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Associations Between Residential Segregation and Smoking During Pregnancy Among Urban African-American Women

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ABSTRACT *Approximately 10% of African-American women smoke during pregnancy compared to 16% of White women. While relatively low, the prevalence of smoking during pregnancy among African-American women exceeds the Healthy People 2010 goal of 1%. In the current study, we address gaps in extant research by focusing on associations between racial/ethnic residential segregation and smoking during pregnancy among urban African-American women. We linked measures of segregation to birth certificates and data from the 2000 census in a sample of US-born African-American women (n=403,842) living in 216 large US Metropolitan Statistical Areas (MSAs). Logistic regression models with standard errors adjusted for multiple individual observations within MSAs were used to examine associations between segregation and smoking during pregnancy and to control for important socio-demographic confounders. In all models, a u-shaped relationship was observed. Both low segregation and high segregation were associated with higher odds of smoking during pregnancy when compared to moderate segregation. We speculate that low segregation reflects a contagion process, whereby salutary minority group norms are weakened by exposure to the more harmful behavioral norms of the majority population. High segregation may reflect structural attributes associated with smoking such as less stringent tobacco control policies, exposure to urban stressors, targeted marketing of tobacco products, or limited access to treatment for tobacco dependence. A better understanding of both deleterious and protective contextual influences on smoking during pregnancy could help to inform interventions designed to meet Healthy People 2010 target goals.*

KEYWORDS *Blacks/African Americans, Pregnancy, Residential segregation, Smoking.*

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INTRODUCTION

Smoking during pregnancy is associated with adverse perinatal outcomes[1–3] and poor child health and development.[4–6] In 1995, the total annual cost of complicated births attributable to smoking during pregnancy in the United States (US) was estimated to be between 1.4 and 2 billion dollars.[7] Successful interventions to reduce smoking during pregnancy have the potential to reduce health care costs and improve the health of mothers and their children. Accordingly, the US national health agenda, *Healthy People 2010 (HP 2010)*, includes a target objective of 99% of all women abstaining from smoking during pregnancy.[8]

Smoking during pregnancy is a modifiable behavior, yet interventions to promote smoking cessation are not always successful.[9] Most studies of maternal smoking focus on individual-level correlates, finding higher rates among women who are unmarried, US born, or who are of low socioeconomic status (SES).[9–12] A small, newly emerging body of research has begun to examine the contribution of neighborhood attributes to smoking patterns.[13–19] Results of these studies suggest contextual factors—including neighborhood socioeconomic disadvantage—play a role in smoking behavior over and above the role of individual-level attributes.[13–19]

We found only one study that examined contextual influences on smoking during pregnancy.[15] Pickett et al. reported higher rates of smoking during pregnancy in neighborhoods with a higher proportion of working-class residents when several measures of individual-level SES (marital status, education, working class) were controlled.[15] The study, however, focused exclusively on White women because of the low prevalence of smoking during pregnancy among minority women in the California study sample.

In 2002, Black or African-American women (hereafter referred to as African American) were less likely to smoke during pregnancy than White women (10 vs. 16%) but were more likely to smoke than Hispanic women (10 vs. 4%).[12,20] While low, the prevalence of smoking during pregnancy among African-American women exceeded the *Healthy People 2010* goal (10 vs. 1%), and this is a justifiable focus of concern.[20,21]

Patterns of smoking prevalence in the US vary regionally. Among African–American women, the prevalence of smoking is lowest in southeastern states.[19,22–24] In one study based on 5 years of data from the National Health Interview Survey, African-American women in the south had a lower prevalence of smoking than did any other group of African Americans categorized by gender and region.[23] The precise mechanisms underlying such regional variation in smoking prevalence among African Americans are poorly understood; however, socioeconomic status, stressful urban environments, immigration patterns, tobacco control policies, the presence of cigarette advertisements, and community cohesiveness are believed to play a role.[19,22,23,25]

A better understanding of individual and contextual influences on smoking during pregnancy among African-American women could be useful for interventions designed to attain *Healthy People 2010* target goals. Moreover, given the fairly low prevalence of smoking during pregnancy in this population, a focus on contextual influences could improve our understanding of protective factors and risk factors. Such information could support efforts to reinforce salutary prenatal health behaviors.

