

# Climate and Health Pollution from Gas Stoves

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Recent findings on gas composition, combustion products, and pollutant exposures



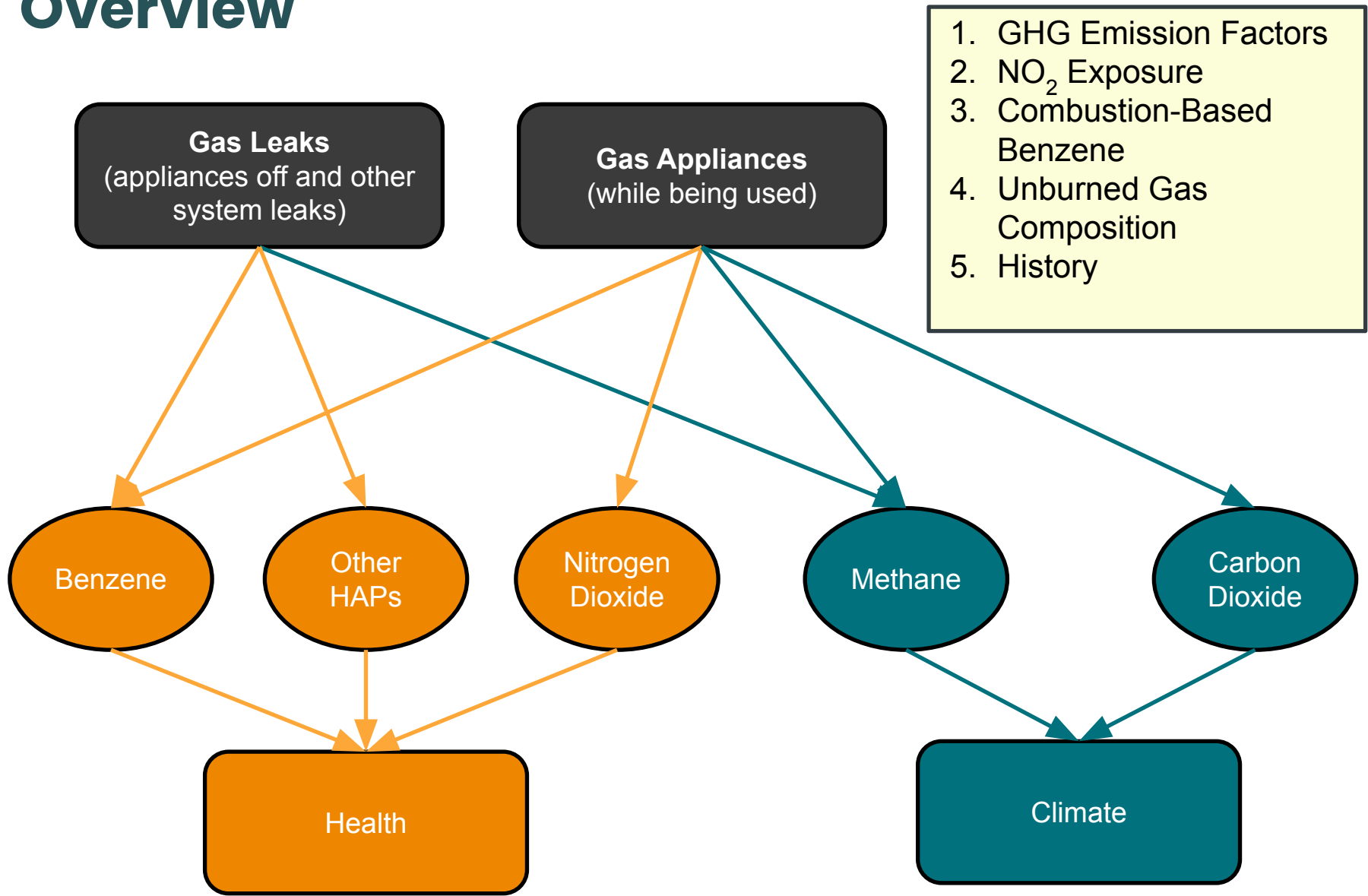
Bringing science  
to energy policy



# About Us

**PSE Healthy Energy** is a nonprofit energy science and policy research institute. Our mission is to generate science-based energy and climate solutions that protect public health and the environment.

# Overview



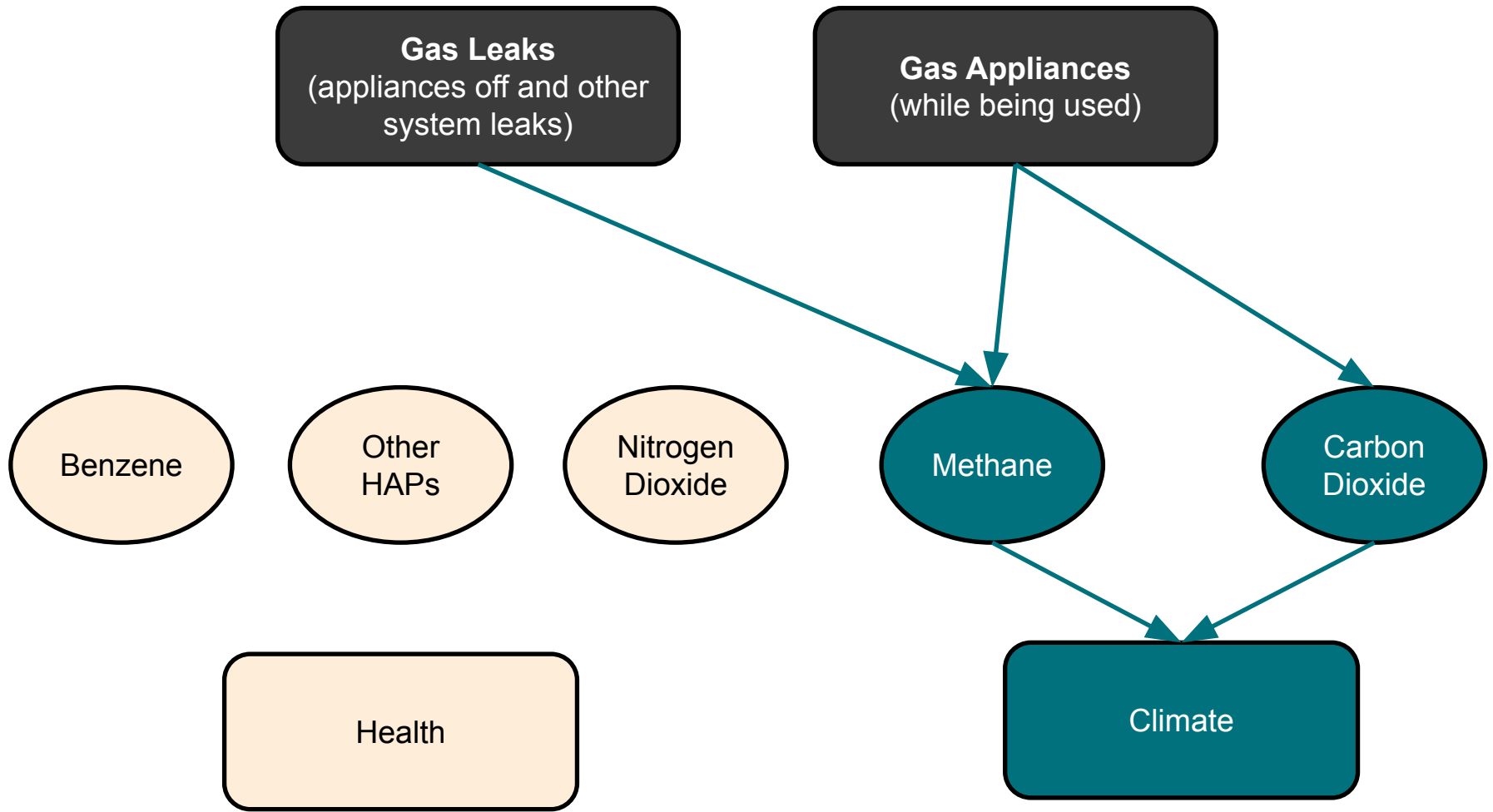
# GHG Emissions from Gas Stoves

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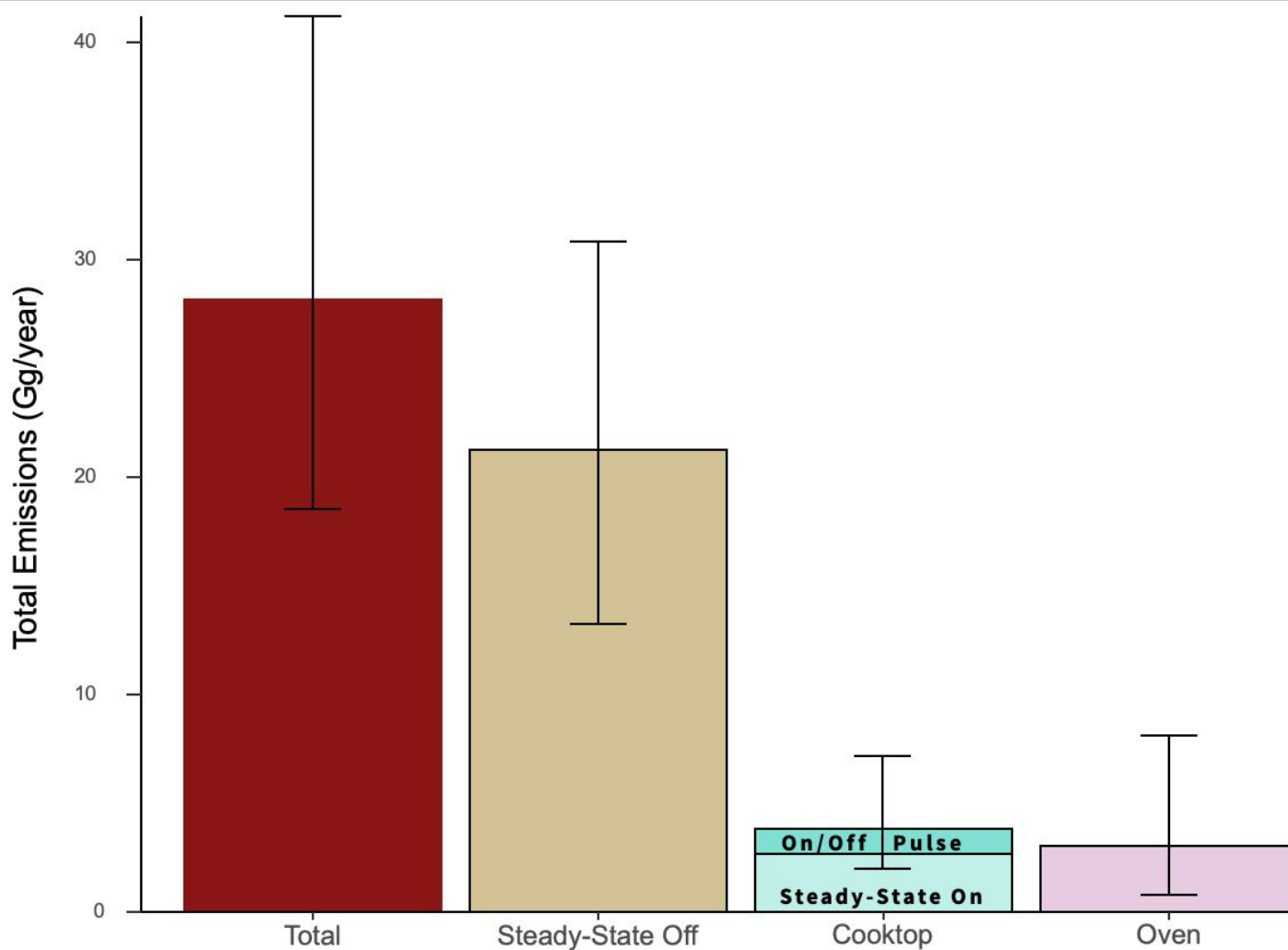
Methane

Carbon  
Dioxide

# Greenhouse Gas Emissions from Gas Appliances



# 76% of methane emissions were attributed to steady-state-off



# Summary of Key findings

- Most emissions from **storage water heaters** and **stoves** were emitted while the appliance was off.

