Housing type and secondhand tobacco smoke exposure among non-smoking New York City adults, 2004 and 2013–14

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ABSTRACT

Secondhand tobacco smoke (SHS) exposure has declined due to smoking reductions, expanding workplace and public smoke-free air laws, and smoke-free housing policy promotion. Population-based studies examining objective SHS exposure biomarkers have documented reductions over time, however non-smoking urban adults are more likely to have elevated cotinine (a metabolite of nicotine) compared with national averages. Evidence suggests residential housing type may impact urban SHS exposure risk. Direct associations between multiunit housing (MUH) and elevated cotinine have been identified among children but not yet examined among adults. We used data from the cross-sectional 2004 and 2013/14 New York City Health and Nutrition Examination Surveys to investigate associations between MUH (single-family versus 2; 3–99; and 100 + units) and likelihood of elevated serum cotinine among nonsmoking adults (2004: n = 1324; 2013/14: n = 946), adjusting for socio-demographics (sex, age, race/ethnicity, education, income) and self-reported SHS exposure variables. Combined and single-year adjusted multivariable regressions were conducted. Elevated cotinine was defined as a serum level of ≥ 0.05 ng/ml. Combined year adjusted multivariable regression analyses found no difference in elevated cotinine by housing type among non-smoking adults. By survey year, elevated cotinine did not vary by housing type in 2004, while non-smoking adults in 3–99 unit buildings were twice as likely to have elevated cotinine compared with single family residents in 2013/14 (adjusted Odds Ratio = 2.55 (1.13, 5.79)). While SHS exposure has declined, relative burden may be increasing among MUH residents. In urban settings with extensive MUH, attention to housing-based policies and programmatic interventions is critical to reducing SHS exposure.

1. Introduction

Numerous studies have concluded that there is no safe level of secondhand tobacco smoke (SHS) exposure. (U.S. Department of Health and Human Services, 2014) (All references to SHS throughout refer only to tobacco smoke) SHS exposure causes adverse respiratory and cardiovascular outcomes, including lung cancer and cardiovascular disease, which increase in a dose-dependent manner with exposure. (U.S. Department of Health and Human Services, 2014; Cameron and Robertson, 1973; Brennan et al., 2004; Chen et al., 2004; Lam et al., 2005) In the US, more than 40,000 annual deaths from lung cancer and ischemic heart disease among non-smoking adults are attributable to SHS exposure. (U.S. Department of Health and Human Services, 2014).

Research suggests that adults living in urban settings may have greater exposure to SHS than adults living in rural settings. Specifically, two population-based biomarker studies have shown that non-smoking adult New Yorkers were more likely to have elevated serum cotinine (a metabolite of nicotine) levels compared with non-smoking adults nationally, both in 2004 and again in 2013/14. (Ellis et al., 2009; Perlman et al., 2016) Historically, the main sources of SHS exposure among adults include home, workplace, and outdoor settings. (Kraev et al., 2009; Farrelly et al., 2005; Pirkle et al., 2006) Smoke-free air laws have significantly reduced workplace SHS. (Farrelly et al., 2005; Pirkle et al., 2006; Menzies et al., 2006) More recently, the expansion of voluntary smoke-free housing policies has begun to contribute to reductions in SHS exposure at home; however, housing persists as a key source of SHS. (Kraev et al., 2009; Homa et al., 2015; Debchoudhury and Farley, 2019; Arku et al., 2014; Pizacani et al., 2012) In New York City

(NYC), the vast majority (70%) of people live in multiunit housing (MUH) and are subject to the policies of the landlord or other ownership body. Multiple cross-sectional surveys among MUH landlords in NYC have demonstrated an increase in the availability of smoke-free units throughout the city between 2012 and 2015 (Debchoudhury and Farley, 2019; Farley et al., 2015) However, since the prevalence of smoke-free policies among buildings with low-income tenants is still lower, the lack of broader policy change may result in inequities across socioeconomic status (Debchoudhury and Farley, 2019; Farley et al., 2015; US Census Bureau, 2014).

