Formaldehyde in New Homes

Ventilation vs. Source Control

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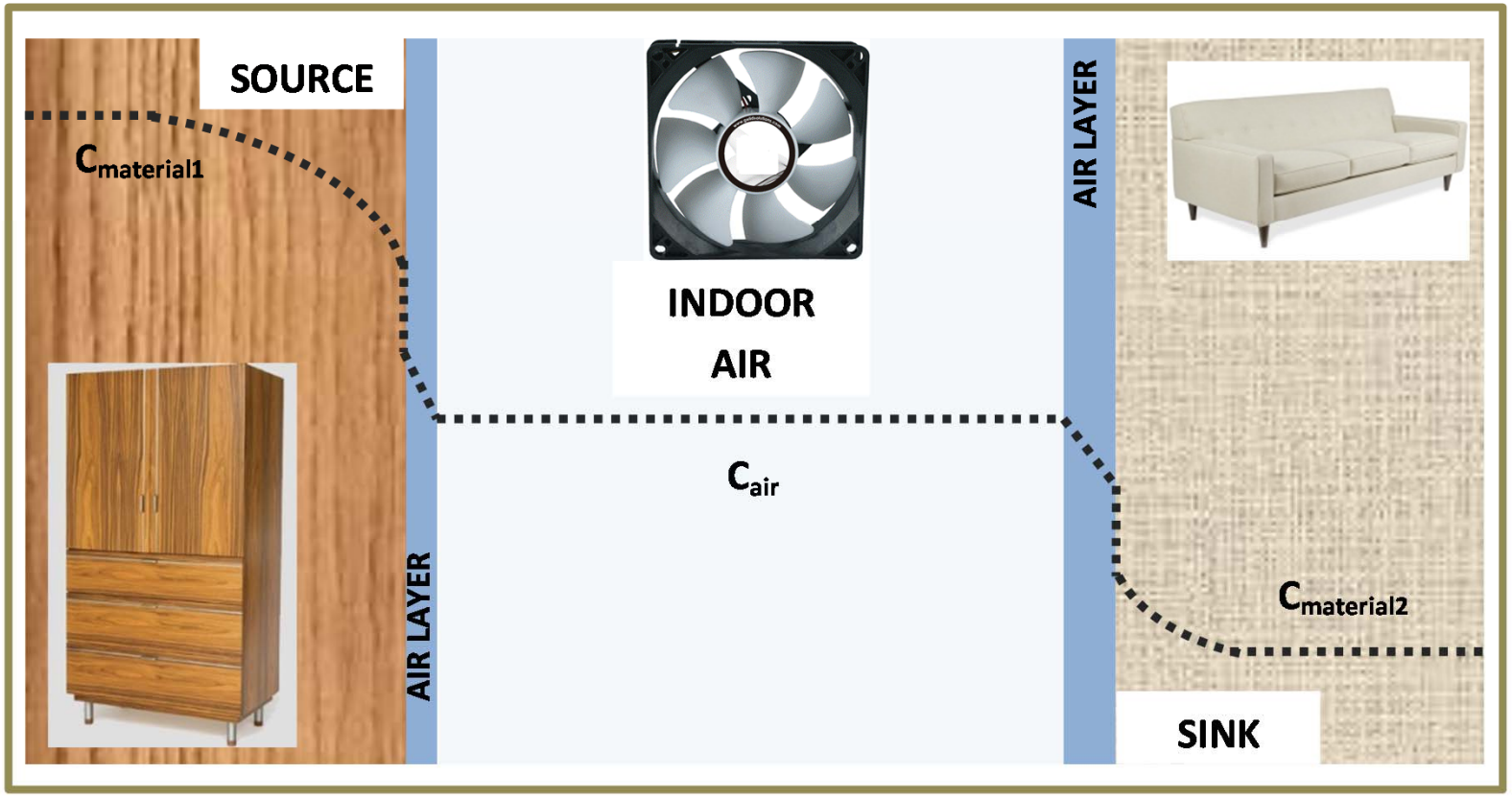
  - Cal. Energy Commission Public Interest Environmental Research
- **Technical Contributions**
  - Fraunhofer
  - Ibacos
  - IEE-SF
- **LBNL Team**
  - Sherman, Hotchi, Russell, Stratton, and Others

Background 1

- Formaldehyde is an irritant and a carcinogen
- Odor threshold: about 800 ppb
- Widely varying health standards
  - US HUD (8-h): 400 ppb
  - Germany: 100 ppb
  - WHO, Japan (0.5-h): 80 ppb
  - Sweden (0.5-h): 50 ppb
  - Canada (8-h): 40 ppb
  - California ARB (8-h): 27 ppb
  - US NIOSH (8-h): 16 ppb
  - CA OEHHA (chronic): 7.5 ppb
- *Goal is to reduce / minimize exposure, may not be viable to declare homes “safe” from formaldehyde

Physics of Formaldehyde Emissions



- Formaldehyde in bulk material, diffuses to surface
- Conventional Understanding:

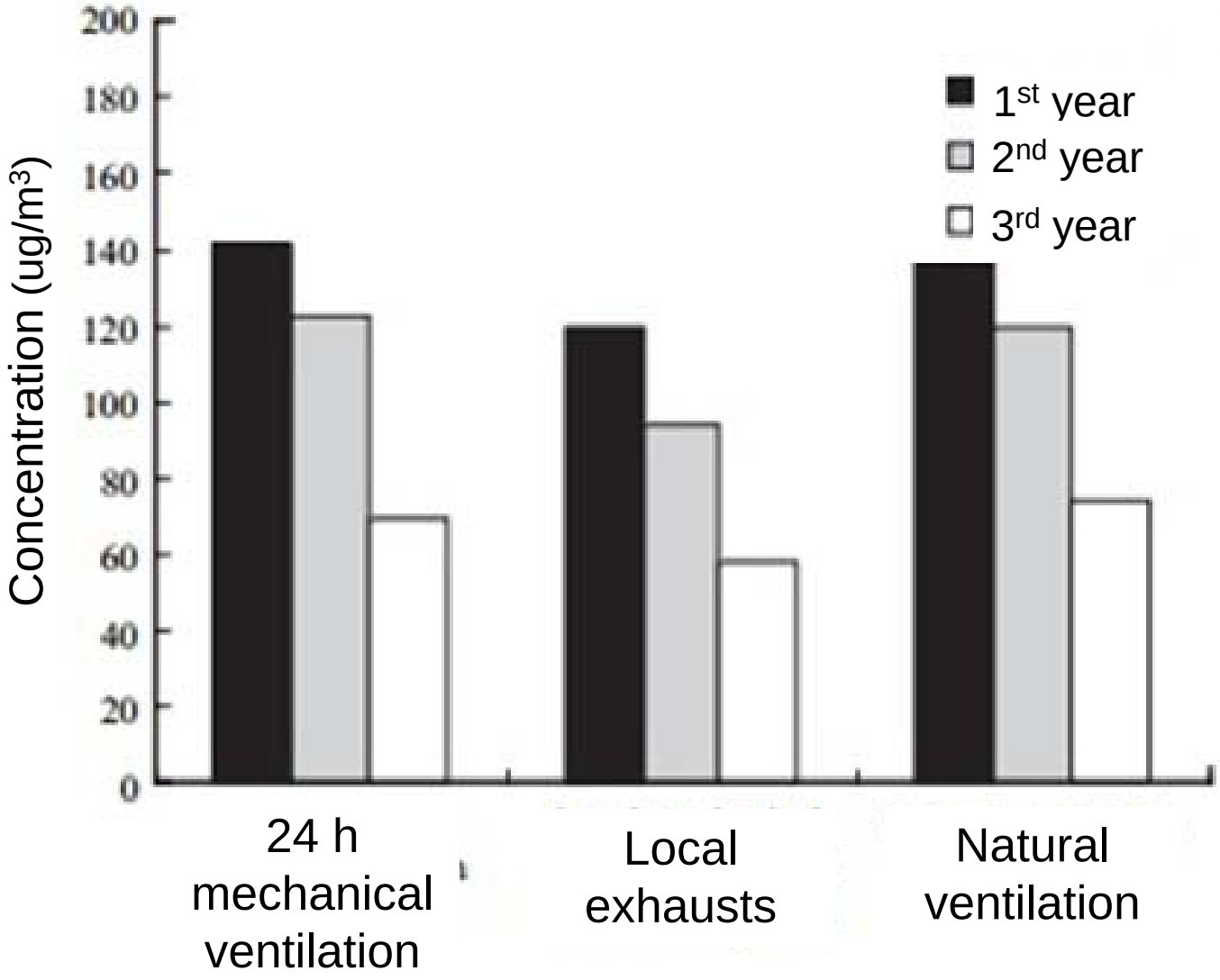
  Increase ventilation → reduce air conc. → increase emissions

