



Emerging Science on Indoor Chemistry A Virtual Information-Gathering Workshop

April 5th, 2021

Committee on Emerging Science on Indoor Chemistry

Board on Chemical Sciences and Technology

Division on Earth and Life Studies

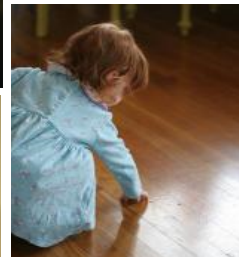
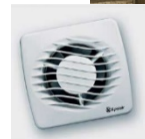
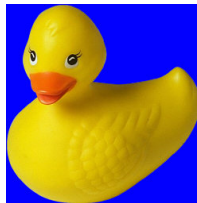
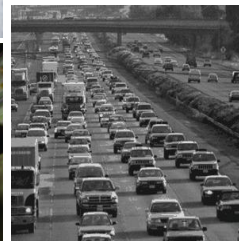
Indoor air exposure disparities: understanding sources, structures and settings

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EMERGING SCIENCE ON INDOOR CHEMISTRY AND IMPLICATIONS:
AN INFORMATION-GATHERING WORKSHOP
National Academies

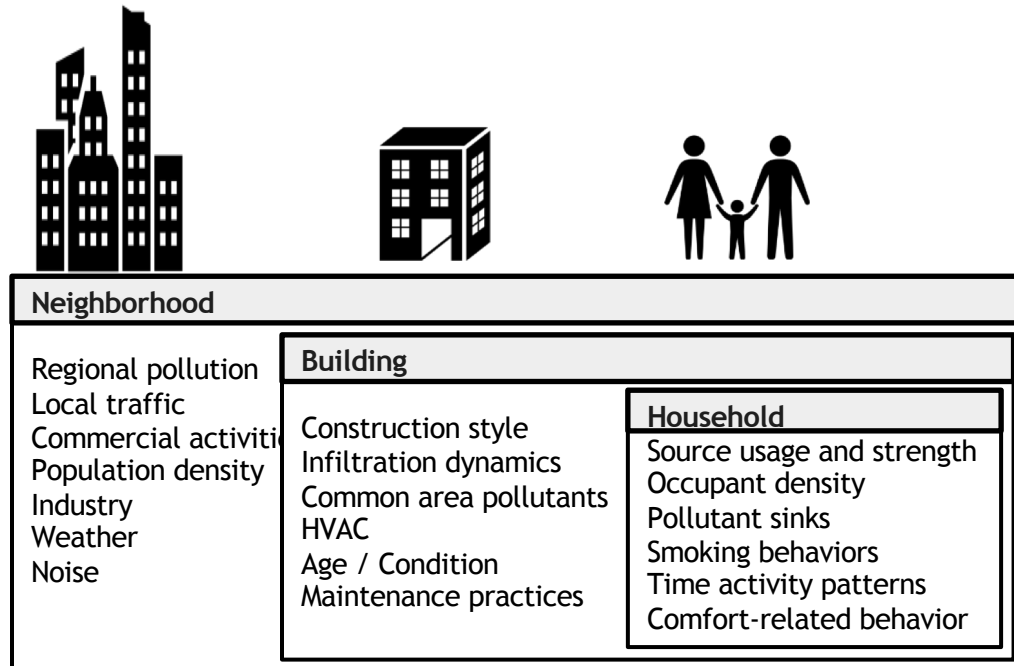
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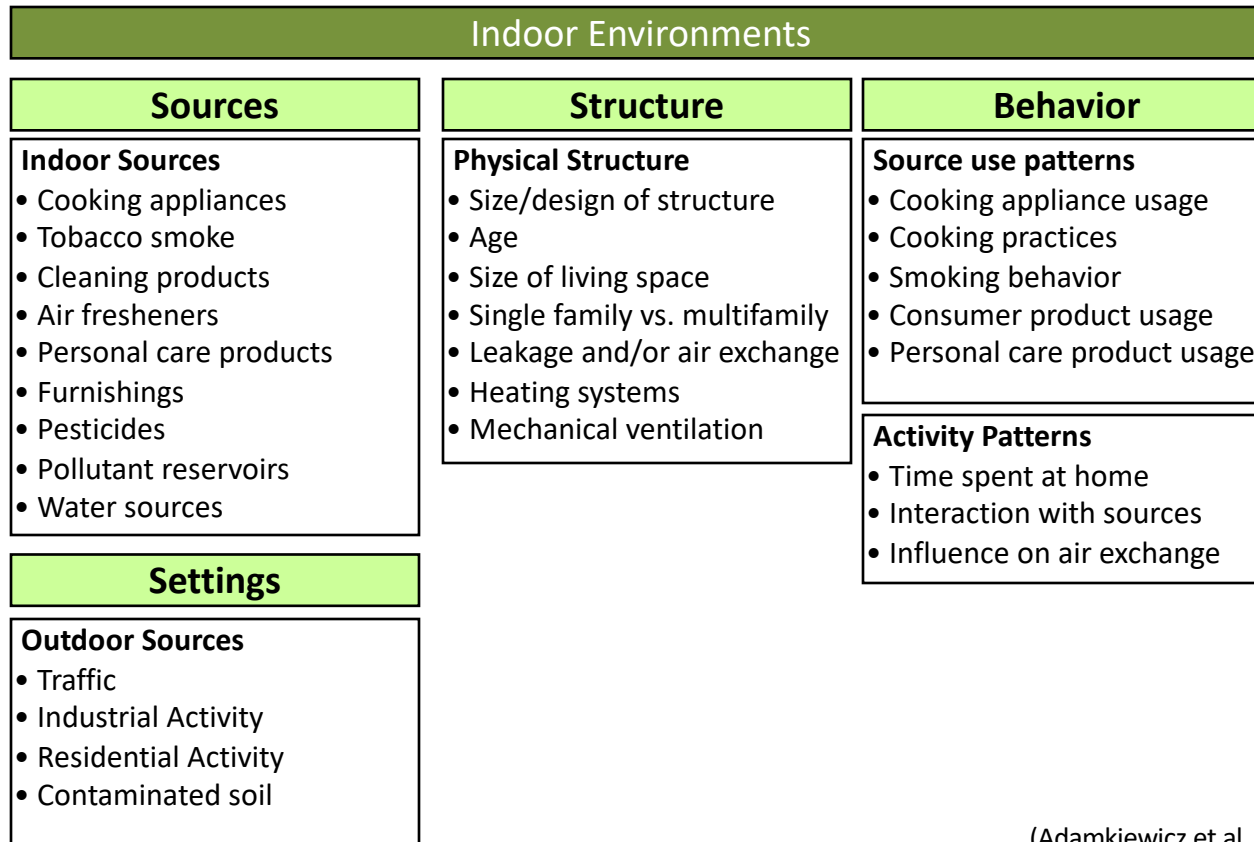


Deconstructing disparity

We need to take a multilevel view of determinants of exposure to indoor pollutants.



