
Prevalence of food allergies in young adults and their relationship to asthma, nasal allergies, and eczema

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Background: The true prevalence of food allergy in adults is generally thought to be uncommon. It is unknown whether there are any relationships between food allergy and atopic diseases.

Objective: To determine the prevalence of probable immunoglobulin (Ig)E-mediated food allergy to peanut, shrimp, cow's milk, wheat, and egg as defined by a positive skin prick test result and relevant clinical history to the same food, and to explore the relationship with atopic diseases.

Methods: Cross-sectional epidemiologic study. One thousand one hundred forty-one randomly selected young adults (aged 20 to 45 years) underwent skin prick testing to five common food allergens (cow's milk, peanut, egg white, shrimp, and wheat), completed a detailed questionnaire, including validated items on respiratory symptoms, history of asthma and other allergic conditions, as well as undergoing lung function testing.

Results: Just over one percent (1.3%, $n = 15$) had probable IgE-mediated food allergy. The prevalence of probable IgE food allergy was: $<0.27\%$ for wheat, 0.09% (95% confidence interval = 0.0 to 0.49%) each for cow's milk and egg, 0.53% (0.21 to 1.09%) for shrimp, and 0.61% (0.25 to 1.26%) for peanut. Those with probable IgE peanut and shrimp allergy were significantly more likely to have current asthma and doctor-diagnosed asthma. Wheeze and history of eczema were also associated with peanut allergy, whereas nasal allergies were associated with shrimp allergy.

Conclusions: The prevalence of probable IgE-mediated food reactions is rare in young adults. Some positive associations between probable IgE-mediated food allergy and allergic diseases were found, but larger study numbers are required to confirm these results.

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INTRODUCTION

Perceived adverse food reactions are common in many developed countries. Community-based studies have previously found the prevalence of reported

food allergy and intolerance to be between 12 and 25%.^{1–5} However, although the true prevalence of food allergy in adults is unknown, it is generally thought to be uncommon, and estimates from double-blind, placebo-controlled trials suggest a community prevalence ranging from 1 to 2%.^{6,7}

Three community-based studies have gathered data on both perceived adverse food reactions and objective measures of true, adverse food reactions.^{1,4,8} However, only one of these studies was able to demonstrate the proportion of those with both perceived adverse food reactions and immunoglobulin (Ig)E-mediated food allergy.⁸ This study found that there was little agreement between self-

reported illness to food(s) known to contain the food allergen of interest, and positive skin tests to the same allergen, thus suggesting that most reactions were not attributable to IgE-mediated food allergy.

To expand upon our previous findings, the aims of the present study were: 1) to determine the prevalence of probable IgE-mediated food allergy, and 2) to explore the relationship between probable IgE-mediated food allergy and other atopic disorders such as asthma, eczema, and nasal allergies. For this study, probable IgE-mediated food allergy was defined as a positive wheal to skin prick testing (SPT) with the relevant food extract and a history of a symptomatic reaction to the same food.

METHODS

Subjects

Computer-generated random samples of 4,455 eligible young adults aged between 20 and 44 years old were selected using the electoral roll as the sampling frame in 1998. The study region was the inner southeastern suburbs (federal electorates of Higgins, Hotham, and Goldstein) of metropolitan Melbourne, the capital city of Victoria, Australia. A cross-sectional postal survey was conducted using the European Community Respiratory Health Survey screening questionnaire,⁹ which was based on the validated International Union of Tuberculosis and Lung Disease bronchial symptoms questionnaire.¹⁰ A response rate of 72% ($n = 3194$) was achieved.

These subjects were then invited to attend our laboratory for further investigation. Participants completed an inter-

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viewer-administered detailed respiratory questionnaire, which included validated items on respiratory symptoms, history of asthma and other allergic conditions, demographics, smoking, family history, occupation, early respiratory infection, home environment, medications, and management of breathing problems.¹¹

The Standing Committee on Ethics in Research on Humans at Monash University and The Alfred Hospital Ethics Committee approved this project. Written informed consent was obtained from all participants.

