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Neighborhood and Individual Socioeconomic Status and Asthma Incidence in African American Women

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Objective: Individual socioeconomic status (SES) has been associated with asthma incidence but whether neighborhood SES has an influence is unknown. We assessed the contributions of neighborhood socioeconomic status (SES), neighborhood housing density, neighborhood racial composition, and individual SES to the development of adult-onset asthma in Black women, accounting for other known or suspected risk factors.

Design and Participants: Prospective cohort study conducted among 47,779 African American women followed with biennial health questionnaires from 1995 to 2011.

Methods and Main Outcome Measures: Incident asthma was defined as new self-report of doctor-diagnosed asthma with concurrent use of asthma medication. We assessed neighborhood SES, indicated by census variables representing income, education, and wealth, and housing density and % African American population, as well as individual SES, indicated by highest education of participant/spouse. Cox proportional hazards models were used to derive multivariable hazard ratios (HRs) and 95% CIs for the association of individual SES and neighborhood variables with asthma incidence.

Results: During a 16-year follow-up period, 1520 women reported incident asthma. Neighborhood factors were not associated with asthma incidence after control for individual SES, body mass index, and other factors. Compared with college graduates, the multivariable HR for asthma was 1.13 (95% CI 1.00-1.28) for women with some college education and 1.23 (95% CI 1.05-1.44) for women with no more than a high school education.

Conclusions: Individual SES, but not neighborhood SES or other neighborhood factors, was associated with the incidence of adult-onset asthma in this population of African American women. *Ethn Dis*. 2016;26(1):113-122; doi:10.18865/ed.26.1.113

Keywords: Asthma, Socioeconomic Status, Neighborhood, African American

Introduction

The prevalence[1,2] of asthma is higher in adults of low individual socioeconomic status (SES). Socioeconomic conditions at the neighborhood level may also be relevant,[3] but little is known about this possibility. An association of lower neighborhood SES with higher adult asthma prevalence observed in a Boston study was mostly explained by individual education and income.[4] In a Chicago study, the prevalence of asthma was inversely associated with neighborhood collective efficacy, while individual SES was unrelated.[5]

While associations between various aspects of neighborhood and adverse health outcomes (eg, mortality, [6] diabetes,[7] obesity[8,9]) have been observed, specific mechanisms linking neighborhood and health have not been explicated.[10] An imbalance of health-related compositional factors – ie, characteristics of neighborhood residents - could explain some or all of disparities in a health outcome, such as asthma, between disadvantaged and advantaged neighborhoods.[11] Compositional factors relevant to asthma are obesity, smoking, and low education, risk factors for asthma incidence.[12,13] Contextual features, ie, neighborhood-level characteristics, that have been postulated as mechanisms linking neighborhood and health include physical factors (eg, built environment, air pollution), institutional factors (poor public services, low access to employment), and social-interactive factors (eg, collective efficacy, social norms).[10,11] Contextual features of disadvantaged neighborhoods that might contribute to the development of asthma are inadequate public services and high levels of poverty and crime that engender chronic stress in residents. Residents of central

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city neighborhoods are also exposed to the physical stressors of crowding, air pollution, and older buildings with higher levels of allergens. Such social and physical stressors may contribute to asthma morbidity.[14-18] Two studies of children have found higher asthma prevalence in the central city, regardless of family income or race,[19,20] suggesting that urban density may be relevant. In addition, residential racial segregation, which is often associated with poor services and housing, may also play a role as a stressor.[21] On the other hand, studies suggest that racially homogenous minority neighborhoods might lead to reduced levels of stress since residents encounter fewer episodes of racism than they would in mostly White neighborhoods.[22,23] The association of asthma with neighborhood racial composition has not been assessed.

