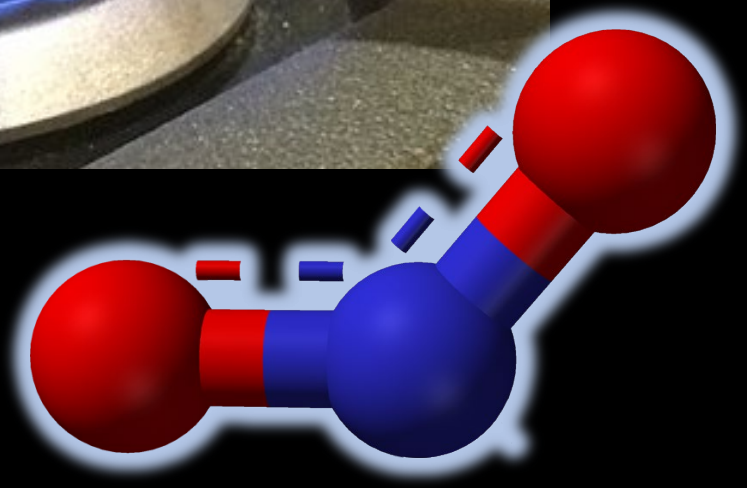

An Update on Indoor NO_2 and Health

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Image from https://commons.wikimedia.org/wiki/File:Stove_Top_.jpg

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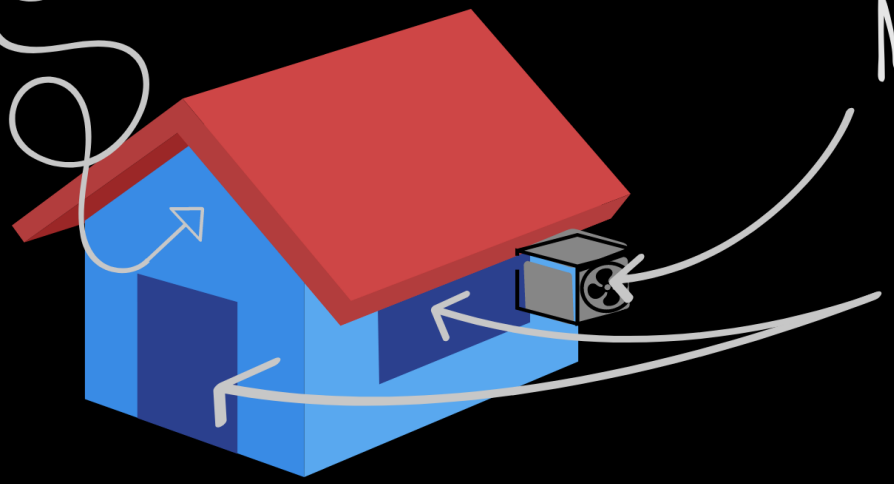
Comments are the author's and do not represent OEHHA, CalEPA or the state of California.

Outline

- Existing NO_2 Guidelines and standards
- Other (non-cardiorespiratory) outcomes for which there is evidence of an NO_2 effect
- Highlighting some recent literature on indoor NO_2 and health, gaps
- Health effects related to gas cooking, some of my work

What determines indoor air quality?

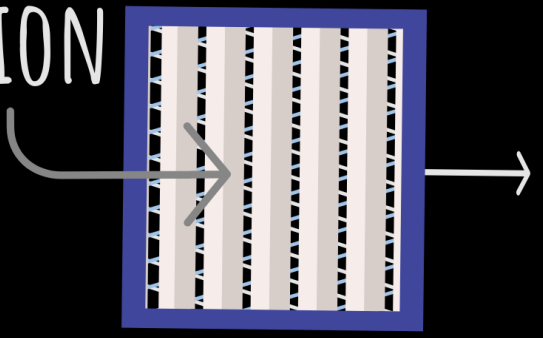
Infiltration



Ventilation: Mechanical and Natural

Indoor Emissions

Filtration



Current Levels	From where?	Released what year?	Based on?
Indoor: 80 ppb (annual) 250 ppb (1 hour)	CARB	2005	-**Lung** irritation -enhanced allergic responses, exacerbation of **asthma**
Residential indoor air: 20 ppb (long-term) 90 ppb (short-term)	Health Canada	2015	**Lung function** changes and **symptoms in children with asthma** Also noted: -short term respiratory effects especially a high doses -slight hematologic, inflammatory and immune effects at high exposures -Long-term residential NO2 associated with symptoms in asthmatic children
Outdoor: 53 ppb (annual) 100 ppb (1 hour)	US EPA	2016	Integrated Science Assessment: -**respiratory effects** (causal for short term, likely causal long term) -cardiovascular effects (suggestive of a causal relationship) -mortality effects (suggestive of a causal relationship) -birth outcomes (suggestive of an effect)
Indoor and Outdoor: 5.23 ppb (annual) 13.08 ppb (24h) 104.6 ppb (1 hour)	WHO	2021	**Mortality** (respiratory, all- cause) -included studies with NO2 concentrations as low as 2.4 ppb