Deconstructing disparity





exposures

modifiers

SES and Ambient Concentrations

Curr Envir Health Rpt (2015) 2:440–450
DOI 10.1007/s40572-015-0069-5



AIR POLLUTION AND HEALTH (JD KAUFMAN AND SD ADAR, SECTION EDITORS)

Socioeconomic Disparities and Air Pollution Exposure: a Global Review

Anjum Hajat¹ · Charlene Hsia² · Marie S. O'Neill³

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Abstract The existing reviews and meta-analyses addressing unequal exposure of environmental hazards on certain populations have focused on several environmental pollutants or on the siting of hazardous facilities. This review updates and contributes to the environmental inequality literature by focusing on ambient criteria air pollutants (including NO_x), by evaluating studies related to inequality by socioeconomic status (as opposed to race/ethnicity) and by providing a more global perspective. Overall, most North American studies have shown that areas where low-socioeconomic-status (SES) communities dwell experience higher concentrations of criteria air pollutants, while European research has been mixed. Research from Asia, Africa, and other parts of the world has shown a general trend similar to that of North America, but research in these parts of the world is limited.

Keywords Environmental justice · Environmental inequality · Criteria air pollutants · Air pollution · Socioeconomic status · Social disadvantage

Introduction

Several review articles related to inequalities in environmental hazards have been conducted over the years [1–9]. Existing reviews focus on a variety of important topics including the following: understanding the origins of environmental inequality [6], the policy implications of environmental justice (EJ) research [6], the interaction between the EJ advocacy movement and the research agenda [8], a methodological critique of the research [1], and finally the issue of whether environmental inequalities in the US disproportionately impact racial/ethnic minorities or populations of low socioeconomic status (SES) [7, 9]. The reviews of the existing body of research clearly highlight both the sheer volume of work around environmental inequalities and the complexity of the issues involved.

Although the terms EJ and environmental inequality are often used interchangeably in the literature, they do have distinct meanings. The concept of justice is normative, involving value judgments that can vary over place and time, while equality can be measured empirically and directly compared [10•, 11]. Inequalities can be defined across other domains such as process (equal access to the environmental decision-making process) and opportunity (equal opportunity to reduce or avoid exposures). These concepts, being difficult to measure, are not often found in empirical research (see Marshall [12•] and Clark [13] for papers that move beyond environmental inequality).

Beyond issues of fairness, environmental inequality reflects the unequal distribution of environmental hazards and benefits.

This article is part of the Topical Collection on *Air Pollution and Health*

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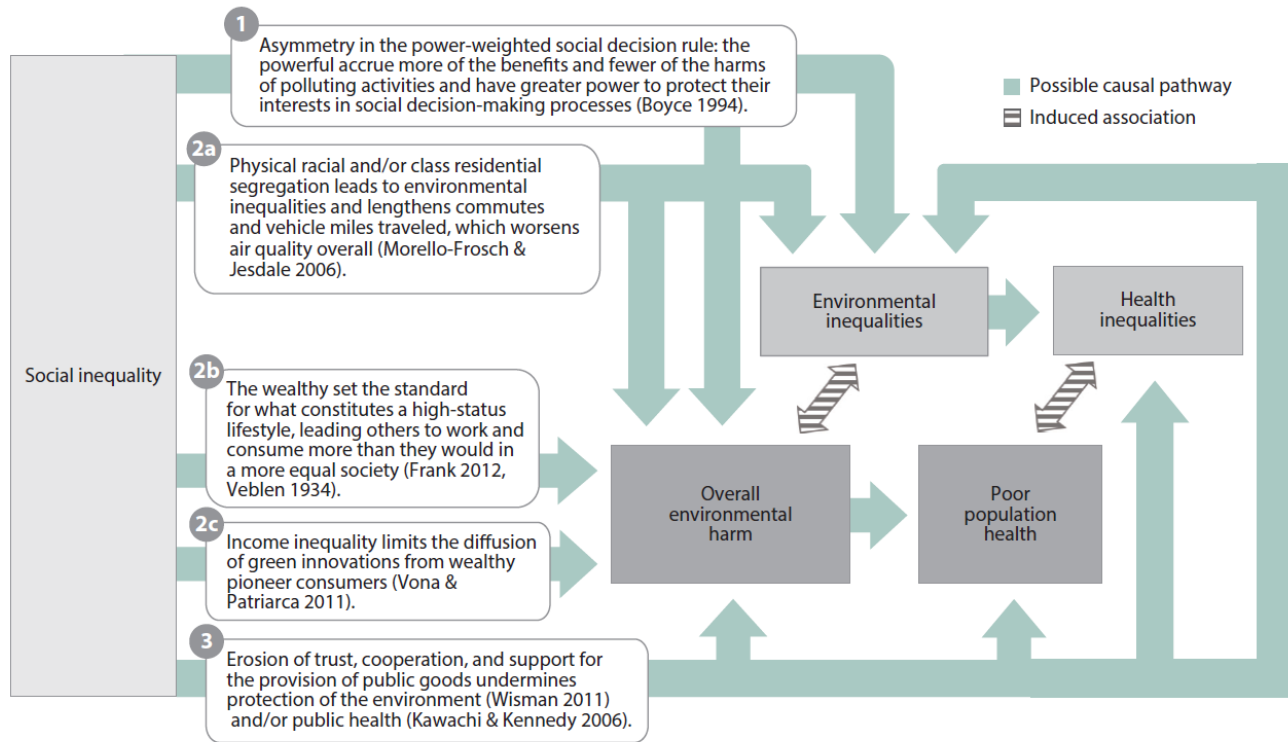
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- Most North American studies have shown associations between low-socioeconomic-status (SES) communities and higher concentrations of criteria air pollutants, while European research has been mixed.
- Research from Asia, Africa, and other parts of the world has shown a general trend similar to that of North America, but research in these parts of the world is more limited.

Hajat, A., Hsia, C., & O'Neill, M. S. (2015). **Socioeconomic Disparities and Air Pollution Exposure: a Global Review.** Current environmental health reports, 2(4), 440-450. DOI: 10.1007/s40572-015-0069-5



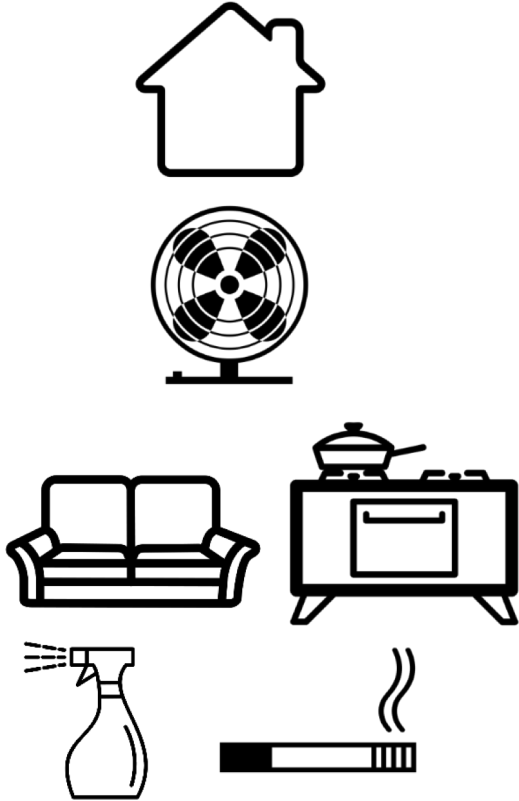
- Power differentials
- Residential segregation

Figure 1

Explanations for a contextual or spillover effect of social inequality on the environment relate to (1) asymmetries in political power, (2) the relationship between inequality and the environmental intensity of consumption, and (3) the erosion of social cohesion and cooperation.

