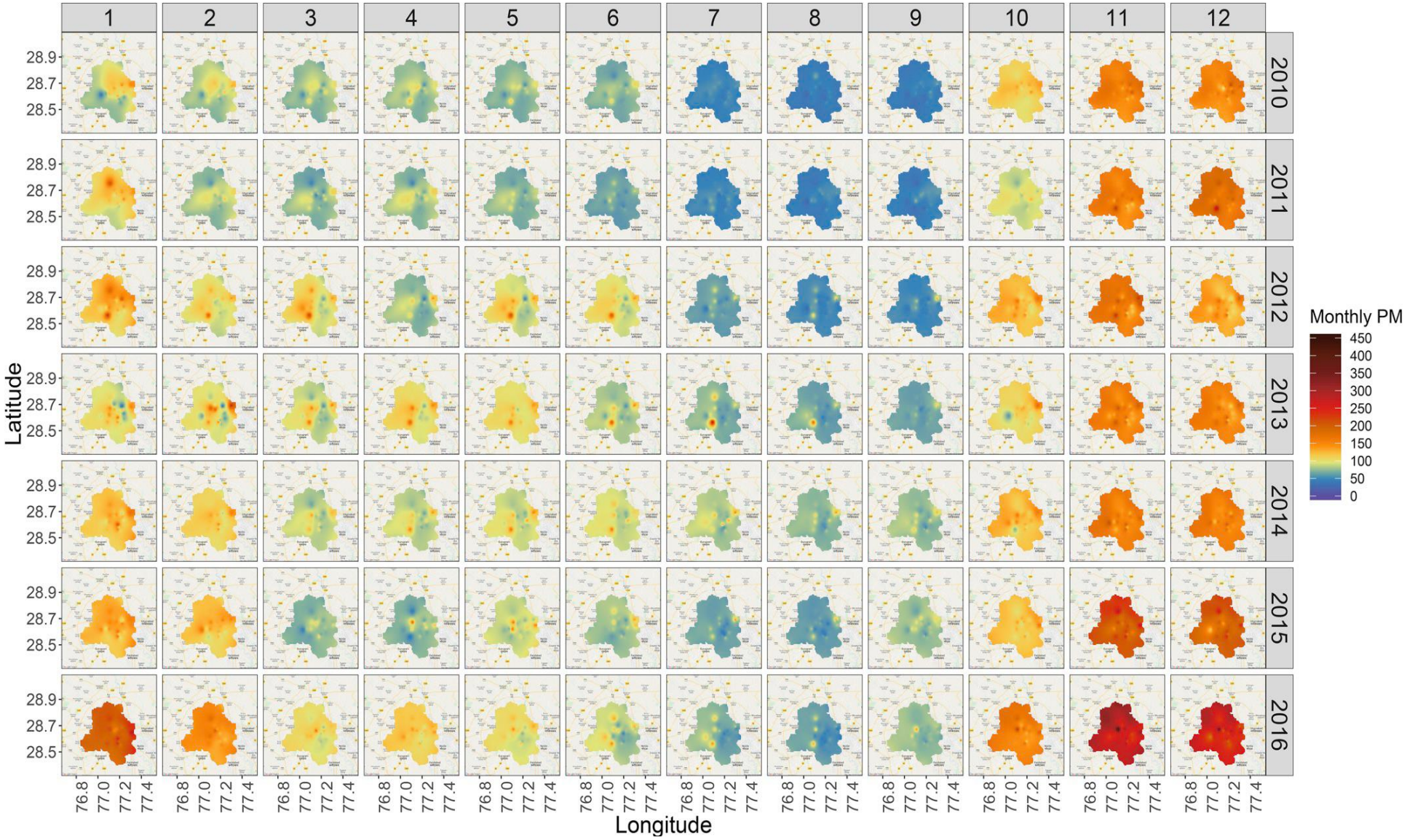
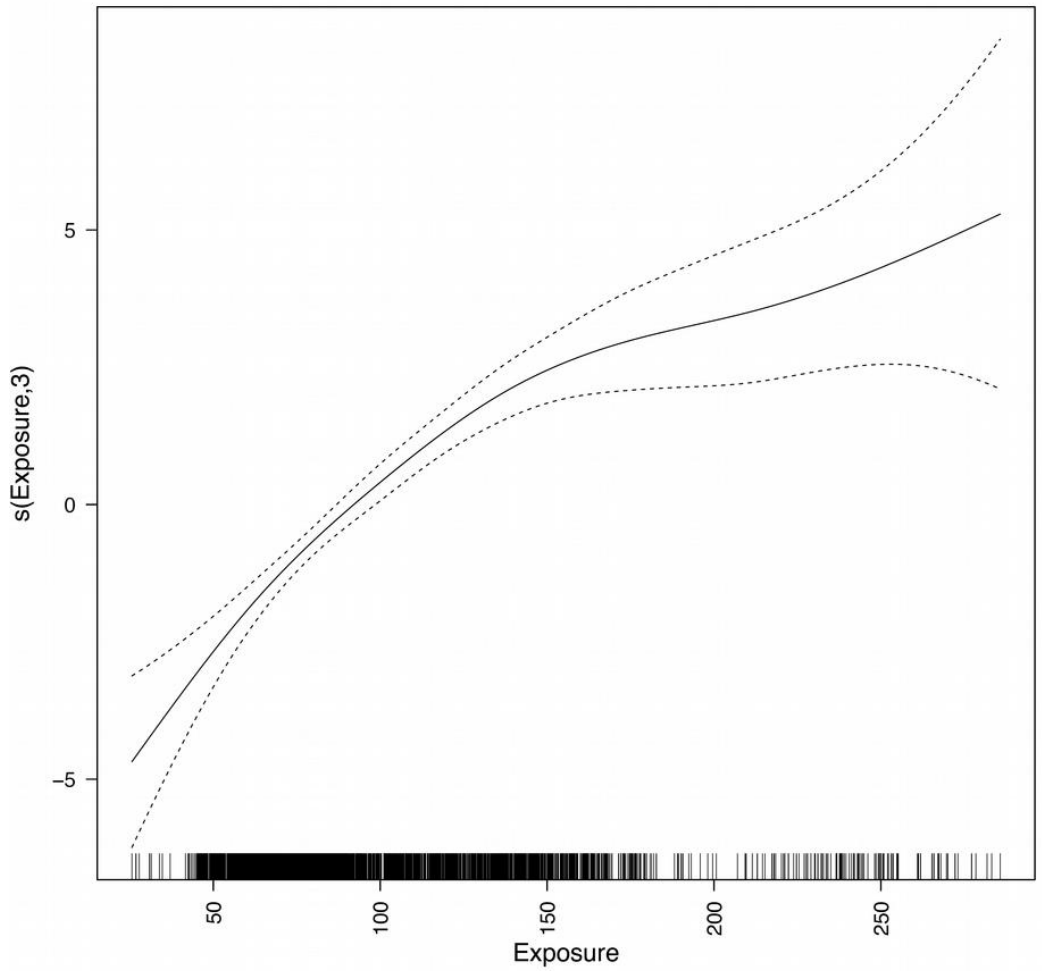
