National Energy & Utility Affordability Coalition

Shelly L. Miller, Professor
Mechanical Engineering

June 7, 2016

University of Colorado
Boulder

Hogares Sanos, Niños Sanos

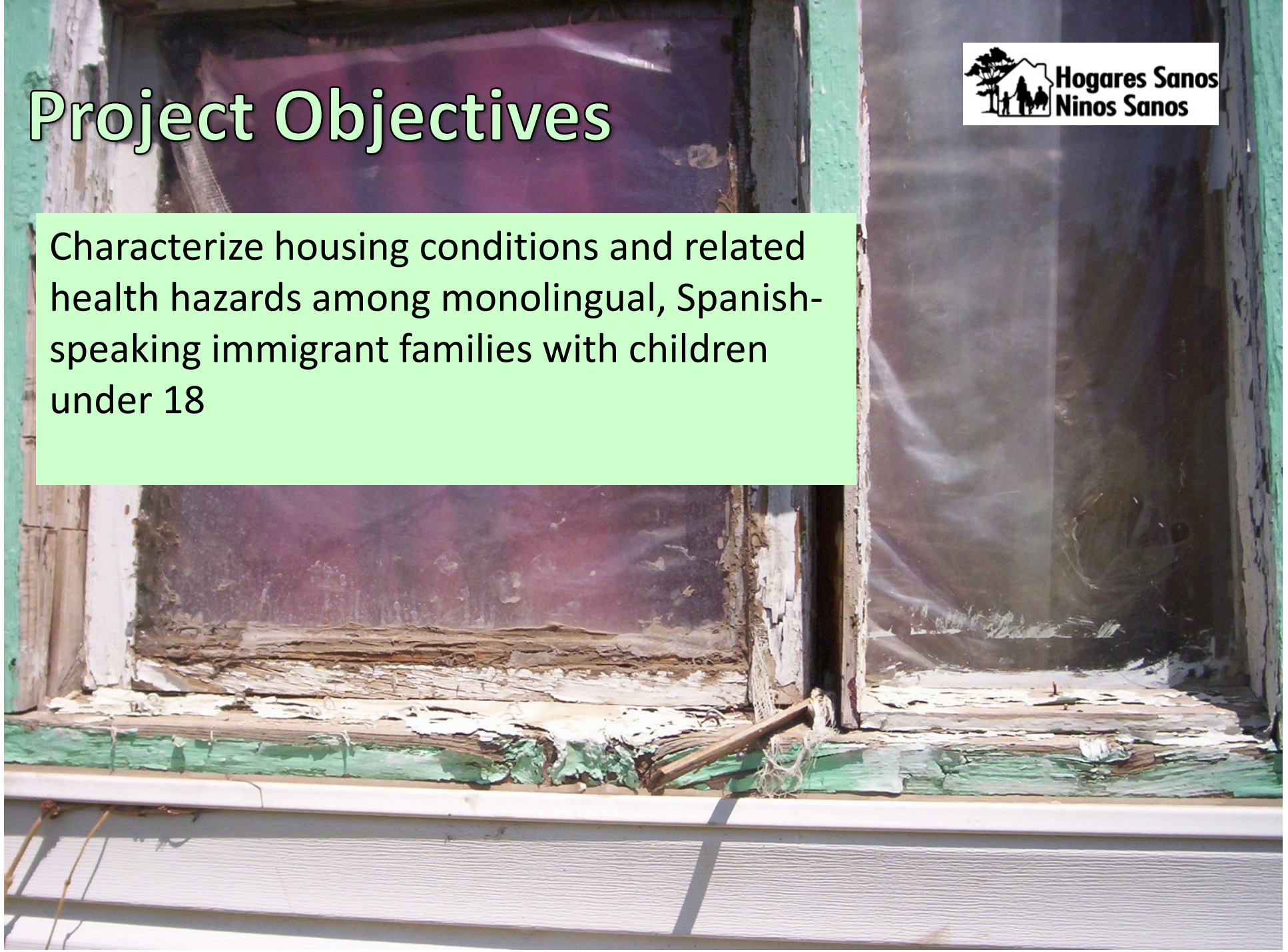
Home Environments, Safety Practices, and Indoor Air Quality Among Recent Mexican Immigrant Families: A Population-Based Study

Jill S. Litt, Carolyn DiGuiseppi, Shelly L. Miller

Colorado School of Public Health
University of Colorado Boulder

Grant support: The US Department of Housing and Urban Development (No. COL-HH0123-04)

Project Objectives



Hogares Sanos
Ninos Sanos

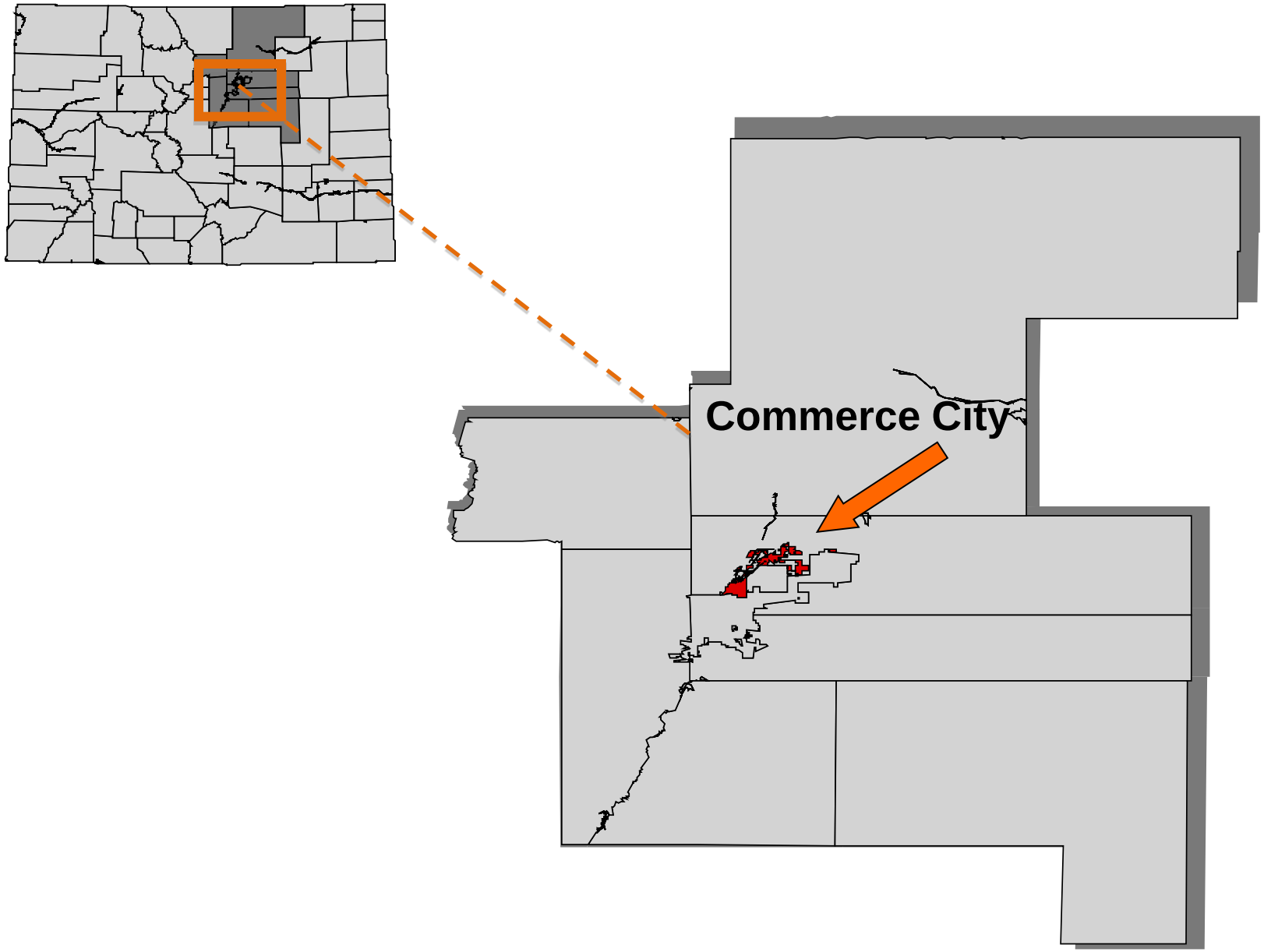
Characterize housing conditions and related health hazards among monolingual, Spanish-speaking immigrant families with children under 18

Why Housing Conditions?