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The objective of our analysis was to prospectively assess the associations of neighborhood SES, housing density, racial composition, and individual SES with the incidence of adult-onset asthma in a follow-up study of African American women, the Black Women's Health Study (BWHS), while accounting for psychosocial and other factors associated with asthma incidence. We hypothesized that asthma incidence would be inversely associated with individual and neighborhood SES, and positively associated with housing density and increasing proportion of the neighborhood that is African American. We also hypothesized that asthma incidence would be highest in the poorest and densest, and the poorest and most segregated neighborhoods. In previous analyses in the BWHS, the incidence of asthma was increased in women who were heavy,[13] were active or passive smokers,[12] or reported high levels of depressive symptoms,[24] experiences of racism,[25] and childhood physical abuse.[26]

Methods

Study Population

The BWHS is a prospective cohort study established in 1995, when 59,000 African American women aged 21 through 69 years enrolled by completing health questionnaires. The cohort is followed biennially by mailed questionnaire to update exposures and ascertain incident disease. The study protocol was approved by the institutional review board of Boston University School of Medicine. Follow-up of the baseline cohort has been completed for 88% of potential years of follow-up through 2011. Women who contributed <10 years of follow-up were similar to women who have contributed >16 years of follow-up in terms of baseline age, body mass index (BMI), neighborhood SES, alcohol consumption, region, and prevalence of asthma. Women with shorter follow-up had lower levels of education and were more likely to be current smokers than women with longer follow-up (24% with no more than a high school education and 23% current smokers in the short follow-up group compared with 16% and 16%, respectively, in the long follow-up group). Follow-up for our analysis was 1995 through 2011 and includes 44,438 participants whose baseline address could be geocoded and who did not have prevalent asthma or lung cancer at baseline. The average length of follow-up was 14 years.

Diagnosis of Asthma

On all questionnaires from 1997 through 2011, participants were asked whether they had been diagnosed with asthma, year of diagnosis, and if they used "inhalers or pills" for asthma at least 3 days per week. Incident asthma was defined as a first diagnosis of asthma after 1995 with concurrent use of asthma medication. During follow-up from 1995 through 2011, 1520 women met the case criteria. In a subset of 43 such women who gave permission to contact their physician, 39 (91%) were confirmed by the physician as having asthma.

Census Data

Residential addresses from 1995 through 2009 were geocoded. Census data from 2000 were assigned to block groups of residence for 1995-2003 and American Community Survey data from 2005 - 2009 (GeoLytics, Inc., East Brunswick, NJ) were assigned to block groups for the remaining follow-up. An index of neighborhood SES was created using factor analysis to select six census variables: median household income; median housing value; % households receiving interest, dividends, or net rental income; % of adults age ≥25 who had completed college; % of population not living below the poverty level; and % of families with children not headed by a single female. Regression coefficients from the factor analysis were used to weight the variables for a combined neighborhood score, with higher scores representing higher neighborhood SES; this dimensionless score had a mean of .01 (SD 0.95) and range of -3.0 to 4.7. Net housing density (residential units/acre excluding water) was used as an indicator of urban density and classified into 5 categories: 1-4 (low: single family houses), 5-8 (medium: single family houses and condominiums), 9-12 (high: small apartments and townhouses), 13-20 (very high: larger apartment buildings and townhouses), and ≥21 (urban: large apartments, duplexes, and townhouses).[27] The proportion of the population that was African American was used to indicate racial composition of the block group. Neighborhood-level variables were treated as time-varying in the analyses, with new values assigned each time the participant moved.

Ascertainment of Individual SES and Covariates

Participant education was ascertained in 1995 and updated in 2003, and education of spouse (or partner if living as married) was ascertained in 2009. Highest education attained by the participant or her spouse was used as an indicator of individual SES. BMI, (weight in kg/height^2 in m), smoking status, alcohol consumption, and use of supplemental female hormones were ascertained at baseline in 1995 and updated on subsequent follow-up questionnaires. Exposure to secondhand smoke (being in the same room with a smoker for ≥1 hour/day for ≥12 months) at ages 0-10, 11-20, 21-30, 31-40, and currently, was obtained in 1997. In 1999, frequency of experiencing depressive symptoms was ascertained by the 20-item Center for Epidemiological Studies Depression Scale (CES-D), which yields a composite score ranging from 0 (no symptoms) to 60 (highest score on all symptoms).[28] In 2005, experiences of childhood abuse were ascertained using questions adapted from the Conflict Tactics Scales[29] and the Pregnancy Abuse and Assessment Screen.[30] Experiences of physical abuse were classified as never, low severity, medium severity, and high severity, based on frequency and severity of abuse.[26] The 1997 follow-up questionnaire ascertained experiences of racism adapted from an instrument developed by Williams et al.[31] Five questions ascertained frequency of experiences of "everyday racism" (eg, receiving poor service in stores), with five responses ranging from "never" to "almost every day"; an everyday racism score was created by averaging subjects' responses to the five questions.[25] Three questions ascertained experiences of institutional racism in housing, on the job, or by the police; response categories were "yes" and "no" and a lifetime racism score summed the positive responses (0,1, 2, or 3).[25] Information was also obtained on participant health insurance and access to a regular doctor (1997) and parental history of asthma (1999). Levels of ambient fine particulate matter (PM2.5) were available for the years 1999-2008 at residential addresses for participants living in any of 56 metropolitan areas (80% of participants), estimated with a hybrid model incorporating land use regression and Bayesian Maximum Entropy techniques.[32]

