The Prevalence, Severity, and Distribution of Childhood Food Allergy in the United States

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KEY WORDS

food allergy, prevalence, morbidity, disparities, epidemiology

ABBREVIATIONS

RDD—random-digit-dialing

CI—confidence interval

Dr Gupta was responsible for the conception and design of the study, oversaw data acquisition, analysis, and interpretation, and participated in drafting and revision of the manuscript; Ms Springston participated in study design, was responsible for data acquisition, provided support for data analysis and interpretation, and was responsible for drafting and revision of the manuscript; Dr Warrier participated in study design, provided support for data analysis, and interpretation, and provided critical revisions to the manuscript, Dr Smith participated in study design, conducted data analysis, participated in data interpretation, and provided critical revisions to the manuscript; Dr Kumar consulted on study design, contributed to interpretation of data, and provided critical revisions to the manuscript; and Drs Pongracic and Holl oversaw study design, contributed to interpretation of data, and provided critical revisions to the manuscript.

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WHAT'S KNOWN ON THIS SUBJECT: Estimates of food allergy in the United States range from 2% to 8% but are limited by several factors. Previous studies often relied on small samples, lacked data on mode of diagnosis/reaction history, were not specific to children, or were limited in scope to a specific allergen.

WHAT THIS STUDY ADDS: This study includes a representative sample of US households to estimate the overall prevalence of food allergy as well as the prevalence of allergen-specific and severe food allergy. Data also provide a framework for discussions of disparity and the distribution of childhood food allergy in the United States.

abstract

OBJECTIVE: The goal of this study was to better estimate the prevalence and severity of childhood food allergy in the United States.

METHODS: A randomized, cross-sectional survey was administered electronically to a representative sample of US households with children from June 2009 to February 2010. Eligible participants included adults (aged 18 years or older) able to complete the survey in Spanish or English who resided in a household with at least 1 child younger than 18 years. Data were adjusted using both base and poststratification weights to account for potential biases from sampling design and nonresponse. Data were analyzed as weighted proportions to estimate prevalence and severity of food allergy. Multiple logistic regression models were constructed to identify characteristics significantly associated with outcomes.

RESULTS: Data were collected for 40 104 children; incomplete responses for 1624 children were excluded, which yielded a final sample of 38 480. Food allergy prevalence was 8.0% (95% confidence interval [CI]: 7.6–8.3). Among children with food allergy, 38.7% had a history of severe reactions, and 30.4% had multiple food allergies. Prevalence according to allergen among food-allergic children was highest for peanut (25.2% [95% CI: 23.3–27.1]), followed by milk (21.1% [95% CI: 19.4–22.8]) and shellfish (17.2% [95% CI: 15.6–18.9]). Odds of food allergy were significantly associated with race, age, income, and geographic region. Disparities in food allergy diagnosis according to race and income were observed.

CONCLUSIONS: Findings suggest that the prevalence and severity of childhood food allergy is greater than previously reported. Data suggest that disparities exist in the clinical diagnosis of disease. *Pediatrics* 2011;128:e9–e17

Childhood food allergy is associated with impaired quality of life, limited social interactions, and comorbid atopic conditions.[1–6] Moreover, there is evidence that hospitalizations for anaphylaxis have increased more than fourfold among young people, with food-induced anaphylaxis being the most common cause.[7] Negative outcomes are compounded by limited treatment options, the absence of a cure, and the ubiquitous and often unidentified presence of allergenic foods in social settings. As a result, food allergy can have a profound social and psychological effect on the daily lives of affected children and their families.

Several studies have estimated childhood food allergy prevalence in the United States over the past 2 decades. (Sicherer[8] has reviewed this topic thoroughly.) A frequently cited statistic is 6% to 8% based on a 3-year study by Bock[9] conducted in the early 1980s. More recently, Liu et al reported a prevalence of 4.2% among children age 1 to 5 years using serologic data for peanut, milk, and egg allergy from the 2005 National Health and Nutrition Examination Survey.[10] Branum and Lukacs[3] reported a prevalence of 3.9% among children younger than 18 years of age based on self-report of a food or digestive allergy collected as part of the 2007 National Health Interview Survey. Finally, a recent meta-analysis commissioned by the National Institute of Allergy and Infectious Disease concluded that the prevalence of food allergy among all age groups likely falls between 1% and10%.[11,12]

Important insight has been gained by these past estimates, but the prevalence of childhood food allergy has yet to be definitively established. Previous studies are often limited by small sample size, lack of data on mode of diagnosis and reaction history, are not specific to children, or are limited in scope to a specific allergen.

