Prevalence of food allergies and intolerances documented in electronic health records

Warren W. Acker, MS,[a,b] Joseph M. Plasek, MS,[a,c] Kimberly G. Blumenthal, MD, MSc,[d,e,f,g] Kenneth H. Lai, MA,[h]
Maxim Topaz, RN, MA, PhD,[a,d] Diane L. Seger, RPh,[a,h] Foster R. Goss, DO, MMSc,[i]
Sarah P. Slight, PhD, MPharm, PGDip,[a,j,k] David W. Bates, MD, MSc,[a,d] and Li Zhou, MD, PhD[a,d,l]   *Boston, Mass,*
Scranton, Pa, Salt Lake City, Utah, Aurora, Colo, and Newcastle upon Tyne, United Kingdom

Background: Food allergy prevalence is reported to be increasing, but epidemiological data using patients' electronic health records (EHRs) remain sparse.
Objective: We sought to determine the prevalence of food allergy and intolerance documented in the EHR allergy module.
Methods: Using allergy data from a large health care organization's EHR between 2000 and 2013, we determined the prevalence of food allergy and intolerance by sex, racial/ethnic group, and allergen group. We examined the prevalence of reactions that were potentially IgE-mediated and anaphylactic. Data were validated using radioallergosorbent test and ImmunoCAP results, when available, for patients with reported peanut allergy.
Results: Among 2.7 million patients, we identified 97,482 patients (3.6%) with 1 or more food allergies or intolerances (mean, 1.4 ± 0.1). The prevalence of food allergy and intolerance was higher in females (4.2% vs 2.9%; $P < .001$) and Asians (4.3% vs 3.6%; $P < .001$). The most common food allergen groups were shellfish (0.9%), fruit or vegetable (0.7%), dairy (0.5%), and peanut (0.5%). Of the 103,659 identified reactions to foods, 48.1% were potentially IgE-mediated (affecting 50.8% of food allergy or intolerance patients) and 15.9% were anaphylactic. About 20% of patients with reported peanut allergy had a radioallergosorbent test/ImmunoCAP performed, of which 57.3% had an IgE level of grade 3 or higher.
Conclusions: Our findings are consistent with previously validated methods for studying food allergy, suggesting that the EHR's allergy module has the potential to be used for clinical and epidemiological research. The spectrum of severity observed with food allergy highlights the critical need for more allergy evaluations. (J Allergy Clin Immunol 2017;140:1587-91.)

Key words: Food hypersensitivity, allergy and immunology, epidemiology, anaphylaxis, prevalence, electronic health records

The prevalence of adverse reactions to food in the United States in 2014 was estimated to be 5% for adults and 8% for children,[1] an increase from 2006 estimates (3% to 4% and 6%, respectively).[2] Reports over the last decade indicate that the incidence of food-induced hospitalizations in the United States increased from 0.6 per 1000 patients to 1.3 per 1000 patients.[3]

However, most studies reporting food allergy epidemiology use cross-sectional surveys, a method often limited by small sample size and selection bias. In addition, many studies focus on a specific food allergen or allergen group, most commonly peanut, tree nut, or shellfish.[4-6] Current electronic health record (EHR) systems in the United States contain an "allergy" module in which health care providers document a patient's adverse reactions to medications, foods, or environmental substances, including reactions reported by the patient or observed clinically. This module must include food allergies to ensure patient safety, especially for hospitalized patients. The EHR allergy module also serves as the only semi-standardized location for allergy documentation between EHRs and enables population-based estimates of food allergy epidemiology.

In this study, we used the EHR allergy module of a large health care system to estimate the prevalence of food allergies and

intolerances and associations with sex and racial/ethnic groups. In addition, we examined the prevalence of specific reactions, including those potentially IgE-mediated and anaphylactic.