Background 2

- Limited recent formaldehyde data for U.S. new homes
  - California New Home Study:
    - 108 homes: Summer/Winter, North/South splits
- Composite wood products are largest sources in homes
- Few examples of apportionment in finished homes

Formaldehyde highest in new homes, Concentrations decrease with age

Single-family houses in Japan
(New in 1st year)



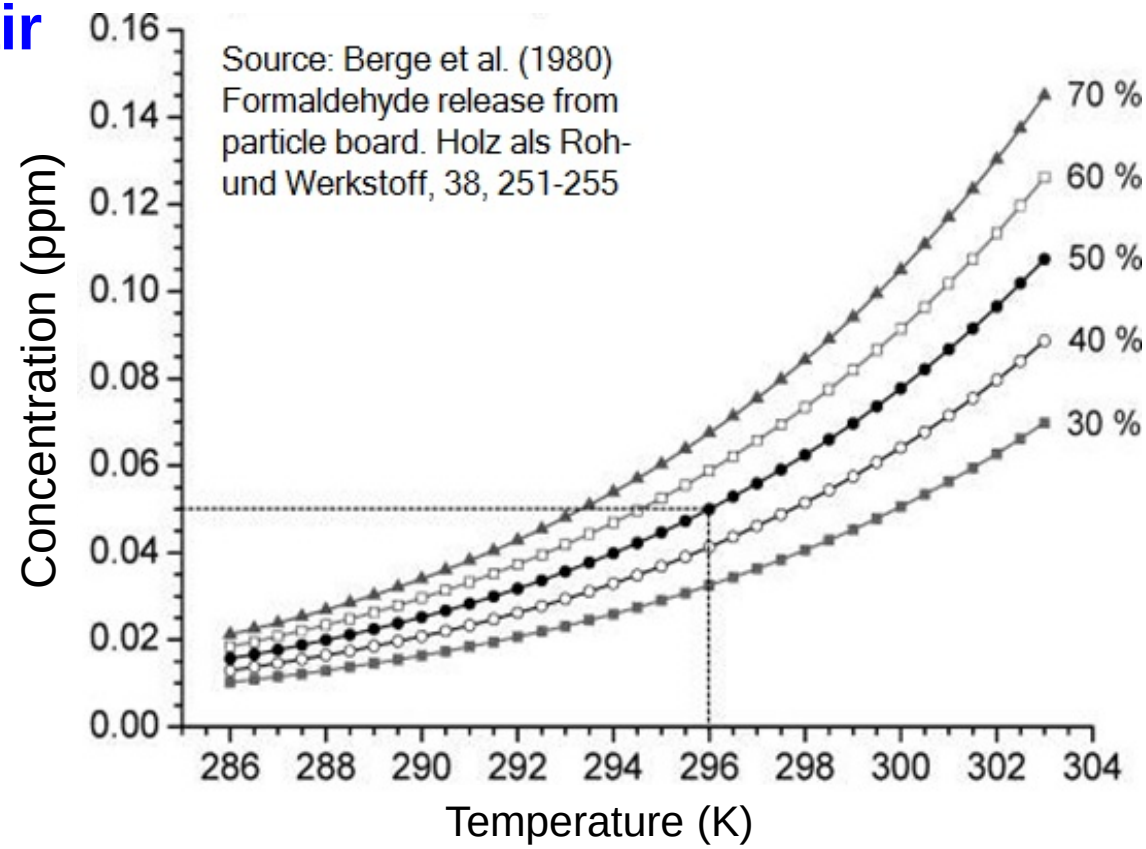
Park JS, Ikeda K. Variations of formaldehyde and VOC levels during 3 years in new and older homes. Indoor Air. 2006 Apr;16(2):129-35.

Formaldehyde Emission Standards

- **CA: Composite Wood Air Toxic Control Measure**
  - **Approved 2007 under authority to regulate outdoor air**
  - **Phased implementation 2009-2012**
- **U.S. Formaldehyde Standards in Composite Wood Products Act**
  - **Approved 2010 to be implemented by Jan 1, 2013**
  - **Based on CA standards**

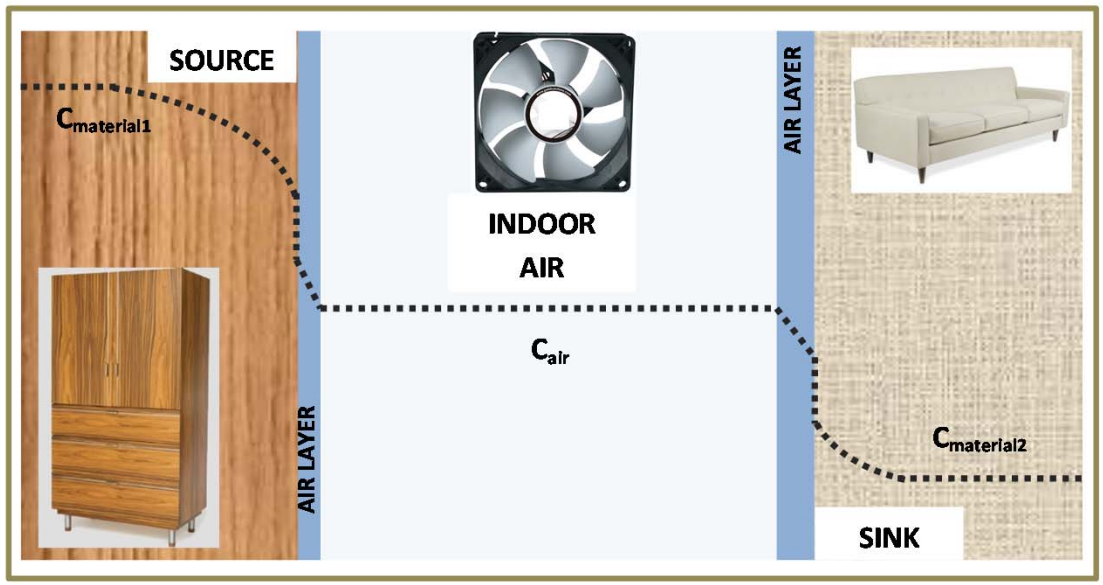
Emissions Determinants

- **Source**
  - **Concentration within material**
    - **Decreases with time**
  - **Diffusion rates and barriers**
  - **Connection to indoor air**
- **Environmental**
  - **Temperature**
  - **Humidity**
  - **Solar insolation**



Controlling Formaldehyde

- **Source control:**
  - Seal with low-permeability laminate
  - Resin formulations that chemically bind formaldehyde
- **Options requiring energy use in building**
  - Dehumidification
  - Air cleaning / treatment
  - Ventilation?

