

Creating Evidence-based Healthy and Energy-Efficient Housing

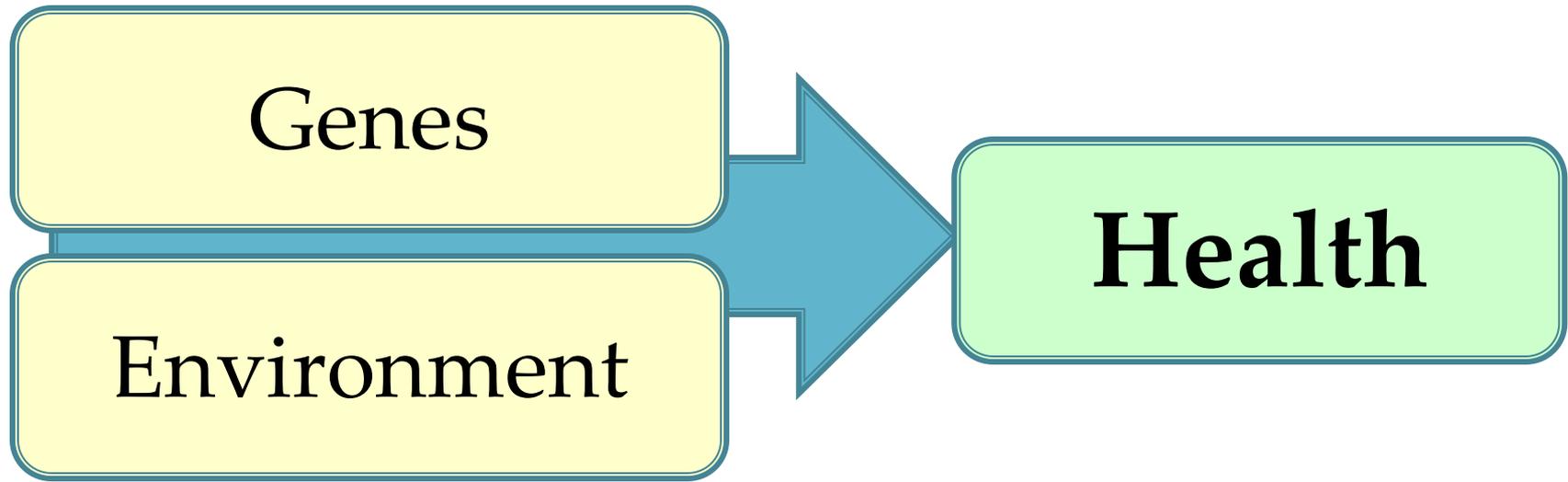


Gary Adamkiewicz, PhD MPH
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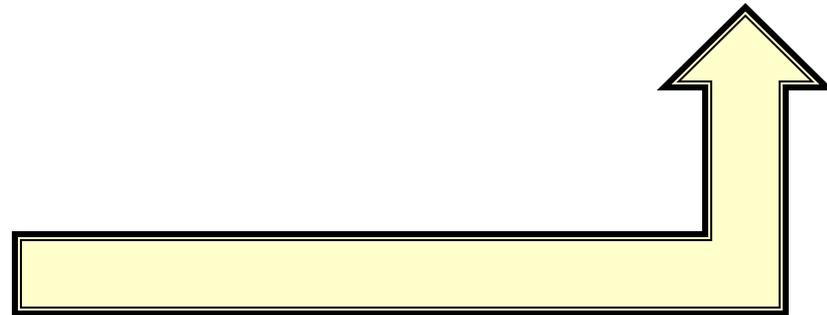
Jack Spengler, PhD
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Determinants of Health



Environment

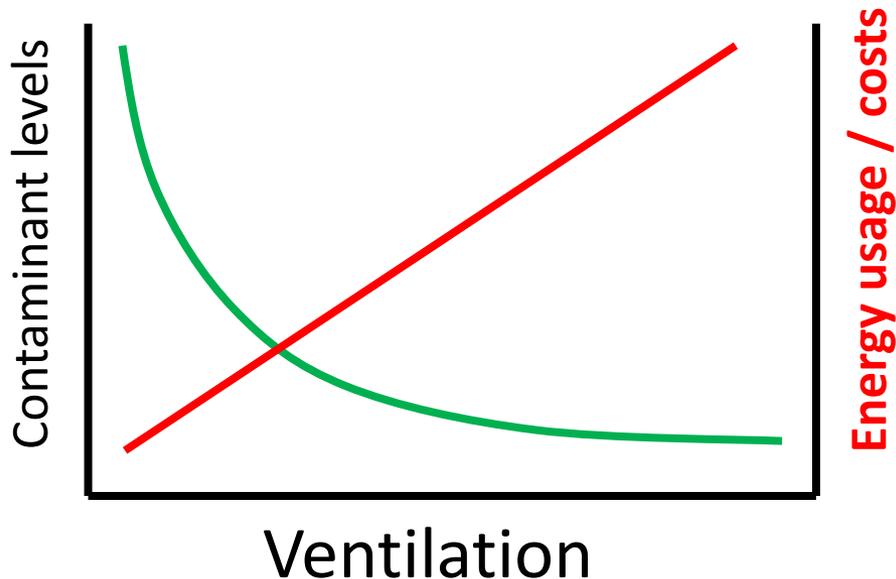
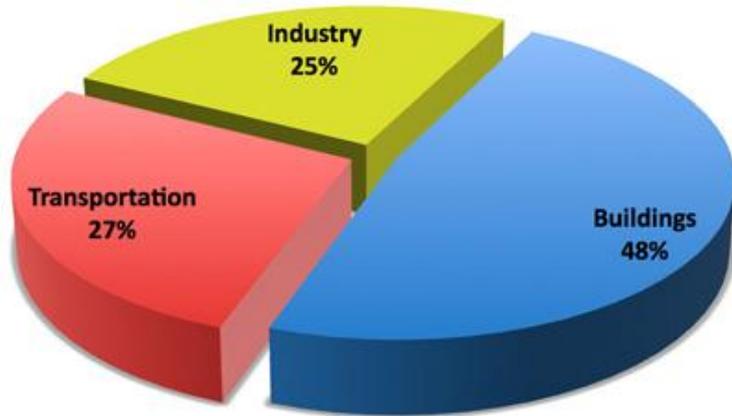
- Diet
- Environmental exposures
- Physical activity
- Occupation
- Neighborhood
- Psychosocial stress
- Healthcare
- etc.



Housing, Health and Energy



Housing, Health and Energy



- **Housing** represents a significant portion of **energy usage** globally
- We need a better understanding of the **tradeoffs/connections between health and energy** as we evaluate housing-based interventions
- Need to evaluate interventions via relevant metrics:
 - health
 - energy
 - cost

Household exposures



ETS



NO₂, CO



Lead



VOCs



Moisture/Mold



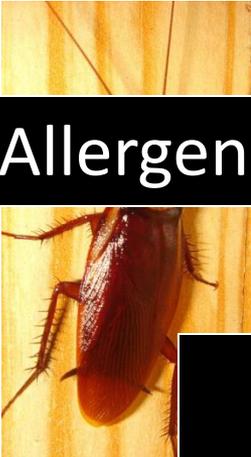
Formaldehyde



Allergens



Pesticides/
Chemicals



Ambient
Pollution



Household exposures/drivers



phthalates

flame retardants



phthalates



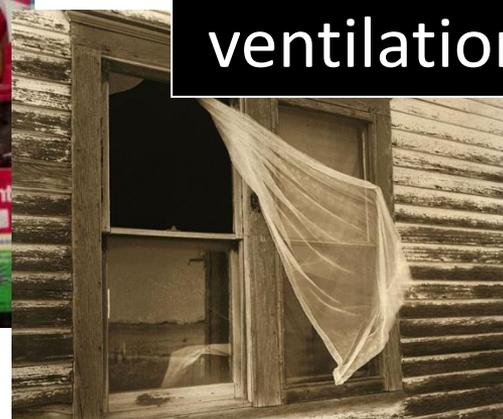
energy

PCBs



pesticides

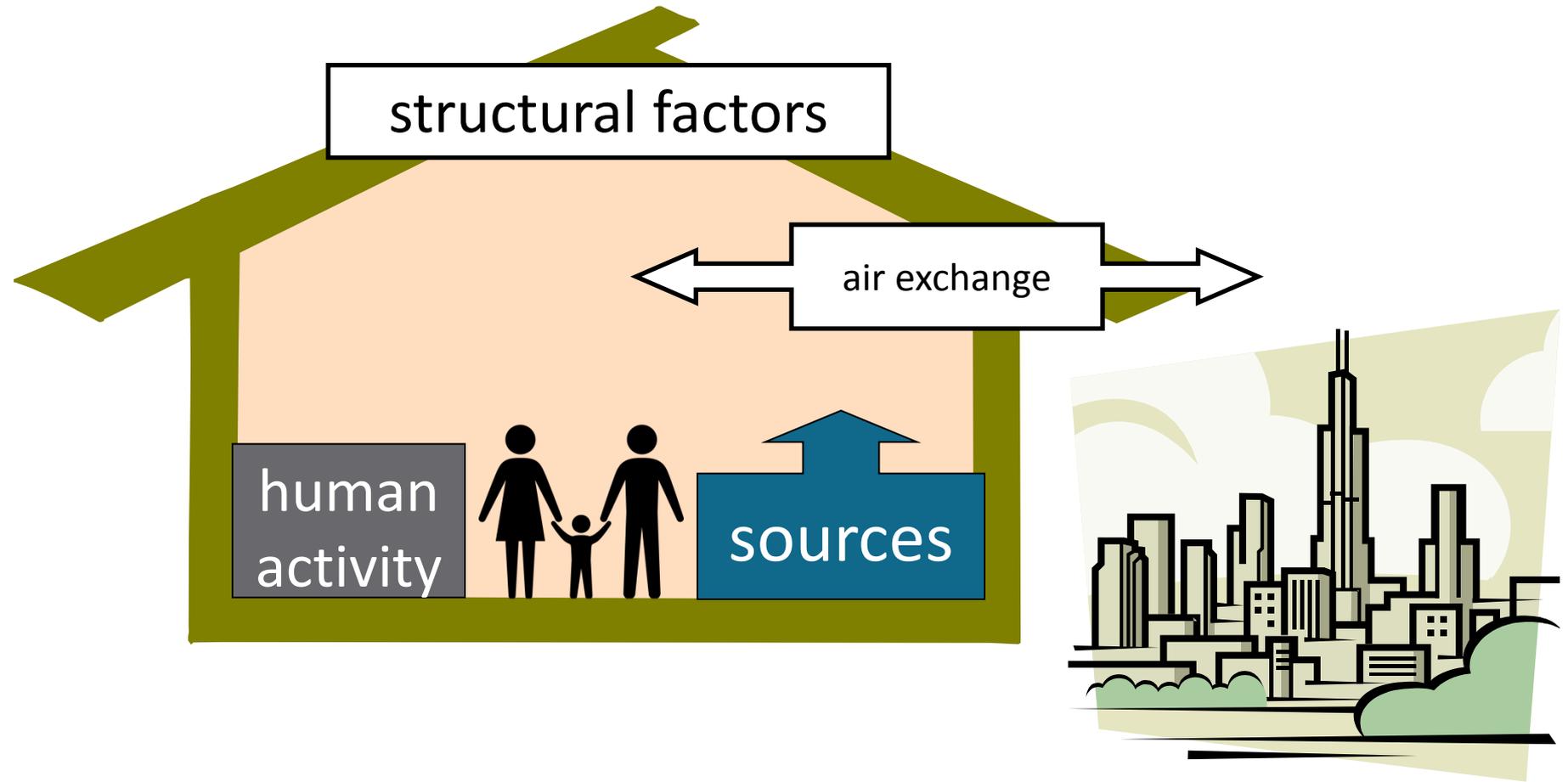
ventilation



PAH



Housing and health



Exposure Determinants

Indoor Environments

Sources

Indoor Sources

- Cooking appliances
- Tobacco smoke
- Cleaning products
- Air fresheners
- Personal care products
- Furnishings
- Pesticides
- Pollutant reservoirs
- Water sources

