

The Prevalence of Food Allergy in Young Israeli Adults



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What is already known about this topic? Many reports have described an increase in the prevalence of food allergy over the past several decades. Information regarding the prevalence of food allergy among adults is limited and consists mainly on patients' inaccurate self-report.

What does this article add to our knowledge? The prevalence of food allergy in young adults was studied, using the unique situation of a mandatory pre-army recruitment health check. The demonstrated difference between self-reported and true food allergy necessitates inclusion of objective measures for a proper food allergy evaluation.

How does this study impact current management guidelines? The screening procedure reported here, using a focused interview and evidence of IgE reactivity in those reporting food avoidance due to allergy, provides a framework for the accurate evaluation of adults' food allergy in future epidemiological studies.

BACKGROUND: Information regarding the prevalence of food allergy (FA) among adults is limited due to their inaccessibility for thorough epidemiological evaluations.

OBJECTIVE: To evaluate the prevalence of FA among Israeli young adults.

METHODS: All recruits (n = 12,592, ages 17-18 years) signing up over 6 months at a single recruitment center of the Israeli army were evaluated for FA. The evaluation included a frontal interview by physicians who used a focused screening set of questions, medical documentation collection, tests of IgE reactivity, and oral food challenges. The latter were performed at an allergy care institute in ambiguous cases. A prediction model for the identification of individuals with true allergy among recruits eliminating foods due to suspected FA was developed using multivariable logistic regression.

RESULTS: Foods elimination due to suspected FA was reported by 148 recruits (1.2%). After diagnostic testing, FA was confirmed in 0.67% (84 of 12,592). The prevalence of food elimination versus diagnosed allergy was 0.2%/0.16% milk, 0.2%/0.14% peanuts, 0.13%/0.09% fish, 0.1%/0.09% sesame, 0.04%/0.015% egg, and 0.36%/0.28% tree nuts, respectively. On multivariable logistic regression analysis, male gender (adjusted odds ratio [OR] = 3.2, 95% confidence interval [CI]: 1.4-7.7), report of a common food allergen (OR = 3.6, 95% CI: 1.4-9.3), previous allergist evaluation for FA (OR = 7.8, 95% CI: 3-20.2), and FA reactions within the past 2 years (OR = 2.8, 95% CI: 1.2-6.7) were significantly identified as independent predictors of true FA.

CONCLUSIONS: The prevalence of FA among Israeli young adults is lower than reported for other western countries. Reliance on food elimination alone does not accurately rule in FA. The use of the identified predictors for FA can facilitate large-scale epidemiological studies in adults. © 2019 American Academy of Allergy, Asthma & Immunology (J Allergy Clin Immunol Pract 2019;7:2782-9)

Key words: Adults; Food allergy; Prevalence; Recruits for army service

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Research reported in this publication was supported by the Israel Defense Forces (IDF) Medical Corps and Directorate of Defense Research & Development, Israeli Ministry of Defense (IMOD DDR&D). This study was funded by grant no. 4440716034 of the Academy section, Medical Corps, Israel Defense Army.

Conflicts of interest: The authors declare that they have no relevant conflicts of interest.

Received for publication December 19, 2018; revised manuscript received and accepted for publication May 24, 2019.

Available online June 6, 2019.

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2213-2198

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<https://doi.org/10.1016/j.jaip.2019.05.046>

IgE-mediated food allergy (FA) is a life-threatening condition¹ with far-reaching implications for the patients' and families' quality of life.² Many reports have described an increase in the prevalence of FA over the past several decades.^{3,4} Meta-analyses on the prevalence of FA revealed that studies with self-reporting had a higher prevalence as compared with FA diagnosed by objective measures such as specific IgE (sIgE) presence and oral food challenge (OFC).^{5,6}

In terms of the pediatric population, epidemiologic research through childhood immunization centers,⁷ neonatal departments in hospitals,⁸ and educational institutions⁹ has provided prevalence information based on objective measures.^{7,8,10} Information

Abbreviations used

AHMC- Assaf Harofeh Medical Center

CI- Confidence interval

FA- Food allergy

IDF- Israel Defense Forces

OFC- Oral food challenge

OR- Odds ratio

PPV- Positive predictive value

SPT- Skin prick test

regarding the true prevalence among adults, however, is more difficult to ascertain and needs to be gathered independently due to several factors. First and foremost, given the development of natural tolerance for some specific common allergenic foods, a significant portion of cases are outgrown by adulthood.⁴ Secondly, some food allergies such as to shellfish¹¹ or in the case of fruits secondary to an oral allergy syndrome are characterized by an adult-onset.¹² Finally, much of the adult population is not committed to follow-up at medical or educational institutions, and therefore is less accessible for thorough epidemiological studies. Many of the adult epidemiological studies, therefore, are based mainly on rough estimates of data obtained from self-reporting information,^{4,13} and objective measures such as sIgE and OFC results are lacking.^{4,6,11}

As a part of the mandatory military service in Israel, the overwhelming majority of young adults (17-18 years old) undergo a thorough medical evaluation during their recruitment procedure. This provides a unique opportunity for population studies in a westernized medical setting and was previously used to evaluate the prevalence of asthma in 17-year-old boys in Israel.¹⁴ This study summarizes the results of the medical evaluation for FA for the 12,592 recruits who were evaluated in one regional recruitment office between May and October 2016. At-risk food-allergic patients were evaluated by tests of IgE reactivity and OFC. Furthermore, given the large cohort, the diagnostic utility of independent factors to predict FA was determined, and can be used to provide a framework to streamline future epidemiological studies in FA.