METHODS
Setting and data collection

In this study, we used food allergy and intolerance data collected at Partners HealthCare, an integrated health care delivery network in the Greater Boston Area composed of multiple community and specialty hospitals as well as community health centers. Partners HealthCare providers recorded patient food allergies and intolerances in an allergy module of the EHR. Patients' allergy information was integrated and stored in the Partners' Enterprise-wide Allergy Repository (PEAR).[7] In this article, we use the term "food allergies and intolerances" to represent any adverse reaction to food, including allergies, idiosyncratic and pseudoallergic reactions, intolerances, and even food preferences.[8-10] The study population consisted of patients seen at any Partners HealthCare center from January 1, 2000, to December 31, 2013. This study was approved by the Partners HealthCare Human Research Committee.

Food allergy and intolerance information in PEAR included a list of specific allergens (ie, culprit foods), reaction(s) to that allergen, and associated data (date/time this information was recorded and any updated information such as new/different reactions). Patients' demographic information (sex, date of birth, and self-reported racial/ethnic group) was extracted from the Partners HealthCare EHR. As described in a previous study,[10] food allergy and intolerance records were processed by a natural language processing tool to the coded form, negated terms were removed, and food allergens were classified into groups. Classification was based on the Food Allergen Labeling and Consumer Protection Act,[11] cross-sensitivity findings, medical terminologies (eg, Systematized Nomenclature of Medicine – Clinical Terms[12]), recommendations of a multidisciplinary expert panel, and a review of the allergy literature.[10] The final food allergen classification consisted of 19 food substance groups.

Patients' adverse reactions associated with food allergens were captured and classified by reaction type (eg, hives/urticaria and anaphylaxis). These adverse reactions represented both patient self-reported adverse reactions to food and physician-recorded symptoms to food. We defined potentially IgE-mediated reactions as those that included anaphylaxis, shortness of breath, tongue swelling, hives/urticaria, itching, bronchospasm/wheezing, angioedema, and hypotension.[13,14] We classified anaphylactic reactions as only those reactions entered as anaphylaxis by the clinical provider (eg, a patient with reactions of shortness of breath and hives would not have been considered anaphylaxis).

To better understand the validity of food allergy data entered in PEAR, we used specific IgE to peanut by radioallergosorbent test (RAST) from 2000 to 2010 and ImmunoCAP from 2009 to 2013 for all patients reportedly peanut allergic or intolerant.

Data analysis

We determined food allergy and intolerance prevalence to each of the 19 food allergen groups, as well as by sex and racial/ethnic group (white, black, Hispanic, Asian, and "other or unknown"). "Other or unknown" racial/ethnic group included those with more than 1 racial identity and patients whose racial/ethnic group was "not given," "unknown," "refused," or missing. We calculated the prevalence of

common (frequency, >1.0%) reactions among patients with 1 or more food allergies or intolerances.

We validated EHR-reported peanut allergies by identifying patients with a documented allergy or intolerance to peanut who had a RAST/ImmunoCAP performed in our health care system, and assessing the grade by IgE level (negative, <0.35 mg/dL; grade 1, 0.35-0.69 mg/dL; grade 2, 0.70-3.49 mg/dL; grade 3, 3.50-17.49 mg/dL; grade 4, 17.50-49.99 mg/dL; grade 5, 50.0-100.0 mg/dL; and grade 6, >100.0 mg/dL). We performed the corollary analysis using only those patients with reported peanut allergies whom we identified as potentially IgE-mediated.

We used chi-square tests to compare documented food allergies and intolerances in each demographic group for all food allergies and intolerances and for each allergen group. For multigroup categories (eg, race), we collapsed each group into binary variables for statistical comparisons. *P* values were calculated, with *P* < .05 being considered statistically significant. Data were analyzed using SAS statistical software version 9.3 (SAS Inc, Cary, NC).

RESULTS
Description of study population

Our overall study population (ie, the PEAR data set) consisted of 2,714,851 patients of whom 55.2% were females and 44.8% were males. Most of our patients were white (70.5%), followed by Hispanic (6.3%), black (5.7%), and Asian (3.6%).