Health Effects Institute Studies- Chronic Low Exposures and Mortality (Europe-ESCAPE)

n ~ 28 million

Figure 3

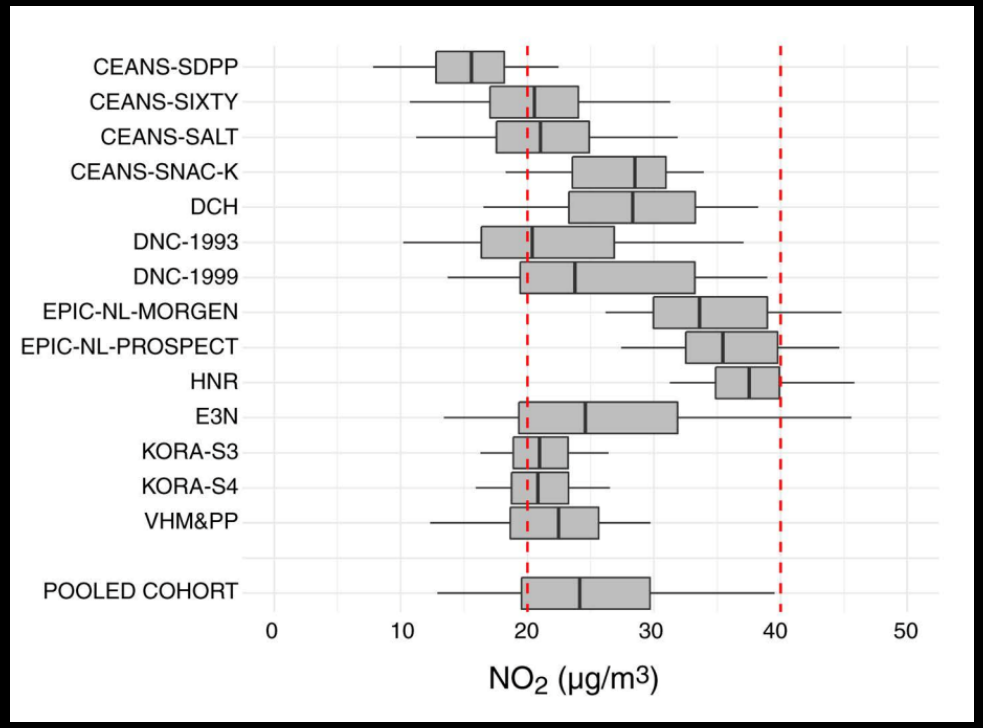
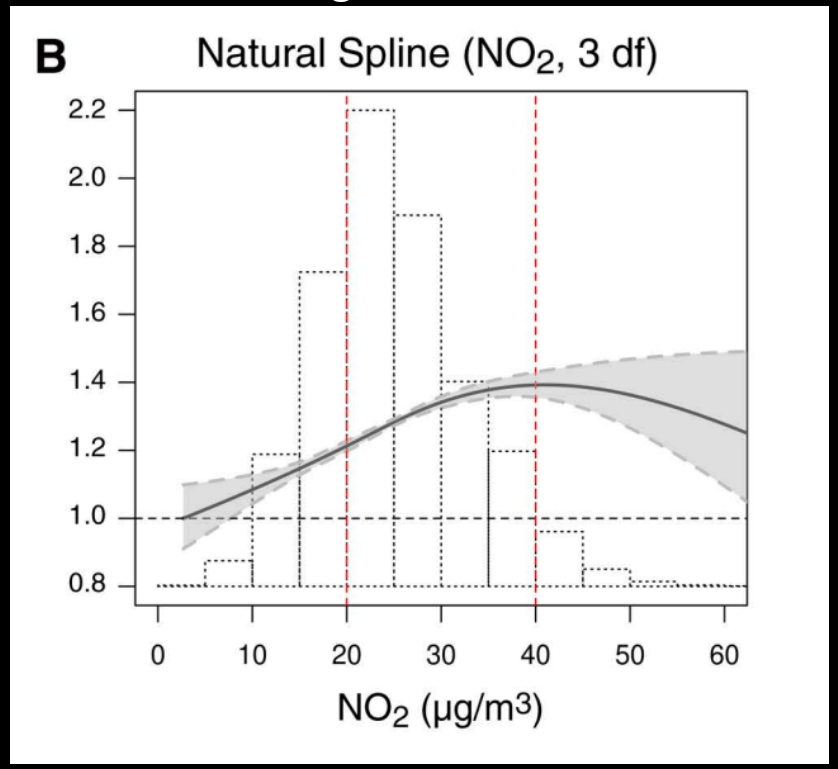


Figure 4b



Brunekreef B, Strak M, Chen J, Andersen ZJ, Atkinson R, Bauwelinck M, et al. 2021. Mortality and Morbidity Effects of Long-Term Exposure to Low-Level PM2.5, BC, NO2, and O3: An Analysis of European Cohorts in the ELAPSE Project. Research Report 208. Boston, MA:Health Effects Institute.