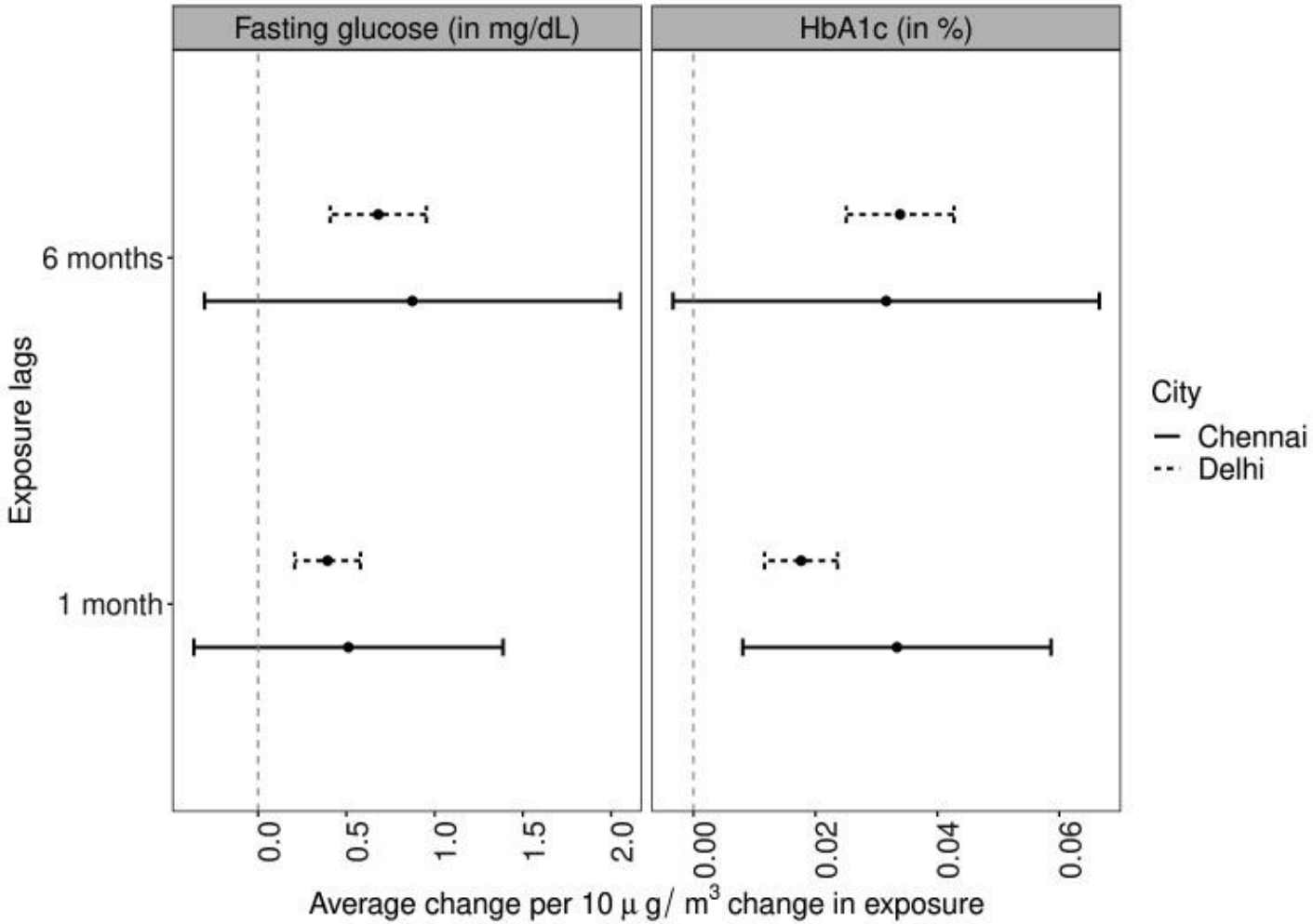
Exposure models from Ensemble Averaging for Delhi NCR



