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Prevalence and Burden of Coconut Allergy in the United States

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Abstract

Background: Epidemiological data about coconut allergy remains sparse in the United States (US) despite the Food Allergen Labeling and Consumer Protection Act's labeling requirement for products containing coconut.

Objective: To provide current estimates of the prevalence, severity, determinants, and distribution of coconut allergy in the US.

Methods: A comprehensive food allergy prevalence survey was administered to a nationally representative, probability-based sample of US households between October 1, 2015, and September 30, 2016. Eligible respondents included adults who were able to complete self- and parent-proxy-report surveys in English or Spanish via web or phone.

Results: Using survey responses for 78,851 individuals, 0.39% (95% CI, 0.33%−0.45%) of the US general population were categorized as having convincing coconut allergy. Among children, 0.22% (95%CI, 0.16%−0.30%) were estimated to have coconut allergy compared with 0.43% (95%CI, 0.37%−0.51%) of adults, while only 0.12% (95%CI, 0.08%−0.18%) of these children and 0.20% (95%CI, 0.16%−0.24%) of adults with convincing IgE-mediated coconut allergy reported physician-confirmed diagnoses. A current epinephrine prescription was reported by 40.1% (95% CI, 33.3%−47.4%) of those with convincing coconut allergy. Reactions involving

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multiple organ systems were reported by 47.5% (95%CI, 40.1%−54.9%) of those with convincing coconut allergy.

Conclusion: Roughly 1 in 260 Americans report symptoms consistent with an IgE-mediated allergy to coconut, although fewer than half of these individuals report receiving a physician diagnosis. Our data indicate that most individuals with reported coconut allergy meeting symptom-based criteria for convincingly IgE-mediated disease have comorbid food allergies, and for many patients, clinical management appears to be suboptimal.

Keywords

Food allergy; coconut allergy; coconut allergy prevalence; FALCPA

Introduction

IgE-mediated food allergy (FA) has been estimated to impact approximately one in ten individuals in the United States (US), resulting in considerable physical health, psychosocial, and economic burden.[1] In 2004, the US congress passed the Food Allergen Labeling and Consumer Protection Act (FALCPA), acknowledging the growing prevalence of food allergy and attempting to facilitate disease management through more informative, standardized food labeling practices.[2] The FALCPA act mandated specific allergen labeling requirements for a food that contains an ingredient that is or contains protein from a “major food allergen “: milk, eggs, fish (e.g., bass, flounder, cod), crustacean shellfish (e.g., crab, lobster, shrimp), tree nuts (e.g., almonds, walnuts, pecans), peanuts, wheat, and soybeans. In light of the latest available epidemiologic data, the FASTER act of 2021 expanded the definition of major food allergen to include “sesame seed”.[3,4]

It is notable that while, botanically-speaking, coconut is a fibrous one-seeded drupe,[5] FALCPA specifically defined coconut as a tree nut for FA labeling requirements, implying that it should be regulated alongside other common tree nuts (e.g., almond, cashew, pistachio, hazelnut, walnut) despite little available epidemiological data estimating its prevalence and severity in the US. To date, the largest study of coconut allergy patients in the US reviewed medical charts of 275 pediatric patients with a history of positive coconut allergen SPT and/or sIgE testing from a large Midwestern academic allergy network.[6] Notably, of the 57/275 patients with a documented history of oral coconut ingestion, approximately half met criteria for mild/moderate anaphylaxis and clinical coconut allergy was most common among Asian and African American children. Mean age at initial reaction in this cohort was 5 years and over 2/3 of patients for whom data were available as well as who exhibited clinical allergy symptoms and sensitization reported a history of topical coconut product application. Among patients with allergic sensitization to coconut, just over half had accompanying patient/parent-report of clinical reactivity, which is comparable to rates reported for other major allergens in the US.[7]

Although it is defined as a tree nut under FALCPA, data indicating increased incidence of coconut allergy among individuals with tree nut allergy remain equivocal, with one small study finding no association between tree nut or peanut sensitization or clinical allergy and coconut sensitization via SPT in 40 patients.[8] In contrast, other work from the midwestern

US found high rates of co-sensitization between coconut and macadamia (ρ = 0.77), moderate correlations with hazelnut (ρ = 0.56), almond (ρ = 0.52), and walnut (ρ = 0.42), and lower rates with other tree nuts, including Brazil nut (ρ = 0.38), pecan (ρ = 0.36), and pistachio (ρ = 0.30).[9] However, it is unclear from these data to what extent these high rates of co-sensitization manifest as clinical co-reactivity. Furthermore, there is extremely little data regarding the burden of coconut allergy among US adults, with or without coexisting tree nut allergy or sensitization. Improving understanding of the current prevalence and public health burden of coconut allergy is particularly needed owing to recent increases in the consumption of coconut and coconut-containing products (e.g., coconut oil), as well as growing use of topical ointments containing coconut, which have been shown to increase risk of coconut sensitization consistent with the dual exposure hypothesis.[10] Coconut oil is commonly classified into wet- processed coconut oil, that is unrefined and extracted from fresh coconut meat[11], and dry-processed coconut oil, which is mostly refined and extracted from older, dried coconut kernels[11,12]. While refined coconut oil is free from protein contaminants[11], unrefined oil contains nearly 30 times more proteins[13]. Although, not yet proven, it can be postulated that unrefined coconut oil has a residual allergenic potency, as seen in case of soybean oil.[14] A recent study in Sri Lanka demonstrated that patients who have an allergy to coconut milk could also react to boiled coconut milk and unrefined coconut oil.[12]

Consequently, the present study aims to estimate the current prevalence, severity, symptoms, distribution, determinants, and psychosocial burden associated with coconut allergy using cross-sectional survey data from a large, nationally representative sample of US households to better understand the public health burden of coconut allergy.

Methods

Data Source

A detailed food allergy prevalence survey was administered to a nationally representative sample of US adults from October 1, 2015, through September 30, 2016. Informed consent was obtained from all respondents prior to enrollment in the study. The research protocol and study activities were approved by the institutional review boards of Northwestern University and NORC.

Survey Development and Design

The original 2009–2010 parent-report survey of pediatric food allergy prevalence, upon which the present survey instrument was based, was developed by pediatricians, pediatric allergists, epidemiologists and health services researchers with support of an expert panel.[15] Expert panel review and key informant cognitive interviews were conducted using the approach described by Gupta et al in previous publications to ensure survey functionality as well as understandability and consistency of responses.[7,16] Although fundamental components of the survey[17] were preserved in order to encourage comparability of estimates between survey administrations, additional elements were added to the 2015–2016 instrument to evaluate emerging research questions relating to FA etiology and management

among adult populations. The revised survey was administered electronically via the web or over the phone. Additional methodological details are provided in prior publications.[7,16]

Study Design

Recruitment—Eligible survey respondents included adults (18 years old) residing in a US household and who were able to complete the survey in English or Spanish via the web or phone. As in the 2009–2010 survey, this study relied on a nationally representative household panel to support population-level inference. Survey respondents were first recruited from NORC's probability-based AmeriSpeak panel, with 7,218 responses of 14,095 invitees resulting in a survey completion rate of 51.2%.

Survey Weighting—Each adult respondent was assigned a base, study-specific sampling weight equal to their nonresponse-adjusted AmeriSpeak sampling weight. Iterative proportional fitting methods were applied to rake adult sampling weights to external population totals associated with age, sex, educational attainment, race/ethnicity, housing tenure, telephone status, and Census Division to improve external validity. Since adults were also invited to provide parent-proxy report responses on behalf of their children, each child was assigned their parent's sampling weight. These child-specific weights were further adjusted to account for random selection of as many as 3 children per household and raked to external pediatric US population totals via iterative proportional fitting. To increase precision and ensure sufficient sample size among key subpopulations, prevalence estimates gleaned from population weighted AmeriSpeak responses were augmented by calibration-weighted, nonprobability-based responses obtained through Survey Sampling International. The final, combined sample weight was derived by applying an optimal composition factor that minimizes mean square error associated with food allergy prevalence estimates. In previous research publications, Gupta et al provide detailed information regarding the complex survey sampling, weighting, and analysis methods used.[7–10,15–16] Overall, adults from 51,819 US households in all 50 states and the District of Columbia completed the surveys, providing parent-proxy responses for 38,408 children and self-report for 40,443 adults.