- Hazards in the home have been shown to cause adverse health effects among children
  - Underlying causes are rooted in structural and maintenance issues, heating, water damage, and excess moisture, etc.
- Home hazards tend to concentrate in deteriorated housing in low-income and/or transitional neighborhoods

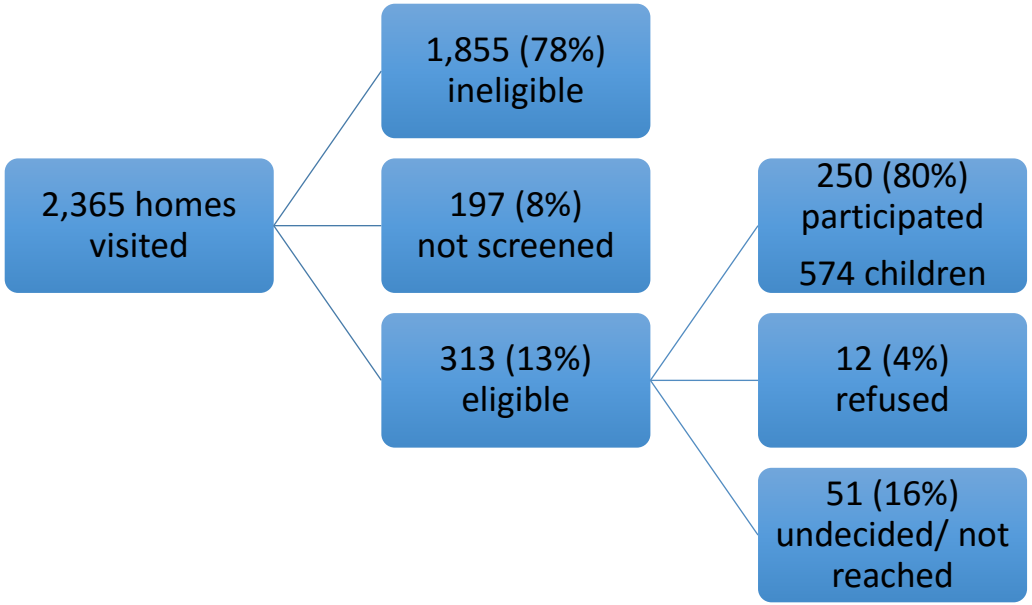
Citations: Lanphear (2002); Brunekeef (1989); DiGuiseppi (1998); Shai (2006); Jacobs (2002); Klitzman, S. (2007)