Mandal et al ***Atmospheric Environment*** 2020

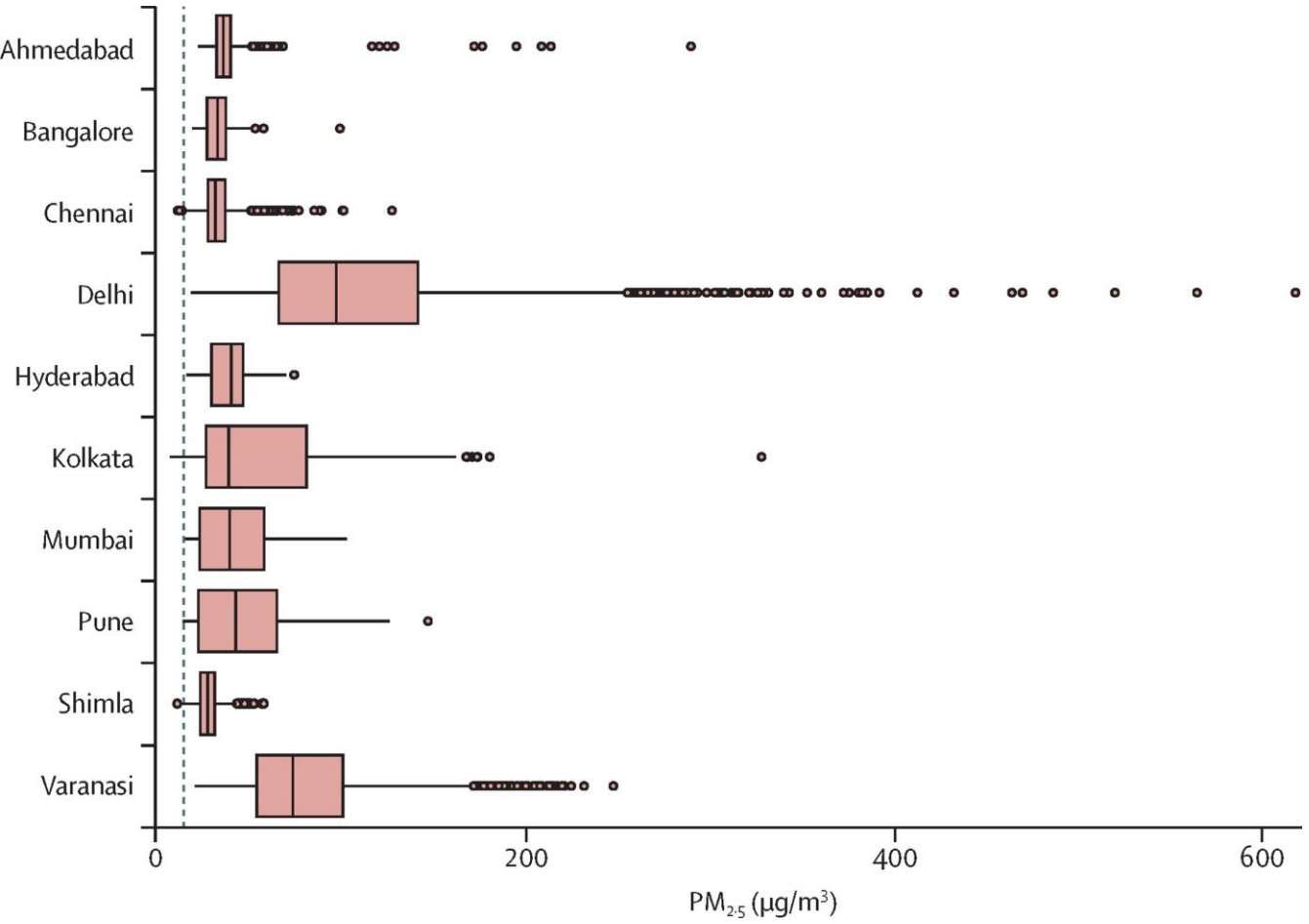
Ambient air pollution and Cardio-metabolic risks –Results from the CARRS Cohort