Cushing L, Morello-Frosch R, Wander M, Pastor M. **The Haves, the Have-nots and the Health of Everyone: The Relationship Between Social Inequality and Environmental Quality.** Annual Review of Public Health. 2015. 36:193–209. doi: 10.1146/annurev-publhealth-031914-122646

Deconstructing disparity



BUILDINGS / SYSTEMS

SOURCES

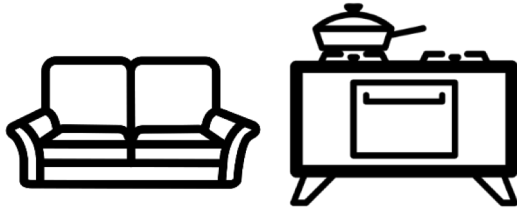
Deconstructing disparity



housing type / size / condition / occupancy
/ single vs. multifamily



housing type / size / condition / climate /
weather / HVAC



furnishings / product usage / cooking fuel
(electric/gas/wood)/ equipment / activity /
spot ventilation / supplemental heating?



smoking prevalence / SHS via multifamily
transfer

Modifiers – infiltration/air exchange



location/ housing type / size /
condition / occupancy / single
vs. multifamily



housing type / size / condition /
climate / weather / HVAC

Some modifiers that determine personal exposure are distributed by SES – building quality, air conditioning, air cleaning devices

Taken together, these factors can introduce significant within-neighborhood variability.

Adamkiewicz G, Zota AR, Fabian MP, Chahine T, Julien R, Spengler JD, Levy JI. **Moving environmental justice indoors: understanding structural influences on residential exposure patterns in low-income communities.** AJPH 2011 Dec; 101 Suppl 1:S238-45.

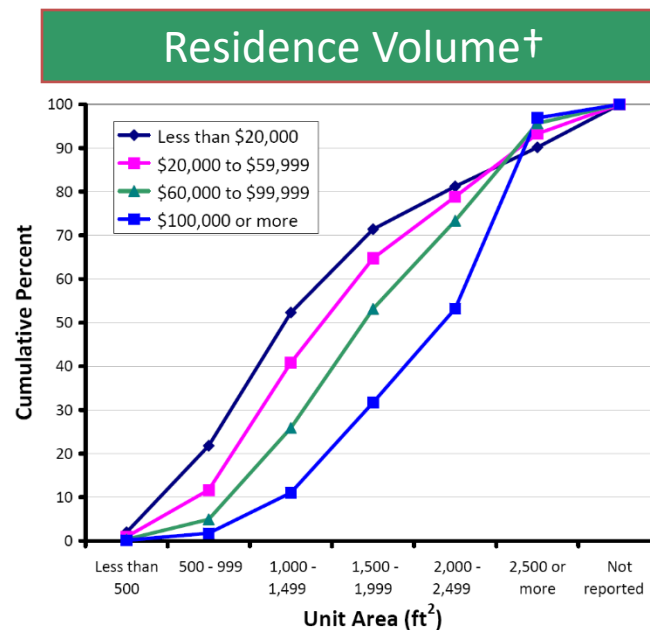
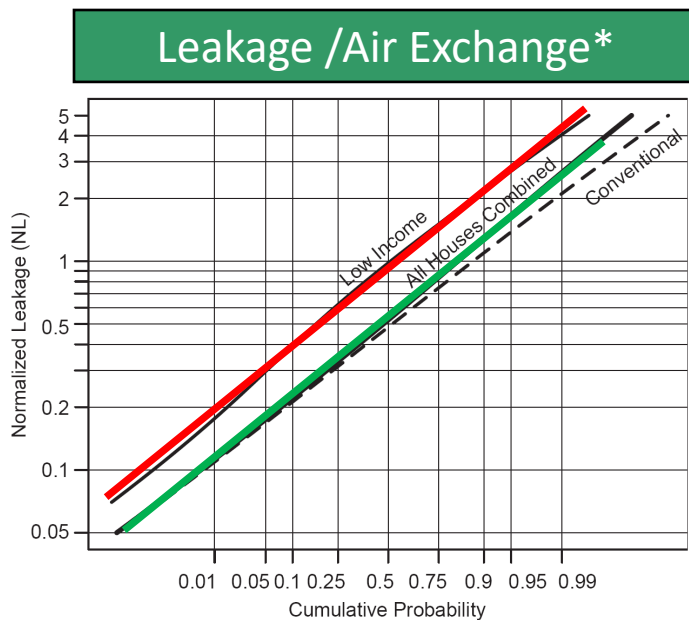
Differences by housing attributes

Housing Variable	Low Income	High Income	Ratio
Built before 1980 (%)	71.56	48.63	1.5
Area of peeling paint larger than 8 x 11 (%)	3.11	0.99	3.1
Any inside water leaks in last 12 months (%)	9.14	7.98	1.1
Neighborhood with heavy street noise/traffic (%)	28.19	16.69	1.7
Industry/factory within ½ block (%)	6.90	1.74	4.0
Unit uncomfortably cold for 24+ hrs (%)	10.70	6.71	1.6
Mean floor area of unit (ft ²)	1524	2853	0.5
Mean occupant density (number per 1000 ft ²)	2.78	1.82	1.5
Homes with cracks in floor, wall, or ceiling (%)	7.13	3.31	2.2

(Low income = <\$30k/yr; High income = >\$100k/yr))

(Adamkiewicz et al 2011, using data from AHS, 1999)

Air leakage and home volume



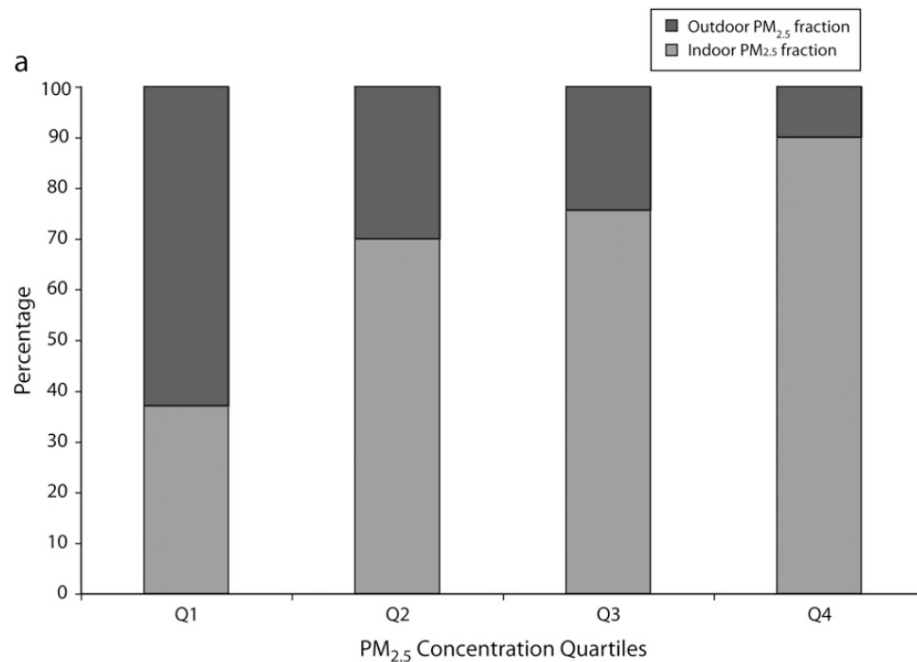
Implications

- Smaller volumes will increase indoor concentrations
- Homes with higher leakage will decrease concentrations

