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# Potential for unintended consequences: The association between smoking and body mass index among public housing residents in Baltimore, MD

Alejandra Ellison-Barnes[a,*], Craig E. Pollack[b,c,a], David Levine[a,b,d], Carl Latkin[d,c], Jeanne M. Clark[a,e], Kimberly A. Gudzune[a]

[a] Division of General Internal Medicine, Department of Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, United States
[b] Department of Health Policy and Management, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, United States
[c] Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, United States
[d] Department of Health, Behavior, and Society, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, United States
[e] Division of Cardiovascular and Clinical Epidemiology, Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, United States

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ABSTRACT

The U.S. Department of Housing and Urban Development (HUD) smokefree rule for public housing may prompt smokers to quit. Cessation, while desirable, can be associated with weight gain, and an excess burden of obesity already exists among public housing residents. Our objectives were to characterize the association between smoking and weight status prior to the policy implementation and to explore eating patterns. We conducted a cross-sectional analysis of survey data collected in 2014–2015 from randomly selected households in two public housing developments in Baltimore, MD. Our independent variable was self-reported smoking status, and dependent variables were measured body mass index (BMI) and uncontrolled/emotional eating scores. We used multivariable linear regression to examine the associations. Respondents included 266 heads of household with mean age 44.5 (SD 12.4). A majority (63.2%) were current smokers. Seventy-five percent were overweight or obese, with mean BMI 32.6 kg/m2 (SD 10.1). In the adjusted regression models, the mean BMI of smokers was significantly lower than that of former/never smokers (31.7 kg/$m^2$ vs. 34.2 kg/$m^2$), and the mean uncontrolled eating score of smokers was significantly higher (24.4 vs 18.7). These results suggest that the new HUD smokefree rule has the potential to promote further weight gain among smokers prompted to quit, highlighting the need to simultaneously consider these two prevalent risk factors in the setting of policy changes.

## 1. Introduction

Housing administered by local public housing authorities (PHAs) under the U.S. Department of Housing and Urban Development (HUD) is home to about 1.2 million of the lowest wealth households in the nation, with an average household income under $15,000. (Office of Housing and Urban Development, 2019) The health of those living in public housing has been shown to be worse than that of the general population, with higher rates of chronic diseases including asthma, diabetes, hypertension, and obesity (Manjarrez et al., 2007). Exposure to tobacco is pervasive in public housing. It has been estimated that around 33.6% of adults receiving housing assistance from HUD are current smokers, compared with under 17% of the general population (Digenis-Bury et al., 2008). The majority of public housing residents live in multiunit housing and thus nonsmokers are also likely to be exposed to harmful secondhand smoke (Farber et al., 2015).

Smoking cessation lowers the risk of health consequences for both the primary smoker and for nonsmokers exposed to their secondhand smoke (US Department of Health and Human Services, 2014). However, smoking cessation often leads to weight gain of 2.6–5.3 kg due to changes in metabolism associated with the absence of nicotine's effect as well as compensatory changes in eating habits after quitting (Bush et al., 2016). Specifically, increased caloric intake, especially increased sugar intake due to changes in flavor perceptions and cravings, may contribute to weight gain following cessation (Bush et al., 2016). Disinhibited, uncontrolled, and emotional eating—all of which describe a loss of control of caloric intake in the setting of internal or external stimuli such as perceived hunger or strong emotions—have been associated with post-cessation weight gain (Hall et al., 1986; Hudmon et al., 1999). The health repercussions of this weight gain are not entirely clear. Moderate weight gain as a result of cessation does not outweigh the cardiovascular benefits of quitting smoking (Hu et al., 2018).

* Corresponding author at: 2024 East Monument Street, Room 2-300, Baltimore, MD 21287, United States.
*E-mail address:* alejandra@jhmi.edu (A. Ellison-Barnes).

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However, greater degrees of weight gain might negate these benefits. Additionally, undesired weight gain may reduce the success of cessation attempts (Meyers et al., 1997). Finally, studies have also shown an association between tobacco cessation and short-term risk of the onset of type II diabetes that is not fully explained by weight gain; this risk is reduced in the long-term after cessation (Pan et al., 2015).

