

Socioeconomic Disparities in Indoor Fine Particulate Matter Exposure

MyDzung T. Chu, PhD, MSPH
Postdoctoral Scientist
George Washington University
Milken Institute School of Public Health
email: mchu@gwu.edu

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Milken Institute School
of Public Health
THE GEORGE WASHINGTON UNIVERSITY



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Poor housing conditions and health

There are many opportunities to promote health by addressing housing conditions including:



Healthy housing is becoming more important in light of



URBAN GROWTH



AGEING POPULATIONS



CLIMATE CHANGE

Associated health effects:

- Mortality
- Asthma
- Cardiovascular events
- Respiratory infections
- Poisonings (e.g. radon, CO, lead)
- Endocrine disruption
- Burns (chemical, fire)
- Physical injuries
- Poor mental health
- Infectious disease

Housing and Health

Intersection of Poverty and Environmental Exposures

VIRGINIA A. RAUH,^a PHILIP J. LANDRIGAN,^b AND LUZ CLAUDIO^c

^a*Columbia Center for Children's Environmental Health, Mailman School of Public Health, Columbia University, New York, New York, USA*

^b*Department of Community and Preventive Medicine and Children's Environmental Health Center, Mount Sinai School of Medicine, New York, New York, USA*

^c*Department of Community and Preventive Medicine, Mount Sinai School of Medicine, New York, New York, USA*



Urban institute, 2020

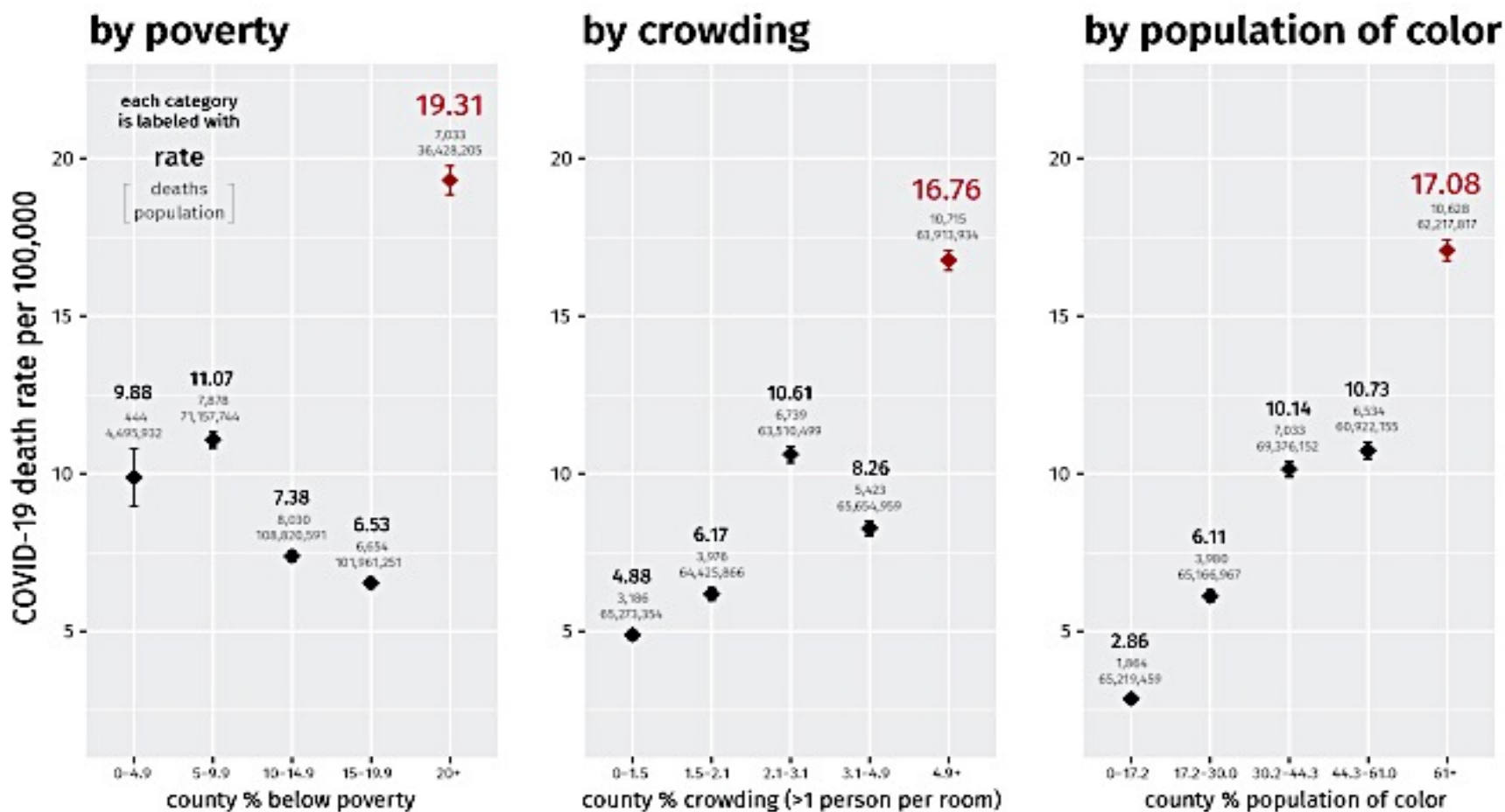
Moving Environmental Justice Indoors: Understanding Structural Influences on Residential Exposure Patterns in Low-Income Communities

| Gary Adamkiewicz, PhD, MPH, Ami R. Zota, ScD, MS, M. Patricia Fabian, ScD, Teresa Chahine, ScD, Rhona Julien, ScD, John D. Spengler, PhD, and Jonathan I. Levy, ScD



Inequities in US COVID-19 Deaths

(as of April 16, 2020)



people living in the most disadvantaged counties have the **highest** COVID-19 death rates

Source: Chen JT, Krieger N. Revealing the unequal burden of COVID-19 by income, race/ethnicity, and household crowding: US county vs ZIP code analyses. *Harvard Center for Population and Development Studies Working Paper Series*, Volume 19, Number 1. April 21, 2020. <https://tinyurl.com/ya44we2r>

Why care about Fine Particulate Matter (PM_{2.5}) ?

