

Epidemiology of childhood peanut allergy

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ABSTRACT

Although peanut allergy is among the most common food allergies, no study has comprehensively described the epidemiology of the condition among the general pediatric population. Our objective was to better characterize peanut allergy prevalence, diagnosis trends, and reaction history among affected children identified from a representative sample of United States households with children. A randomized, cross sectional survey was administered to parents from June 2009 to February 2010. Data from 38,480 parents were collected and analyzed in regard to demographics, allergic symptoms associated with food ingestion, and methods of food allergy diagnosis. Adjusted models were estimated to examine association of these characteristics with odds of peanut allergy. Of the 3218 children identified with food allergy, 754 (24.8%) were reported to have a peanut allergy. Peanut allergy was reported most often among 6- to 10-year-old children (25.5%), white children (47.7%), and children from households with an annual income of \$50,000–\$99,999 (41.7%). Although peanut allergy was diagnosed by a physician in 76% of cases, significantly more peanut allergy reactions were severe as compared with reactions to other foods (53.7% versus 41.0%, $p < 0.001$). Parents were significantly less likely to report tolerance to peanut as compared with the odds of tolerance reported for other foods (odds ratio 0.7, 95% confidence interval: 0.5–0.9). Childhood peanut allergy, which represents nearly a quarter of all food allergy, presents more severe reactions and is least likely to be outgrown. Although it is diagnosed by a physician in nearly three-fourths of all cases, socioeconomic disparities in regard to diagnosis persist.

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Food allergy affects 8% of children in the United States and is a condition of emerging public health importance (United States).¹ Among food allergic children, peanut allergies are one of the most common¹ and rarely outgrown allergies.^{2–5} Furthermore, current research suggests that rates of peanut allergy are increasing.^{1,6–8} Although food allergies manifest in symptoms ranging from mild-to-moderate to severe, allergic reactions to peanuts account for the majority of life-threatening anaphylaxis^{8–11} as well as the largest proportion of fatalities due to food allergy among children.⁹

The omnipresent nature of peanuts in the American diet makes them extremely difficult to avoid in environments where children live, learn, and play.¹² As such, there is an ongoing risk of exposure for peanut allergic children, which places a significant psycholog-

ical burden on families as well as the children themselves.^{13–15} Furthermore, childhood peanut allergies have been known to impair overall quality of life by limiting participation in social activities and negatively impacting family finances.^{15,16}

Previous studies describing the epidemiology of peanut allergy are typically limited by the size of the population studied or include a mixed population of children and adults.^{6,8,10,17,18} Thus, the goal of this study was to better characterize reports of peanut allergy, diagnosis trends, and reaction history among affected children identified from a representative sample of over 40,000 households with children.

METHODS

A representative sample of food allergic children was identified through a randomized, cross sectional survey of over 40,000 United States households conducted between June 2009 and February 2010. The study protocol was approved by the Institutional Review Boards of Ann and Robert H. Lurie Children's Hospital of Chicago and Northwestern University in Chicago, IL. Consent to participate was implicit in completion and return of the survey.

Survey Development and Design

Pediatricians, pediatric allergists, and health service researchers developed the survey with support of an expert panel comprised of leaders in food allergy. A detailed description of the survey methodology is

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available in Gupta *et al.*¹ The final survey was administered electronically and is available upon request. Items assessed caregiver report of date of onset, method of diagnosis, and reaction history for each allergen. Detailed demographic information was also collected.

Study Participants and Recruitment

Adults (more than or equal to 18 years) residing in United States households with at least one child under 18 years of age were eligible to complete the survey in Spanish or English. Participants were instructed to complete the survey on behalf of a child within the household randomly selected by computer algorithm. Participant data from a probability-based sample statistically representative of United States households with children were used to correct for bias introduced by data obtained from a larger dual-sampling approach. Recruitment and weighting schemes are described in Gupta *et al.*¹

Outcome Measures

A peanut allergy was included in the analysis if it was reported to induce one or more of the next reaction symptoms: anaphylaxis (defined as a severe allergic reaction that can lead to death), angioedema of lips/eyes/face, other angioedema, coughing, other oropharyngeal symptoms, eczema, flushing, hives, low blood pressure, pruritus, trouble breathing, vomiting, or wheeze.