Smokefree policies in multiunit housing have been shown to prompt smokers to quit or reduce tobacco use (Pizacani et al., 2012). In late 2016, HUD completed a rule requiring all public housing authorities receiving HUD funding to implement smokefree policies covering both public spaces and individual residences by mid-2018. From a public health perspective, this rule is expected to reduce overall tobacco use among residents, reduce exposure to secondhand smoke, and reduce the risk of fire. Policies banning smoking in public places (including workplaces and restaurants) lead to a reduction in adverse health events including myocardial infarctions, other heart disease, stroke, respiratory disease including asthma exacerbations in children, and preterm births (Been et al., 2014; Hoffman and Tan, 2015).

Though the HUD policy will likely have beneficial health effects overall, it also has the potential to impart adverse health consequences for some public housing residents. Little attention has been paid to the potential adverse effect of worsening of the already-high obesity prevalence among residents. It is important to consider the baseline obesity prevalence as well as characteristics of the population that may predispose them to greater weight gain in the post-cessation period.

Our primary objective was to examine the association between smoking status and BMI among residents of two public housing communities in Baltimore, Maryland in the period before implementation of the HUD policy. Our hypothesis was that mean BMI would be lower among smokers than among former/never smokers. The secondary objective was to examine the association between smoking status and eating habits that have been associated with increased obesity risk, specifically uncontrolled and emotional eating, to explore whether smokers' baseline eating habits might portend a greater risk of weight gain if they quit smoking.

## 2. Methods

### 2.1. Study design

This is a secondary analysis of data from a cross-sectional survey conducted in two public housing developments in Baltimore, Maryland (Gudzune et al., 2018). The study was approved by the Johns Hopkins University School of Medicine Institutional Review Board.

Data collection took place between August 2014 and August 2015. Two housing developments were identified in collaboration with the local housing authority, representing the two sides of the city. Households were randomly selected by a computer program using a numbered list of all residences in the two developments; 600 were selected and of these 556 were occupied and eligible for inclusion. Recruitment was conducted via initial mailings and subsequent in-person household visits (up to 5 attempts). Although up to four adults in each household were surveyed, only the data collected from heads of household were analyzed to ensure all participants were true residents of the developments.

### 2.2. Measures

Our primary independent variable was self-reported smoking status derived from two questions about smoking habits. Residents were asked, "Do you currently smoke cigarettes?" They were then asked, "Have you smoked at least 100 cigarettes in your entire life? (5 or more packs)." We identified a respondent as a *current smoker* if they responded "yes" to the first question, as a *former smoker* if they responded "no" to the first question and "yes" to smoking more than 100 cigarettes, and as a *never smoker* if they responded "no" to both questions. In this analysis, smoking status was dichotomized as current versus former/never given the relatively small number of former smokers.

Our primary dependent variable of interest was measured body mass index (BMI). We measured participants' height and weight using the same methods described in the "Moving to Opportunity" evaluation, and then calculated BMI (Ludwig et al., 2011). For the few participants that declined to be measured and self-reported height and/or weight (n = 14), we used these values to calculate BMI. We examined BMI as a continuous variable. For our secondary dependent variables, we examined measures of uncontrolled eating and emotional eating, which is where an individual eats more than usual because of loss of control of intake or due to emotional distress, respectively. These eating behaviors have previously been associated with obesity (Konttinen et al., 2009). We calculated each respondent's uncontrolled eating score and emotional eating score using questions from the validated Three-Factor Eating Questionnaire, revised 18-item version (TFEQ-R18), which assesses three different types of eating behavior (cognitive restraint, uncontrolled eating, and emotional eating). The maximum transformed subscore for each behavior is 100; the uncontrolled eating score is summated from 9 items and the emotional eating score is summated from 3 items assessed on 4-point Likert scales, transformed using recommended methods (De Lauzon et al., 2004). There are no standardized cutoffs for low versus high scores. These subscores were treated as continuous variables where higher scores indicate greater uncontrolled eating or emotional eating. We did not consider overall TFEQ-R18 scores given the important differences in the constructs that the subscales measure.