Outdoor Sources

- Traffic
- Industrial Activity
- Residential Activity
- Contaminated soil

Structure

Physical Structure

- Size/design of structure
- Age
- Size of living space
- Single family vs. multifamily
- Leakage and/or air exchange
- Heating systems
- Mechanical ventilation

Behavior

Source use patterns

- Cooking appliance usage
- Cooking practices
- Smoking behavior
- Consumer product usage
- Personal care product usage

Activity Patterns

- Time spent at home
- Interaction with sources
- Influence on air exchange

Achieving multiple goals for housing

- Safe
- Affordable
- **GREEN**
- Sustainable
- Renewable
- Energy-efficient
- High performance



(Getty/EHP, 2008)

Where to intervene?



people

education
case management
clinical intervention



places

maintenance
renovation
construction



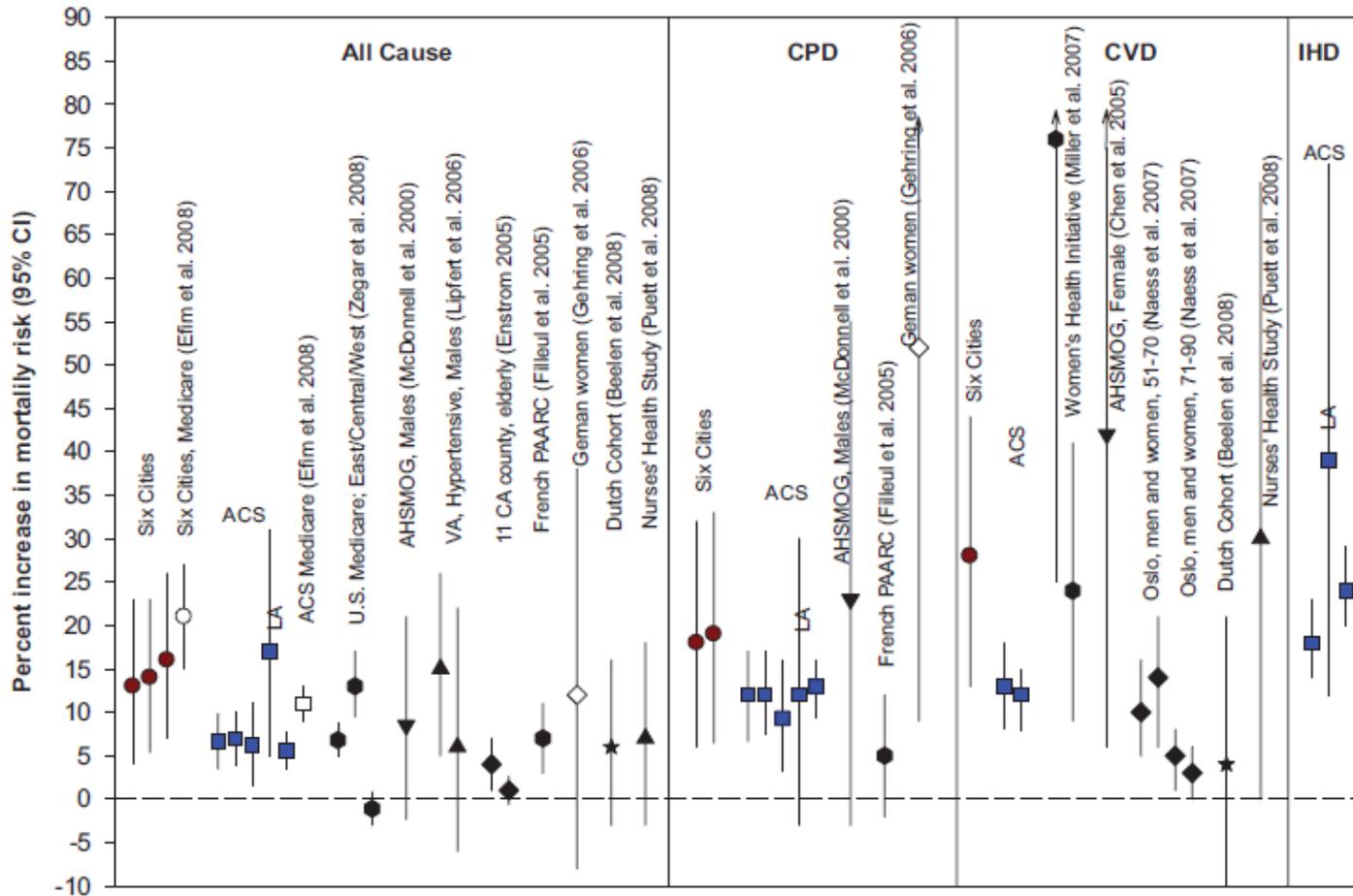
policies

maintenance
purchasing
tenant policies
regulatory

What do we know? Exposures

- **Outdoor pollutants**
 - PM
 - NO₂
 - Ozone
- **Indoor pollutants**
- **Ventilation**
- **Chemical exposures**
- **Biological exposures**

What do we know? Air pollutants



- $PM_{2.5}$
- All cause
- CVD
- CPD

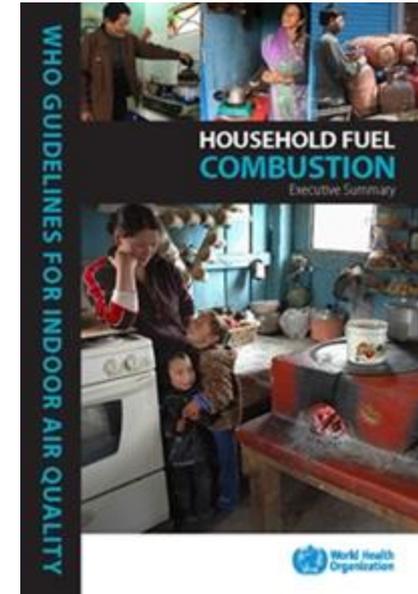
Figure 1. Risk estimates provided by several cohort studies per increment of $10 \mu g/m^3$ in $PM_{2.5}$ or PM_{10} . CPD indicates cardiopulmonary disease; IHD, ischemic heart disease.



What do we know? Combustion

ACCORDING TO WHO (2012)

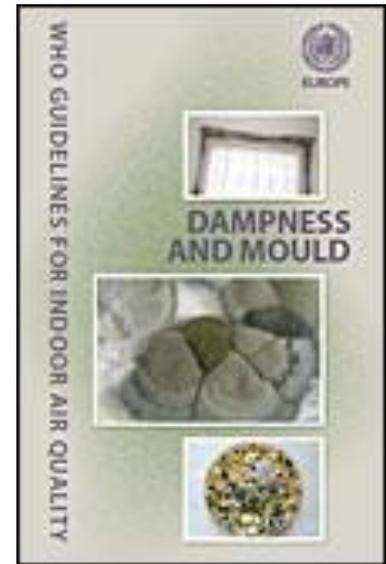
- In 2012, close to 3 billion people, mostly in low- and middle-income countries (LMICs), lacked access to clean or modern energy services for cooking resulting in some **4.3 million premature deaths worldwide**.
- Elimination of the **substantial inequalities in energy access and air quality** in and around the home that exist in the world today will bring substantial health and development benefits.
- Indoor emissions from household combustion of coal have been determined by the International Agency for Research on Cancer (IARC) to be carcinogenic to humans (Group 1). **Unprocessed coal should not be used as a household fuel**.



What do we know? Dampness

ACCORDING TO WHO (2009)

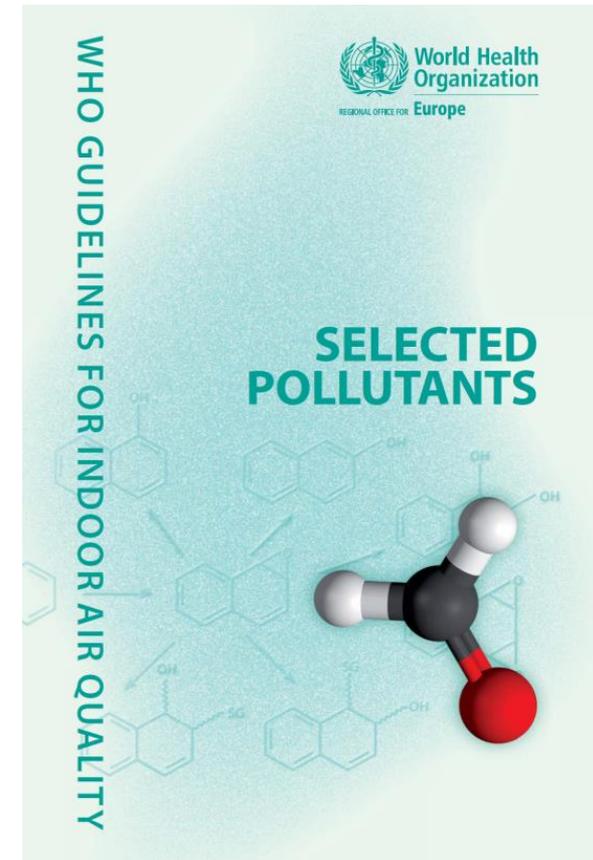
- Occupants of damp or moldy buildings are at **increased risk** of respiratory symptoms, respiratory infections and exacerbation of asthma.
- The **prevalence of indoor dampness varies widely** within and among countries, continents and climate zones. It is estimated to affect 10–50% of indoor environments in Europe, North America, Australia, India and Japan.
- Microorganisms are ubiquitous. The amount of water on or in materials is the most important trigger of the growth of microorganisms.
- Building standards do not sufficiently emphasize requirements for preventing and controlling excess moisture and dampness.
- Management of moisture requires proper control of temperatures and ventilation to avoid excess humidity, condensation on surfaces and excess moisture in materials. Ventilation should be distributed effectively throughout spaces, and stagnant air zones should be avoided.



What do we know? Air pollutants

ACCORDING TO WHO (2010)

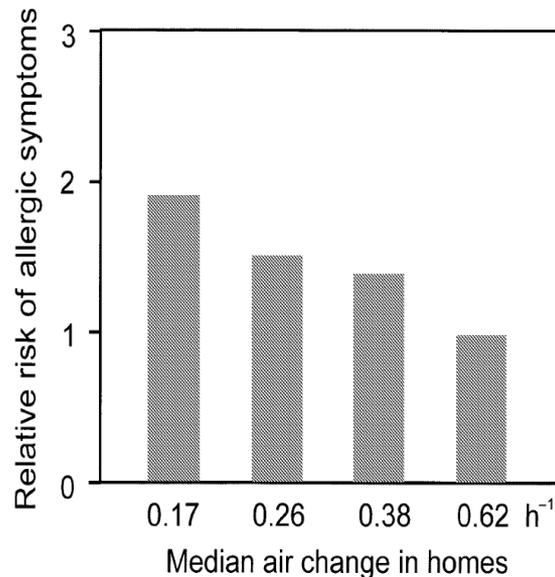
- Benzene
- Carbon Monoxide
 - Incomplete product of combustion
- Nitrogen Dioxide
 - Combustion by-product
- Radon (lung cancer)
 - Subsurface infiltration into homes



