

Clinical Communications

Racial, ethnic, and socioeconomic differences in adolescent food allergy

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Clinical Implications

- Our study indicates the existence of racial/ethnic and socioeconomic differences in the prevalence of food allergy among adolescents. These results further the concern that food allergy may be underdiagnosed and undertreated among racial minorities and economically disadvantaged youth.

TO THE EDITOR:

Food allergy is a growing and serious health problem in the United States.¹ However, the relationships between demographic characteristics, socioeconomic status (SES), and food allergy are unclear. Racial disparities have been identified in the prevalence of food specific IgE² and in the clinical practice of allergy-related health care.³

To evaluate socioeconomic and racial/ethnic disparities in food allergy, we investigated associations of race/ethnicity and SES factors during pregnancy with both food specific IgE and allergic-type symptoms to common food allergens (milk, egg, peanut, soy, and wheat) in adolescents in a large Boston-area cohort.

The study participants were 1148 adolescents from Project Viva, a prospective prebirth cohort. Participants' mothers were enrolled at their initial prenatal visit (between April 1999 and July 2002). Further details about the cohort, exposure and outcome assessment, and statistical analyses are provided in this article's Online Repository at www.jaci-inpractice.org.

We examined the following indicators of SES: maternal education, smoking by the mother during pregnancy and by anyone in the home during the child's first year of life, household income, and median household income from the neighborhood census tract. We determined the race/ethnicity of the adolescent by asking the mother to choose 1 or more racial/ethnic groups for her child.

For those participants with sufficient blood samples to measure specific IgE levels by Phadia ImmunoCAP (Thermo Fisher Scientific, Uppsala, Sweden), we examined sensitivity to each of these 5 common food allergens (milk, egg, peanut, soy, and wheat). We also evaluated IgE-mediated symptoms (hives, wheeze, dyspnea, itchy throat, cough, rhinitis, eczema, nausea/vomiting, diarrhea, loss of consciousness) following food intake, as reported by maternal questionnaire. We assessed associations of adolescent race/ethnicity and SES with allergy symptoms and

allergen specific IgE using logistic regression models. For high prevalence outcomes (peanut and wheat-specific IgE, with prevalence of >27% among non-Hispanic black and "other" participants), we also determined prevalence ratios. All models adjusted for age, sex, race/ethnicity, and parental history of atopy.

For participant characteristics, see Table E1 (in this article's Online Repository at www.jaci-inpractice.org) and for comparison of included and excluded participants, see Table E3 (in this article's Online Repository at www.jaci-inpractice.org). Of the 647 adolescents with sufficient blood samples, 31% had food specific IgE level of more than 0.35 k/UL to at least 1 of the 5 foods (see Table E2 in this article's Online Repository at www.jaci-inpractice.org).

Associations of race/ethnicity and SES indicators with allergic sensitization are reported in Table I. Non-Hispanic black teens had a higher risk of sensitization to each of the 5 foods, reaching statistical significance for peanut (prevalence ratio 2.29; 95% CI, 1.54-3.39) and wheat (prevalence ratio 1.64; 95% CI, 1.15-2.34).

Adolescents whose mothers had less than a college degree versus a graduate degree had higher odds of sensitization to milk (odds ratio [OR], 3.00; 95% CI, 1.46- 6.16) and adolescents whose mothers had a college degree versus a graduate degree had higher odds of sensitization to wheat (OR, 1.73; 95% CI, 1.06-2.81). Associations between low maternal education and each of the other 3 foods were also positive; however, CIs were wide and included 1.0. Adolescents from homes with annual household income of less than or equal to \$40,000 versus more than \$70,000 also had greater odds of sensitization to milk, egg, peanut, and soy, although comparisons did not reach statistical significance. Similarly, this pattern was observed for milk, peanut, soy, and wheat in adolescents from households with incomes between \$40,001 and \$70,000 versus more than \$70,000, reaching statistical significance for soy (OR, 2.02; 95% CI, 1.05-3.89). Maternal prenatal smoking was associated with higher odds of peanut sensitization (OR, 1.80; 95% CI, 0.97-3.34), but the lower confidence limit did cross 1.0. Otherwise exposure to smoking and living in the lowest quartile of census tract income were not associated with allergic sensitization.

