

Comparison of Kitchen and Bathroom Exhaust Ventilation Impact on Indoor Air Quality

National Healthy Homes Conference
Kansas City, August 2025

David E Jacobs, PhD, CIH

CREDITS



Jill Breysse



Sherry Dixon



Dave Jacobs



Jonathan Wilson

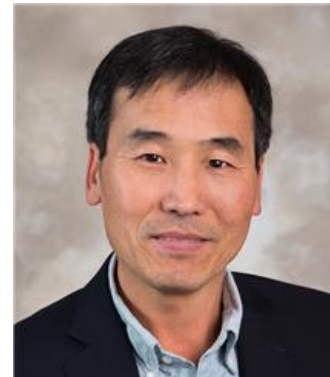
National Center for Healthy Housing



Paul Francisco



Kiel Gilleade



Yigang Sun



Zach Merrin

Indoor Climate Research and Training

..also, Ellen Tohn of Tohn Environmental, Wayland, MA

Weatherization & ASHRAE 62.2 Standard for Acceptable Indoor Air Quality

- Weatherization requires compliance with continuous whole-house ventilation requirements of 62.2-2016+
- Can achieve via **local exhaust** (e.g., bath/kitchen fan) or **whole-house ventilation** (e.g., supply, HRV/ERV)



Gas Cooking in the Home

- 44% of single-family homes use gas cooking [2021-AHS]
- Natural gas combustion → NO₂
- NO₂ Levels:
 - >15 ppb in homes with gas stoves
 - <8 ppb in homes with electric stoves (from outdoors)

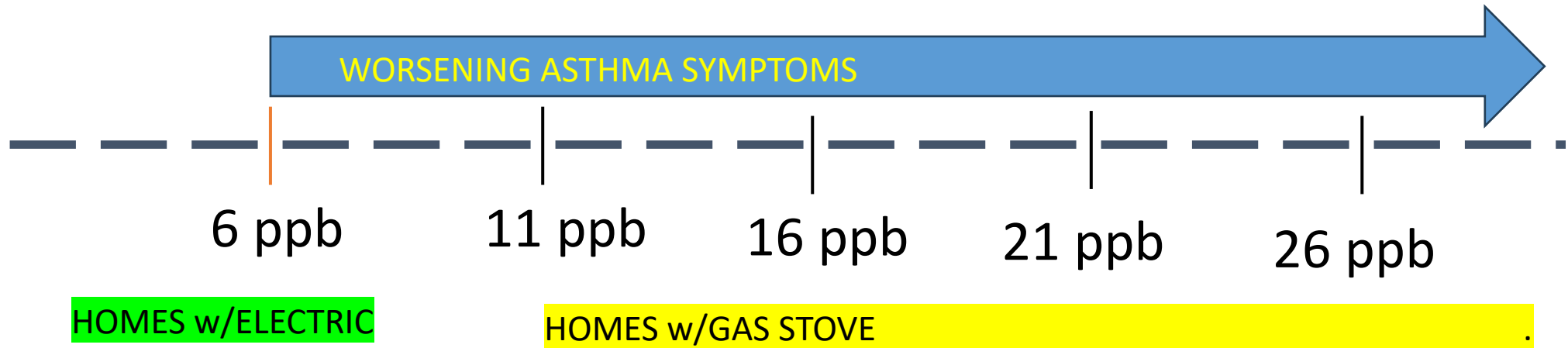
WHO standard (indoor & outdoor) (10 ppb for annual)

EPA indoor standard - None



Key Contaminant of Interest

- Every 5 ppb increase in NO₂ exposure above a threshold of 6 ppb is associated with an increase in children's asthma severity score, wheeze, night symptoms, & rescue medicine use
- (Belanger et. al, 2013)



Gas Cooking in the Home

- Gas stoves - how can we mitigate the problem?
- Exhaust ventilation should help but limited research
 - (Paulin et al 2014) Baltimore study with on-demand range hoods showed no effect on pollutants, however the study didn't track usage; homeowners may not turn them on

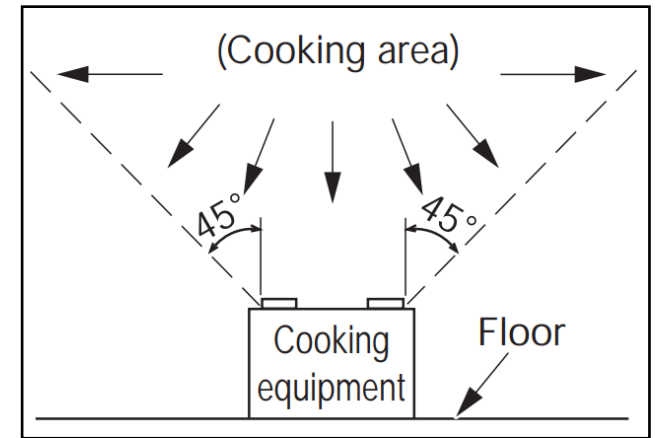
Complying with 62.2 in WAP

- Typical retrofit solution:
 - Local exhaust via continuous bath fan
- Best approach for health?
- Why use?
 - Readily available
 - Low-cost
 - Easy to install
 - Can address moisture in bath/shower



Complying with 62.2 in WAP

- 62.2 compliant continuous exhaust kitchen fans can be rated for inside or outside the cooking area
- Range hoods can help control cooking pollutants
- Bath vs range hood for whole-house ventilation:
 - Indoor air quality (IAQ)?
 - Other WAP benefits?