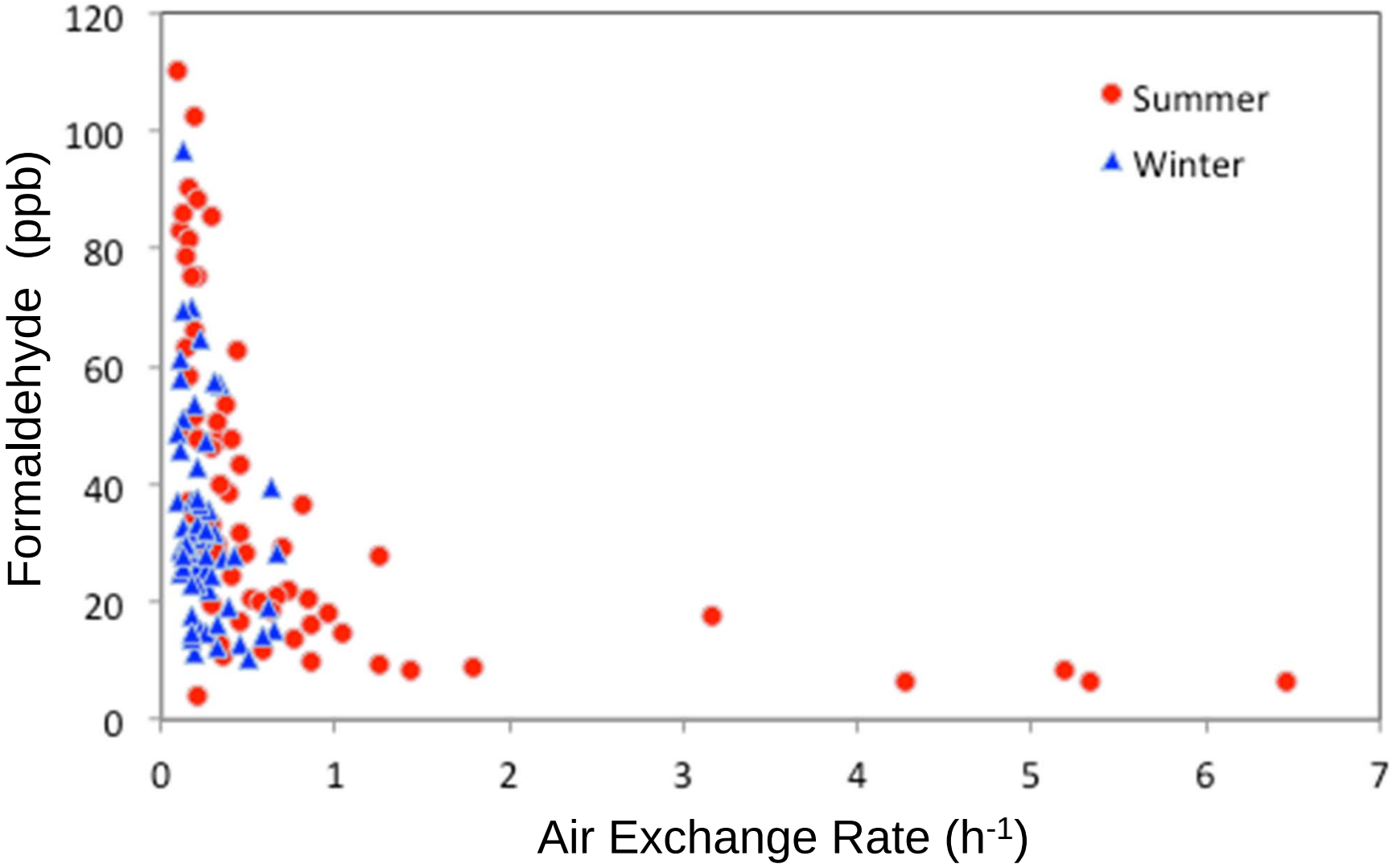


Research Questions

- Can increasing ventilation substantially reduce formaldehyde concentrations in new homes?
- To what extent do emissions increase when air exchange is increased?
- Do homes built with low-emitting materials have lower formaldehyde concentrations? How much?

- This information is needed to evaluate the cost-effectiveness of ventilation and source control!

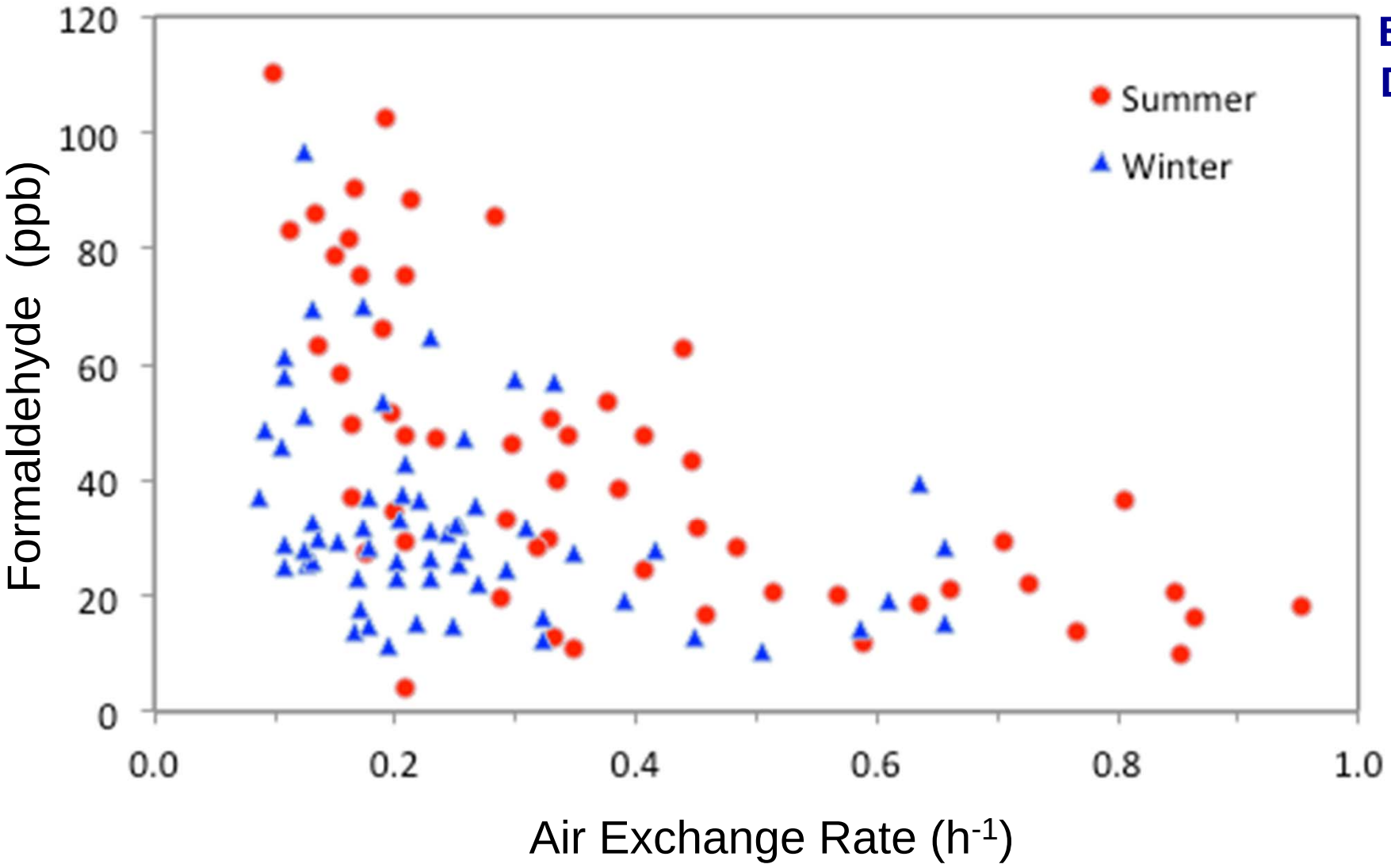
Existing Data: California New Home Study



Built: 2002-5
Data: 2006-7
N=108

Offermann, F. J. 2009. Ventilation and Indoor Air Quality in New Homes. California Air Resources Board and California Energy Commission, PIER Energy-Related Environmental Research Program. Collaborative Report. CEC-500-2009-085.

California New Home Study Data



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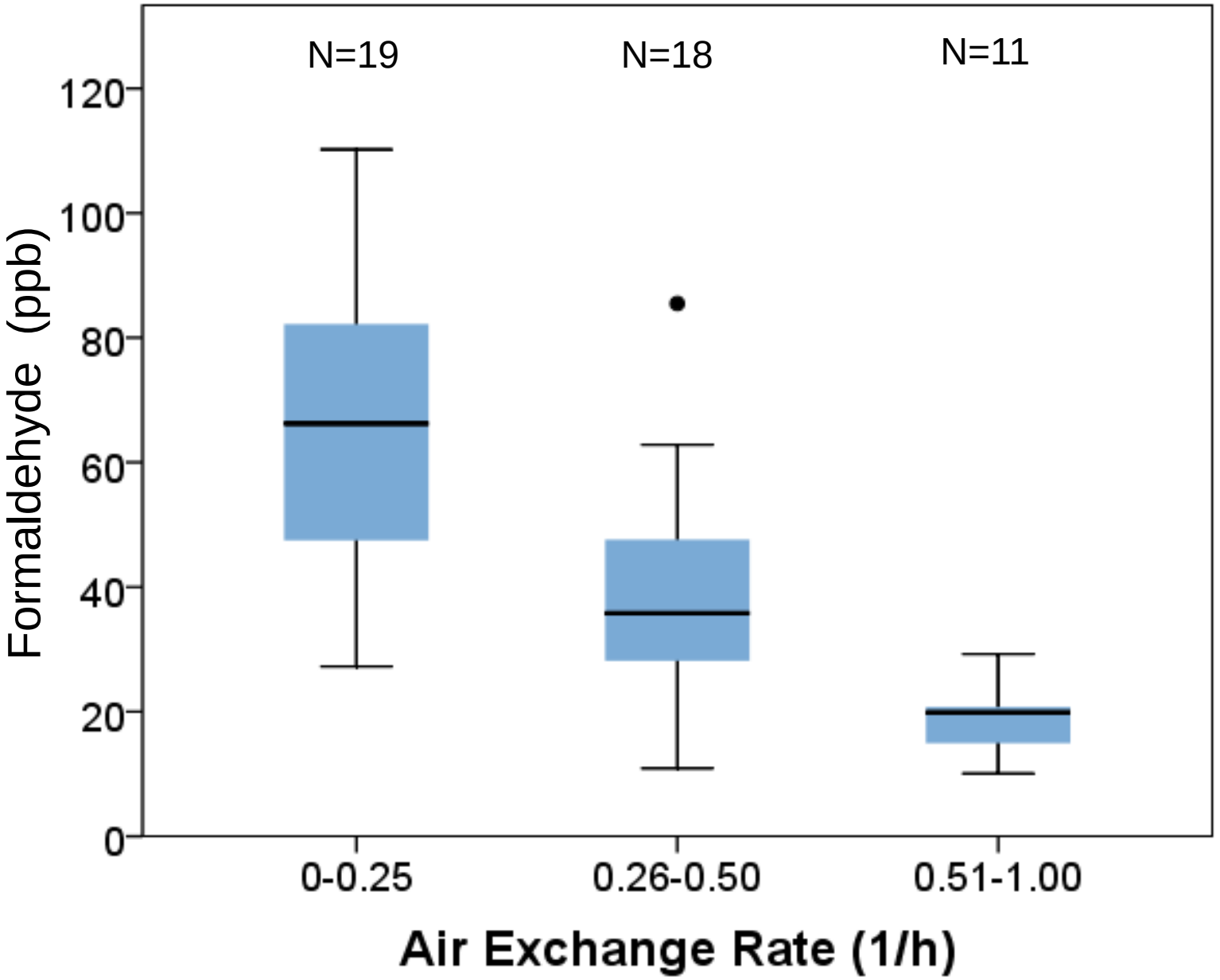
These homes built prior to formaldehyde emission standards

