NYU Grossman School of Medicine

A Matched Analysis of the Association Between Federally Mandated Smoke-free Housing Policies and Health Outcomes among Medicaid-enrolled Children in Subsidized Housing, New York City, 2015–2019

Andrea R. Titus, PhD

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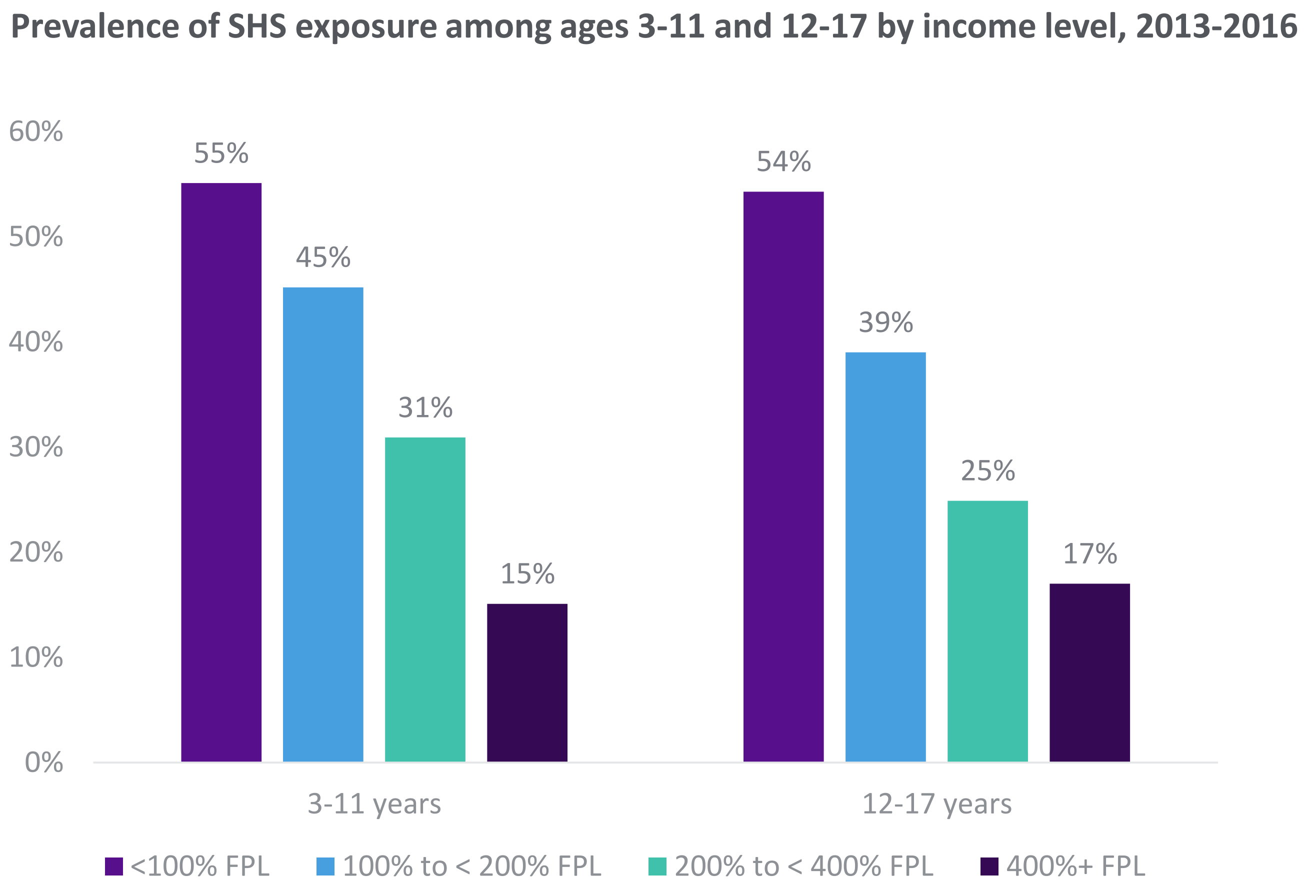
Secondhand smoke (SHS) exposure affects the health of adults and children in the U.S.

- Among adults, SHS exposure is associated with:
  - Nearly 34,000 heart disease deaths annually
  - More than 7,300 lung cancer deaths annually

- Among children, SHS exposure is associated with asthma attacks, respiratory infections, ear infections, and SIDS, among other outcomes

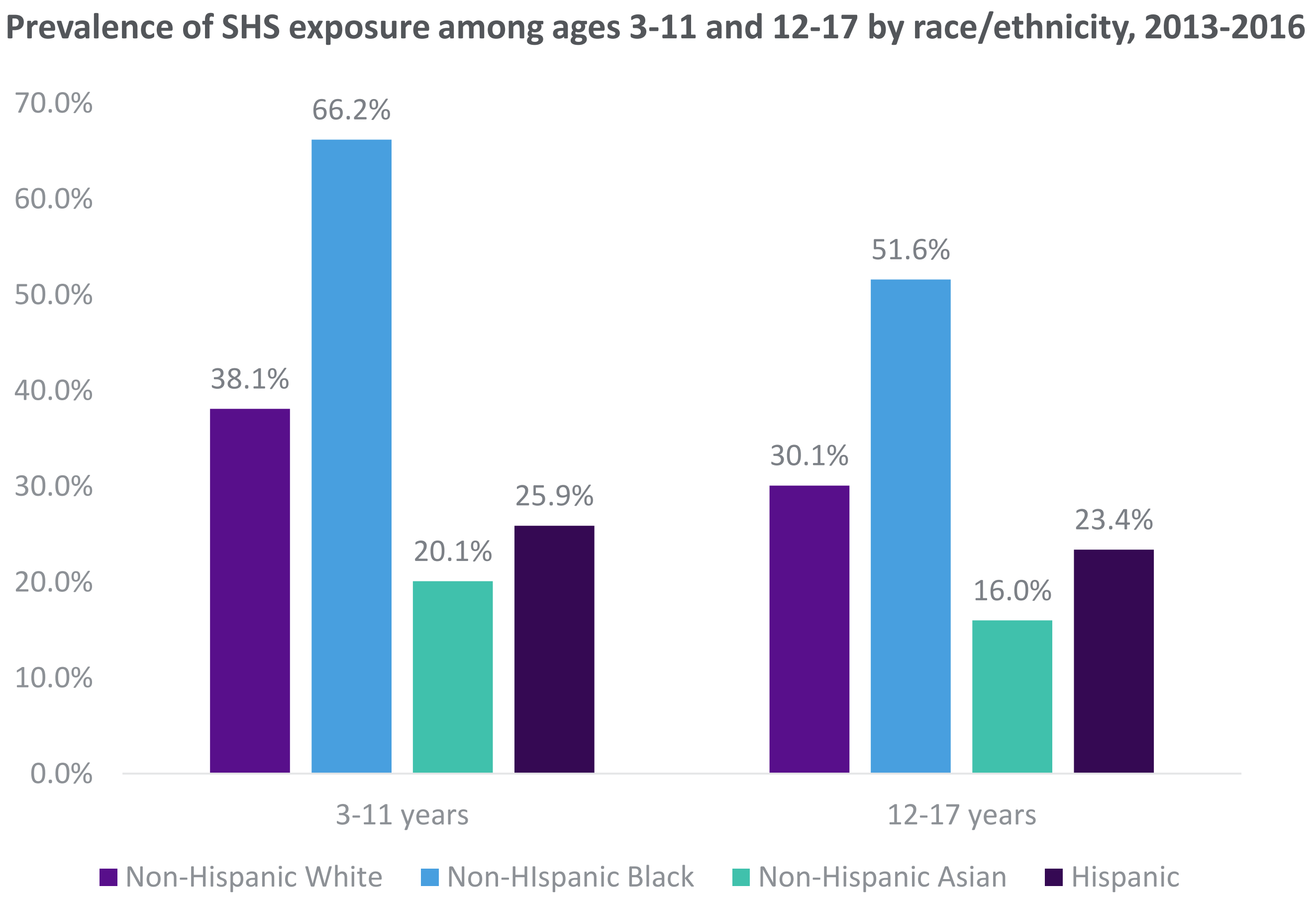
Source: Centers for Disease Control and Prevention

SHS exposure varies by income level in the U.S.