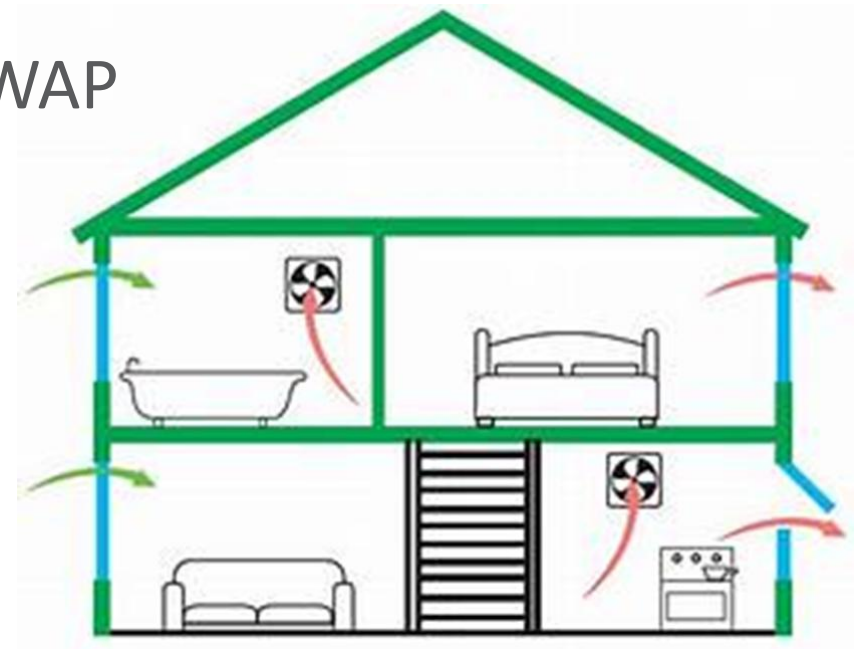
Key Contaminant of Interest

Based on prior research, we expected:

- NO₂ levels would be at least **3.3 ppb lower** with continuous exhaust ventilation

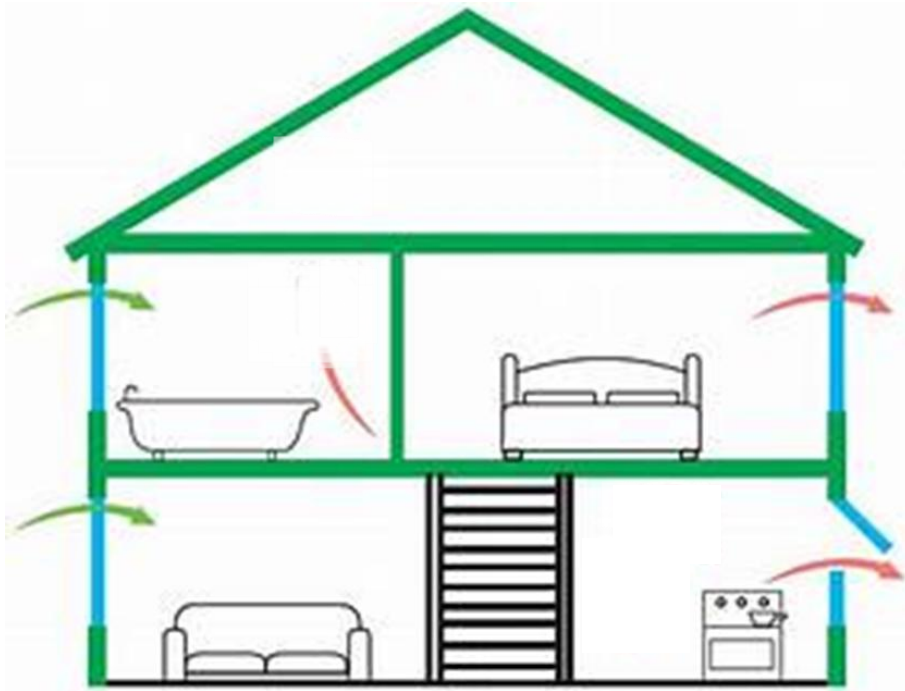
Study: The Plan

- Work with weatherization agencies in IL and CO
- Enroll non-smoking single-family homes with working gas stoves that were participating in WAP
- Target of 120 homes (90 in IL, 30 in CO)
 - 60 homes receive ASHRAE 62.2 bath fan
 - 60 homes receive ASHRAE 62.2 range hood

