

Prevalence and characteristics of peanut allergy in US adults

Christopher Warren, PhD,^{a,b,*} Dawn Lei, MD,^{c,d,*} Scott Sicherer, MD,^e Robert Schleimer, PhD,^c and Ruchi Gupta, MD, MPH^{a,d} *Chicago, Ill; Stanford, Calif; and New York, NY*

Background: Peanut allergy (PA) is the leading pediatric food allergy and a common cause of anaphylaxis. Little is known, however, on the prevalence and characteristics of PA in the adult population and whether phenotypic differences exist between adult-onset and childhood-onset PA.

Objectives: This study describes the current US population-level burden of adult PA.

Methods: A cross-sectional food allergy survey was administered via phone and web in 2015 and 2016, resulting in nationally representative complex-survey weighted data for 40,443 adults. Reported food allergies were considered “convincing” if symptoms to specific allergens were consistent with an IgE-mediated reaction.

Results: The prevalence of current self-reported PA was 2.9% among US adults, with 1.8% having convincing PA. Over 17% of adults with peanut allergy reported onset of their PA in adulthood. In adults with childhood-onset PA, 75.4% reported physician-diagnosed PA, compared with only 58.9% of adult-

onset PA. Despite a similar frequency of food allergy–related emergency department visits within the past year (approximately 1 in 5 adults with PA allergy), adults with childhood-onset PA were significantly more likely to have a current epinephrine prescription compared with those with adult-onset PA (56% vs 44% respectively; $P = .02$) and were more likely to use an epinephrine autoinjector (48% vs 35%, $P = .01$).

Conclusions: Approximately 4.6 million US adults have PA—over 800,000 of whom appear to have developed their PA after age 18 years. Further examination of phenotypic differences between childhood-onset and adult-onset PA may improve understanding and management of adult PA. (*J Allergy Clin Immunol* 2021;■■■:■■■-■■■.)

Key words: Food allergy, atopy, peanut allergy, prevalence, adult-onset food allergy

From the ^aCenter for Food Allergy and Asthma Research, and ^cDivision of Allergy and Immunology, Department of Medicine, Northwestern University Feinberg School of Medicine, Chicago and ^dAnn and Robert H. Lurie Children’s Hospital of Chicago; ^bSean N. Parker Center for Allergy and Asthma Research, Stanford University School of Medicine; and ^eElliot and Roslyn Jaffe Food Allergy Institute, Division of Allergy, Department of Pediatrics, Mount Sinai School of Medicine, New York.

*These authors are cofirst authors and contributed equally to this work.

Supported by grant R21AI135702-PI from the National Institute of Allergy and Infectious Diseases.

Disclosure of potential conflict of interest: R. S. Gupta reports receiving grants from the National Institutes of Health (grants R21 ID# AI135705, R01 ID# AI130348, and U01 ID# AI138907), Rho Inc, Stanford Sean N. Parker Center for Allergy Research, UnitedHealth Group, Thermo Fisher Scientific, Genentech, and the National Confectioners Association; and serves as a medical consultant/advisor for Before Brands, Kaléo Inc, Genentech, Institute for Clinical and Economic Review, Food Allergy Research and Education, Aimmune Therapeutics, and DBV Technologies. S. Sicherer reports royalty payments from UpToDate and from Johns Hopkins University Press; grants to his institution from the National Institute of Allergy and Infectious Diseases, from Food Allergy Research and Education, and from HAL Allergy; and personal fees from the American Academy of Allergy, Asthma and Immunology, outside of the submitted work. S. Sicherer was the American Academy of Pediatrics representative to the National Institute of Allergy and Infectious Diseases Expert Panel for peanut allergy guidelines and also co-author of American Academy of Pediatrics Clinical Reports regarding atopy prevention. R. Schleimer reports National Institutes of Health grant money paid to the institution and to himself, and consulting fees and/or stock ownership from Intersect ENT, GlaxoSmithKline, Allakos, Aurasense, Merck, BioMarck, Sanofi, AstraZeneca/Medimmune, Genentech, Exicure, Otsuka, Aqualung Therapeutics Corp, Actobio Therapeutics, Lyra Therapeutics, Astellas Pharm Inc, and Genzyme/Sanofi Corp; and has Siglec-8 and Siglec-8 ligand-related patents licensed to Allakos Inc. The rest of the authors declare that they have no relevant conflicts of interest.

Received for publication April 23, 2020; revised October 28, 2020; accepted for publication November 24, 2020.

Corresponding author: Ruchi S. Gupta, MD, 750 N Lake Shore Drive, Suite 680 Chicago, IL 60611. E-mail: r-gupta@northwestern.edu.

0091-6749/\$36.00

© 2021 Published by Elsevier Inc. on behalf of the American Academy of Allergy, Asthma & Immunology

<https://doi.org/10.1016/j.jaci.2020.11.046>

Food allergy is a significant health issue that affects millions of people in the United States.¹ It impacts not only a person’s physical health,² but also his/her quality of life,³ and daily living;¹ food allergy also has large economic implications.⁴ Over the past few decades, converging evidence indicates that the prevalence of food allergy has increased both in pediatric and adult populations.^{5,6} While the US population-level burden of food allergy has been more comprehensively characterized in pediatric samples,^{7,8} a recent nationwide survey⁹ suggests that over 1 in 10 US adults may be food-allergic. This rate is higher than the estimate of 1 in 13 reported for the US pediatric population by the same survey.⁸ These findings suggest that many adults may not outgrow their childhood food allergies and/or have developed new food allergies during adulthood.

Peanut allergy (PA) is a major adult and pediatric food allergy,¹⁰ with approximately 75% to 80% of pediatric PA cases persisting into adulthood.¹¹⁻¹³ Allergic reactions to peanut are often severe, can occur on first ingestion, and commonly become more severe over time or after repeated peanut exposure.¹⁴⁻¹⁶ Peanut is a leading cause of fatal and near-fatal anaphylaxis.¹ Management of PA to date has focused on strict elimination and use of emergency rescue treatment in the event of exposure or reaction. However, this may change with the development of a commercialized peanut allergen powder for oral immunotherapy, which is Food and Drug Administration–approved for patients 4 to 17 years of age. Oral immunotherapy with peanut has been demonstrated to effectively desensitize patients with PA, allowing for greater quantities of peanut protein ingestion without symptoms and/or reductions in symptom severity.¹⁷ While numerous studies^{11,13,18-20} have examined the natural history and characteristics of pediatric patients with PA in the United States, relatively little is known about the prevalence and characteristics of PA in adults.

Abbreviations used

EAI: Epinephrine autoinjector
 ED: Emergency department
 OAS: Oral allergy syndrome
 PA: Peanut allergy
 sIgE: Specific IgE
 SPT: Skin prick test

This study describes the current burden of PA among US adults, including its distribution across major sociodemographic groups and in individuals with key atopic comorbidities. Particular emphasis is placed on comparing and contrasting adults with both childhood- and adult-onset PA including risk factors, reaction symptomatology, and clinical outcomes.