Prevalence of documented food allergy and intolerance

A total of 132,734 food allergy and intolerance records were documented for 97,482 (3.6%) food-allergic or intolerant patients. On average, patients with food allergy and/or intolerance had 1.4 ± 0.1 food allergen records in PEAR. The most prevalent food allergen groups (*P* < .001) were shellfish (0.9%), fruit or vegetable (0.7%), dairy (0.5%), peanut (0.5%), and tree nut (0.4%) (Table I; see Table E1 in this article's Online Repository at www.jacionline.org).

Female patients were more likely to have a recorded food allergy or intolerance than males, both overall (4.2% vs 2.9%; *P* < .001) and for every food allergen group except peanut (0.4% for females vs 0.5% for males; *P* < .001). Asian patients (4.3%) had a significantly (*P* < .001) higher prevalence compared with other racial/ethnic groups (3.6%), followed by black patients (3.9%), white patients (3.8%), and Hispanic patients (2.8%). Among the 9 most common food allergen groups, Asian patients had significantly higher food allergy and intolerance prevalence for all groups except additives (Asian 0.1% vs non-Asian 0.2%; *P* < .001) and grain (Asian 0.2% vs non-Asian 0.3%; *P* < .001) (Tables I and E1).

Food adverse reactions

Among 132,734 allergy and intolerance records, there were 148,046 documented reactions experienced by 97,482 patients. Seventy percent of the reactions had 1 or more known adverse reaction documented (ie, they were not documented as "unknown"), accounting for 103,659 reactions. On average, patients had 1.2 reactions (when known) for each unique food allergen. A total of 28.3% of patients with a documented food allergy or intolerance had a reaction of hives/urticaria, followed by anaphylaxis (15.9%) and gastrointestinal irritation (11.5%). A total of 50.8% of patients with a food allergy or intolerance had a corresponding documented reaction that was potentially IgE-mediated (Table II).

TABLE I. Prevalence of documented food allergy of each demographic category for common food allergen groups

Characteristic	Total population, n (%)	Food allergen group, n (%)*									
		Total food	Shellfish	Fruit or vegetable†	Dairy‡	Peanut	Tree nut	Egg	Grain	Additive§	Fish
Total	2,714,851	97,482 (3.6)	25,649 (0.9)	19,803 (0.7)	12,958 (0.5)	12,946 (0.5)	10,581 (0.4)	8,919 (0.3)	6,679 (0.2)	6,277 (0.2)	4,190 (0.2)
Sex‖											
Male	1,215,796 (44.8)	35,192 (2.9)	9,174 (0.8)	5,931 (0.5)	4,705 (0.4)	6,614 (0.5)	4,596 (0.4)	3,715 (0.3)	1,945 (0.2)	1,525 (0.1)	1,641 (0.1)
Female	1,499,055 (55.2)	62,290 (4.2)	16,475 (1.1)	13,872 (0.9)	8,253 (0.6)	6,332 (0.4)	5,985 (0.4)	5,204 (0.3)	4,734 (0.3)	4,752 (0.3)	2,549 (0.2)
Racial/ethnic group¶											
White	1,913,639 (70.5)	71,874 (3.8)	18,709 (1.0)	14,140 (0.7)	9,974 (0.5)	8,721 (0.5)	7,992 (0.4)	6,180 (0.3)	5,563 (0.3)	5,188 (0.3)	2,962 (0.2)
Black	153,739 (5.7)	5,963 (3.9)	1,785 (1.2)	1,422 (0.9)	696 (0.5)	954 (0.6)	445 (0.3)	549 (0.4)	207 (0.1)	228 (0.1)	329 (0.2)
Hispanic	170,289 (6.3)	4,802 (2.8)	1,452 (0.9)	1,129 (0.7)	452 (0.3)	606 (0.4)	331 (0.2)	490 (0.3)	142 (0.1)	133 (0.1)	309 (0.2)
Asian	98,197 (3.6)	4,207 (4.3)	1,148 (1.2)	977 (1.0)	517 (0.5)	749 (0.8)	521 (0.5)	474 (0.5)	180 (0.2)	120 (0.1)	164 (0.2)
Other or unknown	378,987 (14.0)	10,636 (2.8)	2,555 (0.7)	2,135 (0.6)	1,319 (0.4)	1,916 (0.5)	1,292 (0.3)	1,226 (0.3)	587 (0.2)	608 (0.2)	426 (0.1)