The prevalence of food allergy symptoms is reported in Table E2. Of the 1145 participants, 83 (7.2%) reported allergic-type symptoms to any food. Associations of race/ethnicity and SES with allergic symptoms upon food ingestion are presented in Table II. There were no convincing patterns of association for any measures of SES with food allergy symptoms. However, non-Hispanic black adolescents had higher odds of maternal reporting of allergic symptoms to peanut (OR, 2.41; 95% CI, 1.12-5.17) compared with non-Hispanic white adolescents.

In this prospective prebirth cohort residing in the Northeastern United States, there was a pattern of higher odds of sensitization to all 5 foods studied in association with non-Hispanic black race. Lower household income was associated with higher odds of sensitization to soy, and lower maternal educational attainment was associated with higher odds of sensitization to milk and wheat.

TABLE I. Associations of race/ethnicity and SES with food specific IgE*

Characteristic	Adjusted OR or prevalence ratio† (95% CI) for food specific IgE >0.35 k/UL				
	Milk	Egg	Peanut	Soy	Wheat
Adolescent race/ethnicity					
Non-Hispanic white	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Non-Hispanic black	1.42 (0.75-2.68)	1.78 (0.84-3.77)	2.29 (1.54-3.39)	1.68 (0.86-3.28)	1.64 (1.15-2.34)
Hispanic	1.55 (0.73-3.27)	1.75 (0.72-4.26)	1.28 (0.70-2.23)	1.32 (0.55-3.12)	0.66 (0.33-1.31)
Other	0.96 (0.39-2.37)	1.80 (0.74-4.39)	2.25 (1.41-3.58)	1.94 (0.87-4.31)	1.45 (0.92-2.28)
Maternal education					
<College	3.00 (1.46-6.16)	1.53 (0.68-3.46)	1.70 (0.94-3.07)	1.31 (0.63-2.69)	1.23 (0.69-2.17)
College graduate	1.68 (0.85-3.35)	1.30 (0.61-2.75)	1.53 (0.89-2.63)	1.13 (0.58-2.19)	1.73 (1.06-2.81)
Graduate degree	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Smoked during pregnancy (yes vs no)	0.76 (0.31-1.84)	0.86 (0.32-2.31)	1.80 (0.97-3.34)	1.76 (0.84-3.71)	1.37 (0.73-2.54)
Annual household income					
≤\$40,000	1.42 (0.63-3.20)	1.33 (0.51-3.42)	1.37 (0.67-2.77)	1.22 (0.48-3.13)	0.63 (0.30-1.32)
\$40,001-\$70,000	1.29 (0.68-2.48)	0.91 (0.40-2.08)	1.61 (0.92-2.81)	2.02 (1.05-3.89)	1.30 (0.78-2.18)
>\$70,000	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Any smokers at home in first year (yes vs no)	0.80 (0.36-1.78)	0.44 (0.15-1.32)	0.69 (0.34-1.37)	1.17 (0.54-2.56)	0.86 (0.46-1.62)
Census tract median household income (lowest quartile vs upper 3 quartiles)	1.24 (0.65-2.38)	1.59 (0.75-3.39)	0.78 (0.44-1.36)	0.90 (0.44-1.81)	0.72 (0.41-1.25)

All models adjusted for adolescent age, sex, and race/ethnicity and parental history of atopy.

Confidence intervals which did not cross 1.0 were considered significant and are bolded.

*Data from 647 adolescents participating in Project Viva who had IgE samples.

†Prevalence ratio used in models with common outcomes instead of OR (associations of adolescent race/ethnicity with peanut and wheat IgE).