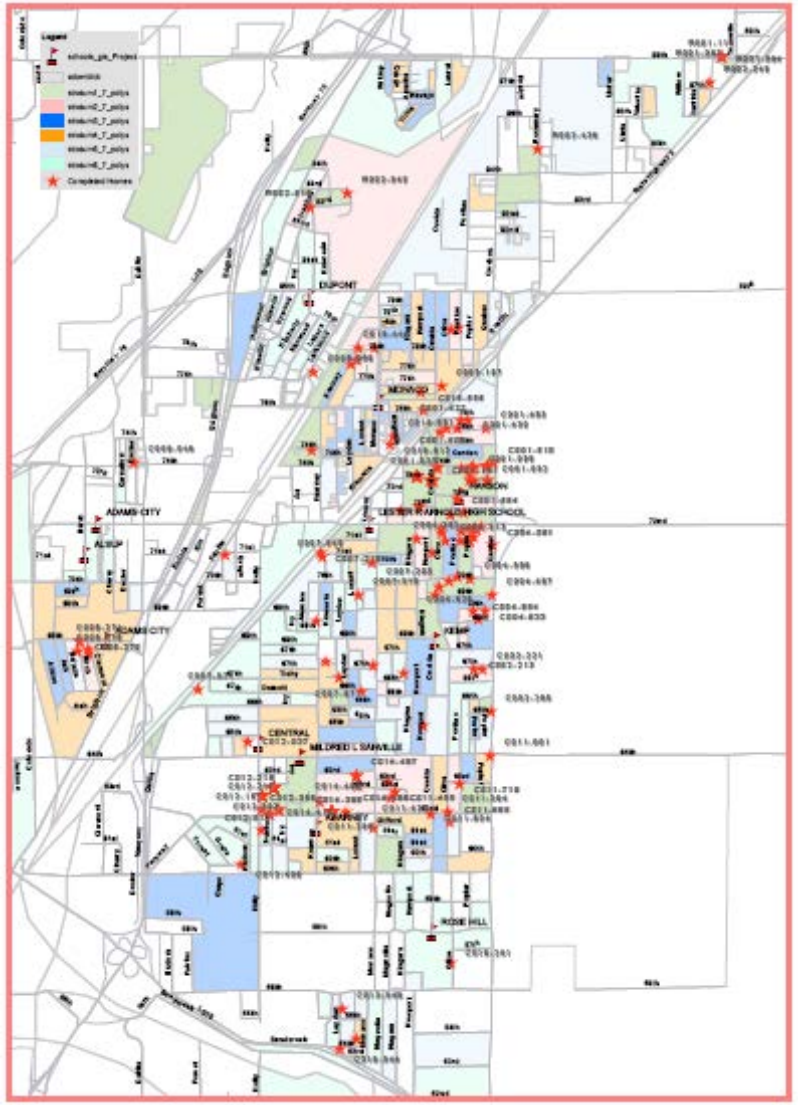
Study Area: Commence City, CO



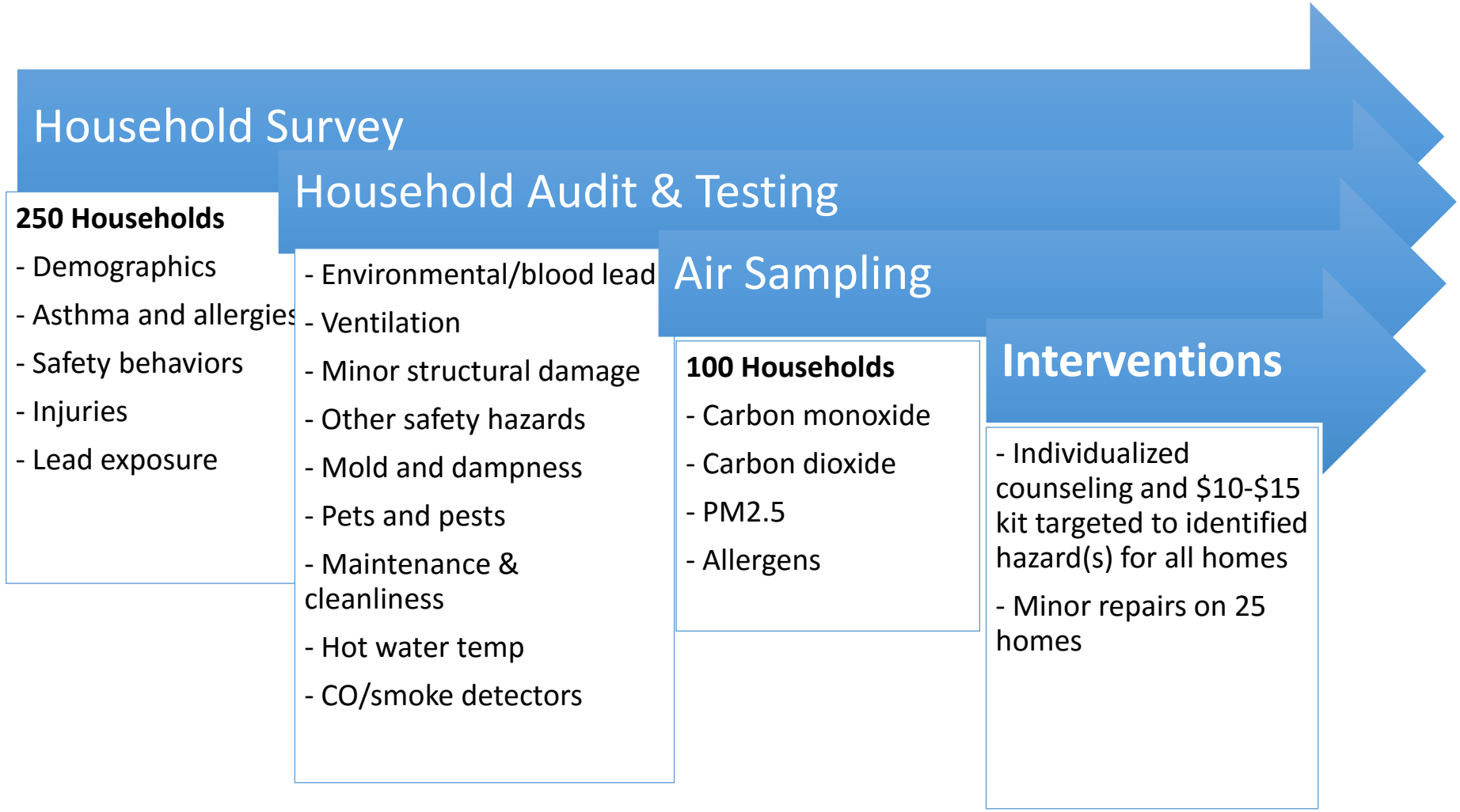
Home Weatherization
INDOOR AIR QUALITY & HEALTH

Survey Recruitment and Participation





Data Collection Framework



Major Conclusions

Hogares Sanos
Ninos Sanos

- Most homes of urban monolingual Spanish-speaking immigrant families with children have multiple problems
  - Moisture and mold (60%), safety hazards (99%), and inadequate ventilation potential (72%)
  - Owner-occupied homes had greater safety risks than rented homes, due to differences in type and age of homes
- Overcrowded homes were at risk for poor indoor air quality
  - CO_2 levels quite high (> 1000 ppm), $PM_{2.5}$ almost 5 times higher than outdoor air, 3% of homes had elevated CO, allergen levels very low, no impacts from smoking or cooking
  - Can improve air quality by opening windows or doors

Home Weatherization
INDOOR AIR QUALITY & HEALTH

Asthma and Atopy

Hogares Sanos
Ninos Sanos

- Prevalence low among sample children (5%)
  - “Healthy immigrant” effect? One-third of children foreign-born
- Interactions between genetic susceptibilities and environmental factors in native and host countries may help explain low prevalence.
- Differences in perception of reported symptoms (rooted in cultural and linguistic differences) may also influence prevalence.
- Asthma and atopic symptom prevalence is partially explained by housing and indoor environmental conditions, not explained by indoor air measurements.

Home Weatherization
INDOOR AIR QUALITY & HEALTH

Unsafe and unhealthy housing conditions may be due to:

- Lack of safe, affordable housing
- Crowding
- Lack of financial resources for repairs due to low income
- Less knowledge about risks due to low education
- Less exposure to safety messages due to language barriers, lack of healthcare access
- Cultural differences in perception of risk, preventability

Home Weatherization
INDOOR AIR QUALITY & HEALTH

Implications

- Conditions among recent immigrant housing are amenable to intervention.
- Solutions must be multi-faceted and include strategies that target household-level improvements and access to health care.
- Partnerships with local housing authorities, public health organizations, health clinics and NGOs are necessary to:
  - Raise awareness of housing and child health needs;
  - Develop healthy housing policies and approaches that remediate homes and address the wide range of hazards in substandard housing; and
  - Maximize reach within immigrant communities and sustain programs over time.

Home Weatherization
INDOOR AIR QUALITY & HEALTH

Weatherization & Indoor Air in Low-Income Single Family Homes in Denver, Colorado

Shelly L. Miller, Jamie L. Humphrey, Prateek Shrestha, John Adgate, Elizabeth Carlton, Elisabeth Root

Colorado School of Public Health
University of Colorado Boulder
The Ohio State University

Grant Support: US Environmental Protection Agency (No. RD 83575201)

Research Questions

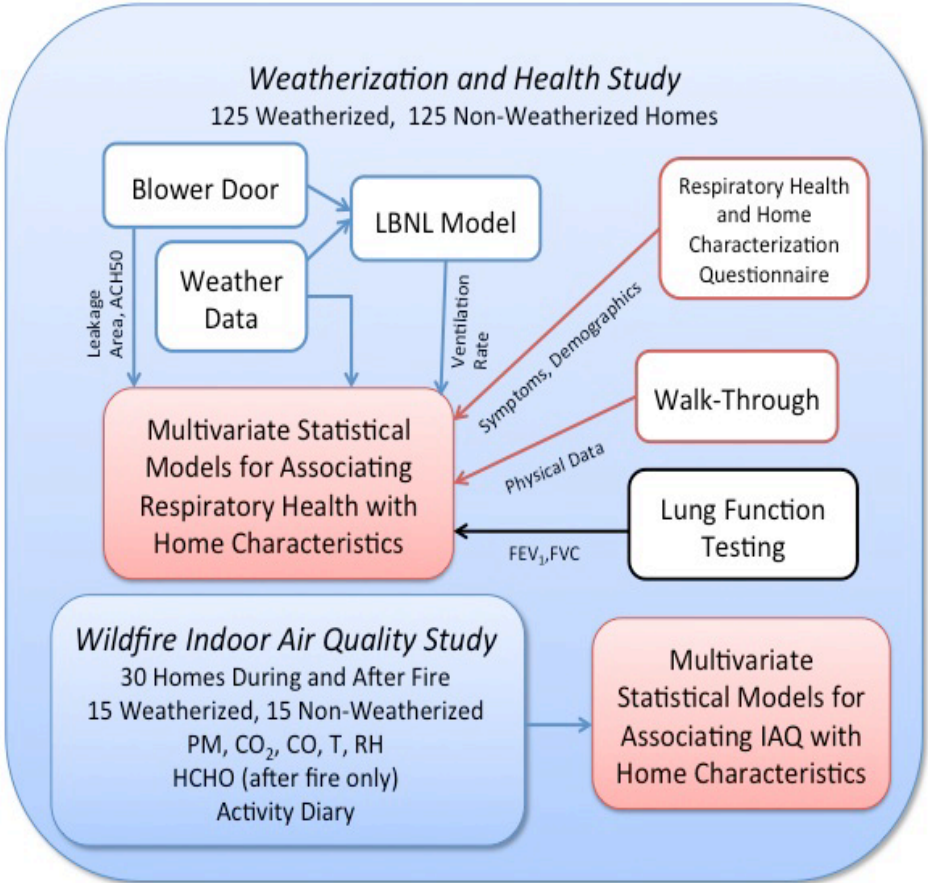
1. Is home weatherization, and associated changes in indoor air quality, related to respiratory health?