Allergies were further analyzed based on diagnostic and reaction history. Diagnostic history included whether or not the allergy was formally diagnosed by a physician and, if so, whether it had been confirmed with a serum-specific IgE test (blood test), a skin-prick test (skin test), and/or an oral food challenge (OFC). Reaction history included age at first reaction, history of seasonal rhinitis, multiple food allergies, and severity of reaction.

Mild-to-moderate reactions were limited to angioedema of the lips/eyes/face, other angioedema, coughing, other oropharyngeal symptoms, eczema, flushing, hives, pruritus, and vomiting. A reaction including vomiting, angioedema, and coughing in combination was also categorized as severe.

Statistical Analysis

In addition to peanut allergy alone, data for the most common food allergens (peanut, tree nut, shellfish, fin fish, milk, egg, soy, wheat, and sesame) were combined and used as a comparison group representing food allergy in general. Data for peanut allergy were also compared with each individual allergen listed above. Analyses were performed at the level of the allergy; multiple observations were made for subjects with

multiple food allergies. The characteristics of the food allergies, prevalence of symptoms, and outcome measures were calculated as weighted proportions.^{19,20} Multiple logistic regression models were adjusted for multiple observations per subject, and survey design and sample weights were estimated to examine association of child characteristics and reaction history with odds of having a peanut allergy compared with the other common allergens.

A model was also estimated to examine associations between child demographic characteristics and reaction history with having a severe reaction history to peanuts, as compared with a mild-to-moderate reaction history. Each model was adjusted for household income, race/ethnicity, age at time of reaction, geographic region, gender, severity of allergy, report of seasonal rhinitis, and report of multiple food allergies. The model comparing mild-to-moderate versus severe peanut allergy included physician diagnosis and diagnostic testing of the allergy. All analyses were conducted using STATA 11.0 (StataCorp LP, 2013, College Station, TX).

RESULTS

Data were collected for over 40,000 children. After incomplete responses were excluded, a final sample size of 38,480 children was examined. From this sample, 754 children were identified with peanut allergy and included in the analysis. The comparison group included 2464 children with food allergy in general.

Demographic Characteristics

Demographic characteristics of children with reported peanut allergy and children in the comparison group are presented in Table 1. Peanut allergy was evenly distributed by gender but was reported most often among children 6–10 years old (25.5%) and least often among children 0–2 years old (11.9%). Race/ethnicity was mutually exclusive, with 47.7% of reported peanut allergy occurring in White, non-Hispanic children, 23.6% in Black, non-Hispanic children, 17.9% in Hispanic children, and 8.1% in Asian, non-Hispanic children. Over 40% of children with a peanut allergy resided in households with an annual income of \$50,000–\$99,999. The demographic characteristics for children with other food allergies were similarly distributed.

Prevalence and Severity

The overall prevalence of parent-reported peanut allergy was 2.0% (95% confidence interval [CI]: 1.8–2.1), which represents 24.8% of all parent-reported food allergies (95% CI: 23.0–26.8) (Table 2). Prevalence did not significantly differ by racial/ethnic group, gender, age, or household income. Among children with addi-

Table 1. Demographic characteristics of parent-reported peanut allergy and other parent-reported food allergy among children