## Total methane emissions:

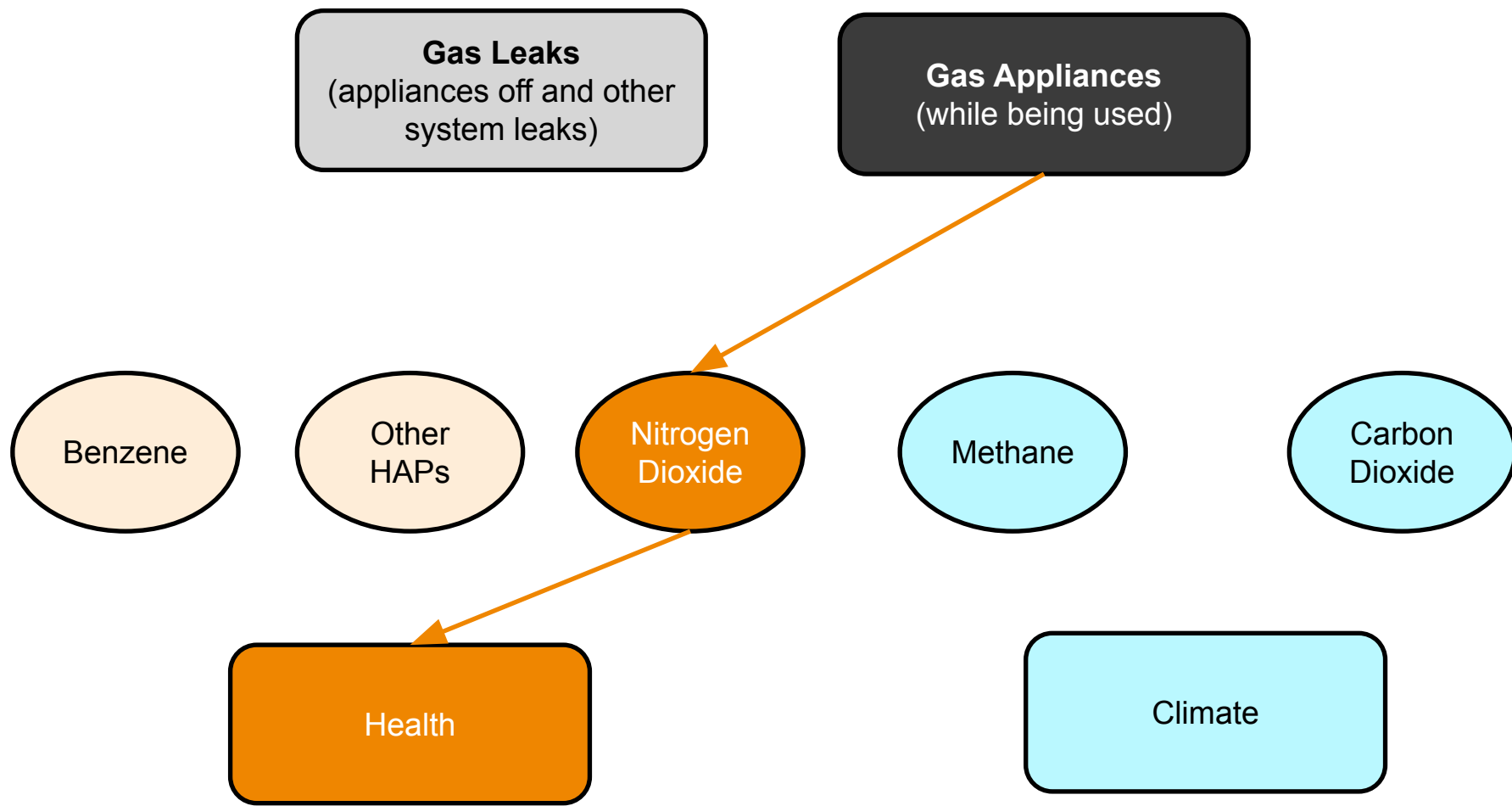
- Stoves: **28.1 Gg CH<sub>4</sub> yr<sup>-1</sup>**; up to **1.3%** of the gas used and equivalent to about 500,000 gasoline-powered cars
- Water Heaters: **82.3 Gg CH<sub>4</sub> yr<sup>-1</sup>**; up to **0.4%** of the gas used
- Methane emissions increase the climate impact of stoves by **39%** and water heaters by **12%**.

# NO<sub>x</sub> Emissions from Gas Appliances

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Nitrogen  
Dioxide

# Nitrogen Dioxide (NO<sub>2</sub>) Emissions from Stoves



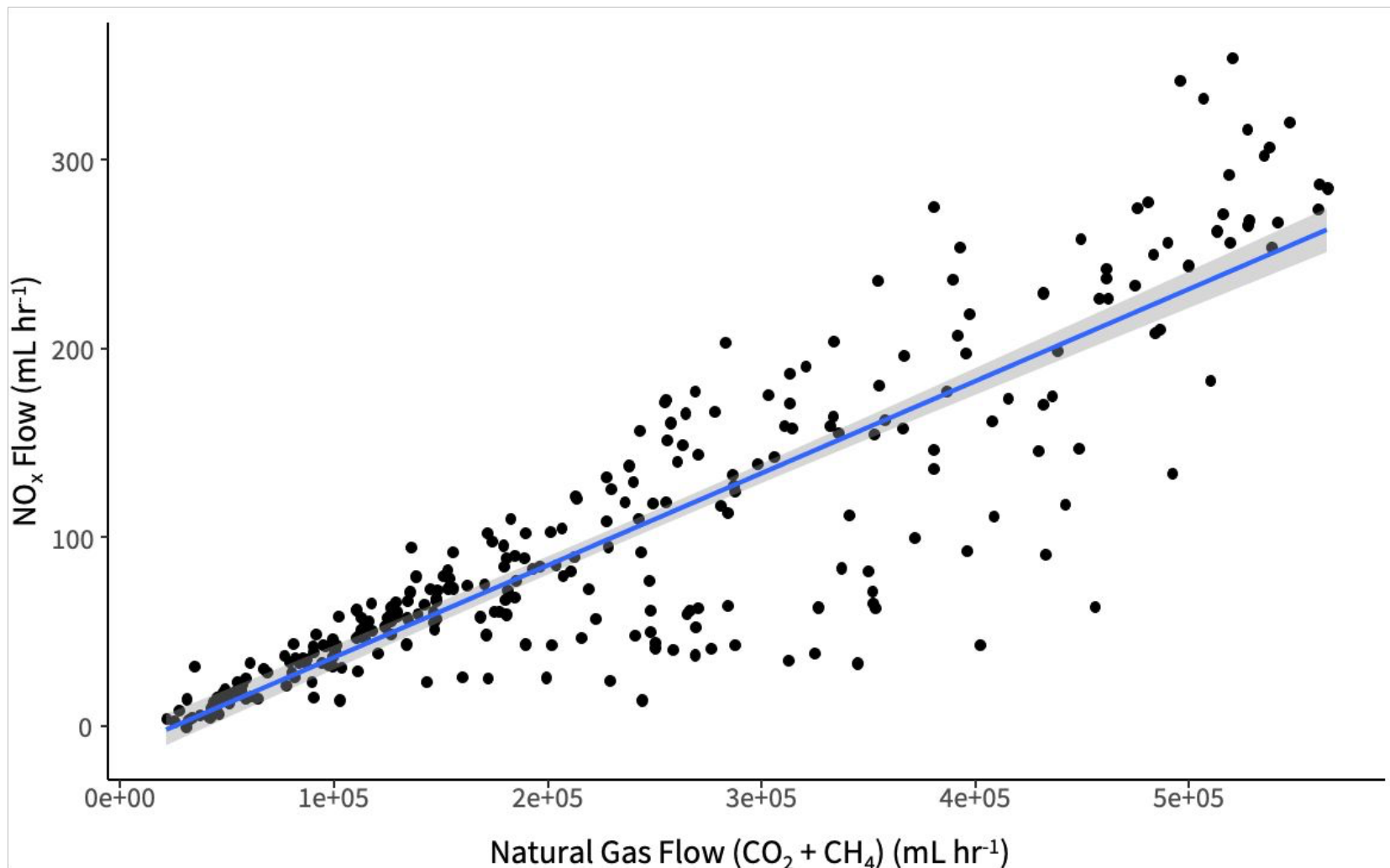
**Gas stoves create air pollution  
when they are used**



**What is in this  
plume?**

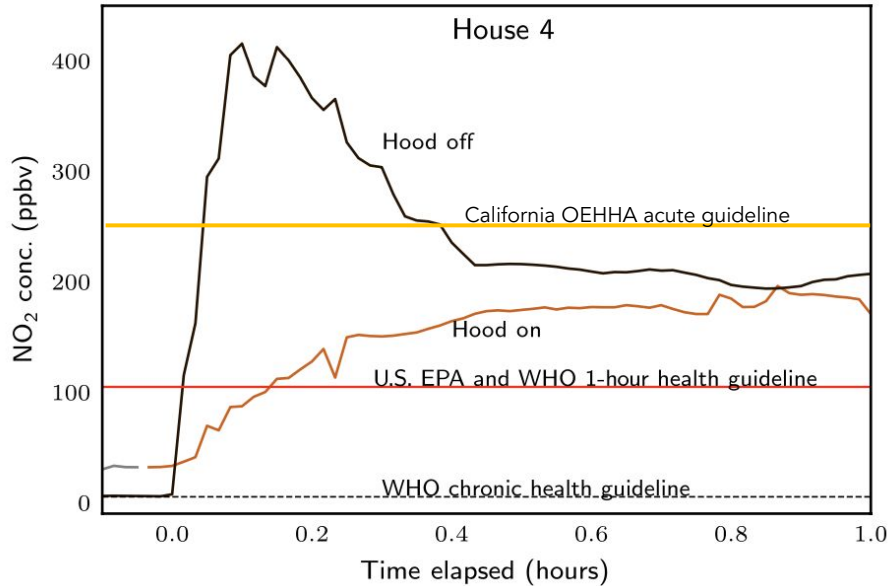


# NO<sub>x</sub> emissions are correlated with natural gas flow

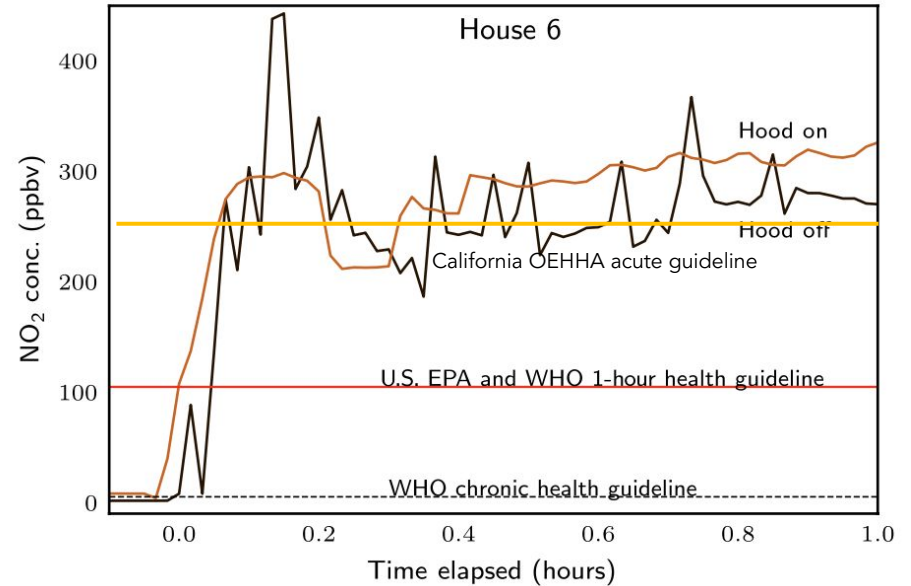


# NO<sub>2</sub> from the gas stoves can exceed health guidelines, even with a range hood on

Kitchen NO<sub>2</sub> with gas oven only (hood on and off)



Kitchen NO<sub>2</sub> with gas oven and 3 burners (hood on and off)