Covariates of interest included age, gender, race, educational attainment, employment status, food insecurity, physical activity level, eating behaviors (via TFEQ-R18), added sugar intake, self-reported comorbid conditions [asthma, chronic obstructive pulmonary disease (COPD), hypertension, myocardial infarction, pneumonia, cancer, diabetes mellitus], and housing development. These were thought to be covariates that might confound or mediate the relationship between smoking status and BMI. Physical activity level was determined from a validated four-item exercise screener that classifies activity into four levels; this measure was then dichotomized to active (high or moderate) versus inactive (low or very low) for the analysis (Ainsworth et al., 1993). Added sugar intake in teaspoons per day was estimated using standard methods from the National Health Interview Survey five-factor dietary screener (National Cancer Institute, 2005). To describe the overall health status of the two groups, we estimated risk groupings based on the Seattle Index of Co-Morbidity (SIC), which incorporates information about age, smoking status, and self-reported chronic medical conditions, as this measure has been associated with an increased risk of death (Fan et al., 2002). However, we did not incorporate the SIC in the regression models as the index duplicates our independent variable of smoking status.

### 2.3. Statistical analysis

Data was analyzed in 2018–2019. We performed descriptive analyses of all variables. We used multivariable linear regression to examine the associations between smoking status and our outcomes of BMI as well as uncontrolled and emotional eating scores, adjusted for age, gender, and neighborhood ("basic model"). We also examined these associations in another regression model that was further adjusted for physical activity level, added sugar intake, and COPD as these were thought to be the covariates that would be most likely to explain any difference in BMI between the two groups. We adjusted for COPD as this was the only assessed comorbidity for which there was a statistically significant difference between the two groups in bivariate analysis. Of note, adding uncontrolled eating and emotional eating as covariates did not change the magnitude or significance of the BMI difference, so this was not included in our final model. Other multivariable linear regressions examined the association between smoking

**Table 1**
Characteristics of Sample, Pooled and By Smoking Status, Unadjusted.

| Characteristic | Overall sample (N = 266) | Current smokers (N = 168) | Former/Never smokers[a] (N = 98) | **P-values**[b] |
|---|---|---|---|---|
| *Demographics* | | | | |
| Age in years, mean (SD) | 44.5 (12.4) | 45.0 (11.4) | 43.5 (14.0) | 0.35 |
| Women | 86.1% | 83.3% | 90.8% | 0.09 |
| Black or African-American race | 95.5% | 95.8% | 94.9% | 0.72 |
| High school graduate or equivalent | 66.2% | 65.5% | 67.4% | 0.76 |
| Employed | 66.5% | 67.9% | 64.3% | 0.55 |
| Food insecure[c] | 67.3% | 69.6% | 63.3% | 0.29 |
| *Health Behaviors* | | | | |
| Moderate or high physical activity[d] | 20.2% | 23.2% | 14.3% | 0.08 |
| Eating pattern, mean score (SD)[e] | | | | |
| Cognitive restraint | 27.9 (16.6) | 27.6 (16.4) | 28.4 (17.1) | 0.71 |
| Uncontrolled eating | 22.3 (16.6) | 24.4 (17.5) | 18.7 (14.5) | **< 0.01** |
| Emotional eating | 25.3 (14.1) | 26.0 (24.1) | 22.1 (20.9) | 0.18 |
| Added sugar intake in tsp, median[f] | 21.1 | 21.8 | 19.7 | 0.26 |
| Current cigarette smoker | 63.2% | – | – | – |
| *Health Status*[g] | | | | |
| Measured BMI in kg/m$^2$, mean (SD) | 32.6 (10.1) | 31.4 (10.3) | 34.8 (9.5) | **< 0.01** |
| Underweight | 3.8% | 5.4% | 1.0% | **0.03** |
| Normal weight | 21.5% | 26.4% | 13.3% | |
| Overweight | 20.4% | 21.0% | 19.4% | |
| Class I obesity | 18.1% | 15.6% | 22.5% | |
| Class II obesity | 14.3% | 12.6% | 17.4% | |
| Class III obesity | 21.9% | 19.2% | 26.5% | |
| Asthma | 35.3% | 36.3% | 33.7% | 0.66 |
| COPD | 17.7% | 21.4% | 11.2% | **0.04** |
| Hypertension | 56.8% | 58.9% | 53.1% | 0.35 |
| Myocardial infarction | 4.1% | 4.2% | 4.1% | 0.97 |
| Pneumonia | 16.9% | 17.3% | 16.3% | 0.84 |
| Cancer | 7.1% | 6.6% | 8.2% | 0.62 |
| Diabetes mellitus | 19.9% | 17.3% | 24.5% | 0.16 |
| Depressive symptoms[h] | 30.8% | 32.7% | 27.6% | 0.38 |
| Calculated Seattle Index of Comorbidity[i] | | | | |
| Low risk | 58.7% | 44.3% | 83.5% | **< 0.0001** |
| Moderate risk | 24.2% | 32.9% | 9.3% | |
| High risk | 11.7% | 16.2% | 4.1% | |
| Very high risk | 5.3% | 6.6% | 3.1% | |

