Peanut allergy diagnoses among children residing in Olmsted County, Minnesota

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Background: Peanut allergy is a major health concern, particularly in developed countries. Research indicates that as many as 2% of children are allergic to peanuts, which represents a 3-fold increase in diagnoses over the past 2 decades.
Objective: This population-based descriptive study used the Rochester Epidemiology Project to estimate the prevalence in 2007 and annual incidence rates of peanut allergy diagnoses from 1999 to 2007 among children residing in Olmsted County, Minnesota.
Methods: Residents of Olmsted County from January 1, 1999, through December 31, 2007, who received medical care at a Rochester Epidemiology Project facility and provided research authorization were eligible for the study. A medical chart review of 547 potential diagnoses resulted in 244 prevalent and 170 incident cases. Annual rates, crude and adjusted for age and sex, were standardized with the use of the indirect method to the Olmsted County population data in 1999. Incidence rate ratios were estimated with Poisson regression.
Results: The prevalence in 2007 was 0.65%. Female children were less likely to be diagnosed than male children (incidence rate ratio = 0.18; 95% CI, 0.07-0.48). Children aged birth to 2 years were significantly more likely to be diagnosed than older children aged 3-17 years (incidence rate ratio = 0.001; 95% CI, 0.0004-0.004). A significant 3-fold increasing trend was observed in diagnoses over time from 2.05 cases per 10,000 children in 1999 to 6.88 cases per 10,000 in 2007.
Conclusions: Peanut allergies are an increasing concern in Olmsted County, Minnesota, as indicated by a 3-fold increase in diagnoses from 2.05 per 10,000 children in 1999 to 6.88 per 10,000 children in 2007. (J Allergy Clin Immunol 2012;130:945-50.)

Key words: *Peanut allergy, children, incidence, prevalence, Olmsted County, Rochester Epidemiology Project*

Abbreviation used
REP: Rochester Epidemiology Project

Food allergies affect approximately 8% of children in the United States.[1-3] The most common foods that induce clinical reactions are cow's milk, wheat, egg, soy, peanut, tree nuts, fish, and shellfish.[1-3] Peanut allergy is an IgE-mediated hypersensitivity reaction to peanut proteins. The allergy typically presents early in life, and only a minority of cases resolve (20%).[4] Reactions to peanut represent the majority of cases of food-induced anaphylaxis.[5] In highly sensitive people, trace quantities can induce severe allergic reactions.[5] Currently, the only available treatment is strict avoidance, recognition of early symptoms of a reaction, and usage of emergency medication.[6]

Peanut allergy is a major health concern, particularly in developed countries in which as many as 2% of children are allergic.[7] Considerable variability exists for published prevalence estimates, which range from 0.5% to 2.0%, and among studies that examine changes in prevalence and incidence rates over time, with some estimates indicating a 2- to 3-fold increase over the past decade.[8-22] Specifically, studies from the United States reported a significant increase in self-reported allergy from 0.4% in 1997 to 1.4% in 2008.[9-11] Research conducted in the United Kingdom reported a significant increase in clinical allergy, defined as evidence of sensitization in conjunction with an adverse reaction to peanut, from 1989 (0.5%) to 1996 (1.4%) and a nonsignificant decrease in 2003 (1.2%).[12-14] Further, studies conducted in Canada report a nonsignificant increase in clinical allergy from 1.34% in 2002 to 1.62% in 2007.[15,16] Finally, an Australian study reported a significant 2.5-fold increase in incidence rates from 1995 (0.47%) to 2007 (1.15%).[17]

The results from these studies are difficult to compare and interpret in the aggregate because of the variability in results, which is likely because of a lack of uniformity in the criteria used to define peanut allergy and methods used to identify persons with allergy to peanut. Identification of cases based on parental self-report or evidence of sensitization alone as opposed to reliance on the "gold standard" for diagnosis, food challenges, or evidence of clinical allergy as indicated in medical records are known to produce inflated estimates of true allergy.[6] There is a paucity of studies that use food challenges to enumerate the prevalence and incident rates of diagnoses over time. As a result, research that identifies cases based on diagnostic criteria outlined by the current guidelines, as opposed to self-report or evidence of sensitization alone, is needed to produce accurate estimates for true allergy. This information will contribute to findings of other studies that use similar methods with the hope of growing a comparable, accurate, reproducible knowledge base.[6]