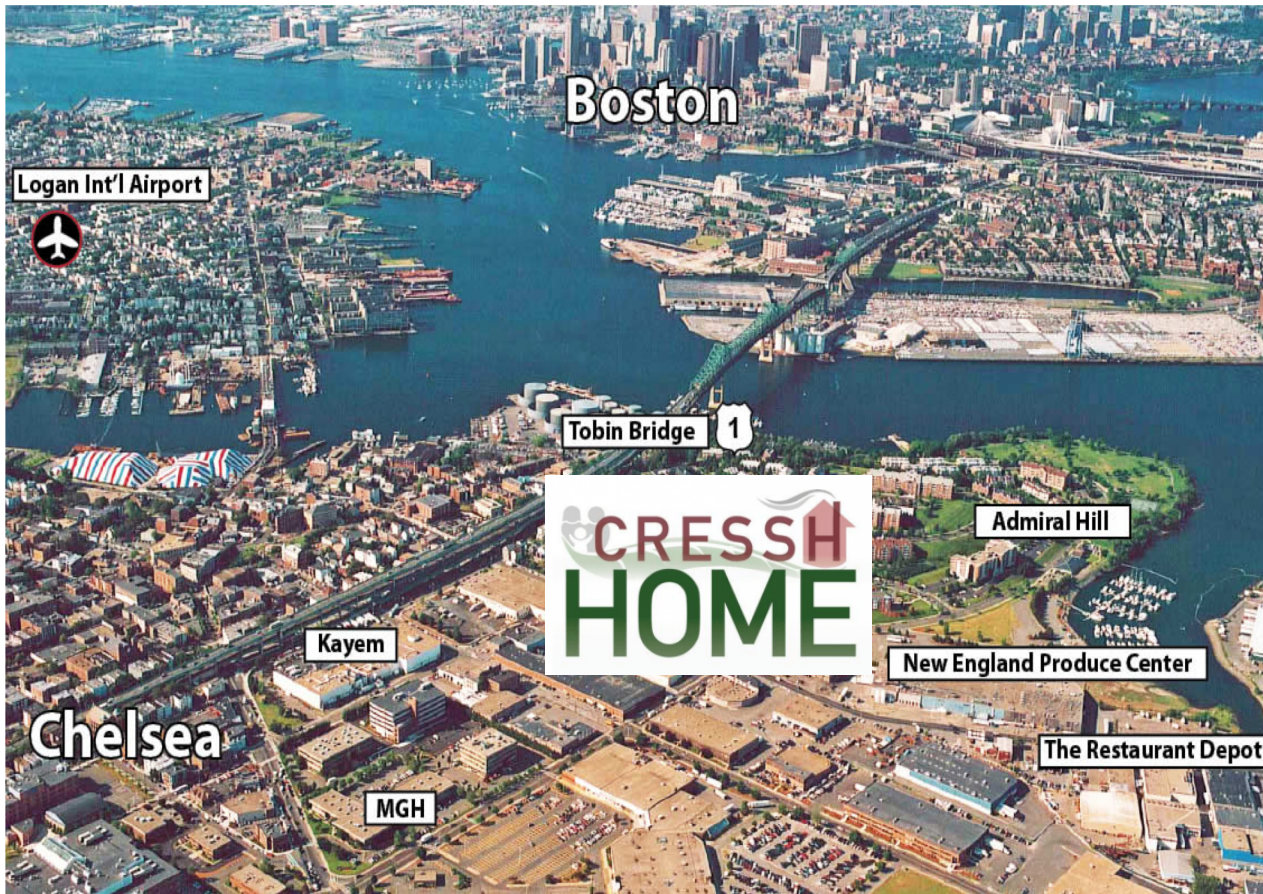
- **Ambient & indoor sources**
- **High risk of chronic exposure**
- **Small size:** Penetrate deep into lungs & gas exchange regions
- **Adverse health effects:**
 - All-cause mortality
 - Cardiovascular: arrhythmia, blood clots
 - Respiratory: COPD, bronchitis, asthma, lung cancer
 - Reproductive: Low birth weight, weight growth
- **Persistent health disparities:**
 - Children, low SES, racial/ethnic minorities
 - People with preexisting heart and lung conditions, older adults



Common outdoor and indoor sources:



Indoor Exposure Disparities in EJ Communities



HOME Study: Home-based **O**bservation and **M**onitoring Exposure

CRESSH: Center for **R**esearch on **E**nvironmental and **S**ocial Stressors in **H**ousing Across the Life Course