2. Does home weatherization protect occupants against pollutants generated by wildfires?

Home Weatherization
INDOOR AIR QUALITY & HEALTH

Study Design

- **Main Study**
  - 125 weatherized; 125 non-weatherized homes
    - Low income, LEAP qualified, non-smoking households, single-family homes, renter or owner
    - Characterizing weatherization, home ventialation, and respiratory health
    - Front range
- **Fire Study**
  - 15 weatherized; 15 non-weatherized homes
    - Indoor & outdoor air quality monitoring during and after wildfire



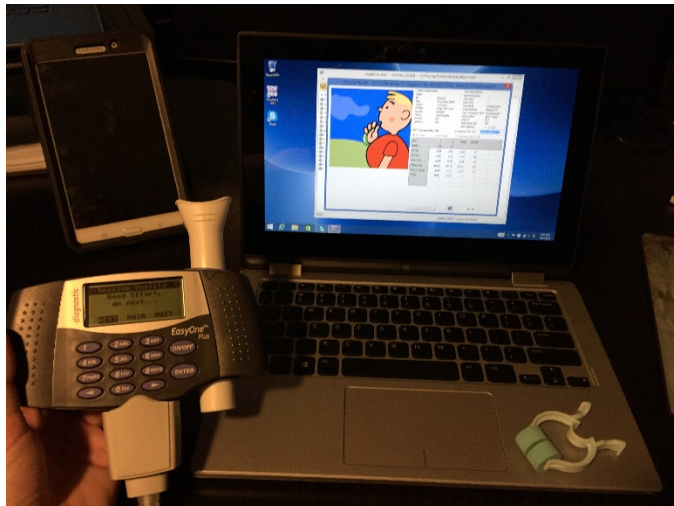
Home Visit: Engineering Team

- 2 hours, 2 engineers
- ACH50 – infiltration at 50 Pa
  - Measure of leakage area
  - Relatively constant
  - Can be link to infiltration rate through LBNL model
- Walk-Through Inspections
  - Ventilation
  - Emergency Efficiently Upgrades
- Carbon Monoxide
- GPS




Home Visit: Respiratory Team

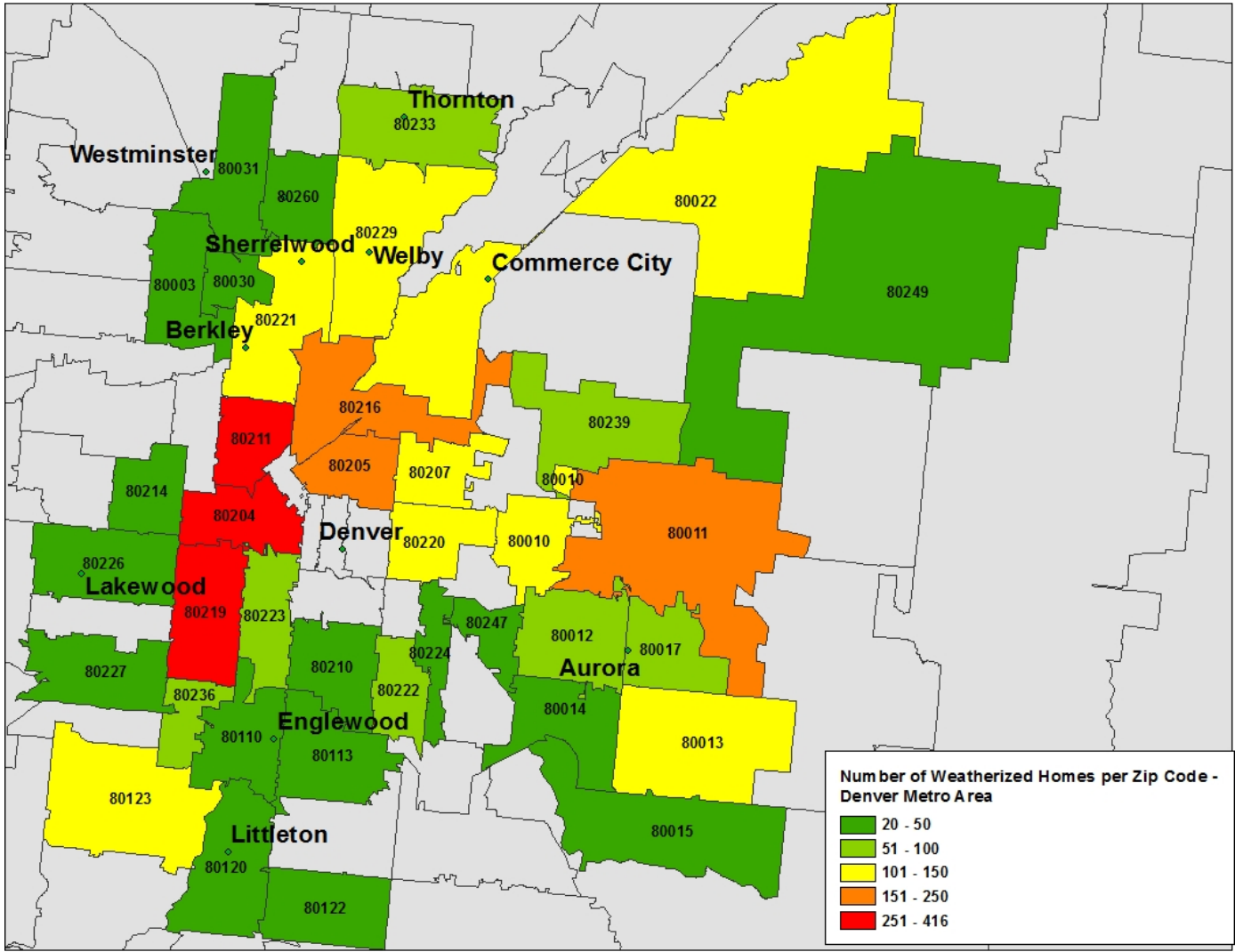
- Informed Consent, Household Roster,
- Lung Function Test – FEV1, FVC, FEV1/FVC,
  - NDD EasyOne Plus Spirometer
- Respiratory & Smoking Questionnaires
- Results & Recommendations
  - List of Weatherization Activities
  - Healthy Indoor Air Checklist
  - Local Resource
  - Results: Lung Function Test
  - Results: Blower Door Test



Geographic Distribution & Response Rates

- 55 Homes
  - 31 weatherized
  - 24 control
- West Side of Denver
  - 80219, 80204, 80211