Adverse Food Reaction Questions

Participants were asked whether they had ever suffered from any "illness/trouble" from food ingestion and whether this response occurred "nearly always" after eating the same food. The offending food(s) and associated symptoms were then listed to distinguish between symptoms of indigestion/food poisoning and food allergy or intolerance. Only those who responded "yes" to both questions were considered to have perceived an adverse food reaction.

Lung Function Testing

Lung function was measured with a rolling seal spirometer (Sensormedics, CA). Initial forced expiratory volume in 1 second (FEV₁) was recorded as the best of five blows which met the American Thoracic Society criteria. Methacholine (MCh; Provocoline, Methapharm Inc, Brantford, Ontario, Canada) was delivered by a Mefar 3B dosimeter (Mefar srl, Bovezzi, Italy) until FEV₁ fell by 20% from the initial value or up to a cumulative dose of 2 mg (10 μ mol) was administered. Details of bronchial hyperreactivity (BHR) measurements in our laboratory have been published elsewhere.¹² Subjects who were pregnant, breastfeeding, taking specific medications, whose initial FEV₁ was <70% predicted, and those who did not consent to the test were not challenged with MCh.

SPT

SPT for seven aeroallergens and five food allergens was performed on the flexor surface of the forearm with standardized allergen extracts (Bayer

Corporation, Sydney, Australia). The allergen panel consisted of *Dermatophagoides pteronyssinus*, cat, ragweed, rye grass, *Cladosporium*, *Alternaria*, *Aspergillus*, cow's milk, peanut mix, shrimp, egg white, wheat, positive (histamine), and negative controls. Wheals were measured after 15 minutes. A positive SPT result was defined as a wheal ≥ 3 mm in diameter. Because of ethical concerns, 11 subjects who reported previous anaphylactic-type responses to any of the food allergens did not have SPT to that allergen performed (5 to each of peanut and shrimp and 1 to egg). These subjects have been considered SPT-positive in this analysis.

Definitions

For this analysis, *atopy* was defined as a positive skin reaction (≥ 3 -mm wheal diameter) to any allergen, in the context of a positive histamine control, and a negative reaction to the negative control, on SPT.^{13,14} BHR was defined as a provocative dose of inhaled MCh causing a 20% fall in FEV₁ ≤ 2 mg MCh.

Several definitions for asthma have been used throughout this paper. *Current asthma* was defined as the combination of wheezing in the past 12 months and BHR.¹⁵ *Asthma* was defined as a positive response to any of the following questions: "Have you had an attack of asthma in the last 12 months?," "Have you been woken by an attack of shortness of breath at any time in the last 12 months?," and "Are you currently taking any medicine for asthma (including inhalers, aerosols, or tablets)?"¹¹ *Doctor-diagnosed asthma* was defined as a positive response to the question "Have you ever had asthma?" and then a positive response to "Was this confirmed by a doctor?" *Wheeze* only was defined as a positive response to the question "Have you had wheezing or whistling in your chest at any time in the last 12 months?"

Statistical Analysis

Data from the questionnaires, lung function tests, and skin prick tests were entered and verified directly into a customized Access database (Access 97, Microsoft Corporation, Bellingham,

WA). Frequency counts, descriptive statistics, and cross-tabulations were performed using the SPSS statistical package.¹⁶ Prevalence rates were given with exact 95% confidence intervals calculated using the EpiInfo statistical package.¹⁷ Associations between categorical variables were analyzed using χ^2 tests; however, where numbers were small, Fisher's exact tests were used instead. A *P* value <0.05 was considered statistically significant for all tests.