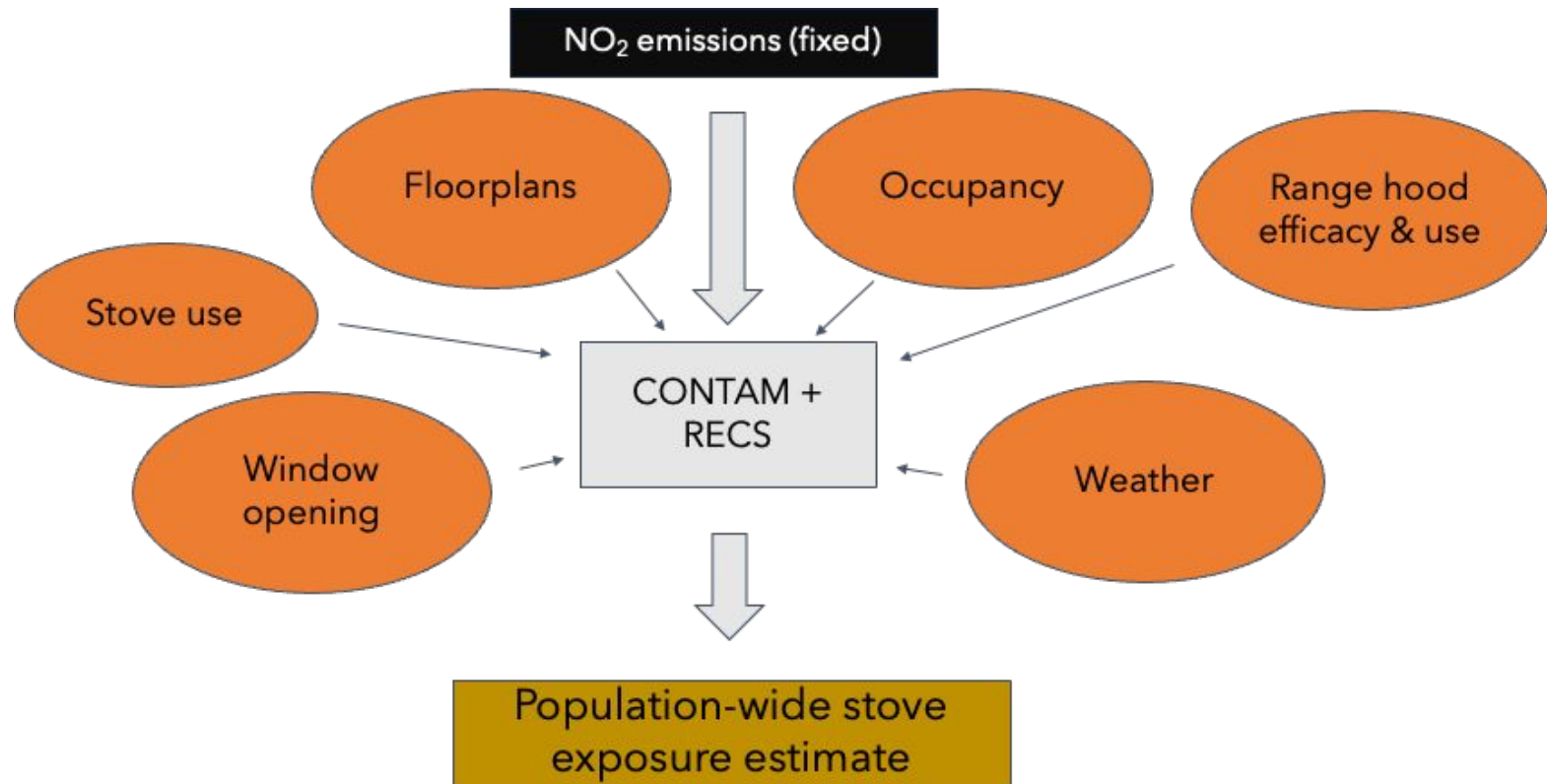


# Population-Level NO<sub>2</sub> Exposure

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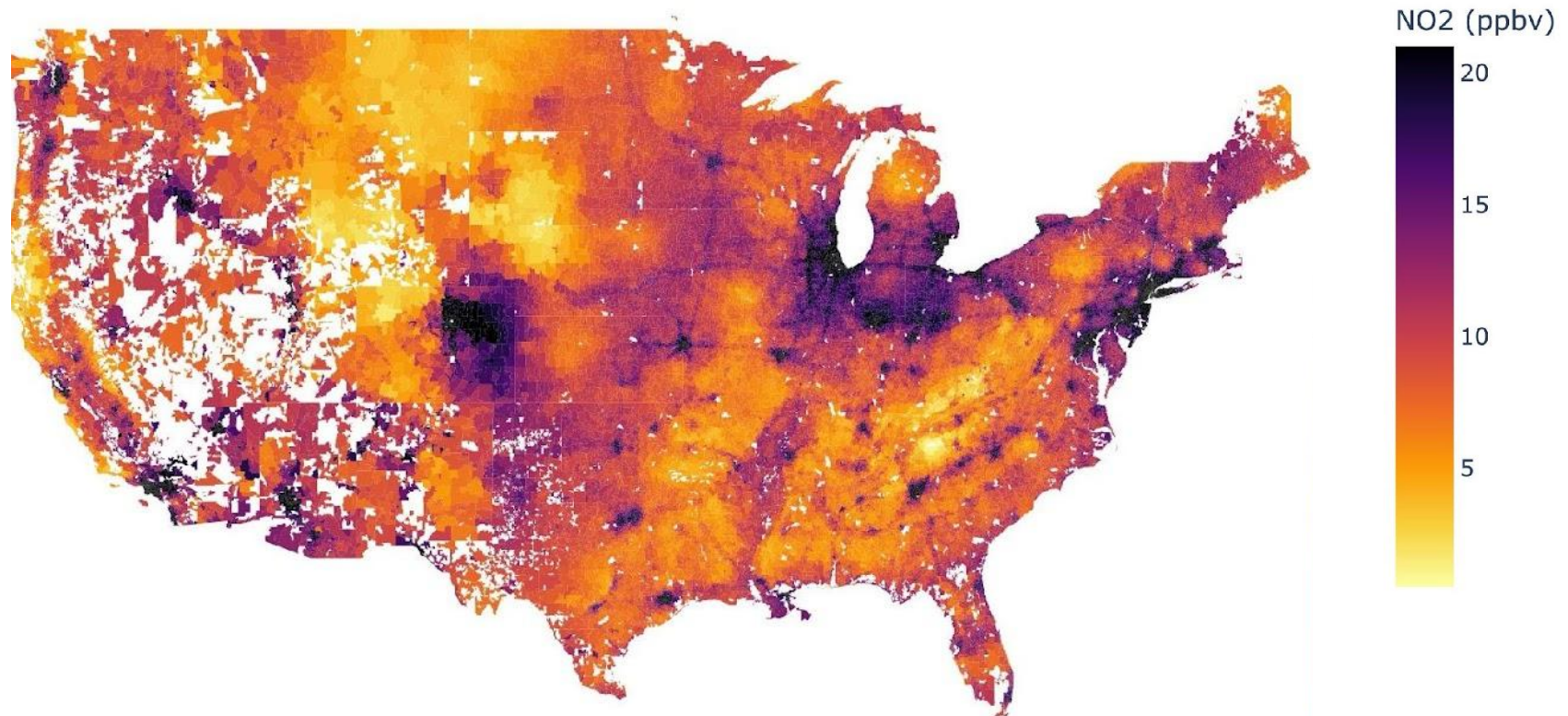
Nitrogen  
Dioxide

# We modeled population-level exposure incorporating numerous variables

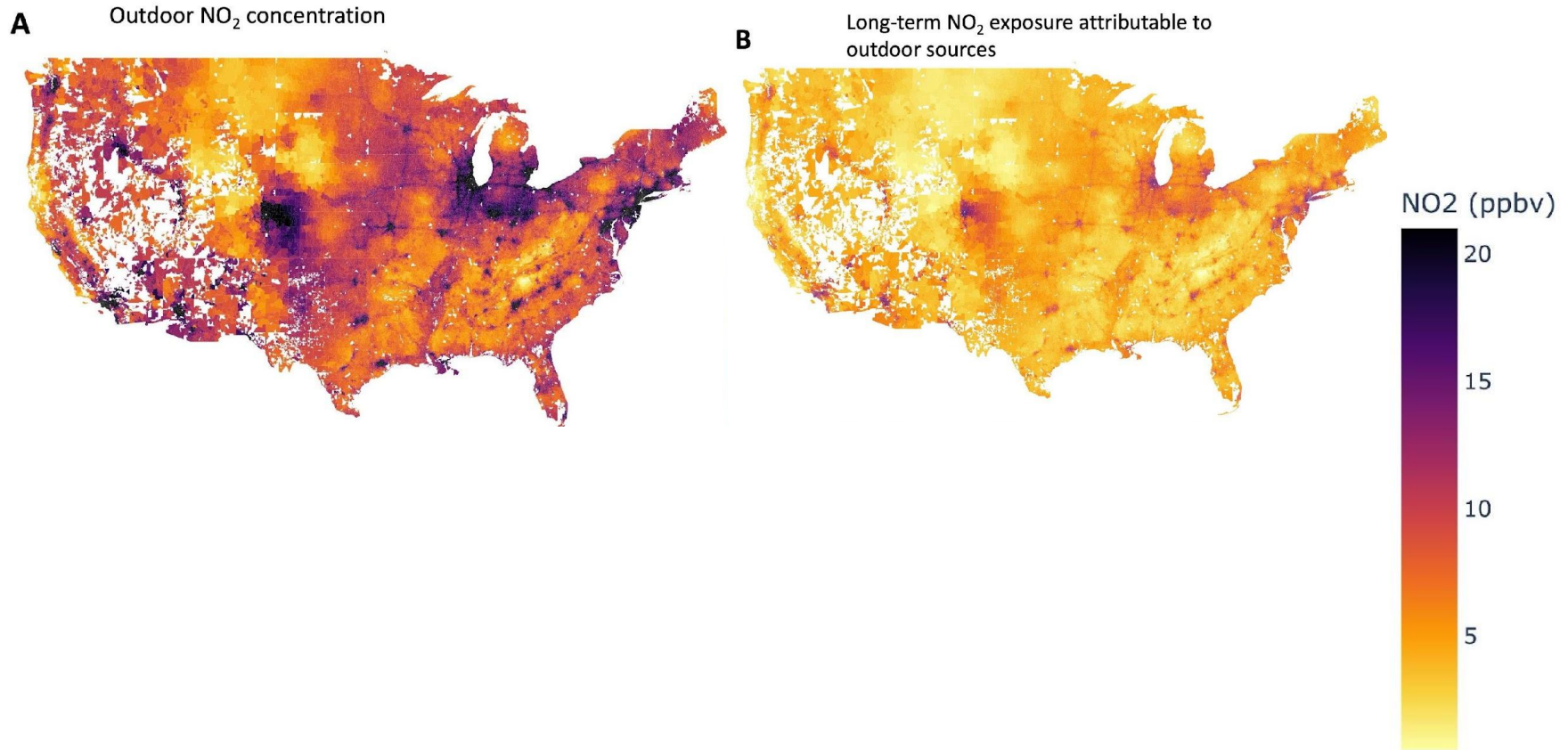


# Outdoor concentration maps are commonly used in disease burden calculations

Outdoor NO<sub>2</sub> concentration

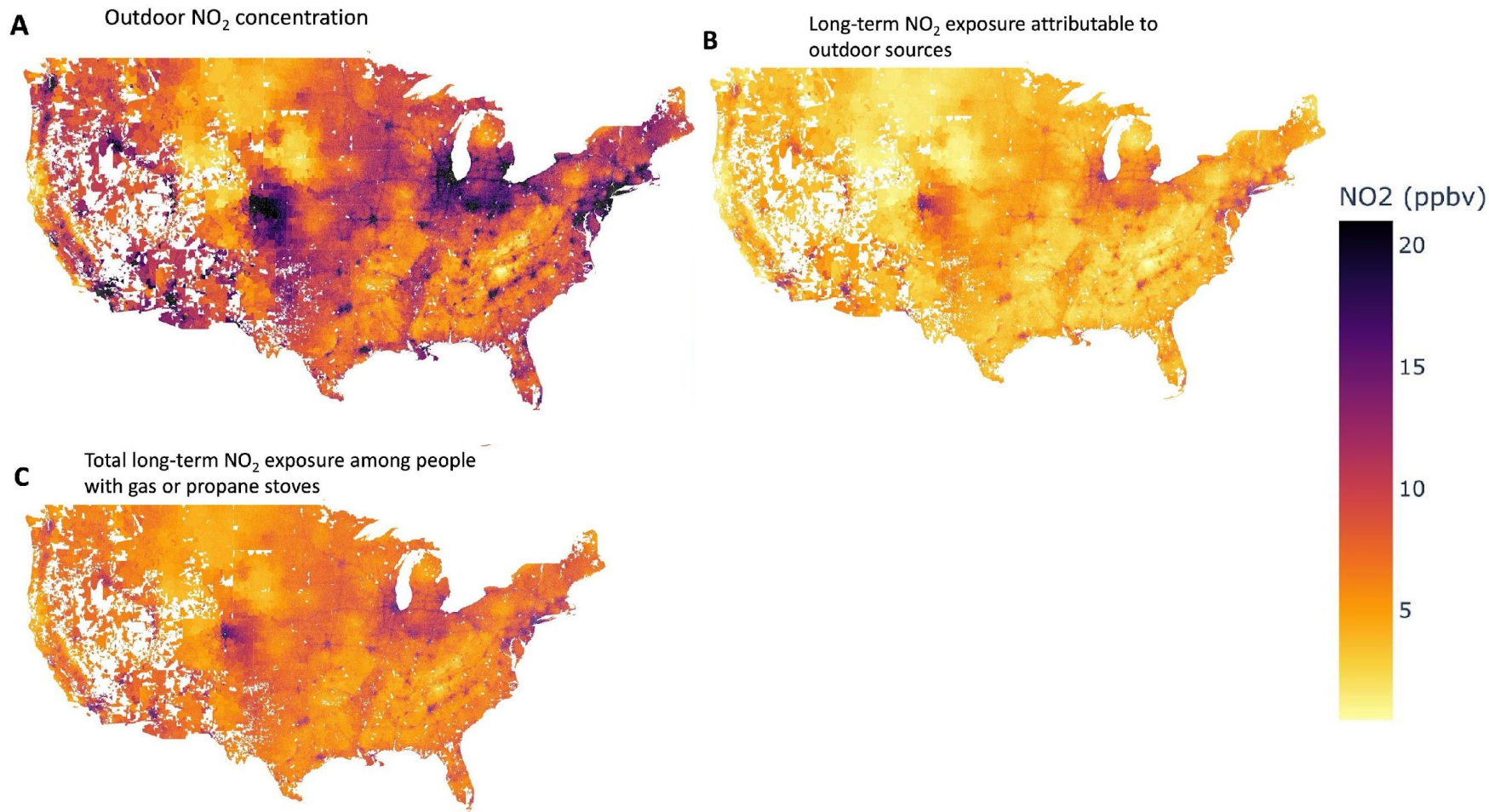


# but they over-estimate outdoor-attributable exposure



Missing pixels are due to areas without ZIP codes

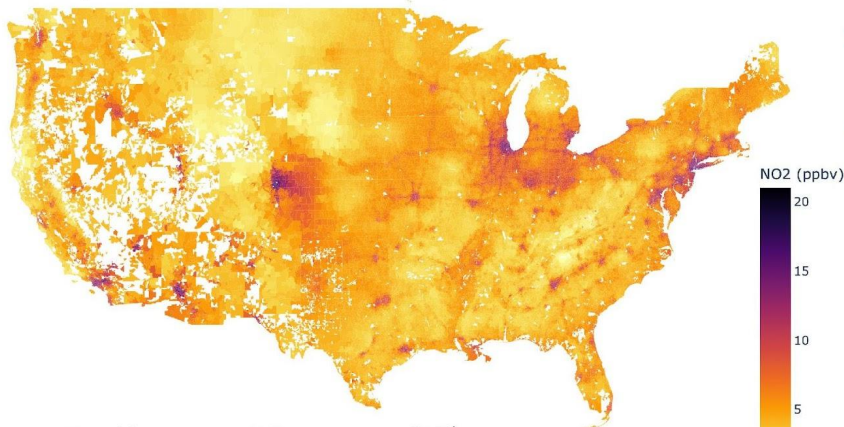
# and don't account for a key indoor source, gas stoves,