Variable	Frequency, % (95% CI)	
	Peanut Allergy <i>n</i> = 754	Other Food Allergies* <i>n</i> = 2464
Age (in years)		
0–2	11.9 (9.2–15.4)	12.6 (10.8–14.6)
3–5	23.8 (20.1–28.0)	19.3 (16.8–22.0)
6–10	25.5 (21.8–29.6)	25.9 (23.3–28.8)
11–13	19.3 (16.0–23.0)	19.4 (17.0–22.1)
14–17	19.4 (16.4–23.0)	22.9 (20.4–25.5)
Gender		
Female	47.8 (43.4–52.3)	47.8 (44.7–50.9)
Male	52.2 (47.7–56.6)	52.2 (49.1–55.4)
Race/ethnicity		
Asian, non-Hispanic	8.1 (5.5–9.2)	7.1 (5.5–9.2)
Black, non-Hispanic	23.6 (19.2–25.0)	22.0 (19.2–25.0)
White, non-Hispanic	47.7 (43.4–52.1)	49.0 (45.9–52.1)
Hispanic	17.9 (14.4–22.0)	18.6 (16.0–21.7)
Multiple/other, non-Hispanic	2.7 (1.9–3.9)	3.3 (2.5–4.3)
Annual household income		
<\$25,000	14.4 (11.2–18.4)	15.1 (12.9–17.6)
\$25,000–\$49,999	23.9 (20.–28.1)	27.0 (24.1–30.1)
\$50,000–\$99,000	41.7 (37.5–46.0)	35.2 (32.4–38.1)
\$100,000–\$149,999	13.3 (10.6–16.4)	14.4 (12.4–16.7)
≥\$150,000	6.8 (4.9–9.4)	8.3 (6.6–10.4)

95% CI = 95% confidence interval; *n* = sample size.

*Includes the eight most common food allergies identified in the sample (shellfish, tree nut, fin fish, milk, egg, soy, wheat, and sesame), without peanut allergy.

tional allergies, tree nut (15.6%) and shellfish (13.3%) allergies were most often implicated. Nearly 50% of children also reported a comorbid seasonal allergy.

More than half of all cases of peanut allergy involved severe reactions (53.7%, 95% CI: 49.2–58.1), which is significantly higher when compared with all food allergies (53.7% versus 41.0%, $p < 0.001$). Odds of severe peanut allergy were significantly higher among children with one additional food allergy (odds ratio [OR] 1.7, 95% CI: 0.9–3.1). Odds of severe reaction also trended upwards with age as children with peanut allergy aged 11–17 years were more likely to experience a severe reaction when compared with children aged zero to two years (see table 4 below).

Diagnosis

Peanut allergy was formally diagnosed by a physician in 76.0% of cases (Table 3). Among those diagnosed peanut allergy, 50.3% of cases were assessed by a skin test, 44.8% by a blood test, and 20.0% by an OFC. Odds of physician diagnosis were significantly higher for children with peanut versus other food allergies (OR 1.34, 95% CI: 1.0–1.7). However, children living in

a household with an annual income of less than \$50,000 had significantly lower odds of receiving formal diagnosis as compared with children living in a household with an annual income of greater than \$50,000 (OR 0.6, 95% CI: 0.3–0.9). Odds of undergoing an OFC were significantly higher among peanut allergic children with one additional food allergy (OR 1.7, 95% CI: 1.0–3.0) (Table 4).

Reaction History

Caregivers reported his/her child's first reaction to peanut at a mean age of 3.6 years (95% CI: 3.4–3.8). Children most often presented with hives (63.1%), angioedema (53.6%), and trouble breathing (35.2%) (Table 2). These symptoms, along with anaphylaxis, were observed significantly more often in children with peanut versus other food allergies. Gastrointestinal symptoms (e.g., diarrhea, vomiting) were significantly less common presentations of peanut allergy.

Among children with former peanut allergy, parents reported that their child outgrew his/her allergy at a mean age of 6.6 years (95% CI: 5.8–7.5). Parents of children with peanut allergy had significantly lower

Table 2. Prevalence, severity, and symptoms of parent-reported peanut allergy and other parent-reported food allergy among children