Source: National Health and Nutrition Examination Survey (NHANES)

SHS exposure varies by race/ethnicity



Source: NHANES

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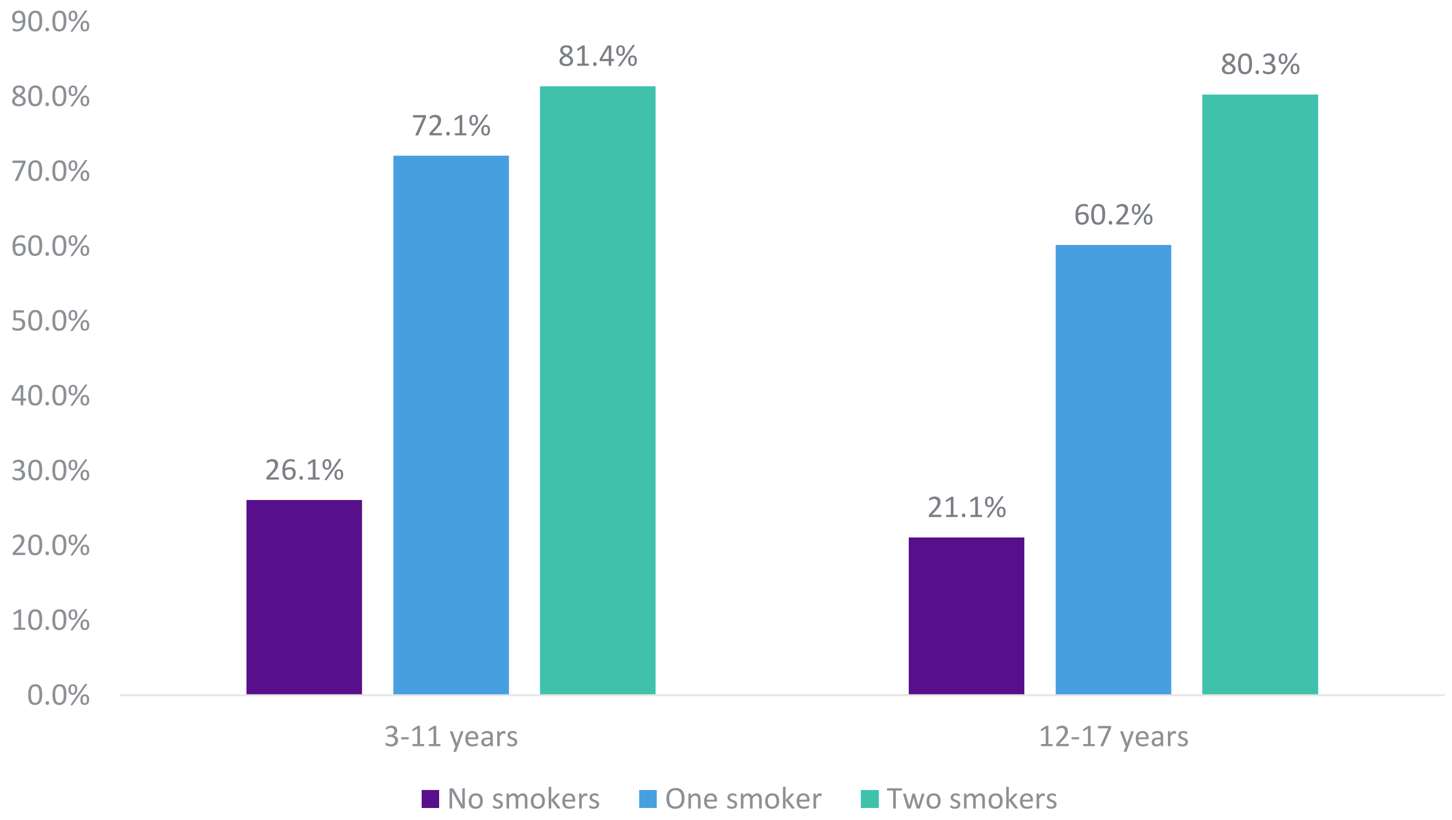
Smoking in the home a major driver of exposure

Prevalence of SHS exposure among ages 3-11 and 12-17 by number of smokers in the home, 2013-2016



Source: NHANES

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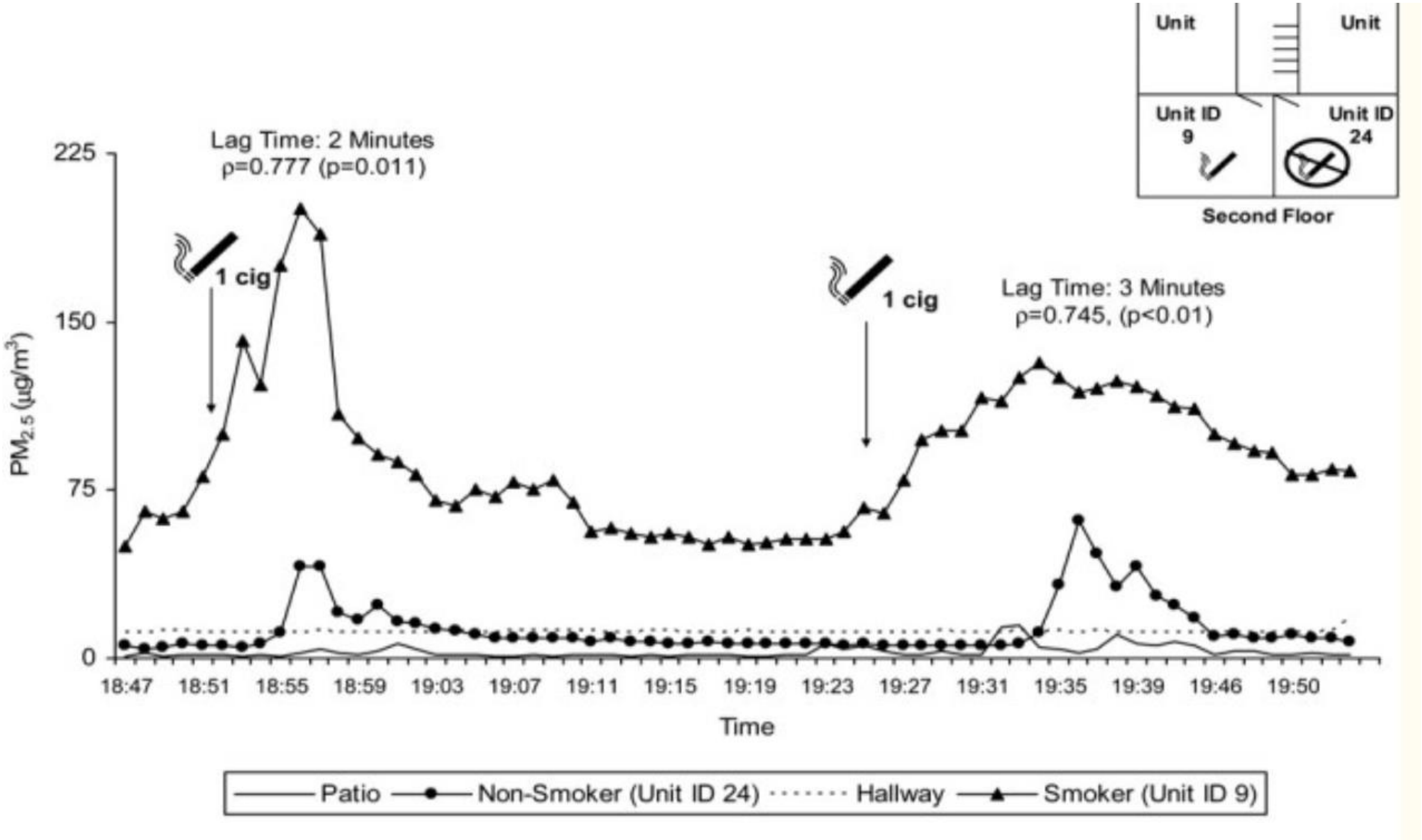
Individuals in multi-unit housing are especially at risk due to transfer between units