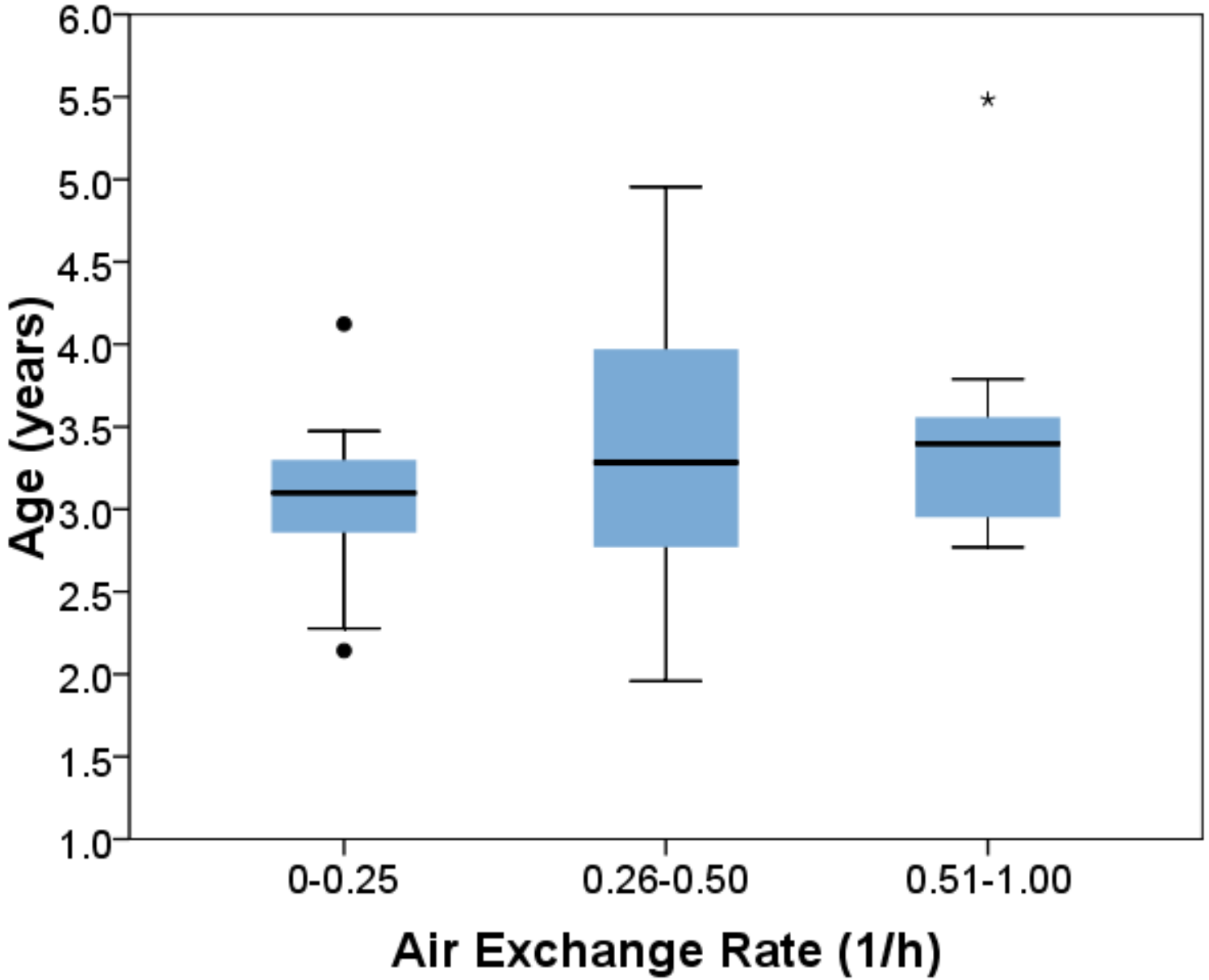
Ventilation impact in CA new homes
Summer data



Built: 2002-5
Data: 2006-7
Age: 1.8-5.5 y

Summer
N=48

Ventilation impact not explained by age variations



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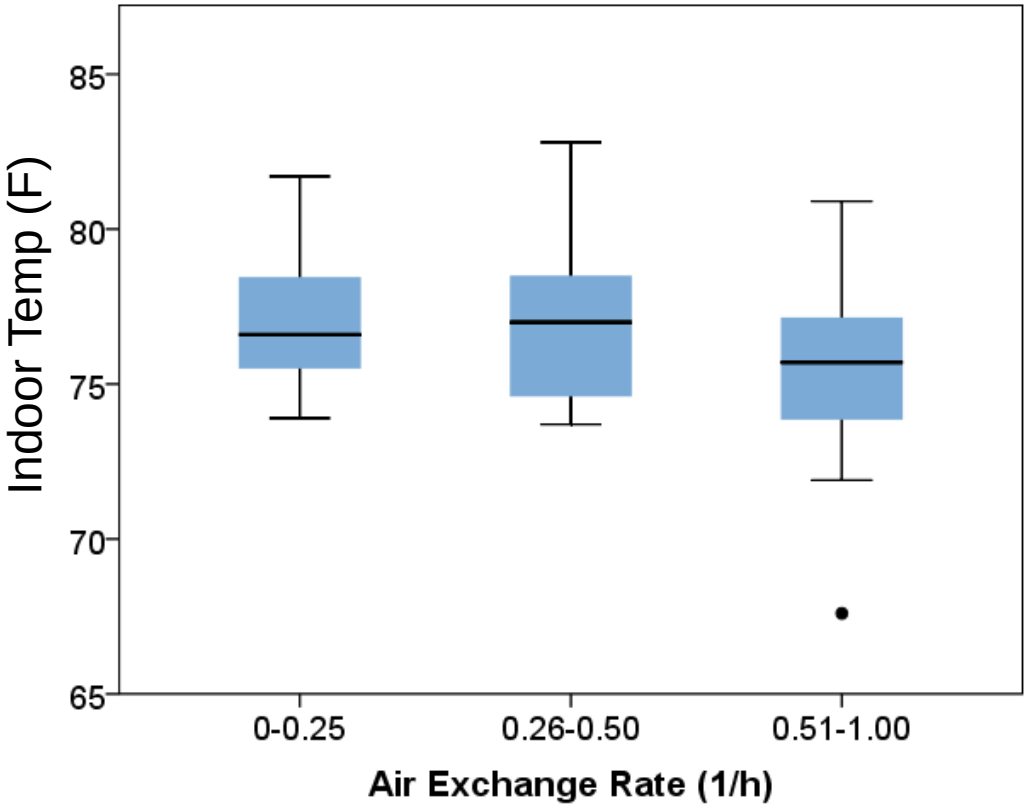
Summer
N=48