Data collected in Baltimore, MD in 2014–2015.
BMI, body mass index; COPD, chronic obstructive pulmonary disease; SD, standard deviation.
[a] Breakdown by former and never smokers available in online supplement.
[b] P-values calculated using Pearson's chi-squared test, student's *t*-test, or Wilcoxon rank-sum test as appropriate. Boldface indicates statistical significance ($p < 0.05$).
[c] Assessed by two-item screener.
[d] Determined from validated four-item exercise screener, measure dichotomized to active (high or moderate) versus inactive (low or very low).
[e] Measured with Three-Factor Eating Questionnaire, revised 18-item version (De Lauzon et al., 2004).
[f] Estimated using standard methods from National Health Interview Survey 5-factor dietary screener.
[g] Self-reported history, unless otherwise noted.
[h] Measured with the Patient Health Questionnaire-2 (PHQ-2).
[i] Index incorporates information about age, smoking status, and self-reported chronic medical conditions; predictive of 2-year morbidity risk (Fan et al., 2002).

status and uncontrolled eating score as well as emotional eating score. These regressions were adjusted for the same covariates, with the addition of BMI. We calculated adjusted mean outcomes by smoking status using point-estimation tests from these models. A sensitivity analysis excluding individuals who self-reported height and/or weight yielded results similar to our main findings. We used Stata Version 15 to perform all analyses.

## 3. Results

Overall, 266 heads of household participated, yielding a response rate of 47.8%. The mean age of participants was 44.5 years (SD 12.4), 86.1% were women, and 95.5% were Black. Nearly all (98.5%) were non-Hispanic. Additional demographic information is presented in Table 1 and in an Online Supplement. In terms of self-reported smoking status, 63.2% were current smokers, 8.7% were former smokers, and 28.2% were never smokers. Mean BMI was 32.6 kg/m$^2$ (SD 10.1).

In unadjusted analyses, the mean BMI among current smokers was 31.4 kg/m$^2$ (SD 10.3) and among former/never smokers was 34.8 kg/m$^2$ (SD 9.5). The between-group difference of 3.4 kg/m$^2$ was statistically significant ($P < 0.008$). In the basic multivariable model, the adjusted mean BMI of current smokers was significantly lower than that of former/never smokers at 31.5 kg/m$^2$ versus 34.5 kg/m$^2$ (-3.0 kg/m$^2$, 95% CI −5.5 to −0.5 kg/m$^2$). In the fully adjusted regression model, this difference remained statistically significant (Fig. 1 and Table 2), with BMI of current smokers at 31.7 kg/m$^2$ versus former/never smokers at 34.2 kg/m$^2$ (−2.5 kg/m$^2$, 95% CI −5.0 to −0.02 kg/m$^2$).