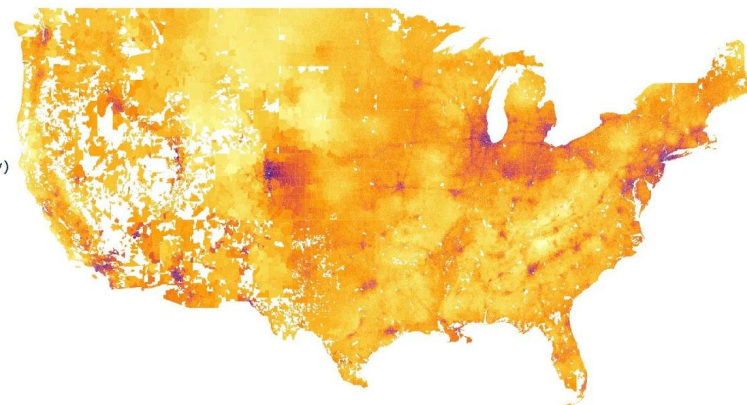
Missing pixels are due to areas without ZIP codes

# which can massively impact overall exposure

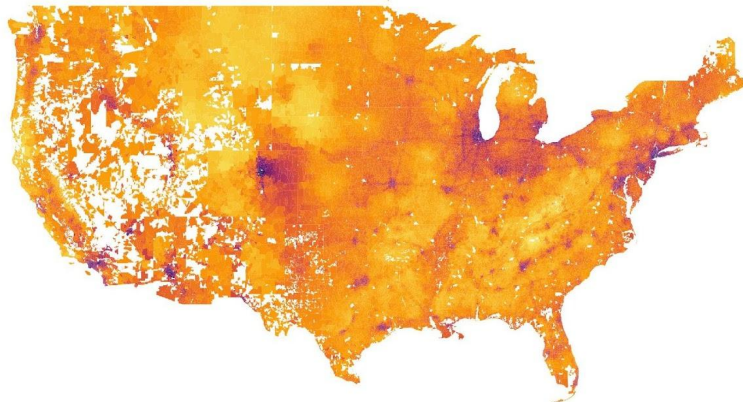
**A** Total long-term NO<sub>2</sub> exposure (households with electric stoves)



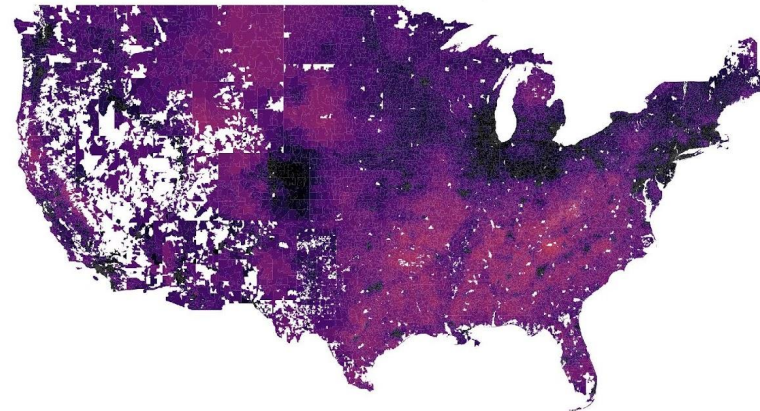
**B** Total long-term NO<sub>2</sub> exposure (5<sup>th</sup> percentile gas and propane stove use)



**C** Total long-term NO<sub>2</sub> exposure (50<sup>th</sup> percentile gas and propane stove use)

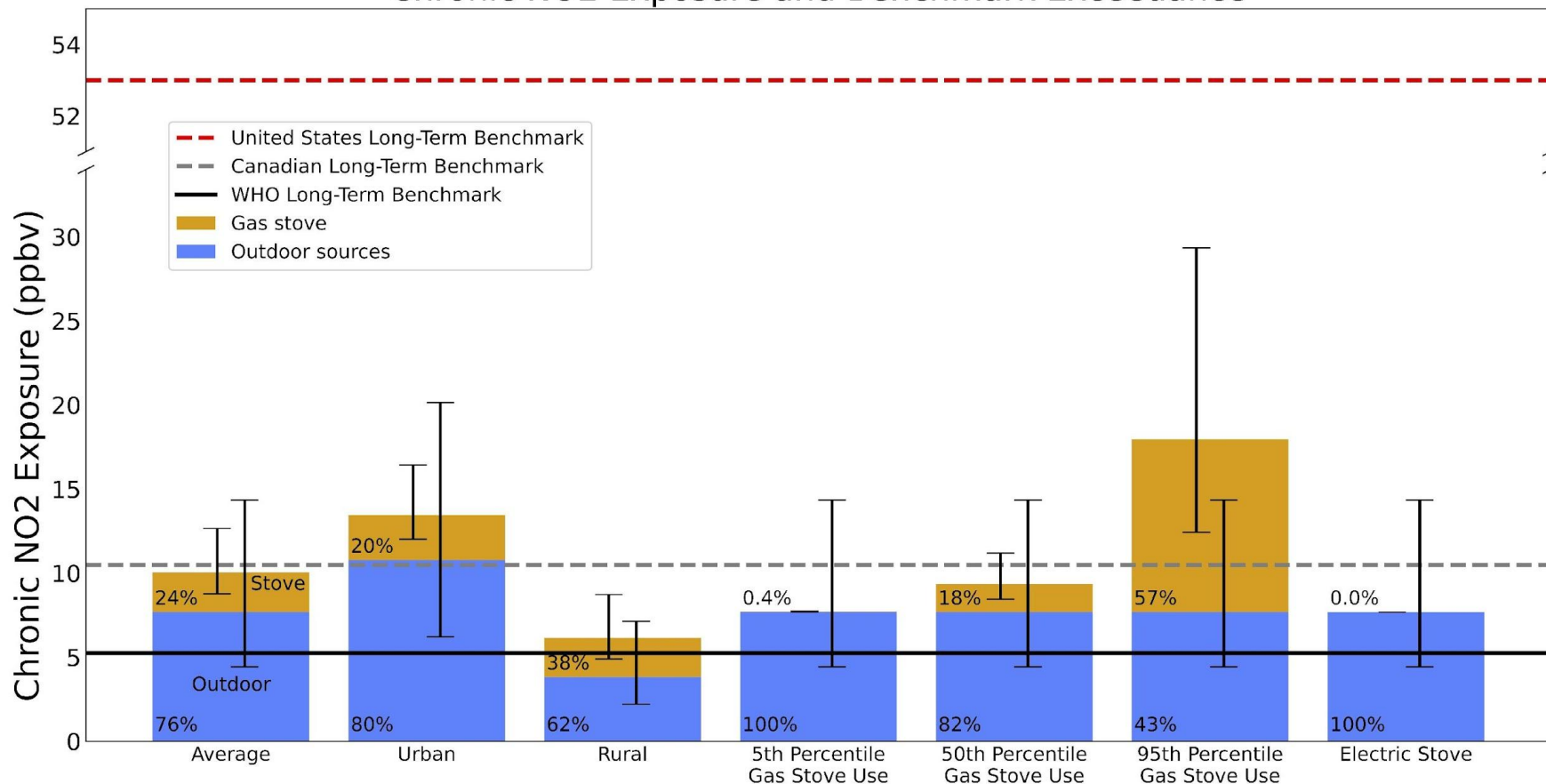


**D** Total long-term NO<sub>2</sub> exposure (95<sup>th</sup> percentile gas and propane stove use)



# Gas stoves are responsible for ¼ of total residential NO<sub>2</sub> exposure, on average

Chronic NO<sub>2</sub> Exposure and Benchmark Exceedance



# Asthma cases due to NO<sub>2</sub> from stoves

- Long-term NO<sub>2</sub> exposure from gas stoves causes ~50,000 cases of pediatric asthma
  - Exact estimate is uncertain due to few and heterogeneous studies on indoor NO<sub>2</sub> (95% confidence interval spans -70k to +142k)
    - Outdoor NO<sub>2</sub> studies are more numerous and have tighter confidence intervals, but may also pick up the effect of other pollutants
  - This estimate does not include risks from other pollutants such as ultrafine particles nor from short-term high-concentration NO<sub>2</sub> exposure
  - The full impact may be closer to 200,000 cases of pediatric asthma (confidence interval: -20 to +380 thousand)

Concentration response factor (asthma cases & indoor NO<sub>2</sub>): W. Lin, B. et al., *Int J Epidemiol*, 2013

Concentration response factor (asthma cases & presence of gas stoves): E. Puzzolo, et al., *Lancet Respir Med*, 2024

Extrapolation to asthma cases: Kashtan, et al., 2024

# Annual respiratory deaths annually, up to 20,000

- Number comes from outdoor studies
- Unclear how applicable these are to indoor exposures
- Not including risks from other pollutants & short-term exposure

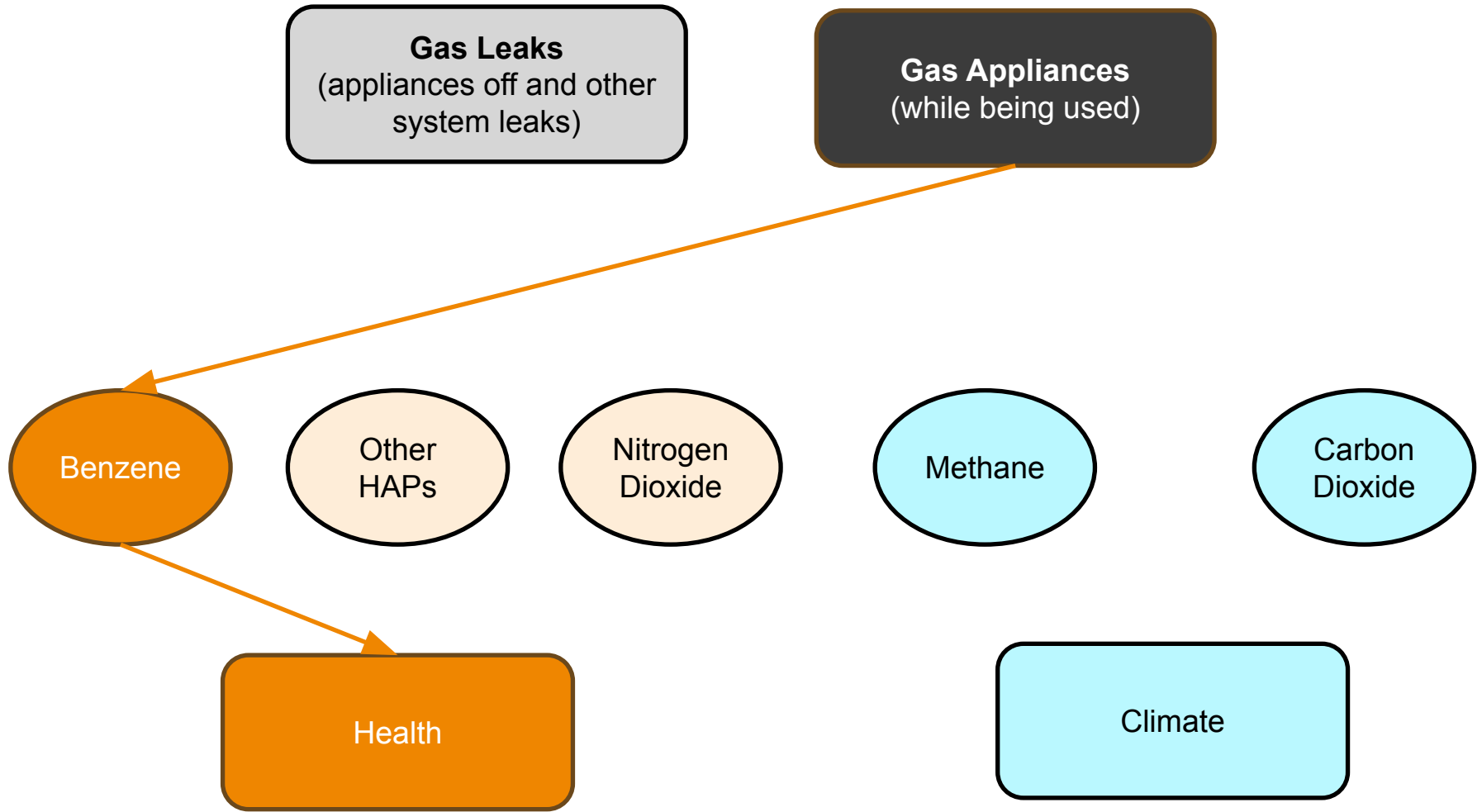
Concentration response factor (deaths & outdoor NO<sub>2</sub>): R. W. Atkinson, *Epidemiology*, 2018  
Extrapolation to premature deaths: Kashtan, et al., 2024