METHODS**Data collection**

A US population-based, cross-sectional survey was administered from October 2015 to September 2016, providing complete responses from 40,443 adults. The study protocol was approved by the institutional review boards of Northwestern University and the nonpartisan research organization NORC at the University of Chicago. Detailed information about survey development, pretesting, sampling, weighting, and statistical procedures have been previously published.^{4,9} In summary, eligible study participants included adults (≥ 18 years old) residing in a US household and able to complete the survey via web or telephone.

As in previous food allergy prevalence surveys,^{8,21} this study relied on a nationally representative household panel for valid population-level inference. Study participants were first recruited from NORC at the University of Chicago's, nationally representative, probability-based AmeriSpeak Panel, where a survey completion rate of 51.2% was observed (7,218 responses per 14,095 invitees). Each respondent was assigned a base, nonresponse-adjusted sampling weight, which was then raked to external population totals associated with age, sex, educational level, race/ethnicity, housing tenure, telephone status, and census division using iterative proportional fitting to improve external validity. Next, to increase the precision of the resulting estimates, study data derived from population-weighted AmeriSpeak responses were augmented by 33,233 additional calibration-weighted, non-probability-based responses obtained through the Survey Sampling International Dynamix platform. Survey Sampling International is a leading survey research organization with a diverse and large web-based panel of potential participants, who were sampled for the present study using previously described methods⁹ designed to minimize self-selection bias.

Outcome measures

The primary outcome measures for the present study were the prevalence of childhood- and adult-onset PA. To exclude likely cases of oral allergy syndrome (OAS) or other non-peanut-specific IgE (sIgE)-mediated conditions, self-reported PA was only considered "convincing" if the most severe reaction reported to that food included ≥ 1 symptom on the stringent symptom list. In practice, ≥ 1 stringent symptom was required for all reported allergies to be considered "convincing," even when allergies were reported to be physician-diagnosed (Fig E1 in this article's Online Repository at www.jacionline.org). Convincing PAs for which respondents reported a physician diagnosis were considered physician-confirmed. A severe reaction history to peanut was indicated by the presence of multiple stringent symptoms occurring within ≥ 2 of the following 4 organ systems (skin/oral mucosa, gastrointestinal, cardiovascular, and respiratory) during the patient's most severe reported allergic reaction to peanut.

Statistical analysis

Complex survey-weighted means and proportions were calculated to estimate the prevalence of PA and other characteristics among US adults using STATA 14 svy: commands (StataCorp, College Station, Tex). Relative proportions of demographic characteristics were compared using weighted Pearson chi-square statistics, which were corrected for the complex survey design with the second-order correction of Rao and Scott²² and converted into *F* statistics. Covariate-adjusted complex survey-weighted logistic regression models compared relative prevalence and other assessed food allergy outcomes by participant characteristics. Two-sided hypothesis tests were used, with 2-sided $P < .05$ considered to be statistically significant.

RESULTS

The prevalence of current self-reported PA was 2.9% (95% CI, 2.7%-3.1%) among US adults. A reported food allergy was considered convincing if the specific allergen-induced symptoms were consistent with an IgE-mediated reaction. Among US adults, 1.8% met these criteria for convincing PA and 1.3% of participants overall reported a convincing PA that was also diagnosed by a physician—a "physician-confirmed" PA. PA prevalence was greatest in adults 30 to 39 years old, with 2.9% (95% CI, 2.5%-3.3%) estimated to have convincing PA.

The mean age at which the first peanut-allergic reaction occurred was 10.4 years among adult patients with a current physician-confirmed PA. Among adults with PA, 17.5% (95% CI, 14.8%-20.7%) reported adult onset of his or her allergy. Of those with adult-onset PA, the mean age for the first peanut reaction was 33 years of age, compared with 6.6 years of age among adults with current, childhood-onset PA.

Demographics

The demographic characteristics of adults with and without PA are reviewed in Table I. Of adults with PA, 55.6% (95% CI, 51.8%-59.3%) were female, compared with 51.6% (95% CI, 50.9%-52.3%) in the general US population ($P = .04$). Among adults with PA, 54.7% (95% CI, 50.8%-58.5%) were white (non-Hispanic) compared with 65.1% (95% CI, 64.4%-65.8%; $P < .001$) of the general US population. Thus, a higher proportion of nonwhite adults are peanut-allergic relative to their distribution in the general US population. Differences in PA prevalence were also observed across income strata, with adults with PA overrepresented among those in households earning between \$50,000 and \$150,000.

In Table II, the demographics of those with childhood-onset versus adult-onset PA are compared. Those with adult-onset PA continue to demonstrate a female predominance (53.0%; 95% CI, 48.8%-57.1%), but less marked than those with childhood-onset PA (67.7%; 95% CI, 59.5%-75%). There were no statistically significant differences between the groups in race/ethnicity distribution nor household income.

Comorbid conditions

Adults with PA were more likely than their non-peanut-allergic counterparts to have comorbid other atopic/allergic conditions including asthma, eczema, environmental allergies, insect sting allergy, latex allergy, and urticaria (see Table III). Distribution of comorbid atopic conditions such as asthma and eczema were

TABLE I. Demographic distribution of adults with current PA versus adults without PA

Variable	Adults without current PA	Adults with current PA	Unadjusted <i>P</i> value
Race/ethnicity			
Asian, non-Hispanic	3.8 (3.6-4.1)	6.3 (4.4-8.9)	<.001
Black, non-Hispanic	11.6 (11.2-12.1)	15.5 (12.7-18.8)	
White, non-Hispanic	65.1 (64.4-65.8)	54.7 (50.8-58.5)	
Hispanic	15.4 (14.8-16.0)	20.9 (17.9-24.2)	
Multiple/other	4.1 (3.9-4.4)	2.7 (1.8-3.9)	
Sex			
Female	51.6 (50.9-52.3)	55.6 (51.8-59.3)	.04
Male	48.4 (47.7-49.1)	44.4 (40.7-48.2)	
Age (y)			
18-29	21.3 (20.7-22.0)	29.8 (26.6-33.2)	<.001
30-39	16.8 (16.3-17.3)	27.2 (23.8-30.9)	
40-49	16.8 (16.3-17.3)	16.6 (14.0-19.7)	
50-59	18.1 (17.6-18.6)	13.9 (11.4-16.8)	
60+	27.1 (26.5-27.7)	12.5 (10.1-15.4)	
Insurance status (only collected on AmeriSpeak sample)			
Uninsured	7.6 (6.6-8.8)	2.1 (.6-7.1)	.380
Private	64.3 (62.4-66.2)	70.8 (50.0-85.4)	
Public	28.1 (26.4-29.8)	27.1 (12.8-48.5)	
Household income (US\$)			
<25,000	16.7 (16.2-17.1)	12.8 (10.6-15.5)	<.001
25,000-49,999	22.0 (21.5-22.5)	20.2 (17.6-23.1)	
50,000-99,999	30.8 (30.2-31.4)	36.8 (33.3-40.4)	
100,000-149,999	19.6 (19.0-20.2)	22.2 (18.8-26.1)	
>150,000	11.0 (10.4-11.5)	7.9 (6.1-10.3)	

Population-weighted frequency expressed as percent (95% CI).