The extent to which food allergy affects children in the United States also remains unclear. Previous estimates of prevalence have not considered the severity of disease. Furthermore, the underlying pathophysiology of disease is varied, and clinical manifestations encompass a diverse spectrum of symptoms.[13] On ingestion of an allergen, an affected child may experience an immunoglobulin E or non–immunoglobulin E-mediated reaction characterized by symptoms ranging from mild pruritus to delayed gastrointestinal symptoms to life-threatening anaphylaxis.

The heterogeneity and limitations of available data necessitate further analysis of all perceived food allergies on a larger scale. In the study described here, report of allergy, mode of diagnosis, and reaction history were collected from a population-based sample of nearly 40 000 US households with children to better estimate the prevalence, severity, and distribution of childhood food allergy in the United States.

METHODS

A population-based, cross-sectional survey was administered between June 2009 and February 2010 to a representative sample of US households with children. The institutional review boards of Children's Memorial Hospital and Northwestern University approved the study protocol. Consent to participate was implicit in completion and return of the survey.

Survey Development and Design

The survey was developed by pediatricians, pediatric allergists, and health services researchers, with support of an expert panel comprising leaders in the field. Expert panel review and cognitive interviews ($N = 10$) were conducted using the approach described by Gupta et al[14] to ensure general understandability and consistency of response.

The survey was then programmed for electronic administration. Quality-control testing was conducted to assure that skip logic and randomization were met. A pretest of 30 interviews was electronically administered to verify survey functionality and understandability. The survey was subsequently finalized based on pretest results.

The final survey is available on request and includes items assessing participant report of a child's food allergies. Questions were asked about the date of onset, method of diagnosis, and reaction history for each reported allergen. Detailed demographic items were also included.

Study Participants

Eligible participants included adults (those aged 18 years or older) able to complete the survey in Spanish or English who resided in US households with at least 1 child younger than 18 years.

Participants were recruited using a dual-sample approach. A target of 6100 participants was recruited from a Web-enabled panel that is a statistically representative sample of US households with children. This sample included households recruited using probability-based random-digit-dialing (RDD) sampling that had or were provided Internet connectivity to complete the survey. An additional 33 900 participants were targeted from an online sample of US households with children who had access to the Internet. Responses from the Web-enabled panel were used to identify and correct for sampling and nonsampling biases (see "Statistical Analysis").

Participant recruitment and survey administration were conducted by Knowledge Networks, a survey research firm in Menlo Park, California. Knowledge Networks developed and

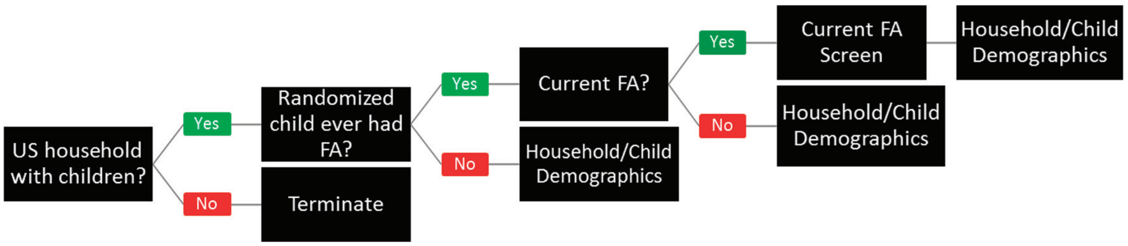

FIGURE 1
Survey scheme based on participant response. FA indicates food allergy.

maintains the Web-enabled panel and secured the online sample. (See the Appendix for details.) Knowledge Networks has documented the reliability and validity of its methodologic approach as well its comparability with the more traditional RDD approach.[15,16]

Data Collection

Current estimates of food allergy prevalence in the literature were used to estimate adequate sample size. Completion of 40 000 surveys was determined to have a power of 0.90 with a significance level of .05 to detect: (1) overall and allergen-specific food allergy prevalence rates from 1% to 9%; and (2) prevalence variability from 1% to 7% among groups as small as 1% of the sample.