Outcome Measures—The primary outcome measures for the study were the prevalence and severity of overall and food-specific convincing coconut food allergy. Reported food allergies, including coconut, were considered convincingly IgE mediated (hereinafter termed convincing) if the most "severe" reaction ever reported to that food included at least 1 symptom on the stringent symptom list developed by our expert panel (eFigure 1). Reported allergies with reaction symptoms characteristic of oral allergy syndrome or food intolerances were excluded and not considered to be convincing based on the food allergy categorization flowchart summarized in eFigure 2, even if such allergies were diagnosed by a physician. Convincing food allergies for which a physician diagnosis was reported were considered physician-confirmed food allergies. For each convincing allergy, a multisystemic reaction history was indicated by the presence of multiple stringent symptoms occurring within 2 or more of the following 4 organ systems: skin/oral mucosa, gastrointestinal tract, cardiovascular, and respiratory tract. A "severe" reaction history, as defined in some prior work,[18] was also applied, which included only individuals reporting coconut-induced

wheeze, fainting or dizziness, and/or low blood pressure. Food allergy-related psychosocial burden was assessed via the 6-item validated Food Allergy Independent Measure.[19]

Statistical Analysis—Complex survey-weighted proportions and 95% CIs were calculated to estimate prevalence, and robust standard errors accounted for household-level clustering. We used the statistical package STATA (Version 17; StataCorp). Weighted Pearson $\chi 2$ statistics, which were corrected for the complex survey design with the second-order correction of Rao and Scott[20] and converted into F statistics, were used for all comparisons of coconut allergy and participant characteristics. Two-sided *P* value less than .05 was considered statistically significant.

Results

Among the total sample of 78,851 participants, an estimated 0.39% (95% CI, 0.33%−0.45%) of the US general population were categorized as having convincing coconut allergy using criteria that required experiencing at least one stringent symptom. Among children, 0.22% (95%CI, 0.16%−0.30%) were estimated to have convincing coconut allergy compared with 0.43% (95%CI, 0.37%−0.51%) of adults (Table 1). Nearly twice as many children (0.47%; 95%CI, 0.37%−0.59%) and adults (0.81%; 95%CI, 0.72%−0.91%) reported current coconut allergy without reaction symptoms that were consistent with established criteria for convincing, IgE-mediated food allergy classification and therefore were not included in overall, convincing food allergy estimates. Further, only 0.12% (95%CI, 0.08%−0.18%) of children and 0.20% (95%CI, 0.16%−0.24%) of adults with convincing IgE-mediated coconut allergy reported a convincing coconut allergy that was physician diagnosed using either oral food challenges, skin prick, or sIgE testing.

Demographics

Demographic characteristics of the cohort with convincing coconut allergy (hereinafter termed coconut allergy unless otherwise specified) are described in Table 2. Of these, 55.4% (95%CI, 48.1%−62.4%) were female, compared with 51.1% (95%CI, 50.5%−51.6%; P =.24) of the general US population. Just over half (56.4%; 95%CI, 48.9%−63.7%) reported non-Hispanic, White race and ethnicity, a slightly lower proportion than the general US population (62.2%; 95%CI, 61.4%−62.9%; P =.32), whereas 19.6% (95%CI, 13.8% −27.2%) were Hispanic, slightly, but non-significantly, exceeding the proportion of Hispanic individuals in the US population (17.4%; 95%CI, 16.7%−18.1%; P = .32). With regard to income, majority of individuals with coconut allergy indicated an annual household income of less than 100,000 (<$25,000: 24.4%; 95%CI, 18.2%−31.8%, 25,000–49,999: 25.2; 95% CI: 19.3–32.2, and 50,000–99,999: 27.5; 95% CI: 21.7–34.1), a trend similar to that of the general population (<$25,000: 16.5%; 95%CI: 16.0–17.0%, 25,000–49,999: 22.0; 95% CI: 21.4–22.6, and 50,000–99,999: 31.0; 95% CI: 30.3–31.7). At the same time, individuals with coconut allergy were much more likely to report either public insurance (37.8%; 95%CI, 20.1%−59.4%) or no health insurance coverage (24.1%; 95%CI, 9.7%−48.4%; P = .007) relative to the general population. Coconut allergy was also over-represented among households with the lowest level of respondent educational attainment (7.3%; 95%CI, 3.5% −14.9% vs. 4.5%; 95%CI, 4.1%−5.0%; P =0.51).

Coconut allergy was estimated to affect residents of all 50 states, and the District of Columbia. No significant differences in prevalence were observed across the 9 census divisions (p=.35).

Comorbid Conditions

As seen in Table 2, individuals with coconut allergy had a higher prevalence of other atopic conditions than the general US population, including asthma (30.3%[95%CI, 24.1%−37.3%] vs 12.2%[11.8%−12.7%]; P < .0001), eczema (10.9%[95%CI, 7.1%−16.4%] vs 6.5%[95%CI, 6.2%−6.9%]; P < .02), eosinophilic esophagitis (1.8%[95%CI, 0.8%−4.2%] vs 0.2%[95%CI, 0.1%−0.2%]; P < .0001), food protein–induced enterocolitis syndrome (2.6%[95%CI, 1.4%−4.6%] vs 0.3%[95%CI, 0.2%−0.3%]; P < .0001), insect sting allergies (9.7% [95%CI, 5.8%−15.9%] vs 3.5%[95%CI, 3.3%−3.7%]; P = .0001), latex allergies (9.5%[95%CI, 5.7%−15.5%] vs 2.0% [95%CI, 1.9%−2.2%]; P < .0001), and medication allergy (19.0% [95%CI, 14.2%−25.0%] vs 11.3%[95%CI, 11.0%−11.7%]; P = .0005).

Family History

Data on parental history of atopy are presented in Table 2. Among individuals with coconut allergy, 45.7% (95%CI, 37.7%−54.0%) reported a parental history of any food allergy; however, these data were based on self-report irrespective of clinical diagnosis or reaction history. Similarly, a parental history of self-reported allergic rhinitis was reported in 44.3% (95%CI, 36.2%−52.7%). Individuals with coconut allergy were more likely than those with other food allergies to report a parental history of reported asthma (36.2% [95%CI, 29.0%−44.0%] vs 26.3% [95%CI, 24.6%−28.1%]; P = .007), and eczema (26.7% [95%CI, 19.8%−35.0%] vs 19.8 [95%CI, 18.3%−21.4%]; P = .05).

Coconut Allergy Symptoms

Individuals with coconut allergy were most likely to report hives (56.4% [95%CI, 48.9%−63.7%]), and other mild cutaneous symptoms (e.g., itching (53.7% [95%CI, 46.4%−60.9%]), rash (41.7% [95%CI, 34.6%−49.2%]), which were reported in comparable rates to those observed among individuals with the “Big 8” allergens (Table 3). However, individuals with coconut allergy were less likely to report other stringent cutaneous symptoms (e.g., swelling [16.6% (95%CI, 12.2%−22.3%) vs 26.7% (95%CI, 25.1%−28.4%)], difficulty swallowing [26.7% (95%CI, 20.6%−34.0%) vs 35.5% (95%CI, 33.7%−37.3%)], and throat-tightening [21.6% (95%CI, 15.7%−29.1%) vs 31.4% (95%CI, 29.7%−33.1%)]. Individuals with coconut allergy were also less likely to report each assessed respiratory symptom, particularly trouble breathing [20.0% (95%CI, 14.6%−26.6%) vs 29.0% (95%CI, 27.3%−30.8%)] and wheezing [13.6% (95%CI, 9.2%−19.5%) vs 21.8% (95%CI, 20.3%−23.3%)]. Individuals with coconut allergy were also less likely to report each assessed gastrointestinal symptom, including vomiting [13.3% (95%CI, 9.1%−18.9%) vs 33.4% (95%CI, 31.6%−35.3%)]. In general, cardiovascular symptom-report was rare, and slightly less common among individuals with coconut allergy than those with other common FAs.