*(Chan et al. 2005)

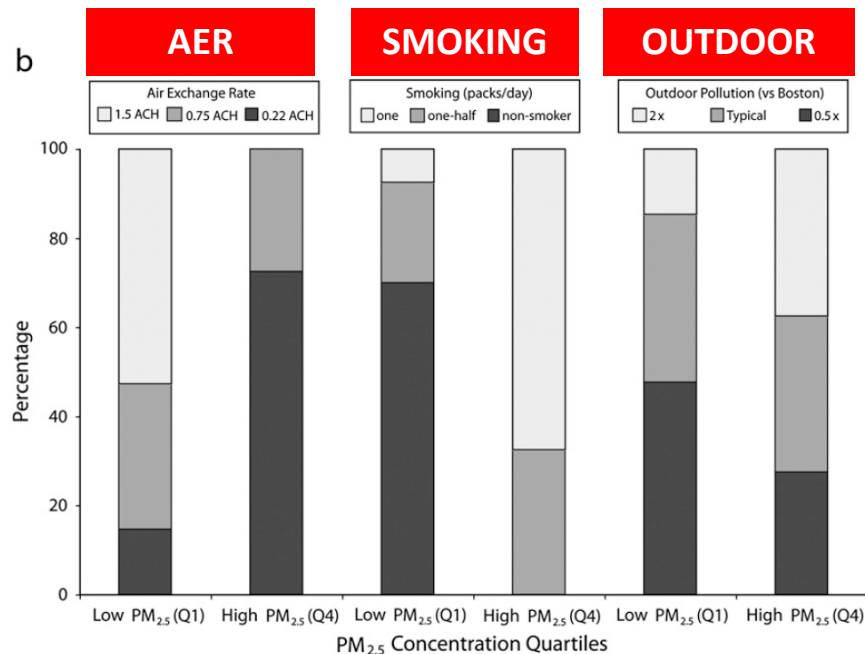
†(AHS 2009)

Deconstructing disparity



- Simulation study
- We varied air exchange, sources and ambient concentrations

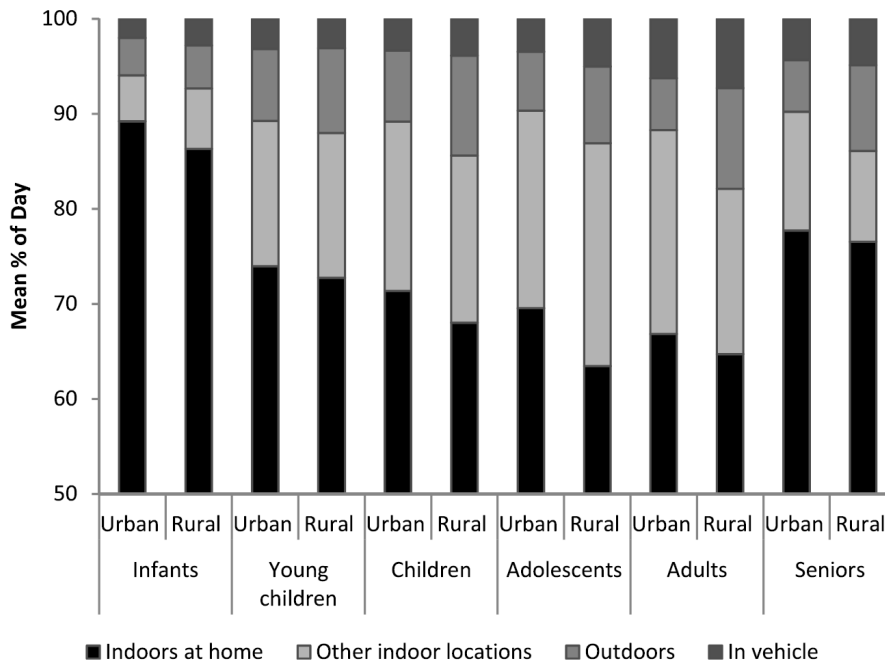
Deconstructing disparity



- All factors contribute, as expected
- Air exchange and major sources matter most

Deconstructing disparity

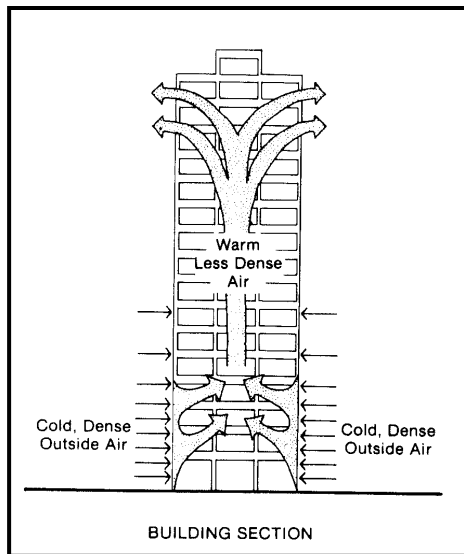
TIME ACTIVITY



- Activity patterns matter
- This is just one example of how indoor/personal exposures are shaped by household characteristics