TABLE II. Demographic distribution of adults with childhood-onset PA versus adults with adult-onset PA

Variable	Adults with childhood-onset PA	Adults with adult-onset PA	Unadjusted <i>P</i> value
Race/ethnicity			
Asian, non-Hispanic	7.0 (4.8-10.2)	3.0 (1.4-6.4)	.16
Black, non-Hispanic	15.0 (12.0-18.7)	17.6 (11.7-25.5)	
White, non-Hispanic	53.8 (49.5-58.0)	58.9 (49.6-67.7)	
Hispanic	21.9 (18.6-25.6)	16.2 (10.1-25.0)	
Multiple/other	2.3 (1.5-3.5)	4.3 (1.8-10.1)	
Sex			
Female	67.7 (59.5-75.0)	53.0 (48.8-57.1)	.002
Male	32.3 (25.0-40.5)	47.0 (42.9-51.2)	
Age (y)			
18-29	34.1 (30.4-38.0)	9.5 (5.5-16.0)	<.001
30-39	29.1 (25.2-33.2)	18.4 (13.1-25.2)	
40-49	15.5 (12.8-18.7)	21.8 (14.9-30.9)	
50-59	12.1 (9.5-15.3)	22.2 (15.6-30.5)	
60+	9.2 (7.0-12.0)	28.0 (20.1-37.6)	
Insurance status (only collected on AmeriSpeak sample)			
Uninsured	2.0 (0.4-8.7)	2.5 (0.3-16.4)	.900
Private	69.9 (44.7-87.0)	73.9 (48.0-89.7)	
Public	28.1 (11.4-54.3)	23.6 (8.8-49.8)	
Household income (\$)			
<25,000	12.7 (10.2-15.6)	13.7 (9.1-20.1)	.890
25,000-49,999	20.1 (17.2-23.2)	21.1 (15.2-28.6)	
50,000-99,999	37.5 (33.6-41.5)	33.4 (25.6-42.3)	
100,000-149,999	2.3 (18.5-26.5)	22.1 (14.5-32.3)	
>150,000	7.6 (5.6-10.1)	9.7 (5.0-17.9)	

Population-weighted frequency expressed as percent (95% CI).

similar between childhood-onset and adult-onset PA, except for a higher frequency of environmental allergies in adult-onset PA (37.5% vs 23.2%; $P = .002$). Patients with adult-onset PA were

also more likely to have latex and medication allergy compared with those with childhood-onset PA (see Fig 1 and Table E1 in this article's Online Repository at www.jacionline.org).

TABLE III. Demographic distribution of adults with convincing PA versus adults without PA

Physician-diagnosed comorbid conditions	Adults without convincing PA*	Adults with convincing PA	Unadjusted <i>P</i> value†
Asthma	12.0 (11.6-12.5)	25.0 (21.9-28.3)	<.001†
Atopic dermatitis/eczema	6.6 (6.3-7.0)	12.4 (10.2-15.1)	<.001†
Environmental allergies	21.4 (20.8-21.9)	25.7 (22.4-29.3)	.01
Insect sting allergy	3.8 (3.5-4.1)	5.8 (4.0-8.2)	.02
Latex allergy	2.3 (2.1-2.4)	4.9 (3.4-7.0)	<.001†
Medication allergy	13.4 (13.0-13.9)	12.0 (9.6-14.9)	.31
Urticaria/chronic hives	0.9 (0.8-1.0)	1.5 (0.9-2.5)	.046

Population-weighted frequency expressed as percent (95% CI).

*"Adults without convincing PA" includes all adult respondents who were not classified as convincingly peanut-allergic, including patients who reported a PA that did not meet "convincing" symptom-report criteria.

†Statistically significant at Bonferroni adjusted *P* value of .05 / 7 = .0071.

Adult-onset versus childhood-onset PA

Comparisons between characteristics of adult-onset and childhood-onset PA are shown in Fig 2 and Table E2 in this article's Online Repository (available at www.jacionline.org). A similar proportion of adult-onset and childhood-onset PA had a history of severe reaction, defined as ≥ 1 stringent symptom in ≥ 2 different organ systems, with 63.8% and 68.6%, respectively ($P = .3$).

As seen in Fig 2, about 1 in 5 individuals in both the adult-onset and childhood-onset PA groups reported ≥ 1 food allergy-related emergency department (ED) visits in the past year (18.2% vs 20.2%, respectively; $P = .59$). Yet, patients with childhood-onset PA were more likely to have a current epinephrine autoinjector (EAI) prescription (55.9% vs 43.8%; $P = .02$). Subjects with childhood-onset PA were also more likely than subjects with adult-onset PA to have used an EAI to treat a peanut reaction (48.1% vs 35.1%; $P = .01$). A larger proportion of patients with adult-onset PA than those with childhood-onset PA had used antihistamines to treat a peanut reaction (62.4 vs 49.8%; $P = .01$). Among adults evaluated for a food-related indication in the ED within the past year, the proportion of childhood-onset PA compared with adult-onset PA with a current EAI prescription was similar (72.0% vs 83.8%, respectively; $P = .31$). Similarly, there was no statistically significant difference in rates of EAI prescription between the 2 groups when examining only those patients with a lifetime history of ≥ 1 food allergy-related ED visits.

Adults with PA with a childhood-onset of PA were 28% more likely to have a physician diagnosis of their food allergy than were their counterparts with adult-onset PA. However, there was no statistically significant difference between the 2 groups in the method of diagnosis, with similar proportions reporting confirmatory skin prick test (SPT), peanut-sIgE blood testing, or oral food challenges.

Adults with adult-onset PA were, however, more likely than those with childhood-onset PA to report multiple food allergies (77.8% vs 65.7%; $P = .005$). Interestingly, the proportion of adults with PA reporting other common food allergies was similar irrespective of PA-onset timing, except that adults with PA who developed their PA during adulthood were significantly more likely to have a convincing tree nut allergy than were their counterparts with childhood-onset PA (42.4% vs 31.4%; $P = .03$). Tree nut allergy was the most common comorbid food allergy among adults with PA, followed by shellfish allergy (Table IV).

As described in Table V, adults with childhood-onset PA were more likely to report comorbid childhood-onset allergies to other common foods. Conversely, patients with adult-onset PA were

more likely to report comorbid adult-onset allergies to other common foods. The only exception among the "top 9" allergen sensitivities was childhood-onset milk allergy, which was similarly common among adults with PA irrespective of whether they developed their PA as a child or as an adult.