While studies of children from non-smoking households have found important differences in serum cotinine levels between those who live in MUH compared to detached housing, similar studies evaluating associations between living in MUH and serum cotinine level have not been conducted among non-smoking adults. (Wilson et al., 2011) Since the majority of New Yorkers live in MUH, increased exposure to environmental SHS within the home could explain why cotinine levels are higher among non-smoking adults in NYC compared to nationally (US Census Bureau, 2014).

This study investigated the relationship between housing type and elevated cotinine among non-smoking NYC adults aged 20 and older, accounting for demographics and additional sources of SHS exposure. We analyzed survey and biomarker data from two representative city-wide surveys, the 2004 and the 2013/14 NYC Health and Nutrition Examination Survey (HANES) and characterized housing type of participants by matching their addresses at the time of the interview to 2005 and 2014 NYC Primary Land Use Tax lot Output (PLUTO) data, respectively.

2. Methods

2.1. Study data

The 2004 and 2013/14 NYC HANES were representative cross-sectional surveys of 1,999 and 1,527 New Yorkers, respectively, ages 20 and older, that were modeled on the National Health and Nutrition Examination Surveys. (Thorpe et al., 2004) The surveys consisted of a brief physical exam, clinical and laboratory tests, and an in-person interview. There were 1,767 New Yorkers who provided blood samples and were tested for serum cotinine in 2004 and 1,195 in 2013/14. The study population was limited to adults who did not smoke (based on measured serum cotinine levels of <10.0 ng/ml) who also had valid NYC addresses (N = 1,320 and N = 946). (Pirkle et al., 1996) Serum cotinine is a more accurate and reliable measurement of SHS exposure than self-reported exposure. (Ellis et al., 2009; USDHHS, 1986).

The 2005 Primary Land Use Tax Lot Output (PLUTO) data set (N = 854,858 tax lots) and the 2014 PLUTO data set (N = 858,914 tax lots) combined land use and geographic data at the tax lot level. They provided information about the buildings and tax lots they occupied and was used to define housing types. The 2005 PLUTO file was used instead of 2004 PLUTO because the 2005 data set contained the Borough Block and Lot (BBL) variable needed to match PLUTO data with NYC HANES data. The PLUTO data was merged with the NYC HANES address information to link building information with NYC HANES respondents. Address information was used separately from survey data to identify tax lot types; once completed, all address information was deleted from the dataset and only tax lot information was merged back into the survey data, to ensure anonymity of participants.

2.2. Measures

The NYC HANES outcome variable, cotinine level, was examined as a dichotomous variable (elevated, ≥ 0.05 ng/ml vs. less than the limit of detection, < 0.05 ng/ml) among non-smoking adults. The serum cotinine samples were analyzed with an isotope dilution, liquid chromatography/tandem mass spectrometry method in 2004 and with a high-

throughput, 96-well plate format in 2013/14; these methods are considered comparable as the changes only improved the automation and did not introduce any bias. (Ellis et al., 2009; Perlman et al., 2016) The limits of detection for NYC HANES serum cotinine were 0.05 ng/ml and anyone with results below that level were considered to have less than the limit of detection of cotinine, and assigned a value of 0.035 ng/ml. (Ellis et al., 2009; Perlman et al., 2016) Due to the censored nature of the data, we opted not to analyze cotinine as a continuous variable, but rather as a dichotomous variable, to avoid missing data issues.