METHODS

Subjects

All recruits (17 years old) from one urban area recruitment center of the Israel Defense Forces (IDF), who started their medical evaluation between May and October 2016, were included. By law, all Jewish non-ultra-orthodox 17-year-olds, with the exception of severely handicapped and some psychiatric patients, are obligated to undergo a medical examination in a regional recruitment center, before their army service. This ensures a high catchment of the study population, estimated to be more than 90% of the non-ultra-orthodox population for this age in this region of the country.¹⁵ The medical inquiry for FA in this group was completed by October 2017. IDF Medical Corps Helsinki committee approval for the publication of the data was obtained.

Food allergy identification

The routine recruitment medical examination procedure is described in the [Methods](#) section in this article's Online Repository at www.jaci-inpractice.org. The diagnosis of FA during the determined period in army recruits was performed in conjunction with

the Institute of Allergy, Immunology and Pediatric Pulmonology, at the Assaf Harofeh Medical Center (AHMC), Zerifin, Israel. Recruitment center physicians received a thorough explanation regarding FA signs, symptoms, and diagnostic methods from an allergist (corresponding author, LN). For cases of uncertainty regarding patients' management, physicians were guided to contact the allergist through e-mail, or in cases of urgency, phone consultation. To accurately identify the overall prevalence of FA and given the high number of recruits to screen ($n = 12,592$), a focused medical inquiry was instituted. Recruits were presented with the question: "Do you avoid any food/s due to FA?" Recruits who responded with a positive or an equivocal/inconclusive answer were subsequently queried: "What is/are the suspected food/s? Were you previously evaluated for FA by an allergist? When was the last FA reaction?" In addition, recruits responding positively were asked to send an updated letter from their allergist regarding their history of reactions, reported signs and symptoms, and results, if any, of evidence of food-specific IgE in blood or by skin prick tests (SPT), over the past year. To note, all Israeli allergy clinics use the same imported diagnostic preparations for SPT (ALK-Abello, Port Washington, NY). Recruits were further asked to send in any historical FA evaluations or documentation of emergency department visits due to allergic reactions. The entire package of information for each identified potential patient was e-mailed to physicians in both the military and the allergist at the AHMC.

Diagnostic evaluation

All the patients who answered positively to avoiding food/s due to an allergy were referred to an allergist. For some patients this was the first referral to an allergist; for others an updated evaluation by their allergist was requested. In addition, patients were invited for further assessment to the AHMC under several scenarios: (1) no history of an allergic reaction to the suspected food/s during the past 2 years; (2) symptoms were not entirely consistent with FA, such as symptoms that either developed greater than 2 hours after the food ingestion or appeared additionally without food exposure, or included only perioral complaints; (3) reports of typical signs and symptoms of FA (detailed in this article's Online Repository at www.jaci-inpractice.org) without evidence for IgE reactivity to the suspected food; and (4) cases in which the medical information was incomplete, such as no assessment for sensitization (SPT or sIgE) to the suspected food was performed.

The clinical evaluation at the AHMC included a review of the reaction history and testing to suspected foods by SPT. SPTs were performed using commercial extracts whenever available (1:10 w/v; ALK-Abello) and extracts from fresh foods in all other cases. In cases of suspected tree nut or sesame allergy, SPT was also performed with locally produced standardized high-protein extracts.^{16,17} SPTs were performed as detailed in this article's Online Repository at www.jaci-inpractice.org.

OFCs to the suspected foods were offered at the AHMC to all the recruits who attended the allergy institute due to scenarios 1, 2, and 3 above, with the exception of 3 patients. These included 2 patients who presented documentation of a severe anaphylactic reaction not responding to the initial adrenaline treatment requiring hospitalization, and a third with severe uncontrolled atopic dermatitis. Two patients could not be rechallenged because they had entered and successfully completed milk oral immunotherapy at the AHMC before their recruitment.^{18,19} Protocols for the OFC can be found in [Tables E1 and E2](#) and in the text in this article's Online Repository at www.jaci-inpractice.org.