Commonly reported peanut-allergic reaction symptoms are presented in Table E3 in this article's Online Repository (available at www.jacionline.org). The most commonly reported symptom among both patients with childhood-onset PA and patients with adult-onset PA were skin/oral symptoms, followed by respiratory symptoms. Overall, the frequency of specific organ system involvement in PA reaction symptoms was similar when comparing patients with adult-onset PA versus patient with childhood-onset PA.

Discussion

This study determined that the prevalence of self-reported PA in the US adult population is 2.9%. However, this estimate was attenuated to 1.8% of the US adult population, or 4.6 million adults, when cases were restricted to only those reporting allergic reaction symptoms consistent with convincing PA. Among US adults, PA was more common among females, non-Hispanic whites, adults with higher household income, and increased comorbid atopic conditions such as asthma, eczema, and environmental allergies.

The prevalence of PA observed in this study is higher than prior estimates among US adult populations, which have ranged between 0.6%¹⁴ and 1.3%.²³ This may be partially explained by increasing prevalence of PA among the pediatric population,^{5,22,24} of whom only approximately 15% to 20% will outgrow their PA by adulthood.^{13,25} Grundy et al²² in 2002, for instance, described a 2-fold increase in reported PA and 3-fold increase in sensitization in a UK cohort of children born between 1994 and 1996 as compared to those born in 1989. An American study showed an increase in pediatric PA prevalence from 0.4% in 1997 to 0.8% in 2002 and 1.4% in 2008.⁷ A total of 1.3% of respondents in this study reported a physician-diagnosed, convincing PA, of which 14.3% had onset of their PA in adulthood. Kamdar et al²⁶ previously reported that $\geq 15\%$ of patients with food allergy had adult-onset of their food allergy, although their study assessed food allergies generally rather than PA specifically.

Adult-onset PA is not well characterized in the literature and this is the first study, to our knowledge, to comprehensively compare characteristics of patients with adult-onset versus childhood-onset PA within a US population-based sample.

Current Atopic Comorbidities by Timing of Current Peanut Allergy Onset

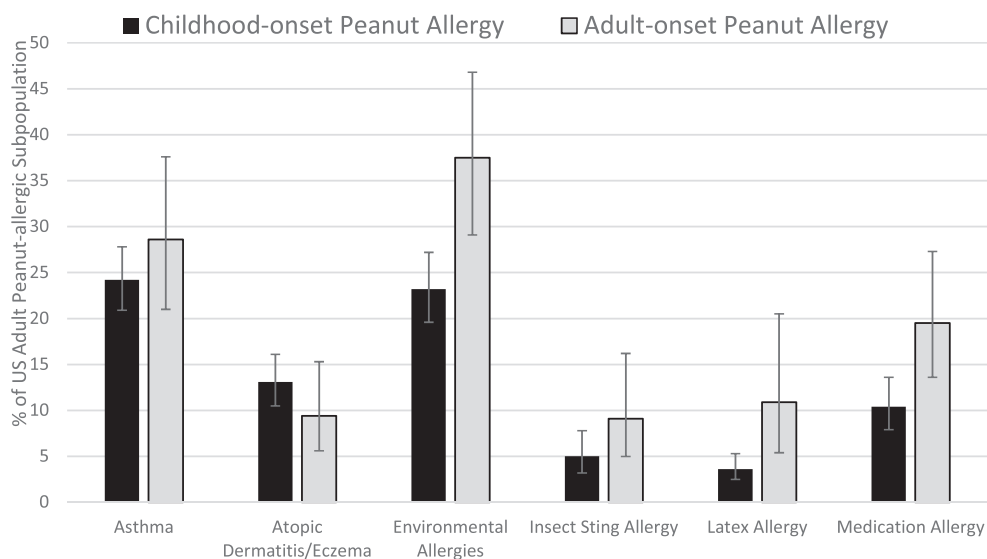


FIG 1. Current atopic comorbidities by timing of current PA onset.

Clinical Allergy Characteristics by Timing of Current Peanut Allergy Onset

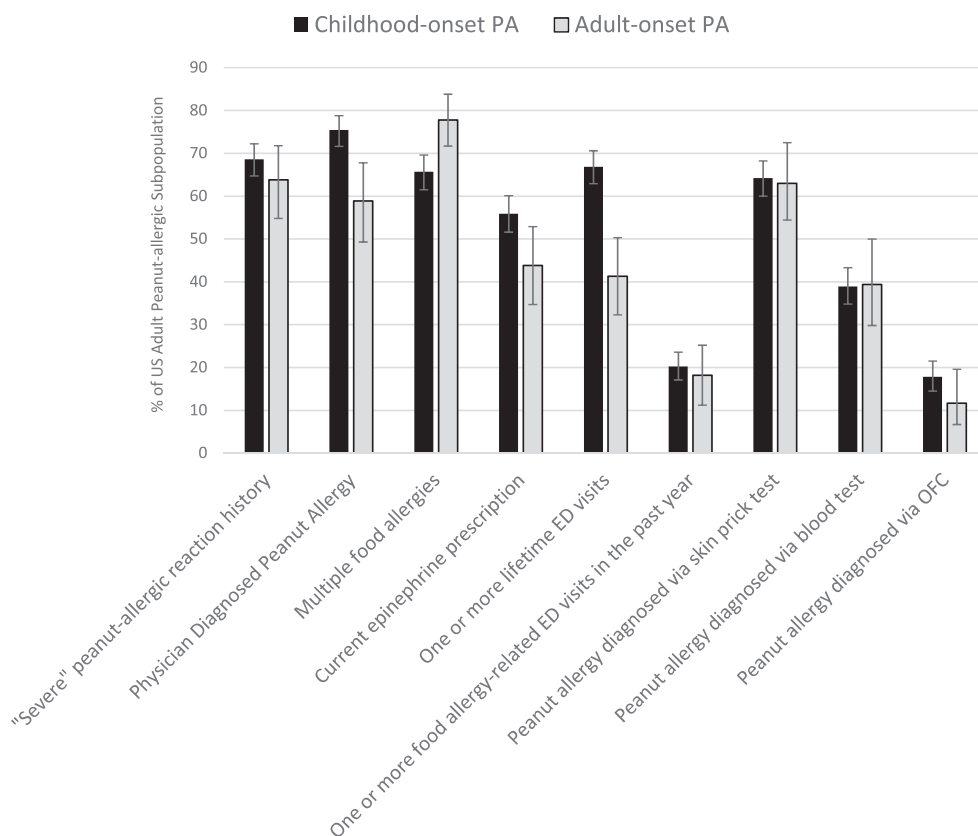


FIG 2. Clinical allergy characteristics by timing of current PA onset. *OFC*, Oral food challenge.

