Portable Air Cleaners, Cardiovascular Health, and Fetal Growth:

Results from Randomized Studies in Canada and Mongolia

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Presentation Overview

- Two randomized studies of portable HEPA filter air cleaners and health:
  - Rural Canadian community
    - Moderate concentrations from **wood stoves**
    - 7-day intervention, healthy adults
    - **Cardiovascular outcomes**
  - City in a developing country (Mongolia)
    - High concentrations from **coal stoves**
    - 7-month intervention, pregnant women
    - **Fetal growth indicators**

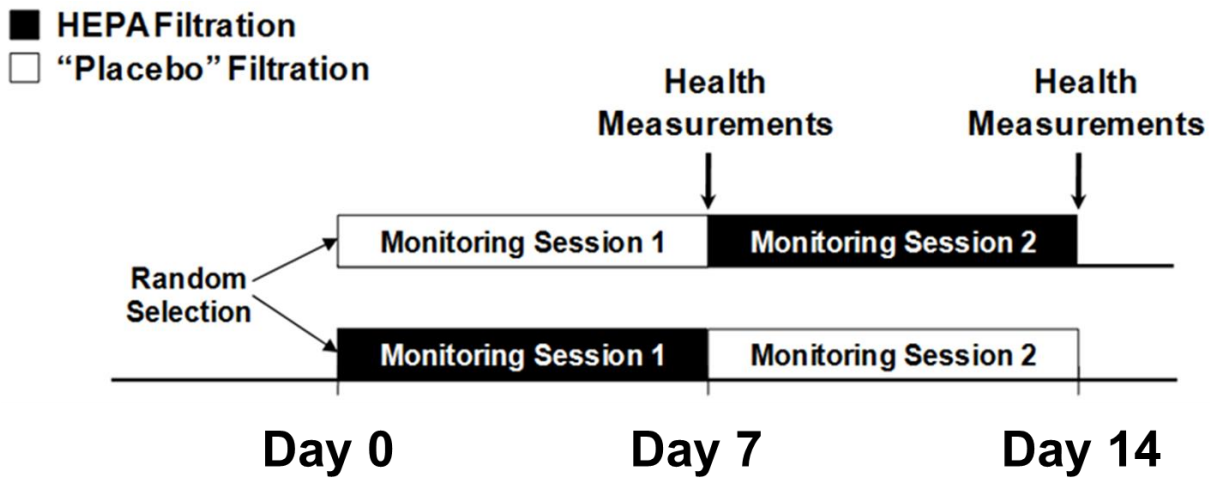
Portable Air Cleaners and Wood Smoke

Photo courtesy of Ben Weinstein

- Smithers, British Columbia
  - Population ~5,300
  - At the time, 63% of homes in the region used wood as primary heating fuel.

Study Design

Single-blind randomized crossover study design:



- 43 healthy adults (mean age: 43 years)
- Honeywell 50300 in living room; 18150 in bedroom
- Two consecutive 7-day monitoring periods
- Measures of oxidative stress, systemic inflammation, and endothelial (blood vessel) function