There is no standard definition for MUH in public health or housing literature. A 2011 study in children utilized three levels: single family detached homes, single family attached homes and MUH, while the NYC Housing and Vacancy Survey considers three or more units multifamily. (Wilson et al., 2011; Lee, 2011) The housing type variable was created by combining PLUTO variables about tax lot information: number of residential units; number of buildings; proximity code (detached or attached buildings); building class (one family dwellings, two family dwellings, walk up apartments, elevator apartments, residence-multiple use, etc.); number of floors; and land use (one and two family buildings, multi-family walk-up; multi-family elevator, etc.) to designate the specific level of housing type. Most determinations of building size were based on dividing the number of residential units on the tax lot by the number of buildings on the tax lot. However, exceptions were made for one-, two-, and some three-unit residences. For example, when the number of units was one and the building class was a single-family home but the number of buildings was greater than one, then the building number variable was disregarded. When the building class indicated "two family dwellings" or "three families walk up apartments," these were used for classification over the building number variable. When information was missing or listed as zero for some tax lots, additional PLUTO variables were used to determine building size such as number of floors, land use, and proximity code. In this study, the variable was categorized as: single-family detached or attached home (1); buildings with two residential units/apartments (2); three to 99 units (3–99); and 100 or more units (100 or more).

NYC HANES socio-demographics included self-reported: age (categorized as 20 to 39, 40 to 59, and 60 and older), sex (male or female), race/ethnicity (non-Hispanic White, non-Hispanic Black, non-Hispanic Asian [including Native Hawaiian and other Pacific Islander], or Hispanic), educational attainment (less than a high school graduate [<HS], high school graduate only [HS grad only], or more than a high school graduate [some college or more]), and household income (less than $20,000, $20,000 to $49,999, or $50,000 or higher).

Although both surveys were conducted after the introduction of NYC smoke-free workplace laws in 2003, respondents were asked whether they smell SHS when at their job or business. In 2013/14 only, respondents were also asked whether anyone smokes in the home.

A variable for wave was included in the overall data set, to allow for examination of differences between 2004 and 2013/14.

2.3. Statistical analysis

2.3.1. Descriptive and bivariate analyses, and unadjusted logistic regression

Demographics, housing type, SHS exposure, and elevated cotinine variables were examined across the combined- and individual-year data sets. Next, elevated cotinine was assessed across the combined- and individual-year data sets by demographics, housing type, and SHS exposure variables. T-tests were used to compare differences between years. Unadjusted logistic regressions of associations between housing type, socio-demographic variables and elevated cotinine among non-smoking adults were explored.

2.3.2. Multivariable logistic regression

Multivariate logistic regression models examined the associations in the combined data set between housing type and elevated cotinine among non-smoking adults, by wave, A) adjusting for demographics,

and B) adjusting for demographics and smelling smoke at their job/ business. Combined models A and B were also examined with an interaction term between wave and housing type.

Multivariate logistic regression models also examined the associations in the individual year data sets between housing type and elevated cotinine among non-smoking adults, A) adjusting for demographics, and B) adjusting for demographics and smelling smoke at their job/business in 2004 and adding an additional SHS-related variables (anyone smoking at home), to model B in 2013/14.

2.3.3. Weighting and adjustment

Data were weighted to account for NYC HANES' complex sampling design, nonresponse and post-stratification adjustment. The NYC HANES weights were further adjusted for item-level nonresponse. SAS-callable SUDAAN version 11.0.3 was used to conduct the descriptive and regression analyses. All statistical differences reported in the text were significant at the $p < 0.05$ level, unless otherwise stated.

The Institutional Review Boards at the New York City Department of Health and Mental Hygiene and the Graduate Center at the City University of New York classified this study as exempt.

3. Results

The demographic profile of non-smoking adults was similar across survey years, except for education levels; the average education levels increased significantly between 2004 and 2013/14. (Table 1) More than a third of non-smoking adults (37.5%) had elevated cotinine levels in 2013/14, down from more than half in 2004 (56.7%). The proportions of non-smoking adults with elevated cotinine declined significantly across all demographic groups over time, except respondents who graduated from high school only, and there was also no change among those who smelled smoke at work.