In households with multiple children, 1 child was randomly selected and participants were instructed to complete the survey for the selected child as outlined in Fig 1.

Outcome Measures

Primary outcome measures were prevalence and severity of food allergy. The definition of food allergy included report of either a convincing or confirmed food allergy. A convincing food allergy was based on participant report in conjunction with ≥1 of the following reaction symptoms: anaphylaxis (defined as a severe allergic reaction that can lead to death), angioedema of the lips, eyes, or face, other angioedema, coughing, other oropharyngeal symptoms, eczema, flushing, hives, low blood pressure, pruritus, trouble breathing, vomiting, or wheezing. A confirmed food allergy met the latter criteria and also included report of physician-diagnosis with serum-specific immunoglobulin E testing, skin prick testing, or an oral food challenge.

A food allergy was categorized by the expert panel as mild-to-moderate or severe based on reaction history. Mild-to-moderate symptoms were limited to angioedema of the lips, eyes, or face, other angioedema, coughing, other oropharyngeal symptoms, eczema, flushing, hives, pruritus, and vomiting. Severe symptoms included any report of anaphylaxis, low blood pressure, trouble breathing, or wheezing. A reaction including vomiting, angioedema, and coughing in combination was also categorized as severe.

Statistical Analysis

Data were weighted using both base and poststratification weights to adjust for potential biases from sampling design and survey response. Base weights adjusted for under- and oversampling by geographic region, area code, and survey language. After base weight assignment, an additional adjustment was added to reflect the probability of selecting a child within a household. Finally, poststratification weights were assigned using demographic distributions from the December 2009 US Census Current Population Survey and the 2006 Pew Hispanic Center Survey.

Prevalence and severity estimates were calculated as weighted proportions.[17] Multiple logistic regression models, adjusted for survey design and sample weights, were estimated to examine the association between household or child characteristics and the prevalence, diagnosis, and severity of food allergy. Each model was adjusted for household income, race/ethnicity, age, geographic region, and gender. All analyses were conducted with Stata 11.0 (Stata Corp, College Station, TX).

RESULTS

Data were collected for 40 104 children. Incomplete responses for 1624 children were not included in the analysis, yielding a final sample size of 38 480.

Demographic Characteristics

Half (51.1%) of the children surveyed were male, with a mean age of 8.5 years (95% confidence interval [CI]: 8.5–8.6). Race/ethnicity was mutually exclusive, with 56.4% of children reported to be white, non-Hispanic; 21.6% Hispanic; 14.1% black, non-Hispanic; and 4.8% Asian, non-Hispanic (Table 1).

Prevalence

The prevalence of food allergy was 8.0% (95% CI: 7.7–8.3) (Table 2). Multiple food allergies were reported for 2.4% of all children (95% CI: 2.2–2.6),

TABLE 1 Demographic Characteristics Among All Children Surveyed ($N = 38\,480$) and Children Surveyed With Food Allergy ($N = 3339$)

Variable	Frequency, % (95% CI)		*P*
	All Children	Children With Food Allergy	
Race/ethnicity			.0000
Asian, non-Hispanic	4.8 (4.6–5.1)	6.2 (5.2–7.3)	
Black, non-Hispanic	14.1 (13.7–14.7)	21.7 (19.7–23.9)	
White, non-Hispanic	56.4 (55.8–57.1)	51.1 (49.0–53.2)	
Hispanic	21.6 (20.9–22.2)	18.0 (16.3–20.0)	
Multiple/other, non-Hispanic	3.0 (2.8–3.2)	3.0 (2.3–3.5)	
Gender			.7311
Female	49.0 (48.3–49.6)	49.3 (47.2–51.4)	
Male	51.1 (50.4–51.7)	50.7 (48.6–52.8)	
Age, y			.0000
0–2	16.8 (16.3–17.3)	13.2 (11.9–14.7)	
3–5	17.0 (16.5–17.5)	19.6 (17.9–21.4)	
6–10	26.7 (26.1–27.3)	25.4 (23.6–27.3)	
11–13	17.2 (16.7–17.7)	17.6 (16.1–19.3)	
14–17	22.4 (21.9–22.9)	24.2 (22.4–26.0)	
Household income, $			.0010
<25 000	20.3 (19.7–20.9)	17.6 (15.9–19.5)	
25 000–49 999	28.9 (28.3–29.5)	28.2 (26.3–30.2)	
50 000–99 999	34.6 (34.0–35.1)	36.5 (34.6–38.5)	
100 000–149 999	11.6 (11.2–12.0)	11.8 (10.6–13.12)	
≥150 000	4.7 (4.4–4.9)	5.9 (5.0–6.9)	
Geographic region			.0000
Midwest	21.9 (21.4–22.4)	17.1 (15.7–18.6)	
Northeast	16.7 (16.3–17.2)	17.1 (15.7–18.6)	
South	37.3 (36.6–37.9)	42.9 (40.7–45.0)	
West	24.2 (23.6–24.7)	23.0 (21.3–24.9)	