Coconut Allergy Characteristics

Information regarding coconut allergy characteristics pooled across children and adults are displayed in Table 4. A reaction to coconut characterized by multiple organ system involvement was reported by 47.5% (95%CI, 40.1%−54.9%) of those with convincing coconut allergy. Severe coconut allergic reactions (i.e., coconut -induced wheeze, fainting or dizziness, and/or low blood pressure) were reported by 16.1% (95%CI, 10.9%−23.2%) of individuals with coconut allergy. Most individuals with coconut allergy reported multiple food allergies (69.8%; 95%CI, 62.3%−76.4%) that also met our convincing symptom-report criteria, with peanut allergy (27.8%; 95%CI, 22.3%−34.0%) being the most common comorbid food allergy, followed by allergy to one or more tree nuts (20.0%; 95%CI, 15.3%−25.6%). A majority (57.3%; 95%CI, 49.8%−64.5%) had an allergy to 1 or more of the “Big 8” food allergens (i.e. peanut, tree nut, cow’s milk, hen’s egg, shellfish, finned fish, wheat, and soy), while 69.8%; 95%CI, (62.3%−76.4%) were allergic to any other food (including but not limited to the “Big 8”). Rates of specific co-occurring convincing food allergies are visualized in eTable 1, stratified between children and adults.

With respect to treatment, a current epinephrine prescription was reported by 40.1% (95% CI, 33.3%−47.4%) of those with coconut allergy. Just over half (59.3%; 95%CI, 51.7%−66.4%) of individuals with coconut allergy reported having visited the emergency department at least once in their lifetime owing to a food-allergic reaction, although the survey did not assess whether the visit was related to a coconut-allergic reaction or something else. Fewer than half (46.2%; 95%CI, 39.1%−53.5%) of individuals meeting established criteria for a convincing coconut allergy reported a physician diagnosis of their coconut allergy. Of those who did have a convincing, physician-confirmed allergy, 73.2% (95%CI, 63.8%−80.8%) were diagnosed using skin prick tests, 28.1% (95%CI, 20.4%−37.2%) via coconut-specific IgE blood tests, and 20.2% (95%CI, 13.4%−29.2%) by oral food challenge.

Food Allergy Related Psychosocial Burden

Table 5 shows the distribution of the 6-item Food Allergy Independent Measure (FAIM), including Expectation of Outcome (EO) and Independent Measure (IM) subscales, among individuals with reported, convincing, and physician-confirmed FA (coconut, peanut, egg, and milk). The FAIM was administered to all survey respondents reporting FA to assess perceived risk of accidental allergen exposure and the severity of the anticipated outcome on a 1- to 7-point scale—with higher scores indicative of greater FA-related psychosocial burden. In our cohort, the mean FAIM score for children with convincing mono coconut allergy was lower than that of children with reported mono coconut allergy [2.51 (SE, 0.28)] vs. [3.06 (SE, 0.28)]. No major differences were evident among adults with reported and convincing mono coconut allergy. Additionally, the mean FAIM scores for both children (2.51; SE, 0.28) and adults (2.52; SE, 0.12) with convincing mono coconut allergy were comparable with the mean FAIM scores for egg [(Children- 2.79; SE, 0.13) vs. (Adults- 2.73; SE, 0.10)] and milk allergy [(Children- 2.61; SE, 0.07) vs. (Adults- 2.7; SE, 0.07)], but lower than that of peanut allergy [(Children- 3.38; SE, 0.14) vs. (Adults- 3.12; SE, 0.06)].

Outgrown Coconut Allergy

Among all individuals with a history of convincing coconut allergy 24.8% (95%CI, 19.0–31.7) of reported outgrowing their allergy, including 31.8% (95%CI, 20.0–46.5) of children and 23.7% (17.3%−31.4%) of adults. Among participants <10 years of age at the time of the survey with a parent-reported history of convincing coconut allergy, 38.3% (95% CI, 22.6%−56.9%) had already outgrown their coconut allergy (eTable 2). Relative distributions of specific demographic characteristics, rates of assessed chronic comorbidities, and family history of atopy are reported in table 6, stratified by whether patient/parent-reported coconut allergy was current or had been outgrown.

Discussion

To our knowledge, this is the first study to comprehensively estimate the population-level burden of coconut allergy among US children and adults, concluding that an estimated 0.39% of the US population has a convincing coconut allergy using criteria that required experiencing at least one stringent symptom. Overall, 0.18% of individuals reported a physician- diagnosed convincing coconut allergy. Further, our data indicate that while coconut allergy affects children and adults of all ages, twice as many adults (0.43%) as children (0.22%) reported a convincing coconut allergy, highest among adults 30–39 years of age. Epidemiological knowledge to date regarding the national prevalence and severity of coconut allergy has been based on case reports and case series, which have the advantage of requiring clinical evaluation and documentation of allergy status, and at the same time are unable to provide insights into the distribution of coconut allergy across the broader US population—which is remarkably heterogenous.

Importantly, there is a growing concern about coconut allergy among individuals with FA, specifically among those with tree nut allergy, for several reasons we have outlined above.[6,21] Interestingly, coconut is an alternative beverage for individuals with cow's milk allergy and has also been reported to be the most common food allergen present in skin products.[22] Given that coconut consumption and use is increasing in the US, issues around labeling of coconut-containing products will likely become increasingly salient in the coming years. As such, we believe that, while inherently limited by their cross-sectional survey-report design, the present findings provide much needed context regarding the US population-level prevalence, severity, distribution, and burden of coconut allergy.

As in prior work,[6] our data indicate that allergic reactions to coconut are occasionally multisystemic, with nearly half of coconut allergy cases reporting multisystemic reaction symptoms to coconut. In contrast, fewer than 1 in 6 children and adults with coconut allergy experienced symptoms of wheeze, hypotension, or fainting/dizziness--symptoms classified as severe in prior epidemiologic research.[18] At the same time, nearly 2 in 5 individuals with coconut allergy reported having a current prescription for an epinephrine autoinjector and 1 in 5 used an epinephrine autoinjector to treat a coconut allergic reaction, suggesting that coconut allergy management practices remain suboptimal.

Previous research indicates that expectation of adverse health outcomes can be an important indication of an individual's health and well-being.[23] The FAIM's EO subdomain

administered to respondents in the present study assesses expectation of outcome if an allergen is accidentally ingested by the allergic individual (namely, the likelihood of ingestion, the chance of a "severe" reaction including death, and the chance of receiving/administering effective treatment). One finding of our study was that in general, psychosocial burden among both children and adults with coconut allergy was lower than their counterparts with more prevalent allergies (e.g. peanut, egg, milk) irrespective of whether convincing or physician-confirmed case definitions were applied. While speculative, this may be because coconut is more easily avoided than other, more ubiquitous allergens as well as the lower cognitive salience of severe outcomes in the minds of patients and their caregivers, owing to the lower prevalence of coconut allergy and less frequent report of high-profile anaphylactic fatalities relative to other "Big 8" allergens. Interestingly, both children and adults with physician-confirmed mono coconut allergy experienced comparable psychosocial burden (EO subscale) and FA-related social and dietary restrictions (IM subscale) to their self-diagnosed counterparts. Individuals who believe they have a food allergy should seek clinical confirmation since targeted clinical testing can lead to a precise diagnosis, reducing unnecessary food avoidance and heightened vigilance that result in poor quality of life for the individual. Testing often with an oral food challenge can confirm an allergy. Moreover, consultation of physicians regarding suspected allergies increases the likelihood of receiving useful counseling on effective allergen avoidance and anaphylaxis management strategies—including identification of anaphylactic signs/symptoms and appropriate treatment, as well as referrals to supportive services (e.g., dieticians, psychological services)[24].

It is important to highlight that in our cohort, peanut allergy was observed in 27.8% of individuals with convincing coconut allergy, while tree nut, almond, and soy allergy were present in 20%, 15.5%, and 14.8% respectively. Previously published work on allergic reactions to coconut suggested frequent co-sensitization with "Big 8" allergens, such as tree nuts and soy.[25] Further, a retrospective chart review at an urban tertiary care center of patients with positive testing result for coconut, suggested that soy, coconut, and walnut co-sensitization is common owing to shared legumin group of seed storage protein between these foods,[6] thus suggesting that sIgE testing might reveal co-sensitization, but not necessarily clinical reactivity. In contrast, another study failed to demonstrate a significant risk of sensitization or allergy to coconut in peanut or tree nut sensitized or allergic children.[21] Clearly, findings from case reports and prior research on coconut co-sensitization have been mixed.[26] For example, an Australian pediatric case series assessing anaphylaxis and allergy to coconut reported that cashew allergy was present in 31% of patients, with walnut and hazelnut noted in 9%.[27] Currently, there does not appear to be sufficient data to recommend that all peanut and tree nut allergic children undergo testing for coconut allergy —particularly given evidence that 50% of those sensitized to coconut upon SPT are not clinically reactive to coconut.[6] Future studies will be needed to further define the predictive values of coconut SPT and sIgE against the gold standard of food challenge.