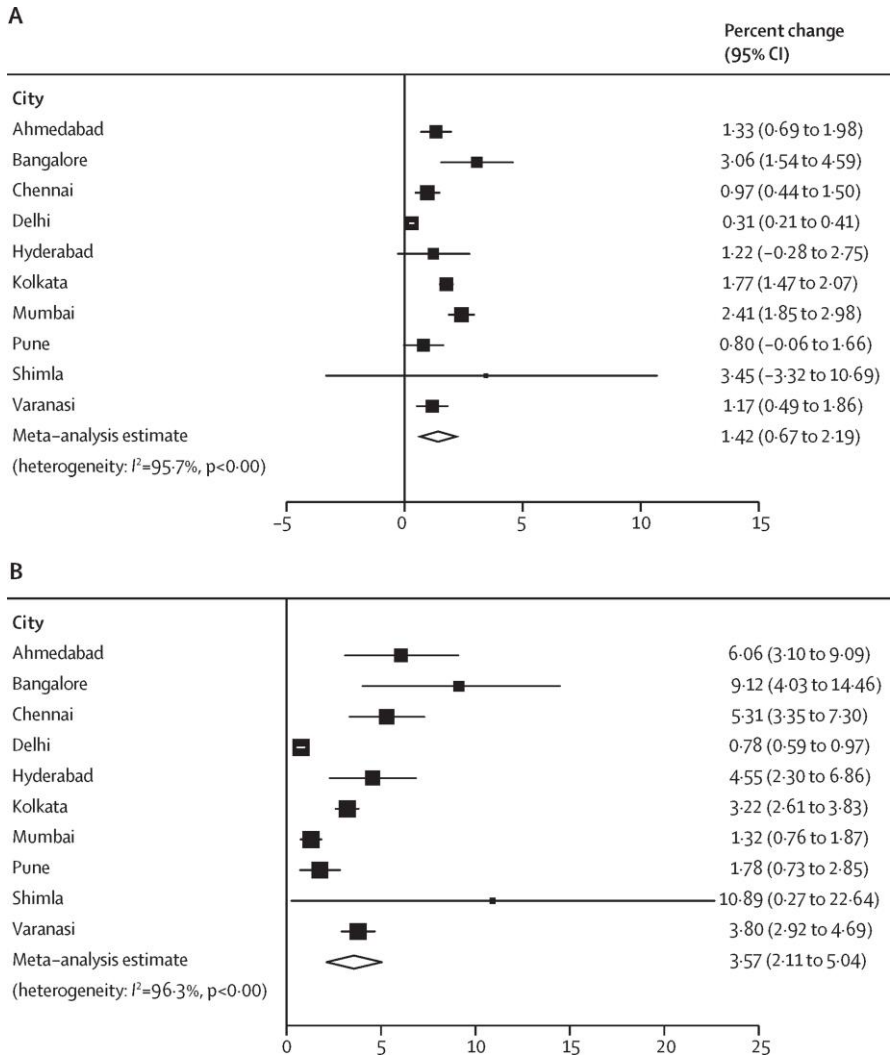




Prabhakaran et al. , ***Hypertension 2020;*** Mandal et al ***BMJ Open Diabetes &Research Care 2023***

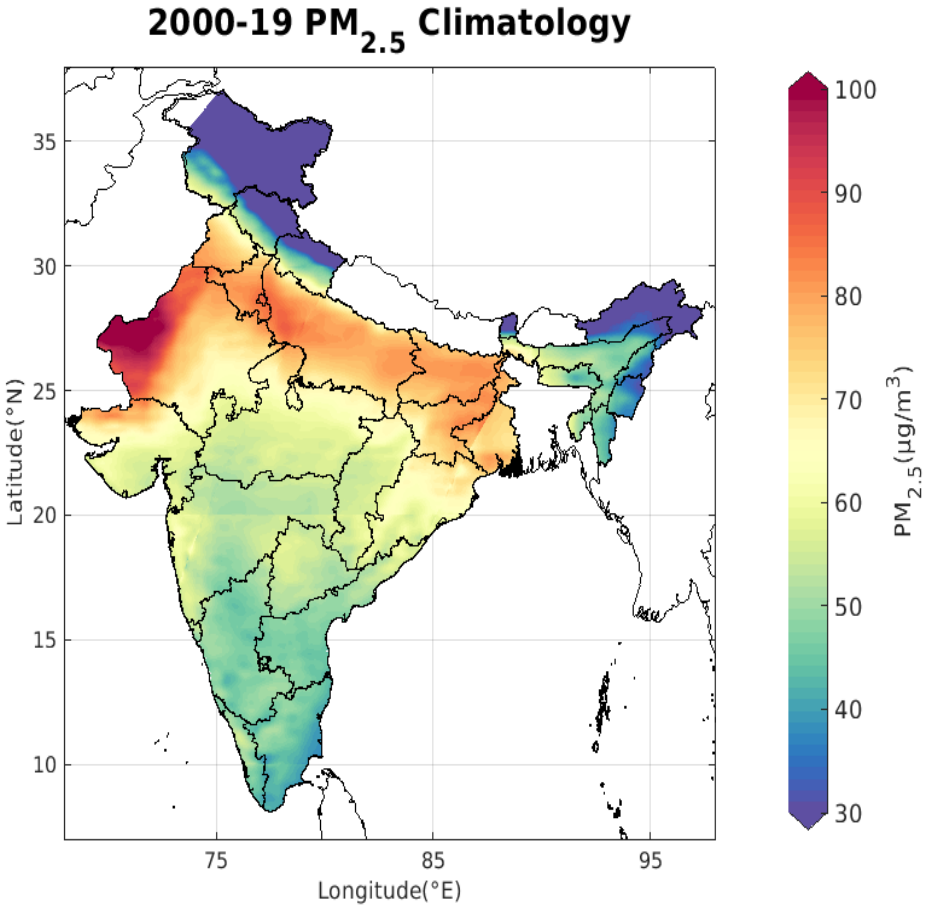
Ambient air pollution and daily mortality in ten cities of India: a causal modelling study