# Pollution from Partial Combustion Products

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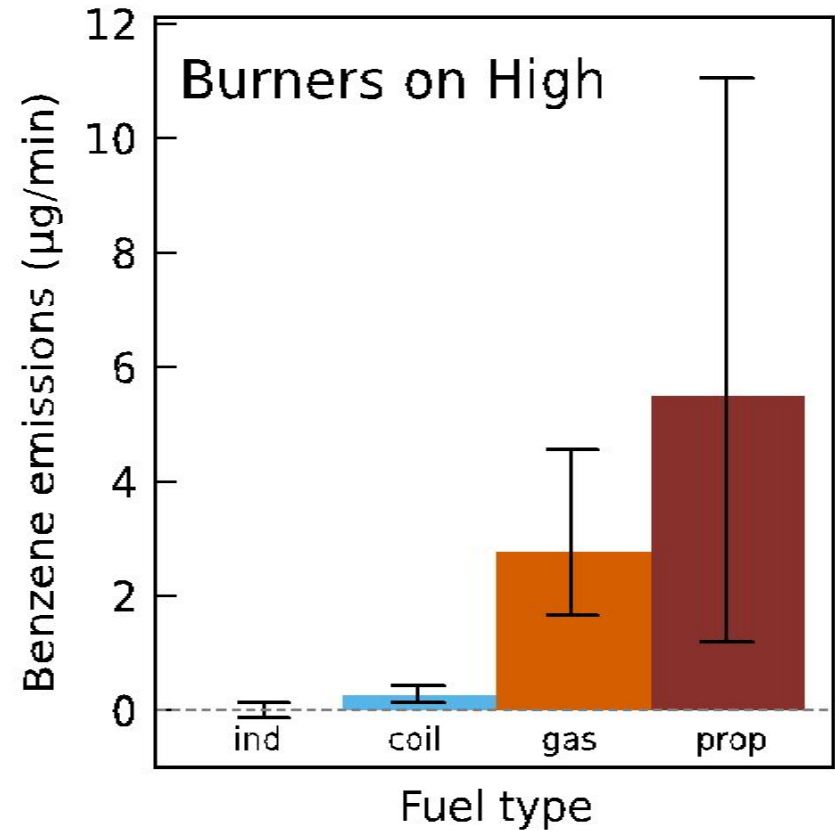
Benzene

# Benzene Emissions: A Combustion Byproduct



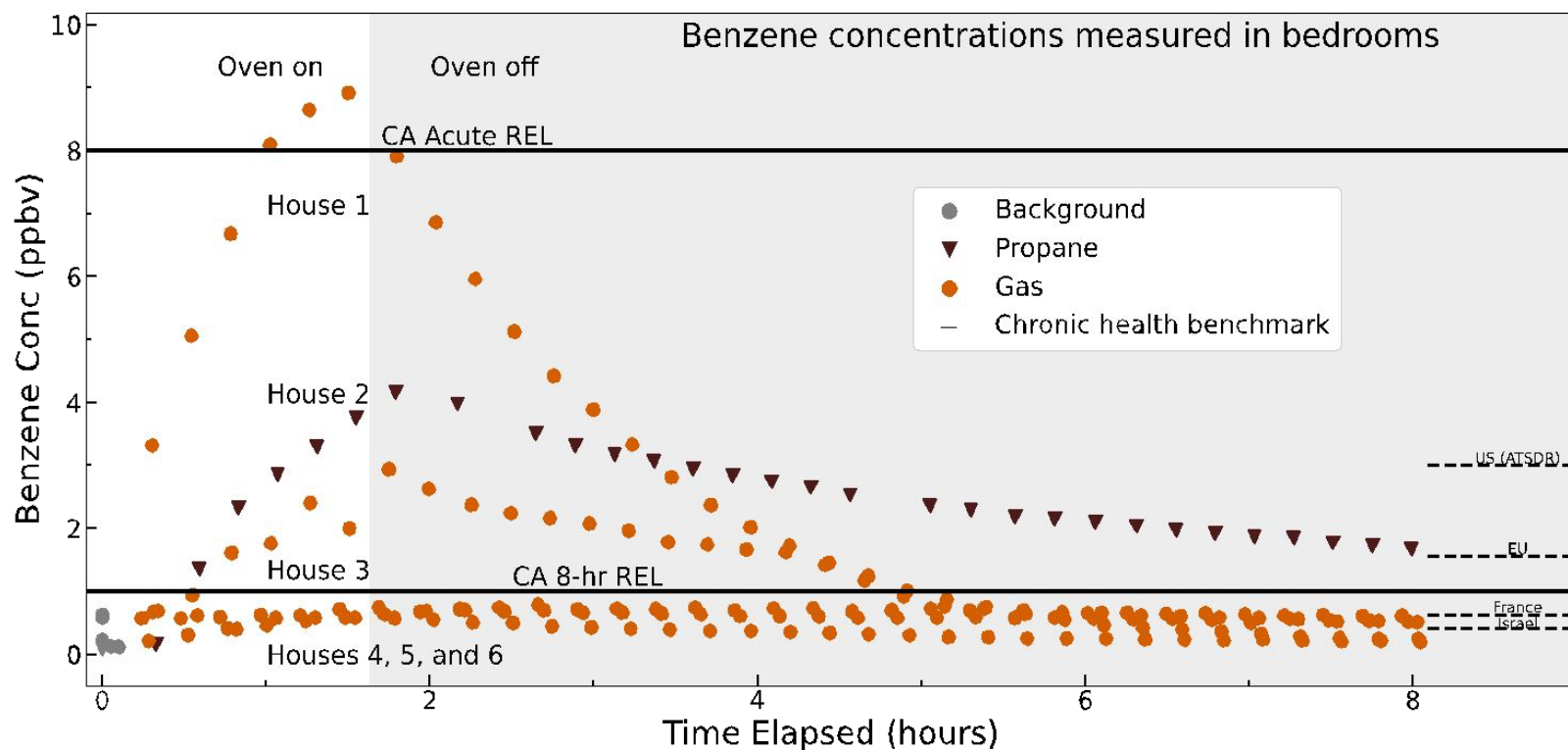
# Fuel choice dictates indoor air pollution

- Gas and propane stoves emit benzene
- Induction benzene emissions undetectable





# Benzene can exceed health benchmarks as well



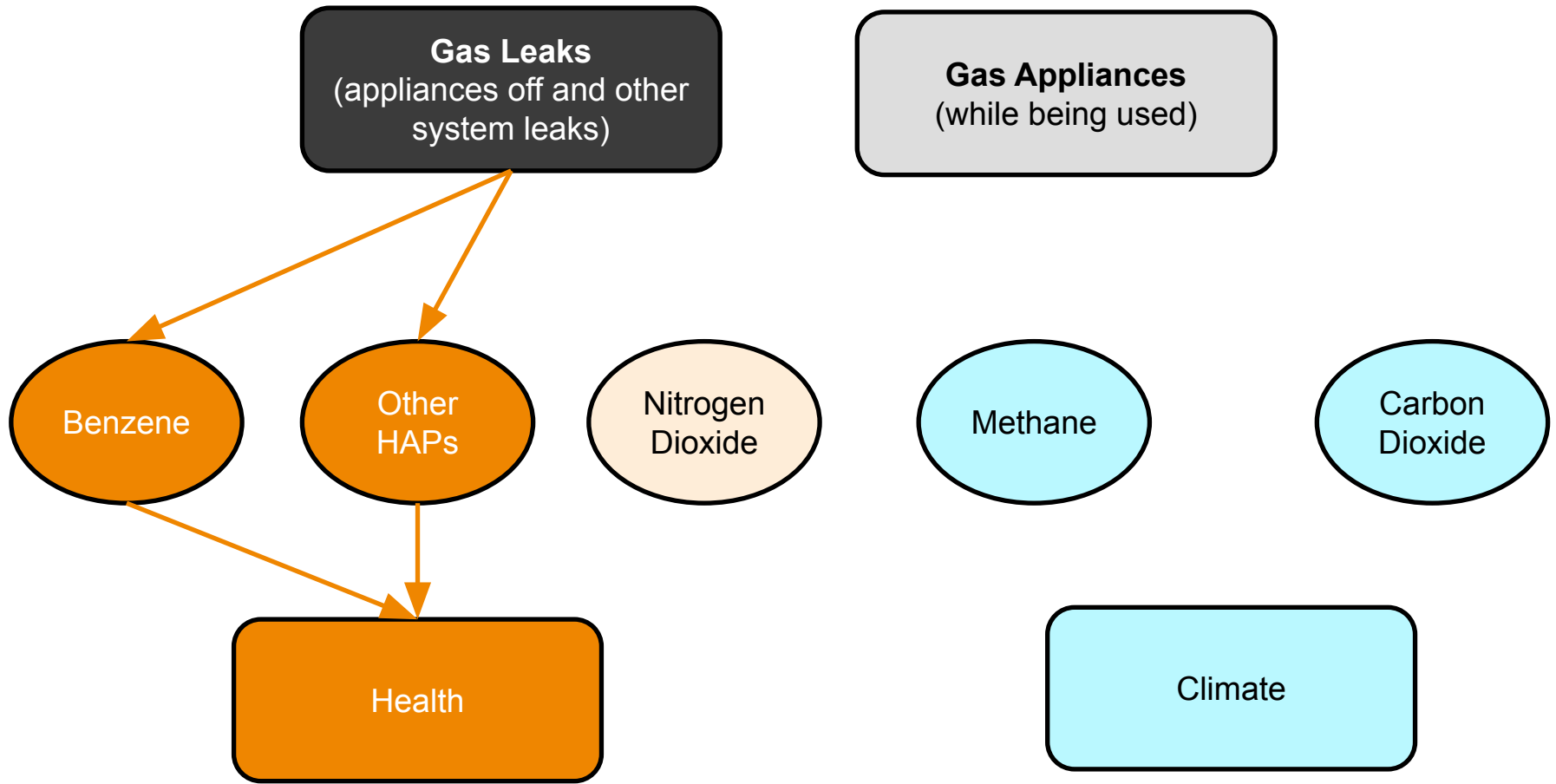
# Gas Composition of Unburned Gas

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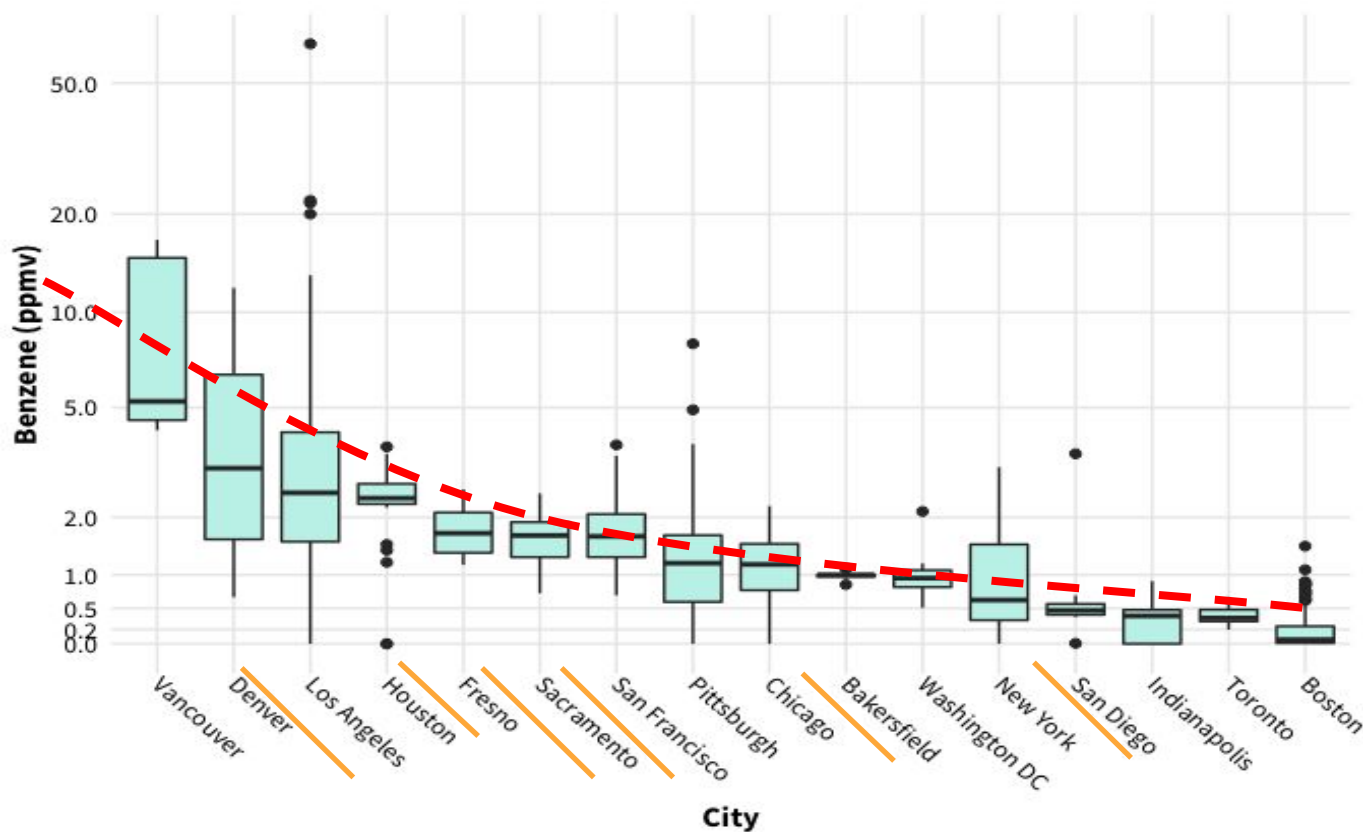
Benzene