TABLE IV. Proportions of childhood-onset PA versus adult-onset PA with other food allergy

Convincing allergy to:	Proportion of adults who have childhood-onset PA	Proportion of adults who have adult-onset PA	Unadjusted <i>P</i> value*
Tree nut	31.4 (27.6-35.4)	42.4 (33.5-51.8)	.03
Milk	15.9 (12.9-19.4)	18.7 (12.1-27.8)	.5
Shellfish	21.0 (18.1-24.2)	24.1 (17.0-33.0)	.46
Egg	10.3 (8.3-12.8)	10.9 (6.8-16.8)	.85
Finfish	9.8 (7.8-12.3)	10.4 (6.4-16.4)	.84
Wheat	8.6 (6.4-11.4)	11.3 (6.8-18.0)	.35
Soy	7.7 (5.6-10.5)	11.6 (6.7-19.0)	.19
Sesame	6.1 (4.5-8.2)	5.2 (2.8-9.5)	.66

Population-weighted frequency expressed as percent (95% CI).

*Statistically significant at Bonferroni adjusted *P* value of .05 / 8 = .00625.**TABLE V.** Timing of onset of childhood-onset PA versus adult-onset PA with other food allergy

Variable	Proportion of adults who have childhood-onset PA	Proportion of adults who have adult-onset PA	Unadjusted <i>P</i> value*
Convincing childhood-onset allergy to:			
Tree nut	27.6 (24.1-31.4)	1.6 (0.4-5.6)	<.001*
Milk	15.2 (12.3-18.8)	10.6 (5.4-19.7)	.29
Shellfish	16.5 (13.9-19.4)	4.7 (2.3-9.5)	<.001*
Egg	9.6 (7.6-11.9)	4.7 (2.1-10.2)	.08
Finfish	8.6 (6.7-11.0)	3.7 (1.5-8.5)	.05
Wheat	7.8 (5.7-10.6)	2.0 (0.6-6.4)	.02
Soy	6.7 (4.7-9.3)	2.3 (0.9-5.8)	.02
Sesame	5.4 (3.9-7.4)	1.5 (0.6-3.8)	.006
Convincing adult-onset allergy to:			
Tree nut	4.9 (2.9-8.1)	46.9 (37.9-56.2)	<.001*
Milk	2.1 (0.8-5.3)	17.3 (11.7-24.7)	<.001*
Shellfish	6.0 (4.3-8.3)	25.5 (18.2-34.4)	<.001*
Egg	1.8 (0.6-5.3)	10.1 (6.4-15.6)	.001*
Finfish	1.4 (0.8-2.5)	8.9 (5.2-14.6)	<.001*
Wheat	1.6 (1.0-2.6)	13.7 (8.7-21.1)	<.001*
Soy	1.8 (1.0-3.3)	17.7 (11.0-27.4)	<.001*
Sesame	0.9 (0.4-2.1)	5.1 (2.6-9.9)	<.001*

Population-weighted frequency expressed as percent (95% CI).

*Statistically significant at Bonferroni adjusted *P* value of .05 / 16 = .0031.

Demographically, patients with adult-onset PA did not significantly differ from patients with current childhood-onset PA with respect to racial/ethnic or household income distributions. Adult-onset PA was more common among females relative to males, but this observed sex difference was smaller than the more dramatic one seen in childhood-onset PA, where female patients outnumber males 2 to 1. This is consistent with previous studies indicating systematic sex differences in food allergy prevalence across the life span.²⁷ Specifically, data from numerous population-based prevalence studies indicate that males are disproportionately affected by food allergy (and other atopic conditions)^{4,28,29} at younger ages,⁴ while among adults, females are at increased risk.^{9,28,30} Interestingly, previous work, which posits that sex hormones may play a key role in food allergy etiology, has observed an attenuation of sex differences around the time of menopause. However, no such attenuation of the sex difference was observed here. In fact, the sex differences were equivalently robust among the youngest (18-29 years) and oldest (60+) adults (37% male vs 63% female within both groups). In these data, the sex difference was attenuated earlier, with a similar sex distribution of PA cases among participants 30 to 59 years of age (Fig E2).

Interestingly, when comparing the severity of peanut-allergic reactions reported by participants, estimates of patients with adult-onset and childhood-onset PA were similar. The proportion of severe reaction in both exceeded 60% (63.8 vs 68.6%, respectively; *P* = .3) as did the proportion presenting to the ED for a food-related indication within the past year (18.2% vs 20.2%, respectively; *P* = .59). Patients with childhood-onset PA were more likely to report ≥1 lifetime food-related ED visit, although this is likely less reflective of PA allergy severity than potential lead-time bias due to earlier diagnosis of PA.

Yet, despite similar markers of PA severity, there were notable differences in PA management practices between the 2 groups, depending on onset timing. The 2014 American Academy of Allergy, Asthma, and Immunology Food Allergy practice parameters³¹ recommend that self-injectable epinephrine be available to patients with food allergy and that patients and/or caregivers be instructed in its use. Our study found that despite approximately 1 in 5 individuals with both adult-onset and childhood-onset PA presenting for food-related indications to the ED within the past year, only 43.8% (95% CI, 35.1%-52.9%) of adult-onset, compared with 55.9% (95% CI, 51.6-60.1%) of childhood-onset PA, had a current EAI prescription (*P* = .02).

In agreement with this, patients with childhood-onset PA were more likely than patients with adult-onset PA to use epinephrine in treatment of a peanut reaction, while patients with adult-onset PA were more likely to use antihistamines. While this could be due to differences in reaction severity between the 2 groups, an examination of the proportion of severe symptoms such as wheezing or low blood pressure (see [Table E3](#)) revealed similar symptomatology between the 2 groups. Instead, this may represent systematic differences in patient education practices regarding appropriate reaction management and/or reduced access to emergency epinephrine among patients with adult-onset PA.

Prior literature has shown that 79% of peanut and tree nut reactions had multisystem and/or respiratory allergic reactions on first ingestion of the allergen.¹⁴ PA remains a leading cause of fatal and near-fatal anaphylaxis.¹ Bock et al³² showed in their 1994 to 1999 case series that peanut and tree nuts accounted for >90% of fatalities due to food-related anaphylactic reactions. A more recent Canadian review of 92 food allergy fatality cases recorded in the Ontario coroner's database from 1997 to 2013 also found that peanut was the leading causal food, with delayed epinephrine use identified as a leading mortality risk factor.³³ Notably, the average age of patients at the time of death was 32 years (range 9-78 years). Finally, a 2017 British review of global fatal anaphylaxis case series concluded that peanut and tree nut remain the most commonly reported triggers of fatal food-induced anaphylaxis.³⁴ Epinephrine remains the first-line treatment for anaphylaxis,³¹ making it exceedingly concerning that the majority of patients with adult-onset PA and just under one-half of patients with childhood-onset PA do not report a current EAI prescription. While a disparity has been noted in the past between management of food allergy in children versus adults,¹⁴ with 46% of children compared with 23% of adults being prescribed epinephrine, the identification of how the age at food allergy onset contributes to subsequent management in adulthood is not well-understood and warrants further investigation.