'System' Effect - Scenarios

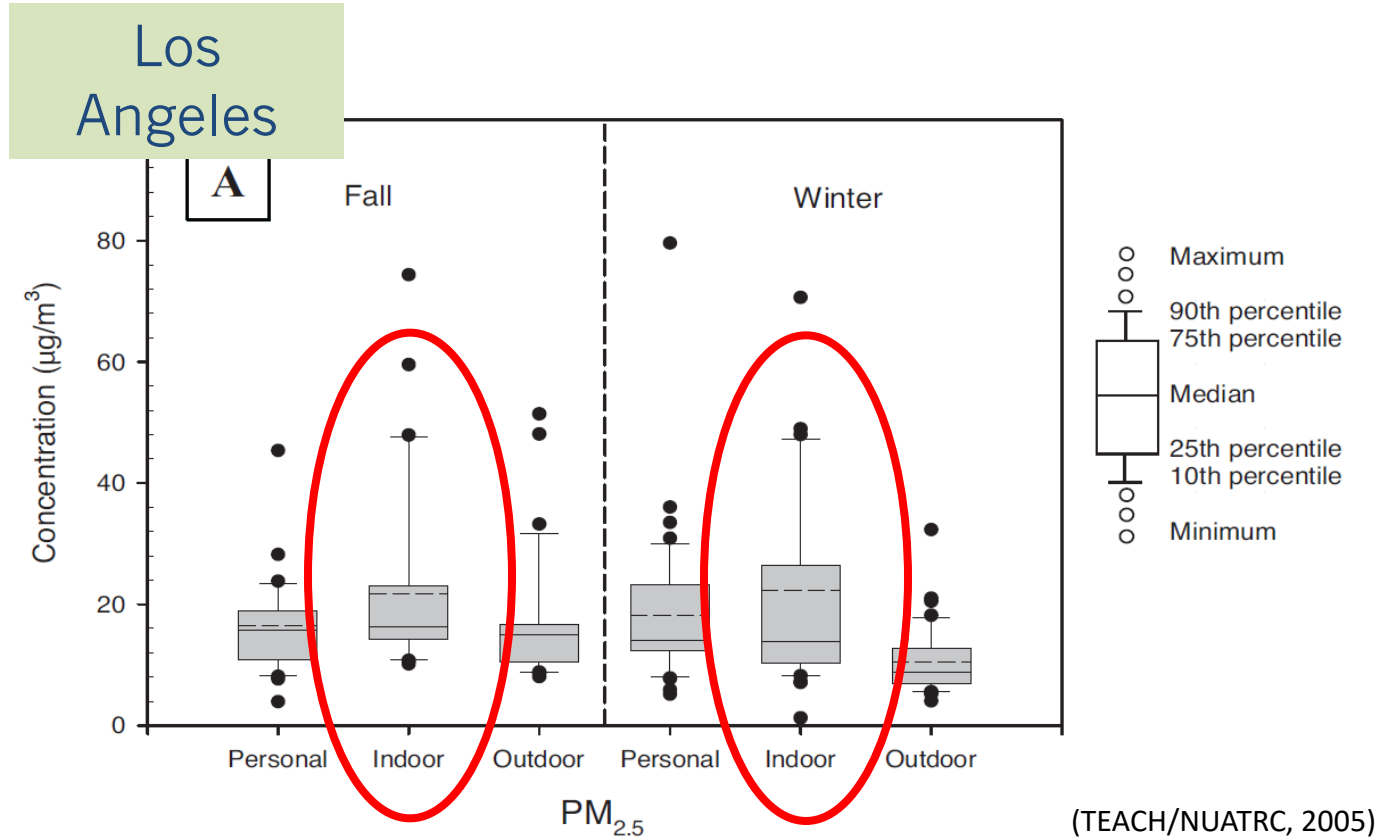
MULTIFAMILY HOUSING – BUILDING PHYSICS



Density-driven flow
patterns can be significant

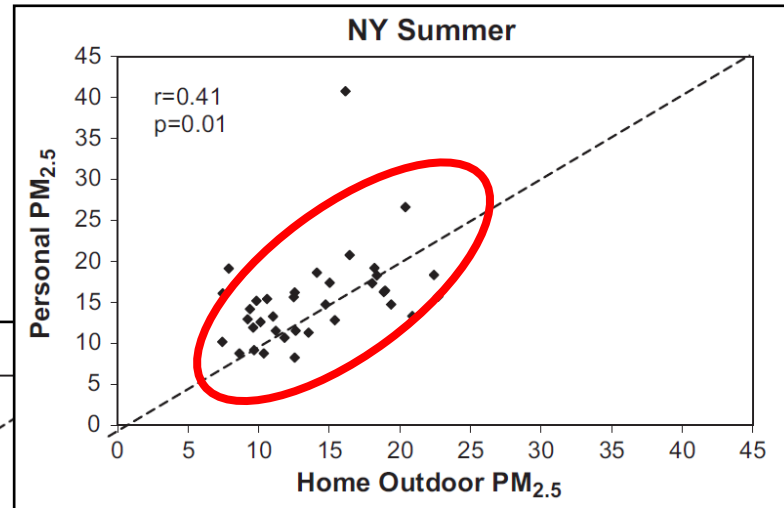
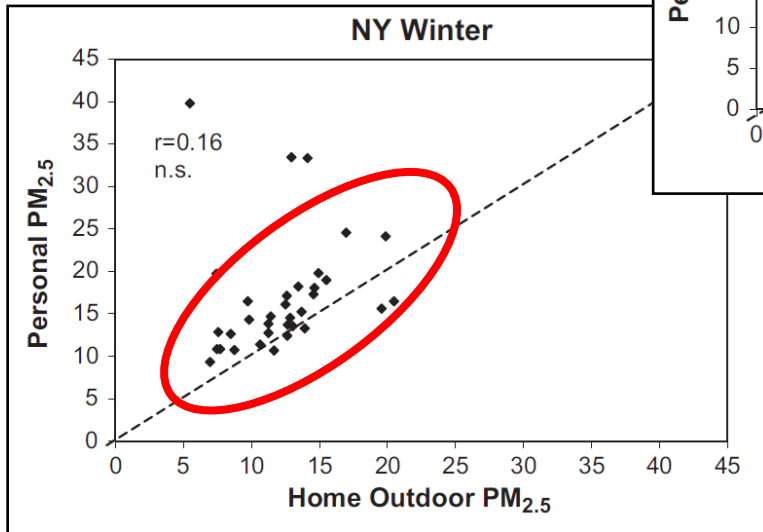
- 'Indoor neighborhood'
- Structural versus *functional* air exchange
 - overheating
 - windows/AC
- Behavior / preference
- 'Small space' effects
 - sources → exposures
 - reduced volume (doors/clutter)

Cohort studies (TEACH)



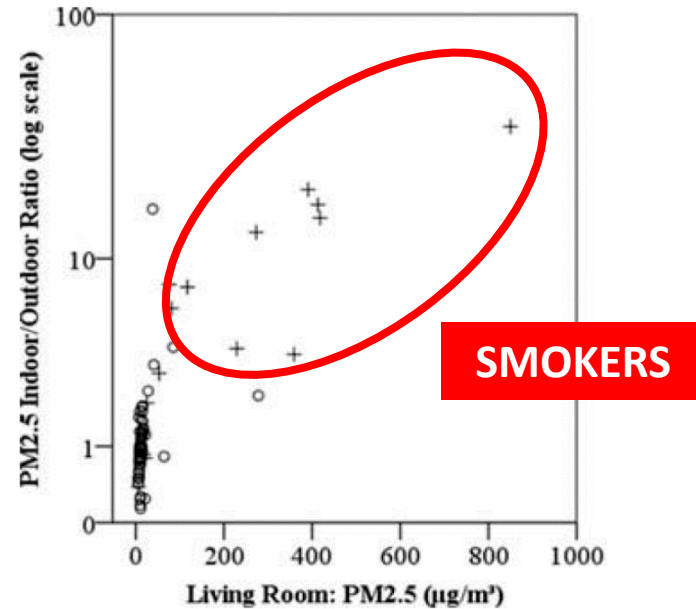
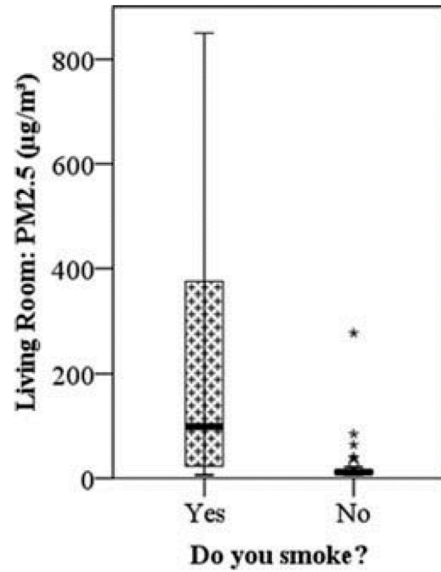
Cohort studies (TEACH)