In a multivariable regression model with combined years (Table 2), we found no association between housing type and elevated cotinine after adjusting for socio-demographic measures and self-reported smelling smoke at work. Table 3 shows the adjusted multivariable regression results by individual survey years. While there was no association between housing type and elevated cotinine in 2004, even after adjusting for self-reported smelling smoke, in 2013/14 non-smoking adults who lived in two-unit buildings (Odds Ratio (OR) = 2.21, 95% Confidence Interval (1.07, 4.53), three to 99 unit buildings (OR = 2.12 (1.12, 4.03)), and 100 or more unit buildings (OR = 2.31 (1.15, 4.63)) had more than twice the odds of having elevated cotinine compared with single detached/attached homes. When all variables representing self-reported exposure to SHS were included (smelling smoke at work and anyone smoking at home), adjusted odds ratios remained elevated for all MUH categories but only non-smoking adults residing in buildings with three to 99 units continued to have significantly elevated adjusted odds ratios (OR = 2.55 (1.13, 5.79)). We conducted sensitivity analyses, examining odds of elevated cotinine with detached and attached single housing units disaggregated, and found no difference in the general pattern of the odds ratios, only a slight increase in the magnitude, when attached or multiunit housing were compared to single houses.

Table 1

NYC HANES 2004 and 2013/14, combined and individual years, demographics and SHS exposure among all non-smoking adults and among those with elevated cotinine.

	Combined	2004	2013/14	Elevated Cotinine Combined	Elevated Cotinine 2004	Elevated Cotinine 2013/14
	N (Column %)	N (Column %)	N (Column %)	N (%)	N (%)	N (%)
Outcome						
Elevated Cotinine						
Yes	1115 (46.7)	776 (56.7)	**339 (37.5)**			
Main Exposure						
Housing type (units)						
1	287 (15.1)	175 (15.7)	112 (14.6)	121 (42.6)	94 (55.2)	**27 (29.9)***
2	357 (16.5)	207 (16.4)	150 (16.5)	176 (46.0)	122 (57.3)	**54 (35.1)**
3 to 99	1339 (55.3)	816 (56.7)	523 (53.9)	691 (48.9)	490 (57.9)	**201 (40.2)**
100 or more	268 (13.1)	121 (11.2)	147 (14.9)	127 (46.3)	70 (54.6)	**57 (40.5)**
Socio-demographics						
Age						
20 to 39	1061 (40.5)	651 (40.8)	410 (40.1)	599 (55.3)	419 (64.3)	**180 (46.9)**
40 to 59	785 (34.3)	473 (34.5)	312 (34.1)	363 (44.5)	264 (55.2)	**99 (34.6)**
60 and older	405 (25.2)	195 (24.7)	210 (25.8)	153 (35.3)	93 (45.9)	**60 (26.1)**
Sex						
Male	912 (44.3)	532 (44.2)	380 (44.5)	507 (52.0)	357 (63.9)	**150 (41.1)**
Female	1339 (55.7)	787 (55.8)	552 (55.5)	608 (42.6)	419 (51.1)	**189 (34.7)**
Race						
White	737 (37.9)	384 (38.6)	353 (37.3)	316 (43.3)	210 (54.2)	**106 (32.8)**
Black	420 (20.4)	257 (22.3)	163 (18.8)	226 (50.7)	154 (57.2)	**72 (43.5)**
Asian	291 (13.1)	170 (11.2)	121 (14.9)	182 (57.1)	128 (69.0)*	**54 (48.2)***
Hispanic	733 (28.6)	486 (27.9)	247 (29.1)	360 (44.2)	274 (54.9)	**86 (35.2)**
Education						
<HS	545 (21.4)	372 (26.0)	**175 (17.1)**	315 (57.2)	244 (65.7)	**71 (45.6)**
HS only	364 (20.0)	236 (17.1)	**128 (22.6)**	189 (49.6)	132 (55.4)	57 (45.9)
Some college+	1336 (58.6)	707 (56.9)	**629 (60.2)**	611 (42.5)	400 (53.7)	**211 (32.8)**
3-level income						
<$20,000	659 (30.0)	427 (31.3)	232 (28.6)	377 (56.2)	270 (63.7)	**107 (48.3)**
$20,000-$49,999	655 (30.2)	422 (32.1)	233 (28.2)	335 (46.9)	249 (56.0)	**86 (36.3)**
>$50,000	797 (39.9)	420 (36.6)	377 (43.1)	336 (39.5)	229 (52.2)	**107 (29.0)**
Smell smoke at work						
Yes	214 (14.4)	128 (13.4)	86 (15.3)	134 (53.3)	87 (53.6)	**47 (51.9)***
Anyone smoke in the home						
Yes	NA	NA	69 (8.5)	NA	NA	54 (76.1)*