TABLE II. Associations of adolescent race/ethnicity and maternal SES with allergic symptoms*

Characteristic	Adjusted OR (95% CI) for allergic symptoms			
	Milk	Egg	Peanut	Wheat
Adolescent race/ethnicity				
Non-Hispanic white	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Non-Hispanic black	1.41 (0.38-5.29)	2.66 (0.63-11.28)	2.41 (1.12-5.17)	0.72 (0.09-6.03)
Hispanic	NA	NA	1.44 (0.48-4.35)	NA
Other	1.52 (0.32-7.16)	1.35 (0.16-11.66)	4.14 (1.90-8.99)	2.29 (0.45-11.50)
Maternal education				
<College	1.85 (0.38-9.14)	0.44 (0.07-2.98)	0.82 (0.34-1.99)	0.85 (0.14-5.18)
College graduate	2.23 (0.56-8.84)	0.60 (0.13-2.80)	1.76 (0.85-3.66)	0.77 (0.17-3.52)
Graduate degree	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Smoked during pregnancy (yes vs no)	1.67 (0.36-7.63)	1.29 (0.16-10.58)	1.16 (0.44-3.08)	1.25 (0.15-10.22)
Annual household income				
<\$40,000	0.57 (0.06-5.57)	NA	0.34 (0.12-1.01)	2.14 (0.32-14.13)
\$40,000-\$70,000	2.67 (0.86-8.27)	0.99 (0.18-5.40)	0.15 (0.03-0.64)	NA
>\$70,000	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Any smokers at home during first year (yes vs no)	1.06 (0.23-4.95)	0.89 (0.10-7.68)	0.90 (0.36-2.22)	0.91 (0.11-7.56)
Census tract median household income (lowest quartile vs upper 3 quartiles)	0.78 (0.17-3.64)	0.18 (0.02-1.79)	1.29 (0.61-2.74)	0.44 (0.04-4.47)

NA, Insufficient prevalence of outcome to estimate OR (95% CI).

All models adjusted for adolescent age, sex, and race/ethnicity, and parental history of atopy.

Confidence intervals which did not cross 1.0 were considered significant and are bolded.

*Data from 1145 adolescents participating in Project Viva who had allergic symptoms data.

Current theories to explain the increasing prevalence of food allergies have focused on hygiene, microbiome, diet, and allergen exposure,⁴ but have not generally focused on racial/ethnic or socioeconomic disparities underlying this growing childhood health

problem. One possible explanation may be early childhood diet. While the Learning Early About Peanut (LEAP) randomized trial demonstrated a reduced risk of developing a peanut allergy in high-risk infants if peanuts are introduced at an early age,⁵ Centers for

Disease Control and Prevention data have shown that early childhood nut consumption varies by race and SES. Specifically, non-Hispanic black youths and those from lower income households consume fewer nuts than do white children and those in higher income households.⁶ These dietary patterns may help explain the higher prevalence of nut allergy observed in our study and others among non-Hispanic black youth.

Our findings are in agreement with other studies in the United States that have found a higher prevalence of food sensitization among non-Hispanic blacks^{1,7} and in those from lower SES homes,⁷ although interestingly prior studies have found self-report of food allergy to be less common in these groups.⁸ Despite an overall decline in food allergy prevalence with age, we demonstrate that racial disparities in food allergen sensitization persist into the teenage years.

Together with evidence of racial disparities in diagnosis and treatment of food allergies,^{2,3,7} our findings indicate a need to educate both the scientific and lay community about demographic risk factors for food allergy in adolescents.

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ONLINE REPOSITORY**METHODS****Study design and subjects**

Participants were from Project Viva, a prospective prebirth cohort study that recruited women during early pregnancy from Atrius Harvard Vanguard Medical Associates, a multispecialty group practice in Eastern Massachusetts. Mothers were enrolled between April 1999 and July 2002. Detailed enrollment criteria have been described previously.^{E1} In-person interviews and questionnaires were administered in early pregnancy after the initial prenatal visit (average of 9.9 weeks of gestation), and midpregnancy at 26 to 28 weeks of gestation. Interviews and questionnaires on child health were administered at 6 months, 1 year, and annually thereafter. Of the 2128 live births, we included 1148 participants with outcome data at the early teen visit (mean age, 13.3 years). Compared with the included participants, those excluded were less likely to have mothers with a graduate degree (23.5% vs 34.2%) and were more likely to have mothers who smoked during pregnancy (16.9% vs 9.0%). However, prevalence of parental atopy was similar (56.7% vs 59.2%) as was adolescent race/ethnicity (18.3% vs 15.6 non-Hispanic black; 10.9% vs 9.5% Hispanic) (Table E3). The institutional review boards of Brigham and Women's Hospital and Harvard Pilgrim Health Care approved this study.