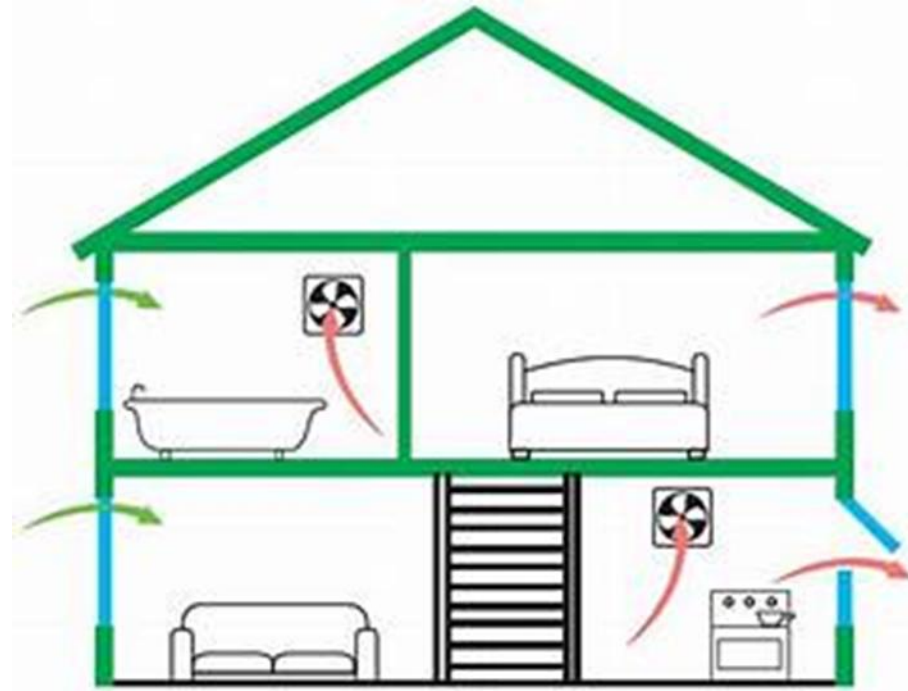


Study: The Plan

Half get continuous bath fan
(standard practice)

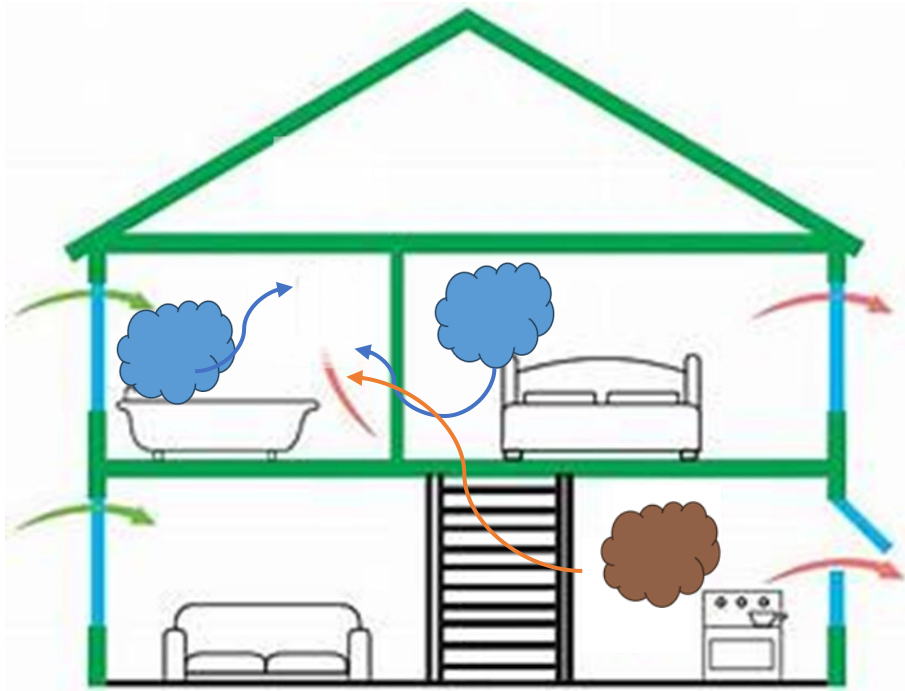


Half get continuous range hood
(atypical solution)

