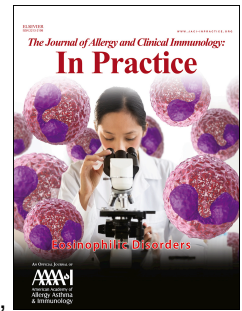


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Access to Allergen-Free Food Among Black and White Children with Food Allergy in the FORWARD Study

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Authors' Conflicts of Interest

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Abstract

Background: Racial differences in access to allergen-free food has not been fully described among children with food allergy (FA).

Objective: To examine access to allergen-free foods among Black and White children with FA.

Methods: Black and White children with FA were enrolled in FORWARD, a multi-site prospective cohort study at four urban US centers. Caregivers completed questionnaires regarding access to allergen-free foods. Univariable statistics described demographics. Bivariable statistics evaluated crude associations with access to allergen-free foods. Multivariable logistic regression evaluated the adjusted effect of race on access to allergen-free foods. Geospatial analyses examined the distribution of race, socioeconomic status, and food desert residence.

Results: Among participants (n=336), White caregivers (88.1%) were more likely to report access to allergen-free foods than Black caregivers (59%) ($p<0.001$). White caregivers were more likely to purchase allergen-free foods online (35.2%) than Black caregivers (12%) ($p<0.001$). Although Black children were more likely to live in a food desert, access to allergen-free food was not related to food desert residence. In the unadjusted analysis, White children were 5.2 times as likely to have access than Black children ($p<0.001$); after adjusting for demographics, this increase in access was no longer significant ($p=0.08$). Other predictors of access to allergen-free foods included online food purchasing, annual household income, respondent education level, milk allergy, and child age >5 years.

Conclusion: In the FORWARD cohort, Black children have less access to allergen-free foods than White children, but much of the difference is accounted for by SES and other participant characteristics.

Highlights Box:

What is already known about this topic? Previous studies have shown that disproportionate morbidity exists among Black children with food allergies compared to White children with food allergies.

What does the article add to our knowledge? Race, socioeconomic status, and access to online food purchasing are identifiable predictors of access to allergen-free foods in children living with food allergies.

How does this study impact current management guidelines? Understanding the social determinants of health, such as access to allergen-free foods, should guide clinical practice and management of food avoidance by providing equitable resources for patients to access allergen-free foods.

Key words: Black, White, Food Allergy, Race, FORWARD, Access, Children, Disparities

Abbreviations:

FA (Food Allergy)

ED (Emergency Department)

US (United States)

FORWARD (Food Allergy Outcomes Related to White and African American Racial Differences)

United States Department of Agriculture (USDA)

Economic Research Service (ERS)

Introduction

The prevalence of childhood food allergy (FA) in the United States (US) is rising, with its most recent prevalence noted to be approximately 8%.⁽¹⁾ Several studies suggest that there are racial and geographic differences in food allergy. Non-Hispanic Black children have had the sharpest increase in FA prevalence over the past twenty years,² and are 1.4 times more likely to have FA compared to White children.¹ Furthermore, children living in urban areas have significantly increased FA prevalence compared to those residing in rural communities.³

Compared to White children with FA, Black children with FA tend to have poorer clinical outcomes. Black children with FA are noted to have an increased likelihood of coexisting atopy, a shorter duration of follow-up visits with an allergy specialist, and higher rates of food-induced anaphylaxis.⁴ Additionally, White children experiencing food-induced anaphylaxis are more likely to receive epinephrine prior to emergency department (ED) arrival and have less risk of subsequent hospitalization compared to Black children.⁵

Barriers to healthcare and food access may be contributing factors for the racial and geographic differences in FA burden among children in the US with FA. In a large national survey, compared to non-FA households, caregivers of children with FA were more likely to report difficulty accessing healthcare and food as stated by the USDA's definition of "food security" being "a measure of consistency of access to enough food for an active healthy lifestyle."⁶ Even after adjusting for income and education, caregivers of Black children with FA were more likely to report lower food security and difficulty affording medications compared to White children with FA. Food insecurity in households of children with FA has additionally been reported to increase the burden of meeting basic nutritional needs.⁷

While racial differences in food security between Black and White children with FA have been documented in the literature, research focused on geographic access to allergen-free food, a key preventative component of FA self-management is lacking. In this study “geographic access” was defined by the United States Department of Agriculture’s (USDA) definition, which is described later in detail. The definition of “allergen-free food” was any food that did not contain a participant’s known allergens. Additionally, given the increasing prevalence of FA among children living in urban areas, it is important to better understand how living in a food desert may influence FA management. Hence, the goal of this study was to examine access to allergen-free food and food desert residence among Black and White children with FA in three US urban centers.