Assessment of child race/ethnicity and maternal SES during pregnancy

We determined the race/ethnicity of the adolescent by asking the mother to choose 1 or more racial/ethnic groups for her child. We created 4 racial/ethnic groups on the basis of the mother's response: non-Hispanic white (reference category), non-Hispanic black, Hispanic (regardless of race if also checked), and other (mixed race, Asian or Pacific Islander, American Indian or Alaskan Native, and other).

We examined the following measures of home environment and indicators of SES: maternal education, smoking by the mother during pregnancy and by anyone in the home during the child's first year of life, household income, and median household income from the neighborhood census tract. Mothers reported their highest level of educational attainment, personal smoking, and household income on questionnaires during pregnancy. Mothers also reported household smoking on the 6-month and year-1 postpartum questionnaires. Median annual income for census tract of residence at the time of study enrollment was determined using data from the 2000 United

States Census. We defined low neighborhood income as a census tract in the lowest quartile of the distribution of our study population (<\$41,771 per year), all of whom lived in the greater Boston area at study enrollment.

Adolescent allergy outcomes

Of the 1148 children who presented for the in-person visit (age, 11.2-16.6 years), 701 had blood drawn and 647 had samples sufficient to measure allergen specific IgE levels by Phadia ImmunoCAP (age, 11.9-16.4 years). Food sensitivity to each food allergen (milk, egg, peanut, soy, or wheat) was defined as positive if the respective food specific IgE level was more than 0.35 kU/L.

We inquired about allergic-type symptoms following allergen intake with the question: "Which of the following food(s) is your child allergic to? Specify the reaction(s) that your child had within one hour of eating them. Please check as many reactions for each food as needed." The listed reactions were as follows: hives on 1 body part, hives on more than 1 body part, nausea/vomiting, diarrhea, wheezing, trouble breathing, itchy throat or mouth, coughing, sneezing, runny or stuffy nose, loss of consciousness, eczema, or worsening eczema. The foods listed included milk, egg, peanut, soy, wheat, and also other allergens (eg, other nuts and shell-fish, which we did not investigate because there was no corresponding IgE measure). We considered an adolescent to have had food allergy symptoms to 1 of the 5 common food allergens if the mother reported that the child had 1 or more of these symptoms to that food. We also classified each adolescent on the basis of whether the mother reported allergic-type reaction to any food. We did not collect data on physician-diagnosed food allergy.

Statistical analysis

We assessed associations of adolescent race/ethnicity and measures of SES with odds of allergic sensitization and symptoms to each of the 5 common food allergens using logistic regression models. We used prevalence ratios rather than ORs for sensitization to peanut and wheat because the outcome was common (the prevalence was >27% among black and "other" race/ethnicity participants). To estimate prevalence ratios, we used PROC GENMOD's log-binomial regression (SAS Institute, Cary, NC) as described by Spiegelman and Hertzmark.^{E2} All models adjusted for adolescent age, sex, and race/ethnicity and parental history of atopy. Parental history of atopy was defined as positive if either parent was reported to have asthma, allergic rhinitis, or atopic dermatitis.