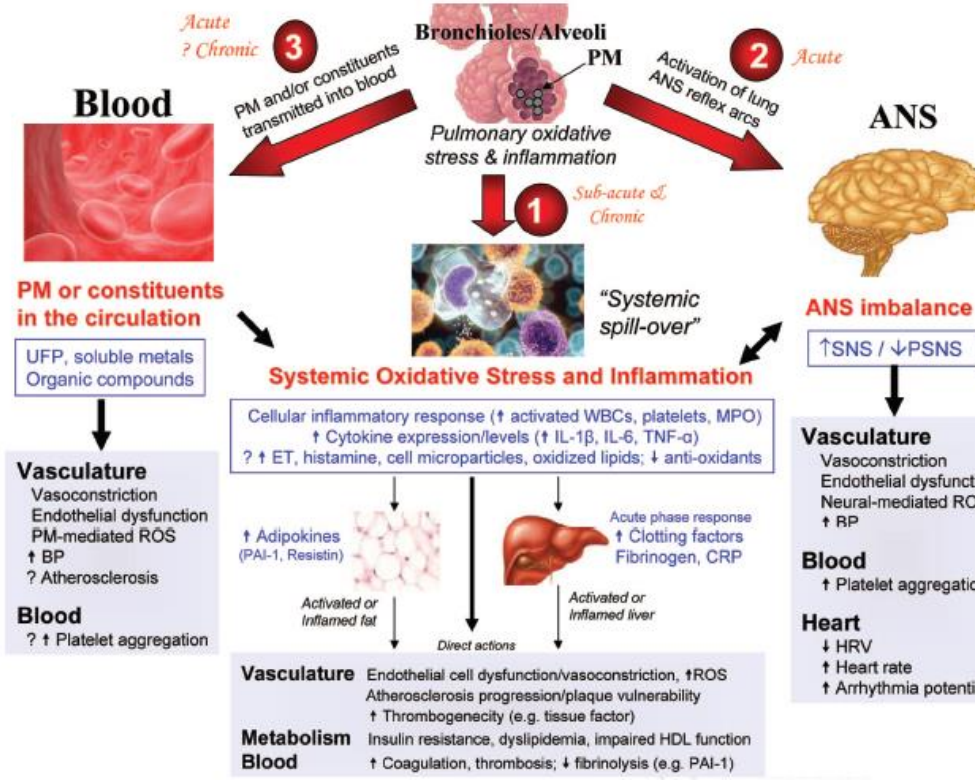
Results

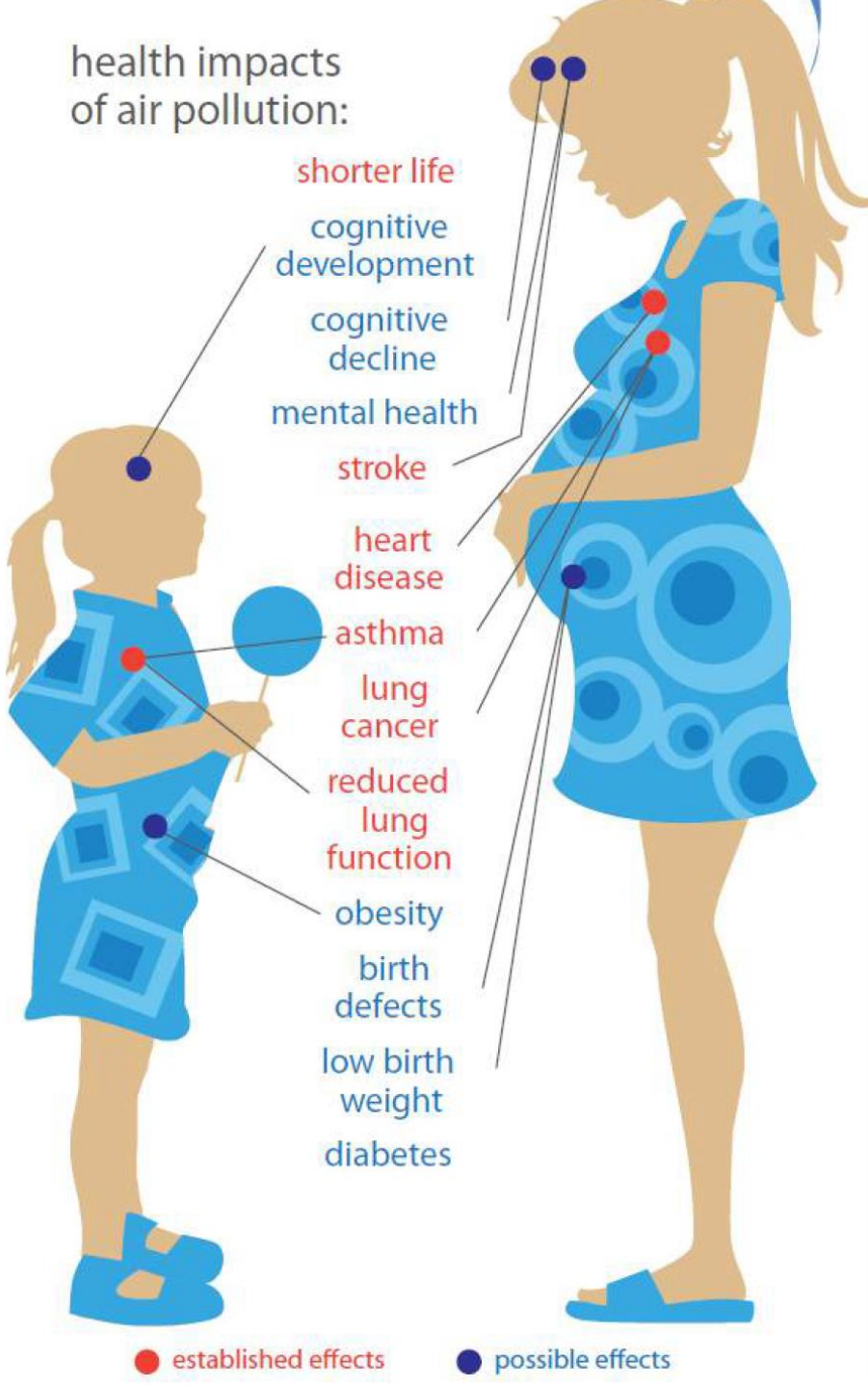
- Air pollution concentrations:
  - $PM_{2.5}$ infiltration efficiency: ↓ 41% (0.34 → 0.20)
  - Indoor $PM_{2.5}$ concentration: ↓ 59% (11.2 → 4.6 µg/m^3)
  - Indoor levoglucosan concentration: ↓ 74% (127 → 33 ng/m^3)

- Health effects:
  - ↑ blood vessel function (reactive hyperemia index)
  - ↓ systemic inflammation (C-reactive protein)
  - No changes in oxidative stress markers

