

# Prevalence of peanut and tree nut allergy in the United States determined by means of a random digit dial telephone survey: A 5-year follow-up study

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**Background:** Allergy to peanuts and tree nuts (TNs) is the leading cause of fatal and near-fatal food allergic reactions. Peanut allergy appears to be increasing in prevalence.

**Objectives:** We sought to determine the prevalence of self-reported peanut and TN allergy among the general population of the United States in 2002 by sex and age and to compare the results with prevalence estimates obtained 5 years earlier.

**Methods:** We performed a nationwide, cross-sectional, random telephone survey by using a standardized questionnaire.

**Results:** A total of 4855 households participated (53% participation rate), representing a census of 13,493 individuals.

Peanut allergy, TN allergy, or both was self-reported in 166 (1.2%; 95% CI, 1.0%-1.4%) individuals in 155 (3.2%; 95% CI, 2.7%-3.7%) households, overall prevalence rates similar to those reported in 1997. Also similar to the 1997 survey, the severity level was high, with 79% reporting respiratory or multiple organ system reactions and 66% experiencing more than 5 lifetime reactions. Despite the severity and reaction frequency, only 74% of the children and 44% of the adults sought evaluation for the allergy, and fewer than half who did were prescribed self-injectable epinephrine. Applying conservative rules to adjust for persons with unconvincing reactions and a false-positive rate of the survey instrument (7%), a final prevalence estimate of 1.04% (95% CI, 0.9%-1.24%) was obtained. A male predominance of peanut-TN allergy was reported in children younger than 18 years (1.7% vs 0.7%,  $P = .02$ ), and a female predominance was reported among adults (1.7% vs 0.9%,  $P = .0008$ ). Although the rate of peanut allergy, TN allergy, or both was not significantly different from 1997 to 2002 among adults, the rate increased from 0.6% to 1.2%

among children, primarily as a result of an increase in reported allergy to peanut (0.4% in 1997 to 0.8% in 2002,  $P = .05$ ).

**Conclusions:** Self-reported peanut allergy has doubled among children from 1997 to 2002, and peanut allergies, TN allergies, or both continue to be reported by more than 3 million Americans. Considering that reactions are severe and the allergy is persistent, these allergies represent an increasing health concern. (J Allergy Clin Immunol 2003;112:1203-7.)

**Key words:** Prevalence, peanut, tree nut, hypersensitivity, food allergy, anaphylaxis, telephone survey

Allergies to peanuts and tree nuts (TNs) are severe, common, and long lasting.<sup>1-3</sup> Although there is a strong clinical impression that allergies to these foods have increased,<sup>2,4</sup> only 1 study thus far has investigated this possibility. Grundy et al<sup>5</sup> reported that among 2 separate birth cohorts, one from 1989 and another from 1994 to 1996 living on the Isle of Wight, the rate of reported peanut allergy for children age 3 to 4 years increased from 0.5% (6/1218) to 1% (13/1273;  $P = .2$ ). They also reported an increased sensitization rate to peanut from 1.1% to 3.3% ( $P = .001$ ).

In 1997, we conducted a random digit dial telephone survey in the United States and found that 1.4% of the general population reported peanut allergy, TN allergy, or both.<sup>1</sup> The rate of reported peanut (0.7%) and TN (0.4%) allergy among adults age 18 years and older was slightly higher than the rates reported for children younger than 18 years (0.4% and 0.2%, respectively). Emmett et al<sup>6</sup> conducted a survey of 2000 households in Great Britain in 1995 and reported a rate of peanut allergy of 0.61% among children aged 0 to 14 years, 0.53% in adults 15 to 44 years of age, and 0.3% among those older than 44 years. We<sup>1</sup> and Emmett et al<sup>6</sup> therefore concluded that because the rates in children and adults were similar, there was a lack of clear evidence for an increase in prevalence. However, neither study was able to compare rates of allergy within an age group over time. We report here the results of a follow-up survey of the general US population in 2002 using a random telephone call list to gain additional information on the rate of reported allergy by age group and to compare the results with those obtained 5 years earlier.