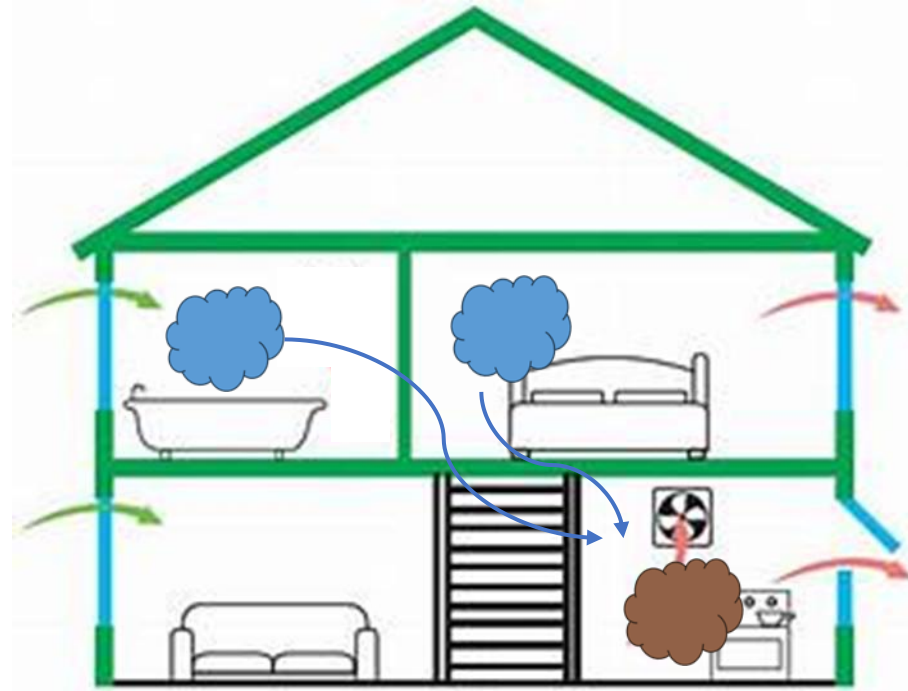


Study: The Plan

A bath fan is good to remove gases, dust, moisture generated in bath



A kitchen exhaust fan should do better at removing gases/particles in the kitchen (from gas stove)