Allen et al., *Am J Respir Crit Care Med*, 2011

Effects Beyond the Lung

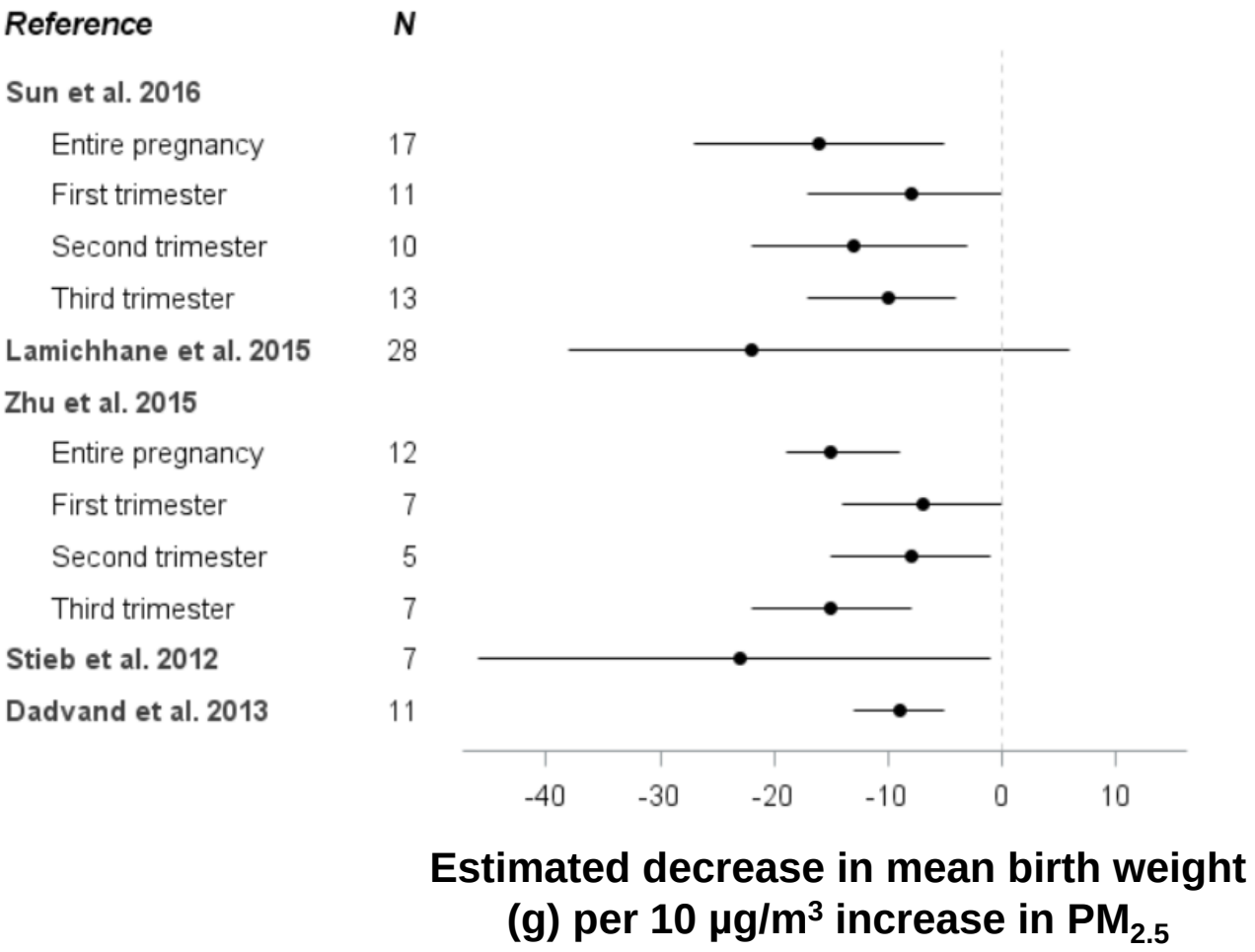




Brook et al., *Circulation*, 2010
BC Lung Association

Rationale

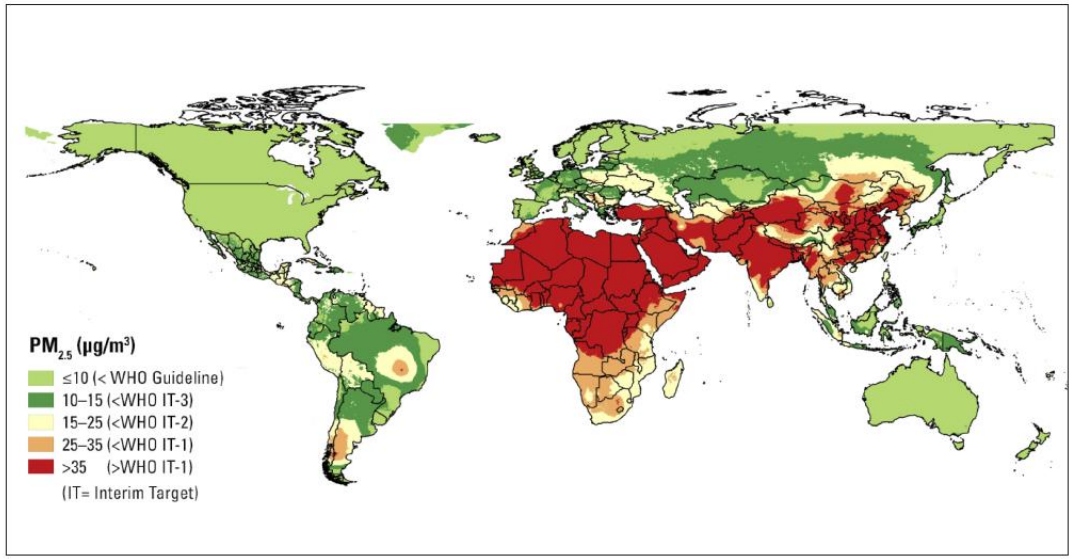
- Meta-analyses of observational studies report ~10-20 gram decreases in mean birth weight per 10 µg/m^3 $PM_{2.5}$



Rationale

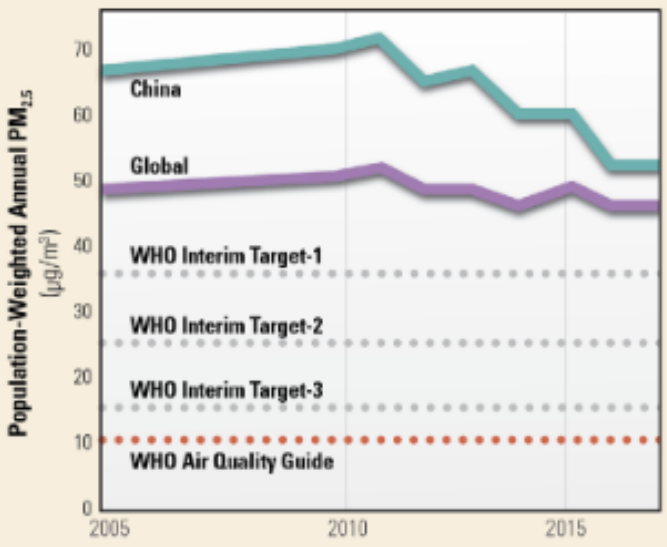
More than 90% of people worldwide live in areas exceeding the WHO Guideline for healthy air. More than half live in areas that do not even meet WHO's least-stringent air quality target.

Figure 2. Annual average $PM_{2.5}$ concentrations in 2017 relative to the WHO Air Quality Guideline.