Bold = significant difference (p < 0.05) between 2004 and 2013/14.

*=Estimates should be interpreted with caution. Estimate's relative standard error (a measure of estimate precision) is greater than 30% or the sample size is<50, making the estimate potentially unreliable.

Table 2
NYC HANES 2004 and 2013/14, combined years, unadjusted and adjusted models.

	Elevated Cotinine Overall Combined, Unadjusted	Elevated Cotinine Overall Combined, Adjusted Model A	Elevated Cotinine Overall Combined, Adjusted Model B
		OR (95% CI)	OR (95% CI)
Housing type (units)			
1	1.00	1.00	1.00
2	1.40 (0.99, 1.98)	1.30 (0.88, 1.92)	1.50 (0.92, 2.46)
3 to 99	**1.63 (1.23, 2.16)**	1.32 (0.95, 1.82)	1.40 (0.93, 2.11)
100 or more	1.38 (0.95, 1.98)	1.28 (0.85, 1.93)	1.01 (0.60, 1.70)
Socio-demographics			
Age			
20 to 39	1.00	1.00	1.00
40 to 59	**0.65 (0.53, 0.80)**	**0.67 (0.53, 0.85)**	0.76 (0.57, 1.00)
60 and older	**0.44 (0.34, 0.57)**	**0.39 (0.29, 0.53)**	0.65 (0.41, 1.02)
Sex			
Male	1.00	1.00	1.00
Female	**0.70 (0.58, 0.85)**	**0.56 (0.45, 0.70)**	**0.50 (0.38, 0.65)**
Race			
White	1.00	1.00	1.00
Black	**1.38 (1.06, 1.79)**	1.28 (0.95, 1.73)	**1.67 (1.15, 2.44)**
Asian	**1.90 (1.40, 2.59)**	**1.51 (1.08, 2.13)**	1.33 (0.88, 2.01)
Hispanic	1.11 (0.88, 1.40)	0.83 (0.62, 1.10)	0.93 (0.65, 1.32)
Education			
<HS	1.00	1.00	1.00
HS only	0.80 (0.58, 1.10)	0.81 (0.57, 1.15)	1.00 (0.62, 1.62)
Some college+	**0.65 (0.52, 0.81)**	**0.68 (0.50, 0.92)**	0.89 (0.61, 1.32)
3-level income			
<$20,000	1.00	1.00	1.00
$20,000-$49,999	**0.74 (0.58, 0.96)**	**0.66 (0.50, 0.88)**	0.75 (0.50, 1.12)
>$50,000	**0.56 (0.44, 0.71)**	**0.56 (0.41, 0.75)**	**0.56 (0.37, 0.85)**
Smell smoke at work			
No	1.00		1.00
Yes	**1.92 (1.37, 2.68)**		1.82 (1.25, 2.65)
Wave			
2004	1.00	1.00	1.00
2013/2014	**0.46 (0.38, 0.55)**	**0.43 (0.35, 0.53)**	**0.34 (0.26, 0.44)**

Bold = significant odds ratio (p < 0.05).
Notes: A) adjusting for demographics, and B) adjusting for demographics and smelling smoke at work.