Ventilation impact not explained by T or RH variations



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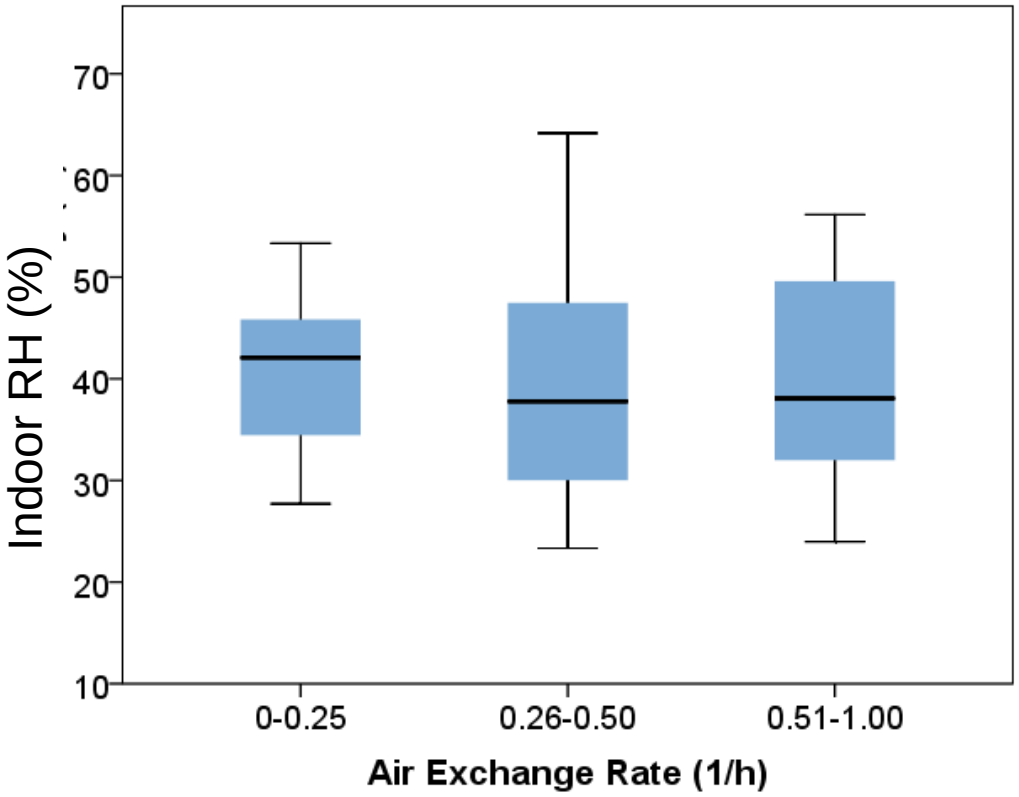
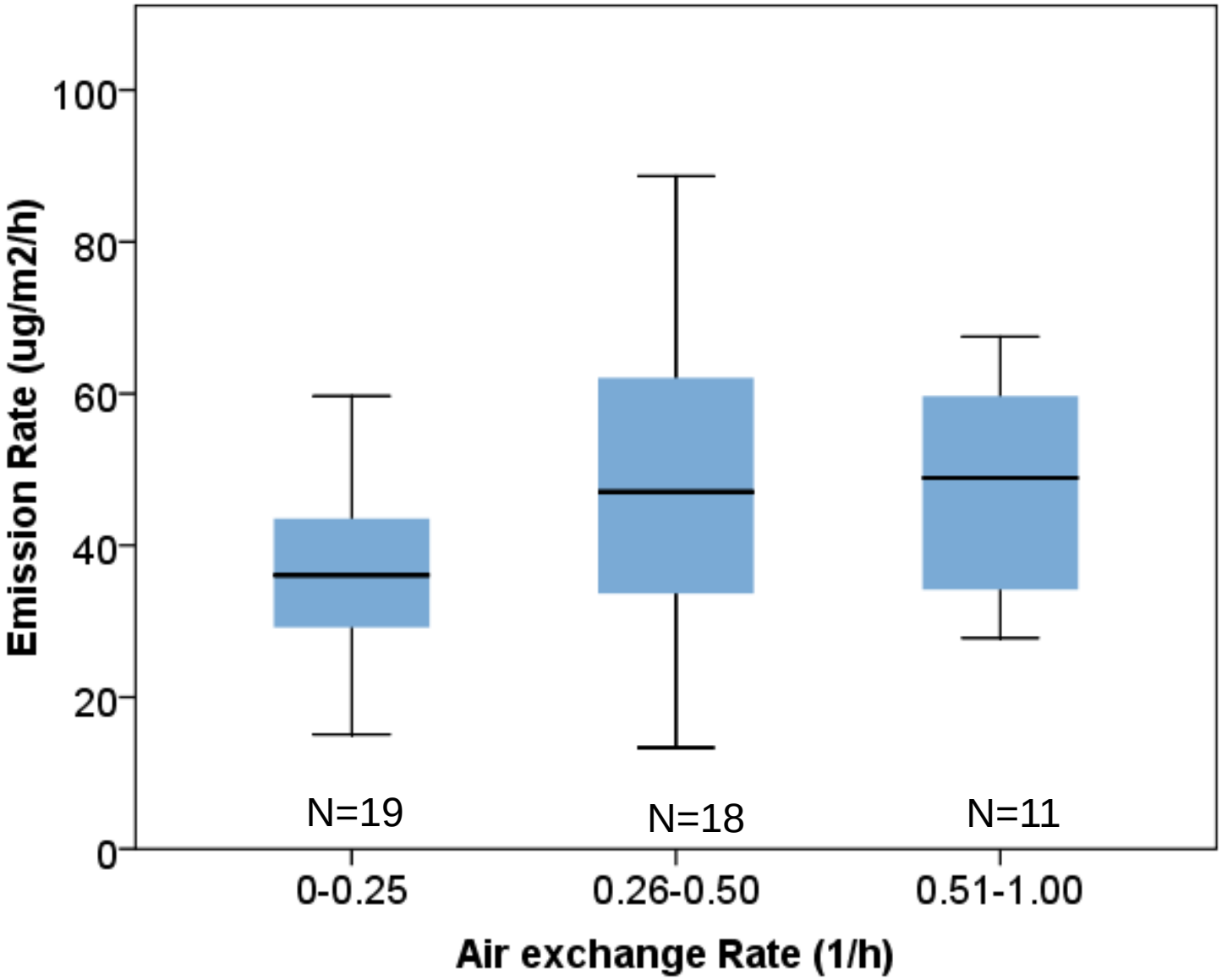
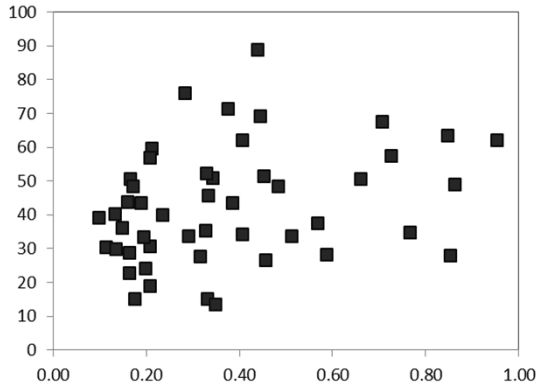


Emission suppressed at low AER





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Summer
N=48

F, df (2.3, 2): P<0.1

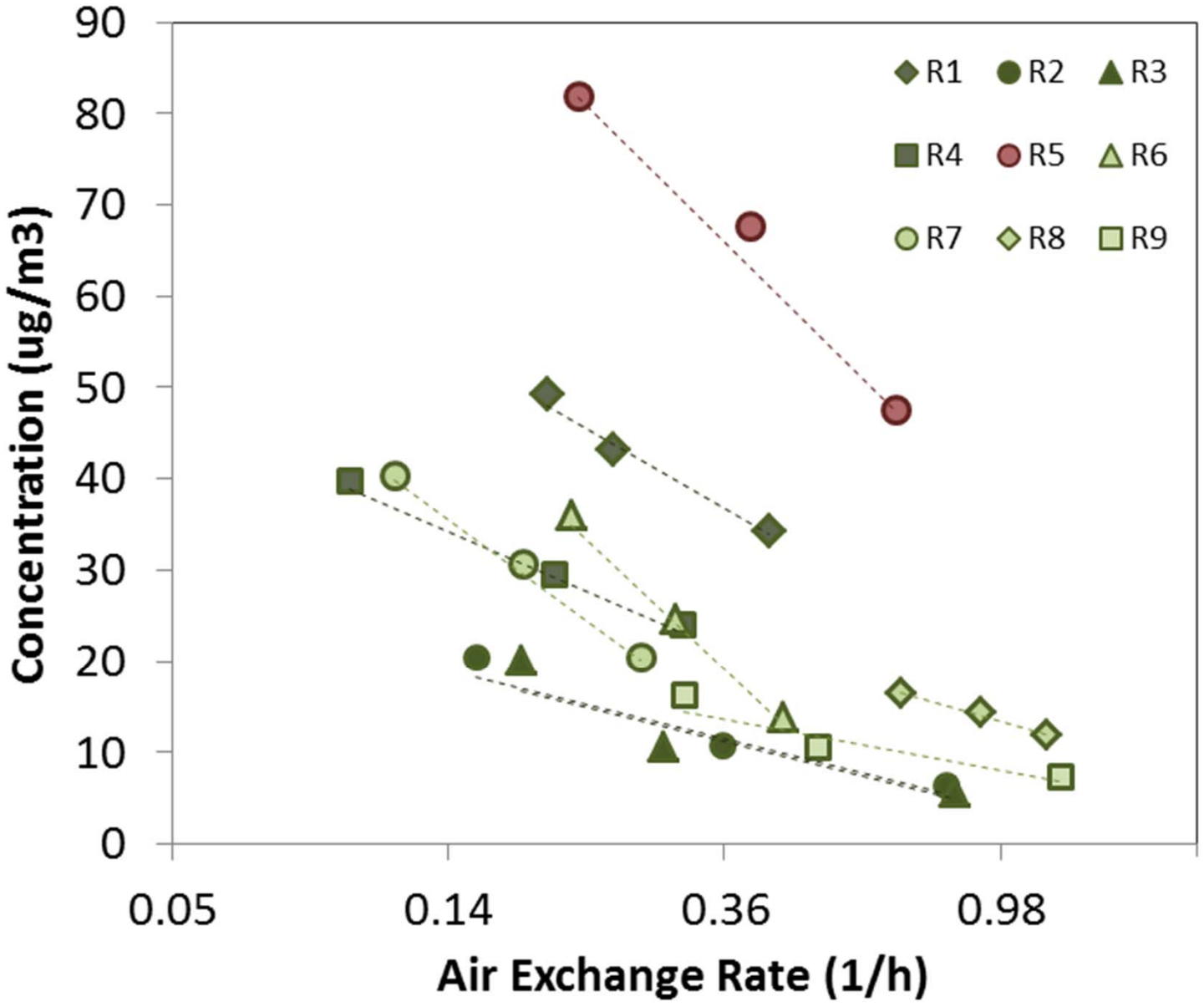
Ventilation Intervention Study

- Modify AER in 9 homes with other parameters fixed
  - Materials
  - Temperature
  - Rel. Humidity
  - Season
- AER control via mechanical ventilation
- Measure AER & concentrations, calculate emissions