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METHODS

The prevalence of peanut allergy in 2007 and annual incidence rates from 1999 to 2007 among children were estimated with data obtained from the Rochester Epidemiology Project (REP).[23,24] The REP is a population-based medical records linkage system in which medical diagnosis data from the primary providers of care in Olmsted County are linked to individual patients. The largest provider of care is the Mayo Clinic, which has maintained a common medical record with its 2 large affiliated hospitals, St Mary's and Rochester Methodist, since 1907. Mayo's indexing system was later extended to the other providers in Olmsted County, including Olmsted Medical Center, its affiliated hospital, and the Rochester Family Medical Center. A Target store outpatient clinic and a nurse practioner's office are the only providers of medical care in Olmsted County that do not participate in the REP.

The REP is an excellent representation of the Olmsted County population. Ninety-eight percent of Olmsted County residents seen from 1998 to 2007 granted permission for at least one of their medical records to be used for research, and 91% granted permission for all of their records to be used for research.[23] Further, compared with 2000 US Census population estimates for Olmsted County, the REP more closely estimated the population aged younger than 18 years than did the US Census.[23]

All diagnoses and surgical procedures from these facilities were numerically coded with the use of either the Hospital Adaptation of the *International Classification of Diseases*, Second Edition, or the *International Classification of Diseases*, Ninth Revision, coding systems. These codes are indexed for computerized retrieval. With the use of this retrieval system, a search was conducted for all patients who had a new diagnostic code related to peanut allergy from 1999 through 2007, were residents of Rochester, Minnesota, and who gave permission for their medical records to be used for research.

A list of patients with a potential diagnosis of peanut allergy in the medical records from 1999 to 2007 was generated, and the medical charts were reviewed to confirm cases of peanut allergy. Specifically, the medical records for 547 patients with codes that represented the following diagnoses were reviewed: allergy food, allergy food with dermatitis, allergy peanuts, allergy food personal history, allergy peanuts personal history, anaphylaxis shock peanuts, anaphylaxis, and allergic reaction. Patients who met the criteria for a diagnosis of peanut allergy, as defined below, were included in the study.

Specifically, to be considered allergic to peanuts, each patient had to meet criterion 1, as outlined below, and at least one of criteria 2 to 4.[6]

1. Positive history of an IgE-mediated type 1 hypersensitivity reaction AND
2. A positive blood test result (≥0.35 kU/L) OR
3. If blood testing is negative, positive skin prick test (>−3.0 mm) OR
4. If both blood and skin prick testing are negative, a positive food challenge

The Mayo Foundation, Olmsted Medical Center, and University of Minnesota institutional review boards approved the study.

Study population

Subjects who did not provide permission for their medical records to be used for research, whose residency information was not available, who were not residents of Olmsted County at the time of diagnosis, and/or did not meet the diagnostic criteria for peanut allergy were excluded from the data set. The complete medical records of each potential subject were reviewed to confirm a case of peanut allergy and to collect information about demographics, health status, presenting symptoms, and outcome. Of the 547 potential cases, 171 (31.3%) unique incident cases were identified who met the diagnostic criteria during 1999-20007. Twelve duplicate cases were eliminated from the original sample of 183 cases, which resulted in 171 unique incident cases. From the sample of 171 incident cases, 1 case was eliminated because of incorrect date information that could not be verified. As seen in Fig 1, the final analytic sample for incident rate calculations consisted of 170 cases. All data were abstracted with an electronic data collection form.

Prevalence

A prevalent case was defined as an Olmsted County resident who was a patient of a REP facility from 1999 to 2007 with a diagnosis of peanut allergy.