New York

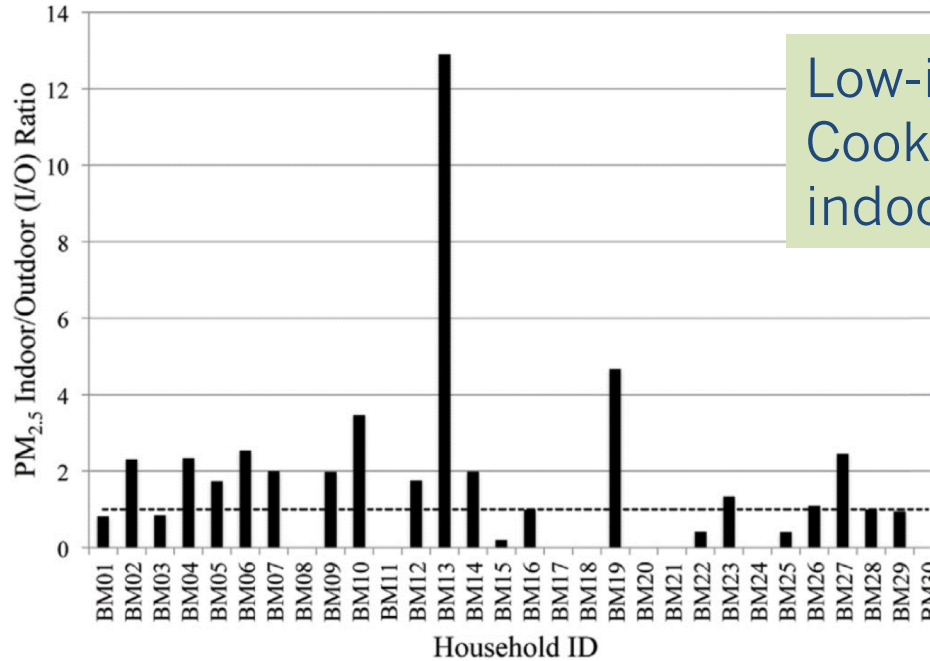


(TEACH/NUATRC, 2005)

Smoking

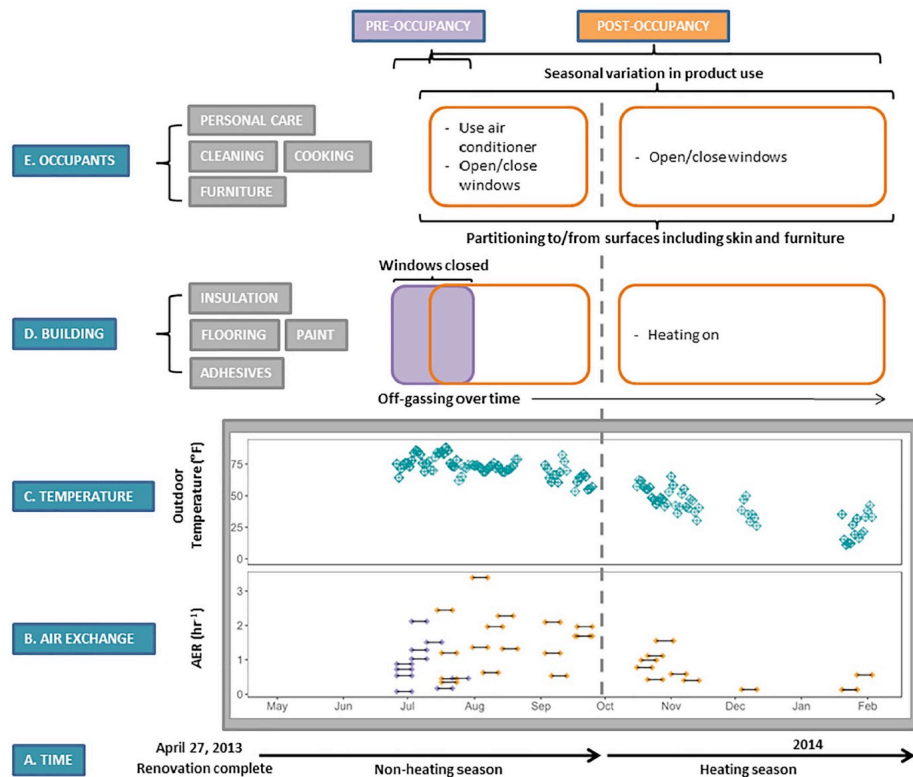


I/O Ratios



Low-income households -
Cooking was a likely source of
indoor PM

Specific sources – e.g.,



Health disparities in low-income communities may be linked to residential exposures to chemicals infiltrating from the outdoors and characteristics of and sources in the home. We targeted nearly 100 semivolatile organic compounds (SVOCs) and volatile organic compounds (VOCs), including phthalates, flame retardants, fragrance chemicals, pesticides, antimicrobials, petroleum chemicals, chlorinated solvents, and formaldehyde, as well as particulate matter. **Among 58 detected chemicals, we distinguished 25 as primarily occupant-related. The pre- to post-occupancy patterns of the remaining chemicals suggested important contributions from building materials for some, including dibutyl phthalate and xylene, whereas others, such as diethyl phthalate and formaldehyde, appeared to have both building and occupant sources.** Chemical classification by source informs multi-level exposure reduction strategies in low-income housing.

Specific sources – e.g., Flame retardants



Are PBDEs an environmental equity concern? Exposure disparities by socioeconomic status

AMI R. ZOTA*

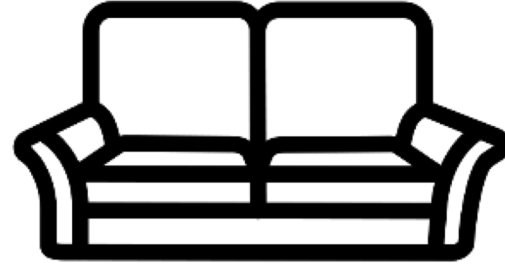
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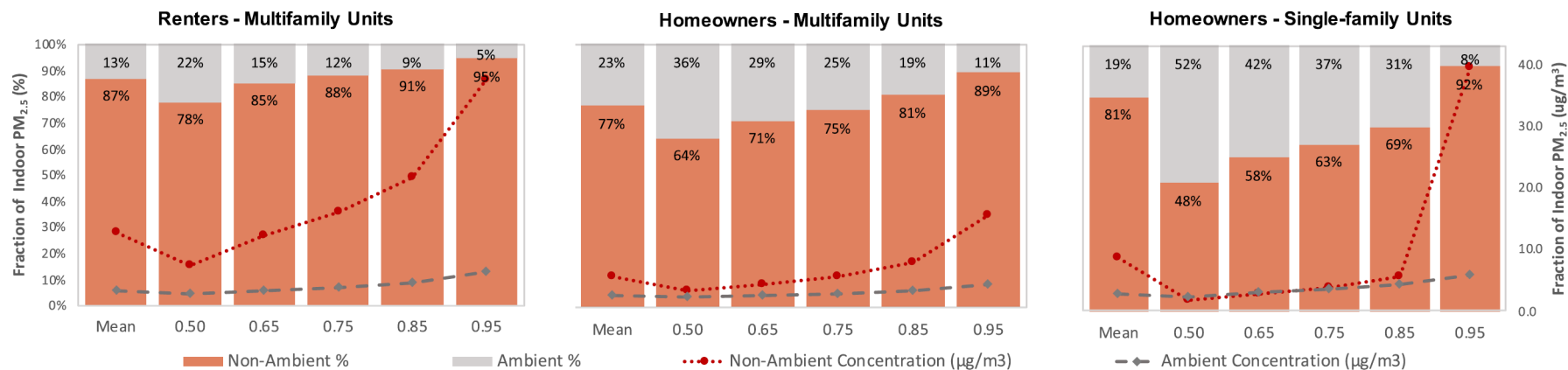
University of California, Berkeley, California