*Percentage is prevalence of food allergy among the entire study population or that specific demographic category.
†Does not include grains or legumes, but does include tea, jasmine, and chamomile.[10]
‡Includes milk and other dairy products (eg, cheese and dairy-based ice cream).[10]
§Additive includes monosodium glutamate, dyes (eg, food coloring, Yellow Dye#5, and FD&C Blue No. 2), food preservative, sweeteners (eg, aspartame, sucrose, and artificial sweetener), and caffeine.[10]
‖All food allergen groups were significantly (*P* < .05) more prevalent among women than among men (all food groups listed in this table, except for peanut).
¶Asians had a significantly (*P* < .05) higher prevalence than did the other racial/ethnic groups for all food groups listed in this table, except for grain and additive, both of which were significantly (*P* < .05) higher in white patients than in the other racial/ethnic groups.

TABLE II. Common documented adverse reactions to food

Reaction	n	Prevalence (%)*
Hives/urticaria†	27,790	28.5
Anaphylaxis†	15,475	15.9
Gastrointestinal irritation‡	11,179	11.5
Itching†	8,093	8.3
Swelling§	6,653	6.8
Angioedema†	5,221	5.4
Vomiting	3,192	3.3
Bronchospasm/wheezing†	2,801	2.9
Shortness of breath†	1,656	1.7
Nausea	1,265	1.3
Headache	1,223	1.3
Other reaction‖	19,111	19.6
Unknown reaction	44,387	45.5
Potentially IgE-mediated reaction	49,894	51.2

*Prevalence is among patients with 1 or more food allergy and percentages add up to more than 100% because patients can have more than 1 documented reaction.
†Potentially IgE-mediated reactions.
‡Gastrointestinal irritation includes entries documented as "GI Upset or "Gastrointestinal Irritation" and is defined as irritation in the abdominal region associated with ingestion of a certain food.
§This category includes all swelling; however, only tongue swelling was included in potentially IgE-mediated.
‖Other reaction consists of 5517 distinct reactions, all with <1% frequency.

Peanut allergy and specific IgE

There were 12,946 patients with an allergy or intolerance to peanut, including 7,318 (56.5%) patients with potentially IgE-mediated reactions to peanut. Among all patients with a documented allergy or intolerance to peanut, 2537 (19.6%) had a specific IgE to peanut performed between 2000 and 2013. Of these tests, results were negative (n = 216 [8.5%]), grade 1 (n = 258 [10.2%]), grade 2 (n = 611 [24.1%]), grade 3 (n = 268 [10.6%]), grade 4 (n = 514 [20.3%]), grade 5 (n = 330 [13.0%]), and grade 6 (n = 340 [13.4%]). Among patients with a potentially IgE-mediated reaction to peanut, 1390 (19.0%) had a specific IgE for peanut performed between 2000 and 2013. Among those tested, 111 (8.0%) were negative, 155 (11.2%) were grade 1, 322 (23.2%) were grade 2, 149 (10.7%) were grade 3, 264 (19.0%) were grade 4, 183 (13.2%) were grade 5, and 206 (14.8%) were grade 6.

DISCUSSION

We assessed more than 2.7 million patients and identified 132,734 food allergy and intolerance records over 13 years for 97,482 unique patients. Using the EHR allergy module, we identified a 3.6% prevalence of food allergy and intolerance, a figure largely consistent with previous estimates using oral food challenges (OFCs),[1,15] and slightly lower than those using self-reported surveys.[6,16] The latter would be expected because exclusive reliance on patient self-reporting can overestimate food allergy prevalence.[17] The overall consistency of these findings with previous knowledge derived from different data sources suggests that data documented in the EHR allergy section have the potential to be used for clinical and epidemiological research in food allergy.