Statistical Analysis

We used Cox proportional hazards models to estimate hazard ratios (HRs) and 95% CI for asthma incidence associated with levels of education, neighborhood SES, % African American, and housing density. Since on average only 1-2 BWHS participants lived in each block group, the intraclass correlation coefficients at the block group level were negligible and multilevel modeling was not necessary. We also created joint categories of neighborhood SES and housing density, and neighborhood SES and % African American (%AA), to identify the poorest and most dense, and the poorest and most segregated neighborhoods. Participants contributed person time from 1995 until diagnosis of asthma, death, loss to follow-up, or end of follow-up, whichever came first. Models were stratified by age in 1-year intervals

and questionnaire cycle in 2-year intervals. For assessing the association of the neighborhood variables with asthma incidence, we controlled for age and questionnaire cycle (model 1), added individual education (model 2), and then added other covariates that are associated with asthma incidence in BWHS, including BMI,[13] active smoking,[12] exposure to secondhand smoke,[12] having health insurance, having a regular doctor, parental history of asthma, use of supplemental female hormones, alcohol consumption, everyday and lifetime racism scores,[25] experience of physical abuse as a child,[26] and CES-D score[24] (model 3). We used the same approach for education: age and questionnaire cycle were controlled in model 1, neighborhood SES was added in model 2, and the covariates listed above added to model 3. The addition of PM2.5 did not materially change the estimates for education or the neighborhood variables, so it is not included in the final models. All neighborhood-level variables and BMI, smoking, use of female hormones, and alcohol consumption were time-varying. We assessed interaction between the three neighborhood variables, and between neighborhood SES and BMI, smoking status, CES-D score, and experiences of racism, by including interactions terms in the models. All analyses were conducted using SAS version 9.3.

Results

As shown in Table 1, participants living in neighborhoods of higher SES were older, leaner, more likely to have higher levels of education and to have health insurance, less likely to smoke and drink or to have been exposed to passive smoke, and more likely to have reported higher levels of racism. PM2.5 levels and CES-D scores were inversely associated with neighborhood SES score. Compared with women at lower levels of education, those at the highest level were younger, leaner, more likely to live in higher SES neighborhoods and have health insurance, to have experienced racism, and to have lower CES-D scores (Table 1). Women at the highest level of education were least likely to drink and smoke.

Table 2 shows HRs for neighborhood factors in relation to asthma incidence. In model 1, the incidence

Table 1. Characteristics of participants at baseline (1995) in strata of neighborhood SES and individual SES self/spouse education[a]

	Neighborhood SES					Individual SES		
	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	≤High school	Some college	College graduate
Age, mean (SD)	38.8 (11.4)	38.7 (10.9)	38.5 (10.7)	38.5 (10.5)	39.9 (10.5)	42.9 (12.0)	38.6 (10.5)	38.1 (10.4)
BMI, mean (SD)	28.9 (7.1)	28.2 (6.6)	27.7 (6.3)	27.3 (6.1)	26.4 (5.8)	29.2 (7.0)	28.3 (6.7)	27.0 (6.1)
Neighborhood SES score, mean (SD)	-	-	-	-	-	-.4 (.9)	-.2 (.9)	.2 (1.0)
Self/spouse college graduate, %	47	58	65	72	80	-	-	-
Had health insurance, %	77	83	85	86	89	72	81	88
Parental history of asthma, %	6	6	6	5	6	5	6	6
Ever smoker, %	40	36	34	33	30	45	41	30
Ever exposed to passive smoke, %	73	73	72	71	69	70	74	71
Ever drinker, %	47	44	42	41	41	52	47	39
CES-D score ≥16[b], %	32	29	27	25	24	39	31	24
Highest category childhood physical abuse score,%	4	4	4	5	5	4	4	5
Above the median of everyday racism score, %	43	44	45	45	47	39	44	47
Experienced discrimination in housing, job, by police, %	53	57	59	60	63	46	56	63
PM2.5[c] ($\mu g/m^3$), mean (SD)	14.0 (2.1)	13.9 (2.3)	13.8 (2.5)	13.6 (2.5)	13.1 (2.5)	13.6 (2.2)	13.8 (2.4)	13.7 (2.4)