corresponding to 30.4% of children with a food allergy. Prevalence by allergen was also estimated. Peanut allergy was most common, followed closely by milk and shellfish (Table 2). Significant variation in prevalence according to age was observed for peanut, shellfish, tree nut, egg, and wheat allergy ($P <$ .05) (Table 2).

Severity

The prevalence of severe food allergy among all children was 3.1% (95% CI: 2.9–3.3), corresponding to 38.7% of children with food allergy. Food allergy reactions were most often severe among children with tree nut or peanut allergy (Table 3).

Associations

Odds of having a food allergy are presented in Table 4. The odds of food allergy were significantly higher among Asian and black children versus white children, children in all age groups versus those aged 0 to 2 years, and for children from geographic regions outside the Midwest ($P <$ .05). Odds were significantly lower among children in households with an income <$50 000 vs ≥$50 000 ($P <$ .05). Gender was not significantly association with odds of food allergy in this model.

Odds of having a diagnosed food allergy were also estimated (Table 4). The odds of a confirmed versus convincing food allergy were significantly higher among children with multiple food allergies versus those without multiple food allergies ($P <$ .05). Odds of a confirmed food allergy were significantly lower among Asian, black, and Hispanic children versus white children and for children in households with an income <$50 000 vs ≥$50 000 ($P <$ .05). Gender, age, and geographic region were not significantly associated with diagnosis of food allergy in this model.

Odds of severe versus mild-to-moderate food allergy among food-allergic children were estimated as well (Table 4). The odds of severe food allergy were significantly higher among children in all age groups versus those aged 0 to 2 years, male versus female children, and children with versus without multiple food allergies ($P <$ .05). Odds were significantly lower among children in households with an income <$50 000 vs ≥$50 000 ($P <$ .05). Race and geographic region were not significantly associated with severity of food allergy in this model.

DISCUSSION

Eight percent of children in this study had a food allergy, which corresponds to an estimated 5.9 million children in the United States. Furthermore, 38.7% of the children surveyed had a history of severe reactions, and 30.4% had multiple food allergies.

Previous estimates of childhood food allergy in the United States have ranged from 2% to 8%.[3,9,10] A study conducted by Branum and Lukacs[3] reported the prevalence of childhood food allergy to be 3.9%, whereas a study by Liu et al[10] estimated prevalence at 4.2% for children age 1 to 5 years and 3.8% for children age 6 to 19 years. The study by Branum and Lukacs was notable for its larger sample size and its specificity to children but was based on caregiver report of food allergy or digestive disorder without report of reaction history or presenting symptoms, and, as such, warrants further corroboration. The study by Liu et al is unique in its use of food-specific IgE to confirm the diagnosis of food allergy. However, it is limited to peanut, milk, and egg allergy only (as well as shrimp in the 6- to 19-year age group). The study described here, which included the largest sample of children to date and gathered information for a wide number of food allergens, sug-