Methods

Data Source

This study used data from FORWARD (Food Allergy Outcomes Related to White and African American Racial Differences), a prospective cohort of Black and White children ≤ 12 years old with a physician-diagnosed FA from Chicago (Ann & Robert H. Lurie Children’s Hospital, Rush University Medical Center), Cincinnati (Cincinnati Children’s Hospital), and Washington, D.C. (Children’s National Hospital). The methodology of FORWARD has previously been described.⁸

Outcomes of Interest

The outcome of interest for this study was parent-proxy-reported access to allergen-free food, through both in-person and online grocery purchases. This outcome was assessed via two survey items from the Diet and Purchasing Survey, administered six months after enrollment. Participants were asked to indicate (yes/no) whether they “have places where [they] can shop for allergy free foods” and/or whether they “buy allergy free foods online.”

Covariates

Demographic information was obtained from the FORWARD intake survey. Child race was categorized as White or Black, based on the parent-proxy response to the intake survey item, "With which race does your child with food allergy primarily identify?". Other demographic variables included male or female child gender, current child age in years, caregiver/respondent education, and annual household income.

Additionally, the total number of "top 9" food allergens (i.e., peanut, tree nut, milk, egg, wheat, shellfish, fin fish, soy, sesame) per child was calculated based on the survey item that asked participants to indicate, "To which food is [child_name] currently allergic?". An indicator was subsequently created to reflect whether the child had multiple (i.e., more than one/only one) current FAs. Food allergy knowledge was evaluated with a 16-point total score based on a 16-item survey that was created, pre-tested, and iteratively revised by a group of pediatric health researchers at Northwestern University/Ann & Robert H. Lurie Children's Hospital. Lastly, the participant's recruitment site was evaluated with a categorical variable.

Statistical Analyses

Descriptive statistics summarized demographics as well as individual survey items. Multivariable logistic regression was used to determine the adjusted probability of access to allergen-free food in relation to a set of independent predictors. To avoid overfitting the model, we included binary indicators for current food allergy type (specific "top 9" FA vs. all other "top 9" FAs) only when a significant crude association with access to allergen-free food was observed. Further, based on the hypothesis that the effect of race on access to allergen free food may vary by income level, cross product terms of race by income were evaluated.

Estimates for survey items with missing data were calculated using the denominator of those who answered the particular survey item. Clustered standard errors were used to account for potential household clustering when more than one child per household was enrolled in the study, which accounted for 6% of the analytic sample. Statistical tests were two-sided with an alpha level of 0.05. All analyses were performed with Stata SE Version 15.1 (College Station, Texas).

Geographic Analyses

The United States Department of Agriculture's (USDA) current definition of a food desert is a "low-income census tract where a substantial number or share of residents has low access to a supermarket or large grocery store." A low-income census tract is defined as "any census tract where (1) the poverty rate for that tract is at least 20 percent, or (2) for tracts not located within a metropolitan area, the median family income for the tract does not exceed 80 percent of statewide median family income; or for tracts located within a metropolitan area, the median family income for the tract does not exceed 80 percent of the greater of statewide median family income or the metropolitan area median family income."⁹ For the purpose of these analyses, "low access" was defined as living more than one mile from a supermarket or large grocery store in urban areas and more than 10 miles from a supermarket or large grocery store in rural areas.⁹ Participant addresses from the analytic sample were geocoded and spatially joined by census tract with data from USDA's Economic Research Service's 2015 Food Access Research Atlas. Each participant was assigned an indicator to reflect living in a census tract flagged by the USDA Economic Research Service (ERS) as a food desert, reflected by the definitions of "low access" and "low-income" above. Descriptive analyses were used to summarize the proportion of the analytic sample living within a low access census tract, and bivariable statistics were used to determine associations with various demographic variables such as race.