Limitations

Strengths of our study include a large, nationally representative sample and survey-based design, which permits estimation of the prevalence of clinically confirmed and unconfirmed

food allergies alike. However, recall bias may influence symptom report of coconut-specific symptoms, particularly for non-recent reactions. Similarly, use of health care services and other allergy characteristics were only assessed via self-report and parent proxy. Nevertheless, by relying on survey-based assessments and not incorporating confirmatory clinical allergy testing, it remains difficult to ascertain how many of the more than 2 million US children and adults (0.73% of the US population) who perceive themselves to be allergic to coconut truly have a current IgE-mediated coconut allergy. The fact that self-reported or perceived food allergy is associated with psychosocial impairment and decreased quality of life owing to the challenges of allergen avoidance underlines the importance of confirmatory allergy testing irrespective of test outcome.[28–31]

Conclusion

Based on our study findings, an estimated 0.73% of the US population reported a coconut allergy, 0.39% reported having a convincing coconut allergy, and 0.18% reported physician-diagnosed convincing coconut allergy. In addition, many individuals experience multi-systemic reactions and substantial food allergy–related use of health care services. Together, our study findings indicate that despite its apparently lower prevalence, severity, and psychosocial impact relative to other major food allergens, coconut allergy nevertheless impacts a substantial number of Americans. We hope that these comprehensive, survey-based epidemiologic estimates of its distribution in the US population provide context to coconut allergy stakeholders, including the general public, policy makers, regulatory agencies, the food industry, scientists, physicians, and families of individuals suffering from food allergy in their effort to address the public health burden of all food allergies.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Conflict of interest:

Christopher Warren receives research grant support from the National Institutes of Health (NIH), and Food Allergy Research and Education (FARE).

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The study protocol was reviewed and approved by the Northwestern University IRB STU#00202279.

Abbreviations/Acronyms:

CI	Confidence Interval
FAIM	Food Allergy Independent Measure
NORC	Note that while historically NORC stood for National Opinion Research Center, it is no longer an acronym
EO	Expectation of Outcome
IM	Independent Measure
FALCPA	Food Allergen Labeling and Consumer Protection Act
SE	Standard Error
sIgE	specific Immunoglobulin-E
SPT	Skin Prick Test
US	United States

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Table 1.

Prevalence of Coconut Allergies by Age, Population-weighted Frequency % (95% CI)

Age Group	Reported Coconut Allergy	Coconut Allergy with Hx of Convincing Symptoms	Physician-confirmed Convincing Coconut Allergy
Coconut allergy prevalence			
All ages	0.73 (0.66–0.*81*)	0.39 (0.33–0.45)	0.18 (0.15–0.22)
Children (<18 years)	.47 (.37–.59)	0.22 (0.16–0.30)	0.12 (0.08–0.18)
0–2 years	0.50 (0.30–0.83)	0.13 (0.08–0.22)	0.05 (0.02–0.12)
3–5 years	0.45 (0.23–0.88)	0.25 (0.09–0.74)	0.08 (0.04–0.19)
6–10 years	0.44 (0.31–0.62)	0.27 (0.16–0.45)	0.18 (0.09–0.36)
11–13 years	0.53 (0.29–0.96)	0.19 (0.11–0.31)	0.14 (0.07–0.26)
14–17 years	0.44 (0.28–0.71)	0.24 (0.14–0.40)	0.11 (0.05–0.26)
Adults (>=18 years)	0.81 (0.72–0.91)	0.43 (0.37–0.51)	0.20 (0.16–0.24)
18–29 years	1.04 (0.85–1.28)	0.51 (0.37–0.70)	0.22 (0.15–0.31)
30–39 years	1.21 (0.95–1.54)	0.72 (0.52–0.99)	0.36 (0.24–0.56)
40–49 years	0.56 (0.40–0.79)	0.30 (0.20–0.46)	0.11 (0.07–0.19)
50–59 years	0.86 (0.65–1.15)	0.47 (0.32–0.69)	0.18 (0.09–0.35)
60+ years	0.48 (0.35–0.65)	0.26 (0.17–0.38)	0.13 (0.08–0.21)
Coconut allergy prevalence among children and adults with any convincing FA			
All ages	5.3 (4.7–5.9)	3.6 (3.1–4.1)	1.7 (1.4–2.1)
Children (<18 years)	4.8 (3.8–6.0)	2.9 (2.1–3.9)	1.6 (1.1–2.3)
0–2 years	5.2 (3.3–8.3)	1.8 (1.1–31.)	0.7 (0.3–1.7)
3–5 years	3.9 (1.7–8.9)	3.0 (1.0–8.5)	1.0 (0.4–2.3)
6–10 years	5.0 (3.4–7.2)	3.3 (2.0–5.5)	2.3 (1.1–4.5)
11–13 years	4.4 (3.0–6.4)	2.5 (1.5–4.1)	1.8 (1.0–3.4)
14–17 years	5.1 (2.9–8.6)	3.4 (2.0–5.6)	1.6 (0.7–3.6)
Adults (18+ years)	5.6 (4.9–6.4)	4.0 (3.4–4.7)	1.8 (1.5–2.3)
18–29 years	6.9 (5.5–8.6)	4.5 (3.3–6.1)	1.9 (1.4–2.8)
30–39 years	7.7 (6.0–10.0)	*5.6 (4.1–7.7)*	2.9 (1.9–4.4)
40–49 years	3.9 (2.7–5.5)	3.0 (2.0–4.5)	1.1 (0.7–1.9)
50–59 years	5.1 (3.7–7.0)	3.9 (2.7–5.7)	1.5 (0.8–2.9)
60+ years	4.1 (2.9–5.8)	2.9 (2.0–4.3)	1.5 (0.9–2.4)

Table 2.

Demographic Distribution of Convincingly Coconut Allergy vs. Not, vs Top 8 allergies, Population–weighted Frequency % (95% CI)

Variable	All (N=38,416 children / N=40,455 adults)	With Convincing Coconut Allergy (N=119 children / N=269 adults)	P–value between Convincingl y Coconut-allergic and non-coconut allergic	With Current Convincing Allergy to other "Big 8" allergies (but not coconut). (N=2665 children / N=4236 adults	P value comparing convincingl y Coconut-allergic vs. those with other Big 8 food allergies only
Race/ethnicity					
Asian, non-Hispanic	3.7 (3.5–4.0)	3.6 (1.7–7.4)	0.32	4.3 (3.7–5.1)	0.86
Black, non-Hispanic	12.0 (11.6–12.5)	12.5 (8.6–17.8)		13.6 (12.2–15.1)	
White, non-Hispanic	62.2 (61.4–62.9)	56.4 (48.9–63.7)		56.7 (54.8–58.7)	
Hispanic	17.4(16.7–18.1)	19.6 (13.8–27.2)		19.5 (17.9–21.2)	
Multiple/other	4.7 (4.4–4.9)	7.9 (4.2–14.1)		5.9 (4.9–7.0)	
Sex					
Female	51.1 (50.5–51.6)	55.4 (48.1–62.4)	0.24	61.3 (59.5–63.1)	0.11
Male	48.9 (48.4–49.5)	44.7 (37.6–51.9)		38.7 (36.9–40.5)	
Age					
0–2 years	3.6 (.3.4–3.8)	1,2 (0.7–2.1)	<.0001	3.1 (2.4–3.9)	0.13
3–5 years	3.6 (3.5–3.8)	2.4 (0.8–6.7)		3.2 (2.7–3.8)	
6–10 years	6.2 (6.0–6.5)	4.3 (2.5–7.1)		5.8 (5.1–6.5)	
11–13 years	3.7 (3.5–3.9)	1.8 (1.1–3.0)		3.3 (2.8–3.9)	
14–17 years	5.2 (5.0–5.5)	3.2 (1.9–5.4)		4.0 (3.5–4.6)	
18–29 years	16.7 (16.2–17.2)	21.9 (16.5–28.5)		19.6 (18.1–21.2)	
30–39 years	13.2 (12.8–13.5)	24.3 (18.2–31.7)		17.3 (15.9–18.8)	
40–49 years	13.0 (12.6–13.4)	10.2 (6.8–15.0)		12.6 (11.5–13.9)	
50–59 years	14.0 (13.6–14.4)	16.9 (11.8–23.7)		15.4 (14.1–16.9)	
60+ years	20.8 (20.3–21.3)	13.8 (9.4–19.7)		15.7 (14.3–17.2)	
Household income, $					
<25,000	16.5 (16.0–17.0)	24.4 (18.2–31.8)	0.010	15.3 (14.0–16.7)	0.002
25,000–49,999	22.0 (21.4–22.6)	25.2 (19.3–32.2)		22.2 (20.7–23.7)	
50,000–99,999	31.0 (30.3–31.7)	27.5 (21.7–34.1)		34.1 (32.3–35.9)	
100,000–149,999	19.5 (18.9–20.2)	12.9 (8.8–18.5)		20.0 (18.3–21.9)	
>150,000	11.0 (10.5–11.6)	10.1 (6.5–15.2)		8.4 (7.4–9.6)	
Insurance Status (AmeriSpeak Only)					
Uninsured	8.0 (6.7–9.6)	24.1 (9.7–48.4)	0.007	7.2 (4.8–10.8)	0.005
Private	66.3 (64.1–68.5)	38.2 (20.6–59.6)		67.1 (60.5–73.0)	
Public	25.6 (23.8–27.6)	37.8 (20.1–59.4)		25.7 (20.2–32.1)	
Respondent Educational Attainment					