a. Age adjusted in 5-year intervals.
b. A score of ≥16 on the CES-D scale is used to identify individuals at high risk of depression.[22]
c. Available for 88% of the BWHS cohort at baseline.

of asthma increased as neighborhood SES decreased; the HR in the lowest quintile of neighborhood SES was 1.35 (95% CI 1.14-1.60) *(P*<.01). Upon adjustment for self/spouse education (model 2), the trend remained significant *(P*=.03), although the HRs were attenuated (HR in lowest SES quintile = 1.22, 95% CI 1.03-1.45). When other covariates were added (model 3), the HRs approached 1.0 and the trend was not significant (HR in lowest SES quintile = 1.06, 95% CI .89-1.26). BMI was the variable most responsible for the difference between the model 2 and model 3 HRs (data not shown). There was no evidence of interaction of neighborhood SES with smoking status, BMI, CES-D, or experiences of racism (all *P*>.05). Housing density and % African American were not associated with asthma incidence in any model (Table 2). HRs for the neighborhood factors did not materially change when modelled together (data not shown).

Table 3 shows model 3 HRs for joint categories of neighborhood SES score with housing density and with %AA. HRs in the joint categories were not significantly different from 1.0, with the exception of the HR of 1.45 (95% CI 1.02-2.06) in the medium tertile of neighborhood SES score with housing density of >12. Results were similar when we confined the analysis to women with no more than a high school education (data not shown). There was no evidence of interaction of neighborhood SES with %AA (P for interaction=.84) or housing density (P for interaction=.25).

Asthma incidence increased as level of education decreased (Table 4). The HR for no more than a high school education, relative to graduation from college, was 1.39 (95% CI 1.20-1.61) in model 1, reduced to 1.33 (95% CI 1.14-1.55) upon adjustment for neighborhood SES, and reduced further to 1.23 (95% CI 1.05-1.44) upon adjustment for

Table 2. Association of asthma incidence and neighborhood factors, Black Women's Health Study 1995-2011

		Hazard Ratio (95% CI)		
Quintile of neighborhood SES score	Cases/person-years	Model 1[a]	Model 2[b]	Model 3[c]
Q1	312/112333	1.35 (1.14-1.60)	1.22 (1.03-1.45)	1.06 (.89-1.26)
Q2	290/109516	1.28 (1.08-1.52)	1.20 (1.01,1.43)	1.07 (.90-1.28)
Q3	323/113778	1.39 (1.18-1.64)	1.33 (1.12,1.57)	1.21 (1.02-1.43)
Q4	288/120928	1.18 (.99-1.40)	1.14 (.96-1.36)	1.08 (.91-1.28)
Q5	246/119163	1.00	1.00	1.0
P for trend		<.01	.03	.64
Housing density (units/acre)				
≤ 4	760/313325	1.00	1.00	1.0
≤8	334/124059	1.06 (.93-1.21)	1.04 (.92-1.19)	1.04 (.91-1.18)
≤12	119/47398	1.00 (.82-1.21)	.97 (.80-1.18)	.95 (.78-1.16)
≤20	98/38240	1.03 (.83-1.27)	1.00 (.81-1.24)	1.01 (.82-1.25)
>20	157/59635	1.04 (.88-1.24)	1.03 (.86-1.22)	1.07 (.90-1.27)
P for trend		.65	.85	.61
Quintile of % African American				
Q1	313/128268	1.00	1.00	1.00
Q2	303/124553	1.00 (.85-1.17)	.97 (.83-1.14)	.95 (.81-1.11)
Q3	291/117173	1.00 (.86-1.18)	.96 (.82-1.13)	.92 (.78-1.08)
Q4	294/110808	1.05 (.90-1.23)	1.01 (.86-1.18)	.97 (.83-1.14)
Q5	267/101913	1.00 (.85-1.18)	.96 (.81,1.13)	.90 (.76-1.06)
P for trend		.73	.76	.34