Geospatial mapping was used to visualize food deserts within the FORWARD study sites and participant location within each census tract. Food desert and median family income maps were created using Esri's ArcGIS Pro version 2.7.0 software. To visualize median family income, USDA ERS's 2015 Food Access Research Atlas was spatially joined to a census tract boundary shapefile. The median family income variable was divided into five classes with graduated color symbology, using Jenks natural breaks ranging from \$9,091 to \$250,000. Geocoded home addresses of FORWARD participants were overlaid onto the classified median family income variable. For context and clarity, city limit shapefiles and place names were added to the geospatial maps.

Results

Demographics

The demographic characteristics of the study sample are shown in Table I. The analytic sample (n=336) consisted of 70.2% White and 29.8% Black participants. Gender and number of food allergies did not significantly differ by race, but Black children in this cohort were significantly older than White children ($p < 0.001$). Additionally, racial differences in socioeconomic status were observed, with caregivers of Black children having significantly lower annual household income and caregiver educational level in comparison to caregivers of White children ($p < 0.001$). Food allergy knowledge scores were also significantly different by race (White: 11.8[SD=2.6]; Black: 8.8 [SD=2.2]; $p < 0.001$).

Access

In the study, 25.7% of children lived within a low access census tract and 34.0% lived in a low-income tract. Yet, only 5.4% lived within a "food desert" as defined by the USDA, incorporating both low access and low-income census tracts. The majority of children, therefore, did not live within a low

access census tract (74.3%), a low-income census tract (66.0%), or a food desert (94.6%). We did not observe a significant association between living in a low access census tract and race. Specifically, 25% of White children lived within a low access census tract compared to 26% of Black children ($p=0.9$). However, we did observe a significant association between living in a low-income census tract and race (White children: 19.6%; Black children: 68.0%; $p<0.001$). We also observed a significant association between living in a food desert, as defined by the USDA, and race. Specifically, 2.1% of White children lived in a food desert by this definition whereas 13.0% of Black children lived in a food desert ($p<0.001$).

As seen in Table II, significant unadjusted differences in access to allergen-free food were observed by race; White children were more likely to have access in comparison to Black children (White: 88.1%; Black: 59%; $p<0.001$) (Table II). Caregivers of White children were also more likely to purchase allergen-free foods online (35.2%), compared to caregivers of Black children (12%).

Crude Analyses

Table III examines the predictors of access to allergen-free food. In the crude analyses, White race in comparison to Black race (OR: 5.2; 95% CI: 2.9 - 9.2), online food purchase (OR: 6.5; 95% CI: 2.5 - 16.8), household annual income of \$50,000 to \$100,000 (OR: 5.3; 95% CI: 2.3 - 14.8), or greater than \$100,000 (OR: 8.2; 95% CI: 4.1 - 16.4) in comparison to less than \$50,000, parents having a Bachelor's (OR: 5.6; 95% CI: 2.6 - 11.9), Master's (OR: 5.5; 95% CI: 2.7 - 11.4) or Professional/Doctorate degree (OR: 7.3 95% CI: 2.6 - 20.8) in comparison to a high school degree, and having multiple food allergies (OR:1.9; 95% CI: 1.1 - 3.2) were significantly associated with access to allergen-free food. Additionally, we observed a crude association between access to allergen-free food and current peanut (OR: 1.8; 95% CI: 1.1 - 3.2), finfish (OR: 0.4; 95% CI: 0.2 - 0.8), and milk (OR: 4.1; 95% CI: 1.8 - 9.4) allergies in comparison to other "top 9" food allergies. Living in a food desert was not associated with access to allergen-free foods (OR: 0.9; 95% CI: 0.3 -

2.9). Specifically, among children living in a food desert, 77.8% had access to allergen-free foods, whereas among children not living in a food desert, 79.5% had access ($p=0.9$). Further, we observed a significant association between FA knowledge score and access (OR: 1.2; 95% CI: 1.1 - 1.3).