In the current study, we focus on racial/ethnic residential segregation (hereafter referred to as segregation) as one possible contextual influence on smoking during pregnancy among African-American women. Segregation—defined as the spatial separation of one group from another on the basis of race/ethnicity[26,27]—is considered a fundamental cause of the concentrated poverty and health inequalities experienced by African Americans in the US.[28–30] While segregation has declined over the last few decades, African Americans remain the most segregated racial/ethnic minority in the US, and most live in urban areas with high segregation.[26] A few health studies, however, have paid attention to the influence of this pervasive form of social stratification.[29,31] We found no studies that examined the influence of segregation on smoking in any population.

METHODS

The study design is cross-sectional. Data were obtained from four publicly available sources: (1) National Center of Health Statistics, 2002 Natality Detail Files[32] (maternal and infant data from US birth certificates); (2) *US Census Bureau, Housing and Household Economic Statistics Division*[33] (MSA-level measures of segregation); (3) 2000 US Census, Summary File-3[34] (other MSA-level attributes); and (4) the Tax Policy Center[35] (state-level cigarette tax rates).

Sample

The study sample included singleton births to US-born, non-Hispanic African-American mothers living in MSAs with population of at least 100,000 and at least 5,000 African-American residents. Births to foreign-born mothers were excluded because rates of smoking during pregnancy are extremely low in this subgroup[12,36] and mechanisms for segregation–health relations might differ by nativity. MSA population restrictions were invoked because geographic identifiers are not available in public-use files for MSAs with fewer than 100,000 residents. We limited the MSAs to those with at least 5,000 Black residents because segregation indices may be susceptible to random changes and geo-coding errors in regions with a small minority-group population.[26,37]

Of the 434,376 births that met our inclusion criteria, 8% had missing information for smoking status and were excluded from the analysis, including all births in California where maternal smoking status is not collected on birth certificates in the standard format. The final sample included 403,842 births to African-American mothers living in 216 MSAs.

Dependent Variables

Cigarette smoking was captured as a dichotomous measure of any self-reported smoking during pregnancy (yes/no) as recorded on birth certificates. Self-reported measures of smoking on birth certificates may underestimate the prevalence of smoking during pregnancy.[38] Accordingly, our results could be conservative estimates, biased toward no association.

Independent Variables

The current study considered two distinct dimensions of segregation: isolation[39,40] and clustering,[41] measured at the MSA-level for non-Hispanic Blacks relative to non-Hispanic Whites. Definitions and formulae are provided in Table 1. Isolation has been examined in prior segregation–health research[31] and has been associated with deleterious health outcomes in multilevel studies.[42–44] In contrast, clustering is

TABLE 1 Measures of segregation

Dimension	Isolation	Clustering
Index	Isolation Index(xP*x)	Spatial Proximity Index
Formula	${}_xP^*_x = \sum_{n=1}^{n} \left[\left(\frac{x_i}{X}\right) \left(\frac{x_i}{t_i}\right) \right]$	$\frac{SP = XP_{xx} + YP_{yy}}{TP_{tt}}$
Description	The minority-weighted average of the proportion of minority group members in each subarea within a region	Weighted average of the mean proximity between members of a minority group and the mean proximity of minority group members to majority group members
Interpretation	Probability minority group residents in a region (MSA) will share geographic subarea (tract) with other minority group residents as opposed to majority group residents	Extent to which minority group members reside in contiguous subareas (tracts) as opposed to subareas scattered over the region (MSA)

rarely studied. In prior work, we found independent influences of isolation and clustering on birth outcomes and speculated that the geographic contiguity of minority group neighborhoods captured by clustering could reflect somewhat different health influences than those associated with isolation.[42]