In unadjusted analyses, the mean uncontrolled eating score was 24.4 (SD 17.5) among current smokers and 18.7 (SD 14.5) among former/never smokers. The mean emotional eating score was 26.0 (SD 24.1) and 22.1 (SD 20.9) among current smokers and former/never smokers, respectively. The fully adjusted regression model examining the association between uncontrolled eating scale score and smoking status showed that current smokers had significantly higher mean scores, at 24.4 versus 18.9 (+5.5, 95% CI 1.4 to 9.6) on the 100-point scale (Table 3). The fully adjusted regression model examining the

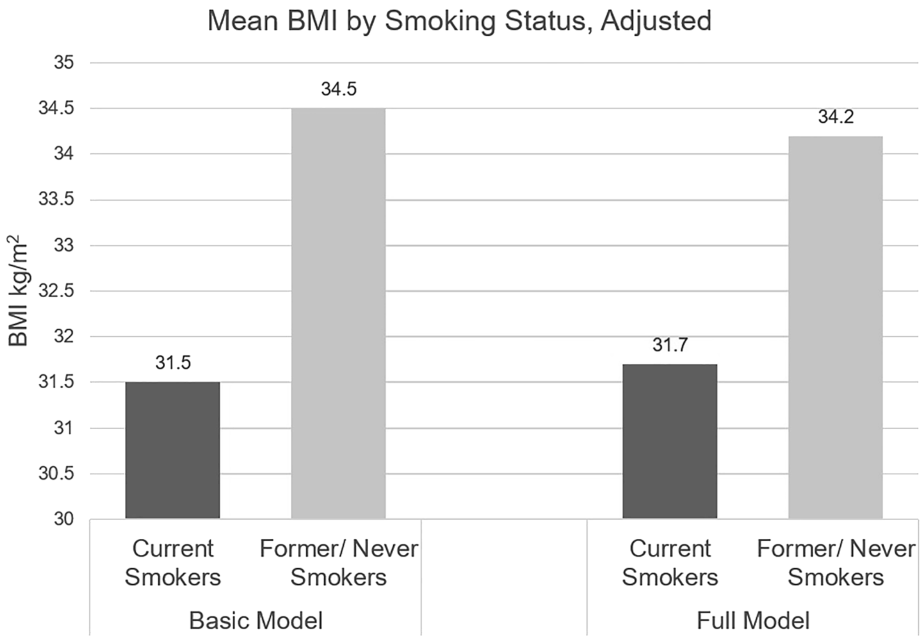


**Fig. 1.** Mean BMI in $kg/m^2$ by Smoking Status, Adjusted Models This figure illustrates the difference in mean body mass index (BMI) between current smokers and former/never smokers. The basic model is adjusted for age, gender, and housing development, while the full model is adjusted for age, gender, housing development, chronic obstructive pulmonary disease, physical activity, and sugar intake. For the basic model the difference in BMI between the two groups is 3.0 $kg/m^2$ (p-value 0.02), and for the full model the difference is 2.5 $kg/m^2$ (p-value 0.05). Data collected in Baltimore, MD in 2014–2015.

association between emotional eating scale score and smoking status showed no statistically significant difference between current smokers and former/never smokers (Table 3).

## 4. Discussion

Prior research has indicated that about one-third of public housing residents smoke tobacco; however, we found that the prevalence of current smokers in this sample of Baltimore public housing residents was substantially higher at 63.2% (Digenis-Bury et al., 2008). Given this extremely high prevalence and the known dangers of tobacco for both users and for those exposed to secondhand smoke, there is a clear need for tobacco control interventions that encourage cessation in this population (US Department of Health and Human Services, 2014). Bans on smoking in public places reduce secondhand smoke exposure and have positive effects on health outcomes (Pizacani et al., 2012; Been et al., 2014; Hoffman and Tan, 2015). The HUD smokefree policy has been criticized as an additional regulation on an already vulnerable and surveilled population that violates individual autonomy and puts residents at risk of homelessness if eviction is used as a penalty (Levy et al., 2017). However, given the health effects of tobacco, the policy is an important step toward improving population health by limiting exposure to secondhand smoke, particularly among children.