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**Abbreviation used**

TN: Tree nut

**METHODS****Survey methods**

The survey was a nationwide, cross-sectional, computer-assisted telephone interview of households performed by the same agency that conducted the study between April and June 1997 (IMR, Inc, an AdvancePCS Company, Hunt Valley, Md).<sup>1</sup> A random sampling of telephone numbers was generated by the Genesys Sampling System (Fort Washington, Pa). Nonresidential calls were excluded from analysis. Interviews were conducted from June 24, 2002, to August 7, 2002, by trained telephone medical interviewers. A specific household was called at different times of the day and on different days to optimize contact with a resident. At least 10 attempts were made to contact a resident of each household. If at the time of a household contact there was no age-eligible adult available, an effort was made to call back at an appropriate time. Calling was done between the hours of 3 PM to 9 PM (local time) Monday through Thursday and 10 AM until 5 PM Eastern Standard Time on Saturday to minimize selection bias related to availability of respondents who are at home during the day.

**Questionnaire contents, selection of eligible respondents, rules for surrogates, definitions, and data processing**

Federal regulations pertaining to consent procedures and subject confidentiality were strictly observed, and the study was approved by the Essex Institutional Review Board. Respondents were eligible if they were 18 years of age or older, were living in the household, and understood the questions without a language-mental-hearing barrier. The initial age-eligible household respondent was invited to participate in the survey. If this respondent was not allergic to peanuts or TNs, he or she was asked to identify individuals within the household who were allergic. If the affected individual was a minor, the initial respondent acted as a surrogate for the minor and completed the interview. If this respondent was unable to act as a surrogate for the minor, another adult was sought. If the affected individual or individuals were adults and unavailable, the household was recontacted until the affected individual could be interviewed. If no household resident was allergic to peanuts or TNs, census data were collected. In households with one or more persons allergic to peanut or TNs, the entire interview was conducted with each allergic person or surrogate if the allergic person was less than 18 years of age. Adults with peanut or TN allergy identified by a surrogate were included in the prevalence estimate, but details of reactions in adults were only included when the affected adult was personally interviewed. For individuals who reported peanut or TN allergy, further specific questions were administered to determine the details of the allergic reactions. Ten additional questions were added to the survey used in 1997 to clarify the occurrence of multiple peanut-TN allergies and the types of nuts involved and to determine additional demographic information (age, race-ethnicity, and state of residence).

Reactions were considered to be convincing if the organ systems affected and symptoms were typical of those involved in allergic reactions (skin with hives or angioedema; respiratory tract with trouble breathing, wheezing, or throat tightness; and gastrointestinal tract with vomiting or diarrhea) and occurred within 2 hours of ingestion. A previous study using these symptoms as criteria for a convincing acute allergic reaction to peanut or TN found that most

subjects (93%) had IgE antibody to the implicated food.<sup>7</sup>

Data management was performed by using SAS statistical software for Windows (version 8); telephone interview data were converted into SAS data sets for analysis. Differences in proportions between groups were tested by means of  $\chi^2$  analysis (2-sided Fisher exact test).

**RESULTS****Participation rate**

A total of 9252 households were contacted: 3503 (37.9%) refused to participate, and an additional 894 (9.7%) were ineligible (age <18 years, 57; language barrier, 524; confusion or hearing problems, 248; and willing but ultimately unable to schedule interview, 65). The total of 4855 participating households represented a census of 13,493 individuals. The overall participation rate of 4855 (52%) households was lower than that of the 1997 survey (67%).

**Demographic characteristics of participants and reported rates of peanut and TN allergy**

A total of 155 (3.2%; 95% CI, 2.7%-3.7%) households reported one or more individuals with peanut allergy, TN allergy, or both, a rate similar to that of the 1997 study (3.4%,  $P = .5$ ). Nine households reported 2 persons and 1 reported 3 persons with peanut allergy, TN allergy, or both. Rates of reported allergy to peanut, TN, or both according to age are shown in Table I. Overall, the rate of any peanut allergy, TN allergy, or both among adults (1.3%) was not different compared with that among children (1.2%,  $P = .76$ ). The distribution of reported peanut and TN allergy according to race-ethnicity and sex according to age is shown in Table II. Race-ethnicity was only determined from the responding household member, and calculations therefore assume all household members are of the same race-ethnicity. Although the rate of allergy was reported lowest among black subjects, it was not significantly lower than that among white subjects ( $P = .25$ ). There is an overall male predominance of peanut-TN allergy reported in children ( $P = .02$ ) and female predominance in adults ( $P = .0008$ ). There were no significant differences in rates of allergy to peanut or TN by geographic region (data not shown). Fifty percent of respondents with peanut allergy, TN allergy, or both indicated additional food allergies (type not specified).