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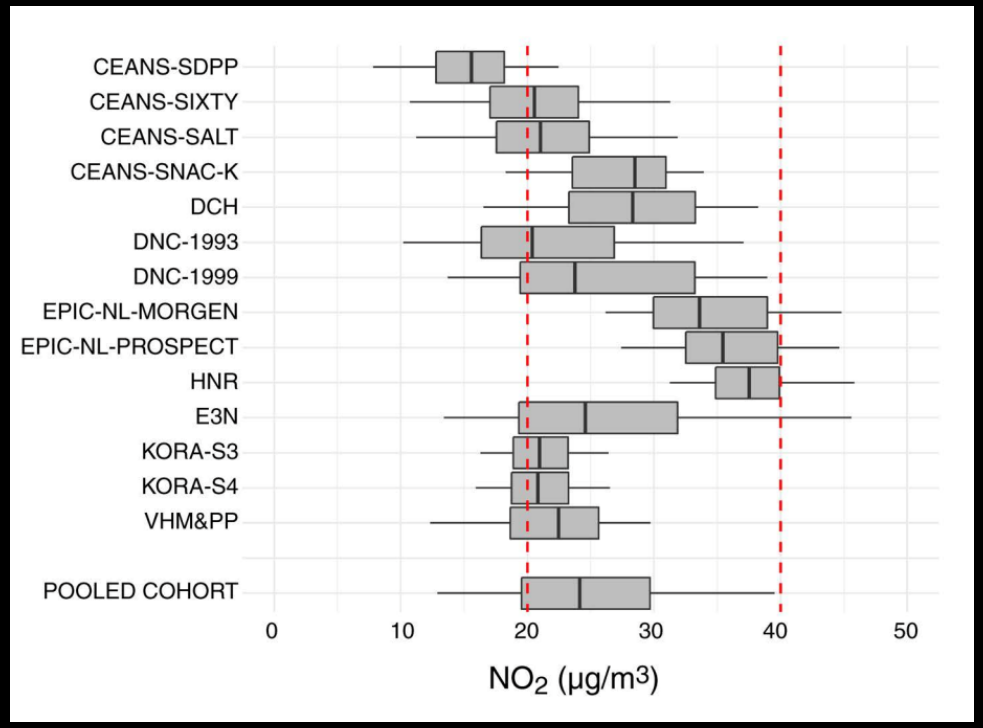
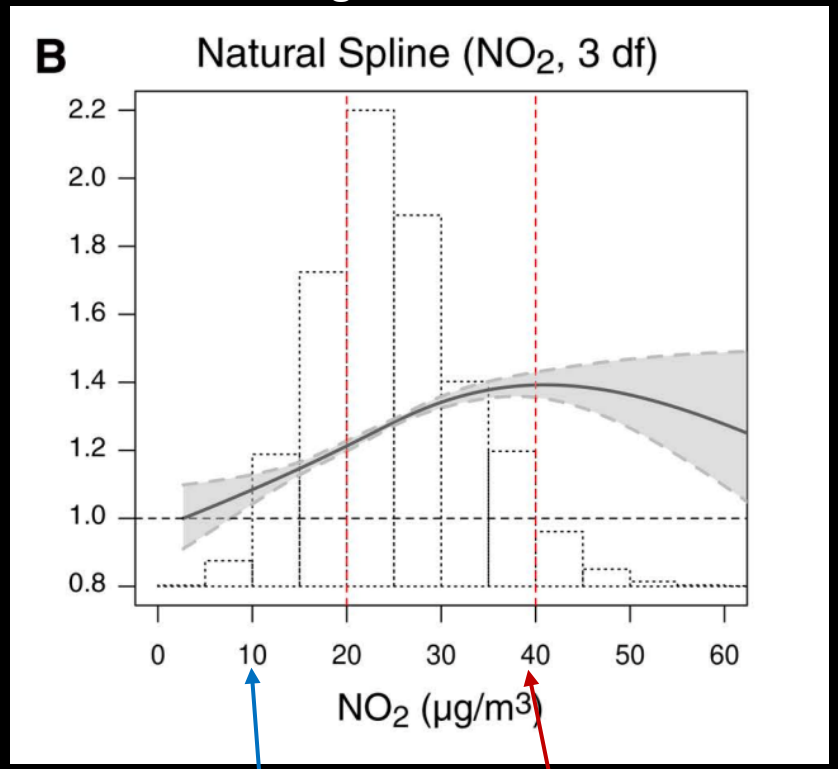