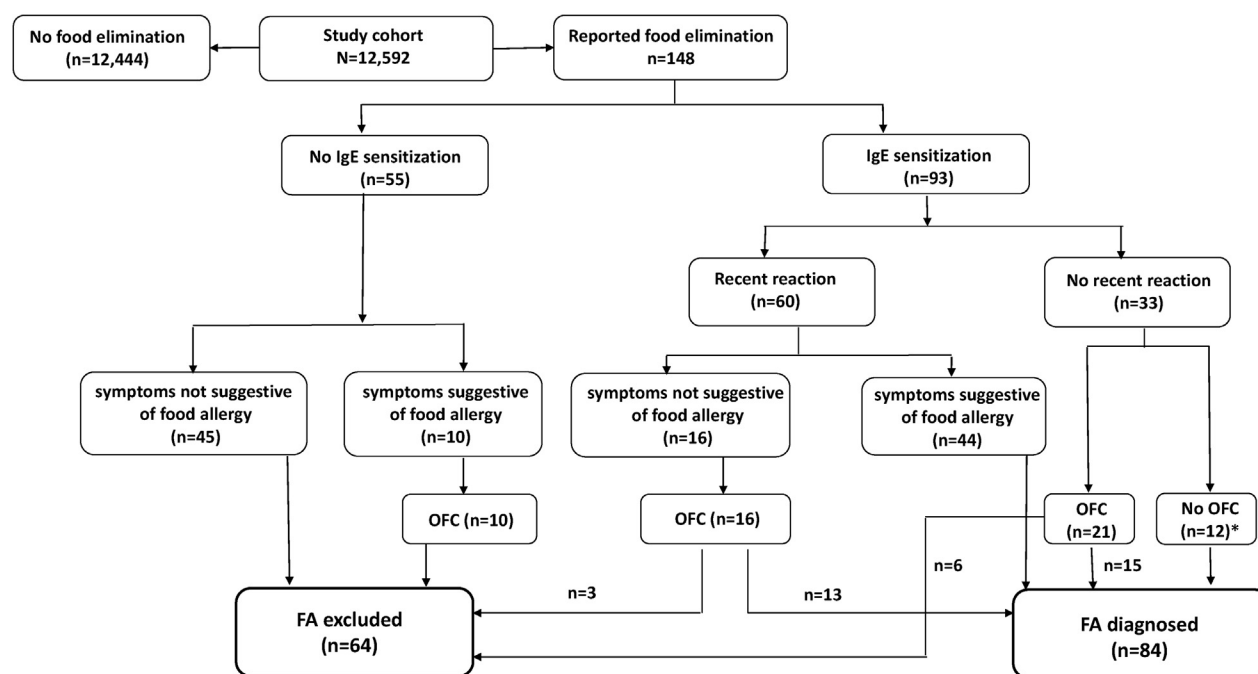


FIGURE 1. Food allergy assessment protocol. Recruits were initially queried whether they eliminated foods from their diet due to food allergy. They were subsequently separated into 2 groups based on evidence of IgE sensitization. Recent reaction = reaction within the past 2 years. *3 contraindicated and 9 refused OFC. FA, Food allergy; OFC, oral food challenge.

Patients with both a negative SPT and a description of an atypical allergic reaction, or a negative OFC were advised to consume the suspected “allergenic food” regularly. Patients whose background and SPT results ($\geq 95\%$ positive predictive value [PPV]) revealed a high risk for clinical FA^{16,17,20} and were not interested in OFC were diagnosed with allergy to the suspected/questionable food according to their existing data. Patients whose SPT results revealed low ($< 95\%$ PPV) risk for clinical FA to the examined food/s were strongly encouraged to undergo OFC, in order to allow them to consume the suspected food/s.

Data transfer and follow-up

The results of the clinical evaluation and the determined allergic status of the referred recruits were conveyed to army recruitment center doctors. All recruits are obligated to inform the recruitment center about any changes to or additional information regarding their health status occurring during the time period between their medical examination and recruitment day. In addition, during the first week of army service, all new soldiers are asked at least 2 more times before entrance to the dining area about possible FA. Any new information is transferred to the military allergy clinic and incorporated into the database.

Statistical analysis

Variables are presented with number (n) and percent. Recruits who reported FA were divided into 2 groups based on their final disposition: recruits with FA and recruits without FA. Associations between allergy status (true/false) and the study variables were examined using univariate logistic regression and presented as crude odds ratios (ORs) with 95% confidence intervals (95% CI) for the probability of having FA. Significant variables on univariate analysis were inputted into a stepwise multivariable logistic regression model

and presented as adjusted ORs with 95% CI and the C-statistics of the final model. For each type of reported FA, the PPV was determined. The data management and statistical analyses were performed using SAS 9.4 software (SAS Institute Inc., Cary, NC). All tests were 2-tailed and $P < .05$ was considered statistically significant.