- THIS SLIDE WILL CHANGE



Results: Demographics

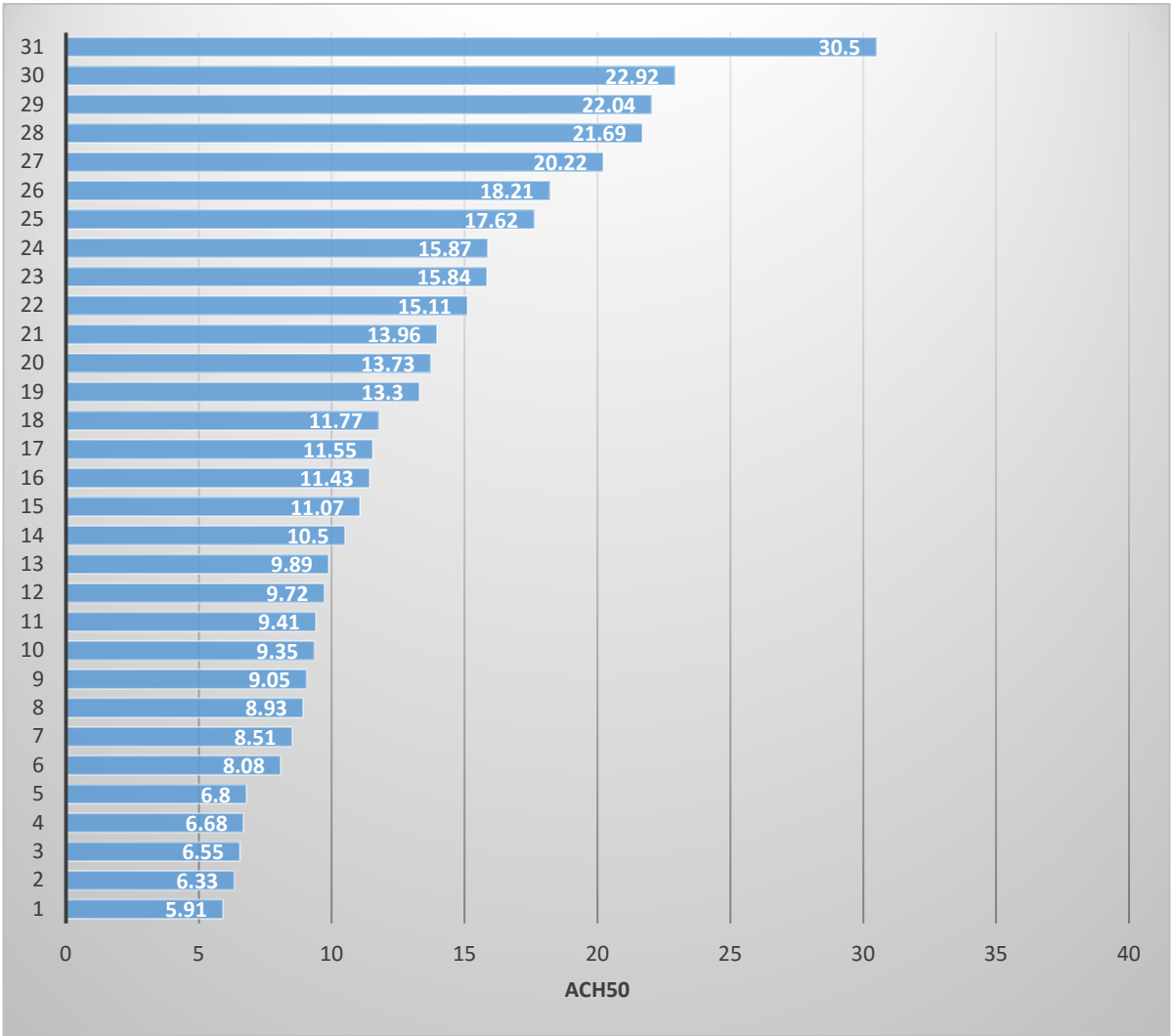
- Breakdown
  - Homes, weatherized, control, participants
- Asthma
- Abnormal spirometry
- Smoking Status
- Sex
- Age
- BMI
- Race/Ethnicity
- THIS SLIDE WILL CHANGE

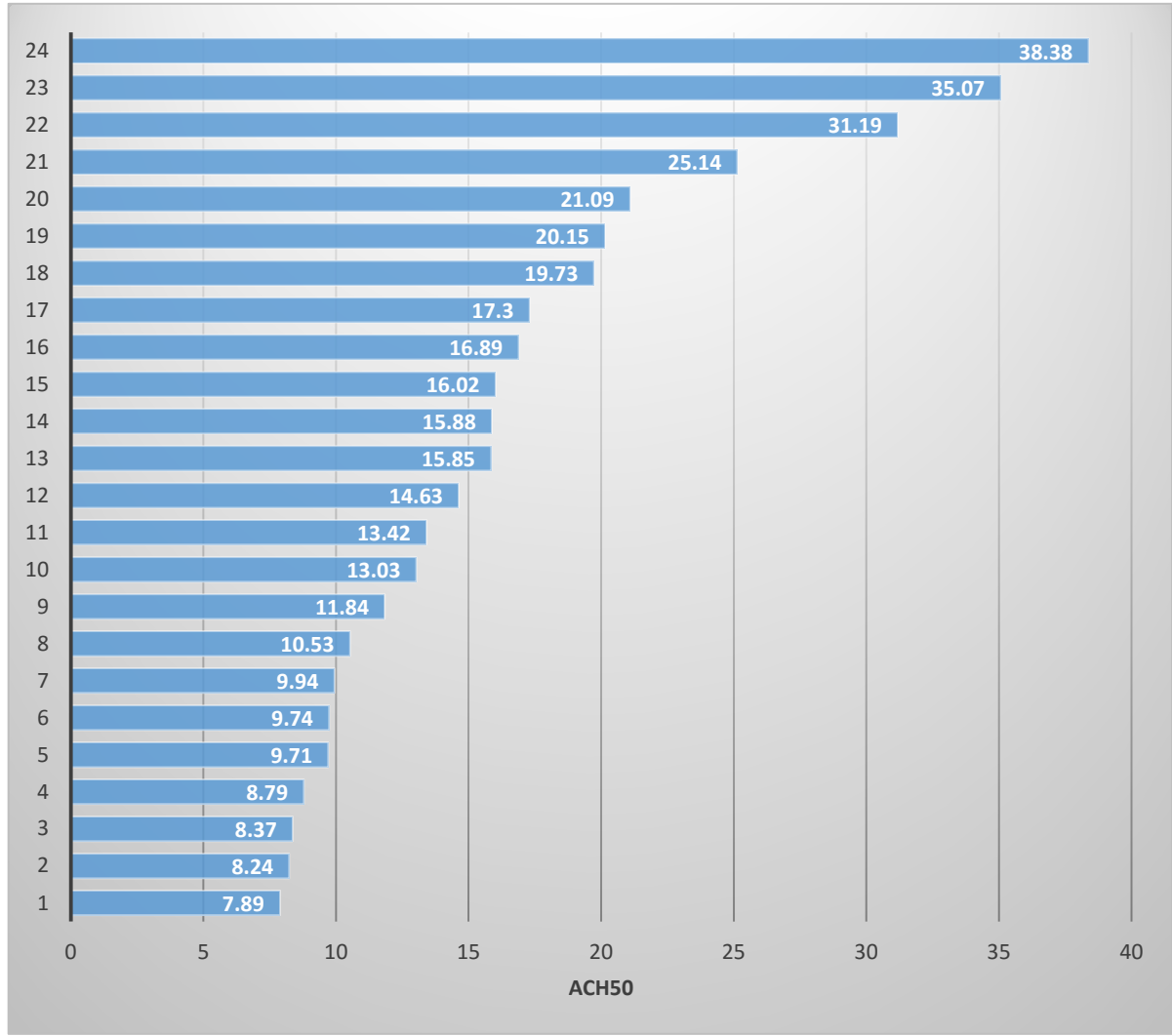
Home Weatherization
INDOOR AIR QUALITY & HEALTH