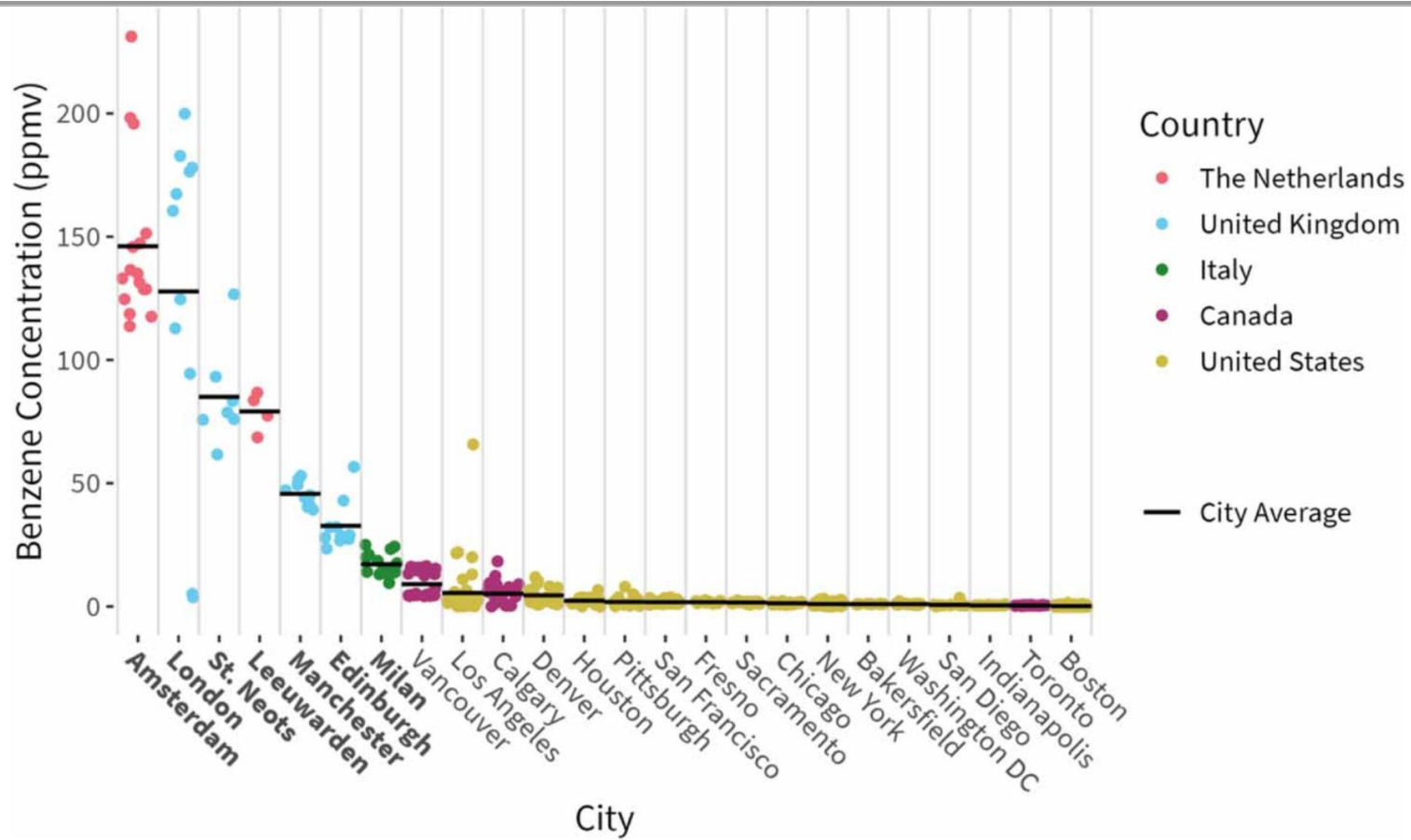
Other  
HAPs

# Gas in California (and elsewhere) Contains Benzene and other Hazardous Air Pollutants



# Benzene concentrations in gas from 17 cities across North America are consistent with CA





Ventilation

Stove  
Leak

MODEL

Benzene  
Concentration

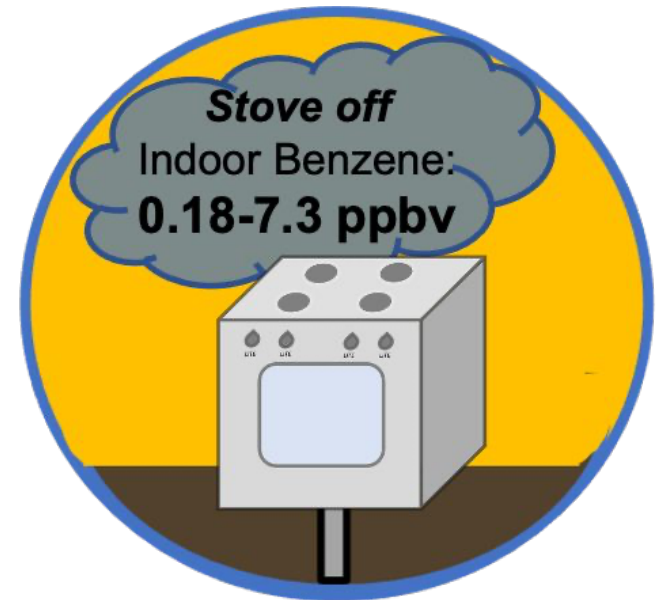
Benzene  
in Gas

Kitchen Size

# Natural gas leaks degrade indoor air quality

Just having a gas stove in your kitchen can create benzene concentrations comparable to secondhand smoke.

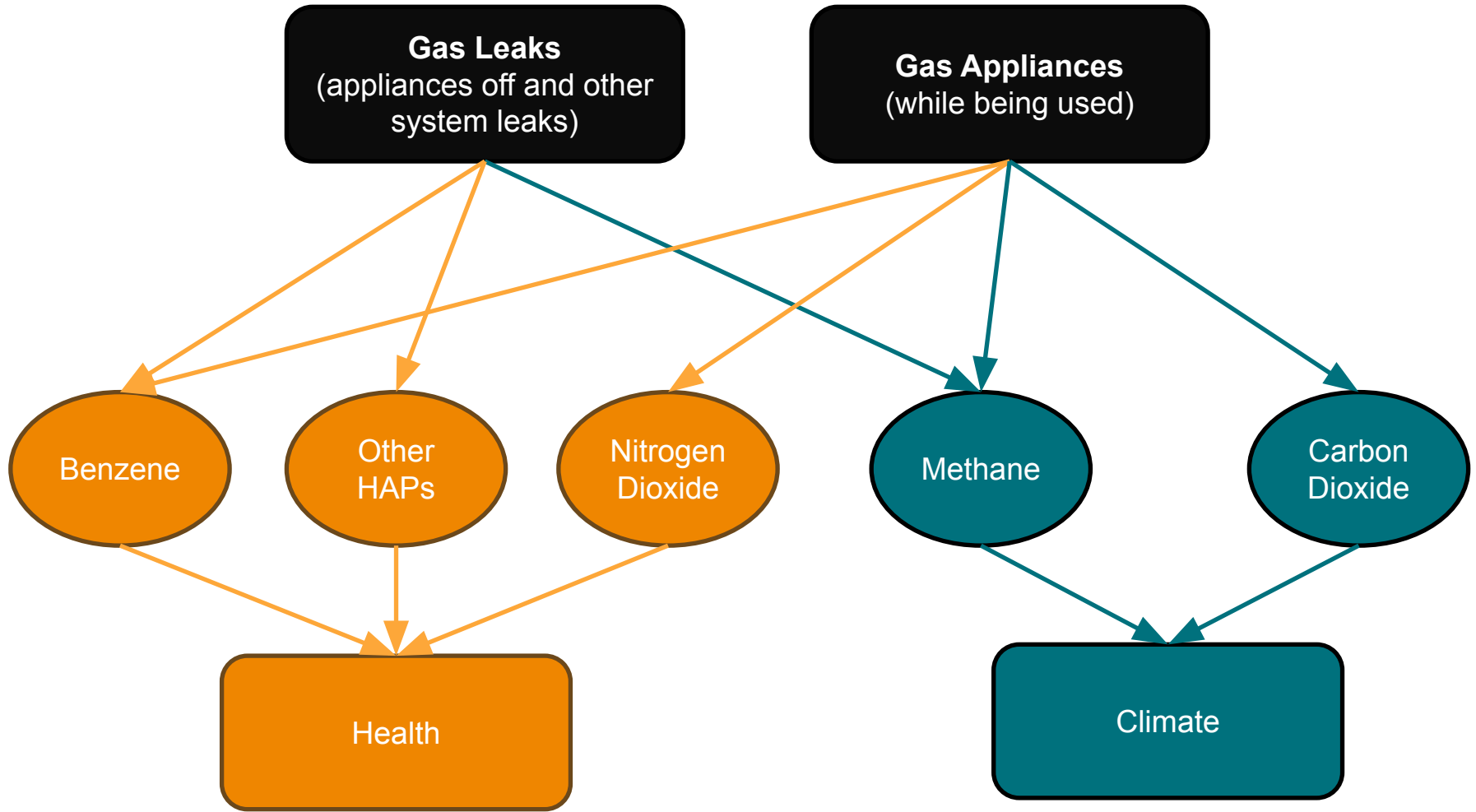
- In California, leaky stoves can exceed California's health exposure guidelines for benzene indoors up to **7x**
- Additionally, 12 other compounds were detected in the unburned gas in California



# Big-Picture Takeaways

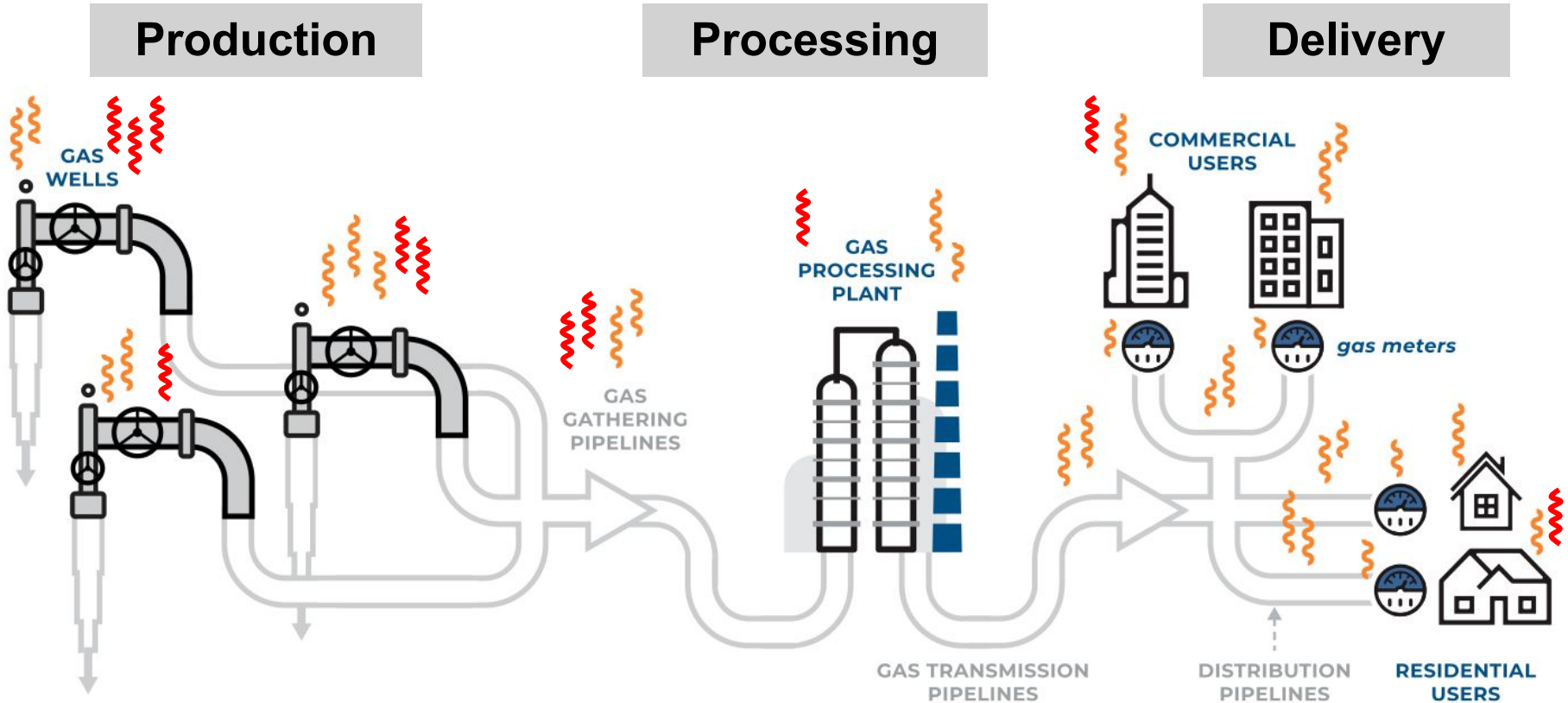
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# Overview



# Gas leaks are an unavoidable part of the system

Methane Hazardous Air Pollutants



Our work builds on the body of evidence that suggests that hazardous air pollutants are co-emitted with methane throughout the gas supply chain.