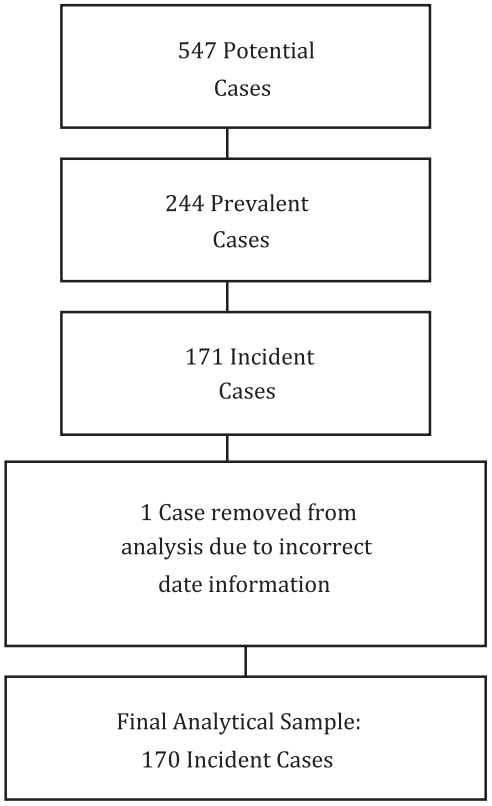

FIG 1. Sample size waterfall.

Prevalent cases are a mixture of existing and new cases of peanut allergy diagnosed in the medical records from 1999 to 2007. Thus, the allergy may have been diagnosed before 1999 and may or may not have been initially diagnosed at a REP facility. It is estimated that approximately 20% of people with peanut allergy diagnosed before the age of 5 years will become tolerant of peanuts. The medical records of all cases were followed in time to determine whether they became tolerant of peanuts, and, if so, the subject was removed from the prevalence estimate by subtracting that case from the numerator total.

Incidence

An incident case was defined as a new diagnosis of peanut allergy made at a REP facility from 1999 to 2007 for an Olmsted County resident.

Tolerance

A child was considered to have become tolerant to peanuts if the child's condition was previously diagnosed as peanut allergic, per study definition, and the child subsequently passed an in-office food challenge.[6]

Statistical analysis

Participant characteristics of all cases were descriptively summarized by means and SDs for continuous variables or by frequencies for categorical variables. These characteristics included age of first diagnosis, year of first diagnosis, and sex.

An estimate of the prevalence of peanut allergy in 2007 was calculated by dividing the numerator, all prevalent and incident cases of peanut allergy in the medical records from 1999 to 2007 minus those children who acquired tolerance, by the denominator, the Olmsted County population aged younger than 18 years estimated from US census data. In calculating incidence rates, the entire population of Olmsted County age 17 years or younger was considered at risk. The overall denominator, as well as age- and sex-specific

TABLE I. Characteristics of children in Olmsted County with incident diagnoses of peanut allergy from 1999 to 2007

	Value
No. of cases	170
Age, no, (%)	
Birth to 2 y	132 (77.7)
3-5 y	26 (15.3)
6-10 y	9 (5.3)
11-17 y	3 (1.8)
Sex, no. (%)	
Male	118 (69.4)
Female	52 (30.6)
Diagnosis year, no. (%)	
1999	10 (5.9)
2000	11 (6.5)
2001	19 (11.2)
2002	10 (5.9)
2003	12 (7.1)
2004	28 (16.5)
2005	22 (12.9)
2006	28 (16.5)
2007	30 (17.7)

person-years, were estimated from decennial census data with linear interpolation between census years.

The incident diagnosis for each case contributed to the numerator for the incidence rate calculation for that respective year. Annual rates, crude and adjusted for age and sex, were standardized with the indirect method to data in 1999 for Olmsted County. Using indirect methods is preferred when rates are unstable because of rare events. A test for trend was conducted to assess whether there was a statistically significant increase in the annual age- and sex-adjusted rates of peanut allergy diagnoses over time.

Poisson regression was used to estimate incidence rate ratios with the use of the log of person-time offset to examine the multivariable relation of incidence rates with age, sex, and diagnosis year. The denominator for the incident rate calculation was estimated with the log of person-years. In each year, the time at risk for those with a peanut allergy diagnosis was estimated as the time until their condition was diagnosed (ie, a person whose condition was diagnosed in March 1999 would contribute 0.25 person-years). For the rest of the population in that year with no disease, it was assumed they contributed 1 person-year. All data were analyzed in SAS 8.0 software (SAS Institute, Cary, NC).