TABLE E1. Participant characteristics of 1148 adolescents in Project Viva, overall and according to race/ethnicity

Characteristic	Overall (n = 1148)	Adolescent race/ethnicity			
		Non-Hispanic white (n = 749)	Non-Hispanic black (n = 179)	Hispanic (n = 109)	Other (n = 110)
Adolescent					
Female	48.4%	49.7%	45.3%	45.0%	48.2%
Age at early teen visit (y)	13.3 ± 1.0	13.3 ± 1.0	13.3 ± 1.0	13.3 ± 1.0	13.2 ± 0.9
Mother					
Education					
<College graduate	28.0%	17.0%	57.0%	60.2%	24.8%
College graduate	37.7%	43.5%	31.3%	18.5%	27.5%
Graduate degree	34.2%	39.5%	11.7%	21.3%	47.7%
Smoked during pregnancy	9.0%	8.0%	10.7%	13.0%	9.1%
Family/household					
Parental history of atopy	59.2%	59.9%	54.2%	59.3%	62.4%
Annual household income					
≤\$40,000	14.2%	5.0%	44.8%	39.3%	17.8%
\$40,001-\$70,000	21.2%	21.5%	24.6%	18.0%	17.8%
>\$70,000	64.6%	73.6%	30.6%	42.7%	64.4%
Any smokers in the household (in first year)	13.0%	9.7%	24.3%	22.1%	11.3%
Neighborhood at enrollment					
Census tract median household income (lowest quartile, <\$41,771/y)	23.2%	9.0%	66.7%	45.0%	28.2%

Values are mean ± SD or %.

TABLE E2. Adolescent outcomes*

IgE > 0.35 kU/L	Overall (n = 647)	Adolescent race/ethnicity			
		Non-Hispanic white (n = 400)	Non-Hispanic black (n = 113)	Hispanic (n = 71)	Other (n = 63)
Milk	71 (11.0)	40 (10.0)	15 (13.3)	10 (14.1)	6 (9.5)
Egg	50 (7.7)	25 (6.3)	11 (9.7)	7 (9.9)	7 (11.1)
Peanut	110 (17.0)	50 (12.5)	31 (27.4)	11 (15.5)	18 (28.6)
Soy	62 (9.6)	32 (8.0)	14 (12.4)	7 (9.9)	9 (14.3)
Wheat	128 (19.8)	71 (17.8)	32 (28.3)	8 (11.3)	17 (27.0)
Allergic symptoms	Overall (n = 1145)	Non-Hispanic white (n = 747)	Non-Hispanic black (n = 179)	Hispanic (n = 109)	Other (n = 109)
Milk	14 (1.2)	9 (1.2)	3 (1.7)	0	2 (1.8)
Egg	9 (0.8)	5 (0.7)	3 (1.7)	0	1 (0.9)
Peanut	46 (4.0)	20 (2.7)	11 (6.1)	4 (3.7)	11 (10.1)
Soy	6 (0.5)	5 (0.7)	1 (0.6)	0	0
Wheat	9 (0.8)	6 (0.8)	1 (0.6)	0	2 (1.8)

Values are n (%).

*Data from 647 adolescents participating in Project Viva who had IgE samples (upper portion) and from 1145 adolescents whose mothers completed the symptom questionnaire (lower portion).

TABLE E3. Characteristics of included and excluded participants

Characteristic	Included participants (n = 1148)	Excluded participants (n = 980)	P value
Adolescent			
Sex			.95
Female	48.4%	49.6%	
Race/ethnicity			.21
Non-Hispanic white	65.3%	61.6%	
Non-Hispanic black	15.6%	18.3%	
Hispanic	9.5%	10.9%	
Other	9.6%	9.1%	
Mother			
Education			<.001
<College graduate	28.0%	44.1%	
College graduate	37.7%	32.4%	
Graduate degree	34.2%	23.5%	
Smoked during pregnancy	9%	16.9%	<.001
Family/household			
Parental history of atopy	59.2%	56.7%	.25
Annual household income			.003
≤\$40,000	14.2%	17.5%	
\$40,001-\$70,000	21.2%	25.7%	
>\$70,000	64.6%	56.8%	
Any smokers in the household (in first year)	13.0%	14.9%	.27
Neighborhood at enrollment			
Census tract median household income (lowest quartile, <\$41,771/y)	23.2%	27.1%	.04

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