Results: ACH50

Weatherized				
Min	Mean	Median	Max	STD
5.91	12.99	11.43	30.50	5.88

Control				
Min	Mean	Median	Max	STD
7.89	16.62	15.24	38.38	8.46

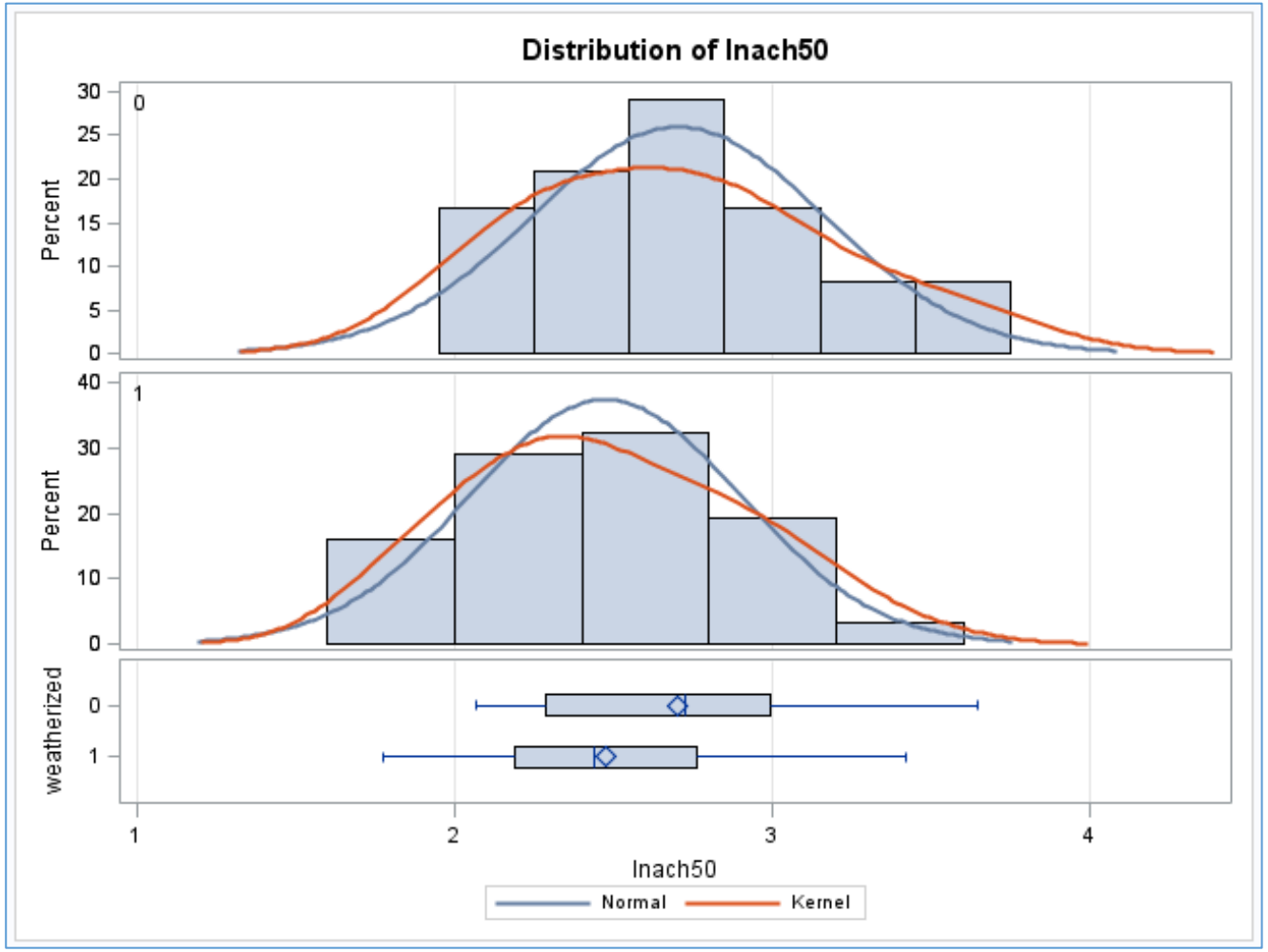




Results: ACH50 x Weatherized

- **Mean difference in Log Ach50 - Weatherized vs. Control**

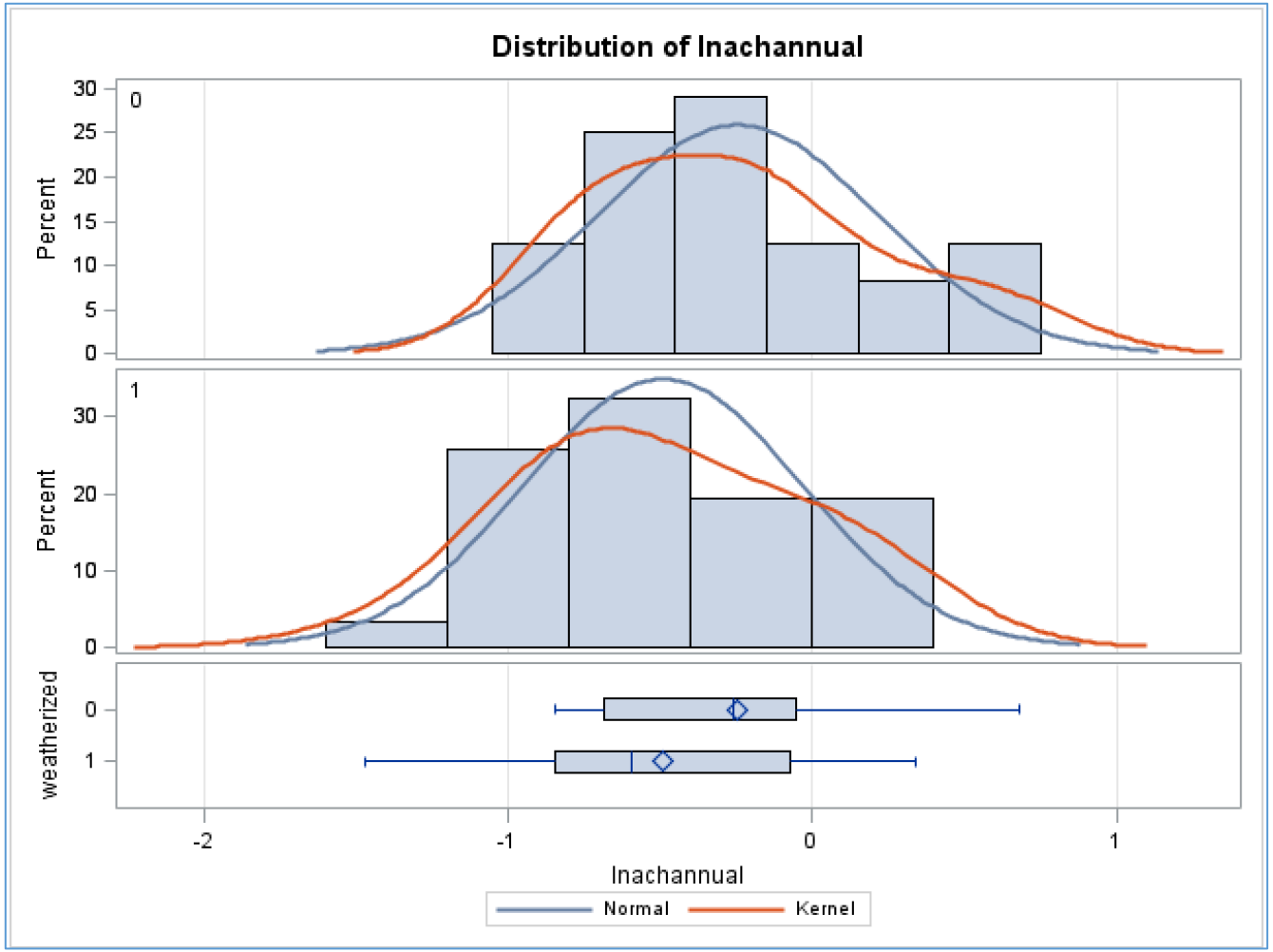
Weatherized	N	Mean	SD	SE	Min	Max
No	24	2.70	0.46	0.09	2.07	3.65
Yes	31	2.47	0.43	0.08	1.78	3.42