Based on the observed effects of similar policies in the past, the 2018 HUD smokefree policy may prompt smoking cessation attempts among residents (Pizacani et al., 2012). Given that smoking cessation is known to promote weight gain, the implementation of this policy has the potential consequence of unintentionally increasing the frequency and severity of obesity among the public housing population (Bush et al., 2016). This potential effect is an especially important consideration in this population, given the existing high prevalence of obesity among the public housing residents. In our study, nearly 55% of the residents had a BMI in the obese range. Prior studies among public housing populations have similarly identified the prevalence of obesity as over 50% (Ludwig et al., 2011). In our sample, the adjusted mean BMI was 2.5 kg (5.5 lbs) lower among current smokers than among former/never smokers (31.7 $kg/m^2$ versus 34.2 $kg/m^2$). Biological and behavioral influences of tobacco likely contribute to current smokers having a lower weight, but it is important to note that both mean BMI values are in the obese range (Bush et al., 2016).

This cross-sectional association between smoking status and BMI is perhaps more striking when taking into account our findings regarding differences in eating habits between groups, particularly uncontrolled eating. Uncontrolled eating is a behavior that has been associated with obesity, yet in our study current smokers, with lower mean BMI, had significantly higher uncontrolled eating scores as compared to former/never smokers (Konttinen et al., 2009). The appetite suppressant and metabolic effects of nicotine may help prevent the higher weight that might otherwise be associated with uncontrolled eating behavior. This finding leads us to theorize that these smokers, many of whom already

**Table 2**
β-Coefficients for BMI in Basic and Full Models, Indicating Difference in BMI ($kg/m^2$) per Unit Difference in Covariate.

| | Basic Model | | Full Model | |
|---|---|---|---|---|
| | β-coefficient indicating difference in BMI ($kg/m^2$) [95% CI] | P-value[a] | β-coefficient indicating difference in BMI ($kg/m^2$) [95% CI] | P-value[a] |
| Current Smoker (Y/N) | −3.02 [−5.53, −0.52] | **0.02** | −2.52 [−5.02, −0.12] | **0.05** |
| Age (per year) | −0.05 [−0.15, 0.5] | 0.33 | −0.10 [−0.20, 0.00] | 0.06 |
| Gender (F/M) | 3.22 [−0.29, 6.73] | 0.07 | 1.59 [−2.03, 5.21] | 0.34 |
| COPD (Y/N) | – | – | −0.27 [−3.46, 2.93] | 0.87 |
| Physical Activity (Y/N) | – | – | −4.37 [−7.47, −1.27] | **0.01** |
| Sugar Intake (per tsp) | – | – | −0.08 [−0.17, 0.01] | 0.08 |
| Housing Development | 2.02 [−0.39, 4.43] | 0.10 | 1.88 [−0.51, 4.27] | 0.12 |

Data collected in Baltimore, MD in 2014–2015.
BMI, body mass index; CI, confidence interval; COPD chronic obstructive pulmonary disease.
[a] Boldface indicates statistical significance ($p < 0.05$).

**Table 3**
β-Coefficients for Uncontrolled and Emotional Eating, Indicating Difference in Uncontrolled or Emotional Eating Score per Unit Difference in Covariate.

| | Uncontrolled Eating | | Emotional Eating | |
|---|---|---|---|---|
| | β-coefficient [95% CI] | P-value[a] | β-coefficient [95% CI] | P-value[a] |
| Current Smoker (vs former/never) | 5.51 [1.43, 9.60] | **< 0.01** | 4.78 [−0.79, 10.35] | 0.09 |
| BMI (per unit) | 0.05 [ −0.15, 0.25] | 0.60 | 0.44 [0.17, 0.71] | **< 0.01** |
| Age (per year) | −0.04 [−0.21, 0.13] | 0.64 | 0.12 [−0.11, 0.35] | 0.31 |
| Female Gender (vs M) | 1.64 [−4.23, 7.51] | 0.58 | 11.08 [3.07, 19.09] | **< 0.01** |
| COPD (vs No COPD) | −0.43 [−5.61, 4.75] | 0.87 | 1.13 [−5.94, 8.19] | 0.75 |
| Physical Activity (vs Inactive) | 0.64 [−4.46, 5.73] | 0.81 | 3.47 [−3.48, 10.43] | 0.33 |
| Sugar Intake (per tsp) | 0.33 [0.19, 0.48] | **< 0.001** | 0.44 [0.25, 0.64] | **< 0.001** |
| Housing Development | −3.36 [−7.24, 0.53] | 0.09 | −8.65 [−13.96, −3.35] | **0.001** |