Variable	Frequency, % (95% CI)		<i>p</i> Value
	Peanut Allergy	Other Food Allergy	
Multiple Food Allergies			
Milk	10.8 (8.3–14.0)	14.1 (11.8–16.8)	0.0623
Fin fish	4.0 (2.6–6.0)	6.4 (5.0–8.2)	0.0227
Tree nut	15.6 (12.7–19.1)	12.1 (9.9–14.8)	0.0330
Shellfish	13.3 (10.2–17.1)	13.3 (11.0–16.0)	0.9958
Egg	8.5 (6.3–11.4)	9.3 (7.4–11.6)	0.5729
Soy	3.6 (2.4–5.4)	6.0 (4.4–8.0)	0.0207
Wheat	3.6 (2.3–5.4)	6.9 (5.2–9.0)	0.0034
Sesame	3.0 (1.8–4.9)	3.2 (2.3–4.4)	0.8000
Seasonal allergy (yes)			
Summer	48.7 (44.3–53.2)	52.8 (49.7–55.9)	0.0856
Fall	25.1 (21.4–29.2)	29.2 (26.3–32.2)	0.0600
Spring	25.7 (22.1–29.7)	27.6 (24.8–30.5)	0.3693
Winter	31.3 (27.4–35.6)	32.4 (29.4–35.5)	0.6295
Prevalence			
Among food allergic children	24.8 (23.0–26.8)	–	–
Among all children	2.0 (1.8–2.1)	–	–
Severity			
Severe	53.7 (49.2–58.1)	41.0 (38.3–43.8)	0.0000
Symptoms			
Hives	63.1 (58.6–67.3)	50.0 (47.2–52.8)	0.0000
Eczema	27.7 (23.9–31.9)	32.1 (29.4–34.9)	0.0554
Wheezing	32.3 (28.4–36.6)	24.2 (21.9–26.8)	0.0002
Low blood pressure	5.8 (4.1–8.2)	5.7 (4.5–7.1)	0.9093
Anaphylaxis	14.2 (11.4–17.5)	8.1 (6.7–9.7)	0.0000
Trouble breathing	35.2 (31.1–39.6)	25.1 (22.7–27.7)	0.0000
Swelling of lips, eyes, or face	53.6 (49.2–58.0)	34.2 (31.7–36.8)	0.0000
Vomiting	22.8 (19.2–26.8)	32.5 (29.9–35.2)	0.0000
Diarrhea	9.6 (7.3–12.6)	25.7 (23.3–28.3)	0.0000
Coughing	17.4 (14.3–21.0)	15.4 (13.4–17.7)	0.2644

95% CI = 95% confidence interval.

odds of reporting tolerance compared with the odds of tolerance reported for other food allergies (OR 0.7, 95% CI: 0.5–0.9).

DISCUSSION

To our knowledge, this was the first study to comprehensively describe prevalence, severity, diagnosis trends, reaction history, and tolerance among peanut allergic children from a large, representative sample of United States households. Peanut allergy was reported among 2% of all children and 25% of food allergic children. Additionally, this study looked at severity, diagnosis, symptoms, and tolerance of peanut allergy and compared these results with what has previously been reported in the literature.

Regarding the prevalence and severity of pediatric peanut allergy, the results of this study are consistent

with previous research findings where studies, both in the United States and abroad, have reported the prevalence of peanut allergy to range between 1% and 2%.^{21–25} Although a previous study found peanut to be the third most prevalent pediatric food allergen,²⁶ this study found it to be the most common allergen in a large, national sample. Additionally, over half of all peanut-induced reactions were severe, which is significantly greater than the percentage of severe allergic reactions induced by other foods. This is consistent with other research reporting severe peanut-induced reactions, including anaphylaxis, at a higher rate than severe reactions to other allergenic foods.^{10,18,25,27,28} The current study also found that severe peanut allergy reactions were more likely among children with multiple food allergies and among older children/adolescents. Increasing severe reactions among older chil-

Table 3. Diagnosis of parent-reported peanut allergy and other parent-reported food allergy among children

Variable	Frequency, % (95% CI)		<i>p</i> Value
	Peanut Allergy	All Food Allergy*	
Physician diagnosis?			
Yes	76.0 (71.9–79.7)	68.5 (65.8–71.2)	0.0012
Yes, with testing	55.7 (51.2–60.1)	44.8 (41.9–47.7)	0.0000
Yes, without testing	20.3 (16.8–24.4)	23.8 (21.4–26.3)	0.1041
No	24.0 (20.3–28.1)	31.5 (28.9–34.2)	0.0012
Tests performed**			
Skin test	50.3 (45.2–55.3)	46.3 (42.8–49.7)	0.1487
Blood test	44.8 (40.0–49.8)	38.1 (34.8–41.6)	0.0154
Oral food challenge	19.8 (15.9–24.4)	20.4 (17.7–23.3)	0.7917

95% CI = 95% confidence interval.