In the present study, patients with adult-onset PA also report significantly lower rates of physician diagnosis (59%) versus 75% in childhood-onset PA. This may reflect a medical care gap between the groups, suggesting lower rates of presentation to a physician for evaluation of food allergy among patients with adult-onset PA and subsequently lower rates of current EAI prescriptions and patient education regarding appropriate reaction management. This variation, as illustrated in [Table V](#), does not seem to stem from ED management, because adults reporting a food allergy-related ED visit within the past 12 months had similar proportions of current EAI prescription irrespective of whether their PA began during childhood or adulthood. Alternatively, it is possible that this variation in physician diagnosis between the 2 groups could reflect that a larger proportion of convincing adult-onset PA may involve non-IgE-mediated reactions or OAS, as opposed to a discrepancy in physician evaluation. The former would be consistent with the higher rates of environmental allergies seen in adult-onset PA (37.5% vs 23.2% in childhood-onset PA). However, the design of this study actively attempted to exclude such individuals through the diagnostic algorithm presented in [Fig E1](#), which required ≥ 1 "stringent" reaction symptom and excluded individuals reporting only mild oropharyngeal/gastrointestinal symptoms to acknowledged triggers of OAS/food intolerances, respectively. Additional clinical

work, incorporating specific environmental allergen testing to differentially diagnose primary food allergy versus OAS cases would provide further clarifying information, to these ends.

The aforementioned gaps in medical care suggest not only avenues of future study but also potential areas of intervention. Future areas of study are needed to examine mechanistic differences in the etiology of childhood-onset versus adult-onset food allergy, whether there are outcome variations in rates of adverse events, anaphylaxis, and fatalities in adult-onset compared with childhood-onset food allergy. It will also be important to better characterize whether and to what extent PAs are managed differently by patients and clinicians depending on their onset timing, particularly with the advent of emerging treatments for pediatric PA.

The use of a survey-based design in this study introduces 2 notable limitations. First, the information provided by participants is self-reported and without confirmatory clinical corroboration such as specific values for patient-reported SPT and sIgE testing. Second, it is possible that recall bias may influence patient reporting of reaction symptomatology, particularly in patients with more distant reactions. Woods et al³⁵ demonstrated that self-report may overestimate the prevalence of IgE-mediated food allergy when compared with results of SPT. However, their small study demonstrated a fair level of agreement between SPT and self-reported food reactions to peanut.

While many of the questions posed by the survey seek to mimic common questions asked during physician food allergy evaluations, which are also self-reported histories of food reactions and as such also limited by recall bias, the absence of corresponding objective testing makes it difficult to determine whether reported reactions truly reflect IgE-mediated food reactions. Unfortunately, confirmatory testing with the gold standard of double-blind placebo-controlled oral food challenges for respondents was impractical in the context of this national survey of over 40,000 adults. Moving forward, further longitudinal data are clearly needed to better understand the natural history of PA among adult patients. This is particularly the case for patients with adult-onset allergies who our data suggest may be more inclined to pursue allergen avoidance without consulting an allergist and therefore may be at elevated risk of unnecessary peanut avoidance.

In conclusion, PA affects nearly 5 million adults in the United States. Roughly 1 in 6 adults with PA experienced their first reaction in adulthood. This study demonstrates that patients with adult-onset versus those with childhood-onset PA are demographically similar, with the exception of an overrepresentation of females among patients with childhood-onset PA. While the reaction severity and symptomatology of patients with adult-onset PA and those with childhood-onset PA are comparable, their management appears to differ. Patients with adult-onset PA are less likely to have a current EAI prescription compared with their counterparts with childhood-onset PA and are also more likely to use antihistamines to treat a reaction. In sum, these data indicate that substantially more US adults are affected by PA than previously acknowledged, and there are important phenotypic differences between patients with childhood-onset versus those with adult-onset PA. Additional work is needed to further contextualize these differences and translate these findings into improved food allergy diagnosis, management, and treatment.

Key messages

- The estimated prevalence of PA was 1.8% among US adults, with >1 in 6 adults with PA reporting adult-onset allergy.
- Disease phenotype and management differed among adults with PA, depending on timing of PA onset.