4. Discussion

To our knowledge, this is the first study using biologically measured serum cotinine levels and objectively confirmed housing types from municipal records examining whether housing type, specifically living in MUH, increases risk of SHS exposure among non-smoking adults. In our study, there was a significant decline in the odds of elevated cotinine among non-smoking adults between 2004 and 2013/14 and no association with housing type in the combined data set. Yet in analyses of each survey period separately, we found that the odds of elevated cotinine were more than double among non-smoking residents of MUH compared with single family homes in 2013/14. These findings are similar to prior research demonstrating elevated cotinine levels among children of non-smoking families living in MUH compared with those living in single-family homes. (Wilson et al., 2011).

Since NYC's initial smoke-free air law was implemented in 2003, supportive social norms around smoke-free air have expanded over time, while concurrently, the number of places where smoking can occur have been greatly reduced with the expansion of smoke-free air laws. (New York City, 2019; Waddell et al., 2014; Pacheco, 2011; Pacheco, 2013) Workplaces, bars and restaurants have been smoke-free since 2003, as have parks, beaches, and pedestrian plazas since 2011. (New York City, 2019) However, most smoke-free housing remains voluntary. This is further complicated by regulations to protect tenants in rent-stabilized apartments, which account for 45% of the rental market in NYC; these regulations prohibit changing terms of existing leases, as would be needed to implement new smoke-free building policies. (Tenants' Rights Guide—New York State Attorney General, 2018)

Further, NYC studies examining smoke-free housing from 2012 to 2015 demonstrated that the prevalence of smoke-free housing is increasing yet remains less likely among buildings with units for lower-income households. (Debchoudhury and Farley, 2019; Farley et al., 2015).

The association between elevated cotinine and housing type in 2013/14 but not observed in 2004 may be due to changes in smoke-free air laws, as well as shifting social norms about smoking. These trends benefited all New Yorkers but without wide-spread adoption of smoke-free housing policies in MUH, the housing environment now contributes relatively more to SHS exposure from other units than it previously did. These trends will require continued monitoring as smoke-free housing efforts continue to expand. They also suggest the need for promoting and expanding tobacco treatment options available to residents of multiunit housing, including resources for residents who may not be ready to quit but want to avoid smoking at home.

To further address these potential SHS exposure disparities within different types of MUH, in 2017, NYC passed a local law requiring buildings with three or more units to develop policies on smoking and share them with current and future tenants. (The New York City Council, 2017) Changes have also occurred nationally, with the US Department of Housing and Urban Development requiring all public housing to be smoke-free as of July 31, 2018. (US Department of Housing and Urban Development, 2019) These efforts contribute to the expansion of smoke-free housing awareness and reduction of inequities from the voluntary implementation model currently in effect.

When all available SHS exposures were included in the 2013/14 model, non-smoking adults who lived in MUH buildings demonstrated more than twice the odds of elevated cotinine compared with non-

Table 3

NYC HANES 2004 and 2013/14, individual years adjusted models.