Although empirical studies have identified three additional dimensions of segregation—dissimilarity, centralization, and concentration[37,45]—we excluded these from our analysis for the following reasons. Dissimilarity (i.e., the unevenness of the minority group distribution over the MSA) was excluded because researchers have argued persuasively that this dimension does not have clear conceptual foundations for associations with health.[27,31] Centralization (i.e., the extent to which minority group members reside in the Central Business District) was excluded because recent work has shown that the central city–suburb distinction has become less relevant to racial/ethnic residential patterns.[46] Finally, concentration (i.e., the amount of physical space occupied by minority group members) was excluded because this segregation measure appears to be more relevant to understanding the spread of infectious disease[47,48] than the diffusion of health behaviors such as smoking.

TABLE A Notation:

i	Indexes census tracts within each Metropolitan Statistical Area (MSA) $i \in \{1, 2 \ldots n\}$
x_i	Total number of African-American residents in census tract i
X	Total number of African-American residents in the MSA
y_i	Total population of White residents in census tract i
Y	Total population of White residents in the MSA
t_i	Total population (Black + White) in census tract i
T	Total population (Black + White) in the MSA
$P_{gg} = \sum_{i=1}^{n} \sum_{i=j}^{n} \frac{g_i g_j c_{ij}}{G^2} = (x, X), (y, Y), (t, T)$	
$c_{ij} = \exp(-d_{ij})$	Refers to a contiguity matrix that equals 1 when units i and j are contiguous and otherwise 0.
d_{ij}	The distance between area i and area j centroids, where $d_{ii}=(0.6a_i)^{0.5}$ and a_i refers to the land area of tract i

We measured isolation and clustering using the recommended indices.[45] MSA-level isolation was measured using the Isolation Index (xP*x), interpreted as the probability that African Americans will encounter other African Americans, as opposed to Whites, in random daily encounters in their neighborhoods of residence.[39,40] MSA-level clustering was measured using the Spatial Proximity Index (SP Index), interpreted as the degree to which the neighborhoods in which African Americans reside adjoin one another or cluster together.[41] The SP Index for our study MSAs ranged between 1 and 2. To simplify interpretation and facilitate comparison with results using the Isolation Index, we adjusted the SP Index by subtracting 1. Accordingly, both indices ranged from 0 (no segregation) to 1 (complete segregation).

Consistent with census-based measures of segregation in most prior work, we used census tracts (including approximately 4,000 residents) as proxies for neighborhoods within the MSA. Census tracts are the smallest geographic unit with the largest amount of US Census information available and are designed to include fairly homogeneous groups with regard to population characteristics, SES, and living conditions.[34]

Prior health studies have modeled segregation as a continuous variable, assuming a linear relationship.[43,44,49–52] Here, we test the linearity assumption by modeling segregation in categories: low, moderate (reference group), and high. To account for differences in the distributions of isolation and clustering, the cut-points for the three categories were established by creating equal numbers of births in each group (i.e., the number of births in each of the three segregation categories was as equal as possible while assuring all births within a given MSA remained in the same category). Using this strategy, the influence of each level of segregation reflects the exposure relevant to the sample of US births. For example, low isolation refers to the range of the lowest values of isolation to which approximately one-third of the births were exposed.

To examine the combined influence of isolation and clustering, indicators were created for living in an MSA with (a) low isolation and low clustering; (b) high isolation and high clustering; and (c) all other isolation–clustering combinations.