REFERENCES

- Jones SM, Burks AW. Food allergy. *N Engl J Med* 2017;377:1168-76.
- Cianferoni A, Muraro A. Food-induced anaphylaxis. *Immunol Allergy Clin North Am* 2012;32:165-95.
- Warren CM, Otto AK, Walkner MM, Gupta RS. Quality of life among food allergic patients and their caregivers. *Curr Allergy Asthma Rep* 2016;16:38.
- Gupta RS, Warren CM, Smith BM, Blumenstock JA, Jiang J, Davis MM, et al. The public health impact of parent-reported childhood food allergies in the United States. *Pediatrics* 2018;142:e20181235.
- Sicherer SH, Sampson HA. Food allergy: a review and update on epidemiology, pathogenesis, diagnosis, prevention, and management. *J Allergy Clin Immunol* 2018;141:41-58.
- Warren CM, Jiang J, Gupta RS. Epidemiology and burden of food allergy. *Curr Allergy Asthma Rep* 2020;20:6.
- Sicherer SH, Munoz-Furlong A, Godbold JH, Sampson HA. US prevalence of self-reported peanut, tree nut, and sesame allergy: 11-year follow-up. *J Allergy Clin Immunol* 2010;125:1322-6.
- Gupta RS, Springston EE, Warrior MR, Smith B, Kumar R, Pongracic J, et al. The prevalence, severity, and distribution of childhood food allergy in the United States. *Pediatrics* 2011;128:e9-17.
- Gupta RS, Warren CM, Smith BM, Jiang J, Blumenstock JA, Davis MM, et al. Prevalence and severity of food allergies among US adults. *JAMA Network Open* 2019;2:e185630.
- Dyer AA, Rivkina V, Perumal D, Smeltzer BM, Smith BM, Gupta RS. Epidemiology of childhood peanut allergy. *Allergy Asthma Proc* 2015;36:58-64.
- Peters RL, Allen KJ, Dharmage SC, Koplin JJ, Dang T, Tilbrook KP, et al. Natural history of peanut allergy and predictors of resolution in the first 4 years of life: a population-based assessment. *J Allergy Clin Immunol* 2015;135:1257-66.e1-2.
- Ho MH, Wong WH, Heine RG, Hosking CS, Hill DJ, Allen KJ. Early clinical predictors of remission of peanut allergy in children. *J Allergy Clin Immunol* 2008;121:731-6.
- Skolnick HS, Conover-Walker MK, Koerner CB, Sampson HA, Burks W, Wood RA. The natural history of peanut allergy. *J Allergy Clin Immunol* 2001;107:367-74.
- Sicherer SH, Munoz-Furlong A, Burks AW, Sampson HA. Prevalence of peanut and tree nut allergy in the US determined by a random digit dial telephone survey. *J Allergy Clin Immunol* 1999;103:559-62.
- Sicherer SH, Burks AW, Sampson HA. Clinical features of acute allergic reactions to peanut and tree nuts in children. *Pediatrics* 1998;102:e6.
- Sicherer SH, Furlong TJ, Munoz-Furlong A, Burks AW, Sampson HA. A voluntary registry for peanut and tree nut allergy: characteristics of the first 5149 registrants. *J Allergy Clin Immunol* 2001;108:128-32.
- Vickery BP, Vereda A, Casale TB, Beyer K, du Toit G, Hourihane JO, et al. AR101 oral immunotherapy for peanut allergy. *N Engl J Med* 2018;379:1991-2001.
- Fleischer DM. The natural history of peanut and tree nut allergy. *Curr Allergy Asthma Rep* 2007;7:175-81.
- Bock SA, Atkins FM. The natural history of peanut allergy. *J Allergy Clin Immunol* 1989;83:900-4.
- Spergel JM, Fiedler JM. Natural history of peanut allergy. *Curr Opin Pediatr* 2001;13:517-22.
- Gupta RS, Warren CM, Smith BM, Blumenstock JA, Jiang J, Davis MM, Nadeau KC. The public health impact of parent-reported childhood food allergies in the United States. *Pediatrics* 2018;142:e20181235, erratum: 2019;143:e20183835.
- Grundy J, Matthews S, Bateman B, Dean T, Arshad SH. Rising prevalence of allergy to peanut in children: data from 2 sequential cohorts. *J Allergy Clin Immunol* 2002;110:784-9.
- Chaudhry RQ, Oppenheimer JJ. Update on food allergy in adults. *Curr Allergy Asthma Rep* 2012;12:311-20.
- Kuwayama SP, Sampson HA. Peanut allergy. *N Engl J Med* 2002;347:1534-5, author reply: 1535.
- Fleischer DM, Conover-Walker MK, Christie L, Burks AW, Wood RA. The natural progression of peanut allergy: resolution and the possibility of recurrence. *J Allergy Clin Immunol* 2003;112:183-9.
- Kamdar TA, Peterson S, Lau CH, Saltoun CA, Gupta RS, Bryce PJ. Prevalence and characteristics of adult-onset food allergy. *J Allergy Clin Immunol Pract* 2015;3:114-5.e1.
- Pali-Scholl I, Jensen-Jarolim E. Gender aspects in food allergy. *Curr Opin Allergy Clin Immunol* 2019;19:249-55.
- Kelly C, Gangur V. Sex disparity in food allergy: evidence from the PubMed database. *J Allergy (Cairo)* 2009;2009:159845.
- Leickly FE, Kloepper KM, Slaven JE, Vitalpur G. Peanut Allergy: an epidemiologic analysis of a large database. *J Pediatr* 2018;192:223-8.e1.
- Acker WW, Plasek JM, Blumenthal KG, Lai KH, Topaz M, Seger DL, et al. Prevalence of food allergies and intolerances documented in electronic health records. *J Allergy Clin Immunol* 2017;140:1587-91.e1.
- Sampson HA, Aceves S, Bock SA, James J, Jones S, Lang D, et al. Food allergy: a practice parameter update-2014. *J Allergy Clin Immunol* 2014;134:1016-25.e43.
- Bock SA, Munoz-Furlong A, Sampson HA. Fatalities due to anaphylactic reactions to foods. *J Allergy Clin Immunol* 2001;107:191-3.
- Xu YS, Kastner M, Harada L, Xu A, Salter J, Wasserman S. Anaphylaxis-related deaths in Ontario: a retrospective review of cases from 1986 to 2011. *Allergy Asthma Clin Immunol* 2014;10:38.
- Turner PJ, Jerschow E, Umasunthar T, Lin R, Campbell DE, Boyle RJ. Fatal anaphylaxis: mortality rate and risk factors. *J Allergy Clin Immunol Pract* 2017;5:1169-78.
- Woods RK, Stoney RM, Raven J, Walters EH, Abramson M, Thien FC. Reported adverse food reactions overestimate true food allergy in the community. *Eur J Clin Nutr* 2002;56:31-6.

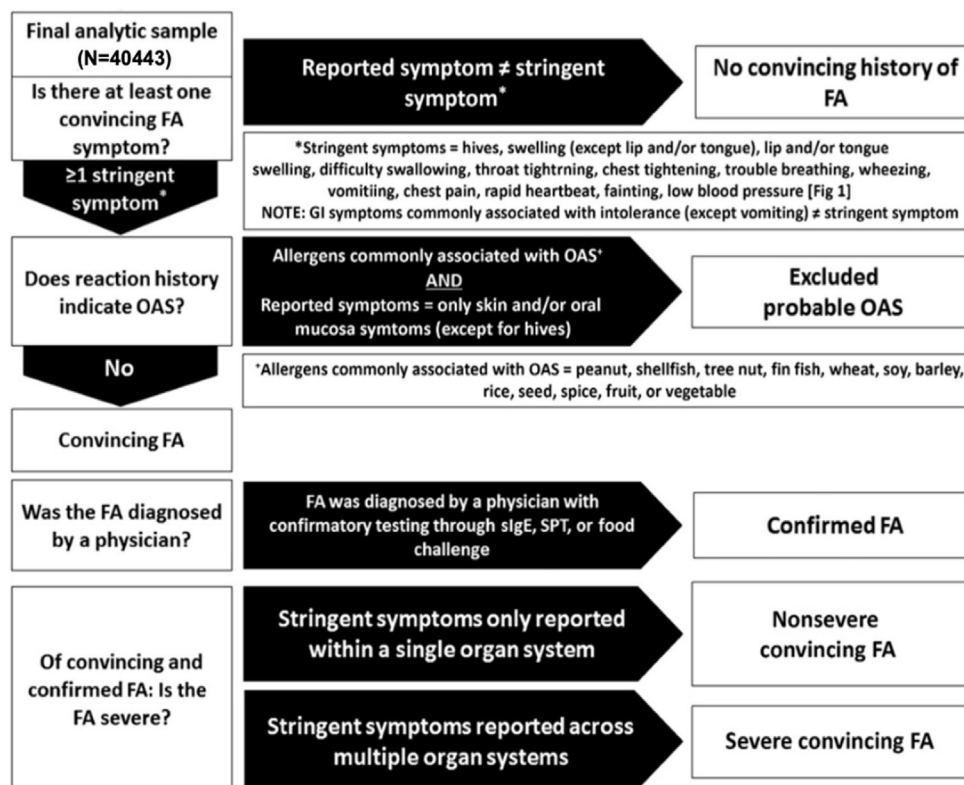


FIG E1. Summary of algorithm used to characterize food allergies (FAs) as “convincing,” “physician-confirmed,” and “severe” using reported allergic reaction symptoms. *GI*, Gastrointestinal; *OAS*, Oral Allergy Syndrome.