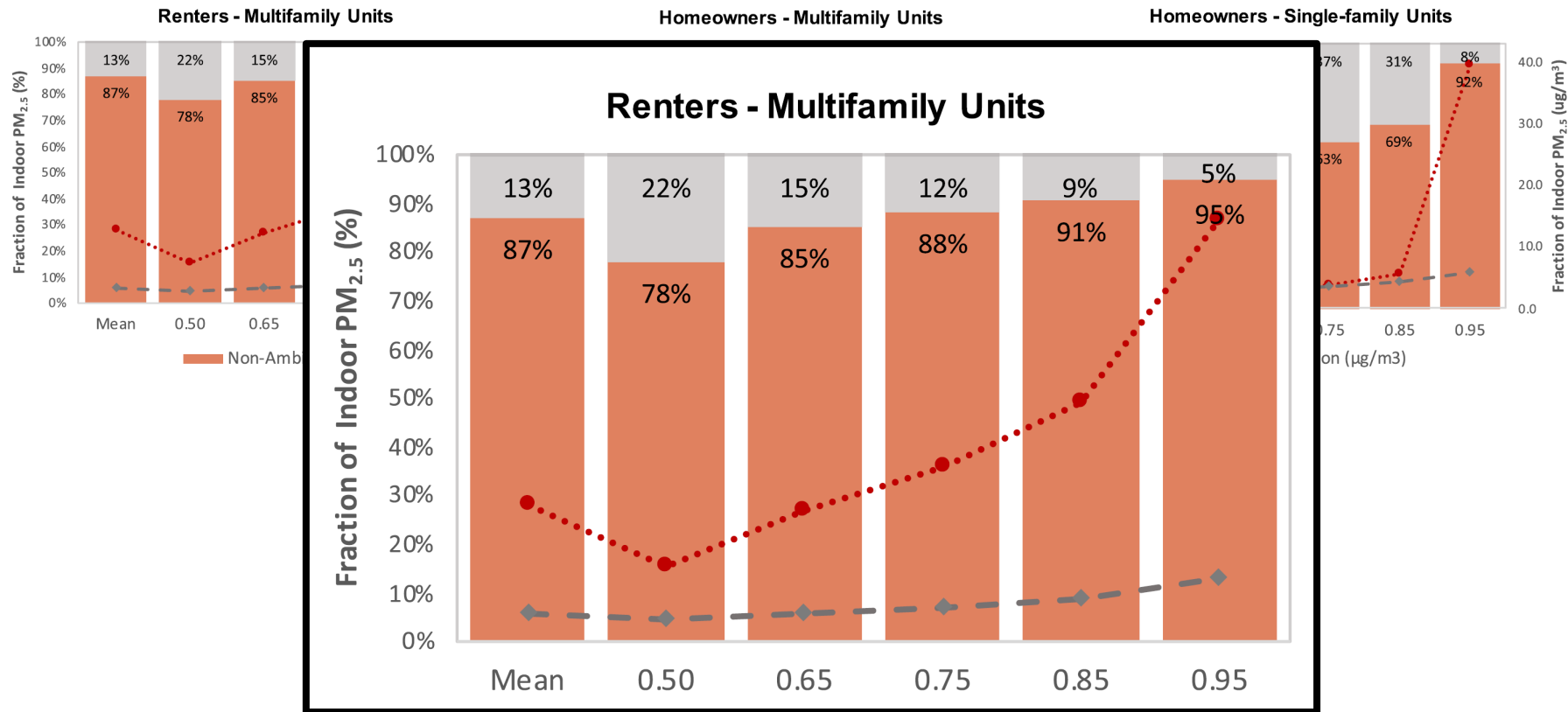
- Potential for differences driven by
 - furniture quality
 - furniture age
 - housing attributes
- Other sources (dietary)
- Where sources are eliminated, this process is differential by income.

Combined effects – e.g. renters

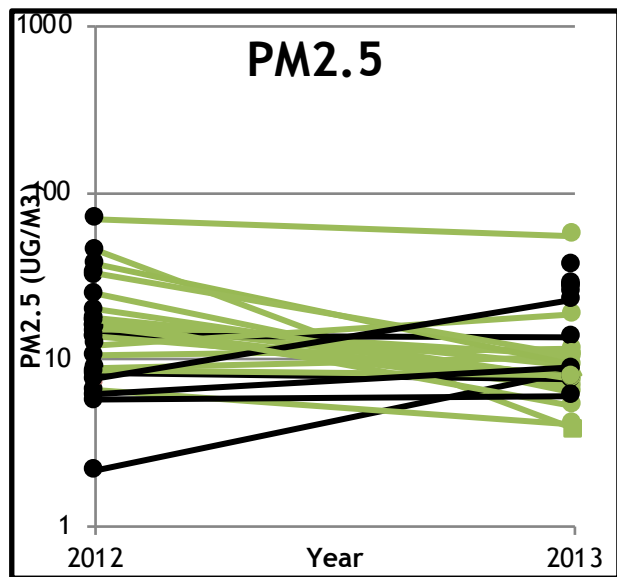
Differences by housing type



Combined effects – e.g. renters



Green Housing – BRIGHT Study



↓ 41.1 %*

Public housing intervention study
New, green units vs. Conventional

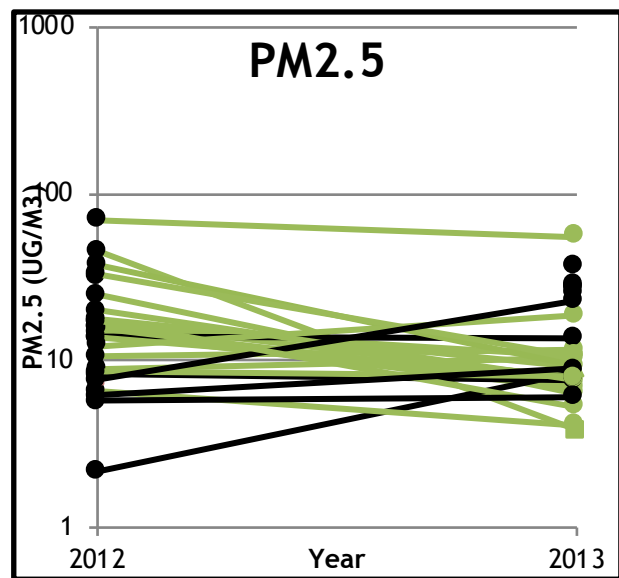
Why?