	Elevated Cotinine Adjusted Model A, 2004	Elevated Cotinine Adjusted Model B, 2004	Elevated Cotinine Adjusted Model A, 2013/14	Elevated Cotinine Adjusted Model B, 2013/14
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Housing type				
1	1.00	1.00	1.00	1.00
2	0.89 (0.55, 1.45)	1.24 (0.66, 2.34)	**2.21 (1.07, 4.53)**	2.03 (0.79, 5.20)
3 to 99	0.98 (0.65, 1.47)	1.07 (0.64, 1.78)	**2.12 (1.12, 4.03)**	**2.55 (1.13, 5.79)**
100 or more	0.82 (0.46, 1.46)	0.71 (0.36, 1.43)	**2.31 (1.15, 4.63)**	1.96 (0.77,4.96)
Socio-demographics				
Age				
20 to 39	1.00	1.00	1.00	1.00
40 to 59	**0,72 (0.55, 0.95)**	0.88 (0.63, 1.24)	**0.60 (0.40, 0.89)**	**0.63 (0.40, 0.99)**
60 and older	**0.41 (0.28, 0.61)**	0.90 (0.47, 1.70)	**0.38 (0.24, 0.61)**	0.53 (0.25, 1.10)
Sex				
Male	1.00	1.00	1.00	1.00
Female	**0.51 (0.39, 0.68)**	**0.43 (0.31, 0.60)**	**0.59 (0.42, 0.83)**	**0.51 (0.32, 0.80)**
Race				
White	1.00	1.00	1.00	1.00
Black	1.03 (0.70, 1.51)	1.36 (0.84, 2.21)	1.72 (1.05, 2.81)	**2.29 (1.25, 4.21)**
Asian	**1.74 (1.11, 2.74)**	1.53 (0.90, 2.59)	1.47 (0.87, 2.48)	1.35 (0.68, 2.70)
Hispanic	0.76 (0.53, 1.09)	0.80 (0.52, 1.22)	0.94 (0.59, 1.51)	1.38 (0.77, 2.47)
Education				
<HS	1.00	1.00	1.00	1.00
HS only	**0.59 (0.39, 0.88)**	0.61 (0.37, 1.01)	1.03 (0.58, 1.83)	1.92 (0.79, 4.68)
Some college+	**0.63 (0.44, 0.92)**	0.70 (0.45, 1.09)	0.69 (0.42, 1.15)	1.54 (0.74,3.21)
3-level income				
<$20,000	1.00	1.00	1.00	1.00
$20,000-$49,999	0.78 (0.55, 1.10)	0.74 (0.48, 1.14)	**0.55 (0.34, 0.87)**	0.82 (0.40, 1.66)
>$50,000	**0.64 (0.44, 0.93)**	**0.56 (0.35, 0.90)**	**0.51 (0.31, 0.82)**	0.63 (0.31.1.28)
Main exposure				
Smell smoke at work				
No		1.00		1.00
Yes		1.25 (0.79, 1.96)		**2.33 (1.30, 4.17)**
Anyone smoke in the home				
No				1.00
Yes				**5.08 (1.85, 13.97)**

Bold = significant odds ratio (p < 0.05).

Notes: A) adjusting for demographics, and B) adjusting for demographics and smelling smoke at work in 2004 and 2013/2014, and also including anyone smoking in the home in 2013/14.

smoking adults in single family homes, yet only those in buildings with 3–99 units remained statistically elevated using an a priori p-value cut-off. This is an important finding, since more than half of NYC non-smoking adults live in buildings of this size. These findings align with other studies showing that those living in a duplex, double or multi-family home, or condo were less likely to experience SHS from outside their home compared with those living in apartments. (King et al., 2010).

There are several limitations pertaining to study design and measurement issues within both the NYC HANES and PLUTO data sets. The NYC HANES data were cross-sectional surveys; thus, it is impossible to draw causal inferences. NYC HANES cotinine levels were used to determine the smoking status of respondents, and those who smoked infrequently could have been misclassified as non-smoking adults. In addition, no measure asking whether anyone who smokes lived in the home was included in the 2004 survey, thus the influence of others smoking in one's home could not be accounted for. Similarly, no measure asking about exposure to smoke in other homes/venues was asked in either year. Furthermore, the measure of housing type in the PLUTO datasets was crude, mainly based on the number of units per building. This does not account for building structure or design, age, repair status, renovation, type of ventilation system, or level of maintenance. There may be other unknown and unaccounted for factors influencing the housing type and elevated cotinine relationship. Lastly, this manuscript does not address secondhand exposure to marijuana smoke, which may be an increasing concern.

5. Conclusion

SHS exposure among non-smoking New Yorkers has decreased substantially due to smoke-free policies and changing social norms. However, as evidenced by our study, the household environment continues to be an important contributor to disparate SHS exposure. Policies and programmatic interventions targeting housing-related SHS exposures should play a critical role in reducing SHS exposure and emerging disparities in the availability of smoke-free housing in urban settings.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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