Socio-demographics statewide vs. Chelsea, MA		
	MA	Chelsea
Population ^a	6,547,785	39,690
% Hispanic/Latina ^a	12.4%	67.0%
% Foreign-born ^a	16.8%	45.4%
Median household income ^b	\$81,215	\$56,802
% Non-English language spoken at home ^b	23.8%	69.8%
% Persons in poverty ^b	9.4%	18.1%
% Renter-occupied units ^b	37.6%	74.1%

^a 2010 Census ^b American Community Survey, 2015-2019



PI: Gary Adamkiewicz,
Harvard T.H. Chan School of Public Health



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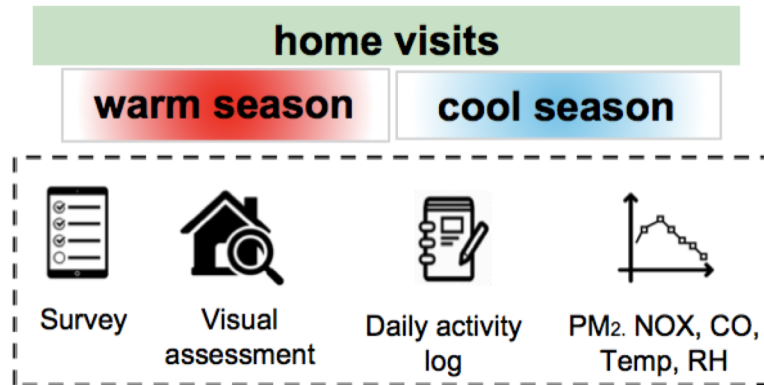
Methods

Population

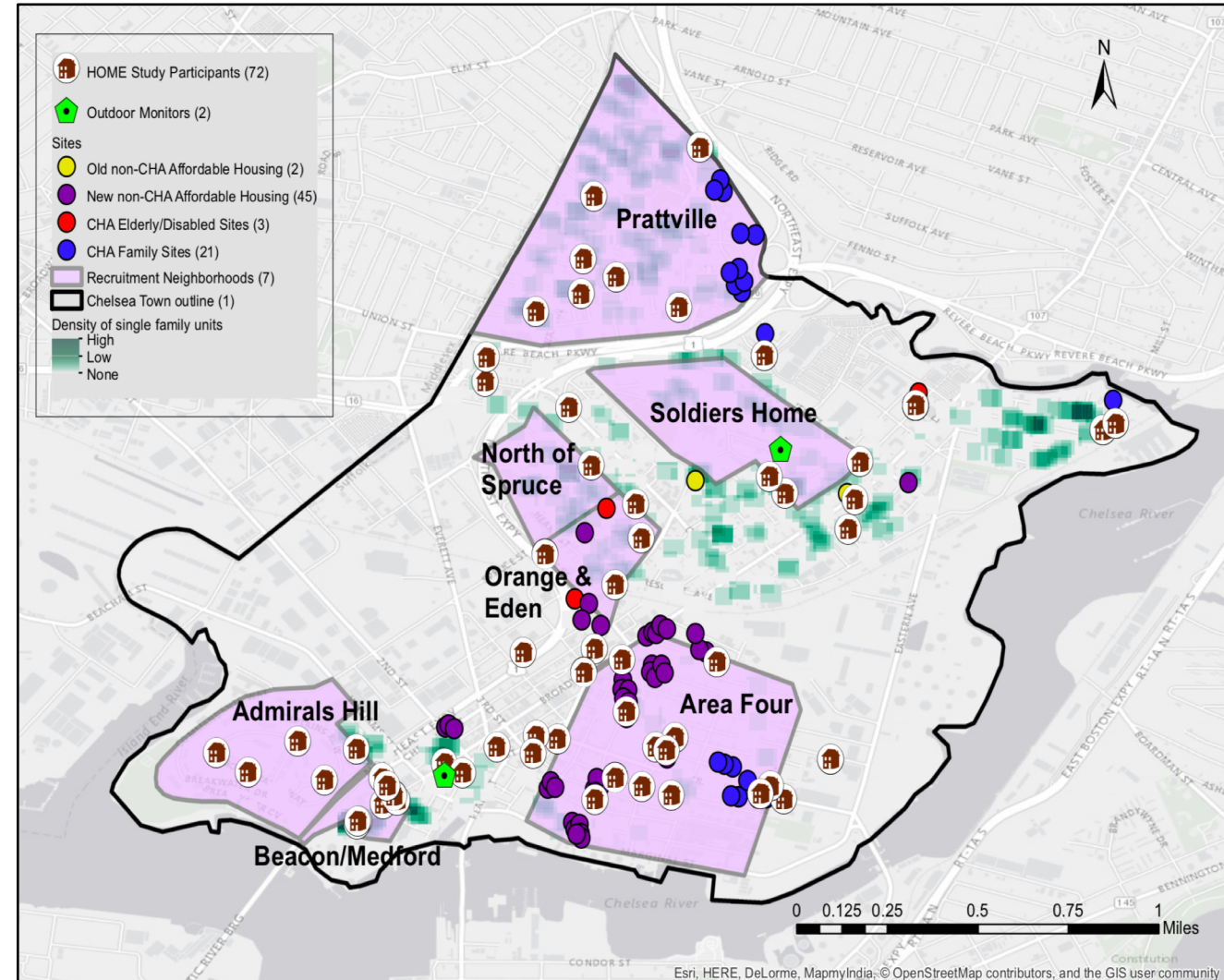


Chelsea, Massachusetts
 June 2016 – August 2017
 Public & Private housing
 N=72 households, 131 sessions