Data collected in Baltimore, MD in 2014–2015.
BMI, body mass index; CI, confidence interval; COPD chronic obstructive pulmonary disease.
[a] Boldface indicates statistical significance ($p < 0.05$).

have obesity, may be at high risk for further increased uncontrolled eating upon smoking cessation. Given the cross-sectional nature of our data, we cannot comment directly as to whether this eating behavior would change after smoking cessation and whether this would lead to weight gain in the study population. However, post-cessation weight gain has previously been associated with a higher baseline disinhibition scale (analogous to uncontrolled eating) score at the time of cessation (Hudmon et al., 1999). Our findings may provide a justification for additional research on the relationship we observed between smoking status and uncontrolled eating, particularly among low-income populations. Finally, we also note that stress has been associated with both smoking status and uncontrolled eating in populations of low-income women, so this factor may play a role and should be investigated in future studies related to these factors (Webb and Carey, 2008; Richardson et al., 2015). When taken together—the high smoking rate, high prevalence of obesity, and uncontrolled eating among smokers—this constellation of factors may suggest that the HUD smokefree policy could contribute to population-level weight gain and worsening disparity in obesity prevalence and severity among public housing residents.

It is critical to consider the potential risk of this theorized weight gain in relation to the known benefits of smoking cessation. Previous studies have shown that there is a net health benefit to quitting smoking despite associated weight gain. A 2013 study found that among over 3,000 American adults, smoking cessation reduced cardiovascular disease risk in those without diabetes, and that weight gain did not modify the association (Clair et al., 2013). Similarly, a 2018 study of data from over 100,000 Korean men found that quitting smoking was associated with a reduction in risk for MI and stroke, and that this association was not moderated by post-cessation BMI change (Kim et al., 2018). Another study found that normal-weight smokers had a higher overall mortality risk than overweight or obese former smokers among an insured, high-income population (Siahpush et al., 2014).

However, it is important to realize that much of the literature examining health benefits and risks related to smoking cessation and weight gain has occurred among predominantly normal weight populations. The mean BMI of the subgroups in the previously mentioned study by Kim et al. ranged from 23.3 to 25.0 kg/m$^2$, and in the Clair et al. study participants' baseline mean BMI was 26.1 kg/m$^2$. In our population, the mean BMI of current smokers was 31.4 kg/m$^2$ (unadjusted), which is in the class I obesity range. Given that we also found that these individuals have high uncontrolled eating scores, this tendency may predispose them to even greater weight gain once the metabolic and distraction effects of cigarettes are removed, thus worsening the severity of their obesity to class 2 or 3. These higher classes of obesity are associated with greater cardiovascular disease risk (Panel and on the Identification, Treatment of Overweight, Obesity in Adults, 1998). We know of no studies that have looked specifically at the long-term health effects of post-cessation weight gain among those who are already obese and cross into higher-risk classes of obesity. Our concerns have merit, as at least one study has suggested that some subpopulations are susceptible to ongoing, rather than short-term, weight gain after cessation that could affect long-term outcomes (Thorndike et al., 2016). Further research is needed to fully understand the long-term health consequences of this post-cessation weight gain and worsened glycemic control among already-obese populations.