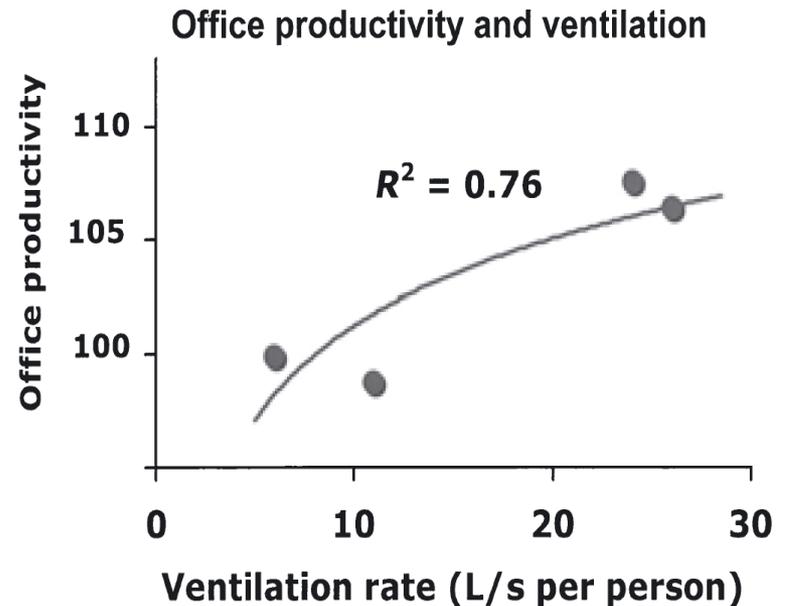
What do we know? Ventilation

VENTILATION AS A ROOT CAUSE

- Inadequate air exchange contributes to numerous IAQ problems
- Moisture accumulation
- Contaminant accumulation
- Thermal discomfort



(From Bornehag, 2005)



[from Fanger (2007), using data from Wargocki et al., (2004) and Tham et al., (2003)]

What do we know? Ventilation

Indoor Air 2011; 21: 191–204
wileyonlinelibrary.com/journal/ina
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INDOOR AIR
doi:10.1111/j.1600-0668.2010.00703.x

Commemorating 20 Years of *Indoor Air*

Ventilation rates and health: multidisciplinary review of the scientific literature

Abstract The scientific literature through 2005 on the effects of ventilation rates on health in indoor environments has been reviewed by a multidisciplinary group. The group judged 27 papers published in peer-reviewed scientific journals as providing sufficient information on both ventilation rates and health effects to inform the relationship. Consistency was found across multiple investigations and different epidemiologic designs for different populations. Multiple health endpoints show similar relationships with ventilation rate. There is biological plausibility for an association of health outcomes with ventilation rates, although the literature does not provide clear evidence on particular agent(s) for the effects. Higher ventilation rates in offices, up to about 25 l/s per person, are associated with reduced prevalence of sick building syndrome (SBS) symptoms. The limited available data suggest that inflammation, respiratory infections, asthma symptoms and short-term sick leave increase with lower ventilation rates. Home ventilation rates above 0.5 air changes per hour (h^{-1}) have been associated with a reduced risk of allergic manifestations among children in a Nordic climate. The need remains for more studies of the relationship between ventilation rates and health, especially in diverse climates, in locations with polluted outdoor air and in buildings other than offices.

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Key words: Outdoor air supply rate; Indoor air quality; Offices; Schools; Homes.

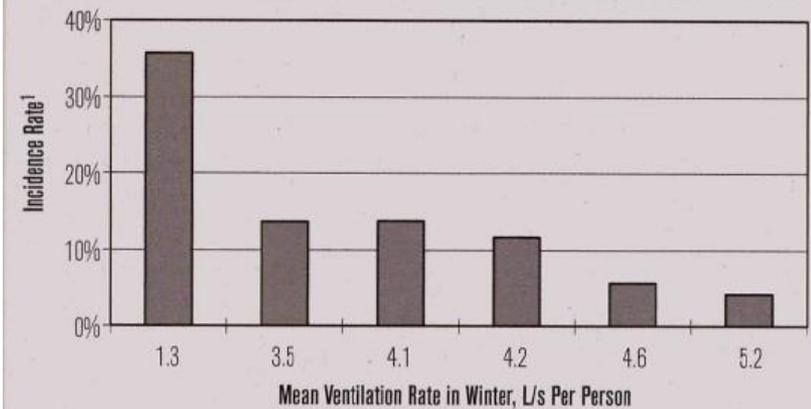
H. Levin

What do we know? Ventilation

ACCORDING TO SUNDELL ET AL. (2011)

- Higher ventilation rates in offices, up to about 25 l/s per person, are associated with reduced prevalence of sick building syndrome (SBS) symptoms.
- Inflammation, respiratory infections, asthma symptoms and short-term sick leave increase with lower ventilation rates.
- Home ventilation rates above 0.5 air changes per hour (h⁻¹) have been associated with a reduced risk of allergic manifestations among children in a Nordic climate.
- The need remains for more studies of the relationship between ventilation rates and health, especially in diverse climates, in locations with polluted outdoor air and in buildings other than offices.

FIGURE 3 Associations between common cold infection rates and mean ventilation rate in winter in buildings constructed after 1993.

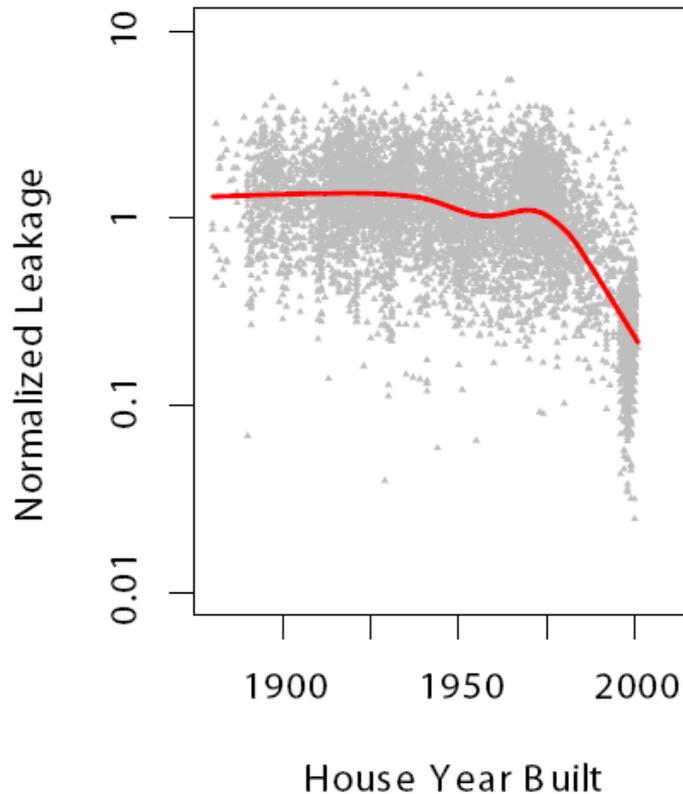


¹Proportion of occupants with ≥ 6 common colds in the previous 12 months.

Sun, Y., Z. Wang, Y. Zhang, J. Sundell. 2011. "In China, students in crowded dormitories with a low ventilation rate have more common colds: evidence for airborne transmission." *PLoS ONE* 6(II):e27140

What do we know? Ventilation

VENTILATION AS A ROOT CAUSE



(From Chan et al. 2003, LBL)

- No need for energy saving goals to work at odds with occupant health

What do we know? Health

■ Asthma

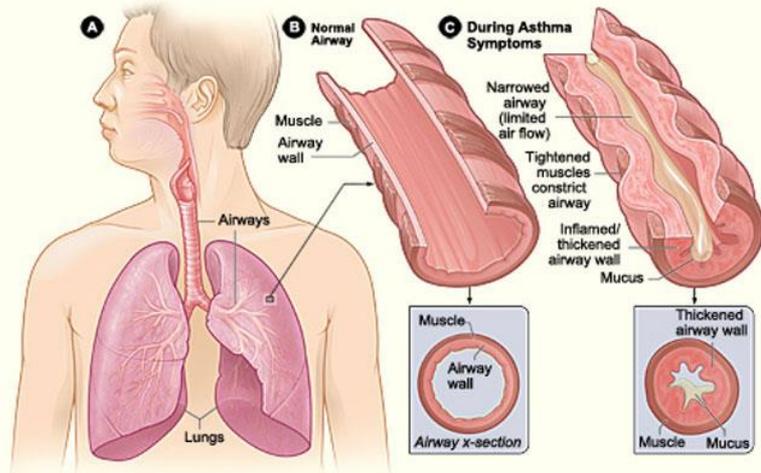


Figure A shows the location of the lungs and airways in the body. Figure B shows a cross-section of a normal airway. Figure C shows a cross-section of an airway during asthma symptoms.

Figure courtesy of U.S. Dept. of Health and Human Services, National Heart, Lung and Blood Institute.

Asthma triggers

Mold



Pets



Dust



Smoke



Chemical odors



Grass and weeds



Cockroaches



Household exposures



Wood-fired Indian Cooking Stove

From EHP, March 2010: Mikkel Ostergaard/Panos Pictures



Fine Particle Exposures

| Group of nations | Concentrations ($\mu\text{g}/\text{m}^3$) | | Exposures (GEE) | | |
|-------------------|---|---------|-----------------|---------|-------|
| | Indoor | Outdoor | Indoor | Outdoor | Total |
| <u>Developed</u> | | | | | |
| Urban | 100 | 70 | 15 | 1 | 16 |
| Rural | 60 | 40 | 3 | <1 | 3 |
| <u>Developing</u> | | | | | |
| Urban | 255 | 278 | 55 | 19 | 74 |
| Rural | 551 | 93 | 176 | 15 | 191 |
| Total | | | 249 | 36 | 285 |

^aGEE = global exposure equivalent, which is the equivalent annual concentration to which the entire world population would have to be exposed to equal the population exposure in that particular micro-environment. For example, the concentration experienced indoors in developed-country cities ($100 \mu\text{g}/\text{m}^3$) results in a population exposure equivalent to the entire world breathing $15 \mu\text{g}/\text{m}^3$ continuously. Urban outdoor concentrations are derived from (6a). Developing-country data aggregated from Table 3.

Typical Exposures

| Pollutant | Concentration | Typical standard |
|-----------------|------------------------|-------------------------|
| Carbon Monoxide | 150 mg/m ³ | 10 mg/m ³ |
| Particles | 3.3 mg/m ³ | 0.1 mg/m ³ |
| Benzene | 0.8 mg/m ³ | 0.002 mg/m ³ |
| 1,3-Butadiene | 0.15 mg/m ³ | 0.003 mg/m ³ |
| Formaldehyde | 0.7 mg/m ³ | 0.1 mg/m ³ |

(http://ehs.sph.berkeley.edu/krsmith/presentations/2011/2011_columbia.pdf)

Research

Tuberculosis and Indoor Biomass and Kerosene Use in Nepal: A Case-Control Study

Amod K. Pokhrel,¹ Michael N. Bates,¹ Sharat C. Verma,^{2,3} Hari S. Joshi,^{3*} Chandrashekhar T. Sreeramareddy,^{3**} and Kirk R. Smith¹

¹School of Public Health, Pokhara, Nepal; ²De

BACKGROUND: In Nepal, studies have indicated that indoor air pollution from biomass and kerosene stoves is associated with tuberculosis (TB). **OBJECTIVES:** Using a case-control study, we examined the association between TB and the use of biomass and kerosene stoves. **METHODS:** A hospital-based case-control study was conducted among women, 20–65 years of age, who were female patients with TB. A questionnaire was administered to all cases and their controls.