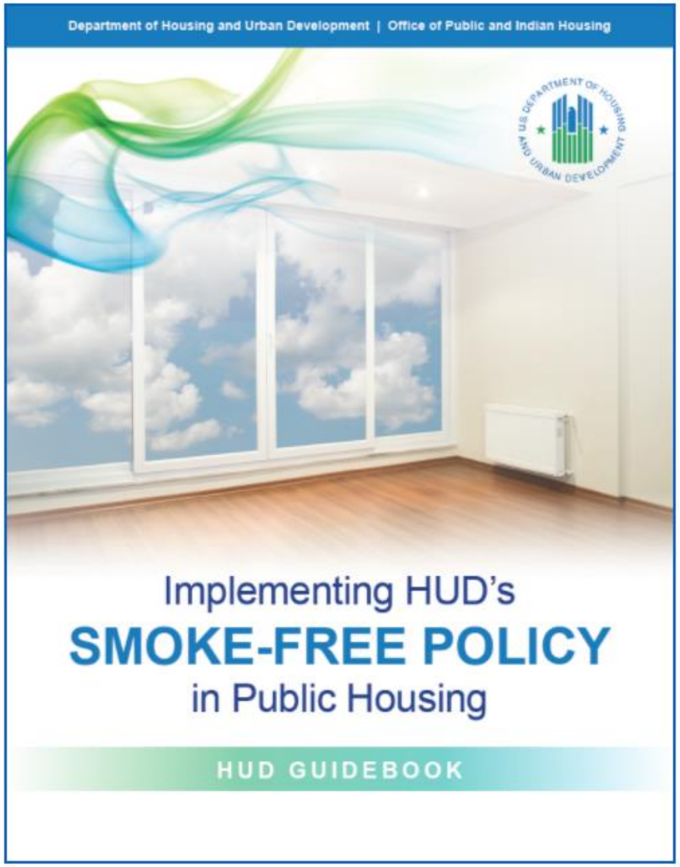
Illustration of real-time changes in $PM_{2.5}$ levels in a multiunit residential building



Source: King 2010

2016 Housing and Urban Development Rule prohibits smoking in public housing

- "Public housing authorities (PHAs) must design and implement a policy prohibiting the use of prohibited tobacco products in all public housing living units and interior areas… as well as in outdoor areas within 25 feet from public housing and administrative office buildings in which public housing is located."



Policy required to be implemented by July 31, 2018

Prior evidence for smoke-free housing (SFH) policies

- **Evidence of air quality changes associated with SFH is mixed**
  - Philadelphia: policy associated with decrease in airborne nicotine in public areas in year following implementation (Klassen 2017)
  - Boston: mixed results; some evidence of reductions in $PM_{2.5}$, however, one study found that airborne nicotine in apartments without resident smokers declined at similar rates between Boston Housing Authority and comparison developments (Russo 2015; MacNaughton 2016; Levy 2015)
  - New York City: no difference in air quality trends between NYC Housing Authority (NYCHA) and comparison developments in early post-policy period (Thorpe 2020); longer-term trends revealed declines in airborne nicotine in NYCHA hallways, relative to comparison (Anastasiou 2023)
  - Norfolk, VA: policy associated with increased $PM_{2.5}$ and airborne nicotine in year following implementation (Plunk 2020)

- **There is little prior literature on health effects of SFH in public housing**
  - Colorado: policy associated with reduction in self-reported breathing problems (Young 2016)

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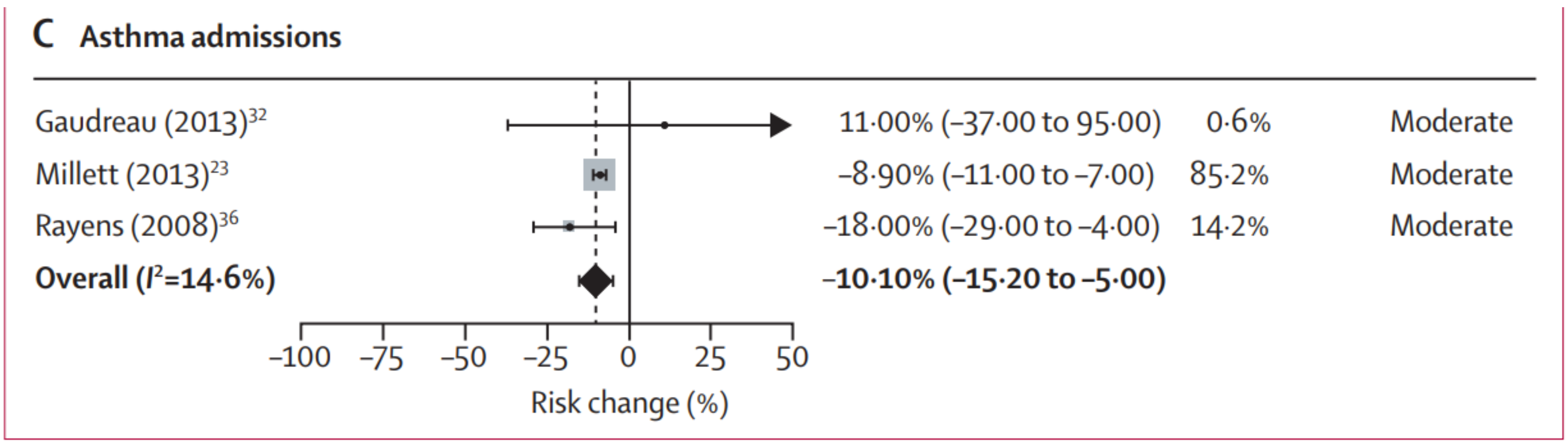
Prior evidence for other smoke-free policies