Adjusted Analyses

After adjustment for gender, age, multiple food allergies, current peanut, finfish, and milk allergies, household income, parental education, FA knowledge score, and recruitment site, the magnitude of the odds ratio for race decreased but remained borderline significant (OR: 2.4; 95% CI: 0.9 - 6.6). Specifically, White children were 2.4 times as likely to have access to allergen-free foods compared to Black children ($p=0.08$). Other strong predictors included online access (OR: 2.5; 95% CI: 0.9 - 7.5), current milk allergy (OR: 4.9; 95% CI: 1.7 - 13.8), and current child age of above 5 years (OR: 2.3; 95% CI: 1.1 - 4.8). Socioeconomic status was also strongly associated with access, including annual household income of \$50,000 to \$100,000 (OR: 2.9; 95% CI: 0.9 - 9.3) or greater than \$100,000 (OR: 2.5; 95% CI: 0.9 - 7.2), in comparison to less than \$50,000. Respondents with a Bachelor's degree were 2.9 times as likely than those with a high school degree to have access to allergen free foods (OR: 2.9; 95% CI: 1.1 - 7.8). Likewise, in comparison to respondents with a high school degree, respondents with a Master's or Professional/Doctorate degree were 1.9 (95% CI: 0.7 - 4.9) and 2.5 (95% CI: 0.7 - 8.7) times as likely to have access to allergen-free foods, respectively. Finally, we tested the cross-product of race by income level, but did not observe a statistically significant interaction ($p > 0.05$).

Discussion

To our knowledge, this is one of the first studies in a diverse sample to identify that access to allergen-free foods is significantly lower in Black children compared to White children with FA. We found both race and socioeconomic status to be significant predictors of access to allergen-free food.

Racial differences in access to allergen-free foods exist, but much of the difference is accounted for by socioeconomic status and other participant characteristics. Income in particular is a strong predictor of access to allergen-free foods. This underscores the high financial cost of specialty foods for children with food allergies. Polk and colleagues reported that on average, allergen-free products cost two to four times more than traditional foods containing common allergens and gluten.¹⁰ The high financial cost of gluten-free and wheat-free products is especially pertinent to Black children as prior studies from our group have shown a trend towards a higher rate of allergy to wheat among Black children compared to their white counterparts.^{4, 8}

In 2013, Gupta et al reported the overall estimated cost of FA at \$24.8 billion annually, or an average of \$4,184 per year per child.¹¹ Bilaver and colleagues further quantified the degree of racial and socioeconomic disparities in direct medical and out-of-pocket costs associated with FA. They found that low-income children spent 2.5 times as much on ED and hospitalization costs due to FA compared to high-income children, but spent significantly less on specialist visits and out-of-pocket costs for preventative measures. They also found that Black children with FA had the lowest levels of direct medical and out-of-pocket costs.¹²

In addition to race and socioeconomic status, current milk allergy was found to be a significant predictor of access to allergen-free foods, even when adjusting for socioeconomic variables. Although cow's milk is commonly consumed during early childhood, alternatives are widely available. With increasing preference for vegan and vegetarian dietary habits, plant-based milk alternatives are becoming more common for families. Additionally, milk substitutes are not only easily found in grocery stores but can also be more easily obtained through food assistance programs.¹³

Study findings also suggest that better FA knowledge is associated with higher reported access to allergen-free food. Increasing knowledge of FA may facilitate improved access if families understand how to read and interpret precautionary allergen labels, where to find allergen-free foods, and how to

incorporate these foods into the diet. This finding serves to emphasize the importance of the allergy clinician and multidisciplinary team in prioritizing FA education as a fundamental standard of FA management.

The definition of food desert used in this analysis was consistent with the USDA's definition of "low access" and "low-income" reported previously.⁹ Based on geospatial mapping data, we found that the majority of study participants did not live within a food desert. Surprisingly, there was no association between living in a food desert and access to allergen free food. Living in a food desert may not have been associated with access to allergen-free food as the majority of participants in the study live in metropolitan areas where public transportation is easily available. Respondents living in rural or suburban areas may have also had access to private transportation to the nearest grocery store or supermarket.