RESULTS: Compared with those who used biomass fuel, the adjusted odds ratio (OR) for TB among those who used kerosene stoves was 0.48–3.05], whereas the OR for those who used biomass fuel was 9.43 (95% CI, 1.5–58.0). **CONCLUSIONS:** This study suggests that the use of kerosene stoves and other stoves, if used for promoting clean energy, may be associated with TB. **KEY WORDS:** biomass, kerosene stove, and tuberculosis. *Environ Health Perspect* 113:1032–1037 (2005) [Online 13 June 2005]

Tuberculosis (TB) is a leading cause of illness and death in Nepal (1999). In 2006, there were 17,000 new TB cases and 1.7

Research

Intervention to Lower Household Wood Smoke Exposure in Guatemala Reduces ST-Segment Depression on Electrocardiograms

John McCracken,^{1,2} Kirk R. Smith,² Peter Stone,³ Anaïté Díaz,⁴ Byron Arana,⁴ and Joel Schwartz¹

¹Department of Environmental Health, Harvard School of Public Health, Boston, Massachusetts, USA; ²Environmental Sciences Division, University of California, Berkeley, California, USA; ³Brigham and Women's Hospital, Boston, Massachusetts, USA; ⁴Center for Health Studies, Universidad del Valle, Guatemala City, Guatemala

BACKGROUND: A large body of evidence suggests that exposure to indoor air pollution from biomass combustion is a cause of cardiovascular disease. **OBJECTIVES:** We tested the hypothesis that an intervention to reduce indoor air pollution from biomass combustion would reduce ST-segment depression on electrocardiograms (ECG). **METHODS:** We used two complementary randomized stove assignments: a) use of open fires during the trial, and b) use of a chimney woodstove that reduced indoor air pollution. **RESULTS:** We tested the hypothesis that an intervention to reduce indoor air pollution from biomass combustion would reduce ST-segment depression on ECG. **CONCLUSIONS:** The use of a chimney woodstove reduced indoor air pollution and ST-segment depression on ECG. **KEY WORDS:** biomass, kerosene stove, and tuberculosis. *Environ Health Perspect* 113:1032–1037 (2005) [Online 13 June 2005]

RESULTS: PM_{2.5} exposure mean and intervention groups, respectively, were 2.26 (95% CI, 1.5–3.1) and 0.26 (95% CI, 0.1–0.4) μg/m³. Similar associations with the biomass fuel were associated with HRV. **CONCLUSIONS:** The stove intervention reduced ST-segment depression, suggesting a potential cardiovascular benefit. **KEY WORDS:** biomass fuel, cardiovascular disease, and HRV. *Environ Health Perspect* 113:1002834 [Online 13 June 2005]

Approximately 3 billion people use biomass (e.g., wood, crop residue) and coal for household heating (Smith et al. 2004). Biomass fuel use occurs in developing countries, where most households generally use open fires or inadequately vented stoves (Smith et al. 2006). These fuel-stove

Research

Indoor Air Pollution and Blood Pressure in Adult Women Living in Rural China

Jill Baumgartner,^{1,2,3} James J. Schauer,^{3,4} Majid Ezzati,⁵ Lin Lu,⁶ Chun Cheng,⁶ Jonathan A. Patz,^{2,3,7} and Leonelo E. Bautista²

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BACKGROUND: Almost half of the world's population uses coal and biomass fuels for domestic energy. Limited evidence suggests that exposure to air pollutants from indoor biomass combustion may be associated with elevated blood pressure (BP).

OBJECTIVE: Our aim was to assess the relationship between indoor air pollution exposure from biomass combustion and BP in women in rural China.

METHODS: We measured 24-hr personal integrated gravimetric exposure to fine particles < 2.5 μm in aerodynamic diameter (PM_{2.5}) and systolic BP (SBP) and diastolic BP (DBP) in the winter and summer among 280 women ≥ 25 years of age living in rural households using biomass fuels in Yunnan, China. We investigated the association between PM_{2.5} exposure and SBP and DBP using mixed-effects models with random intercepts to account for correlation among repeated measures.

RESULTS: Personal average 24-hr exposure to PM_{2.5} ranged from 22 to 634 μg/m³ in winter and from 9 to 492 μg/m³ in summer. A 1-log-μg/m³ increase in PM_{2.5} exposure was associated with 2.2 mm Hg higher SBP [95% confidence interval (CI), 0.8 to 3.7; *p* = 0.003] and 0.5 mm Hg higher DBP (95% CI, -0.4 to 1.3; *p* = 0.31) among all women; estimated effects varied by age group. Among women > 50 years of age, a 1-log-μg/m³ increase in PM_{2.5} exposure was associated with 4.1 mm Hg higher SBP (95% CI, 1.5 to 6.6; *p* = 0.002) and 1.8 mm Hg higher DBP (95% CI, 0.4 to 3.2; *p* = 0.01). PM_{2.5} exposure was positively associated with SBP among younger women, but the associa-

tion was not significant among older women (Smith and Peel 2010). For example, the most recent World Health Organization (WHO) Comparative Risk Assessment did not attribute cardiovascular outcomes to household use of solid fuels (WHO 2009).

In the present study we assessed the relationship between personal exposure to PM from biomass combustion and BP in women in rural China. Our study is particularly relevant to China, which has low incidence of ischemic stroke but high incidence of hemorrhagic stroke relative to other regions (Zhang et al. 2003).

Materials and Methods

Study location and population. The study took place in six villages in northwestern Yunnan province, China (N 26°52', E 100°06'). Most

Health Effects – Indoors and Outdoors



Air pollution is known to be linked with lung cancer, but it is uncertain how many people are in danger.

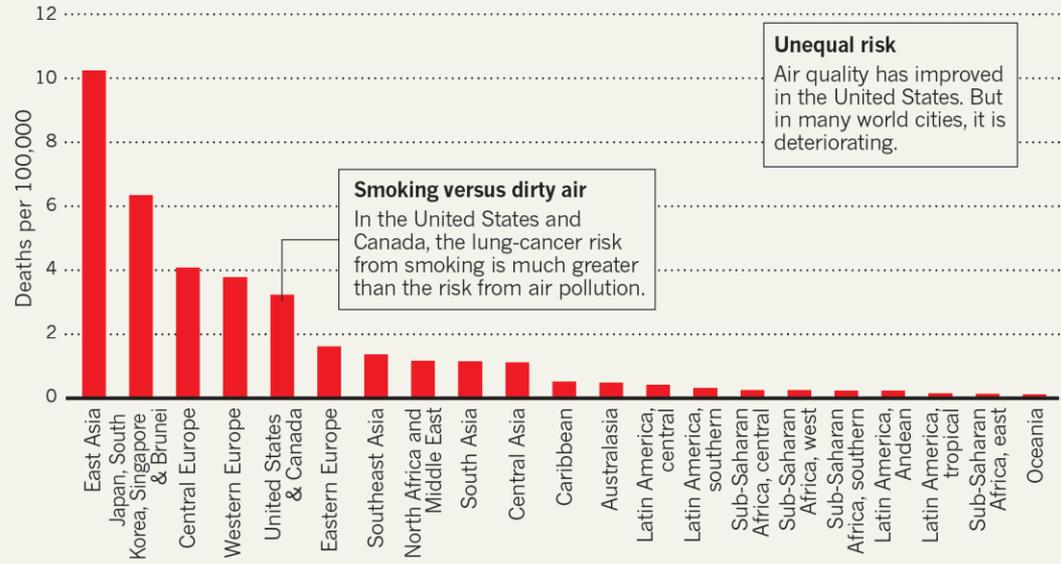
ENVIRONMENT

Breathing trouble

Large-scale studies are confirming suspicions that air pollution significantly increases the risk of lung cancer.

SOMETHING IN THE AIR

Global lung-cancer death rates in 2010 attributable to particulate matter, microscopic airborne droplets or particles that can be traced to sources including power-plant chimneys and dusty fields. The link between lung cancer and fine particulate matter — up to 2.5 micrometres in diameter — is especially strong.



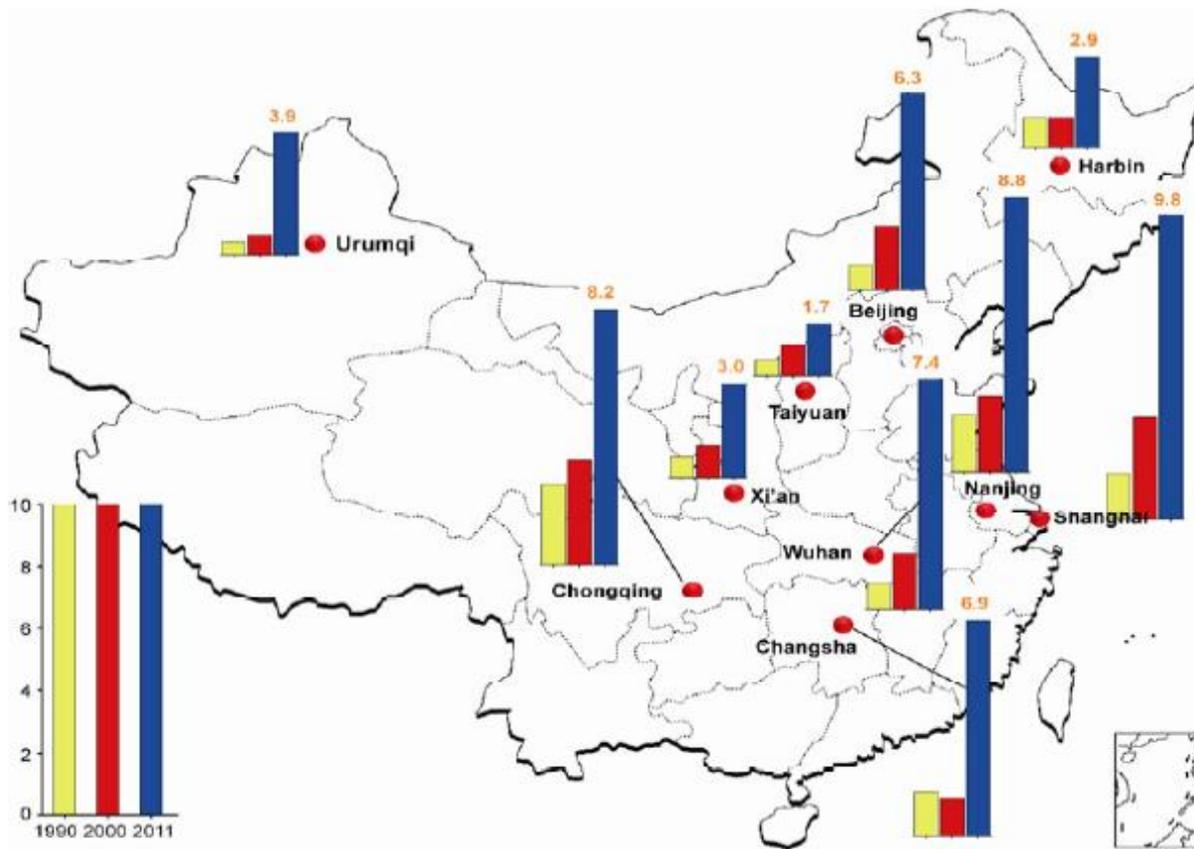
Unequal risk
Air quality has improved in the United States. But in many world cities, it is deteriorating.

Smoking versus dirty air
In the United States and Canada, the lung-cancer risk from smoking is much greater than the risk from air pollution.

China-based studies

EXAMPLE: CCHH STUDY

举例：十城市研究



10 cities 十城市

(从北到南)

(from north to south):

- Harbin 哈尔滨
- Urumqi 乌鲁木齐
- Beijing 北京
- Taiyuan 太原
- Xi'an 西安
- Nanjing 南京
- Shanghai 上海
- Wuhan 武汉
- Chongqing 重庆
- Changsha 长沙

Prevalence of children's asthma in 1990, 2000, 2011

Zhang, Y. et al. Ten cities cross-sectional questionnaire survey of children asthma and other allergies in China. *Chin. Sci. Bull.* 2013, 58 (34), 4182-4189

CCHH Study results

■ CCHH Shanghai

- In logistic regression analyses, early **furred pet-keeping** was positively associated with most of the symptoms and significantly with rhinitis (**ever, adjusted OR=1.41, 95% CI=1.14–1.76**) and doctor-diagnosed hay fever (**1.38, 1.02–1.88**). Current
- **maternal smoking** has a significant and positive association with wheeze (**in the last 12 months, AOR, 95% CI: 1.83, 1.11–2.99**). However, paternal smoking either currently or at child's birth had only weak associations with wheeze and croup.
- Incense-burning (mosquito-repellent incense and incensation) had significant and negative association with doctor-diagnosed asthma (**AOR, 95% CI: 0.85, 0.73–0.99**) and hay fever (**AOR, 95% CI: 0.80, 0.70–0.93**).