RESULTS

Reported and diagnosed food allergy in cohort

Overall, 12,592 recruits (46.5% males) were evaluated during their recruitment procedure. Food avoidance due to an allergy was reported by 148 recruits (Figure 1), 45.9% of whom were males. Among these 148 recruits, 22.3% (33) carried a physician diagnosis of asthma after the age of 6 years. The prevalence of reported and diagnosed FA for the major allergenic foods is presented in Table I. The most frequently reported and diagnosed foods in this study were tree nuts, milk, peanuts, fish, and sesame. Other major allergenic foods such as egg, shellfish, soy, and wheat (Table I), as well as less common allergenic foods including fruits, honey, cinnamon, buckwheat, eggplant, and legumes, among others, were reported by either a single or a few patients (Table E3, available in this article's Online Repository at www.jaci-inpractice.org). Allergy to more than 1 food was reported by 30 (20.3% of those reporting FA) recruits, and the diagnosis was confirmed for at least 2 foods in 18 (12.2%) of them (Table E4, available in this article's Online Repository at www.jaci-inpractice.org). Of the 84 recruits eventually diagnosed with FA, surprisingly, 25 (29.8%) were only first evaluated by an allergist as a result of this survey. Two of these patients had allergy to more than 1 food, and none of them had reported receiving adrenalin before. The foods to which they were allergic

TABLE I. Reported and diagnosed allergies in total cohort to major allergenic foods

Food	Diagnosed allergies, n (%)	Reported allergies, n (%)	PPV of reported (95% CI)	Reported allergies and positive IgE sensitization, n (%)	PPV of reported + SPT (95% CI)
Tree nuts	36 (0.28)	46 (0.36)	78.26% (64.4%-87.7%)	39 (0.3)	92.3% (79.7%-97.3%)
Milk	20 (0.16)	25 (0.2)	80% (60.4%-91.6%)	22 (0.17)	90.9% (72.2%-97.5%)
Peanuts	18 (0.14)	26 (0.2)	69.23% (50%-83.5%)	20 (0.16)	90% (70%-97.2%)
Fin fish	11 (0.09)	16 (0.13)	68.75% (44.2%-86.1%)	11 (0.09)	100% (74.1%-100%)
Sesame*	11 (0.09)	13 (0.1)	84.62% (56.5%-96.9%)	11 (0.09)	100% (74.1%-100%)
Egg	2 (0.015)	5 (0.04)	40% (11.6%-77.1%)	2 (0.015)	100% (34.2%-100%)
Shellfish	2 (0.015)	2 (0.015)	100% (34.2%-100%)	2 (0.015)	100% (34.2%-100%)
Soy	0	5 (0.04)	— [‡]	0	— [‡]
Wheat	0	2 (0.015)	— [‡]	0	— [‡]
Any food	84 (0.67) [‡]	148 (1.17) [‡]	56.76% (48.7%-64.5%)	97 (0.74)	90.3% (82.6%-94.8)

PPV, Positive predictive value; SPT, skin prick test.

*Being considered as major allergenic food by the FDA.²¹

[‡]Not calculated as none were diagnosed allergic.

[‡]The number (%) of patients who were diagnosed or reported an allergy to any food (major allergenic or uncommon food).

to are detailed in Table E5 (available in this article's Online Repository at www.jaci-inpractice.org).

No additional reports of FA surfaced among the 12,444 recruits (Figure 1) after 30 to 36 months from their first medical evaluation. At this point, almost all recruits had already entered army service and had been queried several more times by various functionaries whether they had food allergies before entering the lunchroom. Thus, it is unlikely that additional allergic patients are represented among those recruits who answered they do not avoid foods due to FA.

Sequential food allergy investigation

Among the 148 patients reporting food avoidance due to an allergy, 55 (37.2%) had no evidence of IgE sensitization to the suspected foods (Figure 1). On further query, 45 of them described symptoms that were not suggestive of an allergic reaction and therefore FA was excluded. In contrast, 10 of them described typical reactions consistent with IgE-mediated disease (for description see the text in this article's Online Repository at www.jaci-inpractice.org) and therefore OFCs were performed. All 10 patients passed the OFC.

Evidence of IgE sensitization was detected in 93 of 148 (62.8%) of recruits primarily by SPT (n = 85) or by sIgE (n = 8). Among these patients with evidence of food-specific IgE, 60 reported a recent food-mediated allergic reaction within the past 2 years (Figure 1). In 44 of 60 of these recruits, the reported recent FA reactions included typical symptoms of an allergic reaction and FA was diagnosed. In 16 of 60 recruits, the recent reactions were atypical and inconclusive. After undergoing an OFC, FA was excluded in 3 of these patients and confirmed in the other 13.

In another 33 patients with evidence of IgE sensitization to the suspected food, their last reported allergic reaction to food

was over 2 years ago. Twenty-one of these recruits were challenged and FA was excluded in six of them. Three of the latter patients provided medical documentation of an allergic reaction, including objective signs, and thus likely outgrew their milk/egg allergy since their last reaction. For another 12 patients, OFC was not performed. Nine of these patients refused an OFC, and diagnosis was made based on SPT results that were >95% of the PPV and a convincing history of an allergic reaction. In another 3 patients, it was judged to be contraindicated to perform an OFC, in 2 of them due to their documented severe anaphylactic reactions with multiple adrenalin injections and in the third due to his severe uncontrolled atopic dermatitis.