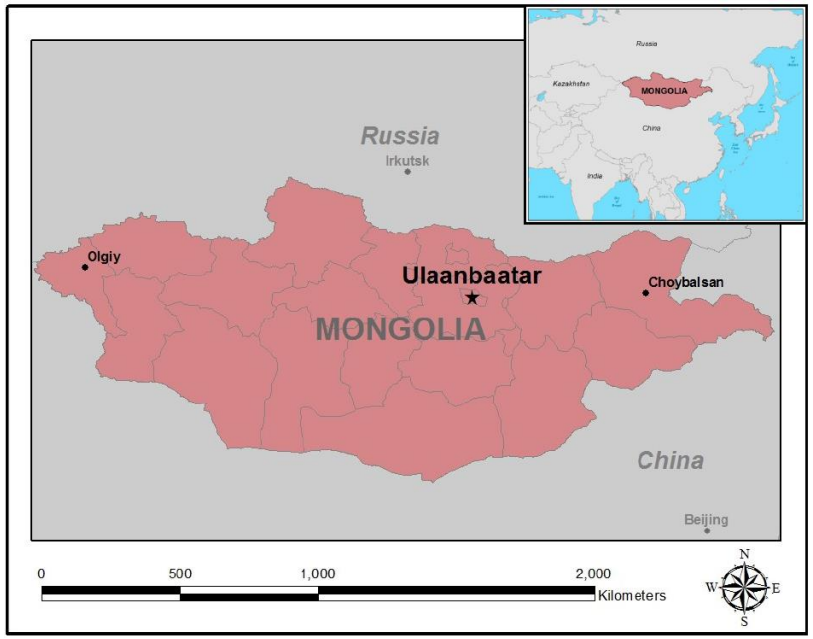
https://www.stateofglobalair.org/sites/default/files/soga_2019_report.pdf

Trends in population-weighted annual average $PM_{2.5}$ concentrations in China and globally compared with the WHO Air Quality Guideline and interim targets.

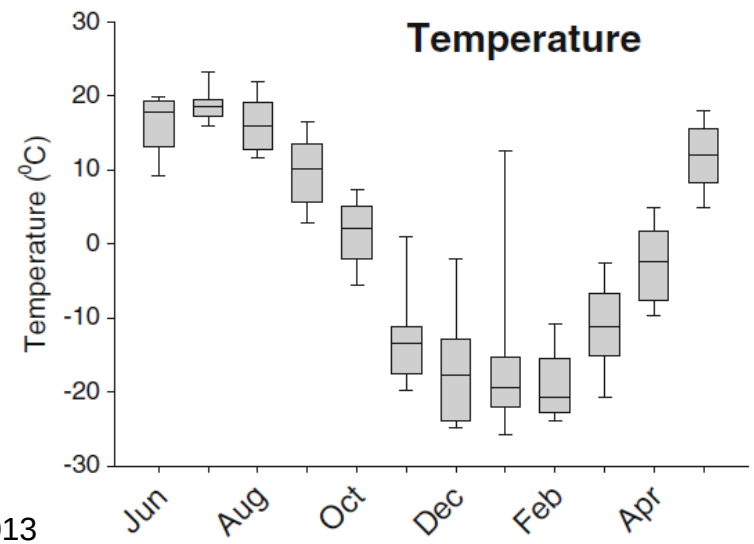


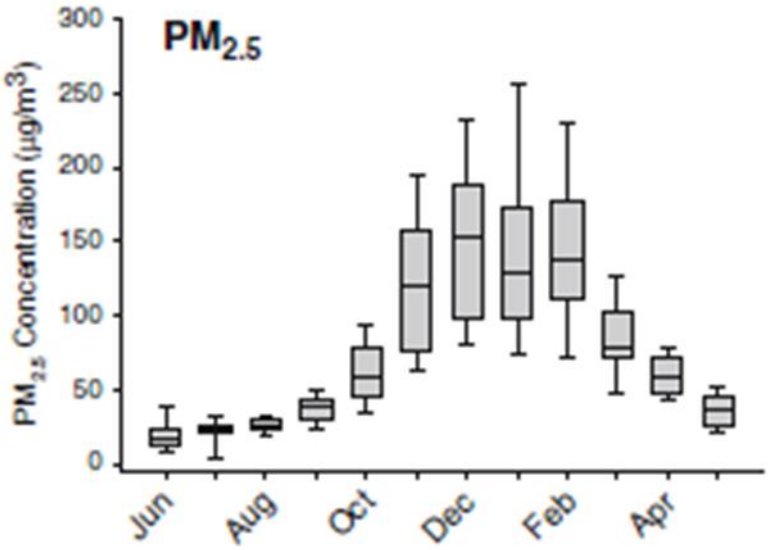
- Emissions reductions should be the goal, but…
- Household-level interventions may mitigate risks in the near term
- Pregnancy represents a well-defined time period for intervention, with potential benefits over the life course

Ulaanbaatar, Mongolia



- Population ~ 1.3 million
- Air pollution:
  - Rapid population growth
  - Cold winters
  - Topography
  - **Coal combustion**





Allen et al.,
Air Qual Atmos Health, 2013

https://www.nationalgeographic.com/environment/2019/03/mongolia-air-pollution/

theguardian

In Ulan Bator, winter stoves fuel a smog responsible for one in 10 deaths

Newsweek

U.S. World Business Tech & Science Culture Sports Health Opinion Nidelible

WORLD

HOW DEADLY POLLUTION BECAME ONE OF MONGOLIA'S BIGGEST PROBLEMS

TIME

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Life in the Most Polluted Capital in the World

By Joseph Hincks | Photographs by Zhang Chi for TIME | Video by Zhang Chi, Aria Chen and Arpita Aneja