Figure 4b



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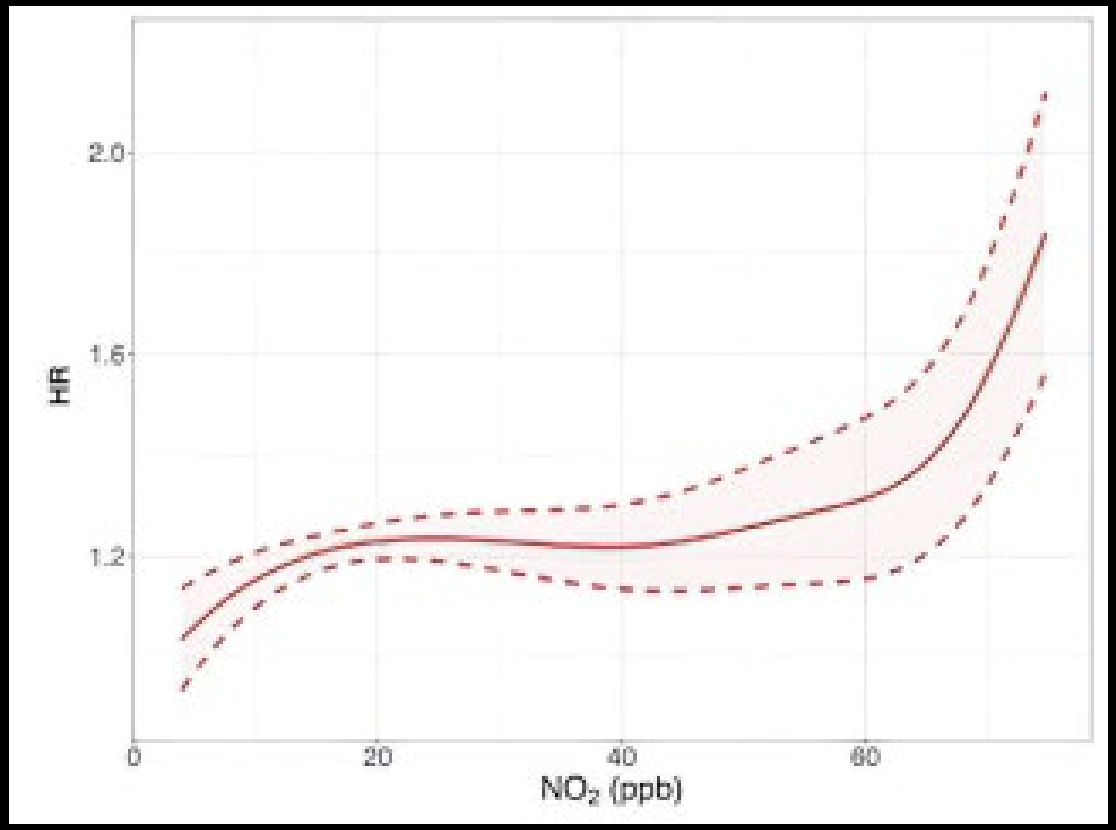
Health Effects Institute Studies- Chronic Low Exposures and Mortality (US)

- 60 million Medicare recipients 2000-2016
- Consistent findings across multiple statistical approaches

Figure 7



Health Effects Institute Studies- Chronic Low Exposures and Mortality (US)

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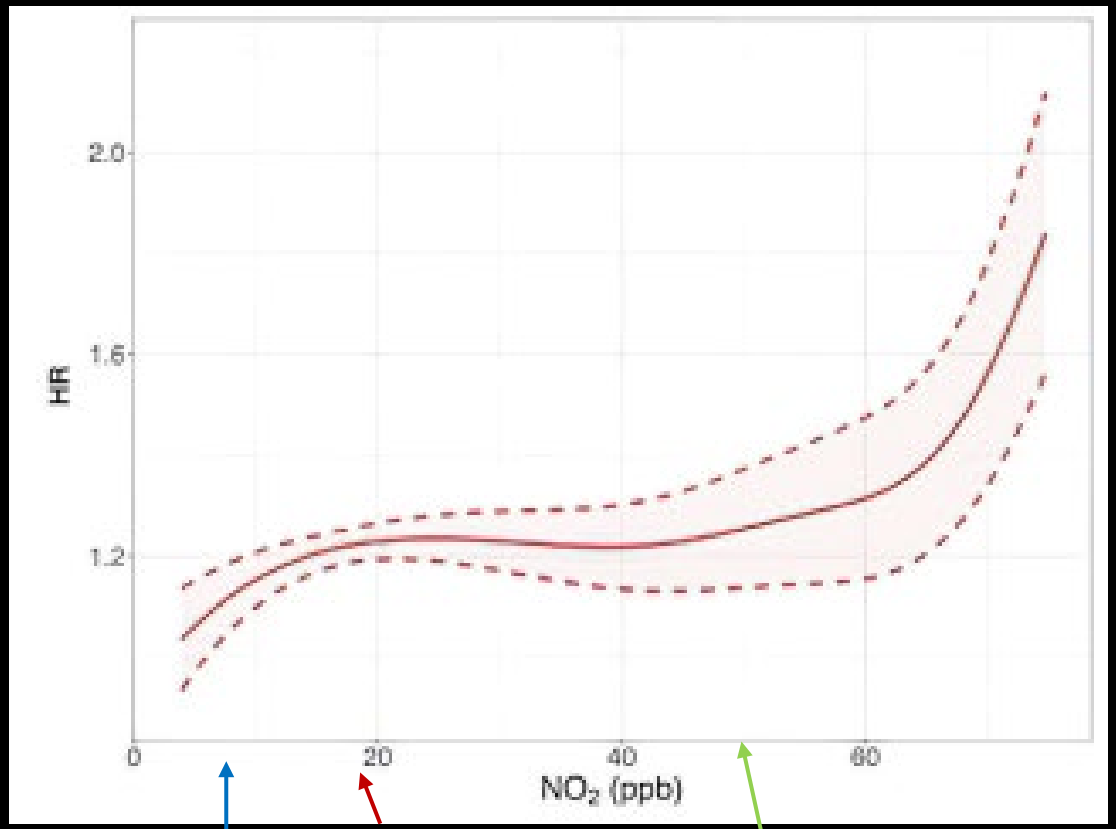
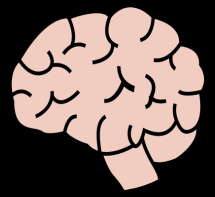


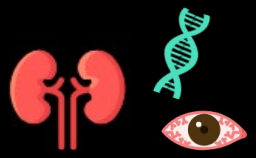
Non-Respiratory or Cardiovascular Outcomes