The role of IgE testing and OFC

The PPVs for the frequently reported (>10) major allergenic foods ranged from 40% to 84.62% (Table I). Using our diagnostic algorithm, the PPV for self-reporting of any FA was 56.76%, and increased to 90.3%, with additional IgE testing (Table I). In a *post hoc* analysis of the entire cohort, only 9 patients who were IgE-sensitized were found to be nonallergic by OFC (Figure 1). The difference in the prevalence of FA in the total cohort was 93 of 12,592 (0.73%) when evaluated dually by patients' report and IgE sensitization tests versus 84 of 12,592 (0.67%) using additionally an OFC for diagnosis. OFC was negative in all recruits without evidence of IgE sensitization.

Predictors for food allergy

The results of this study were further analyzed to identify predictors for FA. Because IgE testing may not be available in all epidemiological research settings, other potential factors associated with current clinical allergy among the recruits who avoided foods were examined and are presented in Table II. Male gender, physician-diagnosed asthma, documented emergency room,

TABLE II. Factors associated with true food allergy, univariate analysis (N = 148)

Parameter	True allergy*			Odds ratio	95% CI	
	No n = 64	Yes n = 84	P value		Lower limit	Upper limit
Sex, male	18 (28.1%)	50 (59.5%)	.0002	3.8	1.9	7.6
Asthma	7 (10.9%)	26 (30.9%)	.0053	3.7	1.5	9.1
Prior allergist visit for FA	9 (14%)	59 (70.2%)	<.0001	14.4	6.2	33.6
Documented reaction in ER	2 (3.1%)	13 (15.5%)	.0273	5.6	1.2	25.7
No recent reaction†	38 (59.4%)	28 (33.3%)	.0018	0.34	1.5	5.7
Reported milk allergy	4 (6.3%)	21 (25%)	.0051	5.0	1.6	15.4
Reported peanuts allergy	8 (12.5%)	18 (21.4%)	.1618	1.9	0.8	4.7
Reported fin fish allergy	5 (7.8%)	11 (13.1%)	.3102	1.8	0.6	5.4
Reported sesame allergy	2 (3.1%)	11 (13.1%)	.0504	4.7	1.0	21.9
Reported eggs allergy	3 (4.7%)	2 (2.4%)	.45	0.5	0.1	3.1
Reported nuts allergy	10 (15.6%)	36 (42.9%)	.0006	4.1	1.8	9.0
Reported an uncommon FA	42 (65.6%)	22 (26.2%)	<.0001	0.2	0.1	0.4
Reported only an uncommon FA	39 (60.9%)	14 (16.7%)	<.0001	0.1	0.1	0.3
Reported allergy to more than 1 food	8 (12.5%)	22 (26.2%)	.0442	2.5	1.0	6.0
Reported allergy to more than 1 major allergenic food	5 (7.8%)	19 (22.6%)	.0204	3.4	1.2	9.8
Previous sIgE testing	9 (14%)	84 (100%)	<.0001			

95% CI, 95% Confidence interval; ER, emergency room; FA, food allergy; sIgE, specific IgE.

Bold indicates statistical significance ($P < .05$).

*148 recruits reported elimination of foods due to allergy. In 64 of them allergy was excluded, whereas the remaining 84 were diagnosed with true food allergy.

†Recent reaction = last reaction to the suspected food within last 2 years.

TABLE III. Multivariable analysis—stepwise logistic regression

Parameter	Coefficient	Adjusted odds ratio	95% CI		P value
			Lower limit	Upper limit	
Intercept	−2.4527				
Male	1.1706	3.224	1.348	7.709	.0085
Previous allergist visit for FA	2.0566	7.819	3.020	20.242	<.0001
Previous reaction to the suspected food in the last 2 y	1.0341	2.812	1.180	6.703	.0196
At least 1 allergy to milk, nuts, or sesame reported	1.2827	3.606	1.395	9.321	.0081

95% CI, 95% Confidence interval; FA, food allergy.

C-statistic = 87.1%; model significance <.0001.

visits for the treatment of an allergic reaction, and reports of milk, nuts, and sesame allergy were associated with a significant risk for true FA existence. A report of allergy to more than 1 major allergenic food was also a predictor for a positive diagnosis of FA. A previous allergist evaluation for FA was significantly associated and had the highest OR for a positive allergic status ($P < .001$; OR and 95% CI, 14.4 and 6.2–33.6, respectively). In contrast to the above, the absence of a reaction to the suspected food during the last 2 years and a reported FA to either single or multiple uncommon allergenic foods were significantly associated with exclusion of the suspected FA.

The significant variables identified on univariate analysis were inputted into a stepwise logistic multivariable regression analysis. Gender, a past allergist visit for evaluation of FA, a recent reaction, and an FA to milk, nuts, or sesame remained independent significant risk factors for a clinical outcome of true allergy (Table III). The predicted probabilities for a true clinical allergy, using varied combinations of the risk factors identified by the logistic multivariable regression model, are presented in Table IV. In this study population, it is evident that some combinations of these variables enable a correct diagnosis of

some patients based on their first interview, without the need of further allergist evaluation (Table IV). For example, in the case of milk, nuts, or sesame allergy, a male, previously evaluated by an allergist, with a history of a reaction during the past 2 years, has a 96% probability for true allergy to the reported food. On the other extreme, a female reporting allergy to foods other than milk, nuts, or sesame, who had never been seen by an allergist and was without a reaction over the past 2 years, had only an 8% chance for a true allergy.