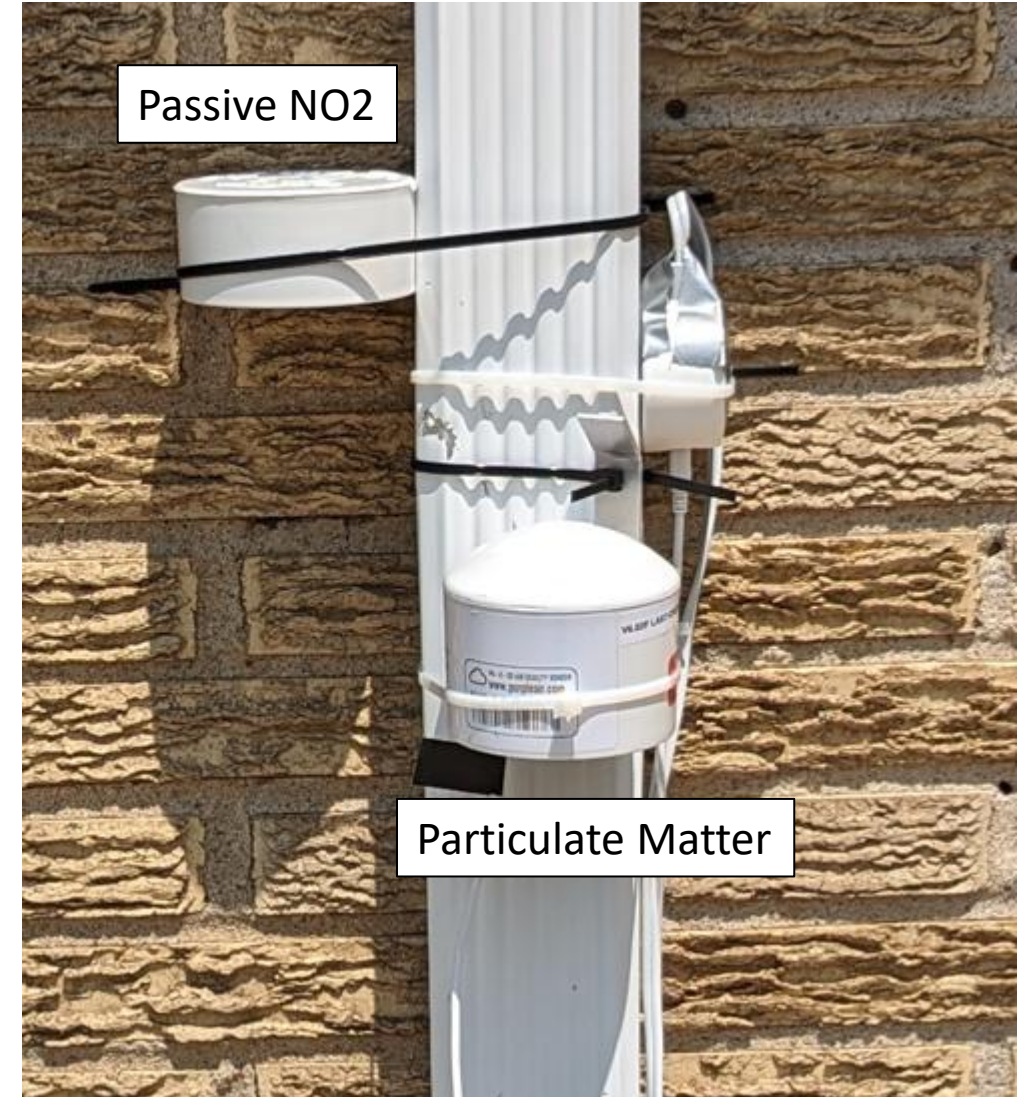
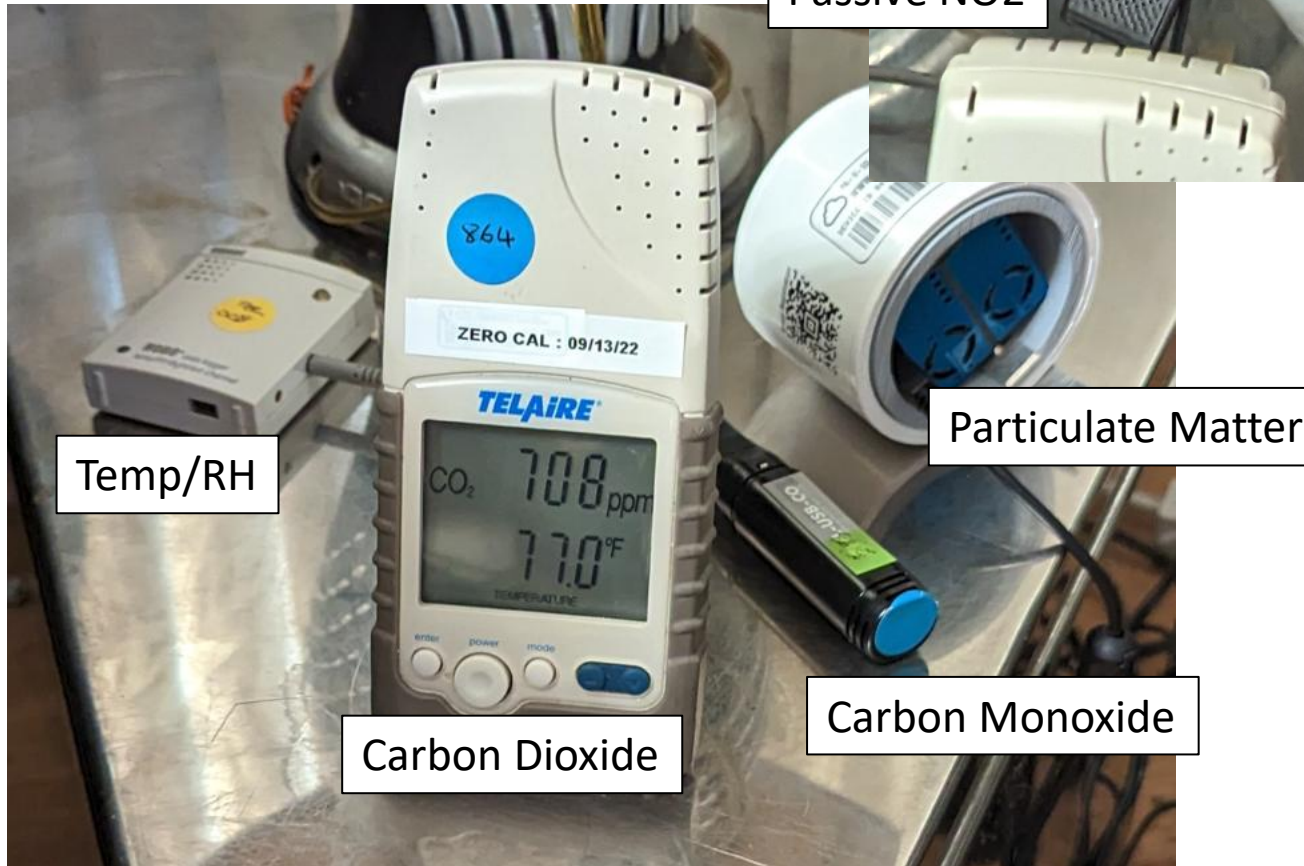
Study: The Plan

- Monitor IAQ inside and outside the home for 1-week pre and post weatherization in the heating season