- Neuropsychiatric outcomes
  - Depression related to short (Fan et al , Sci Tot Env, 2020; Borroni et al, Environ Pollut, 2022), and long-term NO_2 (Borroni et al 2022)
  - Pregnancy exposure and risk of Autism (Chun H, Environ Poll, 2020)
  - Dementia (Peters et al, J Alzheimers Dis, 2019)

- Allergy
  - allergic rhinitis OR 1.13 for long-term NO2 (Li et al, Env Research, 2022)

- Metabolic Effects
  - Diabetes- prevalence OR 1.05, incidence 1.02 (Liu F, Env Poll, 2019), may be higher in females
  - Diastolic blood pressure (Yang B, 2018)
  - Childhood obesity (Huang et al, IJERPH, 2022)



- Other
  - Chronic kidney disease (Markozannes et al, Env Poll, 2022)
  - Conjunctivitis (Chen, IJERPH, 2019)
  - Childhood leukemia especially with pregnancy exposure (Wei et al, Env Sci Poll Res, 2021)

Recent Literature on Indoor NO_2 and Asthma

- Classroom NO_2 levels associated with lung function in children with asthma (Gaffin et al, JACI, 2018) associated with FEV1/FVC ratio down to 8 ppb (see figure to the right)
- Estimate of Disease burden of childhood asthma specifically due to indoor sources (Hu et al, Lancet Reg Health West Pac, 2022)
- Adults with asthma, measured home indoor NO_2 for one week quarterly x 4. Higher NO_2 associated with lower ACT scores (Kang et al, JESEE, 2022)

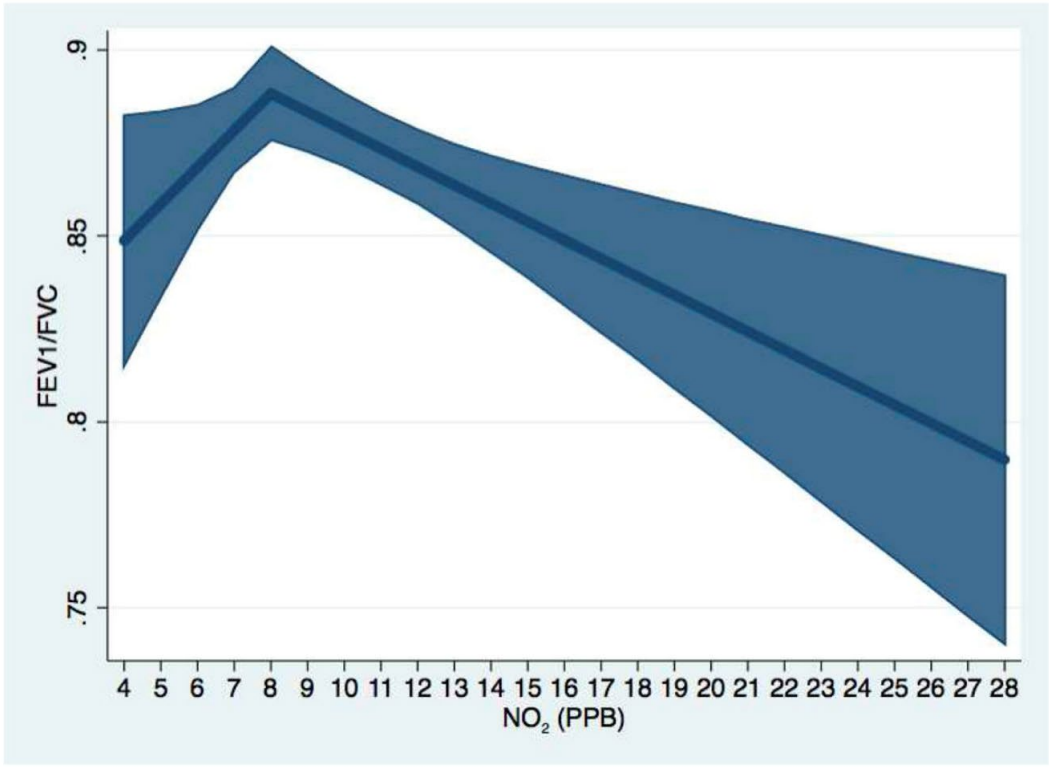


Figure 3.
Effect of classroom NO_2 on FEV_1/FVC. Association of NO_2 and FEV_1/FVC using piecewise linear regression with breakpoint at NO_2 level of 8ppb. Shaded area represents 95% confidence intervals.

Recent Literature and Gaps on Indoor NO_2

Real-time sensing

- Pilot Study found in a simplistic analysis that a history of asthma hospital admissions in the prior year was associated with intermittent NO_2 spikes. (Downen et al, JESEE, 2022)
- How might our understanding of health relevant exposures to NO_2 change as our ability to measure real-time NO_2 changes?

NO_2 Intervention Studies

- Differentiated $PM_{2.5}$ and NO_2 air filtration interventions and did not see an effect of NO_2 on COPD (Woo et al, Sci Tot Env) (median NO_2 8ppb)
- Reduction of NO_2 specifically did not show benefits for children with asthma (17 ppb v 21 ppb) (Gent et al, J Asthma, 2022)
- To what extent are indoor NO_2 interventions health protective, and how does that relate to intervening on other pollutants in the exposure mixture?