	Age (yrs)	Floor area (ft^2)	ACH 50	Low-emitting Material[#]
R1	2.0	2100	1.2	1,2,3
R2	1.5	150	4.0	1,2,3
R3	1.5	150	4.0	1,2,3
R4	0.3	1475	0.6	1,2,3
R5	7.5	1300	4.3	-
R6	0.8	1570	1.0	2,3
R7	1.0	2260	0.7	2,3
R8	2.5	1600	1.0	2
R9	2.5	3440	4.0	2

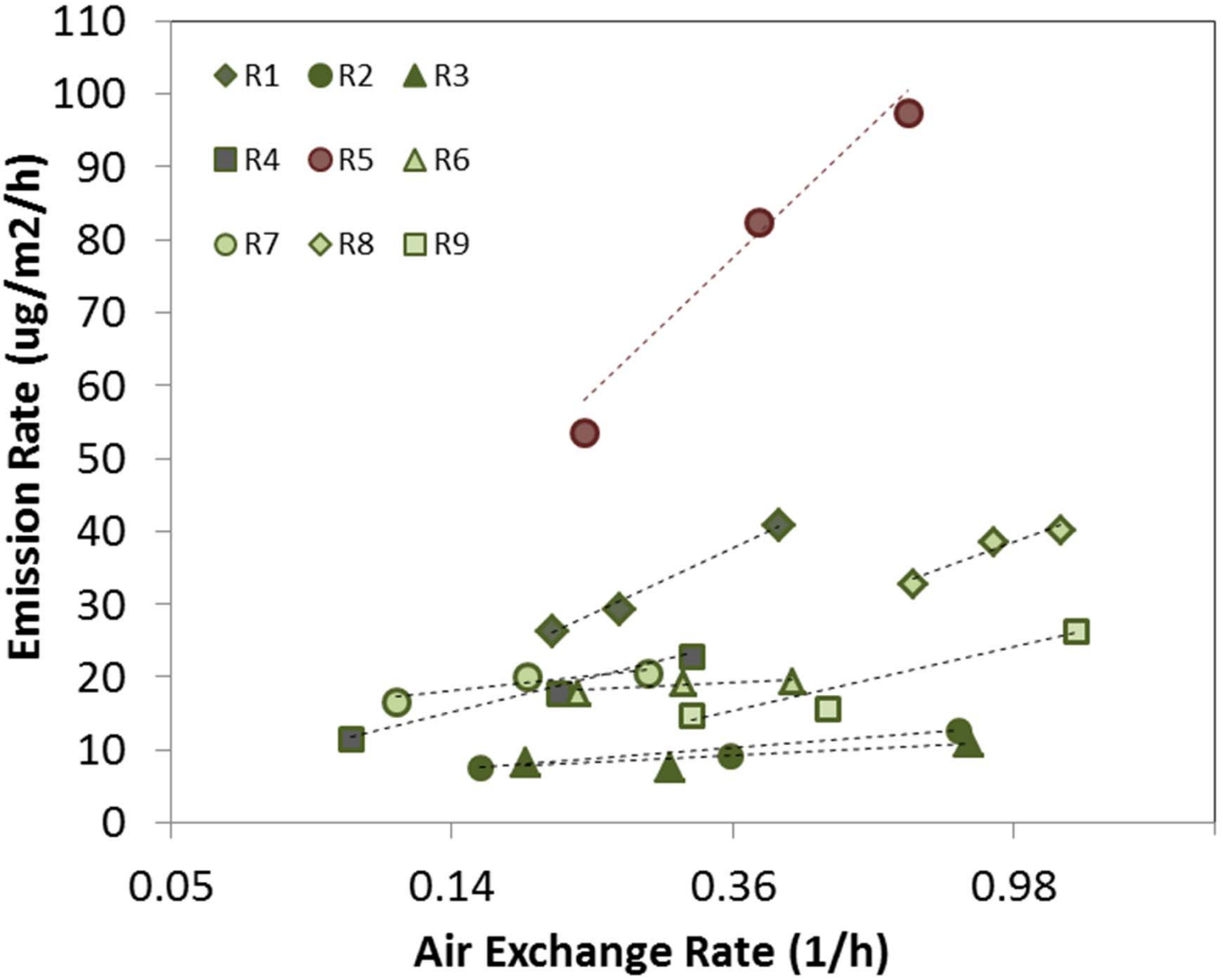
[#]1= Wood products compliant with CA Title 17 or low- or no- formaldehyde standards,
2= Wet surface finishing certified as low-emitting,
3= Carpet materials and backing low-emitting.

Lower concentration with increased AER in each study home



May - Sep 2011
Age: 0.3 - 2.5 y
N = 9 homes

Emission impact of AER varies



May - Sep 2011
Age: 0.3 - 2.5 y

N = 9

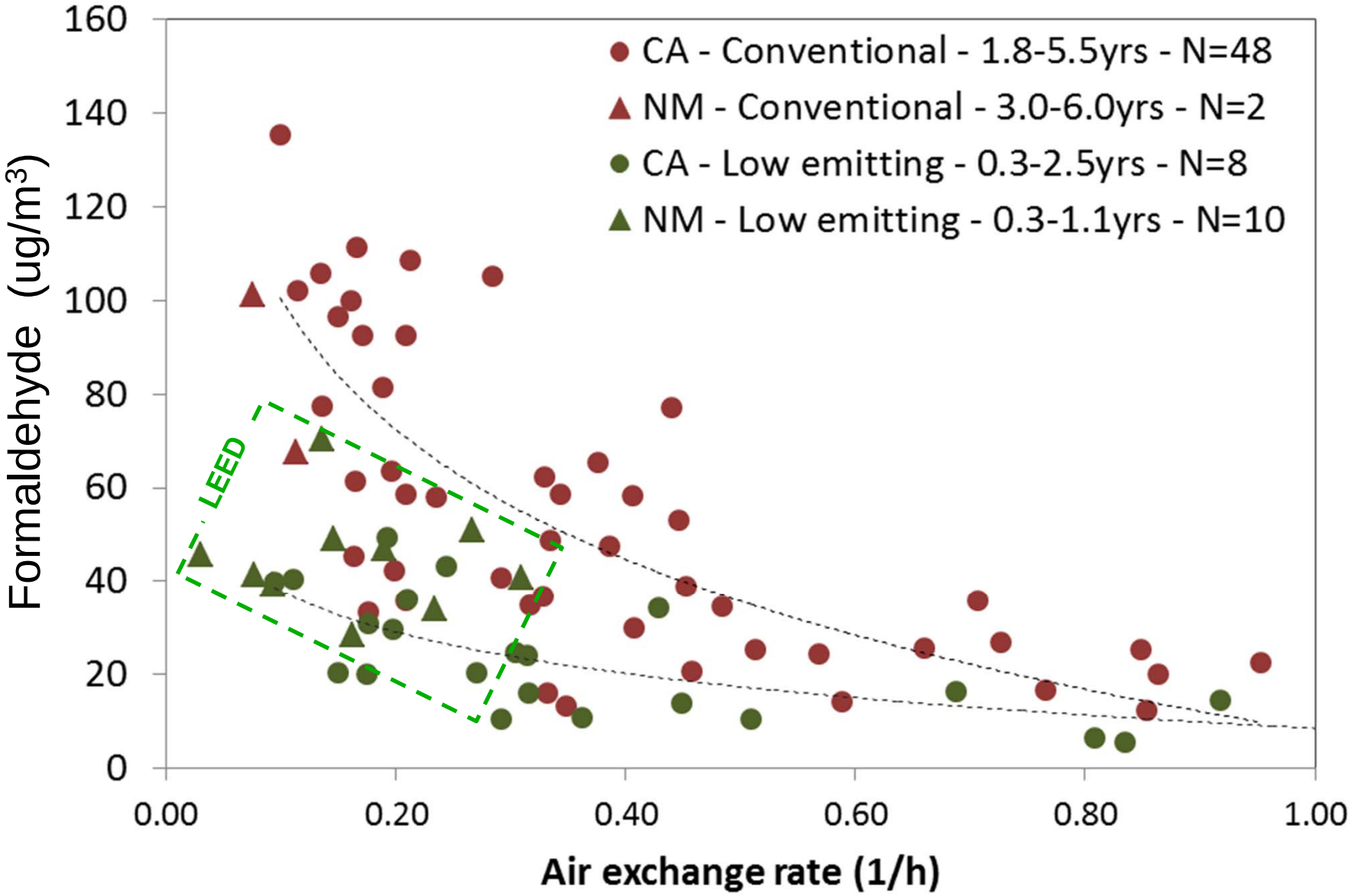
Study of Source Control

Measure concentrations and AER in new homes constructed with low-emitting materials