Measures



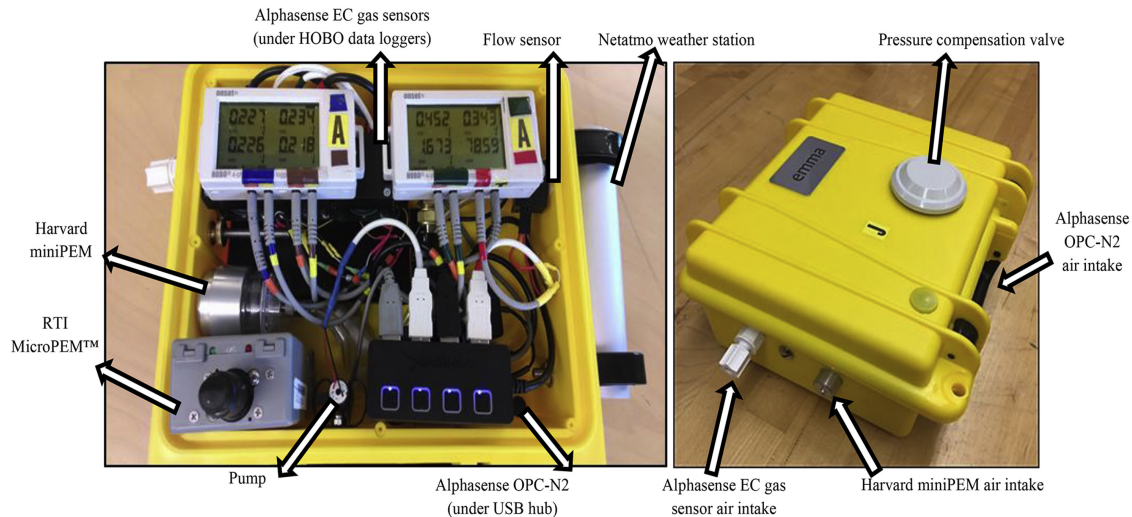
HOME Study Recruitment Map in Chelsea, Massachusetts, 2016-2017



Chu, M. T., Gillooly, S. E., Levy, J. I., Vallarino, J., Reyna, L. N., Laurent, J. G. C., ... & Adamkiewicz, G. (2021). Real-time indoor PM_{2.5} monitoring in an urban cohort: Implications for exposure disparities and source control. *Environmental research*, 193, 110561.

Methods

Low-cost sensors: Alphasense OPC-N2 sensor, co-located with miniPEM (indoor) and Harvard impactor (outdoor) for PM_{2.5} calibrations & weekly adjustment



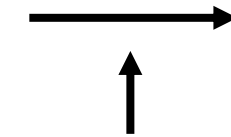
Gillooly, S. E., Zhou, Y., Vallarino, J., Chu, M. T., Michanowicz, D. R., Levy, J. I., & Adamkiewicz, G. (2019). Development of an in-home, real-time air pollutant sensor platform and implications for community use. *Environmental Pollution*, 244, 440-450.

Question



Indoor activities:

Cooking, Range hood use, Candle, Incense, Spray air freshener, Smoking
[2h, daily, seasonal]



Non-ambient PM_{2.5} concentrations (µg/m³)
[5-min time-average]

Housing tenure
Building type

Statistical Analyses



Steady-state, Mass-balance model:

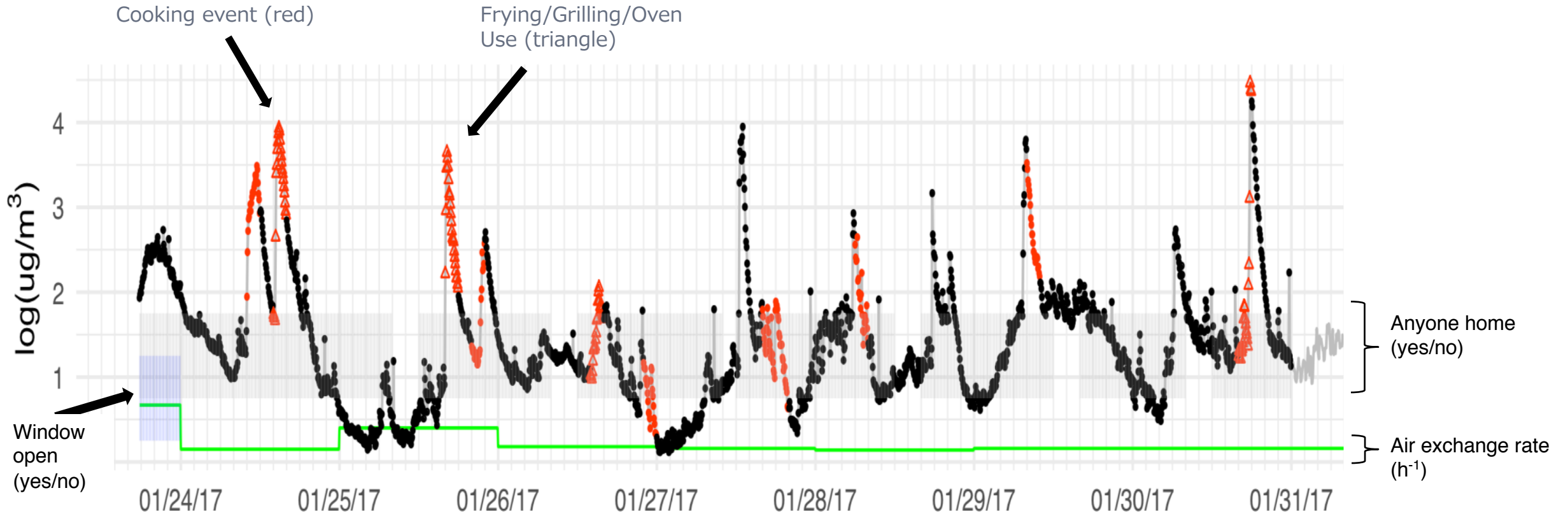
- Estimate non-ambient fraction of total indoor PM_{2.5}