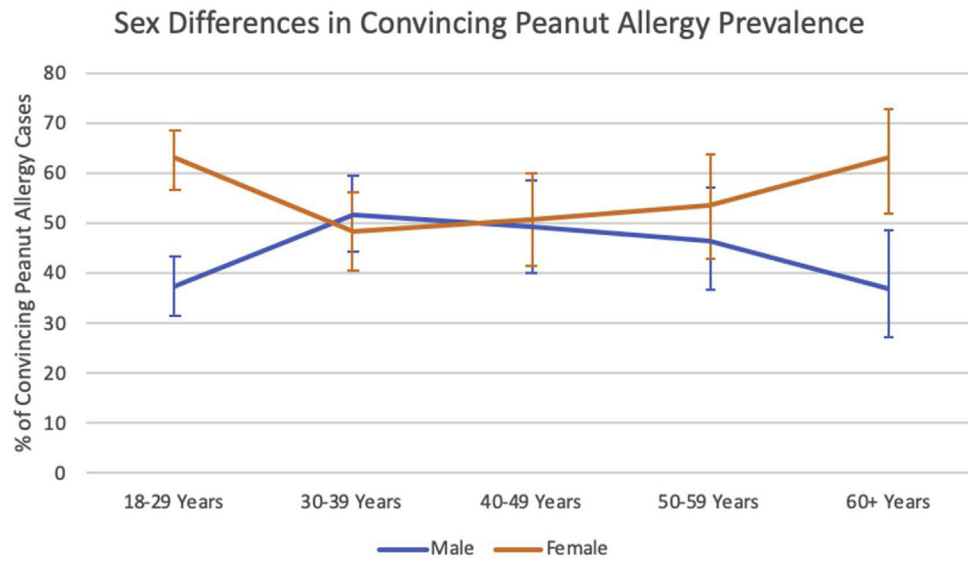


FIG E2. Sex differences in convincing PA prevalence.

TABLE E1. Demographic distribution of adults with childhood-onset PA versus adults with adult-onset PA

Physician-diagnosed comorbid conditions	Adults with childhood-onset PA	Adults with adult-onset PA	<i>P</i> value
Asthma	24.2 (20.9-27.8)	28.6 (21.0-37.6)	.32
Atopic dermatitis/eczema	13.1 (10.5-16.1)	9.4 (5.6-15.3)	.23
Environmental allergies	23.2 (19.6-27.2)	37.5 (29.1-46.8)	.002
Insect sting allergy	5.0 (3.2-7.8)	9.1 (5.0-16.2)	.11
Latex allergy	3.6 (2.5-5.3)	10.9 (5.4-20.5)	.004
Medication allergy	10.4 (7.9-13.6)	19.5 (13.6-27.3)	.006
Urticaria/chronic hives	1.8 (1.1-3.0)	0	.09

Population-weighted frequency expressed as percent (95% CI).

TABLE E2. Characteristics of adults with childhood-onset PA versus adult-onset PA

Variable	Proportion of adults who have childhood-onset PA	Proportion of adults who have adult-onset PA	<i>P</i> value
Severe peanut allergy	68.6 (64.7-72.2)	63.8 (54.8-71.8)	.3
Physician diagnosed FA	75.4 (71.6-78.8)	58.9 (49.3-67.8)	<.001
Multiple food allergies	65.7 (61.5-69.6)	77.8 (70.3-83.8)	.005
Current epinephrine prescription	55.9 (51.6-60.1)	43.8 (35.1-52.9)	.02
≥1 lifetime ED visits	66.8 (62.9-70.6)	41.3 (32.8-50.3)	<.001
≥1 FA-related ED visits in the past year	20.2 (17.1-23.6)	18.2 (12.8-25.2)	.59
PA diagnosed via SPT	64.2 (60.0-68.2)	63.0 (54.2-72.5)	.84
PA diagnosed via blood test	38.9 (34.8-43.3)	39.4 (29.8-50.0)	.93
PA diagnosed via OFC	17.8 (14.5-21.5)	11.7 (6.7-19.6)	.14

Population-weighted frequency expressed as percent (95% CI).

TABLE E3. Symptom characteristics of adults with childhood-onset vs adult-onset PA, proportion % (95% CI)

Symptoms	Childhood-onset PA	Adult-onset PA	P value
Skin/oral/mucosal tissue			
Any stringent skin/oral/mucosal tissue symptom(s)	75.3 (71.1-79.1)	68.4 (59.6-76.0)	.12
Hives	63.1 (58.8-67.3)	60.1 (50.9-68.6)	
Itching	68.8 (65.0-72.3)	54.0 (44.7-63.0)	
Rash	76.0 (72.5-79.2)	58.5 (49.1-67.3)	
Swelling	33.8 (30.0-37.9)	33.7 (24.9-43.7)	
Lip/tongue swelling	42.0 (37.9-46.2)	28.2 (20.8-37.0)	
Difficulty swallowing	47.2 (43.0-51.4)	37.9 (29.6-47.0)	
Hoarse voice	18.4 (15.2-22.1)	23.2 (15.5-33.2)	
Itchy mouth	33.2 (29.5-37.1)	30.2 (22.0-40.0)	
Throat tightening	37.1 (33.0-41.3)	41.6 (32.6-51.2)	
Mouth or throat tingling	20.3 (17.0-24.0)	30.1 (22.2-39.5)	
Respiratory			
Any stringent respiratory symptom(s)	60.1 (56.0-64.1)	56.5 (47.4-65.2)	.47
Chest tightening	30.8 (27.1-34.8)	28.9 (21.0-38.4)	
Nasal congestion	18.6 (15.9-21.8)	27.1 (19.2-36.7)	
Repetitive cough	15.7 (12.5-19.6)	24.9 (17.3-34.5)	
Trouble breathing	33.6 (29.8-37.7)	34.3 (26.0-43.6)	
Wheezing	25.4 (21.8-29.4)	20.1 (14.2-27.6)	
Gastrointestinal			
Any stringent gastrointestinal symptom(s)	12.1 (9.2-15.6)	6.8 (3.4-13.2)	.11
Belly pain	18.9 (16.0-22.2)	27.8 (20.5-36.5)	
Cramps	19.3 (15.9-23.1)	25.0 (18.3-33.3)	
Diarrhea	16.7 (13.5-20.5)	19.4 (13.1-27.8)	
Nausea	16.9 (14.2-20.1)	18.5 (12.4-26.5)	
Vomiting	12.1 (9.2-15.6)	6.8 (3.4-13.2)	
Cardiovascular			
Any stringent cardiovascular symptom(s)	45.4 (41.2-49.6)	46.5 (37.6-55.6)	.83
Chest pain	15. (12.3-18.4)	9.3 (5.9-14.5)	
Rapid heart rate	18.9 (16.1-22.1)	23.4 (16.6-32.0)	
Fainting, dizziness, or feeling light-headed	20.1 (16.5-24.2)	17.3 (11.8-24.6)	
Low blood pressure	6.3 (4.5-8.8)	7.9 (4.5-13.7)	