Results from meta-analysis of smoke-free legislation and asthma hospitalizations



Smoke-free legislation in workplaces and public areas associated with a **10.1% reduction in hospitalizations for asthma**

Source: Been 2014

Analytic goal

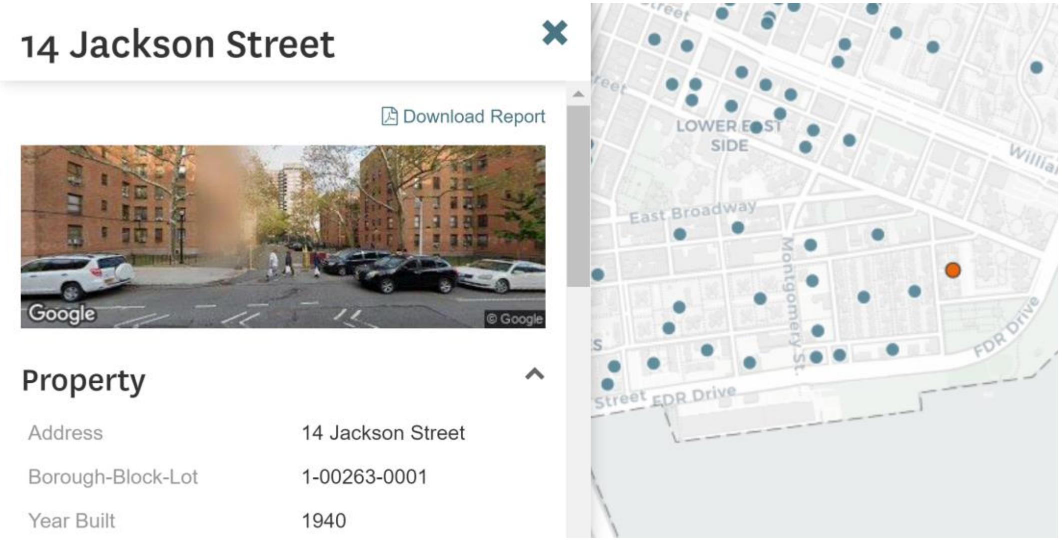
- **Aim**: Use Medicaid claims data to evaluate the impact of smoke-free public housing policies on health care visits associated with asthma, lower respiratory infections, and upper respiratory infections among children living in NYC Housing Authority (NYCHA) buildings

- **Study period:** November 1, 2015 – December 31, 2019, with intervention on July 30, 2018 (post-intervention period begins August 1, 2018)
  - 33 months of pre-policy data, 17 months of post-policy data

- **Design**: Treat SFH policy as a quasi-experiment by comparing changes over time in SHS-sensitive pediatric health outcomes among residents in NYCHA housing matched to residents in other types of subsidized housing in NYC
  - Other subsidized housing programs include other HUD-financed programs (e.g., the section 8 housing voucher program), property tax incentive programs tied to the provision of low-income housing, zoning initiatives, or other city and state housing subsidization programs
  - Secondary analysis: stratification by age group (ages 0-2, 3-6, 7-15)

Advantages to evaluating SFH policies in NYC

- NYC has a large population of residents living subsidized housing
  - NYC Housing Authority (NYCHA) is home to 1 in 17 New Yorkers
  - Over 500,000 New York residents participate in NYCHA affordable housing programs
- Detailed municipal datasets can be used to characterize local built environment



Source: NYU Furman Center, CoreData.nyc

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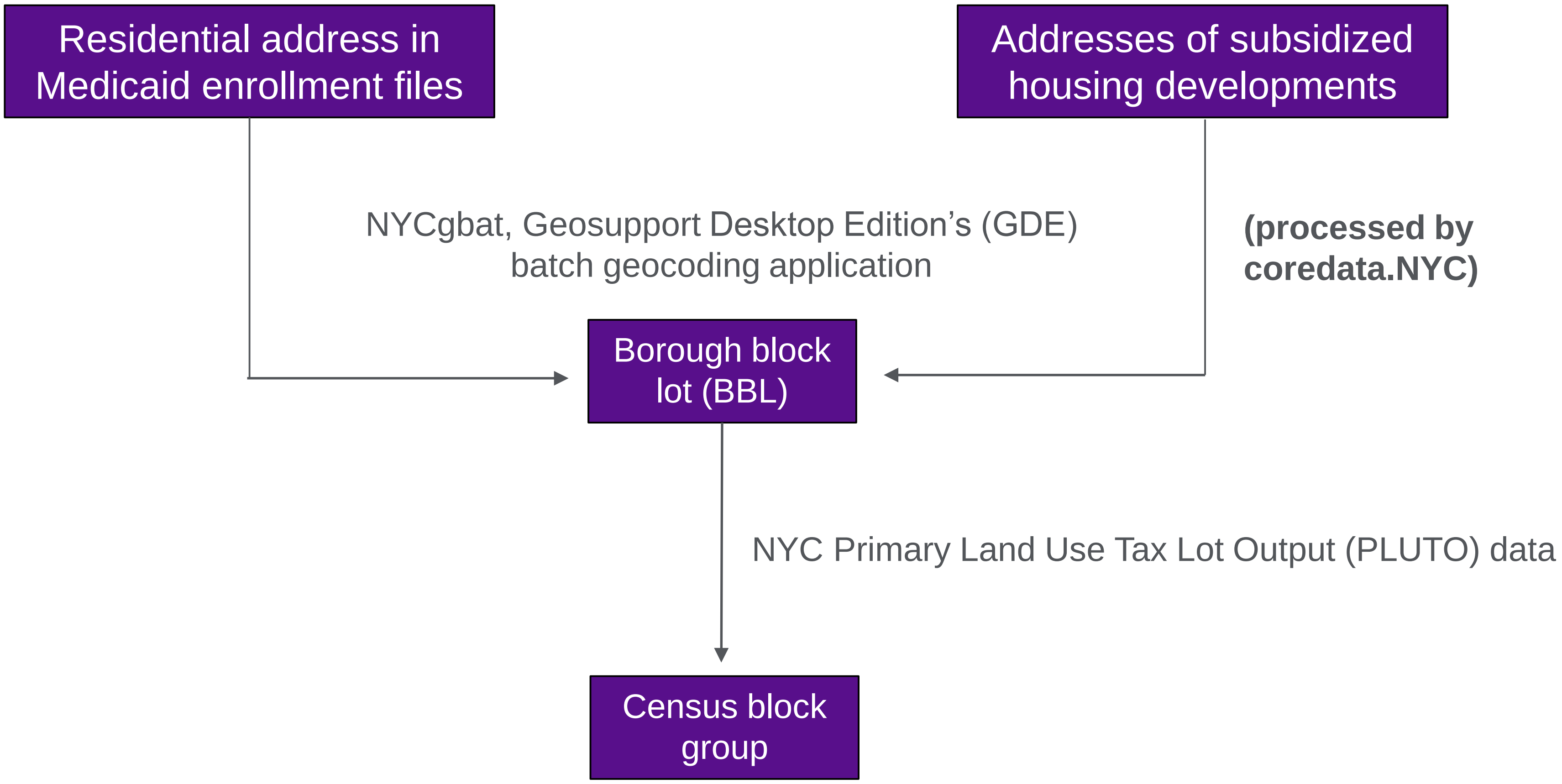
Geocoding process for claims, housing data