a. Age and questionnaire cycle.
b. Age, questionnaire cycle, self/spouse education (≤12 yrs, 13-15, ≥16, missing).
c. Age, questionnaire cycle, self/spouse education (≤12 yrs, 13-15, ≥16, missing), BMI <25.0, 25.0-29.0, 30.0-34.9, 35.0-39.9, ≥40, missing), smoking (never, past, current < 15/day, current ≥15/day, missing), has health insurance (yes, no, missing), female hormone use (never, <5 years, ≥5 years), parental history of asthma (yes, no, missing), alcohol consumption (never, past, current1-3 drinks/wk, 4-6 drinks/wk, 7-13 drinks/wk, ≥14 drinks/wk, missing), childhood physical abuse (none, low, intermediate, high, missing), everyday racism score (< 1.6, 1.6-1.9, 2.0-2.5, ≥2.6, missing), institutional racism score (no to all, yes to 1, yes to 2, yes to 3, missing), CES-D score (<16, 16-22, 23-32, ≥33).

Table 3. Association of asthma incidence with joint categories of neighborhood SES and housing density, and neighborhood SES and % African American, Black Women's Health Study 1995-2011

Combined categories of neighborhood SES and housing density			
Neighborhood SES	Housing density (units/acre)	Cases/PYs	Model 3[a] HR (95% CI)
Low (Tertile 1)	≤4	178/70525	.86 (.68-1.07)
	5-≤12	196/68127	.96 (.77-1.20)
	>12	138/47764	1.0
Medium (Tertile 2)	≤4	76/22341	.94 (.71-1.26)
	5-≤12	61/17296	.98 (.72-1.34)
	>12	42/8829	1.45 (1.02-2.06)
High (Tertile 3)	≤4	504/217685	1.01 (.83-1.23)
	5-≤12	192/85026	.96 (.77-1.20)
	>12	72/38105	.84 (.63-1.12)
Combined categories of neighborhood SES and % African American			
Neighborhood SES	% African American (tertiles)	Cases/PYs	Model 3[a] HR (95% CI)
Low (Tertile 1)	1 (<1%-23%)	59/20598	1.10 (.83-1.46)
	2 (24%-74%)	181/69018	.98 (.81-1.19)
	3 (75%-100%)	272/96805	1.0
Medium (Tertile 2)	1 (<1%-23%)	56/12245	1.34 (.99-1.80)
	2 (24%-74%)	65/19710	1.02 (.77-1.34)
	3 (75%-100%)	58/16513	1.08 (.81-1.45)
High (Tertile 3)	1 (<1%-23%)	384/176128	1.03 (.88-1.21)
	2 (24%-74%)	263/105230	1.16 (.97-1.38)
	3 (75%-100%)	121/59471	.93 (.74-1.15)

PYs, person years

a. Age, questionnaire cycle, self/spouse education (≤12 yrs, 13-15, ≥16, missing), BMI <25.0, 25.0-29.0, 30.0-34.9, 35.0-39.9, ≥40, missing), smoking (never, past, current < 15/day, current ≥15/day, missing), has health insurance (yes, no, missing), female hormone use (never, <5 years, ≥5 years), parental history of asthma (yes, no, missing), alcohol consumption (never, past, current1-3 drinks/wk, 4-6 drinks/wk, 7-13 drinks/wk, ≥14 drinks/wk, missing), childhood physical abuse (none, low, intermediate, high, missing), everyday racism score (< 1.6, 1.6-1.9, 2.0-2.5, ≥2.6, missing), institutional racism score (no to all, yes to 1, yes to 2, yes to 3, missing), CES-D score (<16, 16-22, 23-32, ≥33).

individual-level variables (model 3); the trend remained significant (*P*<.01). The variable most responsible for the reduction in the HR between model 2 and model 3 was BMI (data not shown); other factors, including the psychosocial stressors, had little effect on the HR. When women with less than a high school education were assessed separately (41 cases/7859 person-years) relative to graduation from college, the HR from model 3 was 1.97 (95% CI 1.42-2.74). Results were similar when we used the education of the participant herself, rather than highest of participant/spouse education (data not shown).