*Includes the eight most common food allergies identified in the sample (shellfish, tree nut, fin fish, milk, egg, soy, wheat, and sesame), without peanut allergy.

**Among physician-diagnosed allergy only.

dren has been shown previously^{9,11,29,30} and can potentially be attributed to the food allergy risk-taking behavior of adolescents.^{31–34}

Recent National Institute of Allergy and Infectious Disease guidelines and additional studies state that although the specific IgE and skin-prick test and useful diagnostic tools, an OFC is still the best method for arriving at an accurate and conclusive diagnosis.^{35–37} Unfortunately, diagnosis information by specific allergen is not readily available. However, this study determined that peanut allergy was diagnosed by a physician in more than 75% of reported cases. The peanut allergy diagnosis was confirmed by a skin test in 50.3%, by a blood test in 44.8% of cases, and by an OFC in 20.0% of cases. Although peanut allergy was more likely to be diagnosed than other food allergies, children from lower income households were less likely to be diagnosed than children whose annual household income was greater than \$50,000. This socioeconomic disparity in diagnosis is not uncommon and has been reported by previous studies.^{1,25} Furthermore, socioeconomically disadvantaged children with peanut allergy who remain undiagnosed are less likely to have written emergency action plans and/or access to life-saving medication.^{25,38} It is critical for all children to obtain a physician-verified peanut allergy diagnosis to receive proper testing and accurate diagnosis, as well as a management plan and epinephrine in case of an accidental ingestion.

The age at which parents reported their child's first reaction to peanut in this study was between three and four years, on average. Interestingly, some research of the general pediatric population has reported first reaction age as young as 14 months,^{22,39} whereas other studies have reported peanut allergy onset between the ages of two and three years.²⁴ We also found that

children with an allergic reaction to peanut most often presented with symptoms such as hives, angioedema, and trouble breathing, whereas gastrointestinal symptoms such as diarrhea and vomiting were less common. Hives, angioedema, and trouble breathing, as well as anaphylaxis, occurred significantly more often in children with peanut allergy as compared with other food allergies. The findings of this study are consistent with previously reported research on peanut allergy reaction history, particularly as it pertains to involving multiple organ systems. According to one study, two organ systems were impacted by 31% of peanut-induced reactions, whereas three systems were affected 21% of the time.⁴⁰ Additionally, a study conducted in France determined that almost 90% of reactions presented in symptoms of the skin, whereas only 3% involved the gastrointestinal system.⁴¹ Based on the involvement of multiple organ systems of the human body, it is clear that peanut-induced allergic reactions are typically more severe, as noted above.

Among children who had outgrown their peanut allergy at the time of this study, parents reported a mean tolerance age of 6.6 years. This finding is consistent with previously reporting tolerance findings stating that 20% of children who outgrow their peanut allergy do so by the time they reach school age.^{4,5,42} However, the odds of children outgrowing their peanut allergy were found by this study to be significantly lower than the odds of children developing tolerance to another previously allergenic food. The results of this study corroborate what has been previously reported on the development of tolerance to peanut as compared with the development of tolerance to other foods. For example, it is readily accepted that many children outgrow allergies to egg, milk, wheat, and soy; however, peanut, tree nut, and seafood allergies follow many individuals into adult-

Table 4. Odds of parent-reported peanut allergy, severity, physician diagnosis, and oral food challenge confirmation