RESULTS

There were 244 prevalent cases of peanut allergy among children aged younger than 18 years in Olmsted County, Minnesota, from 1999 to 2007. Seven cases developed tolerance. Thus, the final prevalence estimate in 2007 was 237 cases per 36,312 (the Olmsted County, Minn, population of children in 2007) or 0.65%.

There were 170 incident cases of peanut allergy over this time period (Table I). Most children were between birth and 2 years of age (77.7%) and boys (69.4%). The number of incident cases of peanut allergy increased overall from 1999 to 2007 with 5.9% of new diagnoses in 1999 and 17.7% in 2007.

As seen in Figs 2 and 3, the age- and sex-adjusted rates increased 3-fold from 2.05 cases per 10,000 children in 1999 to 6.88 cases per 10,000 children in 2007 overall with rises and falls throughout the years. A test for trend was conducted to determine whether the annual age- and sex-adjusted rates of peanut allergy diagnoses increased statistically over time. The results indicated that there was a significant increase in peanut allergy diagnoses over time from 1999 to 2007 ($P = .005$).

Figs 2 and 3 present annual rates, age and sex adjusted and age and sex standardized, using the indirect method to the 1999 Olmsted County population. Overall, rates of allergy in girls were lower than the rates in boys each year (Fig 2). Further, the rates were the greatest in the age category of birth to 2 years compared with the older groupings (Fig 3). The figures represent an overall rise in rates from 1999 to 2007 among both sexes and age groups.

The multivariable analyses, as seen in Table II, indicated that girls had a statistically significant 82% lower rate of peanut allergy diagnosis compared with boys after adjustment for age and year of diagnosis (incidence rate ratio = 0.18; 95%CI, 0.07-0.48). Furthermore, the rate ratio for disease, peanut allergy diagnosis, increased over time compared with the reference years, 1999 to 2001. Rates for peanut allergy diagnosis in 2002 to 2004 and 2005 to 2007 compared with 1999 to 2001 were 2.13 (95% CI, 0.61-7.41) and 5.15 (95% CI, 1.63-16.3) times greater, respectively, after adjustment for sex and age of diagnosis, with only the years 2005 to 2007 indicating a significant association with peanut allergy rate. With regard to age, compared with children from birth to 2 years of age, older children aged 3 to 17 years had a 99.9% significantly lower rate of peanut allergy diagnosis after adjustment for year of diagnosis and sex. In multivariable analyses, age, gender, and year of diagnosis remained significantly associated with incident peanut allergy (Table II).

DISCUSSION

The analysis indicates that the 2007 prevalence of peanut allergy in this sample was 0.65%, whereas the incidence increased 3-fold from 2.05 per 10,000 in 1999 to 6.88 per 10,000 in 2007. Boys and younger children (birth to 2 years of age) were significantly more likely to have their condition diagnosed with peanut allergy than were older children (3-17 years) and girls.

Our 0.65% prevalence is within reported ranges yet slightly lower than estimates of clinical allergy and much lower than estimates based on sensitization alone.[7-22] Sensitization is not an accurate estimation of clinical allergy; thus, estimates of sensitization are expected to be much higher than estimates of clinical allergy, such as reported by this study.[6]

Our data suggest that there has been a statistically significant increase in peanut allergy diagnoses over time in this population. The age- and sex-adjusted rates of peanut allergy diagnoses increased 3-fold from 2.05 cases per 10,000 children in 1999 to 6.88 cases per 10,000 children in 2007, which is consistent with other reported studies.[7-22] Further, peanut allergy diagnoses in the year range 2005 to 2007 compared with 1999 to 2001 indicated a significant association with peanut allergy rate, whereas the earlier years 2002 to 2004 did not. The significant increase in diagnoses in more recent years is consistent with other reported studies.[7-22] The cause for this increase is under investigation and was not assessed in this study.

The analysis indicates that girls were significantly less likely to experience a peanut allergy diagnosis than male children, with 69.4% of cases found to be boys. The literature indicates that the prevalence of peanut allergy is greater among boys than among girls with reported estimates in the range of 63% to 69%.[7-22] It is established that rates of atopic diseases differ according to sex.[25] In population-based studies, these

FIG 2. Annual rates per 10,000 children, overall (age and sex adjusted) and sex-specific rates standardized to the 1999 Olmsted County population.