TABLE 2 Prevalence of Common Food Allergies According to Age Group

Age Group	Frequency, % (95% CI)									
	All Allergens (N = 3339)	Peanut (N = 767)	Milk (N = 702)	Shellfish (N = 509)	Tree Nut (N = 430)	Egg (N = 304)	Fin Fish (N = 188)	Strawberry (N = 189)	Wheat (N = 170)	Soy (N = 162)
Prevalence among all children surveyed										
All ages (N = 38 480)	8.0 (7.7–8.3)	2.0 (1.8–2.2)	1.7 (1.5–1.8)	1.4 (1.2–1.5)	1.0 (0.9–1.2)	0.8 (0.7–0.9)	0.5 (0.4–0.6)	0.4 (0.4–0.5)	0.4 (0.3–0.5)	0.4 (0.3–0.4)
0–2 y (n = 5429)	6.3 (5.6–7.0)	1.4 (1.1–1.8)	2.0 (1.6–2.4)	0.5 (0.3–0.8)	0.2 (0.2–0.5)	1.0 (0.7–1.3)	0.3 (0.1–0.4)	0.5 (0.3–0.7)	0.3 (0.1–0.5)	0.3 (0.2–0.4)
3–5 y (n = 5910)	9.2 (8.3–10.1)	2.8 (2.3–3.4)	2.0 (1.7–2.5)	1.2 (0.8–1.6)	1.3 (1.0–1.7)	1.3 (0.9–1.7)	0.5 (0.3–0.8)	0.5 (0.3–0.8)	0.5 (0.3–0.7)	0.5 (0.3–0.7)
6–10 y (n = 9911)	7.6 (7.0–8.2)	1.9 (1.6–2.3)	1.5 (1.2–1.8)	1.3 (1.1–1.6)	1.1 (0.87–1.4)	0.8 (0.6–1,1)	0.5 (0.3–0.7)	0.4 (0.3–0.5)	0.4 (0.3–0.5)	0.3 (0.2–0.5)
11–13 y (n = 6716)	8.2 (7.4–9.0)	2.3 (1.9–2.8)	1.4 (1.1–1.8)	1.7 (1.3–2.1)	1.2 (1.0–1.6)	0.5 (0.4–0.8)	0.6 (0.4–0.8)	0.4 (0.3–0.6)	0.7 (0.5–0.9)	0.6 (0.4–0.8)
≥14 y (n = 10 514)	8.6 (7.9–9.3)	1.7 (1.4–2.1)	1.6 (1.3–1.9)	2.0 (1.7–2.5)	1.2 (0.9–1.5)	0.4 (0.2–0.5)	0.6 (0.4–0.9)	0.4 (0.3–0.6)	0.3 (0.2–0.4)	0.3 (0.2–0.4)
P	.0000	.0001	.0504	.0000	.0000	.0000	.1045	.7700	.0089	.0509
Prevalence among children surveyed with food allergy										
All ages (N = 3339)	—	25.2 (23.3–27.1)	21.1 (19.4–22.8)	17.2 (15.6–18.9)	13.1 (11.7–14.6)	9.8 (8.5–11.1)	6.2 (5.2–7.3)	5.3 (4.4–6.3)	5.0 (4.2–6.0)	4.6 (3.8–5.6)
0–2 y (n = 469)	—	22.2 (17.4–27.8)	31.5 (26.6–36.8)	7.5 (4.7–11.9)	5.4 (3.6–8.1)	15.8 (12.0–20.4)	4.0 (2.3–6.9)	7.5 (5.2–8.2)	4.0 (2.2–7.2)	4.2 (2.7–6.5)
3–5 y (n = 539)	—	30.3 (25.8–35.3)	22.1 (18.3–26.5)	12.9 (9.7–16.9)	14.3 (11.1–18.2)	13.7 (10.5–17.6)	5.7 (3.8–8.6)	5.5 (3.6–8.2)	5.0 (3.2–7.7)	5.1 (3.3–7.8)
6–10 y (n = 847)	—	25.5 (22.0–29.5)	19.6 (16.6–23.0)	17.1 (14.0–20.6)	14.3 (11.6–17.5)	11.1 (8.6–14.3)	6.2 (4.5–8.5)	4.8 (3.4–6.9)	5.0 (3.5–7.1)	4.0 (2.6–6.2)
11–13 y (n = 584)	—	28.1 (23.7–32.9)	17.7 (14.2–22.0)	20.4 (16.8–24.7)	15.2 (12.0–19.2)	6.6 (4.4–9.9)	7.0 (4.8–10.1)	4.6 (3.1–6.8)	8.2 (5.9–11.2)	6.9 (4.7–10.0)
≥14 y (n = 900)	—	20.2 (17.0–23.7)	18.4 (15.3–22.1)	23.8 (20.1–27.9)	13.4 (10.7–16.6)	4.1 (2.9–5.9)	7.2 (5.2–9.8)	4.9 (3.3–7.3)	3.3 (2.1–5.0)	0.3 (0.2–0.4)
P	—	.0050	.0001	.0000	.0010	.0000	.4646	.4486	.0174	.1296

Common food allergens are those reported with a frequency of $n > 150$.