IAQ Sensors

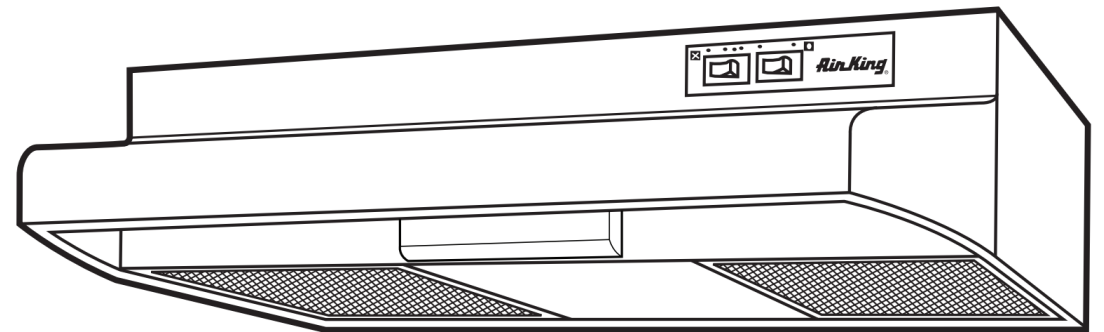


IAQ Sensors



Study: The Plan

- Track:
 - Cooking activity
 - Existing exhaust fan use (bath/range hood)
 - Exterior entryways (door/windows)
- Install 62.2 continuous range hood (Air King ECQ series)
 - Type: under cabinet
 - Sizes: 30", 36"
 - Finishes: white, black, stainless steel
 - On-demand: 150/250 CFM
 - Continuous speeds: 30, 50, 70, 90 CFM



Study Challenges

- Characteristics of WAP participants:
 - Gas stoves (<50% have gas cooking)
 - Smoking exclusion (weatherization clients are more likely to smoke)
- Kitchen range hood installation challenges (real and imagined)
- Finding kitchens that were suitable for the available range hoods

Study Challenges

- Global Pandemic
 - Delayed the project start
 - Disrupted production schedules for weatherization agencies
 - Created supply chain issues with the range hoods

Chicago Tribune

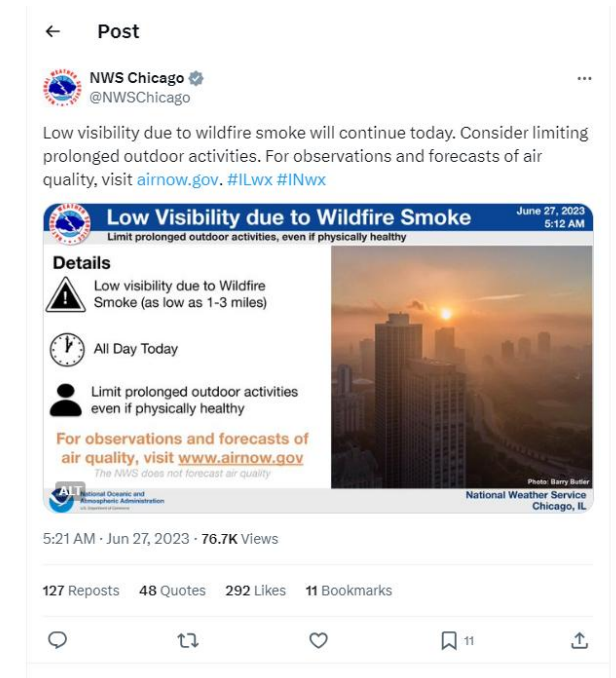
[Health](#) | Gov. J.B. Pritzker issues order requiring...

NEWS > HEALTH

Gov. J.B. Pritzker issues order requiring residents to 'stay at home' starting Saturday

Study Challenges

- Global Pandemic
 - Delayed the project start
 - Disrupted production schedules for weatherization agencies
 - Created supply chain issues with the range hoods
- Wildfires in Canada

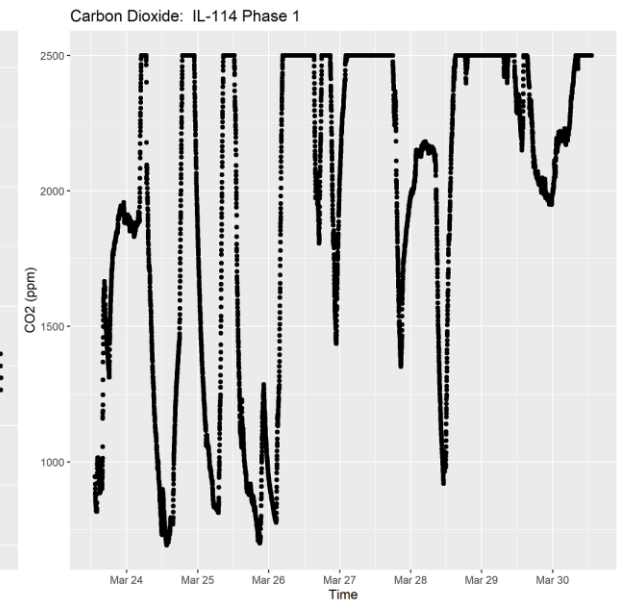
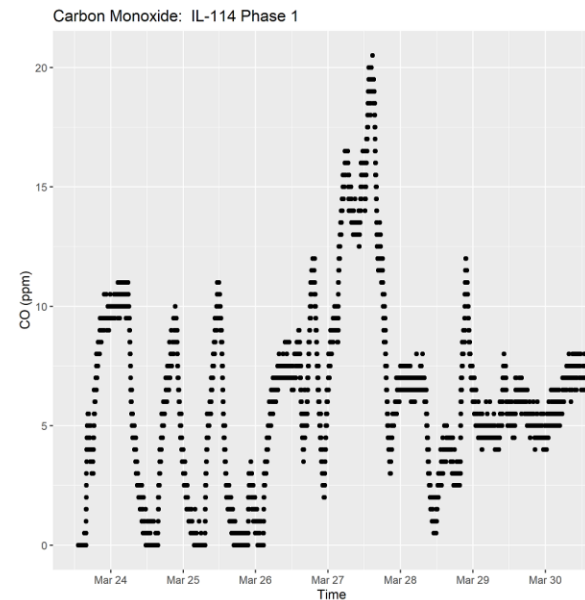