Consistent with most previous studies, we found that females are more likely to have documented food allergies or intolerances,[6,16,18] but that peanut allergies or intolerances were more common in males.[4,18] This sex difference may be due to the overall high prevalence of allergic diseases among females, but alternately may be due to higher rates of awareness and reporting.[19] The higher prevalence documented among Asians was similar to that in previous studies in Western nations,[3,20] but higher than that reported among Asian nations and Asian-born immigrants.[21] This inconsistency may be partially attributable to the different preparation of peanuts; in Asian countries peanuts are primarily boiled whereas in Western countries they are roasted, a preparation that increases the allergenicity of the peanut.[22] Taken together, these findings suggest contributing genetic, cultural, and/or environmental influences.

Food allergy can be morbid[23] and costly; it has been estimated to cost the United States almost $25 billion annually.[24] Examining allergic reactions to food among children, Gupta et al[20] found that almost 40% of children suffered a severe reaction (defined as anaphylaxis, low blood pressure, trouble breathing, or wheezing and a combination of vomiting, angioedema, and coughing). We found that approximately 50% of documented reactions were potentially IgE-mediated (affecting almost 2% of our entire population), with anaphylaxis comprising almost 16% of

reactions. The latter finding may have actually been an underestimate of the true burden of food-induced anaphylaxis because we used a conservative definition of anaphylaxis that did not redefine reactions as anaphylaxis for patients who experienced 2 or more reactions that met the National Institutes of Allergy and Infectious Disease/Food Allergy and Anaphylaxis Network anaphylaxis criteria.[25] This study not only highlights the spectrum of severity observed with food allergy but also identifies the critical need for more allergists/immunologists. With fewer than 7000 allergists/immunologists in the United States,[26] even in the greater Boston area, we do not have the capacity to evaluate all these patients for confirmatory testing. Indeed, availability of allergists/immunologists is likely one contributory reason why specific IgE to peanut was performed in only 1 in 5 patients with EHR report of peanut allergy or intolerance in this study. Yet, confirmatory testing is useful to identify causative allergens, receive appropriate counseling, and avoid unnecessary anxiety about future food reactions or expenses in finding allergy-free alternative foods.

This analysis has several limitations. PEAR data include unverified allergies, intolerances, and other adverse reactions to foods.[10] Many records in PEAR may be inaccurate due to patient self-reporting and food preference. At Partners HealthCare, allergy specialists generally do not document allergy skin test results, specific IgE results, or the results of OFC in PEAR.[10] This is because of both practice patterns and the lack of designated space for these important allergy details in the EHR. In working with allergy specialists, patient safety experts, and informaticians, we envisioned a more useful allergy module that included both subjective and objective allergy signs and symptoms, with results of skin tests, specific IgE via RAST/ImmunoCAP, and OFC.[27,28] Yet, about 1 in 5 patients with EHR allergy module listing of peanut allergy or intolerance had a specific IgE to peanut sent in this health care system, and of those sent among patients with potentially IgE-mediated peanut allergy, most patients (58%) had an IgE value suggestive of true allergy (ie, grade 3 or higher).[29] Another limitation is that prevalence may be overestimated because of increased patient awareness of food allergy and intolerance, with increased awareness leading to increased reporting of food allergies by all or certain demographic groups (eg, females). In addition, the quality of the allergy entries in the EHR depends on the knowledge of health care providers entering/verifying the information; fortunately, most PEAR allergies are entered by medical doctors.[30] Last, our large health care system in Massachusetts may not be representative of other regions because food allergy has been shown to differ by geographic region—with generally higher estimates in New England[31] and in urban areas.[32] Our covered population includes 2 large tertiary care referral centers that may include more patients with severe allergies than the general population. In addition, we report on a population that is predominately white, as New England is 82.4% white[33] compared with only 63.7% for the United States[34] generally.