In 1997, only 4 adults reported both peanut and TN allergy, general details were not provided for 15 persons with reported allergy, and 985 respondents did not provide general demographic details (eg, age). It was unknown at the time whether the survey instrument led to individuals proffering an allergy to one food group with the exclusion of another.<sup>1</sup> In 2002, questions were added to prompt individuals about additional peanut-TN allergies, and 9 (0.3% of the general population) children and 23 (0.2%) adults indicated allergy to both peanuts and TNs. The additional questions also resulted in fewer persons with missing general information (3.6% of individuals in 2002 compared with 8.2% in 1997). The reported rates of allergy in the 1997 survey compared with those

**TABLE I.** Prevalence of peanut and TN allergy in 2002 by age

Age	Total Sample Population, n = 13,493	Type of nut allergy									
		Any nut*		Both peanut and TN		Isolated peanut		Isolated TN		Unspecified nut	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	
0-5 y	869	9	1.0 (0.4-1.7)	1	0.1 (0.0-0.3)	7	0.8 (0.2-1.4)	1	0.1 (0.0-0.3)	0	0.0
6-10 y	851	9	1.1 (0.4-1.8)	2	0.2 (0.0-0.6)	5	0.6 (0.1-1.1)	2	0.2 (0.0-0.6)	0	0.0
11-17 y	1228	10	0.8 (0.3-1.3)	4	0.3 (0.0-0.6)	2	0.2 (0.0-0.4)	3	0.2 (0.0-0.5)	1	0.1 (0.0-0.2)
18-20 y	579	5	0.9 (0.1-1.6)	0	0.0	3	0.5 (0.0-1.1)	2	0.4 (0.0-0.8)	0	0.0
21-30 y	1491	19	1.3 (0.7-1.8)	3	0.2 (0.0-0.4)	6	0.4 (0.1-0.7)	10	0.7 (0.3-1.1)	0	0.0
31-40 y	1556	18	1.2 (0.6-1.7)	3	0.2 (0.0-0.4)	7	0.5 (0.1-0.8)	7	0.5 (0.1-0.8)	1	0.1 (0.0-0.2)
41-50 y	1809	19	1.1 (0.6-1.5)	4	0.2 (0.0-0.4)	4	0.2 (0.0-0.4)	10	0.6 (0.2-0.9)	1	0.1 (0.0-0.2)
51-60 y	1352	24	1.8 (1.1-2.5)	8	0.6 (0.2-1.0)	6	0.4 (0.1-0.8)	6	0.4 (0.1-0.8)	4	0.3 (0.0-0.6)
61-64 y	355	7	2.0 (0.5-3.4)	0	0.0	1	0.3 (0.0-0.8)	5	1.4 (0.2-2.6)	1	0.3 (0.0-0.8)
≥65 y	1345	22	1.6 (1.0-2.3)	2	0.2 (0.0-0.4)	6	0.5 (0.1-0.8)	9	0.7 (0.2-1.1)	5	0.4 (0.1-0.7)
Child (<18 y), age not specified	179	9	5.0 (1.8-8.3)	2	1.2 (0.0-2.7)	3	1.7 (0.0-3.6)	1	0.6 (0.0-1.7)	3	1.7 (0.0-3.6)
Adult (>18 y), age not specified	1,394	12	0.9 (0.4-1.4)	3	0.2 (0.0-0.5)	2	0.1 (0.0-0.3)	1	0.1 (0.0-0.2)	6	0.4 (0.1-0.8)
Age not known	485	3	0.6 (0.1-1.8)	–	–	–	–	–	–	3	0.6 (0.1-1.8)
Overall	13,493	166	1.2 (1.0-1.4)	32	0.2 (0.2-0.3)	52	0.4 (0.3-0.5)	57	0.4 (0.3-0.5)	25	0.2 (0.1-0.3)

\*“Any nut” is reported nut allergy, including peanut, TN, or unspecified nut.