DISCUSSION

This study provides data on the prevalence of FA in young adulthood. All recruits from one urban region in Israel were screened as to whether they eliminated foods due to allergy and their allergy was validated. It also provides information about what clinical characteristics predict true clinical allergy using this approach. The screening procedure reported here provides a framework for evaluation of FA in large epidemiological studies.

The overall prevalence of reported FA in this study population was 1.17%, lower than the 3% to 20% prevalence reported in

TABLE IV. Predictive probability for true food allergy

Gender	Previous allergist visit for FA	Recent reaction	FA reported to predictive foods*	Probability for "true" allergy†
Male	Yes	Yes	Yes	96%
Male	Yes	No	Yes	89%
Female	Yes	Yes	Yes	87%
Male	Yes	Yes	No	86%
Male	No	Yes	Yes	74%
Female	Yes	No	Yes	71%
Male	Yes	No	No	68%
Female	Yes	Yes	No	65%
Male	No	No	Yes	50%
Female	No	Yes	Yes	47%
Male	No	Yes	No	44%
Female	Yes	No	No	40%
Female	No	No	Yes	24%
Male	No	No	No	22%
Female	No	Yes	No	19%
Female	No	No	No	8%

FA, Food allergy.

*Milk, nuts, or sesame.

†Among recruits reporting food elimination due to allergy.

prior studies in adults.^{5,22-24} This difference may be attributed to several methodological factors. First, although other studies compiled their information by telephone interview,^{23,24} internet report,^{24,25} electronic database review,²⁶ or by a questionnaire with comparison with dietary recall information,²⁷ our methods included a frontal focused interview by qualified doctors. The latter method has been shown to be more accurate for assessments based on self-reporting.¹³ Second, the content of the opening question, demanding intentional avoidance of the suspected foods, excludes those who mistakenly believe that they have an allergy despite their consumption of those same foods, as was seen in the NHANES study.²⁷ Third, the evaluation of patients with unconvincing or equivocal histories of FA included OFCs. An additional consideration for the differences in prevalence may be related to some unique characteristics of the studied population, including social and geographical considerations,²⁸ and differences in exposure to some food allergens in Israel compared with other study locales previously reported. For example, shellfish allergy, which constitutes a significant part of FA among adults^{11,29} and was recently reported as the most prevalent food allergen group in the United States,²⁶ is low in Israel due to limited shellfish exposure as a result of Jewish-related dietary restrictions. Another well-known finding, the low Israeli prevalence of peanut allergy compared with other western countries,³⁰ is attributed to the early introduction of peanut protein in a local popular peanut snack "Bamba" to the infant's diet. Finally, a geographical consideration is the endemic low birch exposure that may influence the development of the oral allergy syndrome.¹²

The finding of a higher rate of self-reported allergy as compared with the rate of true allergy is not surprising and supports previous statements regarding the necessity of sIgE testing and OFCs for a proper evaluation of FA.³⁻⁶ The finding, however, that in approximately 30% of patients with true FA there was no allergist evaluation suggests a significant risk for underestimation of the true prevalence of FA, when the source of the research data relies solely on medical records databases.²⁶

This finding cannot be attributed to the difficulty in obtaining an appointment to an allergist, as this service is well available in the study area (within 3 weeks, unpublished observations). This finding, however, is consistent with previous reports of low FA awareness among a similar age group of American college students.³¹

The prevalence of milk allergy described in this study supports the contention that there is very little spontaneous recovery from milk allergy after the age of middle childhood. Similar to a US multicenter study,³² persistent milk allergy in Israel was demonstrated to be 0.17% after the age of 5 years.³³ In the young adult population of the current study, 0.16% had persistent milk allergy. In contrast, a gradual growth of the spontaneous resolution rate over time to egg allergy of up to 91% at age 16 was found in a retrospective single-center chart review study in the United States.³⁴ Similarly, in this study, only 0.04% reported and 0.015% confirmed egg FA, far less than a previous report from Israel of 0.5% at ages 4 to 12 years,³⁰ supporting the notion of spontaneous recovery of egg allergy beyond childhood. Regarding peanut allergy, a previous Israeli study in patients aged 12 to 18 years reported a prevalence of 0.19%,³⁰ similar to the 0.2% found in this study (Table I). This is despite the fact that over 10 years had passed since the first study, suggesting that the prevalence of peanut allergy did not increase over time in Israel. Interestingly, although in Israel the prevalence of reported tree nuts allergy³⁰ is low compared with almost all other western countries,^{6,9,22-25,27} the 0.36% reported and the 0.28% confirmed tree nuts allergy was the most prevalent FA in this study population.