Reasons for the variability in findings regarding access to allergen-free foods could be related to location of Black families' residences compared to those of White families, and their proximity to local grocery stores or supermarkets that carry allergen-free foods. One possible explanation for why living in a food desert was not associated with access to allergen-free food could be related to online purchasing of allergen-free foods, which was reported in 28.3% of survey respondents (35.2% for caregivers of White children compared to 12% for caregivers of Black children). We found that online food purchasing is an important predictor of access to allergen-free food, regardless of race and socioeconomic status. Since the definition of food desert is based on access to a supermarket or grocery store, online allergen-free food purchases may overcome geographical limitations to accessing safe food for individuals with food allergy residing in food deserts. For this to be true, one must also assume that the individual has reliable Internet access and the ability to have packages safely delivered to home addresses. In this sample, participants' reporting of purchasing allergen-free foods online unfortunately does not distinguish between their ability to either afford or access these types of electronic purchases. Some potential barriers to accessing or purchasing allergen-free foods

online could be attributed to the inability to purchase allergen-free food digitally, financial constraints associated with debit or credit card purchases, higher cost of online food purchases and associated delivery fees, and geographical limitations for grocery deliveries.

One limitation of the current study is that although the study identified no relationship between living in a food desert and access to allergen-free foods, this does not completely address the question of food insecurity. The USDA defines food insecurity as “a household-level economic and social condition of limited or uncertain access to adequate food.” For the purpose of this study, we did not analyze food security survey items. Instead, we use SES and residence within a food desert as a proxy. One study in a tertiary care pediatric allergy population found that having both milk and egg allergy were risk factors for food insecurity.¹⁴ As previously reported, Black children with FA are more likely to report low food security.¹⁵

The geographic variability in food security could also partially address the pattern of food desert residence seen in our cohort. In the USDA 2019 report on Household Food Security in the United States, the prevalence of food insecurity was higher than the national average in the state of Ohio, lower than the national average in the state of Illinois, and not significantly different from the national average in the District of Columbia.¹⁶

Study authors also acknowledge that the definition of allergen-free food can be variable among individuals with food allergies. Interpretation of precautionary allergen labeling is difficult to investigate with the current survey format, but may provide more insight with additional qualitative interviewing. The FORWARD study is informative in discovering how families of children with food allergies interpret what is meant by an allergen-free food. The authors also acknowledge that healthy allergen-free foods can be difficult to access for some families. Although this study survey did not explicitly inquire about healthy foods, it is important to emphasize that health food for all is the ideal.

This study identified significant racial and socioeconomic differences in access to allergen-free foods among caregivers of children with FA. Future studies are needed to examine whether the socioeconomic disparities are related to the high cost of allergen-free food. Online food purchases were found to be significantly associated with greater access to allergen-free foods, suggesting that education of caregivers regarding online food purchasing may be an important intervention for future investigation. Given that allergen avoidance is a key component of FA self-management, future studies should also examine whether limited access to allergen-free foods negatively influences FA-related clinical outcomes.

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Table I. Demographic and clinical characteristics of White and Black FORWARD participants at 6 months post-intake

	Total (n=336)		White (n=236)		Black (n=100)		P-Value*
Characteristic	n	%	n	%	n	%	
Gender							
Female	114	33.9	79	33.5	35	35	0.8
Male	222	66.1	157	66.5	65	65	
Current age (categories)							
<=5 years	116	34.5	97	41.1	19	19	< 0.001
> 5 years	220	65.5	139	58.9	81	81	
Current Age (median)							
Median Age	336	6.5	236	5.6	100	8	< 0.001
"Top 9" Food Allergies							
One	125	37.2	92	39	33	33	0.3
One or more	211	62.8	144	61	67	67	
Type of Food Allergy							
Peanut	223	66.4	156	66.1	67	67	0.9
Tree nut	170	50.6	112	47.5	58	58	0.08
Finfish	37	11	13	5.5	24	24	< 0.001
Shellfish	47	14	16	6.8	31	31	< 0.001
Milk	92	27.4	71	30.1	21	21	0.09
Egg	147	43.8	105	44.5	42	42	0.7
Wheat	32	9.5	16	6.8	16	16	0.008
Soy	26	7.7	14	5.9	12	12	0.06
Sesame	61	18.2	51	21.6	10	10	0.01
Annual Household Income							
Less than \$50,000	59	17.6	10	4.2	49	49	< 0.001
\$50,000 to \$100,000	50	14.9	29	12.3	21	21	
Greater than \$100,000	193	57.4	173	73.3	20	20	