Discussion

In this cohort of African American women, neighborhood factors were not associated with incidence of adult-onset asthma. However, asthma incidence was independently associated with individual SES: compared with college graduates, asthma incidence was increased among those who had completed some college, and was higher still among those who had completed no more than high school. Asthma incidence was even greater among the group with less than a high school education, although only <2% of BWHS participants fell into this group. The association of education with asthma incidence was largely independent of neighborhood SES, but BMI appeared to explain some of the association. Psychosocial risk factors for asthma, including experiences of racism and levels of depressive symptoms, did not materially alter the BMI-adjusted HRs. Much of the association between individual SES and incident asthma in this study remains unexplained. People at higher levels of education may have greater knowledge of health-promoting behaviors and be more likely to incorporate them into their lives than people at low levels of education.[33] Low educational attainment may also be a marker for housing affected by

Table 4. Association of asthma incidence with self/spouse education, Black Women's Health Study 1995-2011

	Cases/PYs	Model 1[a]	Model 2[b]	Model 3[c]
Highest education achieved by participant or spouse				
≤High school	240/73583	1.39 (1.20-1.61)	1.33 (1.14-1.55)	1.23 (1.05-1.44)
Some college	471/163464	1.28 (1.14-1.43)	1.24 (1.10-1.39)	1.13 (1.00-1.28)
College graduate	808/368780	1.0	1.0	1.0
P for trend		<.01	<.01	<.01

a. Age and questionnaire cycle.
b. Age, questionnaire cycle, neighborhood SES (quintiles).
c. Age, questionnaire cycle, neighborhood SES (quintiles), BMI <25.0, 25.0-29.0, 30.0-34.9, 35.0-39.9, ≥40, missing), smoking (never, past, current < 15/day, current ≥15/day, missing), exposure to secondhand smoke (never, ever, missing), has health insurance (yes, no, missing), female hormone use (never, <5 years, ≥5 years), parental history of asthma (yes, no, missing), alcohol consumption (never, past, current 1-3 drinks/wk, 4-6 drinks/wk, 7-13 drinks/wk, ≥14 drinks/wk, missing), childhood physical abuse (none, low, intermediate, high, missing), everyday racism score (< 1.6, 1.6-1.9, 2.0-2.5, ≥2.6, missing), institutional racism score (no to all, yes to 1, yes to 2, yes to 3, missing), CES-D score (<16, 16-22, 23-32, ≥33).

important risk factors for asthma (eg, mold and mites) on which we had no information. This may partly explain some of the association. In addition, the underlying mechanisms by which SES influences health have not been completely defined.[34] Higher levels of asthma prevalence have been observed in US adults of lower SES,[1,2,4] but this may reflect poor disease management rather than higher incidence.

Our finding of higher incidence in BWHS participants with lower education is consistent with findings from the Coronary Artery Risk Development in Young Adults (CARDIA) study, the only other US study to assess asthma incidence and individual SES.[35] CARDIA participants were young (aged 18-30 years at baseline) and were followed for an average of 10 years. In the CARDIA study, compared to participants with educational attainment beyond high school, the 10-year incidence of asthma was 80% higher in those who did not graduate from high school, and 36% higher in those who graduated from high school but went no further, adjusted for age, race, sex, and study center.[35] Several European studies have also found 40%-100% higher asthma incidence rates in groups of lower SES, as indicated by occupation or education.[36-38]

To our knowledge, no previous study has assessed the association of adult asthma incidence with neighborhood SES, but two have assessed adult asthma prevalence and neighborhood SES.[4,5] A study in Chicago that used an index of neighborhood SES similar to the one used in our study found no association of that index with the prevalence of asthma/breathing problems, with adjustment for individual SES and other covariates (eg, smoking, weight).[5] In a Boston study, neighborhood SES was classified into three categories according to population of the zip code living below the poverty level (<10%, 10%-19%, and ≥20%).[4] The odds ratio for asthma prevalence in the lowest compared with highest SES areas was 1.3 (95% CI .9-2.0) when adjusted only for smoking, sex, and race; when individual income and education were added, the odds ratio was 1.10 (95% CI .8-1.7).[4] Of note, in this same study, the odds ratio for asthma prevalence among children living in the highest poverty neighborhoods was 7.6 (95% CI 2.4-23.5), adjusted for parental education and family income.[4] Numerous studies of children have found higher prevalence of asthma in disadvantaged neighborhoods,[39-42] although in some studies the higher prevalence disappears upon adjustment for individual-level demographic factors.[43,44] One study reported higher incidence of asthma in children living in disadvantaged neighborhoods, even after adjustment for a range of individual risk factors.[45]

Asthma incidence was independently associated with individual SES: compared with college graduates, asthma incidence was increased among those who had completed some college, and was higher still among those who had completed no more than high school.