CCHH Study results

■ CCHH Beijing

- More" breastfeeding was found to be significantly protective (aOR 0.42, $P < 0.05$) for this subset against Doctor-diagnosed asthma (D-asthma).

■ CCHH Wuhan

- The odds ratio of mice observed for severe eczema was 3.1 (95% CI: 1.4–6.7). It suggests that urbanization, life style and dampness problems at home were significant risk factors for eczema symptoms among children in Wuhan, China.

■ CCHH Nanjing

- The indoor environment typical of modern apartments in China was a risk factor for pneumonia among children.

■ CCHH Urumqi

- Home signs of mold growth or dampness, windowpane condensation, as well as ETS and interior surface materials emitting chemicals were risk factors for allergic symptoms and pneumonia.

CCHH Study results

■ CCHH Urumqi

- Home signs of mold growth or dampness, windowpane condensation, as well as ETS and interior surface materials emitting chemicals were risk factors for allergic symptoms and pneumonia.

■ Changsha

- We conclude that age-related accumulative personal exposure to ambient air pollution may play an important role in the development of rhinitis.

■ Chongqing

- Dampness in homes was generally strongly associated with asthma and allergies among Chongqing children. The strongest association was found between "visible mould" and doctor-diagnosed rhinitis, and the adjusted Odds Ratio(ORA) was 2.27(95%CI:1.48,3.49).

CCHH Study results

Beijing Study of Traffic and SBS Symptoms

- During January and May, 2011, Kindergartens in 11 districts in Beijing were selected.
- Questionnaires (5,888) were distributed by teachers to parents/grandparents of students and then returned to teachers.



'Living near a main road or highway' was associated with a 40% increase in the odds of having SBS symptoms in the past 3 months

Green Housing

What is green building?

EPA's Definition of Green Building

Green building is the practice of creating structures and using processes that are **environmentally responsible and resource-efficient** throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high performance building.

| Aspects of Built Environment | Consumption | Environmental | Ultimate Effects |
|--|--|--|--|
| <ul style="list-style-type: none">• Siting• Design• Construction• Operation• Maintenance• Renovation• Deconstruction | <ul style="list-style-type: none">• Energy• Water• Materials• Natural Resources | <ul style="list-style-type: none">• Waste• Air pollution• Water pollution• Indoor pollution• Heat islands• Stormwater• Noise | <ul style="list-style-type: none">• Harm to Human Health• Environment Degradation• Loss of Resources |

What is green building?



Household exposures/drivers



phthalates



flame retardants



phthalates



PAH

PCBs



pesticides

Asthma/allergy

?

Reproduction

?

Early life exposure for
Endocrine disruptors eg.:

- phthalates
- bisphenol A
- flame retardants

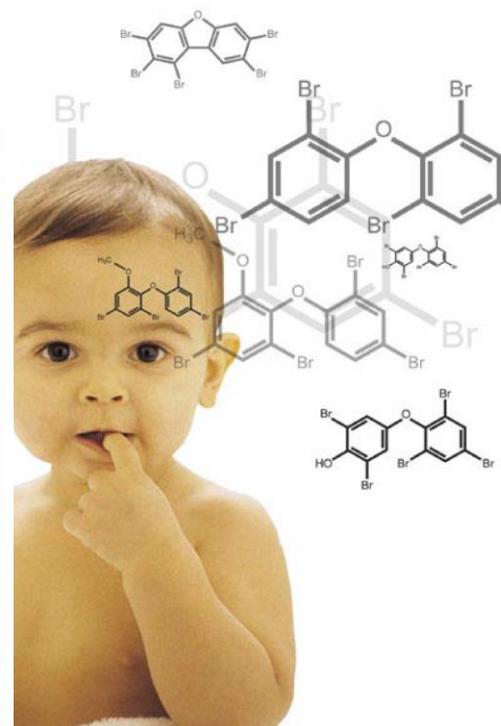
i.a., Indoor related
Exposures in many cases

Obesity

?

Diabetes

?



Autism (ASD)

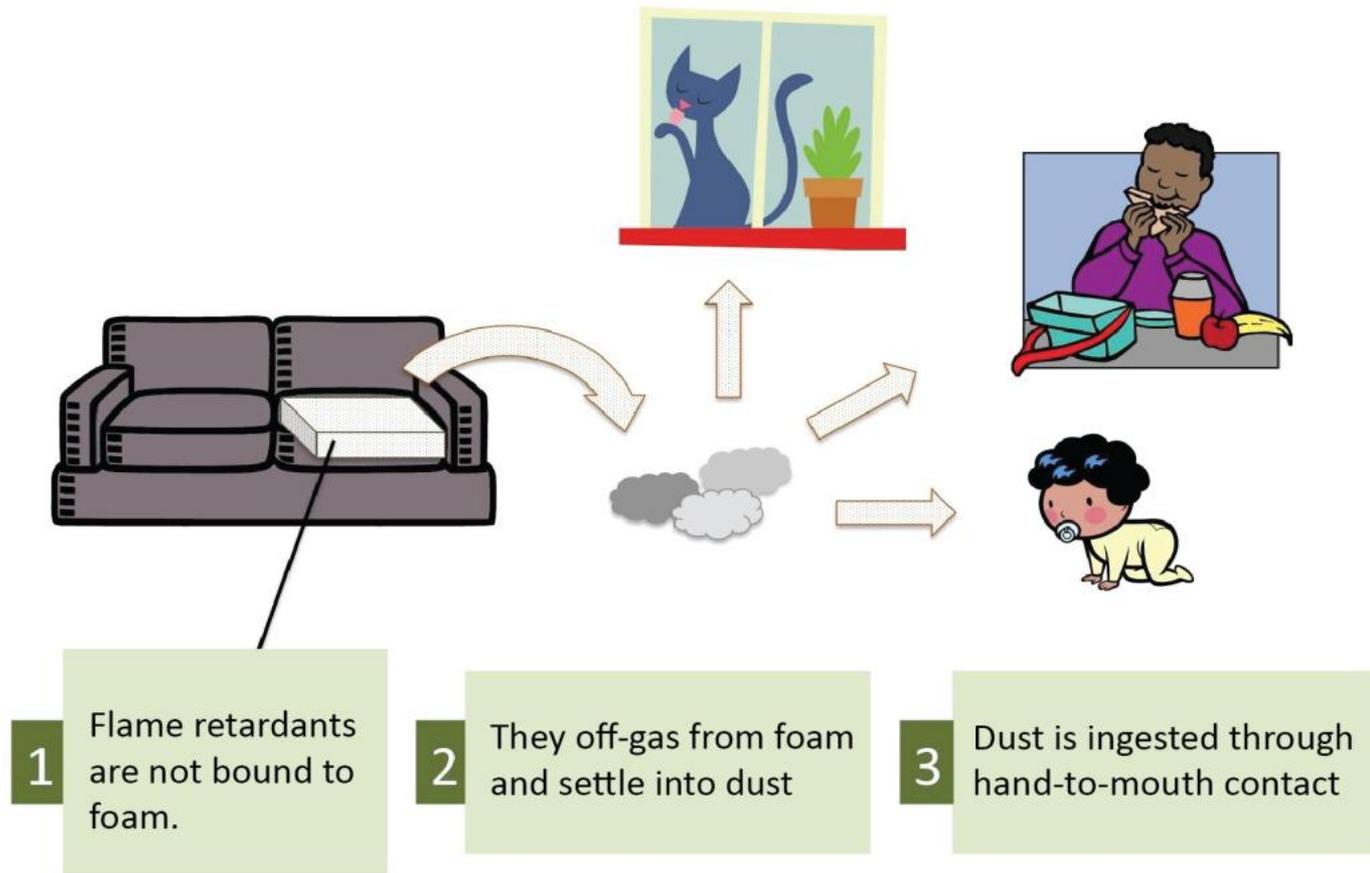
?

Beginning a lifetime of vulnerability. A recent meeting highlighted new data showing that *in utero* exposures to endocrine-disrupting chemicals can initiate changes leading to disease later in life.

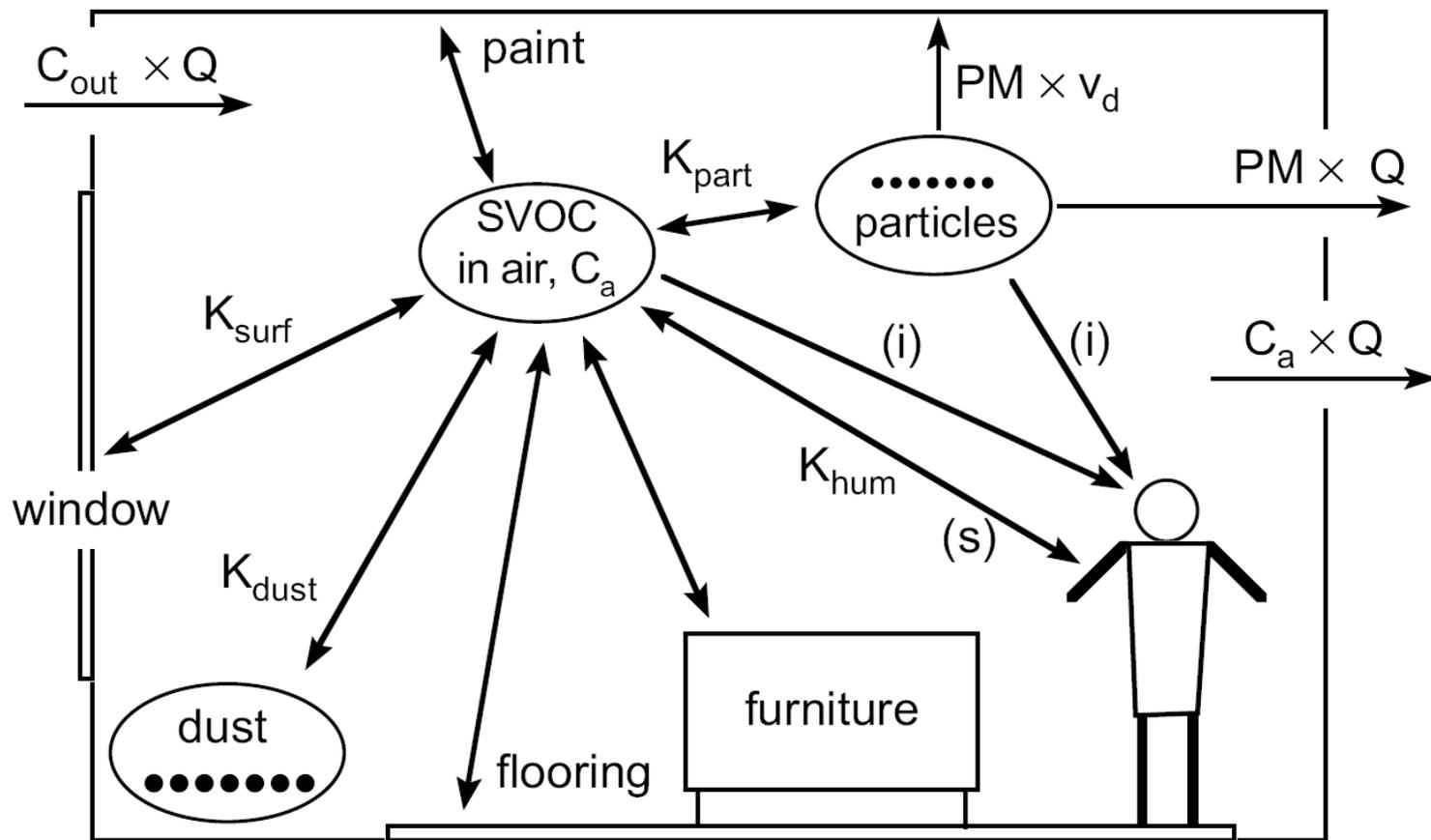


ELIMINATING CHEMICALS IN ENVIRONMENTS

Identifying safer product alternatives to chemicals present in furnishings, clothing, and personal care products will reduce exposure to indoor pollutants.