Control Variables

The statistical models included variables that might confound associations between segregation and smoking (Table 2). Maternal age was categorized below 20, 20–34 (reference), and 35 years and above. Parity was defined as the number of prior live births greater than 20 weeks gestation, categorized as none, one to three (reference), and more than three. Maternal education was used as a proxy for SES because other measures such as income, wealth, or occupation are not available in national vital records data sets.[32] Maternal education was categorized as less than high school (<12 years=reference), completed high school (12 years), and at least some college (>12 years). Marital status was included as a dichotomous variable, either married or unmarried (reference). The mother's region of residence was modeled in categories (Northeast, Midwest, West and South = reference).

All models also included variables representing MSA population and the MSA proportion of African Americans because segregation increases with these area-level attributes.[53] The proportion of families with income below the federal poverty level in 1999 was included to control for SES at the MSA-level of analysis. Finally, because higher state-level tobacco taxes may be associated with reduced smoking prevalence,[54–56] we included a measure of cigarette taxes (tax in dollars per pack of

TABLE 2 Descriptive statistics

MSA and individual characteristics	Number	Percent (%) smoking during pregnancy
Total	403,842	9.9
MSA segregation (isolation and spatial proximity)		
Low isolation (0.04–0.54)	131,794	12.4
Moderate (0.55–0.68)	136,540	7.3
High	135,508	10.0
Low spatial proximity	130,703	11.7
Moderate spatial proximity	135,889	7.0
High spatial proximity	137,250	10.9
Low isolation and spatial proximity	112,052	12.8
Moderate segragation	182,980	7.1
High isolation and spatial proximity	108,810	11.5
Age (years)		
Less than 20	76,913	7.0
20–34 (reference)	291,712	10.2
35 or more	35,217	13.5
Prior children		
None	150,943	5.4
One to three	222,514	10.9
Four or more	29,330	24.5
Married		
Yes	112,483	4.4
No	291,359	12.0
Education		
Less than 12 years	101,407	17.9
High school (12 years)	155,791	9.6
More than 12 years (reference)	146,644	4.6
MSA proportion of families below poverty level		
Low (<8%, i.e., lowest half of the MSA-level distribution)	178,977	11.3
High (≥8%)	224,865	8.7
Region of residence		
Midwest	100,315	14.4
Northeast	65,705	13.2
West	10,621	13.0
South	227,174	6.7
MSA proportion African-American residents		
At or below the median	90,955	14.7
Above the median	312,887	8.5
MSA population		
At or below the median	196,127	9.2
Above the median	207,715	10.5

African American/Non-Hispanic births in 216 U.S. MSAs, 2002

20 cigarettes imposed by the state exclusive of any local taxes)[35] to control for potential confounding by variation in state-level tobacco control policies. The MSA population and the cigarette tax variable were log-transformed to correct skewness. All continuous covariates were centered at their grand means, with their coefficients interpreted as the odds of smoking that corresponds to a unit change in a given

predictor when the others are held at their means (i.e., centered values). The model intercept is interpreted as the odds of smoking during pregnancy among women with individual covariates in the reference categories, who live in MSAs with moderate isolation and average values of the centered MSA covariates.

None of the covariates had more than 10% missing data. Therefore, all covariates with missing values in the birth records (e.g., age, education, parity, etc.) were imputed with the race-specific mean for continuous variables or mode for categorical variables. For each covariate, an indicator of imputed (vs. non-missing) was included in all regression models.

Statistical Analysis

Population average logistic regression models were used to examine relationships between MSA-level segregation and smoking during pregnancy. Models were estimated, in turn, with the isolation categories only, with the clustering categories only, and with the combined isolation–clustering variables. Thus, the models were expressed in the logistic framework as:

$$\text{Smoking during pregnancy } [0/1] = \exp(e)/1 + \exp(e)$$

where,

$$e = B_0 + BX_{ij} + BZ_j + BI_j \quad (1)$$

$$e = B_0 + BX_{ij} + BZ_j + BC_j \quad (2)$$

$$e = B_0 + BX_{ij} + BZ_j + BS_j \quad (3)$$

In each model, X is a vector of individual covariates for the ith woman in the jth MSA, and Z is a vector of area-level variables in the jth MSA. Also, for the jth MSA, I is a vector of isolation categories (low, moderate, and high) in Eq. 1, C is a vector of clustering categories (low, moderate, and high) in Eq. 2, and S is a vector of segregation categories (low isolation and clustering, high isolation and clustering, all other isolation–clustering combinations) in Eq. 3. The B's are the coefficients to be estimated. The standard errors in each model were corrected for the presence of multiple individual observations within the MSAs using the Huber–White estimate of variance.[57] All analyses were conducted using Stata statistical software (College Station, TX) Version 9.0.