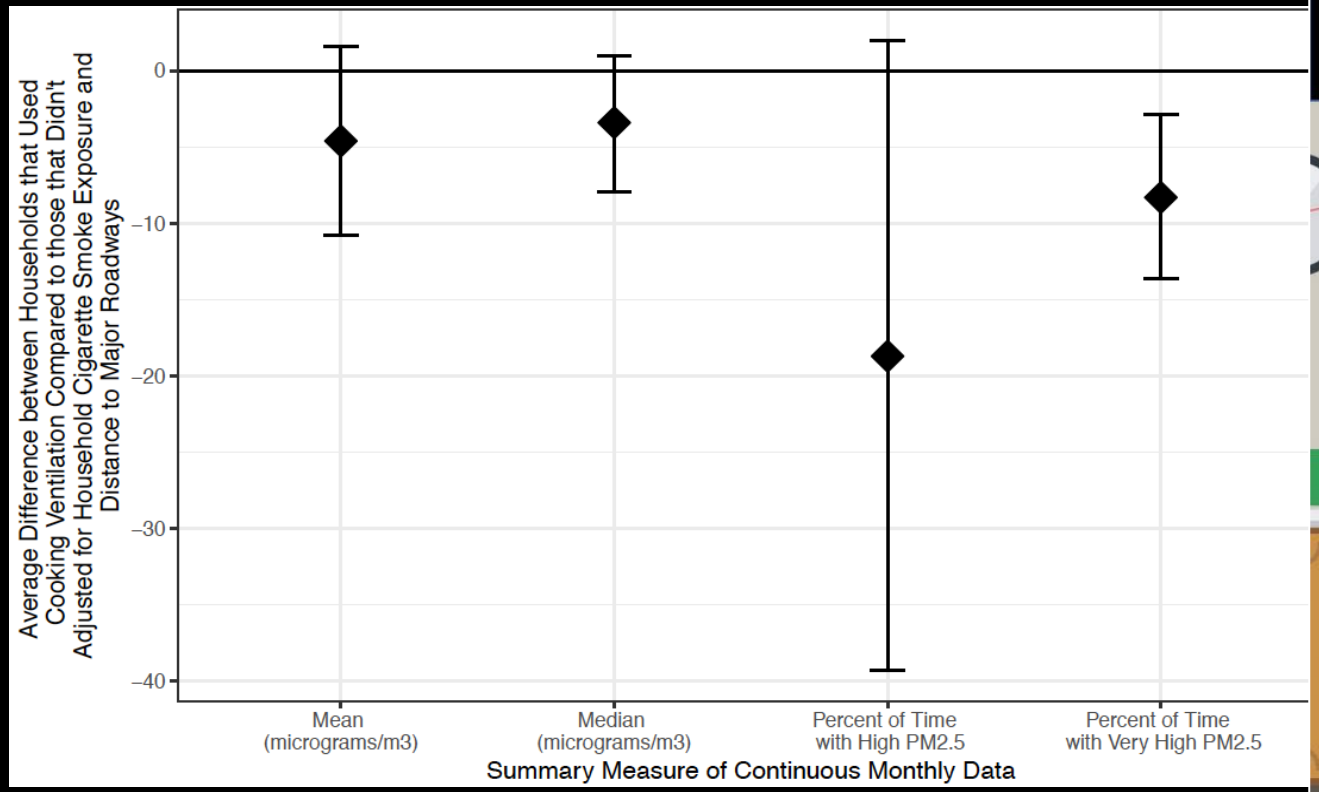
Learning/Neurodevelopment:

- Decreased performance on working memory tasks specifically related to indoor NO_2 at school as well as outdoor , in 2^{nd}/3^{rd} graders followed for 3 years (Forns et al, Env Res, 2022)