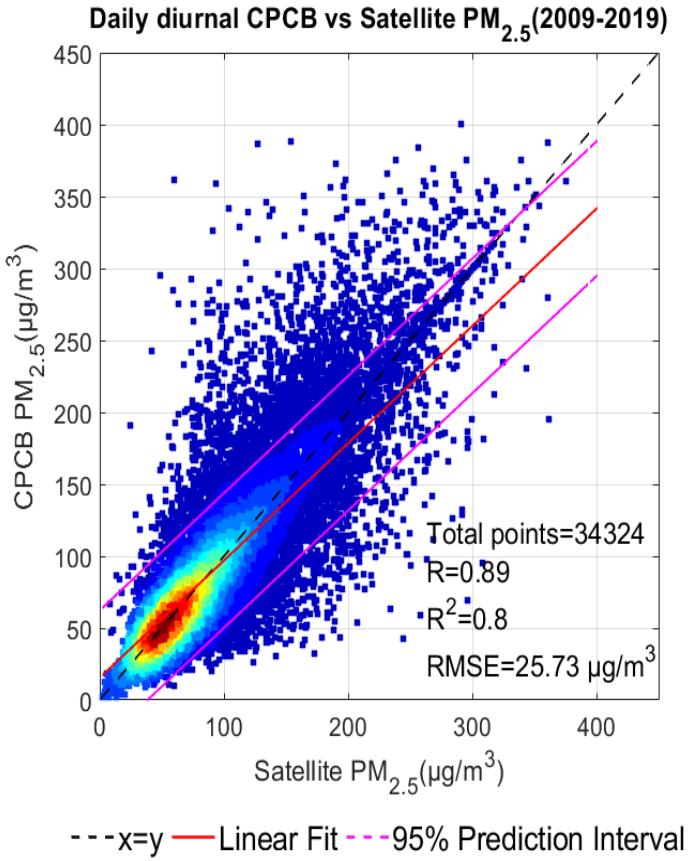


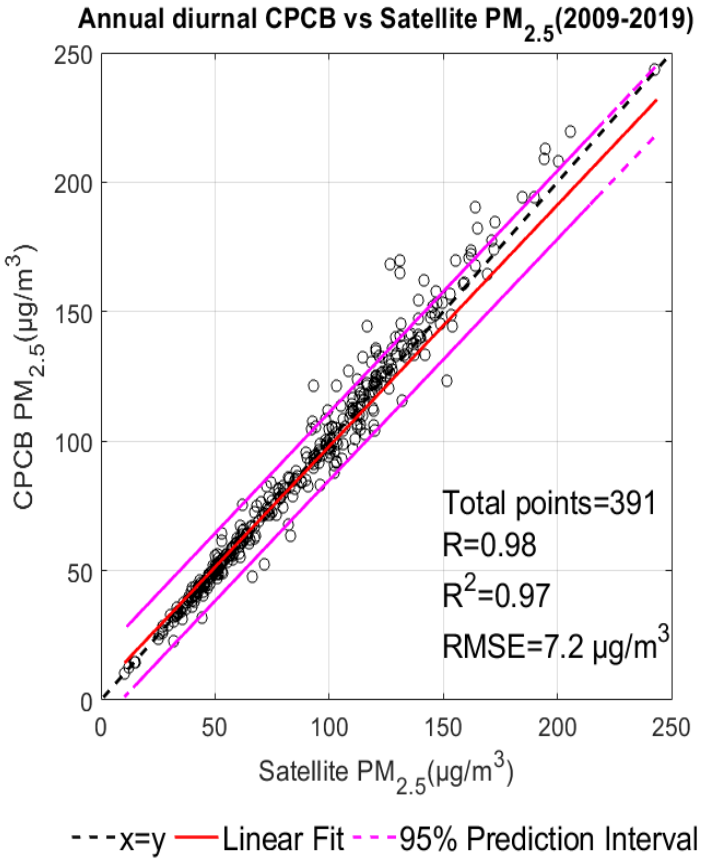


J de Bont et al. , **Lancet Planetary Health 2024**

AOD based exposure models with empirical ground monitoring data







Dey et al ***Atmospheric Environment*** 2020

Health studies using satellite based methods with NFHS data

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Robust relationship between ambient air pollution and infant mortality in India

Priyanka N. deSouza [a,*], Sagnik Dey [b,c], Kevin M. Mwenda [d,e], Rockli Kim [f,g,h], S.V. Subramanian [h,i], Patrick L. Kinney [j]

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Ambient air pollution and acute respiratory infection in children aged under 5 years living in 35 developing countries

Daniel B. Odo [a,b,*], Ian A. Yang [c,d], Sagnik Dey [e,f], Melanie S. Hammer [g], Aaron van Donkelaar [g], Randall V. Martin [g], Guang-Hui Dong [h], Bo-Yi Yang [h], Perry Hystad [i], Luke D. Knibbs [a,j]

Research

A Section 508–conformant HTML version of this article is available at https://doi.org/10.1289/EHP8910.

Child Survival and Early Lifetime Exposures to Ambient Fine Particulate Matter in India: A Retrospective Cohort Study

Jiawen Liao,[1,2] Yang Liu,[1] Kyle Steenland,[1] Ajay Pillarisetti,[1,3] Lisa M. Thompson,[4] Sagnik Dey,[5,6] Kalpana Balakrishnan,[7] and Thomas Clasen[1]

Contents lists available at ScienceDirect

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Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Impact of acute exposure to ambient $PM_{2.5}$ on non-trauma all-cause mortality in the megacity Delhi

Pallavi Joshi [a], Santu Ghosh [b], Sagnik Dey [a,c,d,*], Kuldeep Dixit [a], Rohit Kumar Choudhary [a], Harshal Ramesh Salve [e], Kalpana Balakrishnan [f]

Crop Fires and Cardiovascular Health – A Study from North India

Prachi Singh [a,d,*], Ambuj Roy [b], Dinkar Bhasin [c], Mudit Kapoor [d], Shamika Ravi [e], Sagnik Dey [f]

Spears *et al. Environmental Health* (2019) 18:62
https://doi.org/10.1186/s12940-019-0501-7

Environmental Health

Original Research Article

ISEE ENVIRONMENTAL EPIDEMIOLOGY

OPEN

The Association Between Ambient $PM_{2.5}$ Exposure and Anemia Outcomes Among Children Under Five Years of Age in India

Unnati Mehta[a,b], Sagnik Dey[a,c,d,*], Sourangsu Chowdhury[a], Santu Ghosh[f], Jaime E Hart[b,g], Anura Kurpad[f]

RESEARCH Open Access

The association of early-life exposure to ambient $PM_{2.5}$ and later-childhood height-for-age in India: an observational study

Dean Spears[1,2*], Sagnik Dey[3,4], Sourangsu Chowdhury[3], Noah Scovronick[5], Sangita Vyas[1] and Joshua Apte[6]

LETTER

The association of in-utero exposure to ambient fine particulate air pollution with low birth weight in India

Nihit Goyal[1,*] and David Canning[2]

What have the exposure model based studies shown us?