March 23, 2018

The New York Times | WORLD

ULAN BATOR JOURNAL

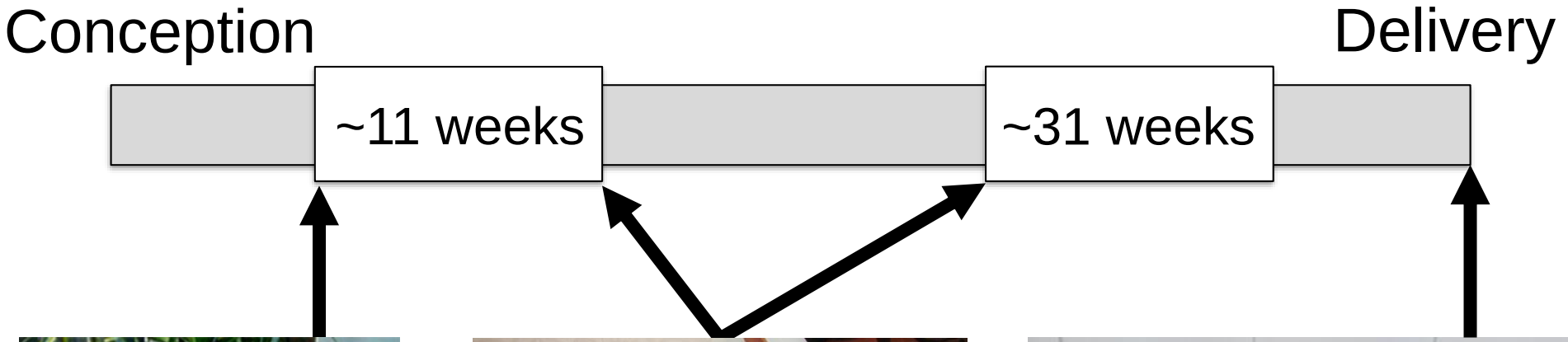
Burning Coal for Survival in the World's Coldest Capital

Photographs and Text by BRYAN DENTON MARCH 15, 2018

Study Design

- **Randomized controlled trial**
  - Intervention group received 1-2 HEPA filter air cleaners for use in homes, and control group received no air cleaners (single blind; participants were aware of intervention status)
  - Coway AP-1009CH air cleaner, CADR (smoke) = 150
- **Study sample:**
  - Non-smoking, ≥ 18 years, ≤ 18 weeks pregnancy, single gestation pregnancy, residing in apartments
- **Sample size:** 540 participants recruited
- **Data collection period**: January 2014 to December 2015

Data Collection



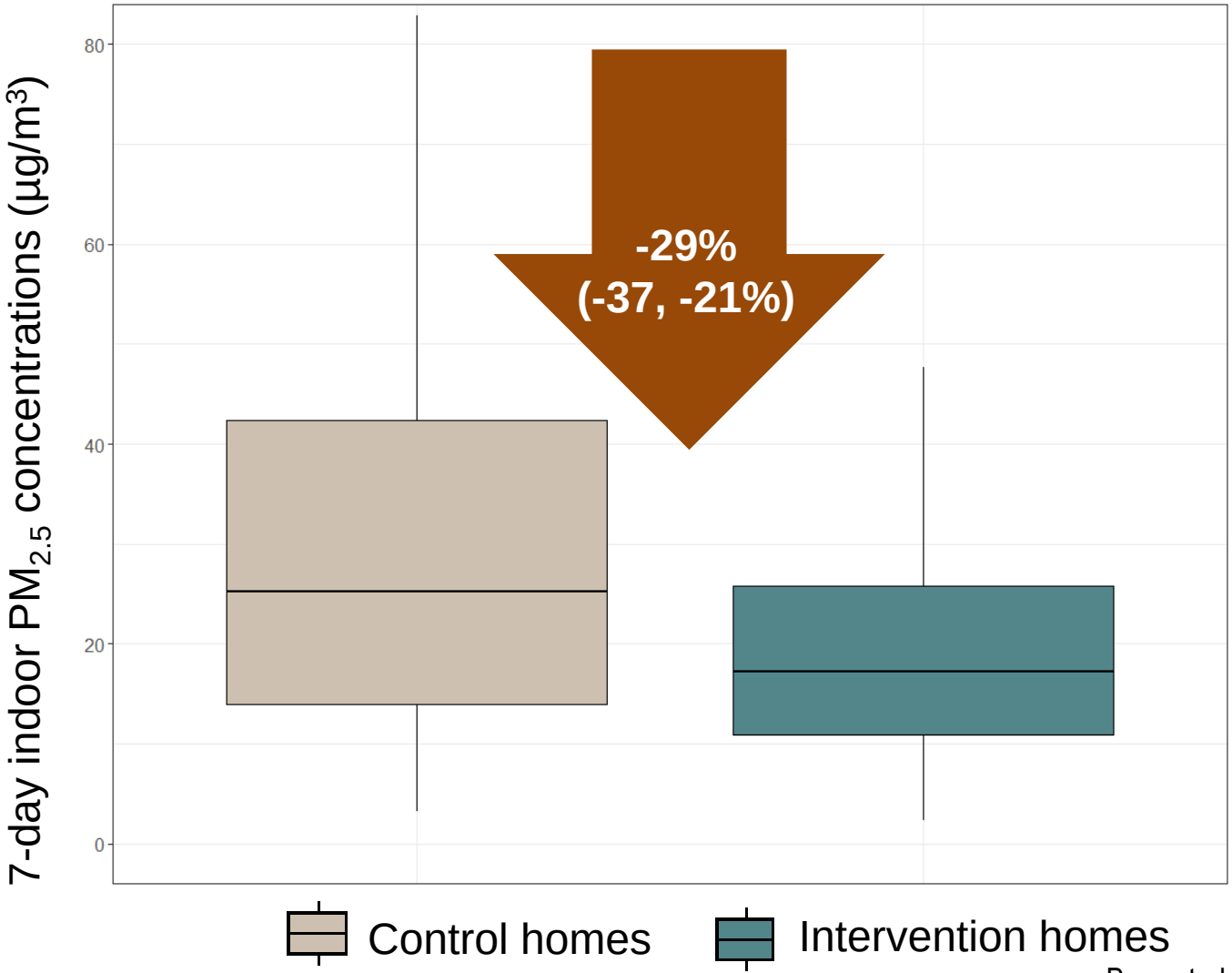
Air cleaner deployed (intervention homes)