The current research setting of obligatory medical evaluations as part of the recruitment procedure enabled 100% catchment of those in which an FA was suspected. All recruits updated their results of sIgE testing, transferred their medical FA information, and except for 2 allergic patients with multiple FA, came for evaluation of the allergist at the AHMC when requested. This situation is unique to an enforced setting where the young adults' cooperation was obligatory. Although a similar setting may be

unavailable in many western countries, the results presented here can assist in the planning and analysis of future epidemiological studies. A first step can rely primarily on a patient's interview to determine if the patient is avoiding foods due to allergies. Coupling this information with the patients' provided clinical reaction history provides a good selection for those patients who require further evaluation, including updated IgE-mediated reactivity (SPT and sIgE) and OFC. Using the results of standardized skin tests with good sensitivity and specificity, FA diagnosis could be established in almost all patients with true FA. Among our study population, recruits without evidence of IgE reactivity were not allergic and the OFC ruled out FA in less than 10% of IgE-positive patients, raising the question for the need of OFC in this age group in future epidemiological research on this topic.

This study has several limitations. First, it is from one geographical area without representation of the Arab, Bedouin, and Druze Israeli population. Second, it was presumed that those who did not eliminate foods due to FA were nonallergic. It is likely, however, that this indeed is the case, because once these recruits entered into service, no restrictions are placed on the kitchen preparing the food regarding potential allergens. Third, once recruits were diagnosed with a true allergy that impacted their daily behavior and army service, they had little incentive to perform OFC on other suspected foods, to rule in or out multiple FA. In addition, there is a risk that recruits would hide information to prevent limitations in getting some military positions. However, the timing of this research was such that the army passed bylaws to implement a decrease in medical profile and position limitations for patients with FA, during the recruitment phase. Thus, recruits only became aware of the new regulations after declaring their suspected FA. In future military FA surveys in Israel, however, this drawback should be seriously considered. Finally, the PPV results for particular foods with a low prevalence had a wide CI, influencing the interpretation of this statistic.

In summary, using the unique setting of a recruitment center, we report on the prevalence of FA among Israeli young adults for all foods. Because of difficulties inherent in conducting large adult population studies in this field, information for comparison is lacking. This study provides information for improved assessment of future adult population studies using a focused interview and evidence of IgE reactivity in those avoiding foods due to an FA.

Acknowledgments

Y. Katz is supported by the Leon Alcalay Chair in Pediatric Immunology, Tel Aviv University. M. R. Goldberg is funded by a Kamea grant from the Ministry of Health, Israel. We would like to thank Mali Dook for coordinating the recruits' clinical visits at the Institute of Allergy, Immunology and Pediatric Pulmonology, of the Assaf Harofeh Medical Center. We would also like to acknowledge Professor Jacob Moran-Gilad and Professor Gideon Lack for helpful discussions.

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ONLINE REPOSITORY

METHODS

Routine recruitment center medical examination

Recruits are interviewed by physicians regarding possible medical problems according to a standardized questionnaire. The recruits are required to sign a declaration stating they reported truthfully without suppression of any medical information. Then after a general physical examination, cases in which the army physician requires further information, recruits are instructed to provide supplementary medical information from their personal health insurance company doctor within a fixed time period. After receipt of the supplementary information, all the data are integrated to produce a medical profile of fitness to be used for task assessments by the Israel Defense Forces.

Description of a typical reaction due to food allergy

Description of an allergic reaction that was considered typical of an IgE-mediated food allergy (FA) appeared within 2 hours from the ingestion of the allergenic food. Symptoms can include a feeling of dyspnea, abdominal pain accompanied by nausea, pruritus, burning eyes, and nasal congestion. For the purpose of this study, symptoms must be accompanied by objective signs such as rash or angioedema of the skin, conjunctival congestion, cough, rhinitis, sneezing, hoarseness, vomiting, loss of consciousness, and documentation of a medical examination with abnormal blood oxygen saturation or a significant decline in lung function tests in comparison with baseline measurements and/or hypotension adjusted for age.

Skin prick test performance

Skin prick tests (SPTs) were performed on the volar surface of the forearm with single peak lancets (Heinz Herenz, Hamburg, Germany), with wheal and flare sizes measured after 20 minutes. Histamine 1 mg/mL (ALK-Abello) and saline were used as the positive and negative controls, respectively.

Oral food challenge

During an oral food challenge (OFC), patients gradually consumed increased amounts of the examined food under medical supervision, according to the protocols described

(Tables E1 and E2). To increase the specificity of the graded OFC results, a challenge was determined to be positive only after the appearance of at least 1 objective sign of an allergic reaction. These included either visible skin or mucosal changes such as rhinitis and conjunctival congestion, dyspnea accompanied by wheezing, gastrointestinal symptoms of vomiting, or abnormal blood oxygen saturation or a significant decline in lung function tests in comparison with baseline measurements. Given the subjectivity of abdominal pain, it was not used to define an allergic reaction as a sole criterion. A decline in blood pressure value was considered diagnostic while accompanying one of the other listed signs and symptoms. In addition, oral and perioral signs and symptoms were viewed as potential local contact reactions and were not used as criteria for a positive challenge result. OFC results were graded as directed by The World Allergy Organization Subcutaneous Immunotherapy Systemic Reaction Grading System.^{E1} Overall, patients experienced only grade I and grade II reactions.