Chi-square/Fisher's exact, Kruskal-Wallis

Linear Quantile Mixed Effects Regression

- Upper quantiles: 50%, 65%, 75%, 85%, 95%

Methods: Real-time PM_{2.5} measurements



Results: Study Population

	Renters in Multifamily unit (N=39)	Homeowners in Multifamily unit (N=22)	Homeowners in Single-family (N=10)	
	Percent	Percent	Percent	<i>p</i> *
Education				
Up to Highschool, GED, Some College	85%	45%	30%	<0.001
Bachelor's degree or higher	15%	55%	70%	
Race/ethnicity				
White non-Hispanic	21%	64%	60%	0.006
Hispanic/Latinx	67%	27%	30%	
Other, Non-Hispanic	13%	9%	10%	
Nativity				
U.S.-born	41%	73%	80%	0.062
Foreign-born	59%	27%	20%	
Interview Language				
English	46%	77%	100%	<0.001
Spanish	54%	23%	0%	
Employment status				
Employed	27%	87%	85%	<0.001
Unemployed	73%	13%	15%	

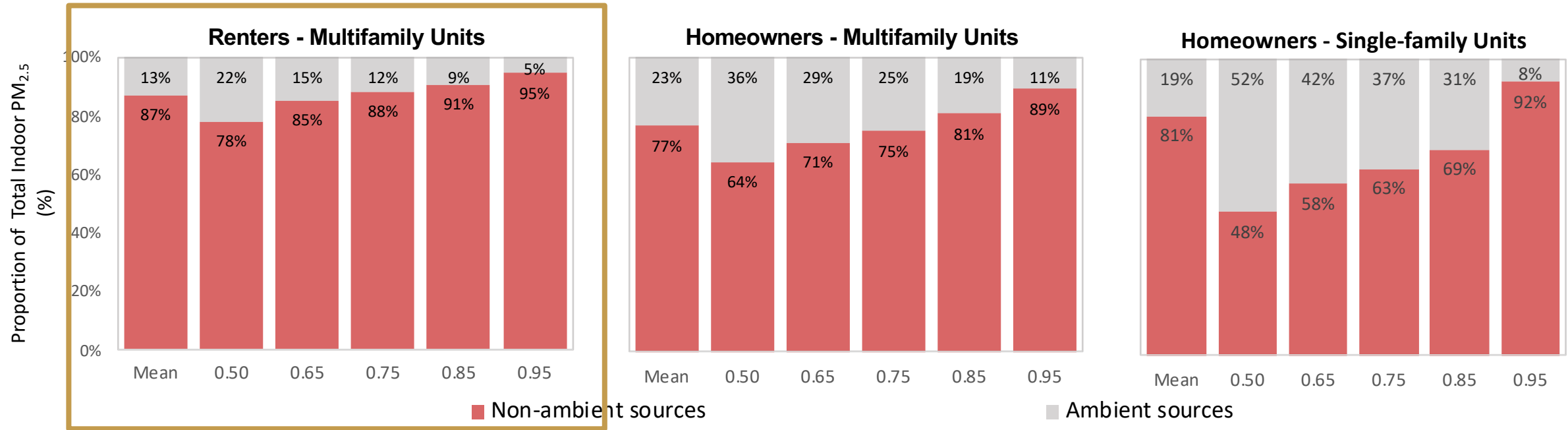
* χ^2 or Fisher's exact test

Results: Differences by Housing Tenure

Environmental measures Mean (SD)	Renters Multifamily unit (N=39)	Homeowners Multifamily (N=22)	Homeowners Single-family (N=10)	p^\dagger
Indoor PM _{2.5} (SD) ($\mu\text{g}/\text{m}^3$)	12.8 (14.3)	6.01 (4.2)	8.8 (17.0)	0.002
Outdoor PM _{2.5} (SD) ($\mu\text{g}/\text{m}^3$)	5.6 (2.3)	5.2 (3.2)	5.2 (2.1)	0.354
Air Exchange Rate (SD) (h^{-1})	0.70 (0.41)	0.52 (0.39)	0.58 (0.42)	0.004