Variable	All (N=38,416 children / N=40,455 adults)	With Convincing Coconut Allergy (N=119 children / N=269 adults)	P–value between Convincingl y Coconut-allergic and non-coconut allergic	With Current Convincing Allergy to other "Big 8" allergies (but not coconut). (N=2665 children / N=4236 adults	P value comparing convincingl y Coconut-allergic vs. those with other Big 8 food allergies only
< High School Graduate	4.5 (4.1–5.0)	7.3 (3.5–14.9)	0.510	3.8 (3.0–5.0)	0.2
High School Graduate	18.8 (18.0–19.6)	19.4 (13.5–26.9)		14.8 (13.2–16.7)	
Some Colleague	22.8 (22.2–23.4)	18.4 (13.6–24.5)		24.3 (22.6–26.0)	
Associates (2 year) Degree	10.1 (9.7–10.5)	13.1 (8.6–19.5)		12.1 (10.9–13.5)	
Bachelors (4 year) Degree	26.8 (26.1–27.5)	26.2 (20.2–33.3)		26.8 (25.1–28.6)	
Master's Degree	12.6 (12.2–13.1)	11.2 (7.5–16.4)		14.0 (12.6–15.6)	
Professional/Doctora te Degree	4.4 (4.1–4.7)	4.3 (1.9–9.5)		4.1 (3.3–5.0)	
Physician Diagnosed Comorbid Conditions					
Asthma	12.2 (11.8–12.7)	30.3 (24.1–37.3)	<.0001	26.2 (24.6–27.9)	0.22
Atopic Dermatitis/ Eczema	6.5 (6.2–6.9)	10.9 (7.1–16.4)	0.02	13.3 (12.0–14.6)	0.37
EoE	.2 (.1–.2)	1.8 (0.8–4.2)	<.0001	0.6 (0.4–0.8)	0.01
FPIES	.3 (.2–.3)	2.6 (1.4–4.6)	<.0001	1.8 (1.4–2.2)	0.26
Environmental Allergies	19.5 (19.0–20.0)	31.4 (24.7–39.1)	0.0002	32.7 (31.0–34.5)	0.74
Insect Sting Allergy	3.5 (3.3–3.7)	9.7 (5.8–15.9)	0.0001	7.0 (6.2–7.9)	0.21
Latex Allergy	2.0 (1.9–2.2)	9.5 (5.7–15.5)	<.0001	6.3 (5.4–7.3)	0.12
Medication Allergy	11.3 (11.0–11.7)	19.0 (14.2–25.0)	0.0005	18.3 (16.8–19.8)	0.78
Urticaria/Chronic Hives	.8 (.7–.9)	1.4 (0.6–3.2)	0.19	2.3 (1.9–2.8)	0.25
Family History of Atopy					
Parental asthma	14.7 (14.2–15.2)	36.2 (29.0–44.0)	<.0001	26.3 (24.6–28.1)	0.007
Parental eczema	11.1 (10.6–11.5)	26.7 (19.8–35.0)	<.0001	19.8 (18.3–21.4)	0.05
Parental allergic rhinitis	31.6 (30.9–32.4)	44.3 (36.2–52.7)	0.001	47.7 (45.6–49.8)	0.44
Parental FA	14.6 (14.1–15.1)	45.7 (37.7–54.0)	<.0001	42.1 (40.0–44.3)	0.41

** top 8 here refers to peanut, milk, tree nut, fin fish, shellfish, wheat, egg, or soy.

Table 3.

Coconut Allergy Reaction Symptoms. Population-weighted Frequency % (95% CI)

Symptoms	% of patients with convincing allergy to big 8 reporting each symptom	% of convincingly Coconut-allergic patients reporting each symptom during most severe reaction to coconut	% of physician-confirmed, convincingly IgE-mediated coconut-allergic patients reporting each symptom during most severe reaction to coconut
Skin/Oral/Mucosal Tissue			
Hives	57.9 (56.0–59.8)	56.4 (48.9–63.7)	61.4 (51.4–70.5)
Itching	59.3 (57.4–61.2)	53.7 (46.4–60.9)	55.6 (45.7–65.1)
Rash	45.0 (43.1–46.8)	41.7 (34.6–49.2)	43.9 (34.5–53.7)
Swelling	26.7 (25.1–28.4)	16.6 (12.2–22.3)	21.8 (14.3–31.7)
Lip/tongue swelling	32.7 (31.0–34.5)	21.5 (16.4–27.8)	30.3 (21.8–40.4)
Difficulty swallowing	35.5 (33.7–37.3)	26.7 (20.6–34.0)	29.8 (21.6–39.6)
Hoarse voice	17.4 (16.0–18.8)	12.5 (8.2–18.6)	18.3 (11.0–28.9)
Itchy mouth	31.7 (30.0–33.5)	26.5 (20.4–33.6)	27.5 (19.4–37.4)
Throat tightening	31.4 (29.7–33.1)	21.6 (15.7–29.1)	21.7 (14.1–31.7)
Mouth or throat tingling	21.9 (20.3–23.5)	19.0 (13.4–26.3)	20.3 (13.1–30.0)
Respiratory			
Chest tightening	22.6 (21.1–24.2)	18.5 (13.7–24.6)	24.7 (17.6–33.4)
Nasal congestion	19.5 (18.0–21.1)	14.8 (10.1–21.2)	20.4 (13.0–30.5)
Repetitive cough	15.8 (14.4–17.3)	12.6 (8.1–19.3)	13.4 (8.0–21.5)
Trouble breathing	29.0 (27.3–30.8)	20.0 (14.6–26.6)	19.8 (13.6–27.8)
Wheezing	21.8 (20.3–23.3)	13.6 (9.2–19.5)	17.8 (11.0–27.5)
Gastrointestinal			
Belly pain	36.8 (34.9–38.8)	13.9 (9.8–19.3)	15.5 (10.1–23.1)
Cramps	34.1 (32.2–36.0)	11.9 (7.8–17.9)	11.2 (7.1–17.2)
Diarrhea	35.5 (33.6–37.4)	11.2 (7.7–15.9)	9.6 (5.8–15.4)
Nausea	35.5 (33.7–37.4)	19.3 (14.1–25.9)	14.6 (9.7–21.5)
Vomiting	33.4 (31.6–35.3)	13.3 (9.1–18.9)	9.0 (5.5–14.4)
Cardiovascular			
Chest pain	9.7 (8.7–10.9)	9.4 (6.4–13.7)	9.0 (5.2–14.9)
Rapid heart rate	16.7 (15.4–18.1)	12.6 (8.6–18.1)	16.3 (10.8–23.8)
Fainting/dizziness	16.7 (15.3–18.2)	13.3 (9.4–18.5)	12.2 (7.7–18.8)
Low blood pressure	5.3 (4.5–6.2)	3.8 (1.2–11.0)	2.1 (0.8–5.0)

N.B. Bold-italicized symptoms were considered “stringent” by the expert panel

Table 4.