Sample eligibility

Primary criteria for inclusion at baseline (November 1, 2015):

- Enrolled in Medicaid in NYC; and
- Between the ages of 0 and 15; and
- With a residential address mapped to public or other eligible subsidized housing BBL; and
- Not dually eligible for Medicaid and Medicare

Eligible N for primary analysis

Unmatched		Matched	
NYCHA	**Comparison**	**NYCHA**	**Comparison**
72,072	108,780	71,114	47,174

Outcomes

Outpatient (non-ED) and ED visits with any diagnosis code* indicating:

- Asthma
- Upper respiratory infections
- Lower respiratory infections

Outcome	ICD-10 codes
Asthma	J45
Lower respiratory infections	A48.1, J10-J10.2, J10.8-J10.9, J11-J11.2, J11.8, J12-J12.3, J12.8-J12.9, J15-J15.9, J16.0, J16.8, J17-J17.3, J17.8, J18-J18.2, J18.8-J18.9, J20-J20.9, J21-J21.1, J21.8-J21.9, J85.1, P23-P23.6, P23.8-P23.9
Upper respiratory infections	J01-J01.4, J01.8-J01.9, J02.0, J02.8-J02.9, J03.0, J03.8-J03.9, J04-J04.3, J05-J05.1, J06.0, J06.8-J06.9

*ICD-10 code lists adapted from Global Burden of Disease Study

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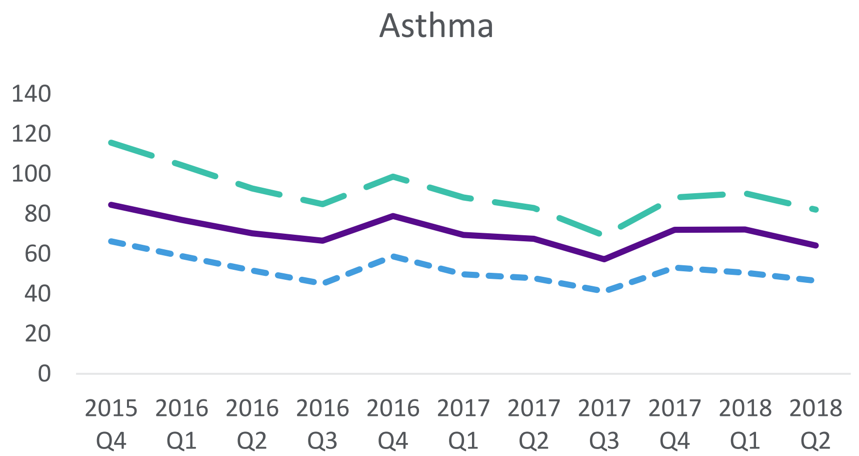
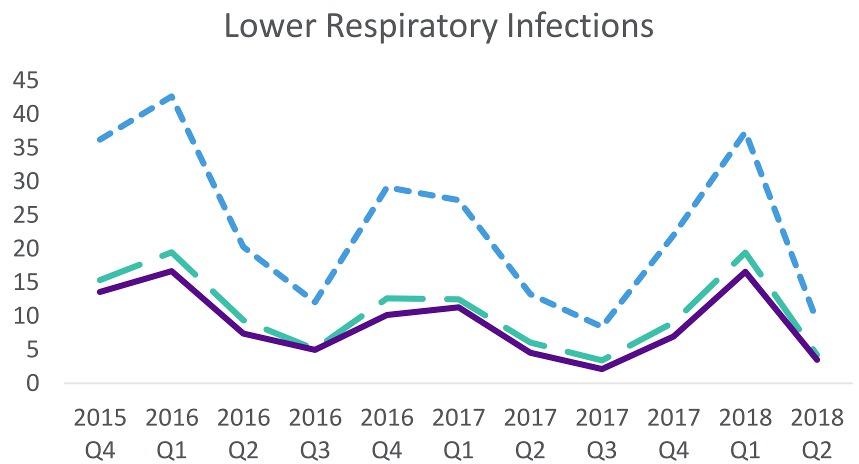
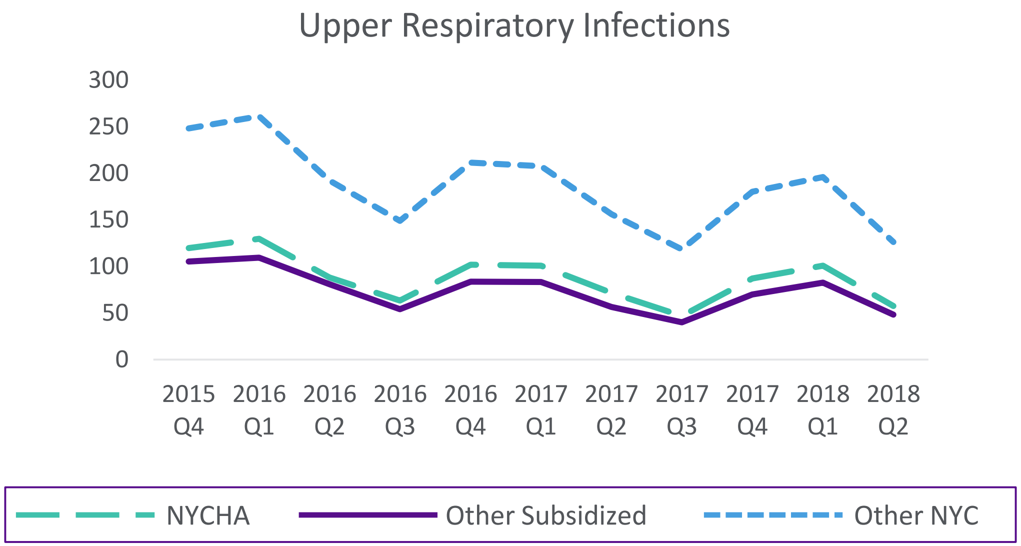
Pre-intervention outcome trends (outpatient visits)

Quarterly outpatient visits per 1,000 Medicaid enrolled children (unmatched)







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Covariates

Demographics: Age, sex, race/ethnicity

Medical history: Disability status, history of chronic condition

Medicaid enrollment history: Medicaid enrollment over pre-intervention period

Medicaid

Built environment and neighborhood characteristics: presence of high-rise in tax lot, census block group demographic and economic characteristics

PLUTO*

American Community Survey

*Primary Land Use Tax Lot Output data

Matching strategy

Matching conducted in multiple stages:

- 5:1 nearest neighbor Mahalanobis distance (MD) matching with replacement, within groups exactly matched on age category, race/ethnicity, sex, and disability status.
  - Within matched groups, MD matching conducted using other baseline covariates and a propensity score for living in a NYCHA development, based on all specified covariates (except age group)
- To improve balance within age subgroups, a LASSO procedure was used to identify important interactions between age group and covariates
- Propensity score model was re-estimated within matched data; overlap weights were calculated