**TABLE II.** Prevalence of peanut and TN allergy by race, ethnicity, and sex by age

Age	Total Population	Type of nut allergy									
		Any nut*		Both peanut and TN		Isolated peanut		Isolated TN		Unspecified nut	
	n	% (± 95% CI)	n	% (± 95% CI)	n	% (± 95% CI)	n	% (± 95% CI)	n	% (± 95% CI)	
White	9867	113	1.2 (0.9-1.4)	25	0.3 (0.2-0.4)	37	0.4 (0.3-0.5)	42	0.4 (0.3-0.6)	9	0.1 (0.0-0.2)
Black	1222	9	0.7 (0.3-1.2)	3	0.3 (0.0-0.5)	3	0.3 (0.0-0.5)	2	0.2 (0.0-0.4)	1	0.1 (0.0-0.2)
Hispanic	765	10	1.3 (0.5-2.1)	2	0.3 (0.0-0.6)	3	0.4 (0.0-0.8)	5	0.7 (0.1-1.2)	0	0.0
Other	825	12	1.5 (0.6-2.3)	1	0.1 (0.0-0.4)	5	0.6 (0.1-1.1)	6	0.7 (0.2-1.3)	0	0.0
Not reported	814	22	2.7 (1.6-3.8)	1	0.1 (0.0-0.4)	4	0.5 (0.0-1.0)	2	0.3 (0.0-0.6)	15	1.8 (0.9-2.8)
Sex/age											
Male (<18 y)	1526	26	1.70 (1.05-2.35)	4	0.26 (0.01-0.52)	15	0.98 (0.49-1.48)	5	0.33 (0.04-0.61)	2	0.13 (0.0-0.31)
Female (<18 y)	1473	10	0.68 (0.26-1.10)	4	0.27 (0.01-0.54)	3	0.20 (0.00-0.43)	2	0.14 (0.00-0.32)	1	0.07 (0.00-0.20)
Male (>18 y)	4338	37	0.85 (0.58-1.13)	7	0.16 (0.04-0.28)	12	0.28 (0.12-0.43)	15	0.35 (0.17-0.52)	3	0.07 (0.00-0.15)
Female (>18 y)	4962	82	1.65 (1.30-2.01)	16	0.32 (0.16-0.48)	22	0.44 (0.26-0.63)	35	0.71 (0.47-0.94)	9	0.18 (0.06-0.30)

There is an overall male predominance of peanut-TN allergy reported in children ( $P = .02$ ) and female predominance in adults ( $P = .0008$ ).

\*“Any nut” is reported nut allergy, including peanut, TN, or unspecified nut.

reported in 2002 are shown in [Table III](#). Data are shown for individuals grouped according to their allergy status with peanut and TN allergy, as reported previously for the 1997 data (eg, including the 4 adults with peanut and TN allergy in both columns of “all with”), and showing the 2002 data adjusted similarly (ie, according to total persons with reported allergy to each food). The prevalence of reported allergy to peanut among children increased significantly from 0.4% in 1997 to 0.8% in 2002 ( $P = .05$ ), but the rate of TN allergy in children and peanut or TN allergy in adults did not change significantly.

### Adjusted prevalence

Information about clinical reactions was available for 145 (87%; 110 adults and 35 children) of 166 individuals. Reactions were not convincing for 11 adults (fatigue,

1; hives after 12 hours, 1; pimples-weight gain, 1; abdominal pain, 1; conjunctival injection only, 1; convincing symptoms but only one reaction with symptoms delayed beyond 2 hours, 3; and convincing symptoms but delayed onset [but recurrent reactions], 3) and 1 child (nasal symptoms only). Thus 12 (8.3%) of 145 subjects with complete information did not have convincing reactions. If a similar rate of unconvincing reactions occurred among the 21 individuals without clinical details, a total of 14 persons of the 166 would be excluded, leaving 152 with convincing symptoms for their first reaction. Reducing the total by another 7% to reflect the potential false-positive rate of the survey,<sup>7</sup> 141 persons would remain, giving a corrected prevalence of 1.04% (95% CI, 0.9%-1.24%), which is not significantly different compared with the corrected prevalence rate in 1997 (1.1%,  $P = .5$ ).