# History and Context



# ice

Institution of Civil Engineers

deleterious. In the latter case aqueous vapour will be in excess, and consequently the due quantity of perspirable matter is not carried off from the lungs and skin, the injurious effects of which have been clearly established by M. Quetelet in his work on man. The injurious effects of an excess of nitrogen and carbonic acid gas are too well known to require comment.

Nitrogen acid gasses or Nitrous acid gas =  $\text{NO}_2 + \text{NO}$

# Natural Gas Association of America, 2<sup>nd</sup> Annual Meeting, 1907



M. M. SWEETMAN, <i>Vice President.</i>	J. H. DUNKEL, <i>Secretary.</i>	C. W. SEARS, <i>Commissioner - Ex-Laws.</i>
C. H. PATTISON, <i>Treasurer.</i>	K. M. MITCHELL, <i>President.</i>	W. H. MCKENZIE, <i>Director.</i>
E. S. SPRINGER, <i>Director.</i>	H. N. SIEGFRIED, <i>Director.</i>	J. F. OWENS, <i>Director.</i>

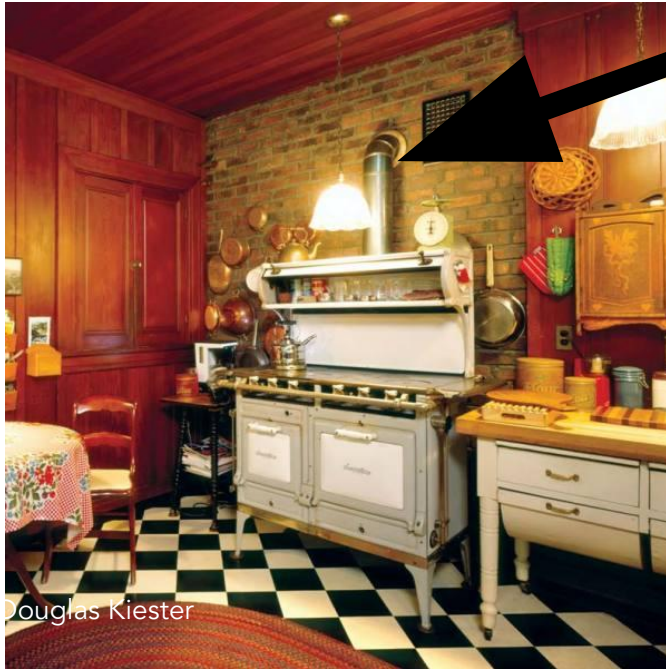
VICE PRESIDENT SWEETMAN : I move that it be the sense of the association that it go on record condemning the use of any appliance without a flue connection.



M. M. SWEETMAN, <i>Vice President.</i>	J. H. DUNKEL, <i>Secretary.</i>	C. W. SEARS, <i>Commissioner - Ex-Laws.</i>
C. H. PATTISON, <i>Treasurer.</i>	K. M. MITCHELL, <i>President.</i>	W. H. MCKENZIE, <i>Director.</i>
E. S. SPRINGER, <i>Director.</i>	H. N. SIEGFRIED, <i>Director.</i>	J. F. OWENS, <i>Director.</i>

PRESIDENT MITCHELL: I believe the association will go on record on that point; no gas of any kind should go into a heating stove without a flue connection...

Dangers of gas stove pollution understood in the 1920s



Flue

1926 gas stove

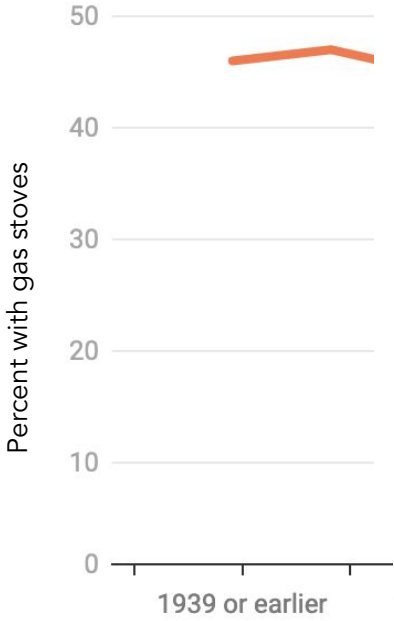
Photo of 1907 Evans House in California (courtesy oldhouseonline.com)

“Cooking with Gas!” coined in 1930s

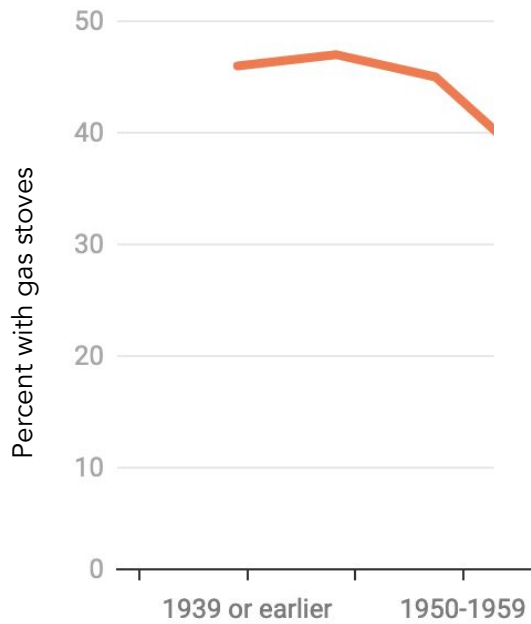


Image of Bob Hope from Walton Gas (accessed 2024)

# Percent of Single Family Homes with Gas Stoves, by Year Built



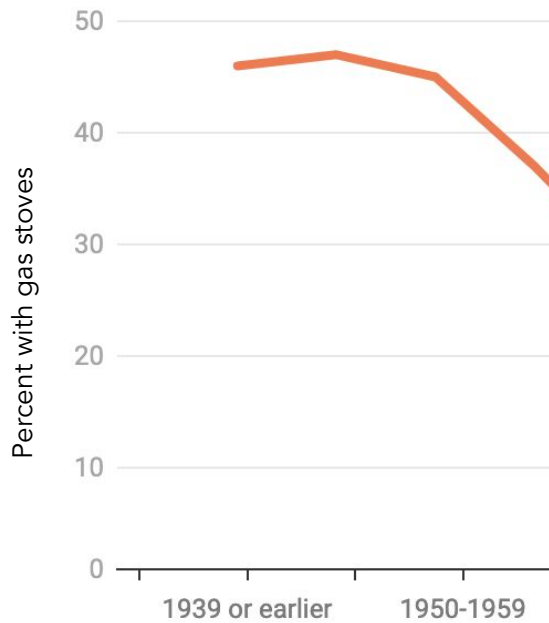
# General Electric



1958

Top: Dept. of Archeology and Historic Preservation, Washington State

# Mounting Health Concerns



Top: Dept. of Archeology and Historic Preservation, Washington State  
 Bottom: New York Times (as reported by the Climate Investigations Center)



## Study Links Respiratory Illness To Use of Gas Stoves in Homes

By GLADWIN HILL

Special to The New York Times

DURHAM, N. C. — Studies made by the Environmental Protection Agency have yielded "preliminary" indications that people who live in homes with gas stoves are more susceptible to respiratory ailments than people who use other cooking devices.

The apparent reason, according to scientists at the E.P.A.'s National Environmental Research Center here, is that gas

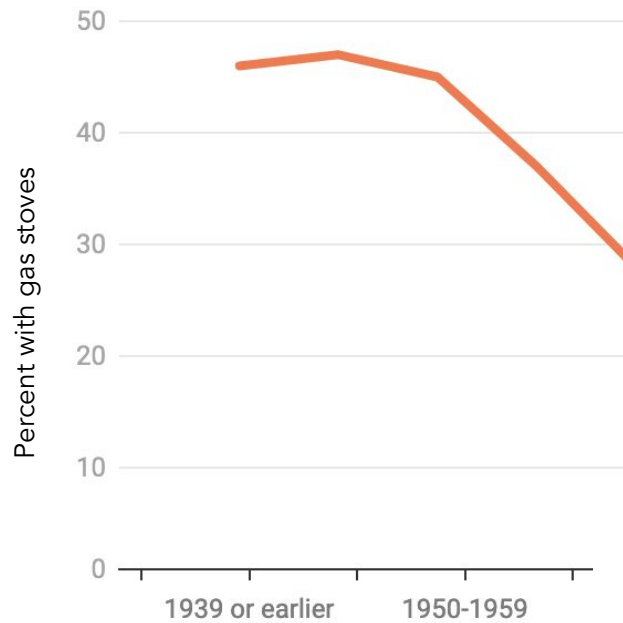
as age, socio-economic status and smoking.

However, the researchers, in an unpublished report, attached two qualifications to the findings. One was that the gas-stove families did not experience an excess of upper-respiratory ailments—the effects seeming "to involve a clinical shift from upper to lower respiratory tract disease."

1973

# Operation Attack

“massive, consistent, long-range public relations program”



Photos: “Burning Questions” Climate Investigations Center Report, 2023

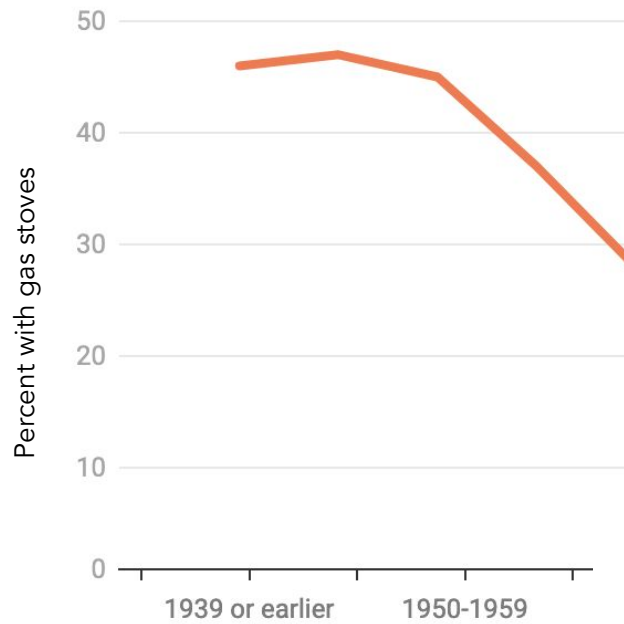


Richard Darrow, Hill & Knowlton president. Photo from a 1969 [speech](#) to Ohio Wesleyan University.



AGA’s “Operation Attack” was a nationwide [campaign](#) that began in 1969 intended to boost the sale of gas ranges over electric ones.

# Operation Attack



Photos (clockwise from top): Vox, Vox, and eBay

Sorry, the beloved chef's use of gas cooking was a gas industry sponcon.

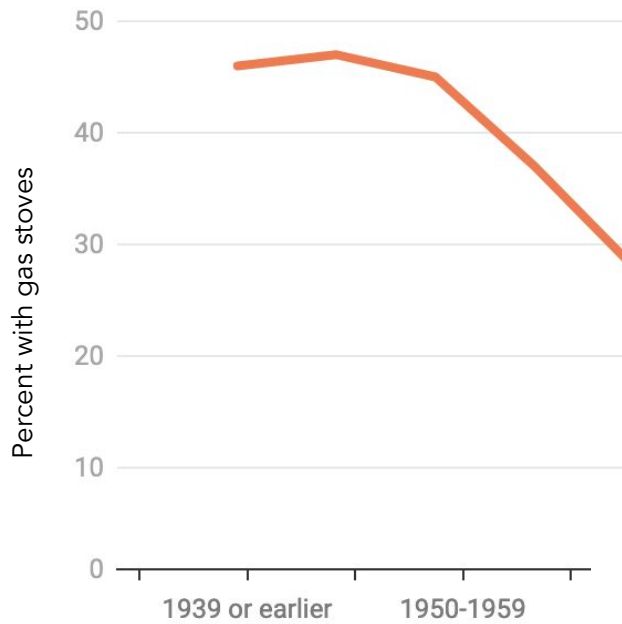
By Rebecca Leber | @releber | rebecca.leber@vox.com | Nov 4, 2023, 6:00am EDT

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Julia Child prepared scallops in her kitchen in Cambridge, Massachusetts, on October 16, 1975, on her Garland gas stovetop. The gas range became almost as iconic as the chef herself, featured in a Smithsonian exhibit today. | Ulrike Welsch/Boston Globe via Getty Images

# Operation Attack



Photos (clockwise from top): Vox, Vox, and eBay

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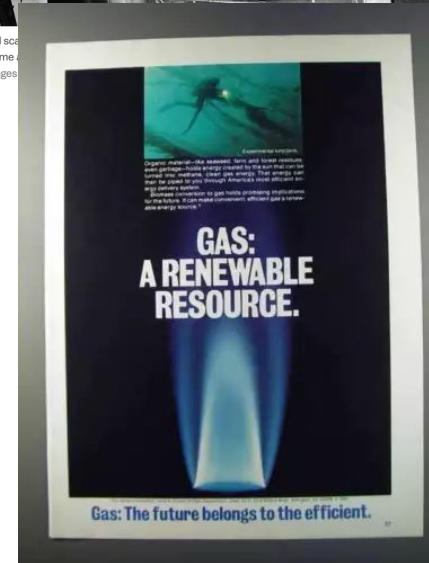
By Rebecca Leber | @rebleber | rebecca.leber@vox.com | Nov 4, 2023, 6:00am EDT