TABLE 3 Severity of Common Food Allergies Among Affected Children (N = 3339)

Reaction History	Proportion, % (95% CI)									
	All Allergens (N = 3339)	Tree Nut (N = 430)	Peanut (N = 767)	Shellfish (N = 509)	Soy (N = 162)	Fin Fish (N = 188)	Wheat (N = 170)	Milk (N = 702)	Egg (N = 304)	Strawberry (N = 189)
Severe	38.7 (36.7–40.8)	52.5 (46.7–58.3)	52.4 (47.9–56.7)	46.8 (41.4–52.3)	42.6 (33.1–52.7)	40.6 (32.5–49.3)	38.0 (29.4–47.5)	31.2 (27.1–35.7)	29.5 (23.7–36.1)	19.6 (13.3–28.0)
Mild-to-moderate	61.3 (59.2–63.4)	47.5 (41.7–53.4)	47.7 (43.3–52.1)	53.2 (47.7–58.6)	57.4 (47.3–67.0)	50.4 (50.8–67.5)	62.0 (52.5–70.6)	68.8 (64.3–72.9)	70.5 (63.9–76.3)	80.4 (72.0–86.7)

Common food allergens are those reported with a frequency of $n > 150$.

TABLE 4 Multiple Logistic Regression Models: Adjusted Odds of Food Allergy, Diagnosis of Food Allergy, and Severe Food Allergy

Variable	Food Allergy vs No Food Allergy	Confirmed vs Convincing Food Allergy	Severe vs Mild-to-Moderate Food Allergy
Race/ethnicity vs white, non-Hispanic			
Asian, non-Hispanic	1.4 (1.2–1.7)	0.7 (0.4–0.9)	0.7 (0.4–1.0)
Black, non-Hispanic	1.8 (1.6–2.1)	0.8 (0.6–1.0)	1.1 (0.8–1.4)
Hispanic	0.9 (0.8–1.1)	0.8 (0.6–1.0)	0.9 (0.7–1.2)
Multiple/other, non-Hispanic	1.1 (0.9–1.4)	1.2 (0.8–1.8)	1.1 (0.7–1.7)
Gender			
Male vs female	0.9 (0.9–1.1)	1.1 (0.9–1.3)	1.3 (1.0–1.5)
Age vs 0–2 y			
3–5	1.5 (1.3–1.8)	1.4 (1.0–1.9)	1.6 (1.1–2.4)
6–10	1.2 (1.1–1.4)	1.2 (0.9–1.)	1.6 (1.2–2.3)
11–13	1.3 (1.1–1.5)	1.1 (0.8–1.6)	1.9 (1.4–2.8)
14–17	1.4 (1.2–1.6)	1.2 (0.9–1.7)	2.1 (1.5–3.0)
Household income, $			
<50 000 vs ≥50 000	0.5 (0.4–0.7)	0.5 (0.4–0.6)	0.8 (0.6–0.9)
Geographic region vs Midwest			
Northeast	1.3 (1.2–1.5)	1.3 (1.0–1.7)	1.1 (0.9–1.5)
South	1.5 (1.3–1.7)	1.1 (0.9–1.4)	1.1 (0.8–1.4)
West	1.3 (1.1–1.5)	1.0 (0.7–1.3)	1.0 (0.7–1.3)
Report of multiple food allergies			
Yes vs no	—	3.1 (2.6–3.8)	3.2 (2.7–4.0)

Each estimate is adjusted for all variables listed in the table.

gests that food allergy affects more children than recently reported.

Allergen-specific prevalence in this study fell within the range of past estimates for milk,[18] shellfish,[18] tree nut,[11] wheat,[11] and soy allergy among children.[11] However, estimates of peanut and fin fish allergy were somewhat higher than previously reported.