7-day $PM_{2.5}$ measurement

Birth measurements (weight, length, head circumference)

Air Cleaner Impact on $PM_{2.5}$

7-day average $PM_{2.5}$ concentrations



Barn et al., *Sci Total Environ*, 2018

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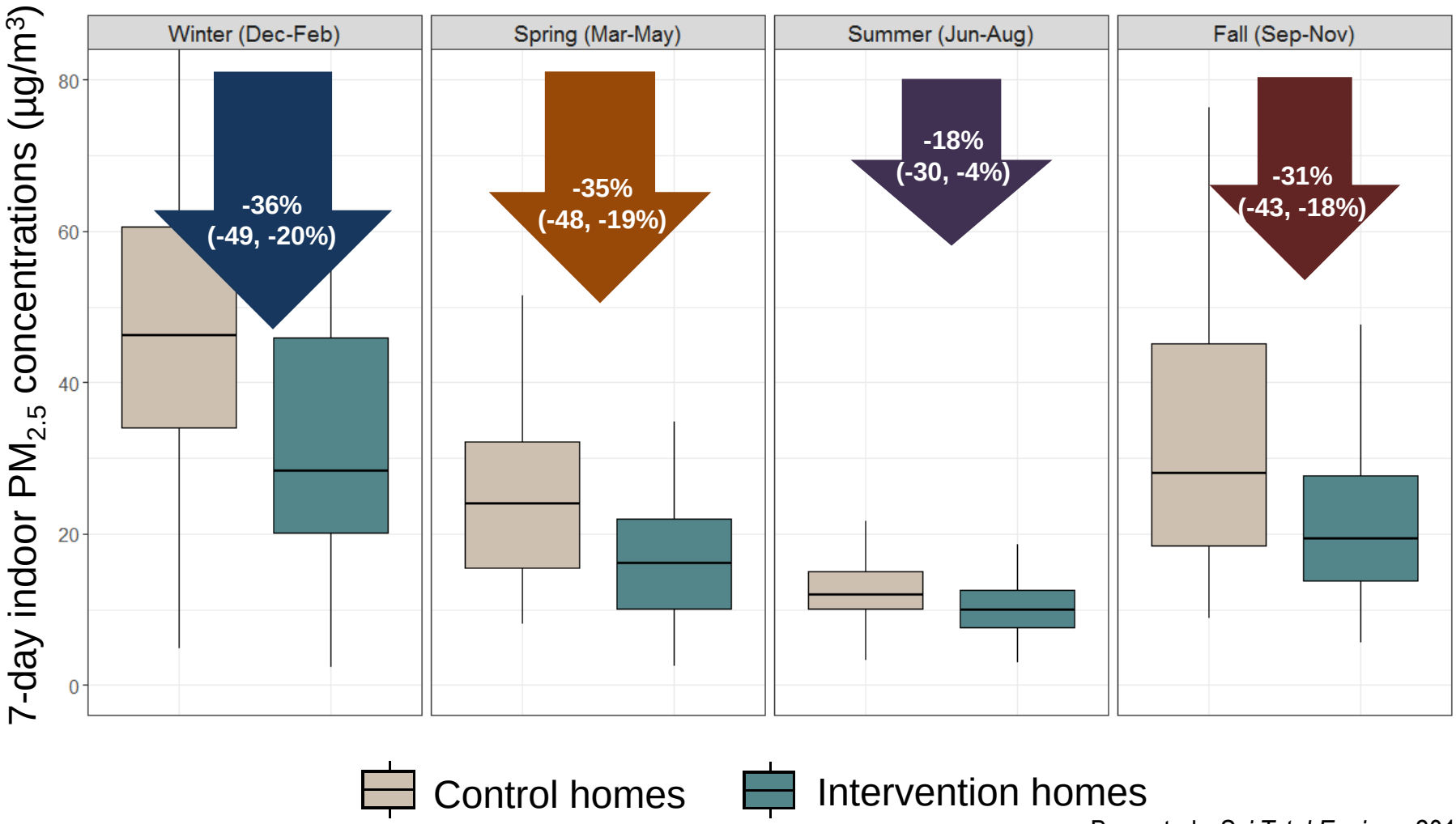