Source: Yang 2021

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Statistical analysis

- Matched difference-in-differences analysis, with policy introduction in July 2018
- GEE models with negative binomial distribution and first-order autoregressive correlation, robust standard errors, and overlap weights (generated from matching process)

$$\log(Y_{i,t}) = \beta_0 + \beta_1 NYCHA_i + \beta_2 PostPolicy_t + \beta_3 NYCHA_i * PostPolicy_t + \beta_4 \text{Covariates}_\text{i} + \varepsilon_{i,t}$$

Y is rate of visits for specified health outcome for individual *i* at time *t*

$NYCHA_i$ is indicator for living in NYCHA development

$PostPolicy_t$ is indicator for post-policy time period

Baseline covariates specified on prior slide (does not include months of Medicaid enrollment)

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Additional analyses and robustness checks

Sensitivity analyses and alternative model specifications:

- Matching on quarterly rates of health outcomes in pre-intervention period
- Defining outcomes using primary diagnosis code
- Restricting analysis to non-movers over the follow-up period
- Restricting analysis to continuously enrolled children
- Including a 3-month washout period following policy introduction

Robustness checks:

- Evaluating associations in “placebo year” prior to policy introduction
- Examining injuries as a negative control outcome

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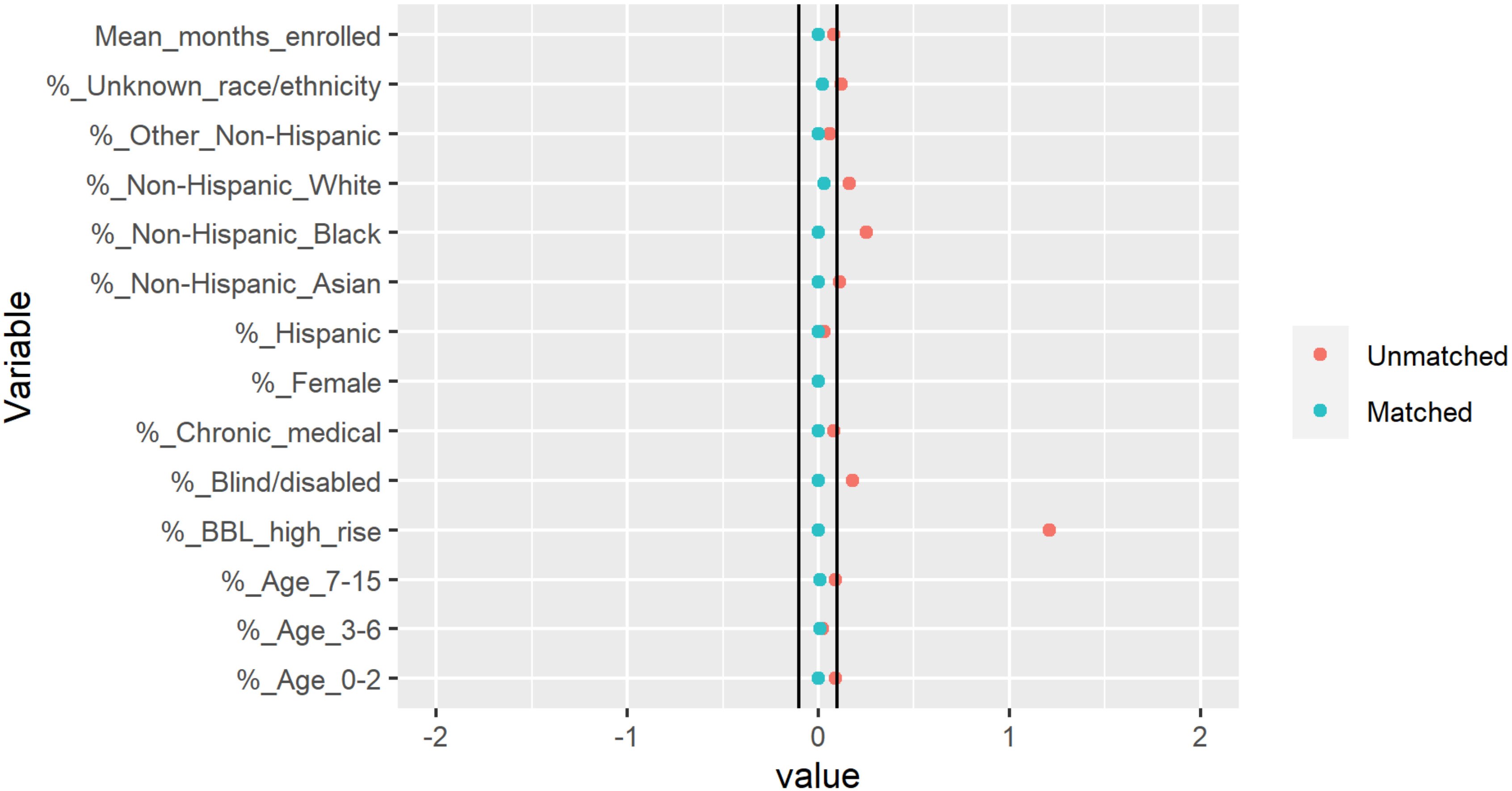
Results: Descriptive characteristics of analytic sample

Standardized mean differences for key covariates in unmatched and matched sample



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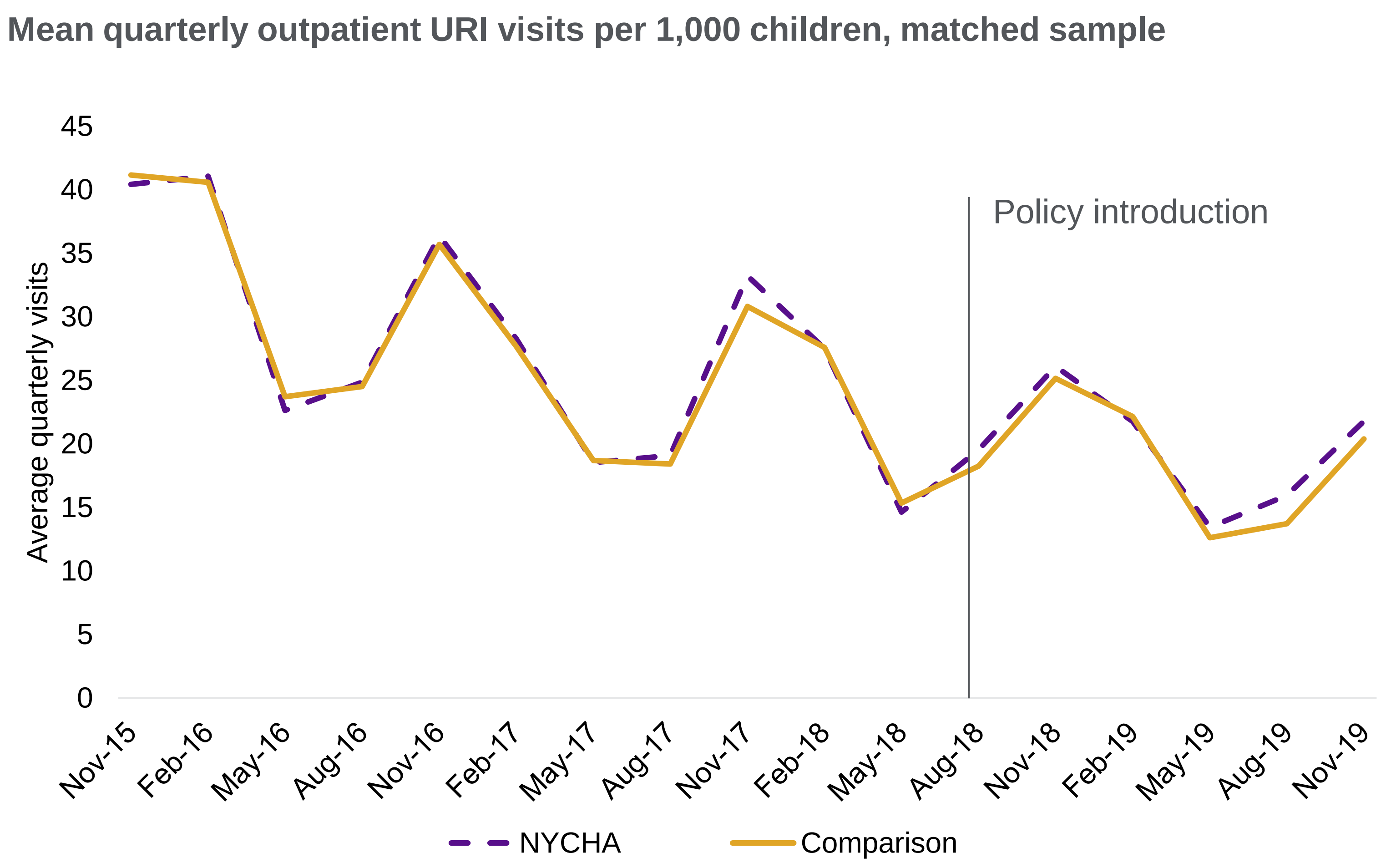
Results: DiD model coefficients