- Model uncertainties are smaller than the expanding base of consistency in the strength of association
- A rigorous base of empirical measurements are critical for validating and expanding the applicability of models
- Modeling and measurement capacities are extremely limited
- Accessible data repositories are not a reality yet
- Integration of health and exposure data will require substantive investments in data/human resource infra-structure
- Risk (mis)-perceptions on modeled health impact estimates require considerable investments in risk communication channels

What is the role of the health sector in implementing AQGs?

What is needed to implement the guidelines?

Key enabling factors

- Key institutional / technical tools and human capacity
- Existence and operation of air pollution monitoring systems
- Public access to air quality data
- Legally binding, globally harmonized AQ standards
- Air quality management systems
- Capacities to conduct health risk assessment to set priorities for action
- Cooperation among different sectors and stakeholders, including the health sector

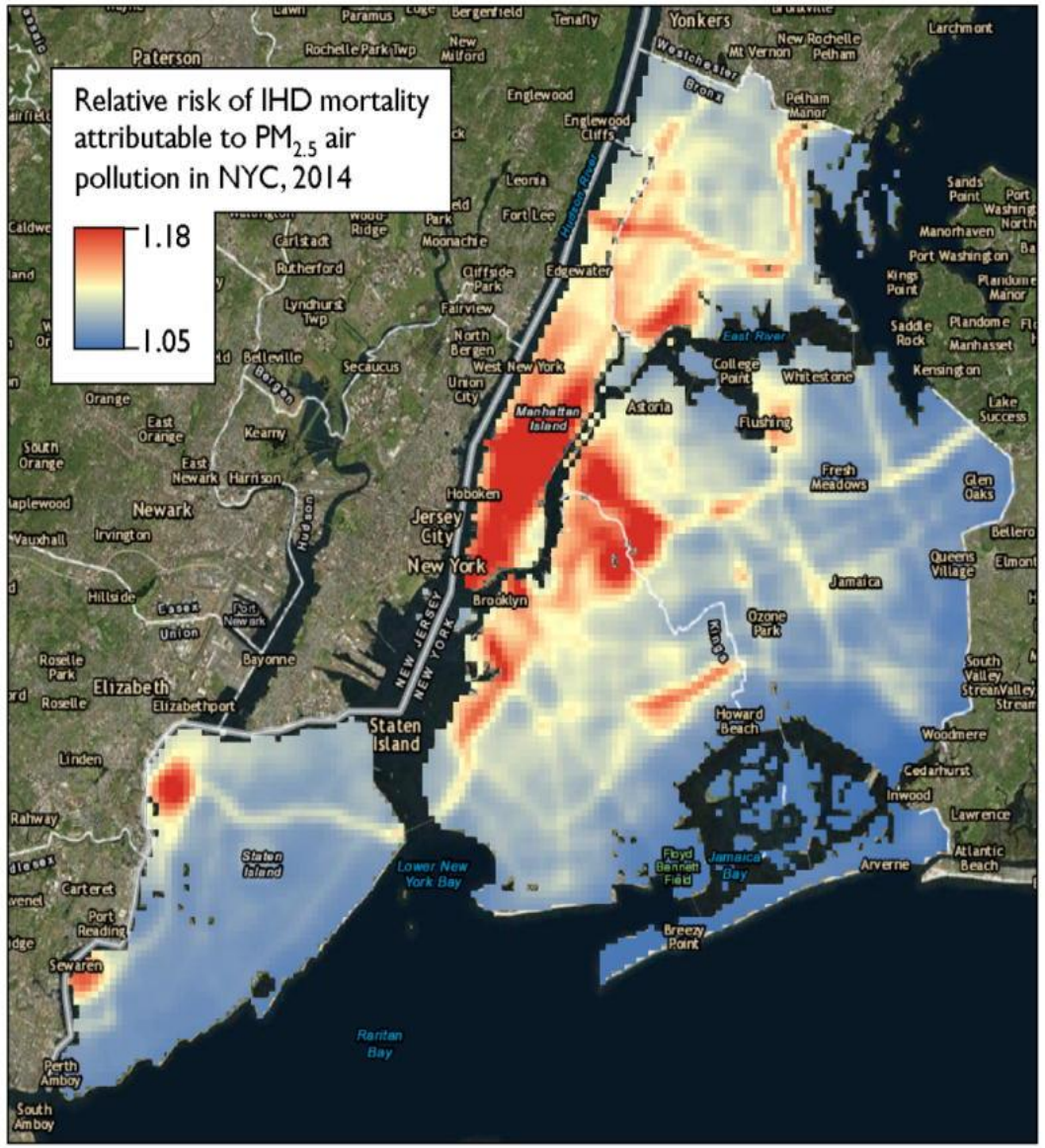
The health sector has a crucial role

The health sector has a role in:

- raising awareness of the impact of air quality on health
- advising the public and patients about how the impact of air pollutants can be mitigated at an individual level;
- gathering evidence on health effects from air pollution;
- and joining advocacy efforts at the national and international levels to ensure that the health arguments are heard.

Engagement of the health community is crucial.

Clinical approach to addressing air pollution and CVD- Can we get to this stage in LMICs??



A. Identify patients more susceptible to pollution-attributable CVD

Consider a Pollution Risk Assessment in the following groups of patients at elevated risk of pollution-related cardiovascular events. Clinicians may also wish to target patients at risk of developing hypertension, diabetes, dyslipidemia, the metabolic syndrome, or pollution-attributable pulmonary, neurologic, or fetal diseases (beyond the scope of this review).