Evaluation for multiple foods allergy

Allergy to more than 1 food was reported by 30 recruits and confirmed for at least 2 foods in 18 of them (Table E4). Patients with suspected FA to more than 1 food were first offered an OFC to the most likely well-tolerated food, according to existing information of previous reactions, SPT size, and the natural history of the specific allergenic food. For 6 patients, with confirmed FA to 1 food, the evaluation for the additional reported foods included OFC. Another similar 6 patients were not interested in OFC; their allergy to the other foods was defined according to their history and SPT results. Five of these patients had large-diameter SPT results for foods with low chances for spontaneous FA recovery; however, the sixth, with SPT results of positive predictive value less than 95%, refused OFC despite the explanations, and egg allergy was confirmed for reasons of caution. Two more patients were unable to invite for FA evaluation in Assaf Harofeh Medical Center due to their long stay abroad. These patients returned to Israel at age 18, already obligated for recruitment, and because their status as having FA was already confirmed (to peanuts and to sesame and tree nuts), recruitment postponement for potential nuts and peanuts allergy exclusion was impossible.

TABLE E1. Oral food challenge protocols

Dose	Milk			Peanuts			Egg			Sesame		
	Interval (min)	Milk protein (mg)*	Milk (mL)	Interval (min)	Peanuts protein (mg)	Peanuts	Interval (min)	Egg protein (mg)	Omelet†	Interval (min)	Sesame protein (mg)	Tahini (g)
1	0	0.3	—	0	0.1	—	0	0.1	—	0	0.3	—
2	15	3	—	15	1.25	—	10	1	—	15	3	—
3	15	15	0.5	15	5	—	10	5	—	15	15	—
4	15	30	1	15	15	—	10	10	—	15	30	—
5	15	60	2	15	50	—	20	50	—	30	60	—
6	15	120	4	30	100	—	20	100	—	30	240	1
7	15	240	8	30	250	—	20	400	—	30	480	2
8	15	480	16	30	300	1	30	1500	1/4	45	1000	4.2
9	15	900	30	30	900	3	30	3000	1/2	60	4000	16.8
10	30	1800	60	60	3000	10	30	6000	1			
11	30	2700	90									
12	30	3600	120									
Observation	90			90			90			90		
Total (min)	300			360			270			330		

Bold values are the target doses of the oral food challenge protocols.

*Doses 0.3 and 3 mg were prepared from milk powder.

†Each omelet is made from 1 scrambled egg.

TABLE E2. Oral food challenge protocols for individual tree nuts

Dose	Walnut			Pecan		Hazelnut		Cashew		Pistachio		Almond	
	Interval (min)	Walnut protein (mg)	Walnut (g)	Pecan protein (mg)	Pecan (g)	Hazelnut protein (mg)	Hazelnuts (g)	Cashew protein (mg)	Cashew (g)	Pistachio protein (mg)	Pistachio (g)	Almond protein (mg)	Almonds (g)
1	0	0.1		0.1		0.1		0.1		0.1		0.1	
2	15	5		5		5		5		5		5	
3	15	20		20		20		20		20		20	
4	20	50		50		50		50		50		50	
5	20	100		100		100		100		100		100	
6	20	210	1.4	125	1.4	120	0.8	145	0.8	140	0.7	190	0.9
7	20	420	2.8	375	4.2	480	3.2	290	1.6	420	2.1	380	1.8
8	30	1260	8.4	1250	14	1920	12.8	1160	6.4	1400	7	1140	5.4
9	60	4200	28	2500	28	3840	25.8	4060	22.5	2800	14	3800	18
Observation	90												
Total (min)	290												

Bold values are the target doses of the oral food challenge protocols.

TABLE E3. Uncommon food allergies reported and diagnosed among study cohort

	Food	Reported allergies	Diagnosed allergies
Fruits and vegetables	Kiwi	8	3
	Peach	8	3
	Mango	7	2
	Banana	1	1
	Apple	2	1
	Figs	2	1
	Strawberry	5	1
	Plum	1	1
	Orange	4	0
	Pineapple	4	0
	Apricot	1	0
	Melon, watermelon	2	0
	Coconut	3	0
	Pomegranate	1	0
	Eggplant	3	0
	Tomato	2	0
Legumes	Pea, lentils, chick pea, broad bean	5	3
Seeds	Pumpkin seeds	1	1
	Poppy seed	2	0
	Pine	1	0
Others	Buckwheat	1	1
	Honey	1	1
	Chicken	1	1
	Cinnamon	4	0

TABLE E4. Number of patients reporting versus diagnosed with multiple food allergies

	Reporting allergy	Diagnosed with allergy
2 Foods	17	7
3 Foods	9	9
4 Foods	4	2

TABLE E5. Diagnosed allergies among patients not previously evaluated by an allergist

Food	Diagnosed allergies
Milk	2
Peanuts	3
Fish	5
Sesame	1
Egg	1
Tree nuts	6
Shellfish	1
Uncommon allergenic foods	9

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