In conclusion, this study represents one of the largest EHR-based reports of food allergy and intolerance and offers insight into the substantial burden of food allergy and intolerance. We found a food allergy and intolerance prevalence of 3.6%, with increased prevalence among woman and Asians. We identified that IgE-mediated reactions constituted half of all documented adverse reactions to foods, with a report of anaphylaxis in 1 in 6 reactions. These findings support the pressing need for more food allergy evaluations, as well as a call for more allergists/immunologists, especially given new recommendations for early food introductions, less reliance on isolated positive test results,[35-38] and more aggressive use of OFC to diagnose food allergy. Last, our findings support that the EHR allergy module may be helpful in determining the epidemiology and risk factors for food allergy, as well as identifying patients for prospective clinical studies and/or food allergy evaluations.

Key messages

- **Food allergy or intolerance was documented among 3.6% of the population, with highest rates among females and Asians.**
- **Shellfish was the most commonly reported food allergen.**
- **About 1 in 2 known reactions to food allergens was potentially IgE-mediated.**
- **One in 6 food allergy or intolerance patients had a documented reaction of anaphylaxis.**

REFERENCES

1. Sicherer SH, Sampson HA. Food allergy: epidemiology, pathogenesis, diagnosis, and treatment. J Allergy Clin Immunol 2014;133:291-307.
2. Sicherer SH, Sampson HA. Food allergy. J Allergy Clin Immunol 2006;117: S470-5.
3. Rudders SA, Arias SA, Camargo CA Jr. Trends in hospitalizations for food-induced anaphylaxis in US children, 2000-2009. J Allergy Clin Immunol 2014;134:960-2.e3.
4. 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.
5. Sicherer SH, Munoz-Furlong A, Sampson HA. Prevalence of seafood allergy in the United States determined by a random telephone survey. J Allergy Clin Immunol 2004;114:159-65.
6. Vierk KA, Koehler KM, Fein SB, Street DA. Prevalence of self-reported food allergy in American adults and use of food labels. J Allergy Clin Immunol 2007;119:1504-10.
7. Kuperman GJ, Marston E, Paterno M, Rogala J, Plaks N, Hanson C, et al. Creating an enterprise-wide allergy repository at Partners HealthCare System. AMIA Annu Symp Proc 2003;376-80.
8. Macy E, Ho NJ. Multiple drug intolerance syndrome: prevalence, clinical characteristics, and management. Ann Allergy Asthma Immunol 2012;108:88-93.
9. Macy E, Poon KYT. Self-reported antibiotic allergy incidence and prevalence: age and sex effects. Am J Med 2009;122:778.e1-7.
10. Plasek JM, Goss FR, Lai KH, Lau JJ, Seger DL, Blumenthal KG, et al. Food entries in a large allergy data repository. J Am Med Inform Assoc 2016;23:e79-87.
11. Food Allergen Labeling and Consumer Protection Act of 2004, Pub. L. No. 108-282, Title II Stat. 108-282, Title II (2004).
12. SNOMED-CT (Systematized Nomenclature of Medicine – Clinical Terms). Available at: http://www.ihtsdo.org/snomed-ct. [updated March 1, 2016; cited March 30, 2016]. Accessed March 30, 2016.
13. Topaz M, Seger DL, Slight SP, Goss F, Lai K, Wickner PG, et al. Rising drug allergy alert overrides in electronic health records: an observational retrospective study of a decade of experience. J Am Med Inform Assoc 2016;23:601-8.

14. Zhou L, Dhopeshwarkar N, Blumenthal KG, Goss F, Topaz M, Slight SP, et al. Drug allergies documented in electronic health records of a large healthcare system. Allergy 2016;71:1305-13.

15. Rona RJ, Keil T, Summers C, Gislason D, Zuidmeer L, Sodergren E, et al. The prevalence of food allergy: a meta-analysis. J Allergy Clin Immunol 2007;120:638-46.

16. Verrill L, Bruns R, Luccioli S. Prevalence of self-reported food allergy in U.S. adults: 2001, 2006, and 2010. Allergy Asthma Proc 2015;36:458-67.

17. 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.