Our study has several strengths. To our knowledge, it is the first prospective examination of neighborhood SES, density, and racial composition in relation to asthma incidence in a population of African American women. It is the largest US study to assess asthma incidence and individual SES, in terms of sample size and follow-up time. We had data on many potential confounders, including outdoor air pollution and psychosocial factors that have been associated with asthma incidence in the BWHS.[24-26] However, we lacked information on occupational or other environmental exposures that might be relevant, such as animal dander and mold. Studies of neighborhood may be vulnerable to selection bias, when people's choice of neighborhood is based on characteristics relevant to the outcome under study.[46,47] For example, individuals at risk of asthma because of a family history might, if they had the resources, choose to live in neighborhoods in which the housing is generally free of mold and mites. We controlled for individual-level SES but we are unable to rule out that this sort of selection bias occurred. The sort of analysis that could rule out such bias - assessment of the association of risk factors for asthma among people who had moved from one type of neighborhood to another type - was not possible because very few women who moved selected a neighborhood of substantially different SES. Of greater threat to validity is compositional factors, which in BWHS include asthma risk factors that have a higher prevalence in low compared to high SES neighborhoods (eg, obesity, smoking); we have controlled for these factors. While women who had fewer years of follow-up had lower levels of education and were more likely to be current smokers than women with complete follow-up, we were able to control for both variables, minimizing the possibility of bias.

We used education as the single indicator of individual SES. SES is typically measured by income, occupational status, and education, singly or in some combination.[48] However, education is considered perhaps the most basic SES component since it has a strong influence on future occupation and earning potential.[34] Education has been found to be a good indicator of SES in African Americans.[49] In BWHS, education has been associated with various health outcomes including weight,[50] diabetes incidence,[7] and breast cancer incidence.[51] While education is a valid indicator of SES, additional information on wealth, including occupation, assets, and reliance on public assistance, would have more completely described individual SES. Finally, we relied on self-report of doctor-diagnosed asthma. The standard method of identifying asthma cases in large national cohort studies is self-report[35,52-54] because it is not feasible in such studies to conduct detailed medical evaluation or physiologic testing to confirm case and non-case status. As noted, in our small validation study, 91% of women who reported incident asthma were confirmed by their physicians as having asthma. Nevertheless, in the absence of physiologic test data, one cannot exclude some degree of misclassification of cases and non-cases; random misclassification would have tended to mute associations.

Conclusion

In conclusion, our results indicate that individual SES is associated with adult-onset asthma incidence in African American women. Body mass index explained some of the association; psychosocial factors did not play an important role. Neighborhood SES was not related to asthma incidence after accounting for level of education and BMI. Housing density or proportion of the neighborhood that is African American were unrelated to risk. In contrast to evidence indicating a role of neighborhood factors in childhood asthma risk, our findings suggest that efforts to prevent adult-onset asthma may best identify women at particular risk on the basis of individual characteristics, including low SES. As many women with low SES and other risk factors for adult-onset asthma (eg, obesity, smoking) reside in low SES neighborhoods, prevention efforts could focus in such neighborhoods.

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Conflict of Interest

No conflicts of interest to report.

Author Contributions

Research concept and design: Coogan, Rosenberg, O'Connor. Acquisition of data: Coogan, Palmer, Rosenberg. Data analysis and interpretation: Coogan, Castro-Webb, Palmer, Rosenberg, Yu, O'Connor. Manuscript draft: Coogan, Castro-Webb, Palmer, Rosenberg, Yu, O'Connor. Statistical ex-

pertise: Coogan, O'Connor. Acquisition of funding: Coogan, Palmer. Administrative: Castro-Webb, Rosenberg, Yu. Supervision: Coogan

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