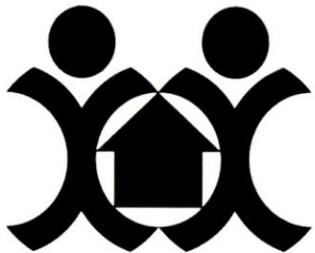
Household exposures/drivers



(i) - inhalation intake; (s) - skin permeation

The **BRIGHT** Study

Boston Residential Investigation on Green and Healthy Transitions



Boston Housing Authority



HARVARD
School of Public Health



CBPH
Committee For Boston
Public Housing



TRINITY
FINANCIAL

MASSART
MASSACHUSETTS COLLEGE
OF **ART AND DESIGN**

Where to intervene?



'green'
transitions

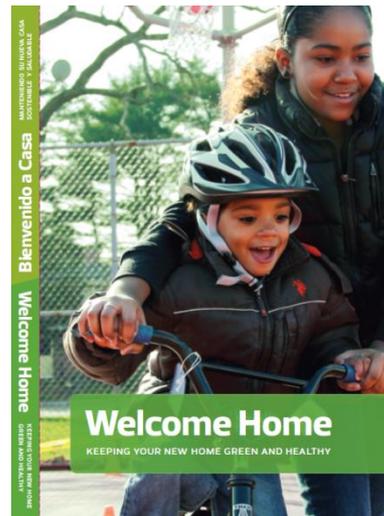
smoke-free
policies



chemical
exposures



better
pest
control
policies



resident
education

Green Housing



Old Colony



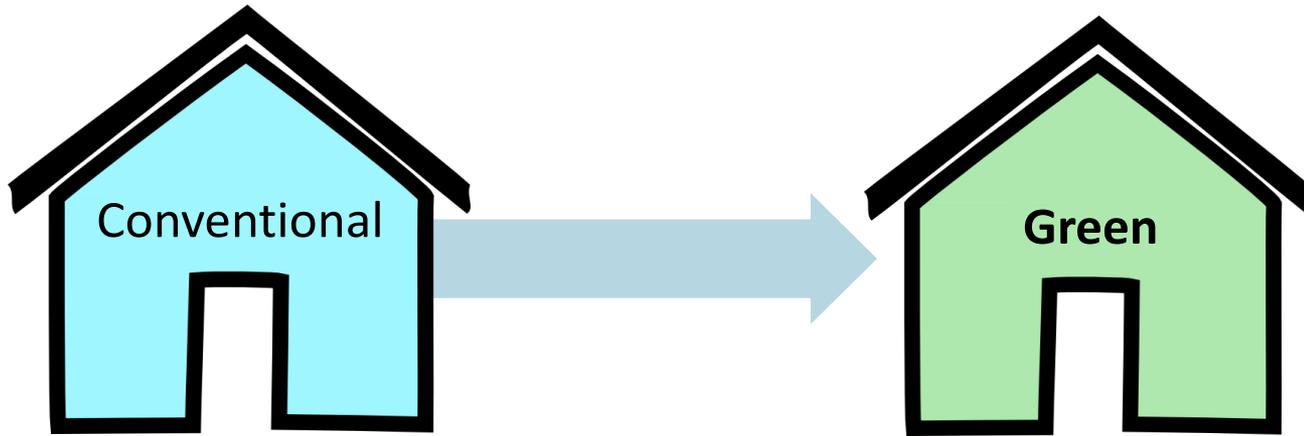
Ruth Lillian Barkley



Washington Beech



Green Housing – BRIGHT Study



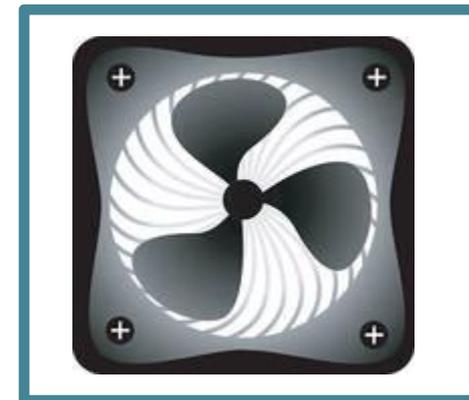
How do these transitions affect:

- Comfort?
- Satisfaction?
- Environmental exposures?
- Health?
- Energy usage?

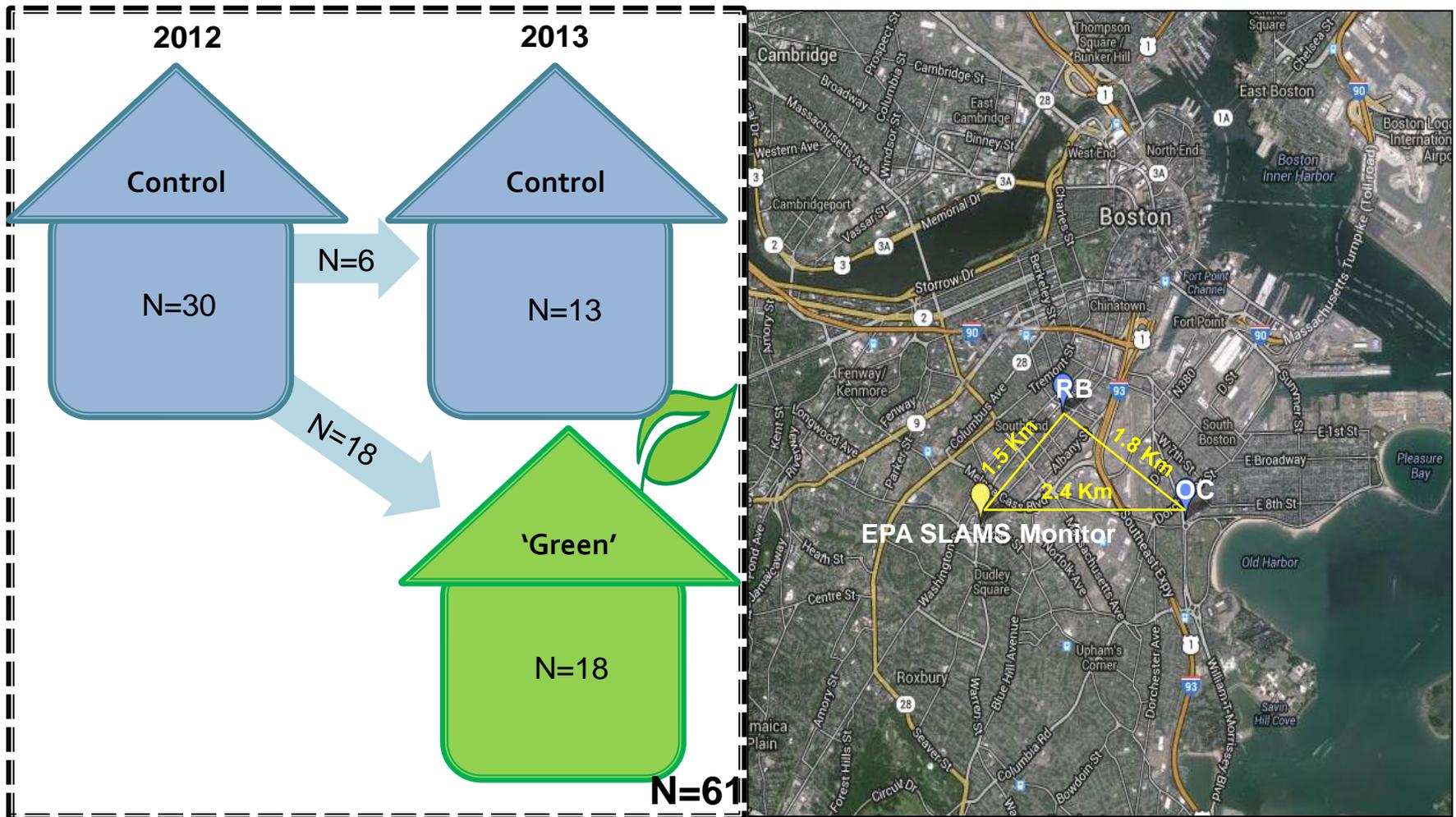
Green Attributes

| Washington Beech | Old Colony | Ruth Lillian Barkley (Cathedral) |
|--|---|---|
| <ul style="list-style-type: none">• Low / No VOC paints, primers, adhesives and sealants• Green label certified floor coverings• Energy Star exhaust fans• Ventilation system compliant with ASHRAE 62.1-2007 and ASHRAE 62.2 | <ul style="list-style-type: none">• Low / No VOC paints, primers, adhesives and sealants• Energy Star appliances and exhaust fans• Sustainable materials for finishes and coverings• Energy-efficient windows• Closed-cell foam insulation at sidewalls• High-efficiency, gas-fired hydronic heat and hot water• PV, co-generation and “green” electricity• ERV units in roof plenums to re-use vertical heat loss | <ul style="list-style-type: none">• Low / No VOC paints, primers, adhesives and sealants• Energy Star appliances and exhaust fans• Sustainable materials for fixtures, finishes and coverings• Energy-efficient windows and entry doors• Closed-cell foam insulation at sidewalls• High efficiency hot water heating system• Individual shut-off valves |

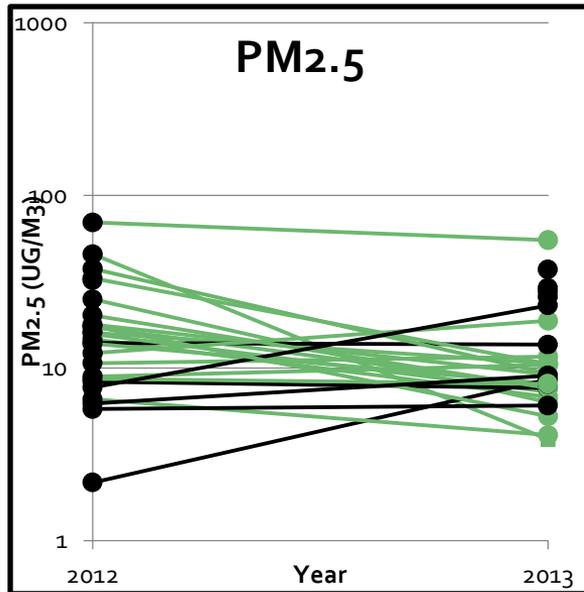
Green Housing – BRIGHT Study



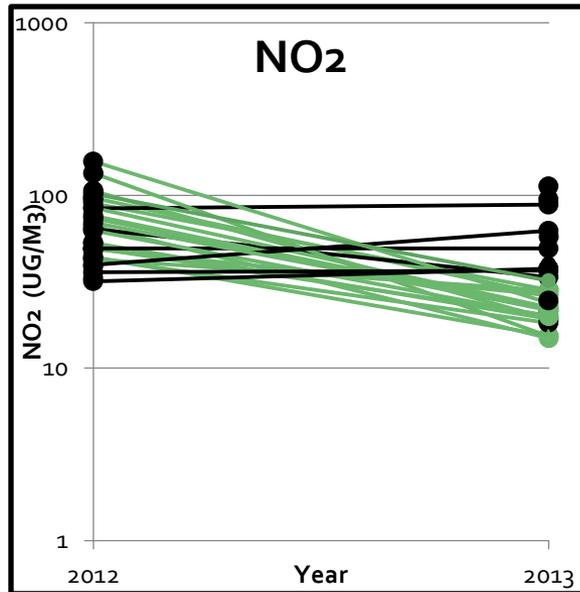
Sampling Study



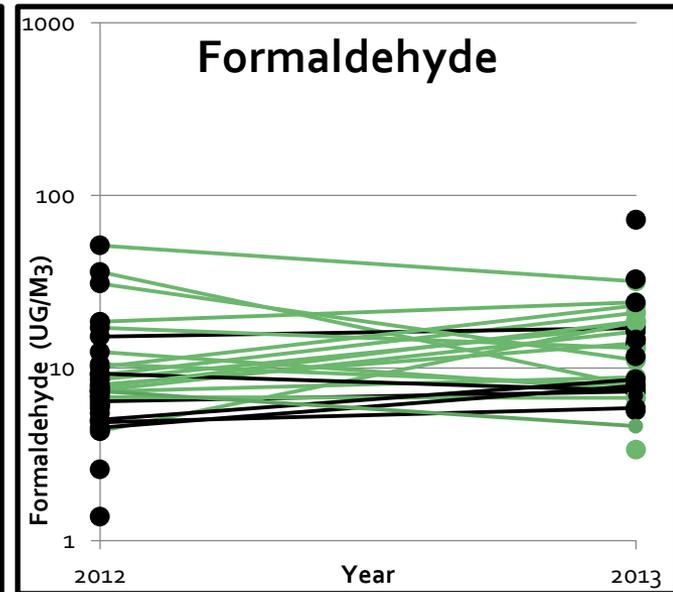
Green Housing – BRIGHT Study



↓ 41.1 %*



↓ 66.1 %*



↑ 29%

47% fewer sick building syndrome symptoms ($p < 0.01$)

Colton MD, MacNaughton PO, Vallarino J, Kane J, Bennett-Fripp M, Spengler JD, Adamkiewicz G, **Indoor air quality in green vs. conventional multi-family low-income housing**, Environ Sci Technol. 2014 Jul 15;48(14):7833-41.