RESULTS

Approximately 10% of the 403,842 women in the study sample reported smoking during pregnancy. The distribution of smoking during pregnancy for each study variable is described in Table 2. In areas of low isolation and high isolation, higher proportions of women smoked during pregnancy than in areas of moderate isolation. A similar u-shaped pattern was observed for clustering and for the variable that captured the combined influence of the two segregation dimensions.

African-American women who smoked during pregnancy were older, had higher parity, and were of lower socioeconomic status. The proportion of births to mothers who smoked during pregnancy was lowest in the south, higher in MSAs with a lower proportion of African-American residents, and higher in MSAs with larger populations. A greater proportion of African American women smoked during pregnancy in MSAs with low poverty (i.e., those in the lowest half of the MSA poverty distribution or <8% of families in poverty) than in MSAs with high poverty (i.e., ≥8% of families in poverty).

In the adjusted regression model of isolation (Table 3), both low isolation and high isolation were associated with higher odds of smoking during pregnancy. However, only the estimate for high isolation approached statistical significance, with a parameter estimate suggesting that high levels of isolation were associated with a 27% increase in the odds of smoking during pregnancy.

In the case of clustering, a u-shaped association was also evident in the adjusted model, with African-American women having 27% higher odds of smoking during pregnancy in MSAs with low clustering and 29% higher odds of smoking in MSAs with high clustering, when compared to their counterparts in MSAs with moderate clustering.

In the third model examining the combined influence of isolation and clustering, the u-shaped association with segregation was again apparent. Compared to African-American mothers living in MSAs with moderate segregation as measured by both dimensions, those living in MSAs with both low isolation and low clustering had 30% higher odds of smoking during pregnancy, whereas those living in MSAs with both high isolation and high clustering had 42% higher odds of smoking.

In all models, individual-level risk factors for smoking included having four or more prior children and maternal age above 35 years. Significant protective factors included higher levels of educational attainment, being married, and having no prior births. Contextual factors associated with lower odds of smoking during pregnancy were larger population, a greater proportion of African-American residents, and higher state cigarette taxes.

DISCUSSION

In this study of births to African-American women, we found a consistent u-shaped relationship between segregation and smoking during pregnancy. Measures of both low and high segregation were associated with higher odds of smoking during pregnancy when compared to measures of moderate segregation. To understand these findings, we utilize a framework that distinguishes between contextual influences on health behaviors that are: (1) contagion processes (i.e., processes that influence the diffusion of health beliefs and information throughout neighborhoods); (2) and structural mechanisms (i.e., neighborhood opportunities, resources, and constraints that affect health behaviors).[13]

The contagion perspective indicates that health behaviors may be shaped, at least in part, by modal neighborhood characteristics or normative standards.[58–60] Applied to smoking, research has shown that individuals may be more likely to smoke if they live in neighborhoods where a greater proportion of the population smokes,[60] possibly because there is less social stigma attached to the behavior. It follows that in areas of low segregation, contagion could weaken minority group norms for health behaviors by introducing the behavioral norms of the majority population and reducing within-group stigma. In this case, the probability of smoking by African-American women would be expected to increase insofar as African-American community norms against smoking during pregnancy are attenuated by exposure to norms of greater tolerance of this behavior among

TABLE 3 Logistic regression models of smoking during pregnancy[a,b]