Table 3. Difference-in-differences coefficient estimates comparing post-intervention outcome rates between children in NYCHA and children in other subsidized housing, matched sample, New York City, 2015-2019

Variable	IRR (95% CI)	p-value
Outpatient visits		
Asthma	0.99 (0.94,1.04)	0.614
LRIs	0.94 (0.85,1.03)	0.195
URIs	**1.05 (1.01,1.08)**	0.007
ED visits		
Asthma	1.05 (0.98,1.13)	0.143
LRIs	1.12 (0.98,1.27)	0.099
URIs	1.05 (0.99,1.11)	0.122

Notes: Bold indicates statistical significance at 0.05 level. IRR estimates and p-values correspond to coefficient associated with treatment*time interaction in negative binomial DiD regression model.

Results: Outcome trends in matched sample



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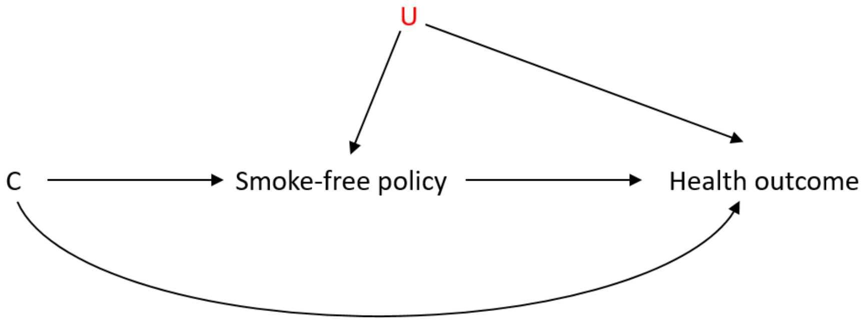
Secondary and sensitivity analyses

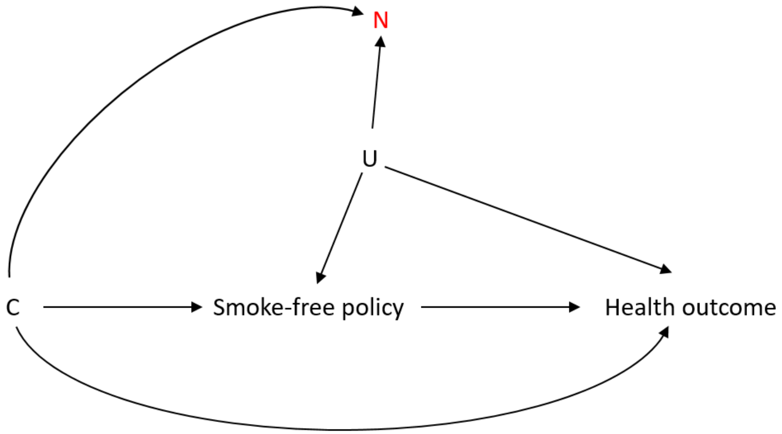
Results generally directionally similar across model specifications

- Restricting to primary diagnosis code -> policy associated with higher rates of asthma ED visits

Robustness checks yielded no statistically significant results

- No associations with health outcomes in placebo year
- No association with injuries as a negative control outcome





C =measured confounders; U = unmeasured confounders; N= negative control

Interpreting results

- Analysis does not suggest that policy is associated with lower rates of health care encounters for SHS-sensitive conditions among Medicaid-enrolled children in early post-policy period

- Statistically significant association with URIs is very small in magnitude
  - Difference between the groups (comparing the pre- and post-policy periods) was 0.8 visits per 1,000 children per month

Interpreting results

Qualitative research suggests ongoing challenges with policy implementation and enforcement

Lack of associations with health outcomes also consistent with air quality findings in early post-policy period

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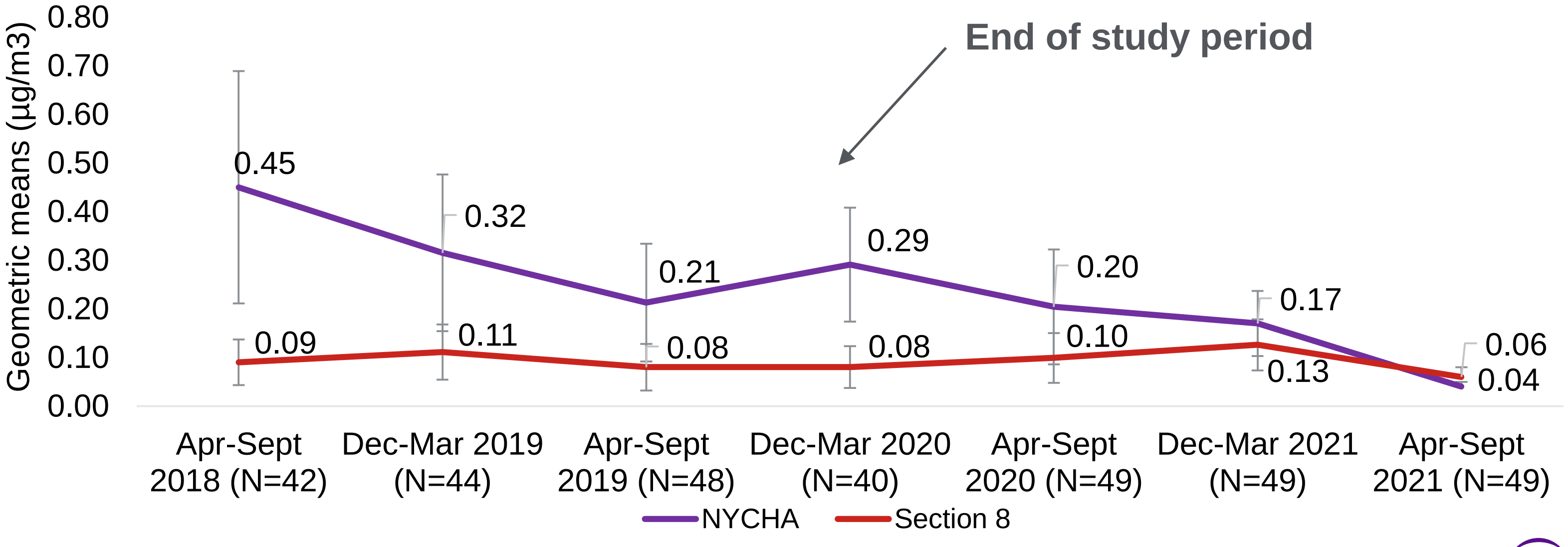
Lack of associations with health outcomes also consistent with air quality findings in early post-policy period