**TABLE III.** Comparison of reported peanut and TN allergies between the 1997 and 2002 surveys

Age	Census		Any nut		Both peanut and TN		Total peanut		Total TN		Unspecified nut	
	1997	2002	1997	2002	1997	2002	1997	2002	1997	2002	1997	2002
Child <18 y	2998	3127	18 (0.6%)	37 (1.2%)	–	9 (0.3%)	12 (0.4%)	26 (0.8%)	5 (0.2%)	7 (0.2%)	1 (0%)	4 (0.1%)
Adult	8049	9881	131 (1.6%)	126 (1.3%)	4	23 (0.2%)	59 (0.7%)	58 (0.6%)	59 (0.7%)	50 (0.5%)	17 (0.2%)	18 (0.2%)
Unknown	985	485	15 (1.5%)	3 (0.6%)	–	–	–	–	–	–	15 (1.5%)	3 (0.6%)
Total	12,032	13,493	164 (1.4%)	166 (1.2%)	4	32 (0.3%)	71 (0.6%)	84 (0.6%)	64 (0.5%)	57 (0.4%)	33 (0.3%)	25 (0.2%)

The prevalence of reported allergy to peanut among children increased significantly ( $P = .05$ ).

### Characteristics of peanut and TN allergies

Among 82 of the 89 subjects with TN allergy with information regarding allergy to specific TNs, 49 indicated allergy to 1, 15 to 2, and 28 to 3 or more different TNs. Frequency of specific nut allergies was as follows: walnut, 51; cashew, 36; almond, 32; pecan, 29; Brazil nut, 25; hazelnut, 24; macadamia nut, 21; pistachio, 18; and pine nut, 16.

The symptoms evoked during a first reaction paralleled those reported in the 1997 study, with symptoms reported as follows: throat tightness, 53%; dyspnea, 41%; wheezing, 29%; angioedema, 51%; urticaria, 47%; vomiting, 17%; diarrhea, 6%; and loss of consciousness, 6%. Multiple organ system involvement was reported by 77%. Only 18% experienced 1 lifetime reaction, and 66% experienced more than 5 reactions. The first reaction was treated in 31% of the patients. Of the 43 reporting specific therapies, 86% received antihistamines, 19% received epinephrine, 26% received steroids, and 9% received intravenous fluids. Despite the severity (79% with respiratory or multiple organ system reaction) and recurrent reactions, only 74% of the children and 44% of the adults were evaluated for the allergy by a physician. Of those evaluated, self-injectable epinephrine was prescribed for 46% of the children and 23% of the adults.

### DISCUSSION

Peanut and TN allergies are particularly severe, common, and rarely outgrown.<sup>1,3,8,9</sup> Previous anecdotal reports from the United States<sup>10</sup> and the United Kingdom<sup>4</sup> have described an increase in sensitization and prevalence, respectively. Recently, Grundy et al<sup>5</sup> reported peanut sensitization and reactivity in a birth cohort of 3- and 4-year-old children on the Isle of Wight, United Kingdom, born between 1994 and 1996 and compared the results with those of a cohort born in 1989. They documented a 2-fold increase in reported peanut allergy (0.5%-1.0%), a 3-fold increase in sensitization, and after further analysis that included oral challenges, the total estimate for clinical peanut allergy was 1.5% of 3- to 4-year-old children. Our study did not include skin tests or oral food challenges, but the rate of reported peanut allergy in children similarly increased 2-fold over a 5-year

period, from 0.4% in 1997 to 0.8% in 2002. The highest rate of peanut allergy was noted in the youngest age groups (at ages one would not expect to see TN allergy because these foods are typically not fed early on for reasons of their being a choking hazard and then perhaps not introduced once peanut allergy was established). The overall rate of reported allergy to peanuts and TNs did not increase over the 5-year period, but because this allergy typically develops in childhood and is infrequently outgrown,<sup>9</sup> one might predict that a growing number of the general population will have these allergies.