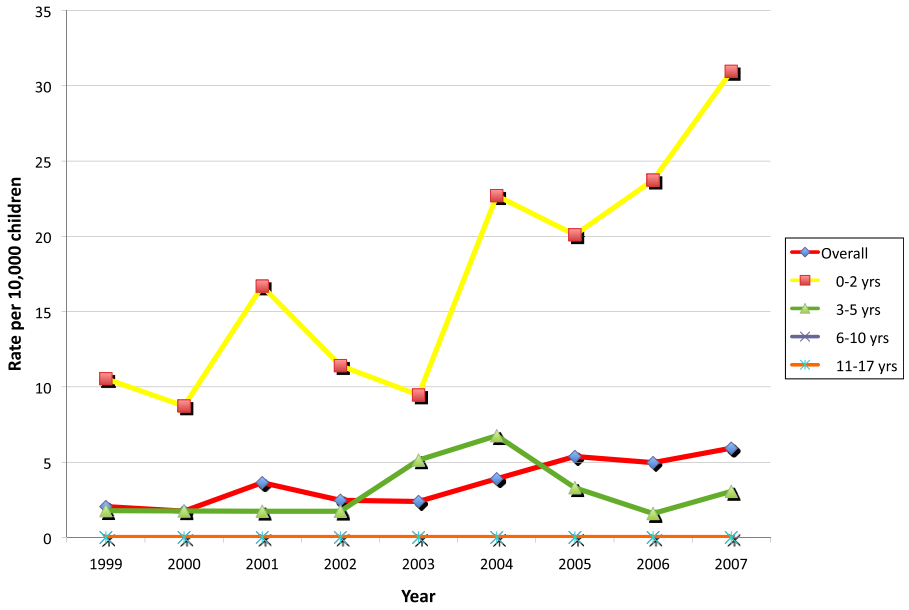

FIG 3. Annual rates per 10,000 children, overall (age and sex adjusted) and age-specific rates standardized to the 1999 Olmsted County population.

differences, assessed as skin test reactivity to one or more of a panel of allergens, have been reported throughout childhood and into early adulthood.[25]

Children aged from birth to 2 years were significantly more likely to have their condition diagnosed with peanut allergy than were older children aged 3 to 17 years. This conclusion is consistent with reported studies and is expected as the introduction of new foods typically begins in this age range, and, if a reaction were to occur, it would be expected to surface at this time.[7-22]

Using the REP to collect retrospective data for this study produced reliable information pertaining to this specific geographic area. Variations in numbers reported by other studies from other geographic areas create hypothesis-generating comparisons. Future prospective studies would also achieve high-quality data and interesting results.

Strengths

The present study has a number of strengths, which allow accurate classification and enumeration of peanut allergic cases in this population. The study takes advantage of the population-based medical data available through the REP resources.[24] This linked medical records system enables access to accurate and

TABLE II. Multivariable adjusted incidence rate ratios and 95% CI of peanut allergy diagnosis by year, sex, and age

Variable	IRR	95% CI
Year		
1999-2001	Reference	
2002-2004	2.13	0.61-7.41
2005-2007	5.15	1.63-16.3*
Sex		
Male	Reference	
Female	0.18	0.07-0.48*
Age		
Birth to 2 y	Reference	
3-17 y	0.001	0.0004-0.004*

IRR, Incidence rate ratio.
*Significant association ($P < .05$).

detailed clinical and laboratory data over many years, which minimizes misclassification bias. Further, because of the nature of the referral system for care in Olmsted County, cases received a final diagnosis of peanut allergy from a physician trained in pediatric allergy. In addition, changes in diagnostic classification during the study period are unlikely to have affected study results because of the nature of the retrieval system led by experts in proper case enumeration. Finally, the REP enumeration of the Olmsted County population closely matches that of the US census, and 98 % of patients receiving care at 1 of the REP facilities consented to inclusion of their medical records into the database.[23] Thus, the patients captured in this medical record review are representative of the Olmsted County population.