- Reduction of SHS
- Ventilation in kitchen
- Reduced infiltration of ambient PM

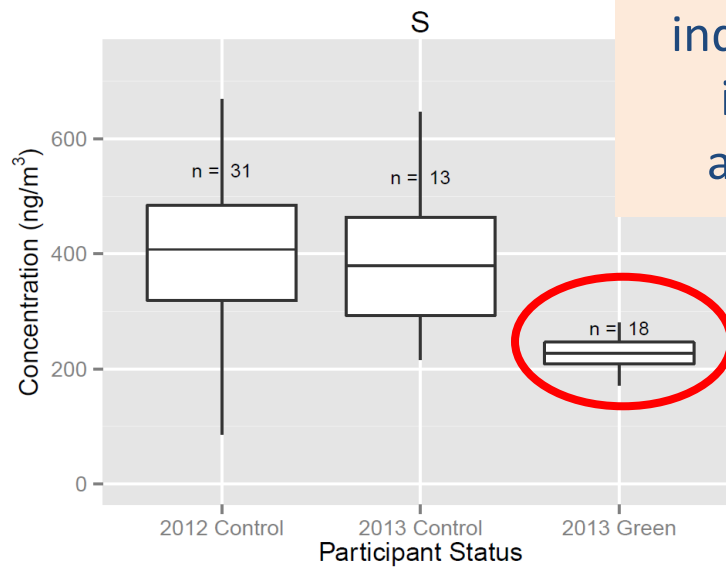
Other findings: 47% fewer symptoms and 66% lower indoor NO₂

***p < 0.05**

Green Housing – BRIGHT Study



↓ 41.1 %*

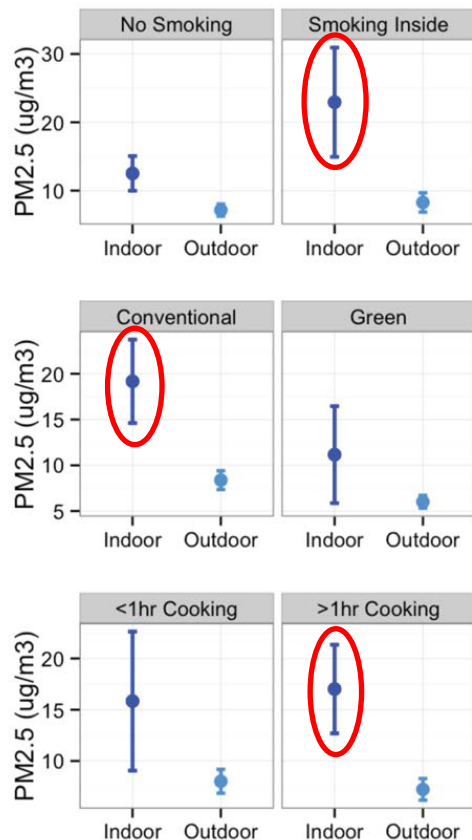


indicates reduced infiltration of ambient PM_{2.5}

Other findings: 47% fewer symptoms and 66% lower indoor NO₂

*p < 0.05

Green Housing – BRIGHT Study



Within a small geographic area, we have seen:

- **Significant between-household variability**
- **Indoor > Outdoor concentrations**
- **Exposures strongly influenced by:**
 - Sources
 - Building design/age
 - Occupant activity

Dollar Stores, Retailer Redlining, and the Metropolitan Geographies of Precarious Consumption

Jerry Shannon

Department of Geography and Department of Financial Planning, Housing, and Consumer Economics, University of Georgia

For the last twenty years, scholarly research has relied primarily on food deserts as a way to frame geographic disparities in access to healthy foods. The results of this research have been empirically mixed, and the term itself has been critiqued as apolitical. Using the alternative framing of retailer redlining, I analyze the rapid growth of dollar stores in twenty-seven metropolitan areas in the United States. Locations for these stores increased by 62 percent nationally during this time period, an expansion that was consistent in all regions of the country. Using descriptive statistics, cross-sectional, and first-difference models, I analyze how neighborhoods' racial makeup was associated with changes in dollar store proximity, controlling for household income, population, and overall retailer density. This analysis shows that proximity to dollar stores is highly associated with neighborhoods of color even when controlling for other factors. This result highlights how the growth of dollar stores and similar spaces designed for economically precarious households both reflect and, potentially, contribute to long histories of racial exclusion. *Key Words:* dollar stores, food access, precarity, retail redlining.

Over the last decade, dollar stores have become a fixture of the U.S. retail landscape.

The number of U.S. locations for the three major dollar store chains—Dollar General, Dollar Tree, and Family Dollar—increased 62 percent between 2008 and 2018 to nearly 30,000 locations (Reference USA 2020). A recent report by the Institute for Local Self-Reliance (ILSR) resulted in more popular attention to this trend (Donahue and Mitchell 2018), and multiple localities have developed ordinances regulating or prohibiting the new stores (Aubrey 2019). These stores offer a range of inexpensive goods, from housewares to food items, in a small retail footprint that fits well in both small rural communities and dense urban neighborhoods. Yet detractors suggest that they price out locally owned businesses and profit by selling unhealthy foods and poorly made goods to economically marginalized populations.

Despite their rapid growth, only a few scholarly articles have examined the impact of these stores or the quality of the goods they sell (Racine et al. 2016; Caspi, Pelletier, et al. 2017). In terms of food access, these stores could be grouped with other small retailers (pharmacies, gas stations, or corner stores), but they offer a wider array of foods than

these retailers. At the same time, dollar stores offer fewer healthy foods than a small grocery or ethnic market. More broadly, the growth of dollar stores mirrors larger economic trends tied to economic precarity for many households, including the rise of flexible employment, increased housing and health care costs, and wage stagnation (Coe 2013; Waite and Lewis 2017). These stores provide low-cost goods that meet immediate needs, but in doing so they might simply make precarity more socially palatable.

This article contributes to research on this growing trend by analyzing the locational strategies evident in dollar store expansion. I analyze the growth of dollar stores in twenty-seven metropolitan areas across the United States using a longitudinal data set of retailers authorized to redeem benefits for the Supplemental Nutrition Assistance Program (SNAP, formerly known as food stamps). Using both cross-sectional and first-difference models, I assess the extent to which these retailers target communities of color while controlling for neighborhood economic characteristics. Dollar stores might meet immediate needs for economically and socially marginalized households in areas with few retail options. Moving beyond the food desert framing and drawing on past work on food access and retail redlining, I argue that

“Retailer Redlining”

“...proximity to dollar stores is highly associated with neighborhoods of color even when controlling for other factors.”

Vulnerability and susceptibility

- **Ambient exposures in context of other exposures**
 - Cumulative risks (indoor + outdoor + occupational)
- **Differential responses to exposure (effect modification)**
 - Underlying disease (e.g., diabetes)
 - Personal factors (gender, BMI, etc.)
 - Psychosocial factors (e.g., stress)

“The standard definition of a person who is susceptible is one who is more responsive to exposure. Recently, the word vulnerability was used either to describe situations where the susceptibility arises from psychosocial, cultural, or economic differences, or as encompassing these plus biological vulnerability, but with the understanding that these components of overall vulnerability were different.” (Schwartz et al. 2011; EPA 2003)

Conclusions

- Multiple determinants can increase risk of exposure
- We need a mechanistic, '**systems**' view of exposure disparities; including contextual and behavioral factors
- We need to understand how exposure disparities are related to **conditions or activities that can be mitigated**
- We need to recognize sub-populations
 - Rural v. Urban
 - Elderly
 - Managed/public housing
 - Environmental justice communities
- We need new tools and approaches

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thanks

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Speaker Slides will be inserted in between
the default Academies' slides.