Hypotheses as to the reason for the increased rate of peanut allergies in children include increased allergenicity of roasted forms, early feeding when the immune system is immature, use of topical ointments containing peanut, and possibly the use of soy formulas.<sup>2,11,12</sup> In addition, a genetic predisposition is clearly involved.<sup>12,13</sup> The rate of atopic disease and allergen sensitization has increased in the past decades, and therefore this increase in food allergy (peanut and TN allergy) might also reflect a nonspecific increase of atopic manifestations possibly explained by the hygiene hypothesis.<sup>14-16</sup>

There are several additional observations from this study in regard to the epidemiologic and clinical features of these allergies. We show that peanut and TN allergies disproportionately affect male children and female adults. The reason for this age-sex distribution of allergy is unknown, but it was also observed in a prevalence study of peanut allergy by Emmett et al<sup>6</sup> in Great Britain and in previous reports of anaphylaxis<sup>17</sup> and food allergy.<sup>18,19</sup> We also observed that allergy to both peanuts and TNs is reported by 20% of those affected and close to the rate of reported coallergy to peanuts and TNs in studies of referral populations (in the range of 20%-50%<sup>4,7,20</sup>). This rate of coallergy was higher than noted in our previous telephone survey; we considered the possibility that coallergy was underreported in that survey<sup>1</sup> at the time and therefore added questions to the current survey that apparently corrected that deficit. Similar to our study in 1999 and also noted in the population-based study by Emmett et al,<sup>6</sup> allergy to peanuts and TNs are often severe and yet frequently undertreated. Unfortunately, relatively few patients seek physician care, and when they do, self-injectable epinephrine is apparently underprescribed, problems noted in a variety of studies.<sup>21</sup> This

lack of medical care is alarming considering that 79% had respiratory or multisystem allergic reactions on their first exposure, and two thirds experienced more than 5 reactions. Apparently, there is a disparity in care for children (46% prescribed epinephrine) compared with care for adults (23% prescribed epinephrine).

Limitations of this study include those inherent to telephone surveys and those related to self-reported diagnosis of allergy. Telephone surveys can be biased in several respects. Overrepresentation of persons with a high socioeconomic status might occur because homes without telephones are excluded, and homes with multiple voice lines are more likely to be selected.<sup>22</sup> In comparing the various demographic features of respondents to the US Census 2000 to the demographic data of the participants (data not shown), there was never more than a 1.9% discrepancy of age distribution, and the disparity in sex distribution was small (47.7% female subjects in this survey and 50.9% in the US Census). Race-ethnic disparities were also small, with equivalent rates of white subjects (74.5% in the survey and 75.1% in the US Census) but with underrepresentation of black subjects (8.7% in the survey and 12.3% US Census) and Hispanic subjects (4.2% vs 12.5%) and overrepresentation of Asian subjects (3.6% vs 1.8%); however, survey respondents often refused or did not report race-ethnicity (9.4%). The overall participation rate was lower than in the previous survey but comparable with recent similar telephone surveys, which probably reflects a response to the increase in telemarketing over the past 5 years.<sup>23</sup>

There are also limitations of the survey instrument to identify true allergy. The gold standard for diagnosing food allergy is the double-blind, placebo-controlled, oral food challenge.<sup>24</sup> It was clearly not practical in this study to challenge subjects culled from the general population. However, peanut and TN reactions are usually acute and severe, and therefore the false-positive rate of historical determination of allergy is generally low. Previous surveys have noted a false-positive rate of 13% (with a surrogate respondent for children by using allergy skin prick tests to peanut to indicate sensitivity) to 14% (in adults).<sup>20,25</sup> In a study using this questionnaire instrument, 7% of 111 patients with convincing histories of acute reactions to peanuts or TNs did not have detectable peanut- or TN-specific serum IgE antibody.<sup>7</sup> Taking these limitations into account, we conservatively report an overall rate of peanut and TN allergy in the United States of 1.04% (95% CI, 0.9%-1.24%) or about 3 million Americans.

In summary, we have documented a similar overall rate of peanut and TN allergy in the United States, as was noted in 1997; however, over this 5-year period, there was an apparent doubling of the rate of peanut allergy in children. The same phenomenon was recently reported from the Isle of Wight, United Kingdom, with rates of peanut allergy similar to those in our study.<sup>5</sup> The reasons for these observations are unknown and probably multifactorial, but the implications are clear. Namely, better

strategies for prevention and treatment are desperately needed because there will likely be a gradual increase in food allergy as the population ages.

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