Coconut Allergy Characteristics. Population–weighted Frequency % (95% CI)

Variable:	% (95% CI) of individuals with convincing coconut allergy	% (95% CI) of children with convincing coconut allergy	% (95% CI) of adults with convincing coconut allergy	% (95% CI) of individuals with physician-diagnosed, convincingly IgE-mediated coconut allergy	% (95% CI) of children with physician-diagnosed, convincingly IgE-mediated coconut allergy	% (95% CI) of adults with physician-diagnosed, convincingly IgE-mediated coconut allergy
Severe coconut Allergic Reaction (i.e. Stringent reaction symptoms occurring within multiple organ systems)	47.5 (40.1–54.9)	43.3 (28.7–59.1)	48.1 (40.1–56.2)	50.2 (40.4–60.0)	38.2 (23.2–55.8)	52.4 (41.3–63.2)
Severe coconut Allergic Reaction (i.e. Wheeze, Fainting/Dizziness and/or hypotension only)	16.1 (10.9–23.2)	21.5 (9.3–42.0)	15.4 (9.9–23.1)	18.3 (11.4–28.0)	12.7 (5.8–25.4)	19.3 (11.5–30.6)
Physician Diagnosed	46.2 (39.1–53.5)	54.9 (39.5–69.5)	44.9 (37.2–53.0)	100	100	100%
Adult–onset coconut Allergy (among adults only)	18.9 (13.4–26.2)	n/a	21.7 (15.4–29.8)	21.5 (13.6–32.2)	n/a	25.4 (16.3–37.4)
Multiple food allergies	69.8 (62.3–76.4)	73.8 (56.8–85.8)	69.2 (60.9–76.5)	58.8 (48.5–68.4)	68.9 (45.0–85.7)	57.0 (45.5–67.7)
Current epinephrine prescription	40.1 (33.3–47.4)	51.4 (36.3–66.2)	38.5 (31.0–46.5)	55.1 (45.2–64.5)	63.4 (42.3–80.4)	53.6 (42.5–64.2)
Comorbid Peanut Allergy	27.8 (22.3–34.0)	35.8 (24.6–48.8)	26.6 (20.6–33.6)	28.5 (21.1–37.3)	37.2 (23.2–53.8)	26.9 (18.8–37.1)
Comorbid Tree Nut Allergy	20.0 (15.3–25.6)	39.9 (25.6–56.0)	17.0 (12.5–22.8)	20.5 (14.5–28.2)	35.2 (21.1–52.4)	17.8 (11.5–26.6)
Comorbid Almond allergy	15.5 (11.6–20.5)	23.9 (15.1–35.8)	14.3 (10.1–19.8)	17.6 (12.1–25.0)	31.1 (17.9–48.3)	15.2 (9.4–23.6)
Comorbid Cashew allergy	12.2 (9.0–16.3)	22.8 (14.1–34.5)	10.6 (7.3–15.1)	12.7 (8.3–18.9)	30.4 (17.3–47.6)	9.5 (5.3–16.4)
Comorbid Hazelnut allergy	13.8 (10.1–18.7)	30.7 (17.1–48.7)	11.3 (7.9–15.9)	13.9 (9.1–20.6)	24.1 (12.6–41.2)	12.0 (7.1–19.6)
Comorbid Pecan allergy	12.3 (8.9–16.9)	21.8 (13.4–33.4)	11.0 (7.3–16.1)	13.7 (8.9–20.6)	30.1 (17.1–47.3)	10.8 (6.0–18.6)
Comorbid Pistachio allergy	11.5 (8.2–15.9)	20.4 (12.3–31.7)	10.1 (6.7–15.1)	12.6 (8.1–19.1)	24.8 (13.1–41.8)	10.4 (5.9–17.7)
Comorbid Walnut allergy	13.7 (10.1–18.3)	21.7 (13.4–33.2)	12.6 (8.7–17.7)	14.7 (9.8–21.5)	28.7 (16.1–45.8)	12.2 (7.3–19.8)
Comorbid Milk Allergy	18.2 (13.4–24.3)	19.4 (12.3–29.2)	18.0 (12.7–25.0)	13.7 (8.9–20.5)	13.6 (7.7–28.9)	13.4 (8.1–21.2)
Comorbid Shellfish Allergy	16.7 (12.0–22.7)	24.8 (15.8–36.8)	15.5 (10.4–22.4)	13.9 (9.1–20.6)	26.1 (14.2–42.9)	11.7 (6.8–19.3)
Comorbid Egg Allergy	12.8 (9.4–17.2)	23.9 (15.2–35.5)	11.1 (7.6–16.1)	8.4 (5.2–13.4)	17.7 (9.1–31.5)	6.8 (3.5–12.5)
Comorbid Fin Fish Allergy	16.9 (12.0–23.4)	13.0 (7.8–20.9)	17.5 (12.0–24.9)	11.8 (7.1–18.9)	1.4 (5.7–21.7)	11.8 (6.6–20.3)

Variable:	% (95% CI) of individuals with convincing coconut allergy	% (95% CI) of children with convincing coconut allergy	% (95% CI) of adults with convincing coconut allergy	% (95% CI) of individuals with physician-diagnosed, convincingly IgE-mediated coconut allergy	% (95% CI) of children with physician-diagnosed, convincingly IgE-mediated coconut allergy	% (95% CI) of adults with physician-diagnosed, convincingly IgE-mediated coconut allergy
Comorbid Wheat Allergy	9.0 (6.4–12.5)	17.1 (10.7–26.2)	7.8 (5.2–11.7)	5.0 (2.9–8.5)	14.7 (7.4–27.3)	3.2 (1.4–7.1)
Comorbid Soy Allergy	14.8 (11.0–19.8)	24.2 (15.2–36.2)	13.5 (9.4–19.0)	8.9 (5.3–14.6)	16.6 (8.4–30.3)	7.5 (3.9–14.2)
Coconut Allergy diagnosed by Skin Prick Test	**Not assessed among those without physician-diagnosis**			73.2 (63.8–80.8)	67.0 (45.1–83.4)	74.3 (64.0–82.4)
Coconut Allergy diagnosed by Blood Test	**Not assessed among those without physician-diagnosis**			28.1 (20.4–37.2)	28.1 (16.6–43.3)	28.1 (19.6–38.5)
Coconut Allergy diagnosed by OFC	**Not assessed among those without physician-diagnosis**			20.2 (13.4–29.2)	29.5 (13.5–52.9)	18.5 (11.6–28.2)
Used EAI to treat a coconut-allergic reaction	20.9 (15.8–27.1)	22.3 (13.1–35.4)	20.7 (15.1–27.6)	28.9 (20.4–39.1)	25.2 (13.1–43.0)	29.5 (20.0–41.2)
Used Antihistamines to treat a Coconut-allergic reaction	46.0 (38.8)	53.3 (38.4–67.7)	44.9 (37.0–53.0)	47.5 (38.0–57.2)	42.5 (26.5–60.3)	48.4 (37.7–59.3)
Used Asthma Inlaher to treat a Coconut-allergic reaction	20.1 (14.9–26.6)	37.2 (22.3–55.0)	17.6 (12.4–24.2)	29.5 (21.0–39.8)	34.8 (18.1–56.3)	28.6 (19.3–40.1)
Used Steroids to treat a coconut-allergic reaction	13.3 (9.2–18.9)	22.3 (10.0–42.5)	12.0 (7.9–17.7)	18.6 (12.7–26.4)	20.5 (11.2–34.5)	18.3 (11.7–27.4)
Atopic comorbidities						
Has physician-diagnosed Asthma	30.3 (24.1–37.3)	51.5 (36.7–66.1)	27.2 (20.7–34.8)	30.5 (22.2–40.4)	43.1 (26.7–61.2)	28.3 (19.1–39.7)
Has physician-diagnosed eczema	10.9 (7.1–16.4)	7.2 (2.8–17.0)	11.5 (7.3–17.7)	10.9 (6.3–18.2)	9.4 (2.8–27.1)	11.1 (6.1–19.5)
Has physician-diagnosed environmental allergies	31.4 (24.7–39.1)	40.6 (26.2–56.8)	30.1 (22.7–38.6)	28.9 (20.6–39.0)	32.2 (18.8–49.3)	28.3 (19.0–40.0)

Table 5.