18. Kotz D, Simpson CR, Sheikh A. Incidence, prevalence, and trends of general practitioner-recorded diagnosis of peanut allergy in England, 2001 to 2005. J Allergy Clin Immunol 2011;127:623-30.e1.

19. DunnGalvin A, Hourihane JO, Frewer L, Knibb RC, Oude Elberink JN, Klinge I. Incorporating a gender dimension in food allergy research: a review. Allergy 2006; 61:1336-43.

20. Gupta RS, Springston EE, Warrier 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.

21. Panjari M, Koplin JJ, Dharmage SC, Peters RL, Gurrin LC, Sawyer SM, et al. Nut allergy prevalence and differences between Asian born children and Australian born children of Asian descent: a state-wide survey of children at primary school entry in Victoria, Australia. Clin Exp Allergy 2016;46:602-9.

22. Beyer K, Morrow E, Li XM, Bardina L, Bannon GA, Burks AW, et al. Effects of cooking methods on peanut allergenicity. J Allergy Clin Immunol 2001;107: 1077-81.

23. Sicherer SH, Noone SA, Munoz-Furlong A. The impact of childhood food allergy on quality of life. Ann Allergy Asthma Immunol 2001;87:461-4.

24. Gupta R, Holdford D, Bilaver L, Dyer A, Holl JL, Meltzer D. The economic impact of childhood food allergy in the United States. JAMA Pediatr 2013; 167:1026-31.

25. Campbell RL, Li JT, Nicklas RA, Sadosty AT. Members of the Joint Task Force, Practice Parameter Workgroup. Emergency department diagnosis and treatment of anaphylaxis: a practice parameter. Ann Allergy Asthma Immunol 2014;113:599-608.

26. AAAAI MEMBERSHIP American Academy of Allergy, Asthma, and Immunology: American Academy of Allergy, Asthma, and Immunology; 2016

[updated 2016; cited June 2, 2016]. Available at: https://www.aaaai.org/about-aaaai/aaaai-membership. Accessed June 2, 2016.

27. Topaz M, Goss F, Blumenthal K, Lai K, Seger DL, Slight SP, et al. Towards improved drug allergy alerts: multidisciplinary expert recommendations. Int J Med Inform 2017;97:353-5.

28. Blumenthal KG, Park MA, Macy EM. Redesigning the allergy module of the electronic health record. Ann Allergy Asthma Immunol 2016;117:126-31.

29. 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.

30. Blumenthal KG, Acker WW, Li Y, Holtzman NS, Zhou L. Allergy entry and deletion in the electronic health record. Ann Allergy Asthma Immunol 2017; 118:380-1.

31. Rudders SA, Camargo CA Jr. Sunlight, vitamin D and food allergy. Curr Opin Allergy Clin Immunol 2015;15:350-7.

32. Partners Healthcare Services Locator: Partners Healthcare. Available at: http://www.partners.org/Services_Locator.aspx. Accessed June 2, 2016.

33. United States Census Bureau. 2011-2015 American Community Survey 5-year estimates. Available at: https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_14_5YR_B02001&prodType=table. Accessed October 30, 2016.

34. United States Census Bureau. Overview of race and Hispanic origin: 2010. 2016. Available at: http://www.census.gov/prod/cen2010/briefs/c2010br-02.pdf. Accessed October 30, 2016.

35. Du Toit G, Katz Y, Sasieni P, Mesher D, Maleki SJ, Fisher HR, et al. Early consumption of peanuts in infancy is associated with a low prevalence of peanut allergy. J Allergy Clin Immunol 2008;122:984-91.

36. Du Toit G, Roberts G, Sayre PH, Bahnson HT, Radulovic S, Santos AF, et al. Randomized trial of peanut consumption in infants at risk for peanut allergy. N Engl J Med 2015;372:803-13.

37. Du Toit G, Sayre PH, Roberts G, Sever ML, Lawson K, Bahnson HT, et al. Effect of avoidance on peanut allergy after early peanut consumption. N Engl J Med 2016;374:1435-43.