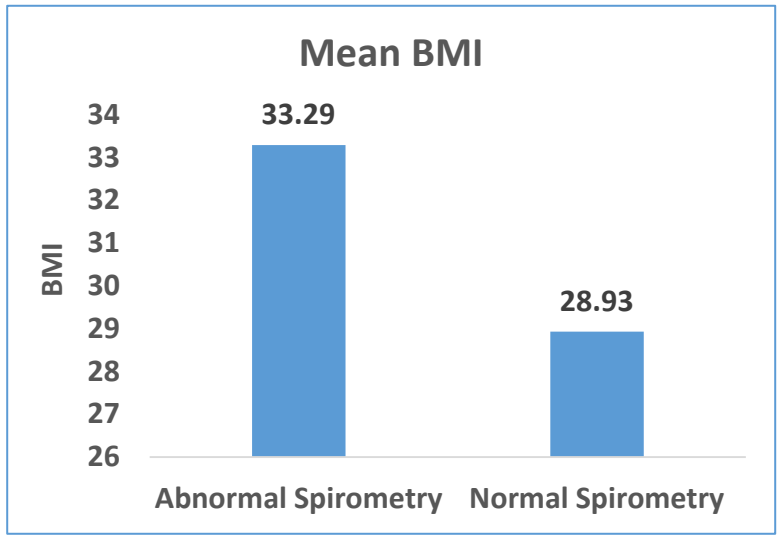
Results: ACH Annual x Weatherized

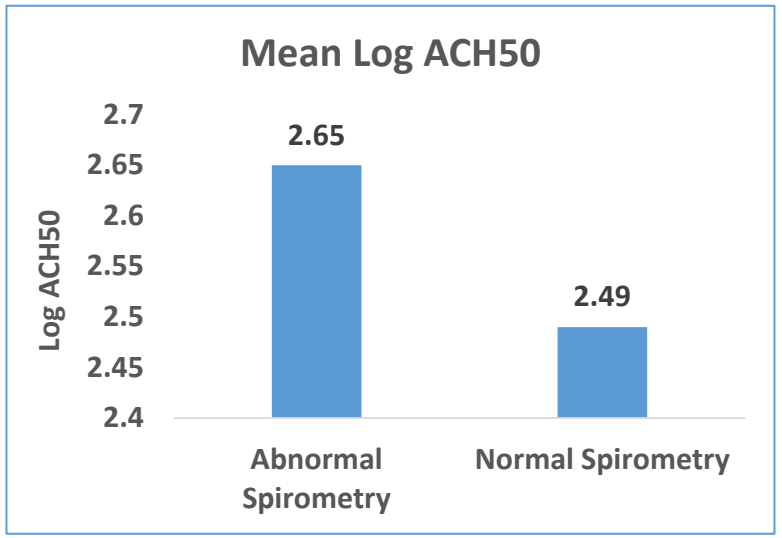
- **Mean difference in Log Annual ACH - weatherized vs. Control**

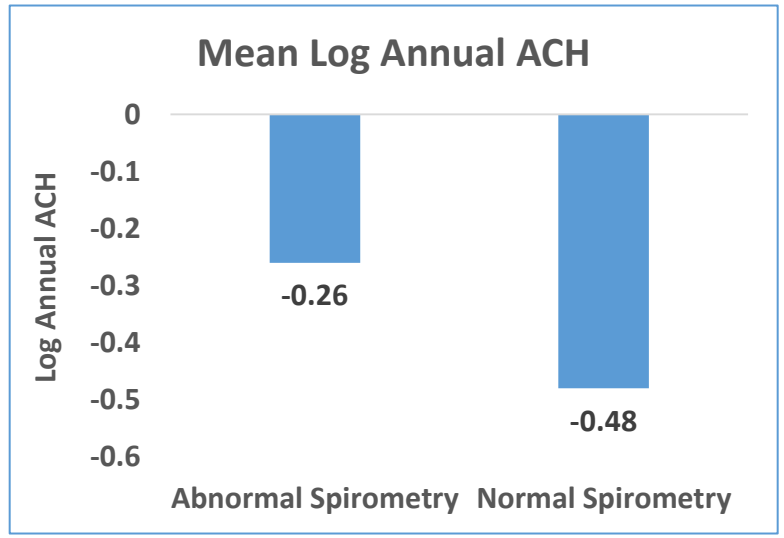
Weatherized	N	Mean	SD	SE	Min	Max
No	24	-0.25	0.46	0.09	-0.84	0.68
Yes	31	-0.49	0.46	0.08	-1.47	0.34



Results: Respiratory Health

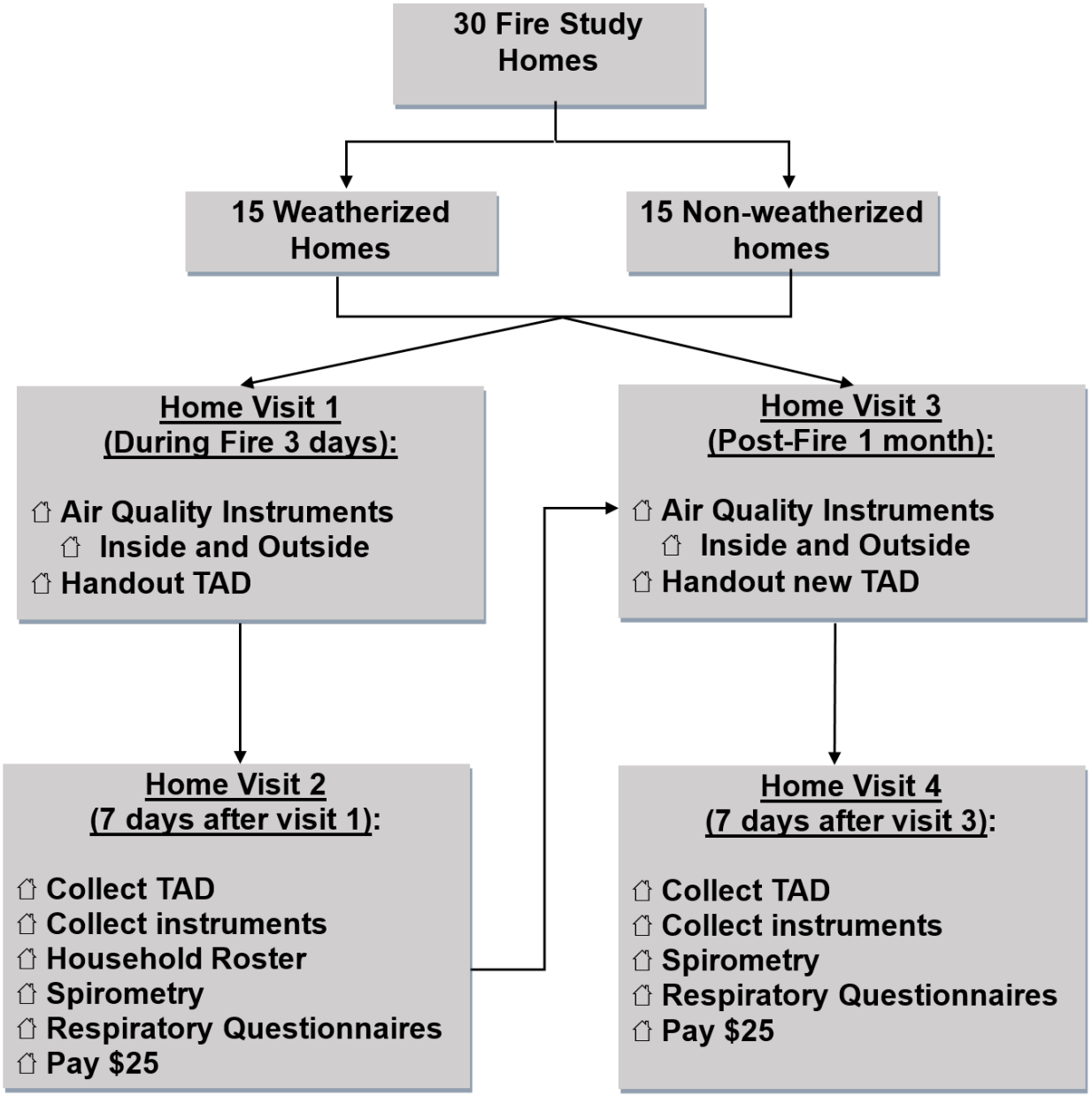






Fire Study

- Gaseous and particulate concentration logging
  - CO, CO_2, NOX, HCHO $PM_{2.5}$, O_3, Temp, RH%



Activity: Windows and/or Doors Open

Day 1	Location	Morning	Afternoon	Evening	Early Morning (Night time)
(M) T W Th F Sa Sun	Kitchen	5 (6) (7) 8 9 10 11	12 1 2 3 4 5	6 7 8 9 10 11	12 1 2 3 4
	Living Room	5 (6) (7) (8) 9 10 11	12 1 2 3 4 5	6 7 8 9 10 11	12 1 2 3 4
DATE	Bedroom	5 6 7 8 9 10 11	12 1 2 3 4 5	6 7 8 9 10 11	12 1 2 3 4
___/___/___	House Empty	5 6 7 8 9 10 11	12 1 2 3 4 5	6 7 8 9 10 11	12 1 2 3 4

Home Weatherization

Information on the Air-Tightness of your house

Thank you for participating in our research study. This form has information about the blower door test that we performed at your house, which gave us an idea of how air-tight your house is.