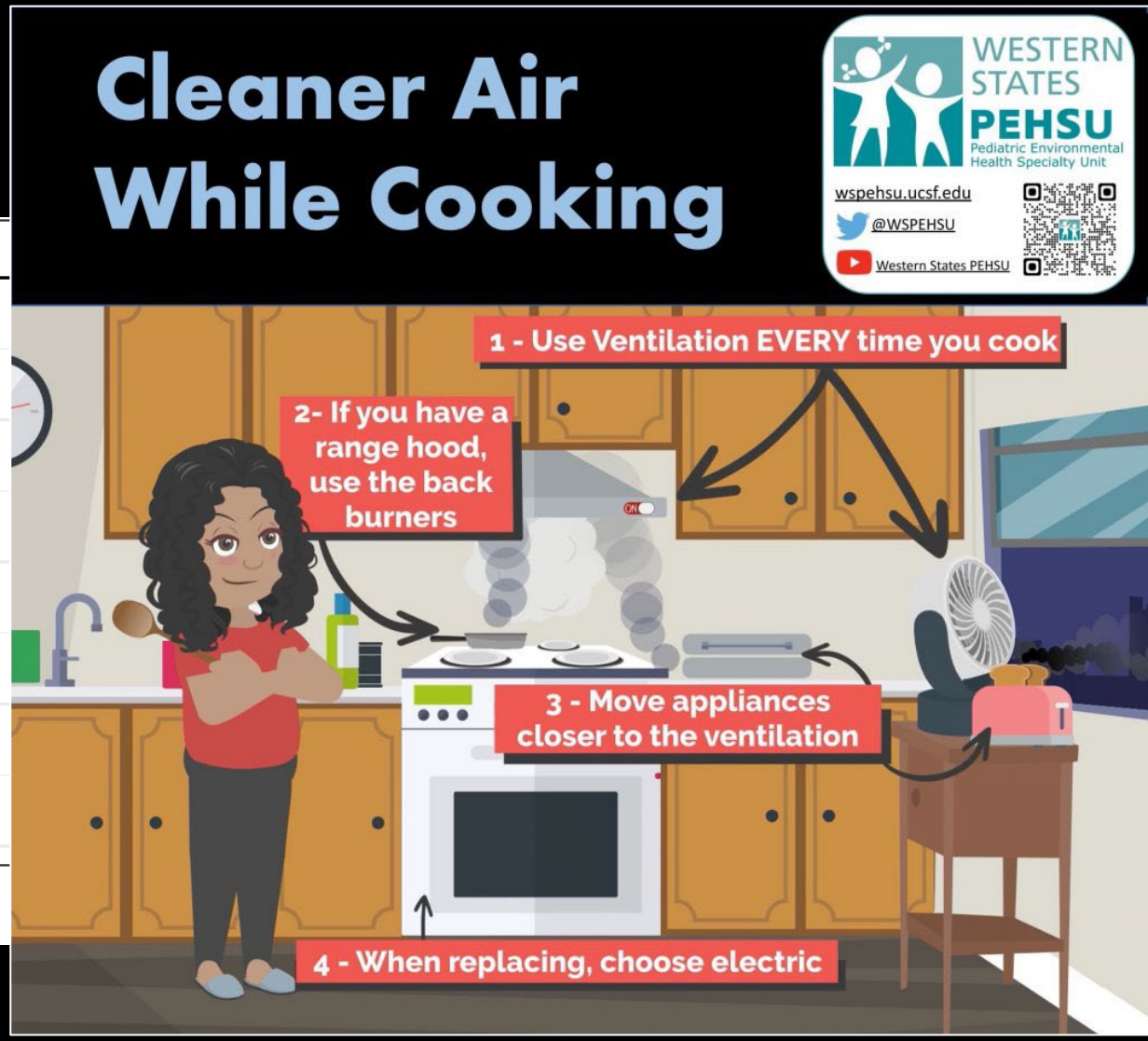
Early 2023 Attention to Cooking Related Pollution

- One of the triggers was a calculation of the population attributable fraction of childhood asthma related to gas stoves as 13% (Gruenwald et al, IJERPH, 2022) based on a 2013 meta-analysis (Lin et al, IJE, 2013) that looked at the relationship between gas cooking and NO_2 exposure with asthma and wheeze

- Also evidence from nationally representative populations that gas stove use-especially when used for heating and when there is a lack of ventilation use- are associated with pediatric respiratory illnesses (Kile et al, Env Health, 2014; Coker, BMC Pub Health, 2015)



(data from Holm et al, Plos One, 2018)



CEVICA: Cooking Electrification and Ventilation Improvements for Children's Asthma

- Factorial RCT of gas vs induction cooking and ventilation
- Crossover RCT of portable induction cooktops for households where construction isn't feasible
- Studying multiple pollutants including PM and NO_2

Thanks to all my colleagues and collaborators!

AIM

CHAPS

Nina Holland, PhD | Betsey Noth, PhD | John Balmes, MD | Tim Tyner, MS | Liza Lutzker, MPH

CHAMACOS

Brenda Eskenazi, PhD | Kim Harley, PhD | Katie Kogut, MPH MSc | Bob Gunier, PhD MPH | John Balmes, MD