MSA segregation	Isolation only OR	Isolation only [95% CI]	Isolation only *P*	Clustering only OR	Clustering only [95% CI]	Clustering only *P*	Isolation and clustering OR	Isolation and clustering [95% CI]	Isolation and clustering *P*
Low isolation (0.01–0.54)	1.18	[0.96, 1.46]	0.11	–	–	–	–	–	–
Moderate	–	–		–	–	–	–	–	–
High	1.29	*[0.97, 1.64]	0.06	–	–	–	–	–	–
Low clustering	–	–	–	1.27	**[1.03, 156]	0.02	–	–	–
Moderate clustering	–	–	–	–	–		–	–	–
High clustering	–	–	–	1.29	**[1.03, 1.62]	0.02	–	–	–
Low isolation and clustering	–	–	–	–	–	–	1.30	**[1.06, 1.58]	0.01
Moderate isolation and clustering	–	–	–	–	–	–	–	–	
High isolation and clustering	–	–	–	–	–	–	1.42	***[1.09, 1.85]	<.01
Age (years)									
Less than 20 years	0.48	***[0.46, 0.50]	<.01	0.48	***[0.46, 0.50]	<.01	0.48	***[0.46, 0.50]	<.01
20–34 (reference)	–	–	–	–	–	–	–	–	–
35 or more	1.90	***[1.75, 2.05]	<.01	1.89	***[1.75, 2.05]	<.01	1.89	***[1.75, 2.05]	<.01
Prior children									
None	0.51	***[0.49, 0.53]	<.01	0.51	***[0.49, 0.52]	<.01	0.51	***[0.49, 0.53]	<.01
One to Three	–	–	–	–	–	–	–	–	–
Four or more	1.83	***[1.76, 1.90]	<.01	1.83	***[1.77, 1.90]	<.01	1.83	***[1.77, 1.91]	<.01
Married	0.41	***[0.39, 0.43]	<.01	0.41	***[0.38, 0.43]	<.01	0.41	***[0.38, 0.43]	<.01
Education									
Less than 12 years	–	–	–	–	–	–	–	–	–
High school (12 years)	0.42	***[0.41, 0.44]	<.01	0.42	***[0.41, 0.44]	<.01	0.42	***[0.41, 0.44]	<.01
More than 12 years (reference)	0.20	***[0.19, 0.21]	<.01	0.20	***[0.19, 0.21]	<.01	0.20	***[0.19, 0.21]	<.01
Region									
Midwest	2.16	***[1.46, 3.18]	<.01	0.14	***[1.49, 3.07]	<.01	2.04	***[1.43, 2.91]	<.01
Northeast	2.39	***[1.53, 3.74]	<.01	2.37	***[1.54, 3.66]	<.01	2.29	***[1.51, 3.49]	<.01
West	1.77	***[1.22, 2.57]	<.01	1.69	***[1.18, 1.43]	<.01	1.66	***[1.17, 2.34]	<.01
South	–	–	–	–	–	–	–	–	–

	Isolation only			Clustering only			Isolation and clustering		
	0.97	***[0.96, 0.99]	<.01	0.97	***[0.96, 0.98]	<.01	0.98	***[0.96, 0.99]	<.01
MSA total population (log)[c]	0.85	***[0.80, 0.91]	<.01	0.87	***[0.81, 0.94]	<.01	0.85	***[0.79, 0.91]	<.01
State cigarette tax per pack (log)[c]	0.86	***[0.75, 0.91]	<.01	0.87	**[0.75, 0.99]	0.05	0.87	**[0.77, 0.99]	0.04
MSA percent families in poverty[c]	0.16	***[0.01, 20.26]	<.01	0.59	***[0.01, 44.26]	0.81	0.19	***[0.01, 12.47]	0.43
Intercept[d]	0.19	***[0.15, 0.23]	<.01	0.18	***[0.15, 0.23]	<.01	0.19	***[0.15, 0.23]	<.01