Limitations

The results of this study may vary from the true population prevalence and/or incidence because of a few potential reasons. There are several instances in which a case of peanut allergy may not have been counted because of the conservative case definition used in this study. For instance, a child who is labeled with peanut allergy in the medical records yet has no evidence of confirmatory testing was not considered a case. In addition, a child who tested positive for peanut allergy yet had never ingested peanuts was not considered a case. A sensitivity analysis was conducted to enumerate potentially missed cases, which indicated that there were 63 possible cases. Including potential misses in the assessment increased the prevalence estimate to 0.83% (300 cases per 36,312 children).

In addition, the possibility exists that an incident event was improperly classified as a first-time diagnosis, leading to an overestimation of incidence. Every effort was made to review all medical records to be sure that each incident event was in fact the first-time diagnosis. Further, cases only include those persons who seek medical care for their condition and does not include persons who self-diagnosis and avoid peanuts. Therefore, the results reflect physician-diagnosed cases, which may not capture all cases in a population.

Tolerance was defined in this study as confirmation of acquiring oral tolerance through an in-office food challenge, which is in accordance with the guidelines.[6] There were several instances in which a child's allergy testing levels became negative, yet there was no indication in the medical charts of a confirmatory food challenge. Further, many of these cases did not have any additional allergy or medical visits pertaining to peanuts. This subset of children may have acquired tolerance; however, this could not be confirmed through documentation of passing an in-office food challenge and thus could not be included in our tolerance count. Therefore, our tolerance count may be low and subsequently our prevalence could be slightly high.

A recent study estimated the prevalence of general practitioner-recorded diagnosis of peanut allergy in the English population in 2005 (0.51 per 1000 patients).[25] The prevalence estimate was lower than other reports, which the investigators believed was a result of under-recording in general practice.[26] It is not likely that under-recording affected the results of this study. The Mayo Clinic is a unique institution in which the close work environment between general practitioners and specialists in conjunction with the electronic medical records system makes undercoding of diagnoses infrequent.[23,24]

Every effort was made to ensure that the list of diagnostic codes used to identify cases was complete. The list of codes, which was used as the search criteria to identify cases of children with an allergy to peanut, was compiled in consultation with pediatric allergists at the Mayo Clinic who counsel patients and code diagnoses daily. Therefore, it is unlikely that missed diagnostic code(s) affected the prevalence estimate.

The sample size of this study is small, and as such the results must be interpreted cautiously. Further, in comparison with the 2000 US Census data, Olmsted County was shown to be less ethnically diverse, more highly educated, and wealthier than the US population, which may limit extrapolation of results outside this geographic area.[23] In addition, research indicates that latitude may influence the prevalence of food allergies in a population.[27] Olmsted County, Minnesota, is a northern community in which vitamin D levels obtained through sun exposure are potentially lower than those found in children in more southern communities. This factor may contribute to the prevalence estimates reported but was not evaluated. Finally, the rise in incident cases may be due to an increased awareness of peanut allergies by patients and/or physicians, both of which the study did not assess.

Conclusions

Among children residing in Olmsted County, Minnesota, the prevalence of peanut allergy in 2007 was 0.65% and the incidence rate increased 3-fold from 2.05 per 10,000 children in 1999 to 6.88 per 10,000 children in 2007. The results provide important data to clinicians in Olmsted County, Minnesota, in terms of patient counseling and management. For instance, clinicians may explain to patients that 0.65% of children have their condition, which has increased 3-fold over the past decade. Further, an accurate indication of the number of children with allergy to peanut is significant to Olmsted County public health practioners in preparation for awareness, safety, and educational efforts. In conjunction with additional empirical support about the increasing prevalence of peanut allergies among children, enhanced perception of risk further supports efforts about enforcement of labeling laws and bans of peanuts in high-risk settings. Finally, additional confirmation of an increase in rates further supports the need for research into etiology, prevention, and therapeutic techniques.

Clinical implications: Peanut allergies are an increasing concern in Olmsted County, Minnesota, as indicated by a 3-fold increase in diagnoses from 2.05 per 10,000 children in 1999 to 6.88 per 10,000 children in 2007.

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