Patient–reported food allergy–related psychosocial burden as assessed by the Food Allergy Independent Measure among individuals with a single food allergy to coconut, peanut, egg, or milk (e.g. “mono–allergy”)

Variable:	Mean (SE) of individuals with reported mono coconut allergy	Mean (SE) of children with reported mono coconut allergy	Mean (SE) of adults with reported mono coconut allergy	Mean (SE) of individuals with convincing mono coconut allergy	Mean (SE) of children with convincing coconut mono allergy	Mean (SE) of adults with convincing mono coconut allergy	Mean (SE) of individuals with physician-confirmed mono coconut allergy	Mean (SE) of children with phyician-confirmed mono coconut allergy	Mean (SE) of adults with physician-confirmed mono coconut allergy
Composite FAIM	2.73 (0.11)	3.06 (0.25)	2.55 (0.11)	2.52 (0.12)	2.51 (0.28)	2.52 (0.12)	2.44 (0.14)	2.32 (0.32)	2.50 (0.13)
EO1	3.06 (0.17)	3.43 (0.39)	2.88 (0.18)	2.74 (0.19)	2.91 (0.48)	2.67 (0.20)	2.52 (0.22)	2.22 (0.40)	2.66 (0.24)
EO2	3.31 (0.17)	3.68 (0.39)	3.12 (0.17)	3.02 (0.19)	2.84 (0.38)	3.08 (0.21)	2.71 (0.23)	2.41 (0.29)	2.86 (0.29)
EO3	2.26 (0.15)	2.55 (0.38)	2.11 (0.15)	2.07 (0.17)	1.94 (0.43)	2.12 (0.16)	2.00 (0.23)	1.77 (0.52)	2.11 (0.20)
EO4	2.83 (0.17)	3.13 (0.27)	2.67 (0.22)	2.72 (0.22)	2.86 (0.39)	2.67 (0.27)	2.73 (0.35)	2.78 (0.52)	2.71 (0.45)
IM1	2.78 (0.13)	3.15 (0.22)	2.59 (0.16)	2.64 (0.14)	2.68 (0.24)	2.62 (0.17)	2.60 (0.21)	2.79 (0.30)	2.51 (0.28)
IM2	2.10 (0.13)	2.40 (0.26)	1.94 (0.15)	1.94 (0.15)	1.83 (0.22)	1.98 (0.19)	2.08 (0.21)	1.94 (0.30)	2.15 (0.27)
Variable:	**Mean (SE) of individuals with reported mono peanut allergy**	**Mean (SE) of children with reported mono peanut allergy**	**Mean (SE) of adults with reported mono peanut allergy**	**Mean (SE) of individuals with convincing mono peanut allergy**	**Mean (SE) of children with convincing coconut peanut allergy**	**Mean (SE) of adults with convincing mono peanut allergy**	**Mean (SE) of individuals with physician-confirmed mono peanut allergy**	**Mean (SE) of children with physician-confirmed mono peanut allergy**	**Mean (SE) of adults with physician-confirmed mono peanut allergy**
Composite FAIM	3.25 (0.09)	3.35 (0.13)	3.11 (0.06)	3.28 (0.09)	3.38 (0.14)	3.12 (0.06)	3.37 (0.12)	3.48 (0.17)	3.17 (0.06)
EO1	3.31 (0.07)	3.30 (0.10)	3.32 (0.10)	3.30 (0.07)	3.31 (0.10)	3.27 (0.10)	3.29 (0.09)	3.30 (0.11)	3.28 (0.13)
EO2	4.03 (0.12)	4.17 (0.19)	3.83 (0.10)	4.10 (0.13)	4.23 (0.20)	3.90 (0.10)	4.23 (0.16)	4.40 (0.23)	3.90 (0.10)
EO3	3.01 (0.12)	3.19 (0.19)	2.74 (0.09)	3.07 (0.13)	3.24 (0.20)	2.80 (0.09)	3.20 (0.17)	3.36 (0.24)	2.88 (0.10)
EO4	2.95 (0.10)	3.02 (0.15)	2.84 (0.08)	2.96 (0.11)	3.06 (0.16)	2.81 (0.09)	3.04 (0.13)	3.12 (0.19)	2.88 (0.09)
IM1	3.44 (0.11)	3.52 (0.18)	3.33 (0.09)	3.47 (0.12)	3.54 (0.19)	3.37 (0.10)	3.57 (0.15)	3.65 (0.22)	3.41 (0.12)
IM2	2.77 (0.11)	2.89 (0.17)	2.60 (0.08)	2.78 (0.12)	2.91 (0.18)	2.56 (0.08)	2.93 (0.15)	3.06 (0.21)	2.67 (0.10)
Variable:	**Mean (SE) of individuals with reported mono egg allergy**	**Mean (SE) of children with reported mono egg allergy**	**Mean (SE) of adults with reported mono egg allergy**	**Mean (SE) of individuals with convincing mono egg allergy**	**Mean (SE) of children with convincing coconut egg allergy**	**Mean (SE) of adults with convincing mono egg allergy**	**Mean (SE) of individuals with physician-confirmed mono egg allergy**	**Mean (SE) of children with physician-confirmed mono egg allergy**	**Mean (SE) of adults with physician-confirmed mono egg allergy**

Variable:	Mean (SE) of individuals with reported mono coconut allergy	Mean (SE) of children with reported mono coconut allergy	Mean (SE) of adults with reported mono coconut allergy	Mean (SE) of individuals with convincing mono coconut allergy	Mean (SE) of children with convincing coconut mono allergy	Mean (SE) of adults with convincing mono coconut allergy	Mean (SE) of individuals with physician-confirmed mono coconut allergy	Mean (SE) of children with phyician-confirmed mono coconut allergy	Mean (SE) of adults with physician-confirmed mono coconut allergy
Composite FAIM	2.82 (0.07)	2.89 (0.11)	2.76 (0.09)	2.76 (0.08)	2.79 (0.13)	2.73 (0.10)	2.84 (0.10)	2.83 (0.16)	2.85 (0.11)
EO1	3.25 (0.12)	3.25 (0.18)	3.25 (0.15)	3.16 (0.13)	3.06 (0.19)	3.23 (0.18)	3.29 (0.17)	3.11 (0.24)	3.47 (0.23)
EO2	3.40 (0.10)	3.55 (0.14)	3.29 (0.14)	3.37 (0.11)	3.44 (0.15)	3.31 (0.15)	3.55 (0.12)	3.59 (0.17)	3.51 (0.15)
EO3	2.27 (0.11)	2.52 (0.18)	2.09 (0.13)	2.22 (0.13)	2.42 (0.21)	2.07 (0.15)	2.23 (0.18)	2.49 (0.27)	1.98 (0.20)
EO4	2.57 (0.11)	2.61 (0.14)	2.54 (0.17)	2.58 (0.13)	2.58 (0.15)	2.59 (0.18)	2.57 (0.18)	2.63 (0.19)	2.50 (0.30)
IM1	3.04 (0.11)	3.11 (0.15)	3.00 (0.15)	2.95 (0.13)	3.03 (0.18)	2.89 (0.18)	3.13 (0.15)	3.09 (0.23)	3.17 (0.19)
IM2	2.38 (0.09)	2.32 (0.13)	2.43 (0.12)	2.25 (0.09)	2.19 (0.14)	2.30 (0.12)	2.28 (0.11)	2.10 (0.15)	2.46 (0.18)
Variable:	**Mean (SE) of individuals with reported mono milk allergy**	**Mean (SE) of children with reported mono milk allergy**	**Mean (SE) of adults with reported mono milk allergy**	**Mean (SE) of individuals with convincing mono milk allergy**	**Mean (SE) of children with convincing milk allergy**	**Mean (SE) of adults with convincing mono milk allergy**	**Mean (SE) of individuals with physician-confirmed mono milk allergy**	**Mean (SE) of children with physician-confirmed mono milk allergy**	**Mean (SE) of adults with physician-confirmed mono milk allergy**
Composite FAIM	2.77 (0.05)	2.73 (0.08)	2.81 (0.05)	2.70 (0.05)	2.61 (0.07)	2.79 (0.07)	2.87 (0.06)	2.84 (0.09)	2.91 (0.08)
EO1	3.41 (0.08)	3.39 (0.13)	3.44 (0.09)	3.32 (0.09)	3.24 (0.13)	3.42 (0.11)	3.34 (0.10)	3.32 (0.15)	3.38 (0.11)
EO2	3.17 (0.07)	3.09 (0.12)	3.25 (0.07)	3.13 (0.08)	3.05 (0.13)	3.23 (0.09)	3.41 (0.10)	3.37 (0.16)	3.46 (0.12)
EO3	1.86 (0.05)	1.86 (0.08)	1.86 (0.06)	1.81 (0.06)	1.77 (0.08)	1.85 (0.85)	2.05 (0.09)	1.99 (0.11)	2.14 (0.14)
EO4	2.25 (0.06)	2.17 (0.09	2.33 (0.07)	2.15 (0.07)	2.06 (0.10)	2.26 (0.08)	2.31 (0.09)	2.18 (0.12)	2.48 (0.12)
IM1	3.26 (0.08)	3.18 (0.13)	3.33 (0.09)	3.18 (0.08)	3.07 (0.12)	3.31 (0.11)	3.39 (0.10)	3.43 (0.14)	3.35 (0.13)
IM2	2.67 (0.09)	2.66 (0.14)	2.67 (0.12)	2.59 (0.09)	2.50 (0.11)	2.68 (0.16)	2.73 (0.11)	2.77 (0.13)	2.68 (0.19)