Peanut allergy was found to affect 2.0% of children. This estimate is close to that reported by Hourihane et al[19] in the United Kingdom (1.8%) but double that confirmed by Ben-Shoshan et al[20] in Canada (1.0%). Interestingly, in the study by Ben-Shoshan et al, peanut allergy was probable among 1.7% of children.

Fin fish allergy was found to affect 0.5% of children. Ben-Shoshan et al[20] found that 0.18% of children had a probable fin fish allergy but none of them had a formal diagnosis. Among adults and children, oral food challenges suggest a prevalence of 0.3%.[11] When interpreting these variations in prevalence, it is important to consider that those with a probable allergy may be truly allergic absent a formal diagnosis.

To our knowledge, prevalence of severe childhood food allergy for a representative sample of US children has not been previously estimated. The lack of data on the severity of childhood food allergy has made it difficult to articulate best practices. Our study found that >38.7% of food-allergic children had a history of severe food-induced reactions. Severe reactions were most common among children with a tree nut, peanut, shellfish, soy, and fin fish allergy, ranging from >50% of tree nut and peanut-allergic children to >40% of children with fin fish allergy.

Current literature suggests that adolescents are at greater risk for severe food allergy than children of any other age.[21] Consistent with past reports, this study found that odds of severe food allergy progressively increased with age, peaking at more than twofold higher odds of severe reaction history among children aged 14 to 17 years versus those aged 0 to 2 years. Odds were most pronounced among children with versus without multiple food allergies—the former had a more than threefold higher odds of severe food-induced reactions. Although this finding seems somewhat intuitive, to our knowledge it has not been previously reported.

The identification of significant differences in odds of food allergy and diagnosed food allergy suggests that disparities may exist in both the etiology and management of disease. Age and geographic region were significantly associated with having a food allergy but not with odds of having a confirmed versus convincing food allergy. This finding suggests that these associations are not the result of varying clinical practices by age or region. Rather, they may be indicative of underlying causes of disease, such as pathophysiologic differences in the development of food allergy by age. Indeed, food allergy prevalence was highest among children 3 to 5 years at 9.2%. The role of geographic region in etiology is less clear and warrants further investigation.

Unlike age and geographic region, findings suggest that differences in prevalence by race and income may represent socially constructed disparities. For example, black and Asian children had significantly higher odds of food allergy compared with white children but had significantly lower odds of having the allergy diagnosed. In short, these children were more likely to have food allergy but less likely to receive a formal diagnosis. Interestingly, the odds of food allergy among Hispanic children were lower compared with white children in both models, although only to a degree of statistical significance in the confirmed versus convincing model. It is possible that Hispanic children are protected against food allergy in a manner not yet identified.

Limitations to this study need to be highlighted. Reaction history and diagnosis of food allergy were based solely on participant report, which is subject to recall bias. Furthermore, data on the reproducibility of reaction symptoms were not collected and the survey was not validated to ensure accuracy of diagnosis. However, the prevalence of a number of specific allergies is consistent with that reported by other studies, lending credibility to the definition of food allergy used in this study.

CONCLUSIONS

Findings suggest that the impact of food allergy in the United States may be greater than previously reported. The prevalence of childhood food allergy was estimated at 8.0%, which is considerably higher than many recent reports. Furthermore, 38.7% of food-allergic children had a history of severe food-induced reactions. Data also suggest that disparities exist in childhood food allergy and its clinical diagnosis. These findings provide critical epidemiologic information to guide strategies for the prevention of food-induced reactions and for the diagnosis and management of childhood food allergy.

APPENDIX METHODS

The data in this study were collected by Knowledge Networks using an online survey that used a combination of the Knowledge Networks KnowledgePanel sample and an opt-in sample. Although the KnowledgePanel sample is probabilistic and nationally representative, it was not large enough for the purposes of this study. To obtain enough participants, Knowledge Networks combined their KnowledgePanel sample with an opt-in sample and then used weights to calibrate the overall sample. After excluding subjects with missing data for the outcomes and demographic characteristics, 6892 subjects from the KnowledgePanel and 31 588 subjects from the opt-in panel were included in the analyses.