Geometric mean cotinine levels in NYCHA housing hallways, compared to control hallways in Section 8 buildings



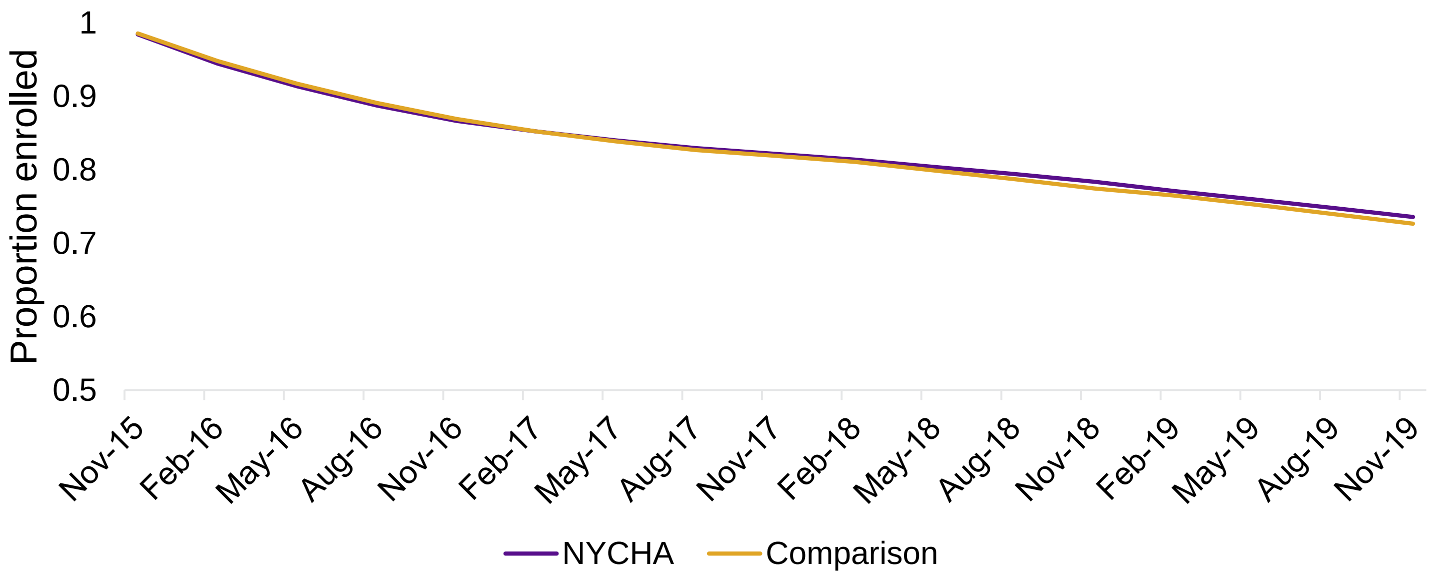
Source: Anastasiou 2023

Possible interpretations of counterintuitive findings (1)

Residual confounding or statistical artifact

- Potential for deterioration of housing environments over time or other secular trends that differentially impacted NYCHA and other subsidized housing developments over time (robustness checks designed to assess this)
- Differential churn/enrollment over time

Proportion of original sample enrolled over study period



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Possible interpretations of counterintuitive findings (2)

One prior SFH evaluation found increases in $PM_{2.5}$ and SHS following policy introduction

Table 1. Average Daily Indoor $PM_{2.5}$ and Airborne Nicotine by Comparison and Adjusted Change in Mean Daily $PM_{2.5}$ and Airborne Nicotine Following SFH Implementation in Norfolk, VA

	Observed pre-SFH air quality		Observed post-SFH air quality		Adjusted change (95% CI)	
Comparison	$PM_{2.5}$ (μg/m^3)	Nicotine (μg/m^3)	$PM_{2.5}$ (μg/m^3)	Nicotine (μg/m^3)	$PM_{2.5}$ (μg/m^3)	Nicotine (μg/m^3)
One month pre- and post-SFH	27.48	0.31	19.94	0.21	−7.23 (−8.98, −5.49)	−0.23 (−0.43, −0.04)
December 2017 vs. December 2018	18.92	0.36	25.18	0.45	7.87 (5.45, 10.28)	0.10 (0.00, 0.19)

CI = confidence interval. Observed values reflect measurements taken in common areas of five midrise buildings that implemented SFH in response to the HUD rule. Adjusted change in $PM_{2.5}$ and nicotine were estimated using linear mixed modeling with random site and time effects and included an additional building that did not implement SFH as a control.

Source: Plunk 2020

Strengths and limitations

- Strengths
  - Large population of individuals living in NYCHA or other subsidized housing developments – supported quasi-experimental study design
  - Multiple secondary and sensitivity analyses
  - Health outcome monitoring was coupled with air quality monitoring, qualitative research to contextualize findings

- Limitations
  - Limited post-policy period data
  - Potential for residual confounding
  - Comparison population likely very heterogeneous
  - Other subsidized housing developments may have had independent SFH policies

Conclusions

- In NYC, introduction of a smoke-free policy was not associated with lower rates of Medicaid claims for any outcomes in the early post-policy period
- Exposure to the smoke-free policy was associated with slightly higher rates of outpatient claims for URIs, though changes were very modest
- Air quality monitoring and qualitative research highlights need for ongoing health outcome research and policy implementation support
  - 3-year air quality data suggests that air nicotine is trending downward in NYCHA hallways compared to Section 8 control group, though trend is not apparent in nonsmoking apartments, stairwells

Next steps

Policy implications

- Addressing high levels of SHS exposure in multifamily housing remains a priority, given disparities in respiratory health outcomes across housing environments
- Policy priorities include supporting implementation of SFH policies, including improving access to cessation support and further engaging residents in implementation
- SFH is one aspect of a wider healthy homes agenda, which also includes investing to improve environmental and structural health of buildings

Research implications

- We are continuing to monitor air quality in building common areas over time
- Given evolving implementation landscape, we are also examining health outcome trends over longer post-policy period (through 2022)
  - Analyses underway exploring pediatric health outcomes, adult health outcomes (e.g., respiratory infections, CVD outcomes) using all-payer claims data
- Mixed methods evaluation, including focus on policy implementation process, has been key to contextualizing findings

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SMOKE-FREE HOUSING

NYCHA:
Ann-Marie Flatley
Andrea Mata
Jyoti Parth

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Shannon Farley
John Jasek
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Thank you

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