	Missing/Unknown	34	10.1	24	10.2	10	10	
Caregiver/Respondent Education Level								
Less than Bachelor's Degree		76	22.6	21	8.9	55	55	< 0.001
Bachelor's Degree		98	29.2	79	33.5	19	19	
Master's Degree		112	33.3	92	39	20	20	
Professional or Doctoral Degree		48	14.3	44	18.6	4	4	
Missing/Unknown		2	0.6	0	0	2	2	
Reside in Food Desert (Low Access/Low Income Census Tract) #								
	Yes	18	5.4	5	2.1	13	13	< 0.001
	No	317	94.6	230	97.9	87	87	
Reside in Low Access Census Tract[#]								
	Yes	86	25.7	61	26	25	25	0.9
	No	249	74.3	174	74	75	75	
Reside in Low Income Census Tract[#]								
	Yes	114	34	46	19.6	68	68	< 0.001
	No	221	66	189	80.4	32	32	
* P-value for significance of chi-squared independence test between item and child race (Black or White).								
# One observation was missing for these analyses (total n=335)								

Table II. Access to allergen-free foods among White and Black FORWARD participants at 6 months post-intake

[illegible]

Table III. Crude and adjusted relationships between race and access to allergen-free foods

	Access to allergen-free foods (n=336)			Access to allergen-free foods (n=302)*		
	Crude OR	95% CI	P-Value	Adjusted OR	95% CI	P-Value
Race						
Black (reference)	1.0	–	–	1.0	–	–
White	5.2	2.9 - 9.2	< 0.001	2.4	0.9 - 6.6	0.08
Online Access to Allergen-Free Foods						
No (reference)	1	–	–	1.0		
Yes	6.5	2.5 - 16.8	< 0.001	2.5	0.9 - 7.5	0.09
Living within Food Desert						
No (reference)	1.0	–	–	1.0	–	–
Yes	0.9	0.3 - 2.9	0.9	2.1	0.6 - 7.9	0.3
Household Income Level						
Less than \$50,000 (reference)	1.0	–	–	1.0	–	–
\$50,000 to \$100,000	5.8	2.3 - 14.8	< 0.001	2.9	0.9 - 9.3	0.07
Greater than \$100,000	8.2	4.1 - 16.4	< 0.001	2.5	0.9 - 7.2	0.09
Parental Education						
High school degree (reference)	1.0	–	–	1.0	–	–
Bachelor's degree	5.6	2.6 - 11.9	< 0.001	2.9	1.1 - 7.8	0.03
Master's degree	5.5	2.7 - 11.4	< 0.001	1.9	0.7 - 4.9	0.2
Professional/Doctoral degree	7.3	2.6 - 20.8	< 0.001	2.5	0.7 - 8.7	0.2
Gender						
Male (reference)	1.0	–	–	1.0	–	–
Female	1.0	0.6 - 1.8	0.9	1.1	0.5 - 2.1	0.8
Current Age Category (years)						
<=5 years (reference)	1.0	–	–	1.0	–	–
> 5 years	1.4	0.8 - 2.4	0.3	2.3	1.1 - 4.8	0.03
Multiple FA #						
Single FA # (reference)	1.0	–	–	1.0	–	–

Multiple FA #	1.9	1.1 - 3.2	0.03	1.2	0.5 - 2.9	0.7
Type of FA #						
Peanut	1.8	1.1 - 3.2	0.03	1.2	0.5 - 2.8	0.7
Finfish	0.4	0.2 - 0.8	0.007	0.8	0.3 - 1.9	0.6
Milk	4.1	1.8 - 9.4	< 0.001	4.9	1.7 - 13.8	0.003
FA# Knowledge Score (continuous)	1.2	1.1 - 1.3	< 0.001	1.0	0.9 - 1.2	0.8
Recruitment Site						
Northwestern/Lurie (reference)	1.0	–	–	1.0	–	–
Rush	0.4	0.2 - 0.8	0.01	0.5	0.2 - 1.5	0.2
Cincinnati	0.7	0.3 - 1.4	0.3	0.6	0.2 - 1.9	0.4
DC	0.7	0.3 - 1.5	0.4	0.6	0.3 - 1.6	0.3

* There were 34 missing observations for income, which were excluded from the adjusted analyses.

FA (Food Allergy)