† Kruskal-Wallis rank sum test

Results: Proportion of Total Indoor PM_{2.5} by Source Type

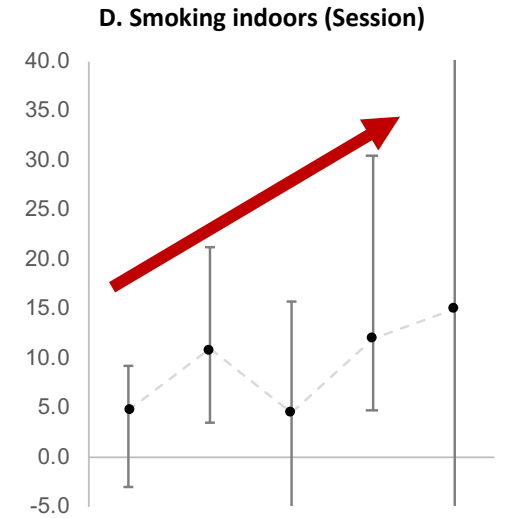
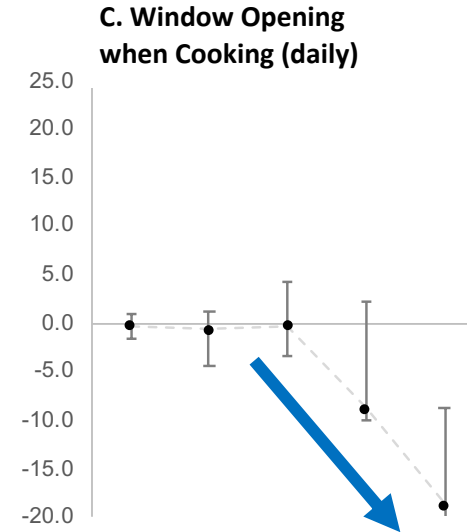
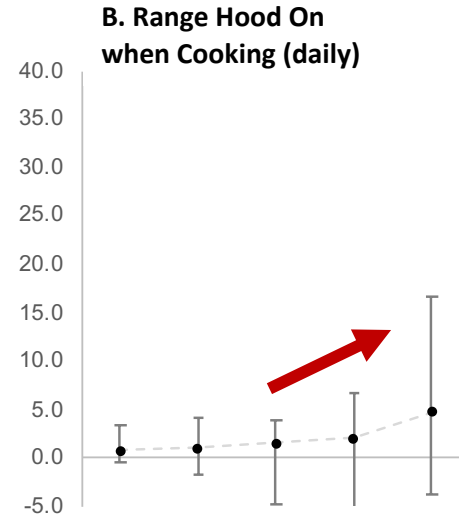
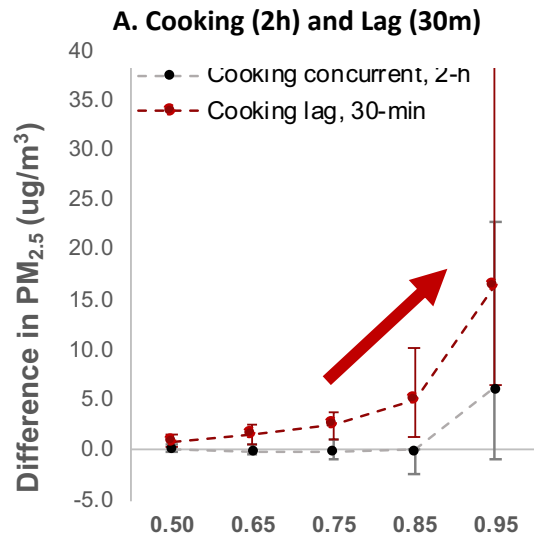


Renter Households reported higher prevalence of:

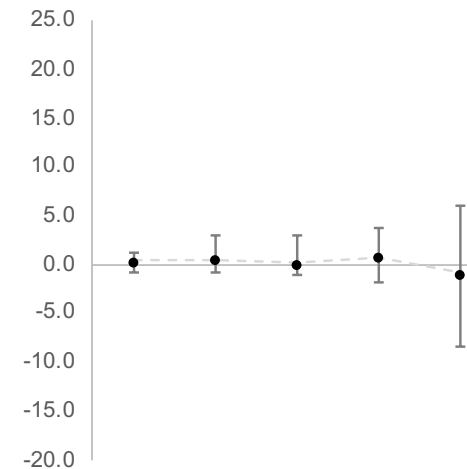
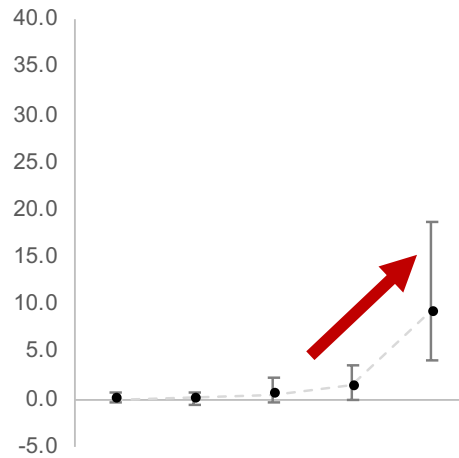
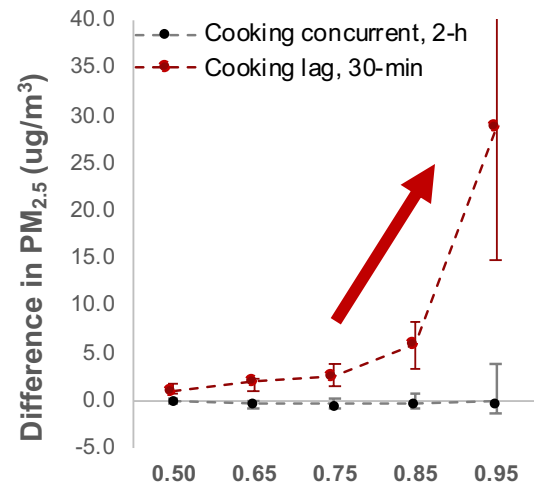
- Activities: Cooking, smoking, incense use, spray air freshener use, window opening, range hood use
- Building: Second-hand smoke, no central air, no weatherization

Results: Non-Ambient Source Predictors of Indoor PM_{2.5}

Renters
Multifamily units



Homeowners
Single- &
Multifamily units



Models adjusted for candle and spray air freshener use; window opening and AC use in the living area; year of sampling; hour of day; indoor relative humidity; number of occupants per bedroom; and number of levels within unit.