- Lower socioeconomic status
- Advanced age
- Obesity
- Diabetes
- Coronary artery disease
- Multiple cardiac risk factors

B. Qualitative Risk Assessment

Patients at risk can be asked about the following risk factors that predict elevated exposure to fine particulate matter air pollution. The three most significant predictors of pollution exposure are in bold and summarized in the proposed screening tool (Figure 5). This assessment may be unnecessary in communities with pervasive solid fuel use or universally elevated outdoor air pollution.

Household air pollution
- **Burning of solid fuels at home for cooking, heating, lighting, or other purposes**
- Use of rudimentary or inefficient stoves
- Frequency of burning and time spent around stove
- Burning solid fuels indoors
- Poor ventilation (eg, no chimneys, windows, eaves)

Outdoor air pollution
- **Live or work in urban industrial environment**
- **Time spent in/around heavy traffic**
- Residence near major thoroughfare
- In-car behaviors (eg, windows down, air filtration off)
- Time spent exerting self outdoors
- Prevalence of solid fuel cooking/heating in the community

C. Quantitative Risk Assessment

Duration and concentration of $PM_{2.5}$ exposure can be quantified using a wearable device, or through the following statistical approaches. Exposure levels then are passed through an Exposure-Response function to determine Relative Risk of CV events.

Household air pollution

Statistical methods for estimating HAP exposure:
1. Regression analysis based on household characteristics, (eg, fuel type, kitchen type, ventilation, cooking duration, and geographical location)
2. Pre-calculated community estimates

Outdoor air pollution

Spatial estimates of average OAP exposures at patients' home or work addresses:
1. Interpolation from surface measurements
2. Land-use regression models
3. Satellite-based measurements

Estimating cardiac risk attributable to pollution exposures
- Exposure estimates from above can be passed through an exposure-response curve to provide a patient-tailored estimate of Relative Risk of cardiovascular events attributable to air pollution.

D. Interventions & Recommendations

A tailored subset of the following interventions can be offered to patients determined to be at elevated CVD risk.

General recommendations
- Target exposures identified in the initial pollution exposure assessment
- Prioritize treatment of traditional cardiovascular risk factors to lessen susceptibility to harmful effects of air pollution
- Consider dietary supplements to reduce pollution-attributable oxidative stress and autonomic dysfunction
- Prioritize community-tailored interventions that are financially viable and culturally acceptable in the local context
- Collaborate with government efforts to establish and enforce air quality standards and reduce pollution emissions

Household air pollution

Adoption of low-emission stove-fuel combinations
- Prefer electric or clean-burning gas stoves
- Consider high-efficiency, low-emission biomass stoves

Improved household ventilation and air filtration
- Chimneys, hoods, windows, doors, eaves, fans, etc.
- Cook outdoors and/or away from living areas
- High efficiency particulate arrestance air filters and central air conditioners
- Home insulation, window seals, and pot lids to reduce fuel requirement for cooking or heating