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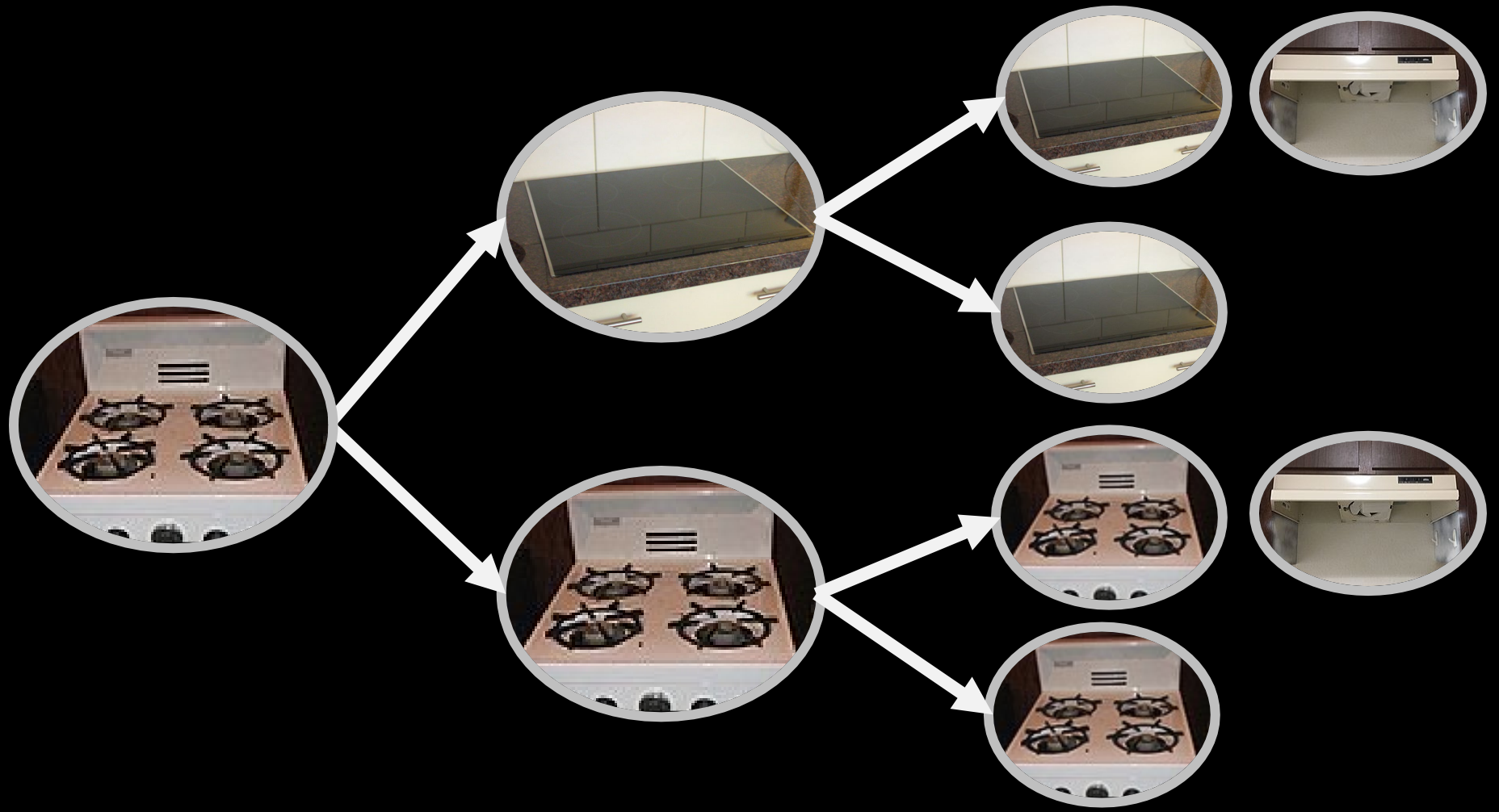
Why are Children More Vulnerable?

1. Differences in Physiology that increase Dose
2. Unique Windows of Development
3. Behaviors and Preferences that Increase Exposure

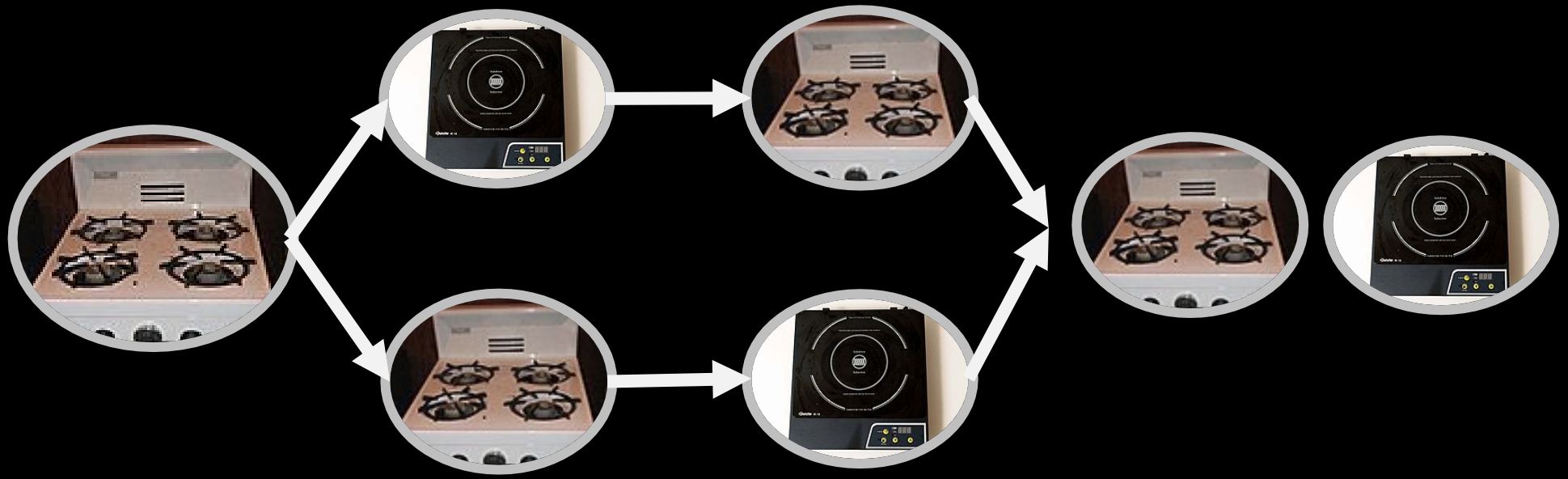
Holm et al 2020

CEVICA: Cooking Electrification and Ventilation Improvements for Children's Asthma (Arm 1)



Electric Induction stove image from: https://commons.wikimedia.org/wiki/File:Kookplaat_inductie.JPG
Gas stove image from https://commons.wikimedia.org/wiki/File:Gas_stove.jpg
Range hood image from: https://commons.wikimedia.org/wiki/File:Broan_Range_Hood.jpg

CEVICA: Cooking Electrification and Ventilation Improvements for Children's Asthma (Arm 2)



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