Variable	Frequency, % (95% CI)			
	Peanut Allergy	Peanut Allergy with Severe Reaction History	Peanut Allergy with Physician Diagnosis	Peanut Allergy with Oral Food Challenge
Age versus 0–2 years				
3–5	1.3 (0.9–1.9)	0.9 (0.4–2.0)	1.0 (0.5–2.2)	0.6 (0.3–1.6)
6–10	1.1 (0.7–1.5)	1.1 (0.5–2.3)	2.0 (0.9–4.4)	0.6 (0.3–1.5)
11–13	1.1 (0.7–1.5)	1.3 (0.6–2.8)	1.6 (0.7–3.4)	0.6 (0.2–1.4)
14–17	1.0 (0.6–1.3)	1.3 (0.6–2.7)	1.2 (0.6–2.7)	0.6 (0.2–1.6)
Gender				
Male versus female	1.0 (0.8–1.2)	1.1 (0.8–1.6)	0.9 (0.6–1.4)	0.7 (0.4–1.2)
Race/ethnicity versus white, non-Hispanic				
Asian, non-Hispanic	1.1 (0.8–1.6)	0.5 (0.2–1.2)	0.1 (0.1–0.3)	0.2 (0.0–1.2)
Black, non-Hispanic	1.2 (0.9–1.5)	0.8 (0.4–1.3)	0.7 (0.4–1.3)	1.0 (0.5–2.0)
Hispanic	1.0 (0.8–1.3)	0.9 (0.5–1.5)	0.5 (0.3–0.9)	0.8 (0.4–1.8)
Multiple/other, non-Hispanic	0.9 (0.6–1.3)	0.8 (0.4–1.8)	0.6 (0.2–1.6)	0.5 (0.1–1.9)
Annual Household Income				
<\$50,000 versus ≥\$50,000	0.9 (0.7–1.0)	0.7 (0.5–1.1)	0.6 (0.3–0.9)	1.3 (0.7–2.2)
Comorbid food allergies versus peanut only				
1 additional food allergy	—	1.6 (1.0–2.5)	1.2 (0.7–2.0)	1.7 (1.0–3.0)
≥2 additional food allergies	—	1.7 (0.9–3.1)	1.3 (0.6–2.7)	1.5 (0.7–3.0)
Comorbid seasonal rhinitis versus none	0.8 (0.7–1.0)	1.5 (1.0–2.2)	1.1 (0.7–1.7)	2.3 (1.4–3.8)
Testing and diagnosis				
Diagnosis only, no testing	—	1.5 (0.8–2.7)	—	—
Testing with diagnosis	—	3.2 (2.0–5.3)	—	—

Adjusted for all variables listed in the table; bold values indicate $p < 0.05$.
95% CI = 95% confidence interval.

hood.^{43–46} Because peanut allergy is likely to be a lifelong condition among those it affects, it is necessary to provide accurate diagnoses, proper management, and ongoing support to peanut allergic individuals, particularly children.

This study is not without limitations. The large, opt-in online sample included in this dual sample approach may have resulted in selection bias. However, the probability-based, statistically representative sample of United States households with children was used to reduce this bias. In addition, the parent-reported nature of peanut allergy identification may have been subject to recall bias. Although peanut allergy identification was not confirmed through skin test, blood test, OFC, or patient chart review, parent-reported peanut and food allergy was only considered valid if specific reaction symptom criteria, previously developed by an expert panel, were met. Furthermore, parent-reported peanut allergies were stratified into

three categories based on the validity of the diagnosis: physician diagnosis confirmed with testing, physician diagnosis without testing, and parent-reported without physician diagnosis.

CONCLUSION

Childhood peanut allergy is a serious and increasingly prevalent chronic condition in the United States. Peanut allergy is the most common type of food allergy, impacting nearly 25% of food allergic children. Although peanut allergy is more likely to be diagnosed by a physician when compared with other food allergies, peanut allergic children often experience severe reactions more frequently and are less likely to outgrow their allergy. The severity of many peanut allergies coupled with the high likelihood of not developing tolerance to peanuts negatively impacts the quality of life for many food allergic children and their fami-

lies. As a result, efforts are needed to improve general awareness and lifelong management of peanut allergy so that affected individuals are able to lead a safe, productive, and happy life not inhibited by the constant fear of a severe allergic reaction.

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