African American/Non-Hispanic births (n=403,842) in 216 U.S. MSAs, 2002

[a]*OR* Odds ratio, *CI* confidence interval, *P P* value;

[b]Models included indicators of missing values of age, parity, marital status, education, region; missing, imputed=1, non-missing=0

[c]Centered at the grand mean

[d]Interpreted as the odds of smoking among women with individual covarites in the reference categories who live in MSAs with moderate isolation and averate values of the centered MSA covarietes

*P>0.05 and <0.10

**$P \geq$0.01 and <=0.05

***P<0.01

working class Whites. Accordingly, a contagion process is one possible explanation for our finding that lower segregation was associated with higher odds of smoking during pregnancy.

It is also possible that low segregation reflects structural attributes associated with smoking instead of, or in addition to, contagion effects. If so, our results point to factors associated with low segregation that are deleterious toward maternal smoking behavior. Possibly, low segregation or residence in more racially mixed MSAs is associated with greater exposure to experiences of racial discrimination[61] and concomitantly with higher rates of smoking in response to stress. It is also plausible that these findings reflect an interaction between the segregation patterns within urban neighborhoods and the class-based smoking contagion effect found by Pickett and colleagues.[15] As racial barriers to residential mobility break down, the neighborhoods that are most accessible to African Americans are those inhabited by working class Whites.[62] Similarly, a greater proportion of smokers within the working class could account for the unexpected finding of greater smoking prevalence during pregnancy among African-American women living in low poverty vs. high poverty MSAs.

A contagion process is less compelling as an explanation for the second study finding that high segregation was associated with elevated odds of smoking during pregnancy. In highly segregated MSAs, contagion effects should strengthen within-group norms for health behaviors. Because the norm among African Americans is against smoking during pregnancy, we would expect contagion within areas of greater segregation to reduce the odds of smoking among African-American women.[20,63] We found the opposite, leading us to consider structural mechanisms as the most plausible explanation for our findings.

Many structural factors associated with high segregation could influence smoking during pregnancy. First, segregation is associated with racial discrimination and limited opportunities in housing, employment, and education, which contribute to African-American disadvantage.[30,51,58] Pregnant women with limited opportunities, stressful employment, or family problems may smoke more to reduce stress.[9] Second, within MSAs with high segregation, the distribution of resources and amenities may favor neighborhoods occupied by Whites rather than predominantly African-American neighborhoods.[58] Such resources could include tobacco-dependence treatments for pregnant women including behavioral counseling and pharmaceutical interventions. Finally, other structural factors associated with segregation may play a role in health behaviors including the implementation of tobacco control regulations,[64–68] targeted marketing of tobacco products,[29,51,69–71] the presence of urban environmental stressors,[72,73] and community cohesion.[66,73,74]

An important result in this study is our finding that the association between segregation and smoking was not linear as others have assumed. Pregnant women who lived in areas of low and high segregation were more likely to smoke than those who lived in areas of moderate segregation. Consequently, we advocate for future research that accounts for potential nonlinear relationships between segregation and health outcomes.

Our results indicate that prior findings regarding lower smoking prevalence among African-American women in southern states[19,22,24] appear to extend to pregnant women. Future research among African-American women in the South could be helpful for identifying protective factors related to smoking during pregnancy.

It is noteworthy that the magnitude and significance of the estimated effects of segregation in this study differed slightly by dimension. Specifically, our estimates were of somewhat greater magnitude and significance using the clustering dimension, whereas, associations with isolation were, at best, marginally significant. Furthermore, estimates associated with the combined isolation and clustering dimensions were of greater magnitude than the estimates with clustering alone. Taken together, these findings call attention to the distinct geographic patterns associated with each dimension and suggest that although isolation and clustering are quite highly correlated,[45] any remaining variance may reflect somewhat different aspects of the maternal residential environment.