Takeaways

- Majority of indoor $PM_{2.5}$ concentrations from non-ambient (e.g. cooking, smoking) vs. ambient sources
 - Higher proportion at upper exposure quantiles
 - Higher exposure for renter households
- Renters exposed to higher $PM_{2.5}$ concentrations due to a combination of behavioral and building factors amenable to intervention.
- Environmental justice implications:
 - Majority of renters were non-English speakers, foreign-born, without a college degree, unemployed
- Recommendations: Multi-level approach
 - Landlord & Tenant education
 - Financial assistance
 - Building-wide improvements



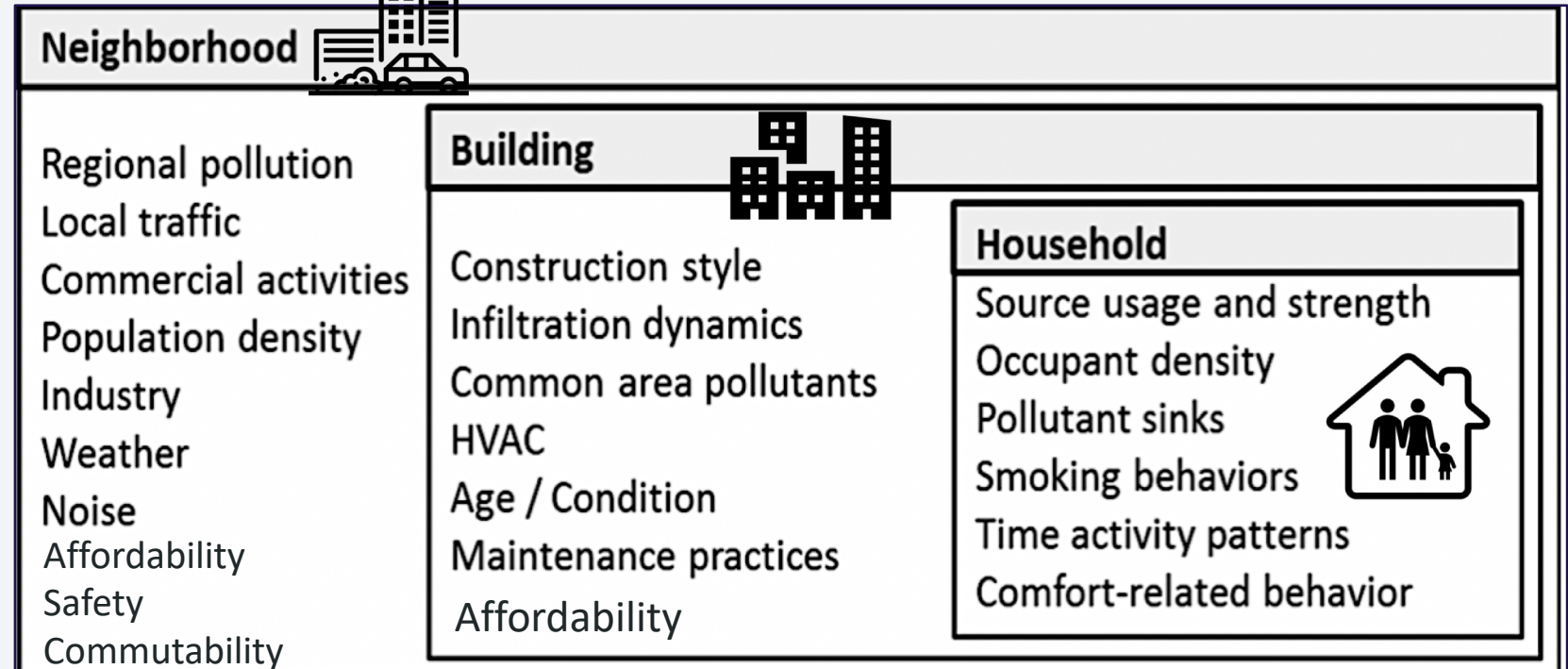
Multilevel framework for residential environmental exposures