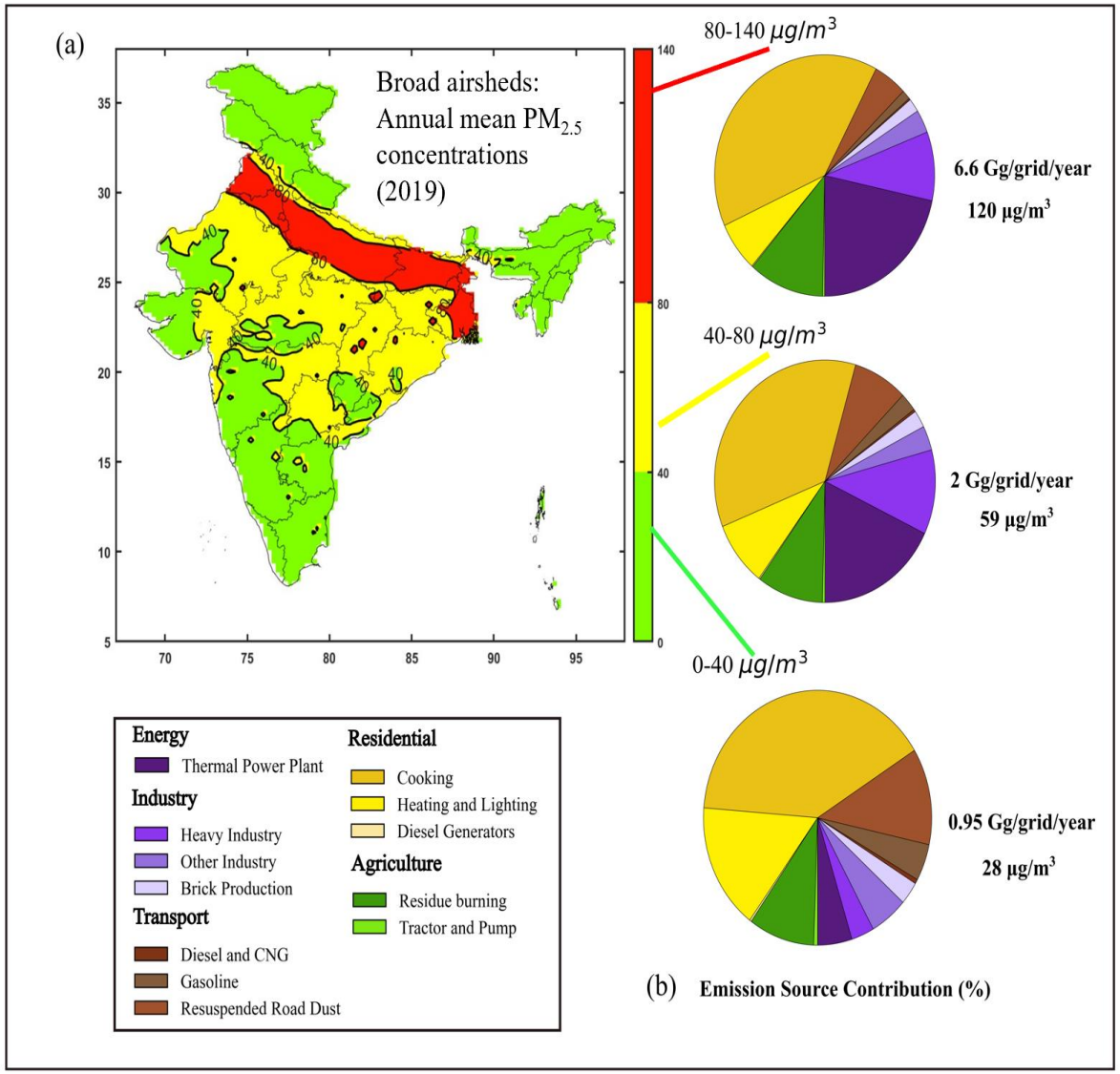
Outdoor air pollution

Behavior changes to reduce exposures
- Build and connect to community pollution alert systems
- Avoid high-exposure locations and times
- Minimize traffic exposure, rush hour and major roadways
- Avoid prolonged/heavy exertion outdoors on polluted days
- Keep car and home windows closed

Equipment to reduce exposures
- Personal air filters (eg, N95 respirator, face mask, nasal plugs)
- Central air conditioners and high efficiency particulate arrestance air filters

Hadley et al ***Circulation*** 2018

Engaging in Inter-sectoral Inter-disciplinary dialogues for actions - Risky territory for epidemiologists????

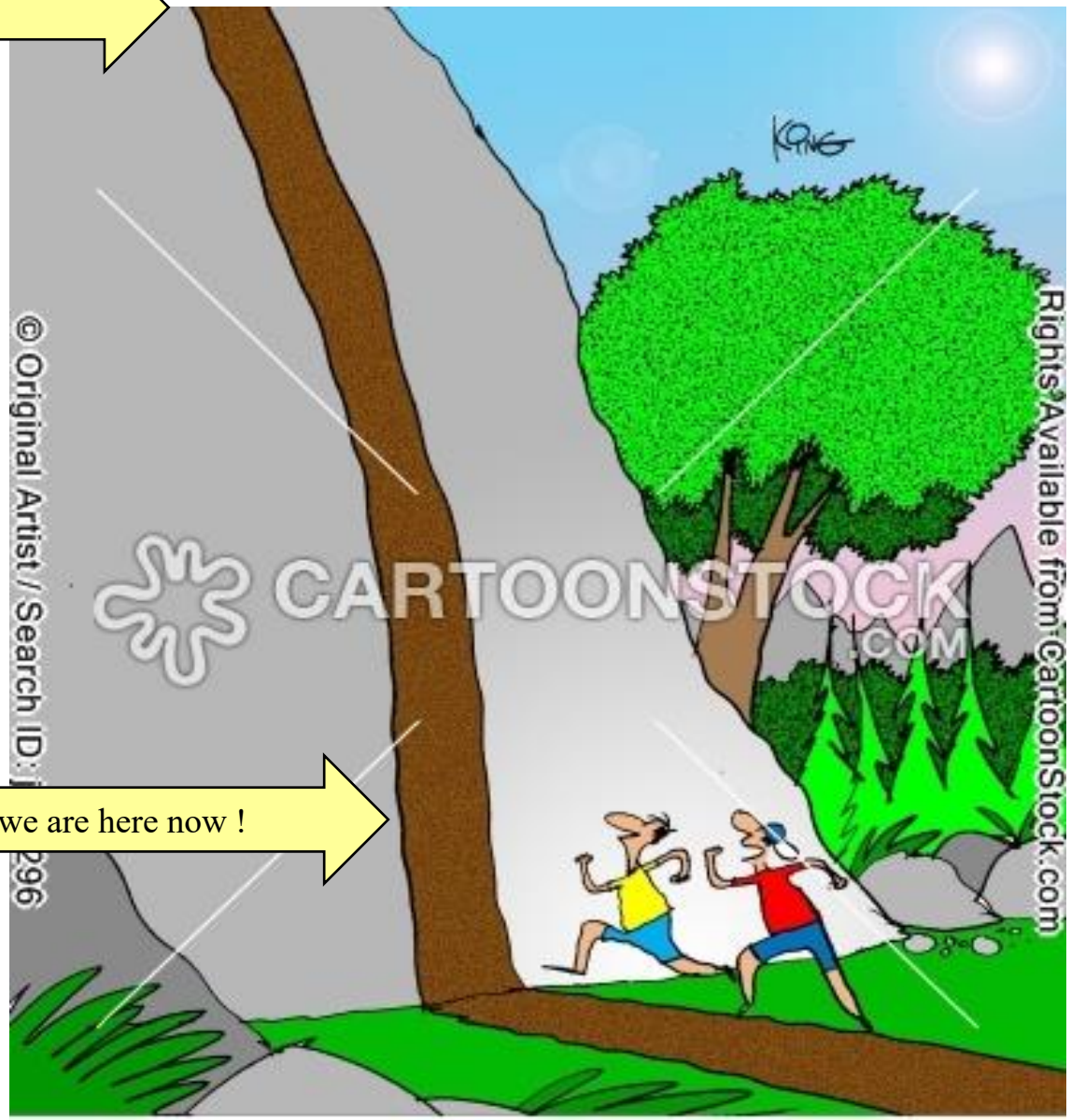


Venkatraman et al 2024

Grateful thanks to
Our field teams and global network of collaborators


THANK YOU

…and hoping to get there !



…and so…we are here now !

"This is where the trail gets a little more challenging."

Together we can!