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Julia Child prepared scallops on a gas stove. The gas range became a staple in the kitchen. Globe via Getty Images

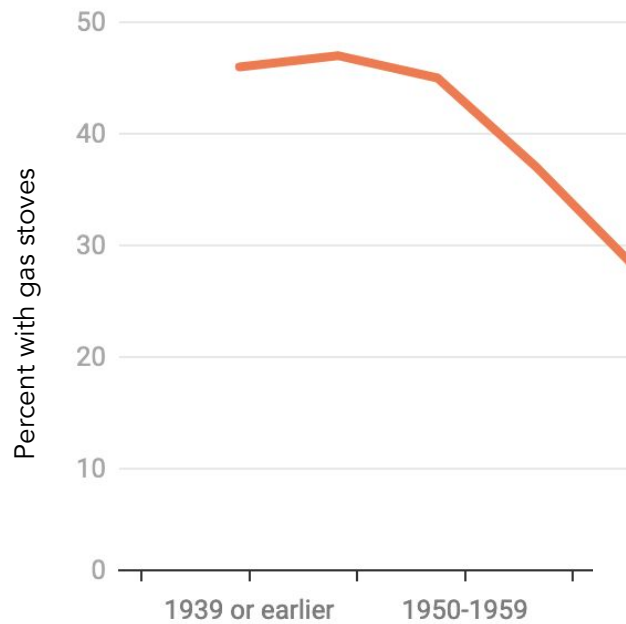
stovetop. h/Boston



*“In the past, industry has given little twists to the facts of science, to convert them into sales propaganda, without much risk. The cigarette industry has indeed been doing this for years. We can therefore readily understand its assumptions that the same technique will work now in devising propaganda.”*

Hill and Knowlton Memo to Tobacco Industry Planning Committee, 1953

“Burning Questions” Climate Investigations Center Report, 2023

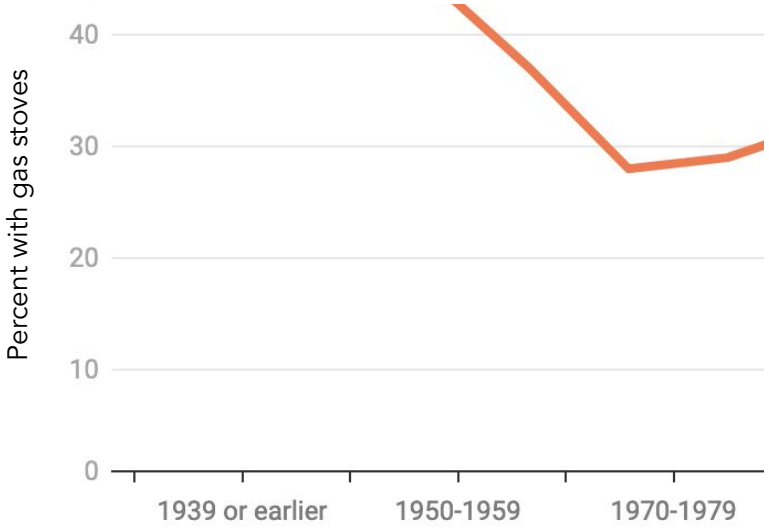


#### Some of Hill and Knowlton's Science-Related Recommendations:

- Establish a "Research Committee" or "Institute" (for apparent independence)
- Publicize the results of industry-sponsored research efforts through every possible channel
- Adopt a skeptical stance, arguing that more research is needed
- Once a company or industry averts any immediate crisis, continue with the formula over the long term



The AGA paper, “*Putting Gas Range Emissions in Perspective*,” was presented at a Symposium of Indoor Air Pollution held at the University of Massachusetts in 1981.

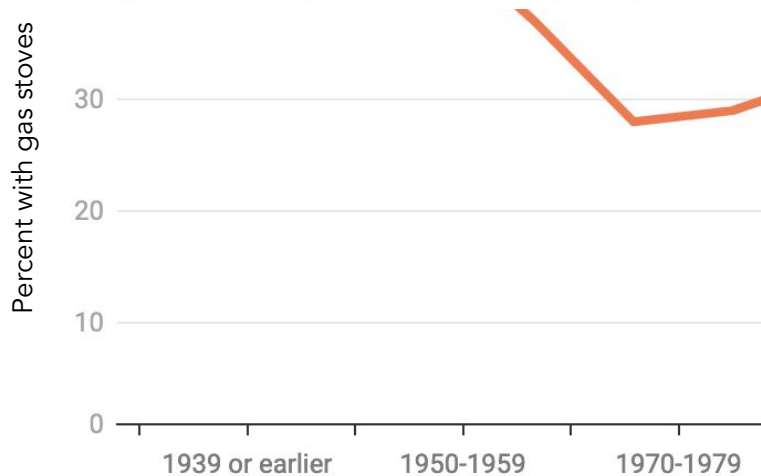


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Topical discussions which focused on the current status of indoor air quality and the health effects of exposure to indoor air pollutants were prepared. These discussions conclude that the epidemiological evidence is inconclusive regarding the effects of indoor air pollution on residential populations. The need for special concern regarding sensitive populations is also uncertain because the response measured in experimental exposure studies may be an adaptive response rather than a pathological change.

A. D. Little's 1981 report for the Gas Research Institute, "Potential Health Effects of Residential Energy Conservation Measures," promoted doubt and uncertainty. (Emphasis added)



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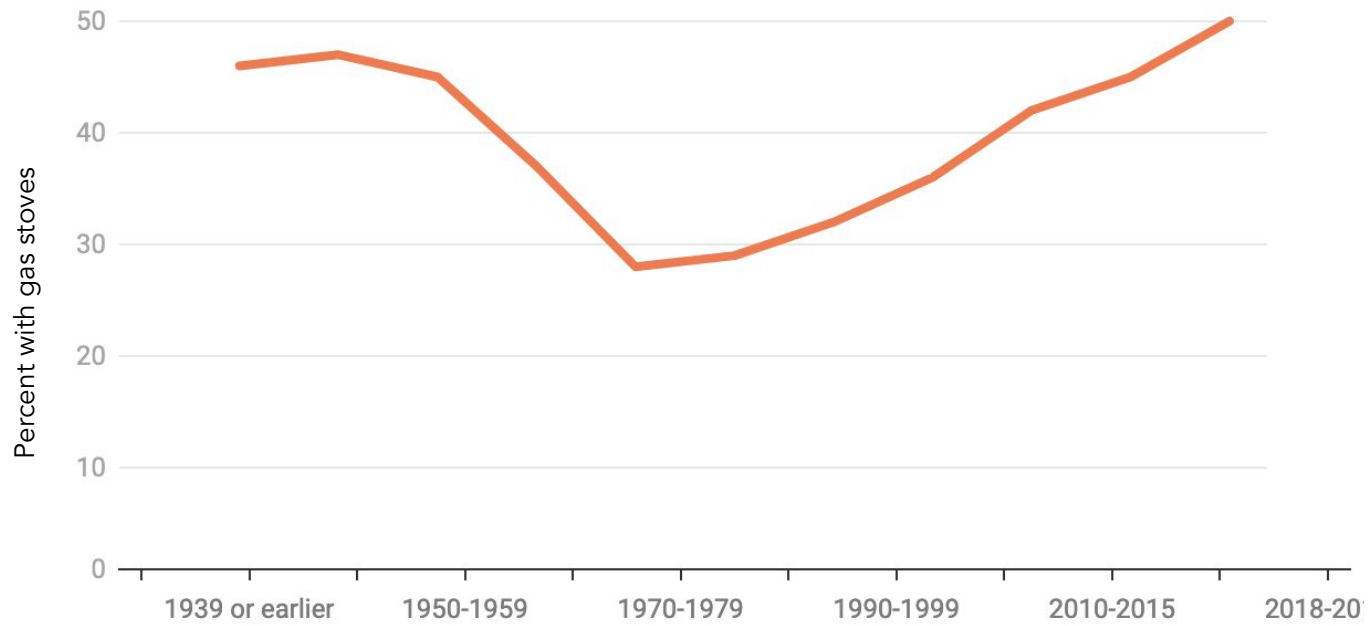
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## Studies on pediatric asthma and gas stoves assessed by the EPA in 1982

Study Population	AGA Funded?	Association Found with Asthma?	Authors
Children (8,120)	No	Yes	Speizer et al., 1980
Children (2,554)	No	Yes	Melia et al., 1977
Children (4827)	No	Yes	Melia et al., 1977
Children (808)	No	Yes	Florey et al., 1979 & Goldstein et al. 1979
Children (895)	Yes	No	Mitchell et al. 1974
Children (174)	Yes	No	Keller et al., 1979

Reformatted from a table reported by the Climate Investigations Center and reported by NPR

Once a company or industry averts any immediate crisis, continue with the formula over the long term



# Latest Study Misleading on Natural Gas Stoves

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MAY 3, 2024

The new study by [Kashtan et al.](#) estimated the number of childhood asthma cases and adult deaths due to natural gas use based largely on two published meta-analyses. A meta-analysis is a statistical combination of results from multiple studies addressing a similar research question. The conclusions of this new [Kashtan](#) study rely on two major meta-analyses, neither of which support the study's claims.

The researchers encased the tested kitchen area in plastic sheets, sandbags, and painter's tape – which in no way represents the kind of kitchen in which normal people cook.



Institute for Energy Research

(Koch and Exxon-funded)

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epidemiology literature... does not provide sufficient evidence regarding causal relationships between gas cooking or indoor NO<sub>2</sub> and asthma or wheeze



Gradient study funded by AGA

(for-profit consulting firm)

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NEWS NEWS RELEASES

## New Study Finds Research on Natural Gas Cooking and Asthma Fails to Demonstrate Causal Relationship

APR 20, 2023

- The peer reviewed [“Gas Cooking and Respiratory Outcomes in Children: A Systematic Review.”](#) was published in *Global Epidemiology* on April 18, 2023.

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Li et al., *Global Epidemiology*, 2023



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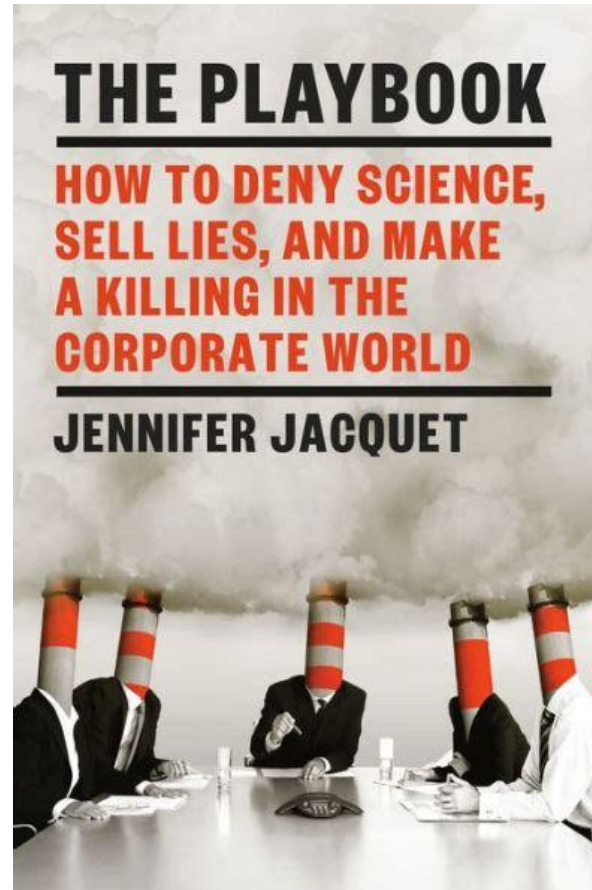
# Overwhelming Support for Gas Appliances Pushes DOE to Go from Banning 96% of Gas Stoves to Maintaining 97% of the Market

JAN 29, 2024

Smoking

Asbestos

Opioids



Fossil fuels

Beryllium

Lead

Claims regarding PR firms: R. J. Brulle, C. Werthman, *Clim Change* (2021).

Claims regarding industries using disinformation tactics: *Agnotology* by R. Proctor & L. Shiebinger (beryllium); *Deceit and Denial* by G. Markowitz & D. Rosner (lead); *Empire of Pain* by P. R. Keefe (opioids); *The Golden Holocaust* by R. Proctor (smoking); *Merchants of Doubt* by Naomi Oreskes (fossil fuels/climate change); X. Baur, A. L. Frank, *Journal of Occupational Medicine and Toxicology* 16, 1–10 (2021) (asbestos); *The Playbook* by J. Jacquet (tying industries together)

Smoking

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PR Firms

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Dangers of gas stove pollution used to be common sense



Flue

1926 gas stove

The AGA & their PR firms created ignorance. Today, stove pollution is controversial.



1926 gas stove

Flue

No hood,  
no flue



2024 gas stove

# Acknowledgements

## Coauthors and Collaborators

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- Sebastian Rowland
- Angélica Ruiz
- Abenezer Shankute
- Seth Shonkoff
- Simone Speizer
- Chenghao Wang

Stanford  
University

CCAC  
Central California  
Asthma Collaborative

Jackson Lab



# Citations

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3. Kashtan, Y. S., Nicholson, M., Finnegan, C., Ouyang, Z., Lebel, E. D., Michanowicz, D. R., ... & Jackson, R. B. (2023). Gas and propane combustion from stoves emits benzene and increases indoor air pollution. *Environmental Science & Technology*, 57(26), 9653-9663.
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# Thank You

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