Study: The Reality

- 60 homes enrolled (53 in IL, 6 in CO); 48 homes completed the study.
 - Completions per arm:
 - 31 x ASHRAE 62.2 bath fan (30 suitable for analysis)
 - 17 x ASHRAE 62.2 range hood
 - Reasons for attrition:
 - Ineligible (4) e.g., smoking
 - Oven used as heater (1)
 - Homeowner schedule (3)
 - Production schedule (4)

Study: The Reality

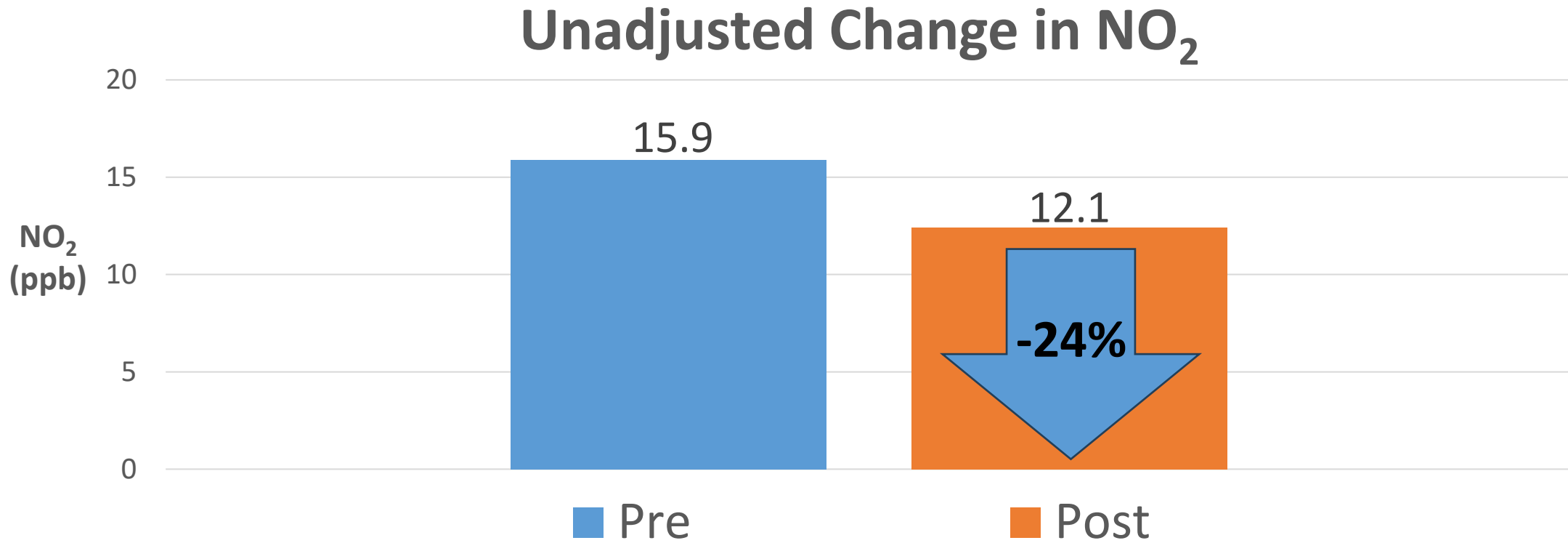
- 60 homes enrolled (53 in IL, 6 in CO); 48 homes completed the study.
 - Completions per arm:
 - 31 x ASHRAE 62.2 bath fan
 - 17 x ASHRAE 62.2 range hood
 - Reasons for attrition:
 - Ineligible (4) e.g., smoking
 - **Oven used as heater (1)**
 - Homeowner schedule (3)
 - Production schedule (4)



Study: Analysis Complication

- 82% of Kitchen arm homes (14 / 17) had exterior venting hoods at baseline, including 7 study fans installed at baseline and set to on-demand mode
- 33% of Bath arm (10/30) also had existing on-demand exterior venting hoods.