Note: FAIM questions were worded as follows:

	How big do you think the chance is that you…
EO1:	*…will accidentally eat something to which you are allergic?*
EO2:	*…will have a* ***severe*** *reaction if you accidentally eat something to which you are allergic?*
EO3:	*…will die if you accidentally eat something to which you are allergic?*
EO4:	*…* ***cannot*** *do the right things (or have the right things done by others) should you accidentally eat something to which you are allergic?*
IM1:	*How many products are you unable to eat because of your food allergy?*
IM2:	*How much does your food allergy affect the things you do with others?*

Table 6.

Comparing characteristics of individuals with current and outgrown convincing coconut allergy

Variable	All	With Convincing Coconut Allergy	With Convincing Outgrown Coconut Allergy
Race/ethnicity			
Asian, non-Hispanic	3.7 (3.5–4.0)	3.6 (1.7–7.4)	2.7 (0.9–7.4)
Black, non-Hispanic	12.0 (11.6–12.5)	12.5 (8.6–17.8)	13.1 (7.1–22.9)
White, non-Hispanic	62.2 (61.4–62.9)	56.4 (48.9–63.7)	53.8 (38.5–68.4)
Hispanic	17.4(16.7–18.1)	19.6 (13.8–27.2)	29.4 (16.2–47.3)
Multiple/other	4.7 (4.4–4.9)	7.9 (4.2–14.1)	1.0 (0.2–5.0)
Sex			
Female	51.1 (50.5–51.6)	55.4 (48.1–62.4)	36.6 (23.8–51.7)
Male	48.9 (48.4–49.5)	44.7 (37.6–51.9)	63.4 (48.3–76.2)
Age			
0–2 years	3.6 (.3.4–3.8)	1,2 (0.7–2.1)	4.7 (1.7–12.0)
3–5 years	3.6 (3.5–3.8)	2.4 (0.8–6.7)	3.4 (1.5–7.7)
6–10 years	6.2 (6.0–6.5)	4.3 (2.5–7.1)	7.3 (2.6–18.5)
11–13 years	3.7 (3.5–3.9)	1.8 (1.1–3.0)	0.6 (0.2–2.1)
14–17 years	5.2 (5.0–5.5)	3.2 (1.9–5.4)	2.2 (0.9–5.2)
18–29 years	16.7 (16.2–17.2)	21.9 (16.5–28.5)	36.0 (21.9–53.0)
30–39 years	13.2 (12.8–13.5)	24.3 (18.2–31.7)	7.9 (4.0–14.9)
40–49 years	13.0 (12.6–13.4)	10.2 (6.8–15.0)	18.1 (8.2–35.2)
50–59 years	14.0 (13.6–14.4)	16.9 (11.8–23.7)	9.9 (4.5–20.2)
60+ years	20.8 (20.3–21.3)	13.8 (9.4–19.7)	9.9 (4.7–19.8)
Household income, $			
<25,000	16.5 (16.0–17.0)	24.4 (18.2–31.8)	29.4 (15.6–46.1)
25,000–49,999	22.0 (21.4–22.6)	25.2 (19.3–32.2)	27.2 (16.1–42.2)
50,000–99,999	31.0 (30.3–31.7)	27.5 (21.7–34.1)	18.9 (11.9–28.8)
100,000–149,999	19.5 (18.9–20.2)	12.9 (8.8–18.5)	23.6 (12.6–39.8)
>150,000	11.0 (10.5–11.6)	10.1 (6.5–15.2)	1.8 (0.6–5.2)
Insurance Status (AmeriSpeak Only)			
Uninsured	8.0 (6.7–9.6)	24.1 (9.7–48.4)	19.4 (2.3–71.3)
Private	66.3 (64.1–68.5)	38.2 (20.6–59.6)	80.6 (28.8–97.7)
Public	25.6 (23.8–27.6)	37.8 (20.1–59.4)	0 (0)
Respondent Educational Attainment			
< High School Graduate	4.5 (4.1–5.0)	7.3 (3.5–14.9)	12.9 (6.0–25.6)
High School Graduate	18.8 (18.0–19.6)	19.4 (13.5–26.9)	17.6 (8.5–32.7)
Some Colleague	22.8 (22.2–23.4)	18.4 (13.6–24.5)	23.9 (12.0–41.9)
Associates (2 year) Degree	10.1 (9.7–10.5)	13.1 (8.6–19.5)	2.7 (1.0–6.8)
Bachelors (4 year) Degree	26.8 (26.1–27.5)	26.2 (20.2–33.3)	26.3 (15.0–41.8)
Master’s Degree	12.6 (12.2–13.1)	11.2 (7.5–16.4)	7.5 (3.0–17.5)

Variable	All	With Convincing Coconut Allergy	With Convincing Outgrown Coconut Allergy
Professional/Doctorate Degree	4.4 (4.1–4.7)	4.3 (1.9–9.5)	9.2 (2.2–31.8)
Physician-diagnosed Allergic Comorbidities			
Asthma	12.2 (11.8–12.7)	30.3 (24.1–37.3)	18.0 (9.4–31.7)
Atopic Dermatitis/Eczema	6.5 (6.2–6.9)	10.9 (7.1–16.4)	5.9 (2.5–13.1)
EoE	.2 (.1–.2)	1.8 (0.8–4.2)	1.6 (0.4–6.1)
FPIES	.3 (.2–.3)	2.6 (1.4–4.6)	1.8 (0.6–4.9)
Environmental Allergies	19.5 (19.0–20.0)	31.4 (24.7–39.1)	4.1 (1.8–9.0)
Insect Sting Allergy	3.5 (3.3–3.7)	9.7 (5.8–15.9)	5.8 (2.0–15.4)
Latex Allergy	2.0 (1.9–2.2)	9.5 (5.7–15.5)	4.3 (1.8–10.1)
Medication Allergy	11.3 (11.0–11.7)	19.0 (14.2–25.0)	5.7 (2.4–13.0)
Urticaria/Chronic Hives	.8 (.7–.9)	1.4 (0.6–3.2)	0.9 (0.3–3.3)
Other Chronic Condition	6.4 (6.1–6.7)		
Family History of Atopy (lifetime)			
Parental asthma	14.7 (14.2–15.2)	36.2 (29.0–44.0)	29.3 (16.5–46.4)
Parental eczema	11.1 (10.6–11.5)	26.7 (19.8–35.0)	25.1 (13.1–42.8)
Parental allergic rhinitis	31.6 (30.9–32.4)	44.3 (36.2–52.7)	42.5 (27.9–58.5)
Parental FA	14.6 (14.1–15.1)	45.7 (37.7–54.0)	45.4 (30.0–61.8)