38. Boyce JA, Assa'ad A, Burks AW, Jones SM, Sampson HA, Wood RA, et al. Guidelines for the diagnosis and management of food allergy in the United States: summary of the NIAID-sponsored expert panel report. J Allergy Clin Immunol 2010;126:1105-18.

TABLE E1. Prevalence of documented food allergy for the 10 less common food allergen groups

Characteristic	Total population, n (%)	Food allergen group, n (%)*									
		Seed	Soy	Meat	Spice	Alcohol	Fungus†	Legume‡	Extract§	Infant formula‖	Nutritional supplement¶
Total	2,714,851	3,718 (0.1)	2,961 (0.1)	1,771 (0.1)	1,288 (<0.1)	1,283 (<0.1)	1,173 (<0.1)	1,062 (<0.1)	548 (<0.1)	44 (<0.1)	17 (<0.1)
Sex#											
Male	1,215,796 (44.8)	1,452 (0.1)	1,241 (0.1)	685 (0.1)	351 (<0.1)	369 (<0.1)	314 (<0.1)	493 (<0.1)	175 (<0.1)	24 (<0.1)	6 (<0.1)
Female	1,499,055 (55.2)	2,266 (0.2)	1,720 (0.1)	1,086 (0.1)	937 (0.1)	914 (0.1)	859 (0.1)	569 (<0.1)	373 (<0.1)	20 (<0.1)	11 (<0.1)
Racial/ethnic group**											
White	1,913,639 (70.5)	2,800 (0.1)	2,168 (0.1)	1,168 (0.1)	1,018 (0.1)	974 (0.1)	936 (<0.1)	751 (<0.1)	444 (<0.1)	26 (<0.1)	13 (<0.1)
Black	153,739 (5.7)	196 (0.1)	151 (0.1)	125 (0.1)	66 (<0.1)	32 (<0.1)	70 (<0.1)	80 (0.1)	27 (<0.1)	2 (<0.1)	1 (<0.1)
Hispanic	170,289 (6.3)	125 (0.1)	117 (0.1)	208 (0.1)	60 (<0.1)	28 (<0.1)	42 (<0.1)	39 (<0.1)	19 (<0.1)	1 (<0.1)	1 (<0.1)
Asian	98,197 (3.6)	137 (0.1)	192 (0.2)	87 (0.1)	32 (<0.1)	144 (0.1)	32 (<0.1)	69 (0.1)	11 (<0.1)	1 (<0.1)	1 (<0.1)
Other or unknown	378,987 (14.0)	460 (0.1)	333 (0.1)	183 (0.1)	112 (<0.1)	105 (<0.1)	93 (<0.1)	123 (<0.1)	47 (<0.1)	14 (<0.1)	1 (<0.1)

*Percentage is prevalence of food allergy among the entire study population or that specific demographic category.

†Fungus includes cultivated mushrooms, yeast, truffles, and portobello mushrooms.[10]

‡Legume is defined as members of the legume family (eg, bean, chickpea, snow pea, red bean, and kidney bean), except peanut and soy, which are categorized into separate groups, on the basis of previous cross-sensitivity studies.[10]

§Extract includes types of edible cooking oils (eg, olive oil) as well as other extracts (eg, annatto, and yeast extract).[10]

‖Infant formula includes infant formulas (eg, Enfamil, Prosobee, Lipil, Similac, Elecare Powder, Nutramigen, and Enfacare) as well as breast milk and baby food.[10] Although the true allergen may be dairy or soy, this was not able to be determined.

¶Nutritional supplements include dietary supplements (eg, Ensure, Duocal, red yeast, and fiber).[10]

#All food allergen groups in this table were significantly ($P < .05$) more prevalent among women than among men, except for infant formula.

**Asian patients had a significantly ($P < .05$) higher prevalence than did the other racial/ethnic groups for soy, alcohol, and legume. White patients had a significantly ($P < .05$) higher prevalence than did the other racial/ethnic groups for seed, fungus, spice, and extract. Hispanic patients had a significantly ($P < .05$) higher prevalence than did the other racial/ethnic groups for meat.