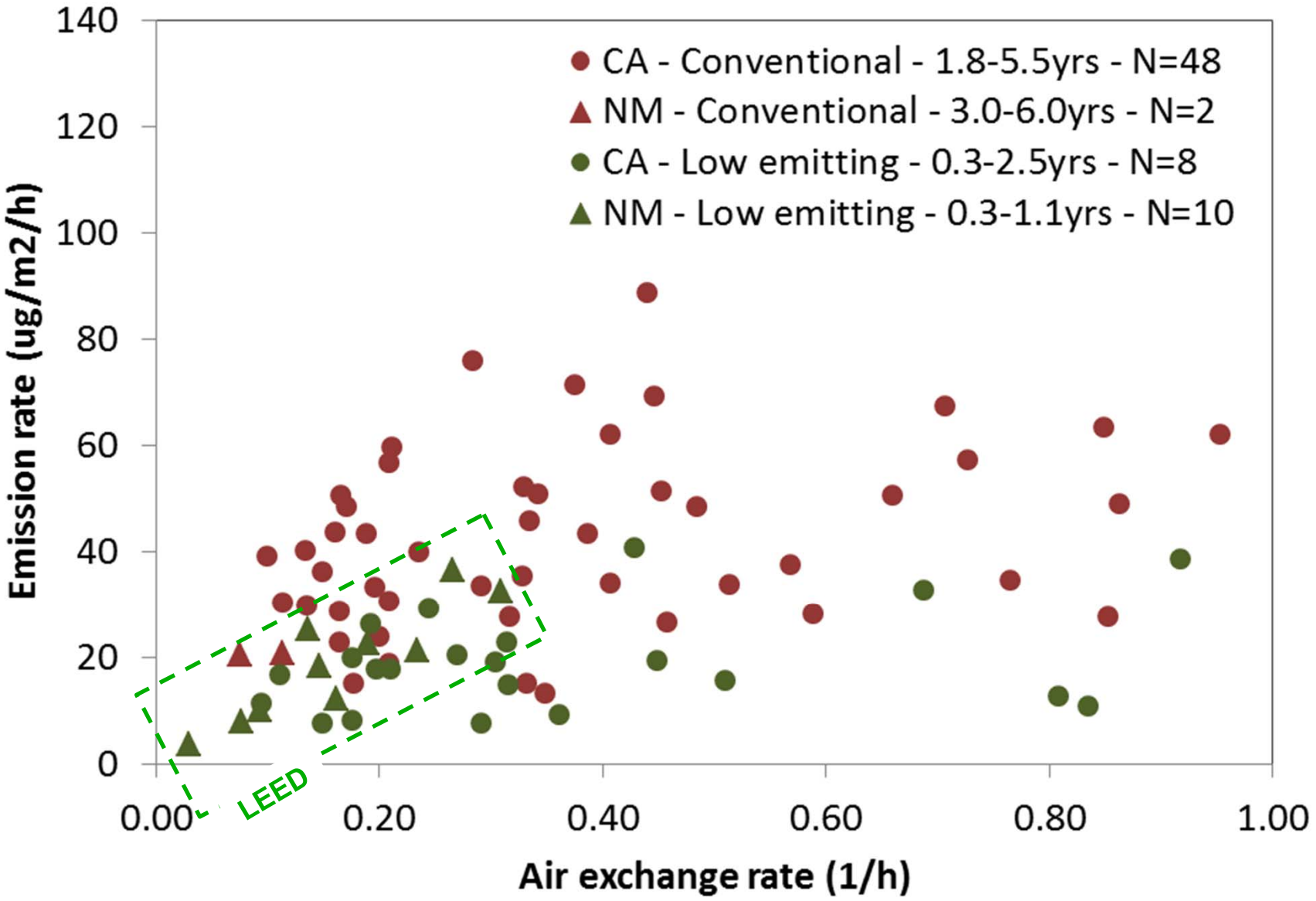
- 10 LEED / Indoor Air Plus homes in New Mexico (NM)
  - 0.3 – 2.5 years old
  - ATCM compliant wood products
- 8 California homes complying with ATCM:
  - 0.3 – 1.1 years old
- Additional data being collected in CA-compliant homes

Compare to CNHS and NM conventional homes

Low-emitting materials yield lower formaldehyde concentrations



Low-emitting materials yield lower emission rates, still depend on AER



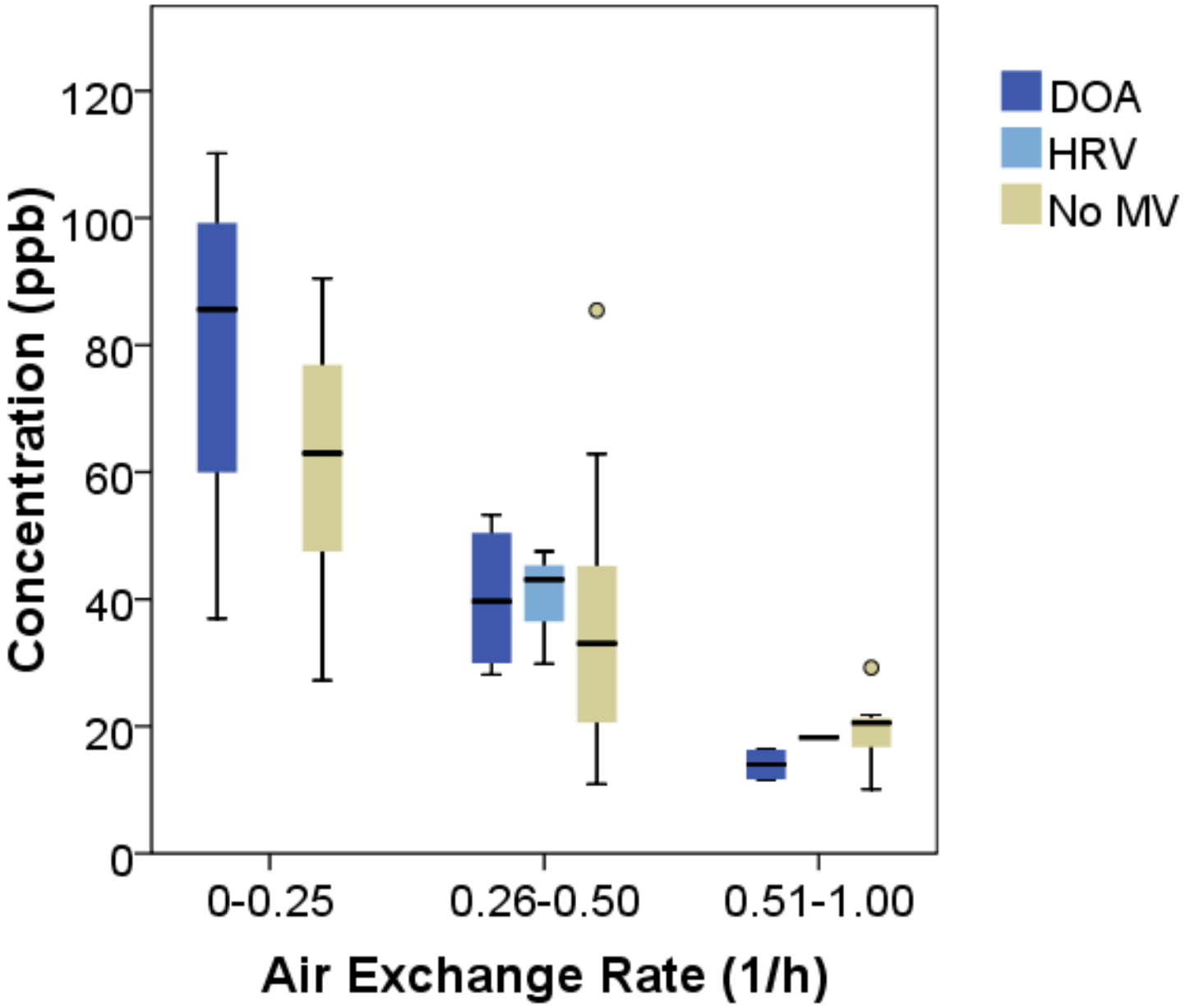
Conclusions

- Emission limits on composite wood products reducing formaldehyde in new homes
- Increasing ventilation can reduce near-term concentrations, exposures
- Benefits of adding ventilation depend on starting point b/c emissions increase
- Increasing ventilation should deplete sources more rapidly
- Open questions
  - What is value of health benefits?
  - How much impact does higher ventilation have in long term?
  - Time evolution of homes with low-emitting materials?