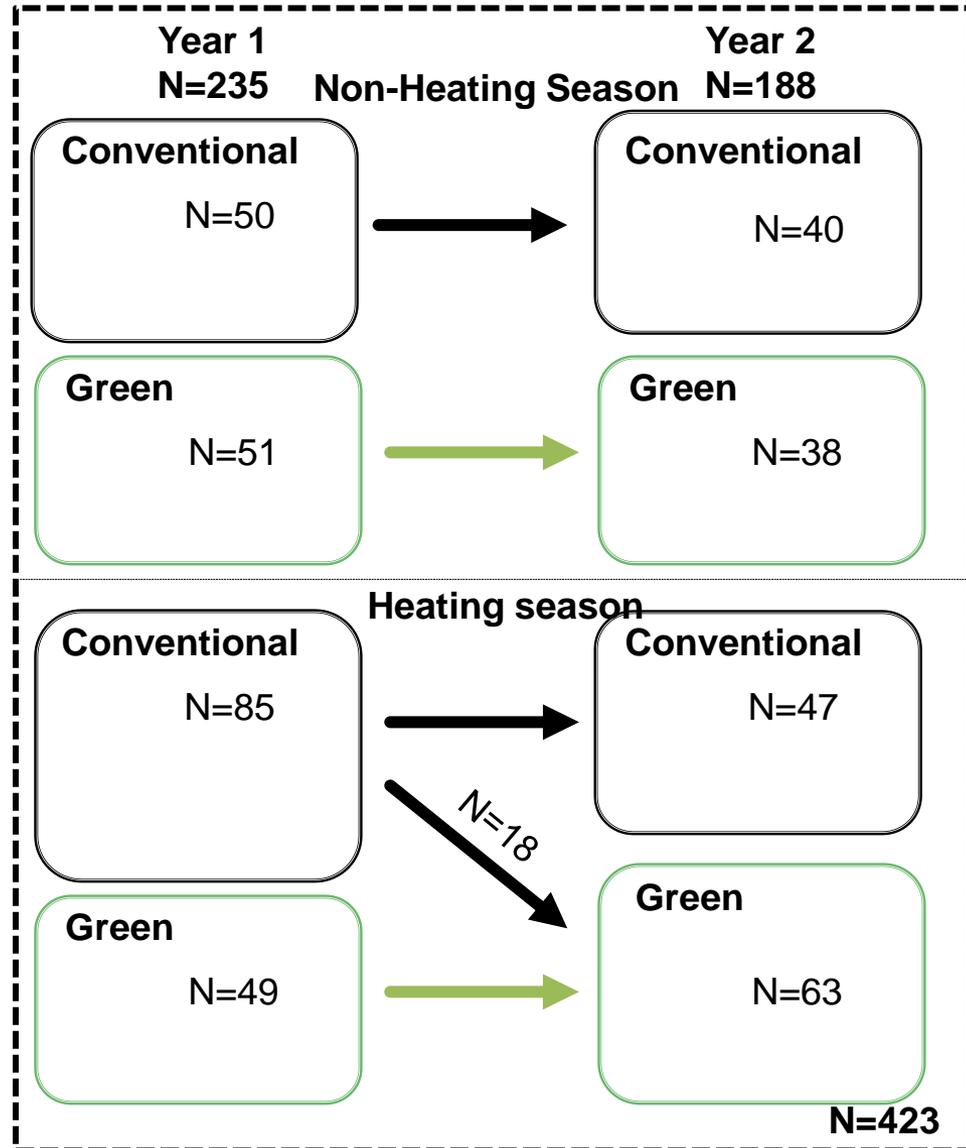
* $p < 0.05$

Survey Study Design

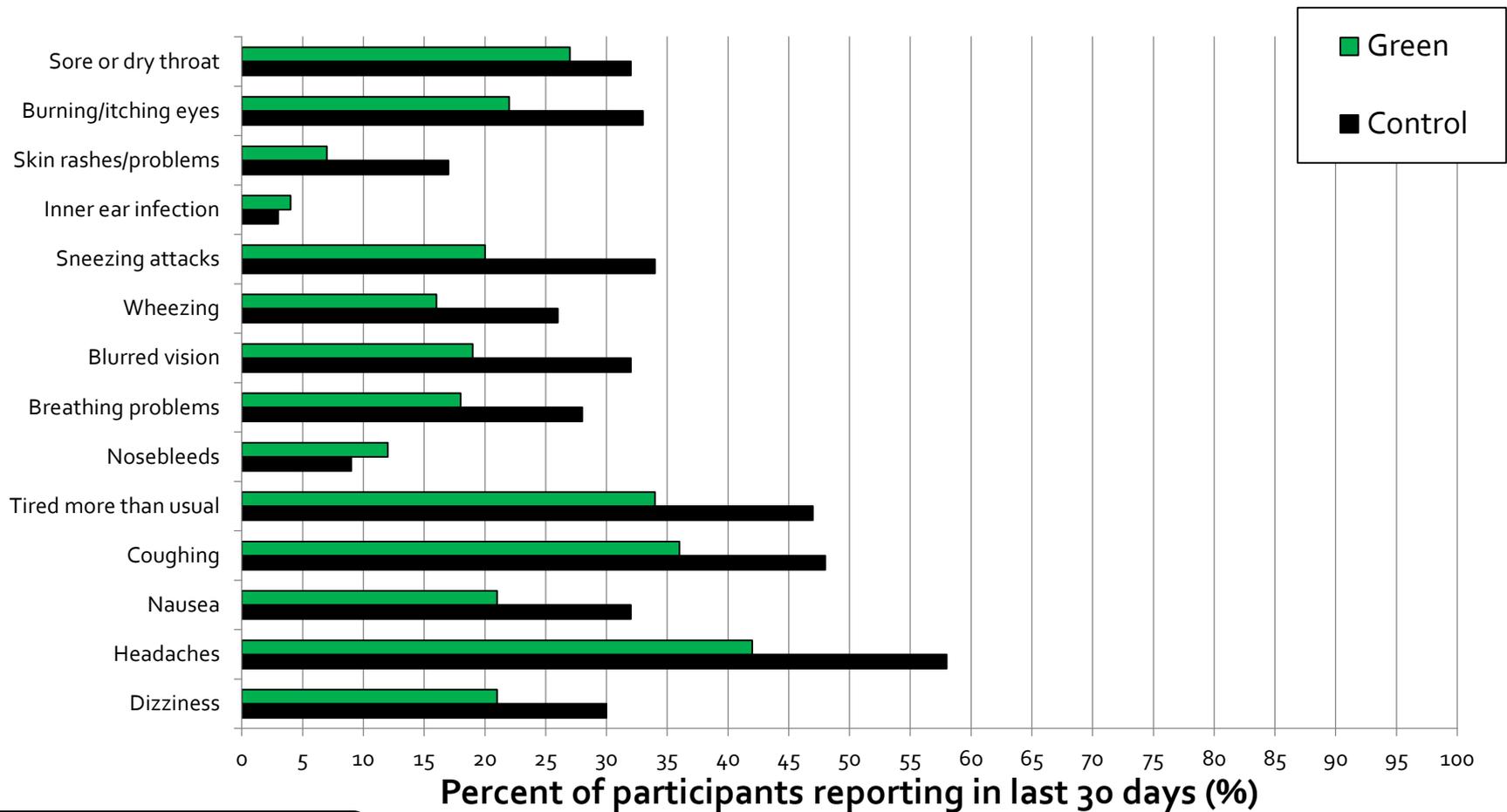


Measures:

- Comfort
- Health
- Symptoms
- Satisfaction

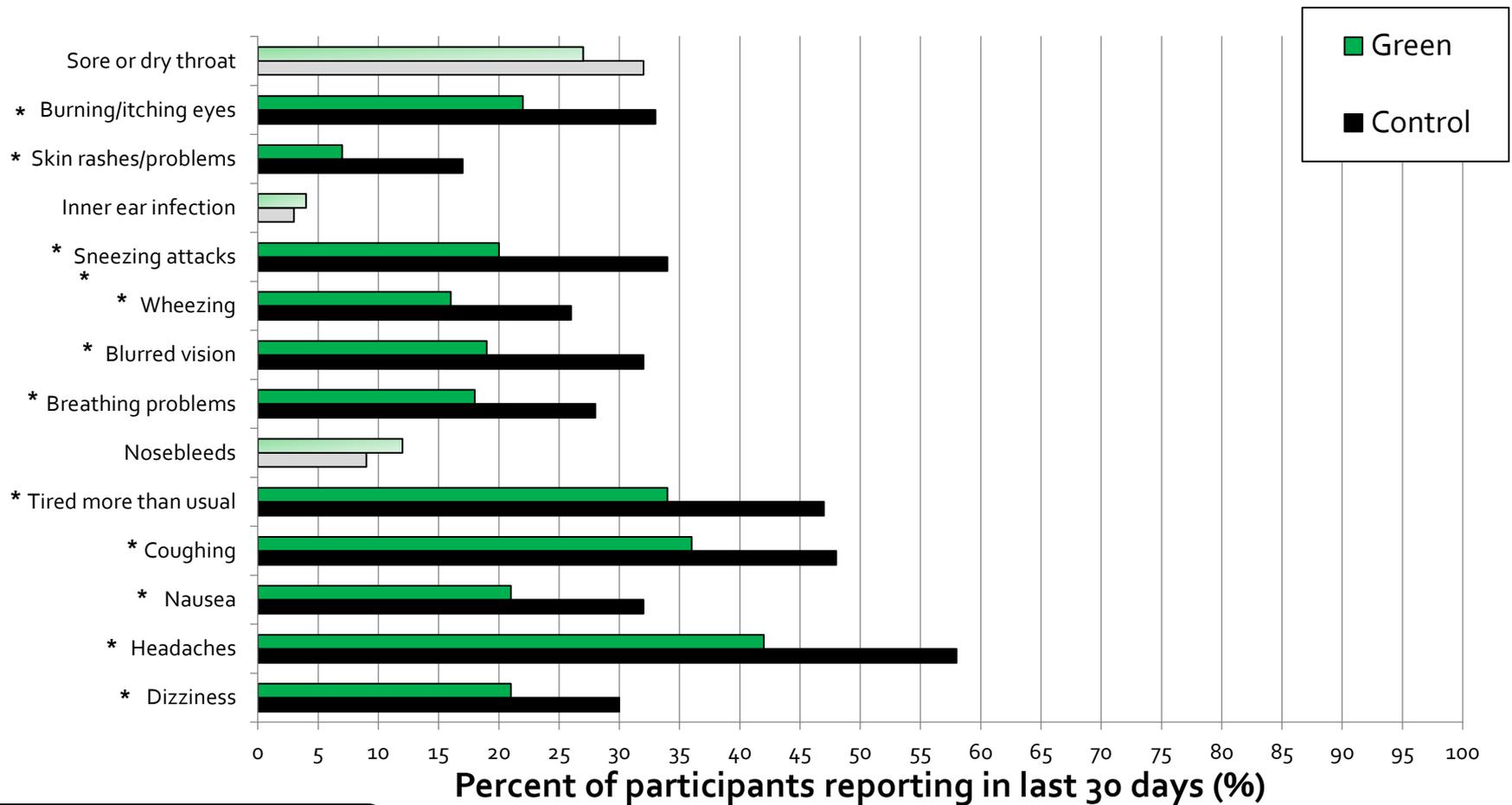


Symptoms at home in last 30 days



YEAR 1 and 2

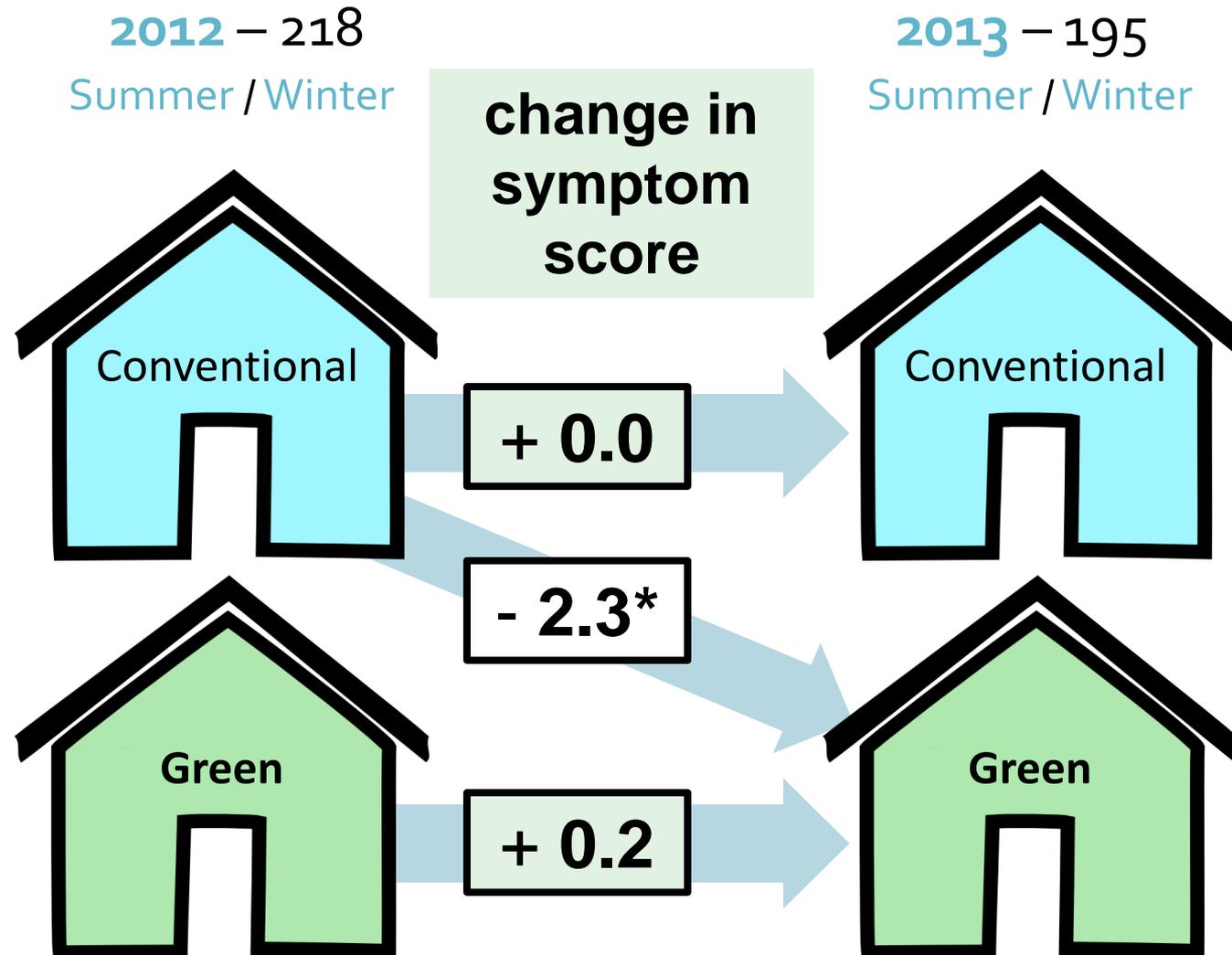
Symptoms at home in last 30 days



YEAR 1 and 2

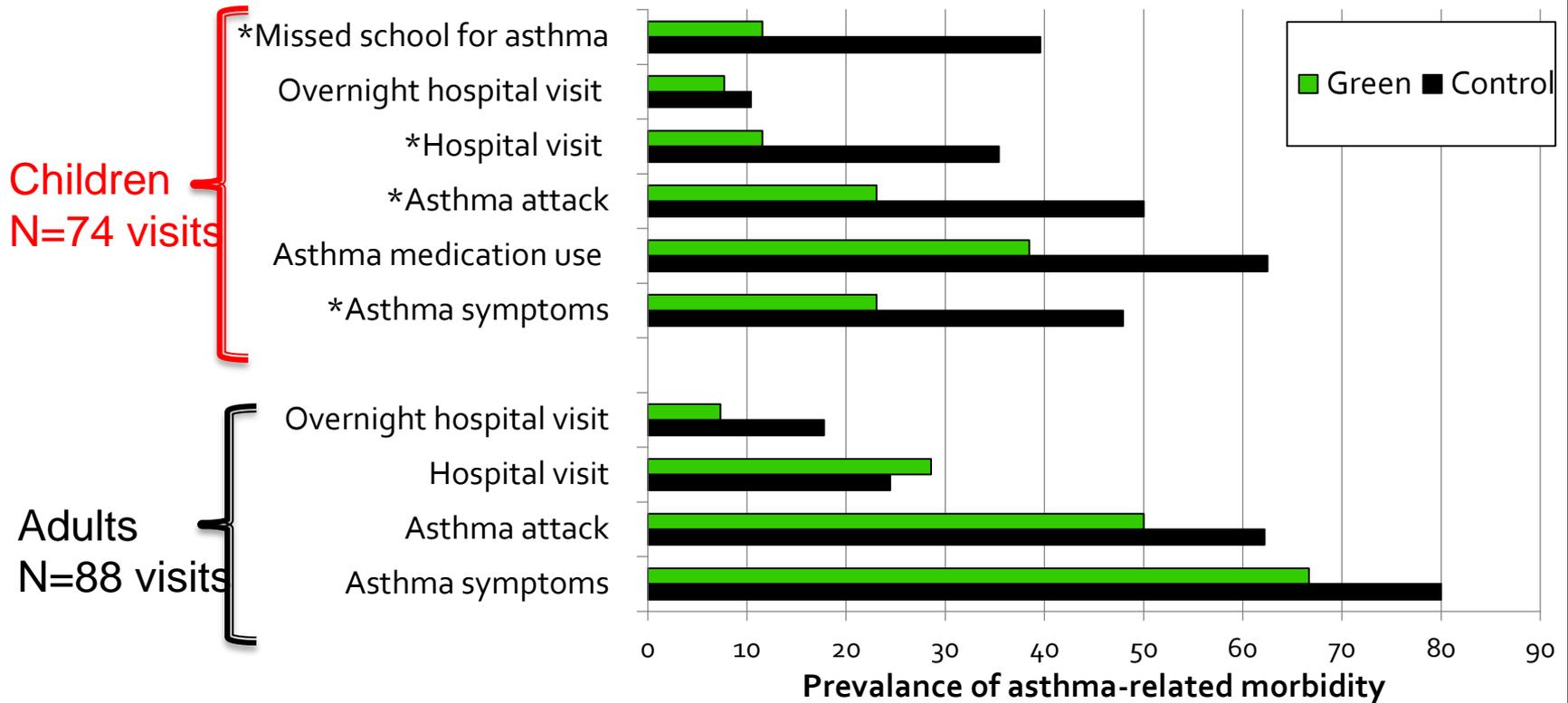
*p < 0.05

Symptoms at home in last 30 days



*p < 0.05

Results: Asthma Morbidity

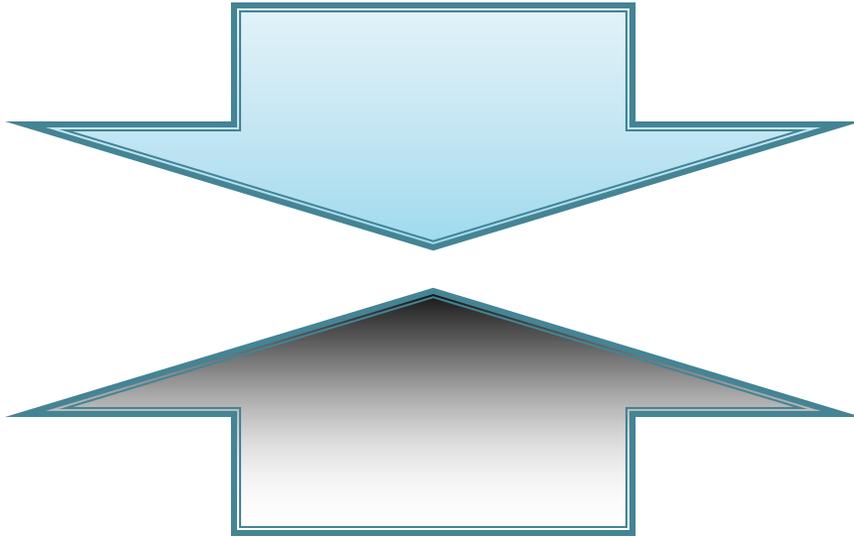


Odds ratios (OR) for **control** children experiencing:

- Asthma symptoms: 2.9 (1.0, 8.3)
- Asthma attack: 3.2 (1.1, 9.1)
- Hospital visit: 4.2 (1.1, 16.6)
- Missed school for asthma: 4.8 (1.4, 16.6)

Final thoughts

Programs, policies, systems



Households, families

Keys to success:

- Address root causes
- Understand systems
- Every encounter is an opportunity
 - people
 - homes
- Need new partnerships

Final thoughts

- **Improvements across several metrics**
 - Exposures
 - Health
 - Energy
- **Structural vs. Behavioral factors**
- **Design vs. Management vs. Maintenance**
- **Alignment of goals**
 - **Energy + Health**
 - ventilation
 - **Energy + Satisfaction**
 - thermal comfort



Green Housing – BRIGHT Study



3

Keeping It Green & Healthy

Your apartment has been designed to be green and healthy. These things are good for you and good for the environment!

Green

A green home is specifically designed to use less energy, water, raw materials, and other resources. These features reduce the impact that your home has on the community and the planet.

A green home can:

-  **Save you money** by reducing your utility bill.
-  **Save the planet** by reducing energy use and waste.
-  **Keep you healthy** by reducing harmful chemicals in your home.

Percentage of adults who reported asthma symptoms

Live in BHA housing



Live in subsidized, non-BHA housing



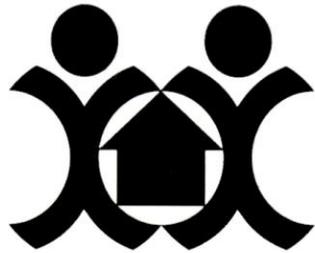
All others



SOURCE: Boston Housing Authority and Boston Public Health Commission

- BPHC's analysis of BRFSS data showed **decline in current asthma symptoms** from 2006-2010 for BHA residents
- No decline seen for other housing types
- Differences remained after adjustments for age, gender, ethnicity, smoking habits, health insurance, and whether foreign-born

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