Barn et al., *Sci Total Environ*, 2018

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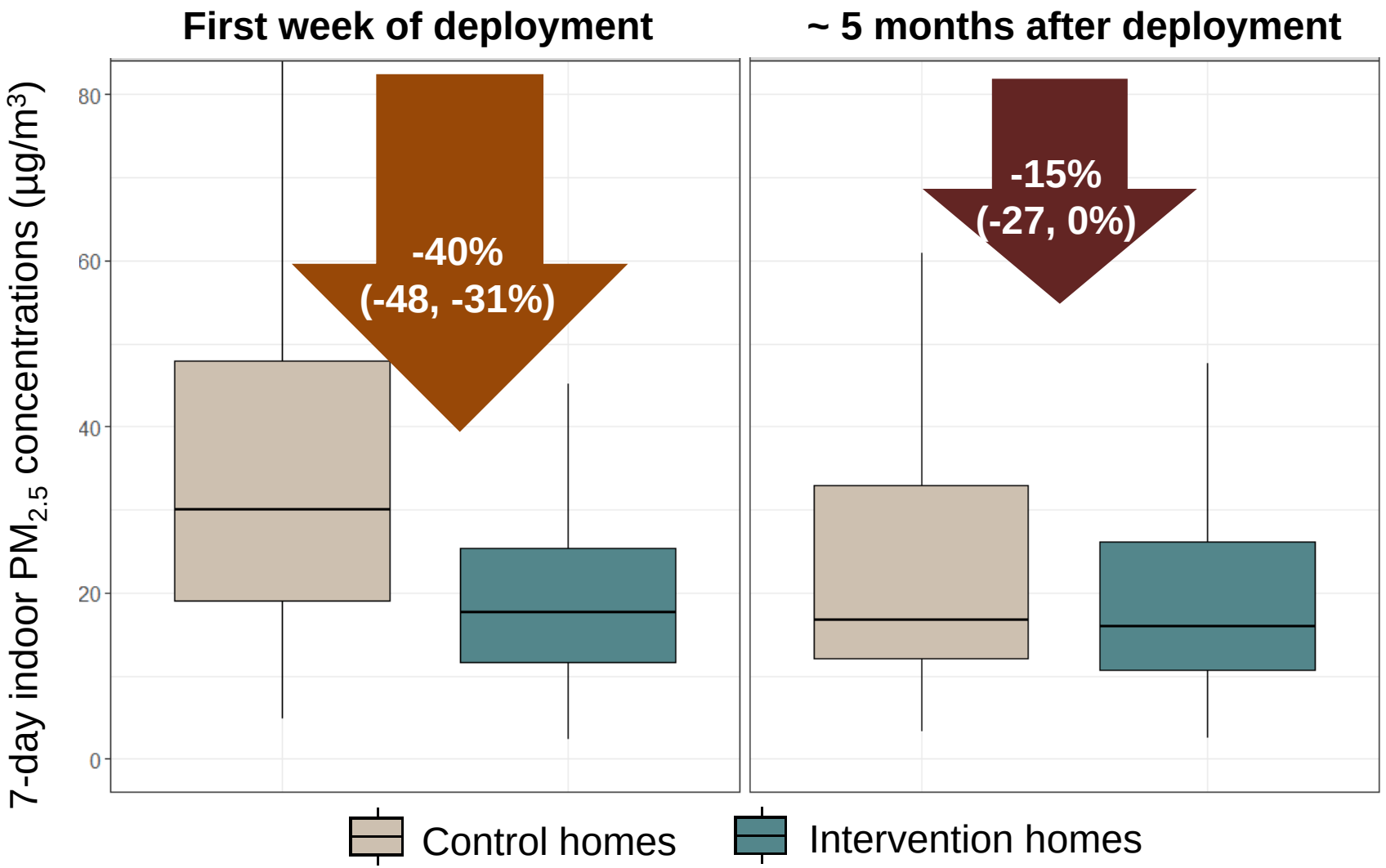
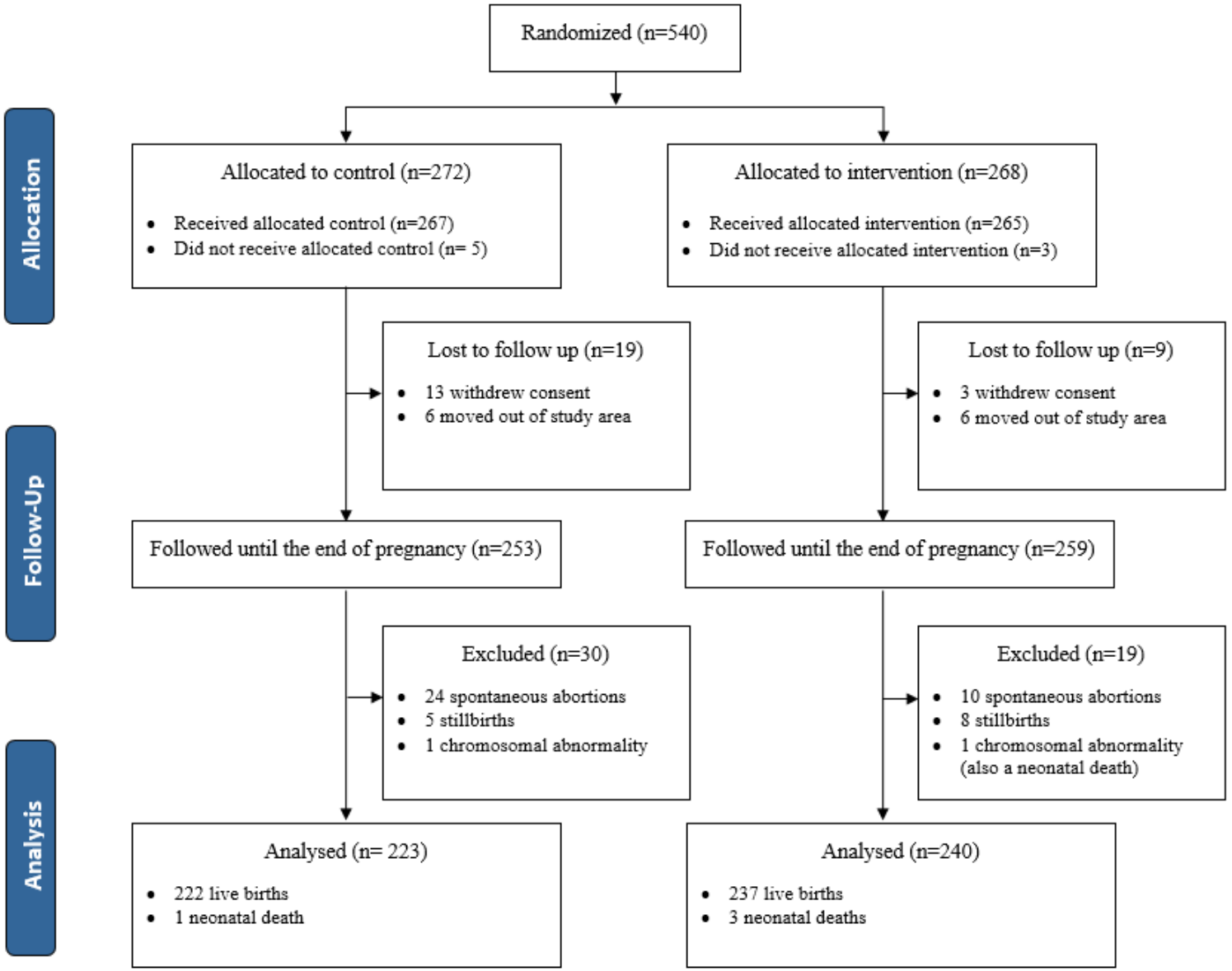