Systemic Factors

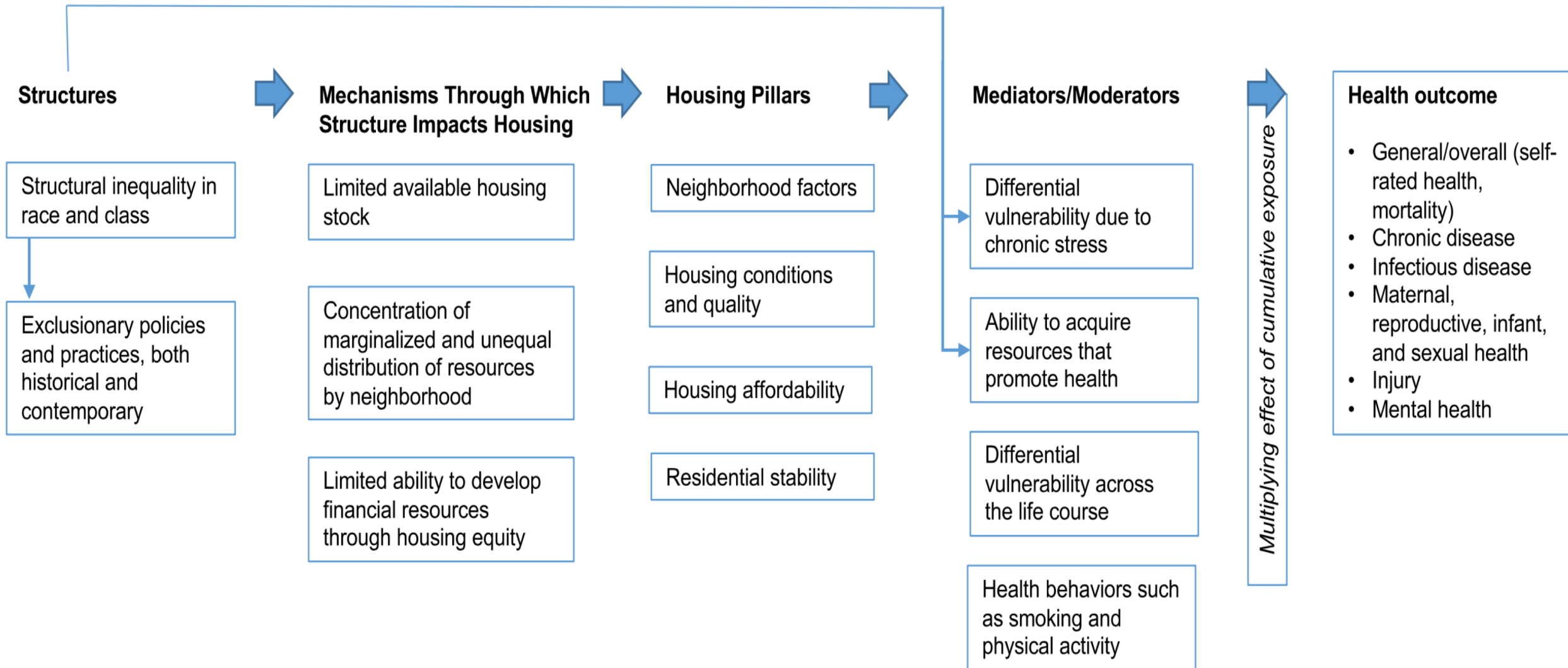
Social determinants of health
Intergenerational wealth/poverty
Institutional & Interpersonal Racism
Housing & financial policies
Zoning policies, redlining



Neighborhood and housing access



Housing and Health Equity Model



Swope, C. B., & Hernández, D. (2019). Housing as a determinant of health equity: A conceptual model. *Social Science & Medicine*, 243, 112571.

Our HOME Study Participants!!!

Co-authors:

- Gary Adamkiewicz, HOME Project Lead
- Sara E. Gillooly
- Jon I. Levy
- Jose Vallarino
- Lacy N. Reyna
- Jose Guillermo Cedeno Laurent
- Brent A. Coull

Other CRESSH HOME Team members:

- Marty Alvarez
- Kelli Gonzalez

CRESSH Community Engagement Core

- Madeleine Scammell
- Claire Schollaert

GreenRoots

- Roseanne Bongiovanni

Analysis guidance:

- Tamarra James-Todd, Dissertation Committee
- David R. Williams, Dissertation Committee
- Steven Worthington, Harvard Institute for Quantitative Social Science

Funders:

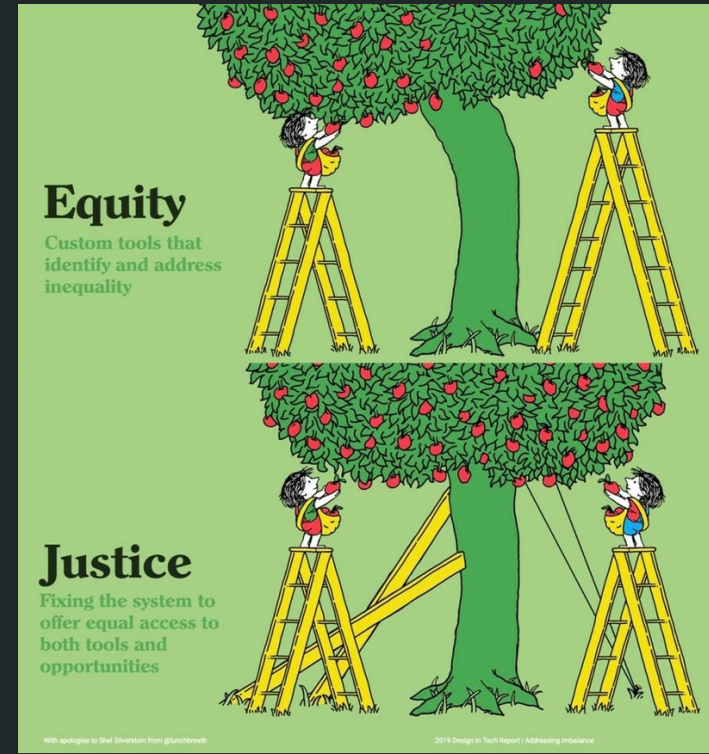
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Thank you!

MyDzung Chu, PhD, MSPH

Post-Doctoral Scientist

Department of Environmental and Occupational Health

George Washington University Milken Institute School of Public Health

Email: mchu@gwu.edu | [LinkedIn](#) | [@mydz_C](#)