WHAT WE FOUND



Multi Variate: Effect of fans on NO₂

- The use of an exterior exhausting kitchen range hood during at least 50% of meals cooked was associated with lower NO₂ levels. This included the:
 - Continuous venting range hoods we installed
 - Existing on-demand range hoods residents used
- Based on this analysis (which also controlled for number of occupants), a **continuously venting range hood reduced NO₂ levels by 28%** in a home that did not use a range hood at least 50% of the time previously.
- A **continuous bath fan would reduce NO₂ levels by 17%**. (2.7 ppb) reduction.
- Homes with both fans in use had a **40%** reduction in NO₂ (6.4 ppb)

Other Observations

- Peak 1 hour **carbon monoxide** level declined 71% in homes with a continuously exhausting range hood.
 - Bath fans did not have a significant effect
- Peak **1 hour carbon dioxide** level declined 16% in the average home after continuous fan installation, regardless of location.
- The **mean carbon dioxide** level declined 11% after continuous fan installation, regardless of location.
- **Fine Particulate Matter** levels were not affected by fan installation.

Interpretation

- Continuous range hoods removed cooking gases (NO_2 and CO) better than continuous bath exhaust.
- Gases from non-stove sources (CO_2), were not affected by fan location.
- The installation of a continuously venting range hood is therefore recommended.

Challenges for weatherization agencies

- Finding kitchens that were suitable for the available range hoods was difficult with 15 reassignments from kitchen to bath arm
- More variety in range hoods compared to bath fans, and they have specific installation requirements
 - e.g., under cabinet range hoods require a good condition cabinet to duct through
- Limited selection of range hoods exist that comply with 62.2 as well have multiple continuous flow settings
- Some kitchen requirements differed between agencies depending on customer needs
 - e.g., will only duct through attic to minimize cold air complaints

Challenges for weatherization agencies

- Agencies and contractors have more experience in installing and evaluating bath fans than range hoods for 62.2
- 3 range installs were reported to agencies due to insufficient flow rates measured by research staff
 - Installs achieved 62.2 but on-demand flow rates were being constricted
- Value to customer if installing new or replacing old range hood, more difficult to say when replacing over the range microwave
- Need to improve guidance for assessors to determine which fan option works best for their situation

Conclusions

- Limitation: Study lacked a large group of “pure cases” where homes went from no range hood use to continuous kitchen exhaust. A follow-up study would be warranted to confirm our results.
- Agency barriers to installing a range hood where one does not currently exist must be addressed before widespread adoption.
- We project NO₂ levels would fall from 15.9 to 11.4 ppb in the average home in this study after continuous range hoods installation.
 - 11 ppb is higher than the NO₂ levels observed in homes with electric stoves.
 - 11 ppb higher than 6 ppb threshold for asthma effects that Belanger reported.
- Electrification is a better option

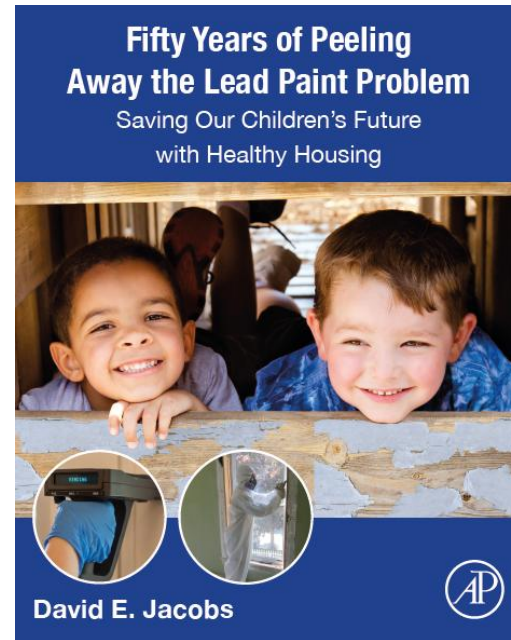
CREDITS

- Thanks to the households in Illinois and Colorado who participated by allowing us to:
 - conduct air sampling in their homes for two weeks
 - answer questions about their daily household activities
- Thanks to HUD for funding this research (Grant no: MDHHU0051-19) and Gene Pinzer (program officer)
- Thanks to weatherization agencies and energy efficiency providers in Colorado Springs, CO (ERC); St. Clair Co, IL (SCCCAA), and the Chicago metro area (CEDA and UEG) for their support in finding homes and installing exhaust fans

Preview PHAMOUS Study

- (Passive House Asthma Mitigation by Optimizing Unique Building Systems)
- Study hypothesis PH dwellings will have lower indoor PM2.5 levels than those observed in control group dwellings with exhaust-only ventilation
- PH units very tight building envelopes to reduce infiltration of outdoor PM2.5
- PH units have continuously running balanced ERVs with a high efficiency filter
- Over 100 units
- Findings to be presented at next year's conference

Thank You!



Dave Jacobs, PhD, CIH
Chief Scientist, National Center for Healthy Housing
Adjunct Associate Professor, University of Illinois Chicago School of Public Health
Djacobs@nchh.org

www.nchh.org ♦ [@NCHH](https://twitter.com/NCHH) ♦ facebook.com/HealthyHousing

National Center for **HEALTHY HOUSING**