Barn et al., *Sci Total Environ*, 2018

Trial Profile



Barn et al., *Environ Int*, 2018

Select Cohort Characteristics

	Control (n = 223) ---------- Median (25%-75%) or N (%)	Intervention (n = 240) ---------- Median (25%-75%) or N (%)
Mother's age at enrollment, yr	28 (25 – 33)	30 (25 – 33)
Gestational age at enrollment, weeks	11 (9 – 12)	11 (9 – 13)
Mother completed university	179 (80%)	191 (80%)
Married / common-law	184 (83%)	191 (80%)
Pre-pregnancy BMI, kg/m^2	21.7 (19.6 – 23.9)	21.4 (19.8 – 24.0)
Smoked at any time during pregnancy	19 (9%)	20 (8%)
Lived w/ smoker at any time during pregnancy	112 (50%)	115 (48%)
Caesarean delivery	88 (39%)	86 (36%)
Female child	108 (48%)	109 (45%)
Birth weight, grams	3450 (3150 – 3800)	3550 (3200 – 3800)

Barn et al., *Environ Int*, 2018

Unexpected Intervention Effects

- The intervention was associated with:
  - A *lower* risk of spontaneous abortion:

    OR = 0.38 (95% CI: 0.18, 0.82)

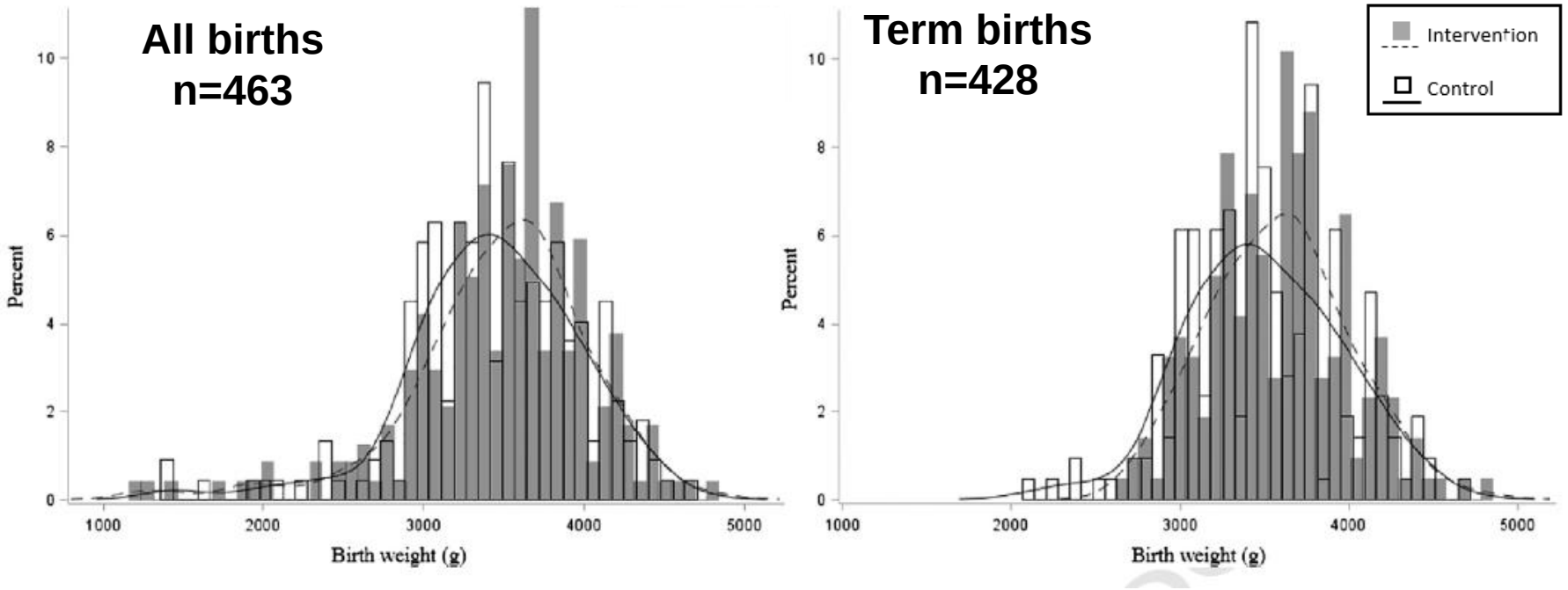
  - A *higher* risk of preterm birth:

    OR = 2.37 (95% CI: 1.11, 5.07)

- The intervention may have enabled fetuses to survive long enough to be born preterm

Barn et al., *Environ Int*, 2018

Intervention Effects on Fetal Growth



- The intervention was not significantly associated with average birth weight among all births: **18 g (95% CI: -84, 120 g)**
  - After adjusting for differences in pre-term birth, the intervention was associated with an increase in mean birth weight: **84 g (95% CI: -1, 170 g)**
- Among full-term births, the intervention was associated with an increase in mean weight: **85 g (95% CI: 3, 167 g)**

Barn et al., *Environ Int*, 2018

Summary

- Short-term use of portable HEPA filter air cleaners may improve cardiovascular health indicators
  - Supported by several more recent studies
  - Implications for effects in other systems in the body
- Long-term use reduced concentrations in a high-pollution setting, but efficacy decreased over time
  - "Air cleaner fatigue" – noise, concerns about electricity costs
- Some evidence of improved fetal growth among women who used air cleaners during pregnancy
- When possible, our goal should be to reduce emissions
  - Household interventions may mitigate risks
  - Pregnancy is a well-defined time to intervene

Thank You

- Study participants
- Research staff
- Dr. Prabjit Barn
- Funding agencies

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