Several limitations must be considered for the interpretation of the results of this study. First, the associations between segregation and smoking during pregnancy found in this study cannot be used to infer causal relationships. Our measures of segregation may be markers for other factors rather than independent causes, and our findings could reflect residual confounding by the factors we were unable to measure. At the MSA-level of analysis, we controlled for the proportion of poor families in the MSA-a measure of area SES consistent with prior work.[43,44] Our findings were robust when this variable was removed from the models (results not shown), and we conclude that the results presented reflect the influence of segregation or other associated factors, over and above the influence of the proportion of poor families in the MSA. It should be noted that our poverty variable is distinct from other SES measures including economic segregation and income inequality, which we did not measure. Other omitted MSA-level variables that could affect our results include local tobacco control policies, commercial marketing of tobacco products and community-based public health efforts to increase smoking cessation which may vary widely in quality and by MSA.

At the individual level, our results may also underestimate the influence of SES. The birth records we used for individual data included no measures of SES other than maternal education.[32] While education is a stable measure of SES,[75] other measures including occupation, income, and assets would provide more complete information. Furthermore, birth certificates do not include detailed variables associated with smoking during pregnancy such as quit attempts or the smoking status of other household members.

Second, our results may be sensitive to the cut-points we used to categorize the segregation dimensions. There are arguably many ways in which segregation indices can be categorized and no clear theoretical foundations on which to base such decisions. Our method involved clear decision criteria and allowed us to test for nonlinear effects while accounting for the differences in the distribution of the two indices. Future research will be required to test whether the cut-points used in this work are relevant in other samples and to the study of other health outcomes.

Third, our measure of smoking during pregnancy has several limitations. As previously stated, this measure is self-reported, some women may underreport smoking during pregnancy,[38] and consequently, our estimates may be biased toward no association. The prevalence of smoking in our study was comparable to national estimates,[8,12] and we found no systematic differences in any of the study variables among women with missing smoking status compared to those in our sample. As a simple dichotomous measure (i.e., any smoking during pregnancy), our dependent variable did not account for timing or duration of smoking during pregnancy. In addition, because data on smoking were unavailable for California, our results cannot be generalized to women living there.

Fourth, our results are MSA-level estimates. We were not able to identify the actual census tracts within which the women lived in the MSAs. More precise geographic information is required to confirm our results at smaller geographic scales.

Fifth, our results are subject to limitations associated with the use of census-based measures of segregation. The isolation and clustering indices are based on only two population groups (non-Hispanic Whites and African Americans), and therefore, do not capture spatial patterns of residence in relation to other racial/ethnic groups. Our measures of segregation employ census tracts as proxies for neighborhoods within MSAs; however, census tracts may not accurately represent residents' experiences of neighborhood boundaries or the social distance between racial/ethnic groups.[76,77]

Finally, our results may reflect selection bias arising from the process through which individuals choose to live in neighborhoods with particular normative or structural characteristics.

CONCLUSIONS

This study examined individual and social–environmental influences on smoking during pregnancy among urban African-American women. In models that controlled for individual risk factors, we found a significant u-shaped association between segregation and smoking during pregnancy among African-American women living in urban areas. The pattern between segregation and smoking differed slightly according to the dimension of segregation under consideration. These results underscore the multidimensional nature and complexity of racial/ethnic residential segregation and suggest the need for future research to understand which aspects of segregation explain the nonlinear relationship and the differences by dimension.

Harmful effects of segregation on health and on the social and economic opportunities available to African Americans are well documented.[29,31,51,58] In addition, most African Americans prefer to live in more racially integrated neighborhoods.[29,31,51,58] The protective role that moderate segregation plays on maternal smoking behavior points to a need to better understand the forces underlying this complex association and to possible opportunities for interventions that reinforce salutary behaviors in African-American communities. A better understanding of both deleterious and protective contextual influences on smoking during pregnancy within urban areas could add new information to current efforts to reduce smoking during pregnancy among all US women.

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