KnowledgePanel Methods

Knowledge Networks created the KnowledgePanel by randomly recruiting subjects using sampling methods that included both RDD and address-based sampling. After recruitment, subjects who did not have e-mail access were provided with the necessary equipment and services to access online content. By providing online access, subjects that might otherwise be excluded from participating in online surveys were included in the sample. For the RDD sample, Knowledge Networks used a sampling frame of US residential telephone landlines. Areas with a high concentration of black and Hispanic households were oversampled, and sampling was done without replacement. Households with a mailing address that matches their telephone number receive a letter indicating they have been selected to participate in the panel and that they will receive a phone call. Subjects are then recruited by telephone; trained interviewers attempt to contact and recruit potential subjects. Households without computers and/or access to the Internet are offered a computer and free Internet access in exchange for completing weekly surveys. Households with computers are offered incentive points that can be redeemed for cash. To address the increasing number of households without landlines, Knowledge Networks added address-based recruitment in 2009.

Survey Administration

Households with children younger than 18 years were randomly selected for this survey. Members who were selected for the survey received an e-mail with a link, and then received an automatic e-mail reminder if they did not respond. Panel members have access to a personalized online list of surveys that need to be completed. Usually, panel members are assigned no more than 1 survey per week. Ongoing incentive programs, including raffles and sweepstakes, are used to retain member panels, and additional incentives may be offered for longer surveys.

Weighting

The data in this study were weighted using a series of weights that adjusted for the sampling design and various sources of sampling and nonsampling error. The weights included a base weight, a panel demographic poststratification weight, a Spanish language base weight, a child adjustment in the base weight, and a study-specific poststratification weight. Details for how the weights were created are discussed below.

The first weight for the KnowledgePanel is the base weight. The base weight addresses several sources of deviation from an equal probability of selection. The first is the undersampling of telephone numbers that were not matched to a valid mailing. The KnowledgePanel sample is partially based on a sample of RDD-generated phone numbers. After the sample of phone numbers is obtained, they are matched to mailing addresses. Approximately 30% to 40% of these numbers will not have a matching address, and these are undersampled to increase the efficiency of recruiting. The second aspect of the base weight addresses households that have multiple landlines. KnowledgePanel collects data about the number of landlines in a household and then weights the selection probability for these households. The third issue that the weight adjusts for is some minor oversampling of certain cities when the sample was started. In addition to oversampling from these cities, the weight also adjusts for potential oversampling of the 4 largest states and states located in the central region of the country. Because some households are located in areas in which Knowledge Networks was unable to provide Internetaccess, the base weight also includes an adjustment to address the undersampling of these areas. Finally, the base weight adjusts for oversampling of black and Hispanic telephone numbers, and incorporates panel members from the address-based sample described above.

The second weight is the Spanish Language Base Weight. Starting in 2008, Knowledge Networks started recruiting households that were Spanish-language dominant. The recruitment interviews in these households were conducted in Spanish. To recruit Spanish-language dominant households, 11 regions were screened using both RDD methods as well as lists of Hispanic surnames. The weight includes 3 adjustments. The first adjusts for the number of telephone landlines in a household. The second adjusts for balancing the RDD and listed surname samples. The final adjustment uses Pew Hispanic Center surveys and census regions to adjust for the degree of Spanish language spoken at home.

Because the sample included only 1 child in every household, the base weight was adjusted for the number of children within each household. The number of children was collapsed into 3 categories (1 child, 2 children, and ≥3 children), and the starting weights were then adjusted.

After the base weights were calculated, the panel demographic post-stratification weights were applied. This weight is designed to address the effects of nonresponse and noncoverage bias in the panel membership. The adjustment is based on recent data from the Current Population Survey for demographic characteristics and from the 2006 Pew Hispanic Center Survey to adjust for Spanish language usage. Because the survey data do not address Internet availability, the benchmark for this adjustment is based on KnowledgePanel recruitment data. The variables included in the post-stratification weights were gender, age, ethnicity, race, education, census region, metropolitan area, income, and parent language spoken at home.

Finally, after the survey was fielded, poststratification weights were applied to address survey nonresponse and noncoverage. These weights were based on the same data and variables as the demographic weights. The poststratification weighting adjustment was completed through iterative proportional fitting.

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