What do the results mean?

The results of a blower door test are displayed in terms of **ACH50**, which refers to the ***Air Changes per Hour*** (ACH) occurring at a pressure differential of 50 Pascal between the interior and the exterior of the house. The lower values of ACH50 indicate a good level of air-tightness of your house, whereas a higher value of ACH50 indicates a leakier house.

The ranges of ACH50 for different leakiness values are as follows:

ACH 50	What does it mean?
< 1.5	Very tight (requires installation of fans to bring in adequate fresh air into the house)
1.5 to 3	Tight (also requires fan installations to bring in adequate fresh air into the house)
3 to 6	Typical, pretty good new construction or retrofit
6 to 10	Leaky
10 to 20	Very leaky (A lot of energy is being wasted trying to heat and cool the leaking air)

- **During the test we conducted at your house, we found that the ACH50 was _____**

Our comments/recommendation:

- Your home is too air-tight. This may cause health problems to you and your family. Please contact your home weatherization service provider to consult about installing a mechanical ventilation system.
- Your home is too leaky. You are wasting a lot of energy (electricity) trying to heat your place during winters and cool your place during summers, and a lot of that energy just leaks out of your house and adds to your monthly utility bill. Try contacting your home weatherization service provider and seek home weatherization services and benefits to minimize the air leaks in your house.
- Your home is neither too tight, nor too leaky. No action required.

Test conducted by: Signature: _____

Print name here: _____

Date: _____

If you have any questions, please contact us at:
Website: **www.colorado.edu/cuweatherize**
Email: cuweatherize@colorado.edu
Phone: 720-668-0573

Home Weatherization

Information on Carbon Monoxide Testing

What is CO?

Carbon monoxide (CO) is an odorless, colorless toxic gas which is lighter than air and is produced from burning of fuels like gasoline, propane, natural gas, coal, wood, charcoal, or kerosene etc. in an insufficient supply of air or oxygen. Due to continued exposure to CO, people suffer from "CO poisoning" which can be lethal in extreme conditions.

What are the symptoms of CO Poisoning?

The first symptoms of low to moderate CO poisoning are similar to the flu (but without the fever). They include headache, fatigue, shortness of breath, nausea and dizziness. High level CO poisoning results in symptoms that become worse over time including mental confusion, vomiting, loss of muscular coordination, loss of consciousness and ultimately death. Because CO is odorless, colorless, and otherwise undetectable to the human senses, people may not know that they are being exposed.

What CO level is dangerous to my health?

CO concentration is measured in **ppm** or *parts per million* units. Just as per cent means out of a hundred, parts per million means out of a million. So, for example, 1 ppm of CO is the same as saying 1 gram of CO in 1 million grams of air (or, 0.0001% CO in air).

The National Standards require the level of exposure to CO to be **below 35 ppm** for a 1-hour average value. (http://www.epa.gov/ttn/naaqs/criteria.html)

Results from the test at your home: Today, we used an instrument called the TSI-QTRAK to measure the CO level at various locations within your home. After measuring CO levels at every room, we chose a location with the highest reading and left the instrument there to take continuous readings for 1 hour. We got the following results:

- **Highest CO level found in _____room, with a 1-hour average value of _____ ppm.**

Our comments/recommendation:

☐ The CO level in your home is too high. We recommend opening windows to the outside immediately. Keep the windows open until necessary changes have been made to the combustion appliances in your home. If you are experiencing any of the CO poisoning symptoms mentioned above, visit a medical professional as soon as you can and tell him/her that you suspect being exposed to higher than normal levels of carbon dioxide. Have professionals check and repair your
ces.
n required.

If you have any questions, please c
Website: **www.colorado.edu/cuw**
Email: cuweatherize@colorado.ed
Phone: 720-668-0573

Home Weatherization

Healthy Indoor Air Quality Checklist

Everyone can have a healthy home. A preventive, systematic approach to health, safety, and comfort is a homeowner's best defense against poor indoor air quality. This checklist shows some key action steps to take in each room and area of the home.

Bedrooms, Living Rooms, and Family Rooms

- Install smoke and carbon monoxide alarms
- If your home was built before 1978:
  - Test your home for lead paint

Kitchens

- Never use the stove or oven to heat the house
- Use a range hood fan or other kitchen exhaust fan that vents outside
- Install smoke and carbon monoxide alarms
- Stop cockroaches, ants, and mice without pesticides:
  - Starve them – put away food, clean up, cover the trash and garbage
  - Deny them water – fix leaks and wipe up spilled water

Bathrooms

- Clean up moisture and mold safely
- Use a bathroom exhaust fan that vents outside

Household

- Check for water leaks and water damage

Basement, Crawl Space, Utility and Laundry Areas

- Change furnace/AC filter every two months
- Have gas appliances and furnaces checked yearly to make sure they do not release extra carbon monoxide
- Make sure the clothes dryer vents outside
- Test for radon. If there's a high level, hire a specialist to eliminate the hazard. Contact Christine Kelly, the Radon Program Coordinator for the state of Colorado, to obtain free/inexpensive radon testing. 303-692-3442.

Test Conducted by: Signature: _____

ame here: _____

_____

If you have any questions, please contact us at:
Website: **www.colorado.edu/cuweatherize**
Email: cuweatherize@colorado.edu
Phone: 720-668-0573

Home Weatherization

Interpreting the Lung Function Test Results

Spirometry can tell you how much air your lungs can hold. This can tell us how healthy your lungs are.

Today, we measured you **forced expiratory volume in one second (FEV1)** measurement. This is a measure of how much air can be exhaled in one second following a deep breath.

- Your FEV1 results are compared to what medical professionals expect for healthy individuals who are the same age, height, and sex as you.
- This tells us whether your lung functioning is "normal" or "abnormal."
- Health professionals consider FEV1 measurements to be normal when your lung function is at least as good as 80% of people like you; values under 80% are considered abnormal.
- Abnormal results may indicate a problem with your lungs.

Below, we've listed the spirometry results for each household member that we tested today.

Household Member	FEV1 Spirometry Result Normal or Abnormal

Our comments/ recommendation:

☐ At least one member of the household was identified to have an abnormal FEV1 Spirometry result. We recommend that you seek advice from a medical professional regarding your lung functioning.

☐ Lung function test of all the members were normal. No action required.

Test Conducted by: Signature: _____

Print name here: _____

Date: _____

If you have any questions, please contact us at:
Website: **www.colorado.edu/cuweatherize**
Email: cuweatherize@colorado.edu
Phone: 720-668-0573

Home Weatherization

Weatherization Activities List

We found by inspection the following weatherization activities done at your house:

- ☐ Main entrance door weather stripping
- ☐ Other door weather stripping (door to outside)
- ☐ Weather stripping in windows
- ☐ Window caulking around window pane
- ☐ Window caulking around window frame
- ☐ Attic insulation
- ☐ Water heater tank insulation
- ☐ Foam sealing of cracks and openings
- ☐ Ductwork sealing if ductwork present
- ☐ Mechanical ventilation system installed
  - ☐ It is operating
  - ☐ It is sealed to outdoors correctly

Comments:

_____

_____

_____

_____

_____

_____

_____

Test Conducted by: Signature: _____

Print name here: _____

Date: _____

If you have any questions, please contact us at:
Website: **www.colorado.edu/cuweatherize**
Email: cuweatherize@colorado.edu
Phone: 720-668-0573

Home Weatherization

INDOOR AIR QUALITY & HEALTH

THANK YOU!

Shelly.Miller@Colorado.Edu