Extra Slides

- **The following slides will not be shown unless requested or needed**

No Mechanical Ventilation Benefits only by Increasing AER



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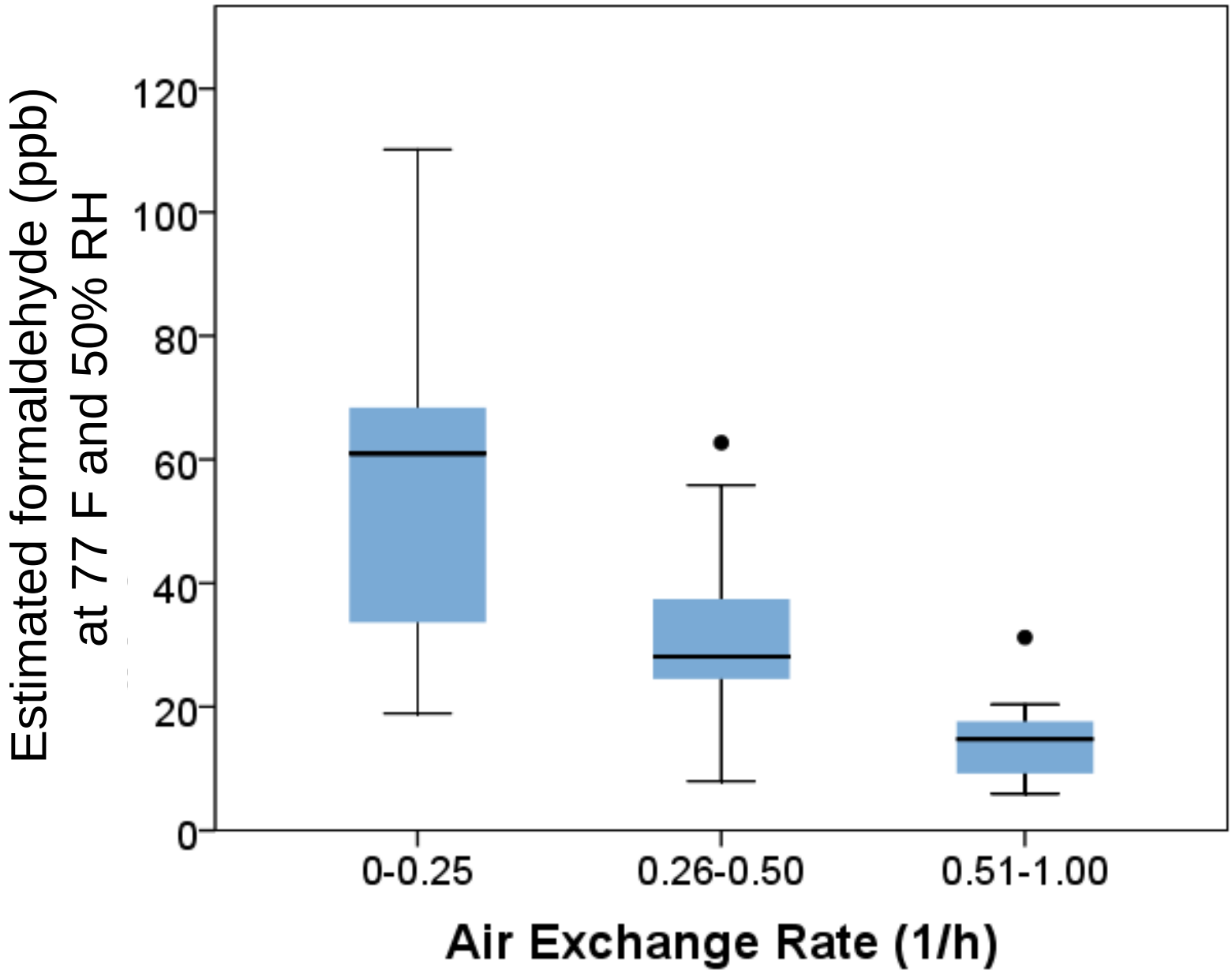
Summer
N=48

Health Benefit Calculation

- Methodology described in Logue et al., Environmental Health Perspectives, 2012
- 10 ppb reduction for 100K people for 1 year saves 5 DALYs
- Assume 25K homes for every 100K people living in new homes
- $100K per DALY -> $500K per year ->
- $20 per 10 ppb per year
- 10 ppb lower over 10 years -> $200 per home

Ventilation impacts in CA new homes (Adjusted to 77 F and 50% RH)



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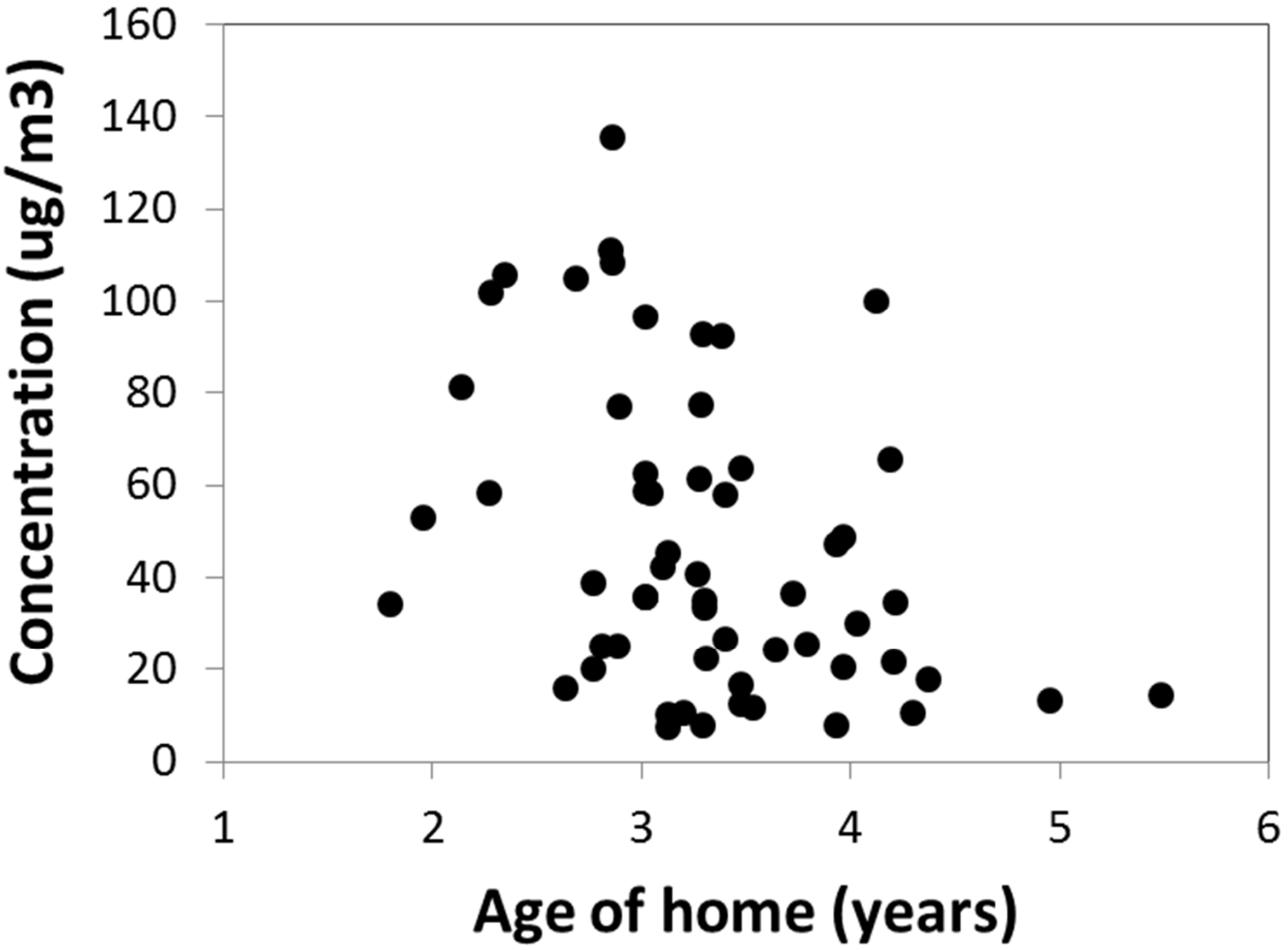
No Clear Age Signal in CNHS



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