Various strategies for minimizing weight gain during smoking cessation have been studied. A 2012 Cochrane review found that most pharmacologic interventions for cessation (bupropion, varenicline, nicotine replacement therapy) limit weight gain only during the time individuals are actively taking the medication, without a maintained effect (Farley et al., 2012). Evidence for educational programs, personalized weight management support, low-calorie diets, and cognitive behavioral therapy to prevent post-cessation weight gain is mixed (Farley et al., 2012). One study looking at smoking cessation and weight management through a quitline found that providing these services simultaneously as opposed to sequentially reduced cessation success without reducing weight gain (Bush et al., 2018). However, there is some evidence that improved diet quality and increased physical activity can mitigate weight gain without increasing relapse (Hu et al., 2018). In terms of specifically addressing uncontrolled eating behavior, both psychosocial and bariatric surgical interventions have been studied and shown to be associated with a change in behavior and subsequent weight loss in general populations outside the context of smoking cessation (Moldovan and David, 2011). Additional research on effective post-cessation weight management strategies is needed, particularly in low-wealth populations that face additional contextual challenges.

To mitigate the potential unintended consequences of weight gain and obesity progression with the smokefree policy, HUD might consider offering other support services such as weight management assistance along with smoking cessation services to enable residents to gain the most benefit from quitting. This prospect may be difficult, as we note that the existing evidence on post-cessation weight management interventions is mixed and the costs of such services may be prohibitive. In terms of funding, there is limited information available on the cost of integrating weight management, nutrition, and cessation services. However, the cost of standard smoking cessation services is low and smoking cessation services are covered by all state Medicaid programs, though benefits vary by state, and in some states Medicaid also offers weight management support (Ku et al., 2016; Centers for Medicare and Medicaid, 2019). Additionally, effective yet relatively low-cost weight management programs have been developed (Mitchell et al., 2015). Whether local agencies receiving HUD funding have been directed to offer or refer to these services as part of policy implementation is unclear. While referring residents attempting to quit smoking as a result of the policy to appropriate support services may add an additional challenge to implementation of the HUD rule, it may help improve cessation outcomes and has the potential to minimize weight gain.

## 5. Limitations

There are several limitations of our study. First, the sample population is made up of predominantly low-income African-American residents of two public housing developments in Baltimore, Maryland, which may limit generalizability. Additionally, only the primary survey respondents were analyzed, and these were mostly women. We note that statistics from HUD describe a predominance of women among heads of household in public housing. (Office of Housing and Urban Development, 2019) The response rate was 48%, and no information is available on nonrespondents, though demographics of the sample are similar to those of other samples of public housing residents in Baltimore (Ludwig et al., 2011). Detailed smoking habits were not collected, so specific tobacco products used, baseline daily quantity, duration of smoking history, and time since cessation are unknown. Former smokers were not analyzed separately as there were relatively few in the sample. Additionally, this cross-sectional study captures only one measurement of BMI and questions about weight change were not included in the survey, so we cannot determine weight change over time.

## 6. Conclusion

Smokefree policies are an important tobacco control tool, protecting nonsmokers from exposure to secondhand smoke while simultaneously reducing tobacco use at the population level. The recently implemented HUD smokefree rule applying to public housing may lead to smoking cessation attempts among residents. Our results support the hypothesis that this policy might also lead to an unintended consequence of population-level weight gain and progression of obesity, as our study shows that current smokers in this population of public housing residents already have a mean BMI in the obese range as well as higher uncontrolled eating scores than former/never smokers.

Future research should explore whether the HUD smokefree policy results in smoking cessation among public housing residents, and whether there is any associated weight gain among those who recently quit. More broadly, additional research is needed on the health effects of cessation-related weight gain among those with obesity at the time of quitting, and on effective interventions for preventing weight gain in the post-cessation period.

## CRediT authorship contribution statement

**Alejandra Ellison-Barnes:** Conceptualization, Formal analysis, Writing - original draft. **Craig E. Pollack:** Writing - review & editing, Supervision. **David Levine:** Writing - review & editing. **Carl Latkin:** Writing - review & editing. **Jeanne M. Clark:** Writing - review & editing, Supervision. **Kimberly A. Gudzune:** Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing - review & editing, Supervision, Funding acquisition.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2020.101081.

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