RESULTS

Subject Characteristics

A total of 1,601 adults completed the respiratory questionnaire, whereas 1,141 completed the skin prick tests and lung function, and 1,075 completed the MCh challenge for BHR. The mean ($\pm$ SD) age of the sample was 34.6 ± 7.1 years and 54% of the sample were female. Eighty-four percent of the sample were Australian born; 88% of the sample were currently employed, 4% not employed, 8% employed in domestic duties, and 0.1% were retired. Overall lung function was normal, with a mean percentage predicted FEV₁ of $109.5\% \pm 14.1\%$ (range = 32 to 164% predicted). Table 1 summarizes the prevalence of the outcome variables of interest.

Perceived Adverse Food Reactions

Almost 12% (11.7%, *n* = 187) of the sample perceived adverse food reactions. The types of reported reactions are shown in Table 2. The most commonly reported food items to be responsible for perceived adverse food reactions were dairy products (20.3%), fresh/frozen/canned fruits (19.3%), and alcohol (13.3%; Table 3).

Those with current asthma were significantly more likely to report perceived adverse food reactions than were nonasthmatic patients ($\chi^2 = 5.37$, *P* = 0.02). No significant associations were found between the reporting of perceived adverse food reactions and atopy (*P* = 0.52), BHR (*P* = 0.08), eczema ever (*P* = 0.19), current eczema (*P* = 0.53), nasal allergies (*P* = 0.64), doctor-diagnosed asthma (*P* =

Table 1. Prevalence (95% Confidence Interval) of Asthma, BHR, and Allergic Conditions (N = 1601)

Item	n	% of population	95% CI
Atopic*	717	62.8	60.0–65.6
BHR positive†	262	24.4	21.9–27.0
Dr.-diagnosed asthma	385	24.0	22.0–26.2
Current asthma (in past 12 months)†	180	16.7	14.6–19.1
Asthma	87	5.4	4.4–6.6
Wheeze only (in past 12 months)	559	34.9	32.6–37.3
Nasal allergies/hayfever	778	48.6	46.2–51.0
Ever had eczema, skin allergies (confirmed)	435	27.2	25.0–29.4
Current eczema, skin allergies (in past 12 months)	307	19.2	17.3–21.2

* N = 1,141.

† N = 1,075.

Table 2. Types of Reactions Reported by Those Who Perceived Adverse Food Reactions (n = 187)

Symptoms	N	% positive cases
Diarrhea/vomiting	82	43.9
Breathlessness/wheeze	75	40.1
Rash/itchy skin	67	35.8
Severe headache	45	24.1
Runny/stuffy nose	43	23.0
Anaphylaxis/systemic symptoms	36	19.3
Lower gastrointestinal tract symptoms (eg, abdominal pain)	31	16.6
Nausea	15	8.0
Upper gastrointestinal tract symptoms (eg, indigestion)	12	6.4
Other respiratory symptoms/asthma	12	6.4
Lethargy/mood changes/sleep changes	10	5.3
Palpitations/flushing/dizziness	6	3.2
Nasal/sinus problems	4	2.1
Increased mucus/phlegm production	3	1.6
Mouth ulcers	3	1.6
Eczema	2	1.1
Not known	2	1.1
Other (16 different items)	14	7.5

Responses exceed 100% as subjects listed type of reaction(s) for up to three different food reactions.

0.50), asthma ($P = 0.81$), or wheeze only ($P = 0.23$).

Sensitization to Food Allergens

Of this sample, 7.6% ($n = 87$) were sensitized to at least one food allergen on SPT. The prevalence of sensitization to specific food allergens in this community sample of adults ranged from 0.35% for cow's milk to 3.77% for peanut (Table 4). Four subjects were sensitized to two food allergens (2 to both peanut and wheat; 1 to both

peanut and shrimp; 1 to both shrimp and wheat).

Sensitization to Food Allergens and Perceived Adverse Food Reactions

Just under 1 in 40 (2.3%; $n = 26$) of this sample were both sensitized to a food allergen and reported perceived adverse food reactions. Two subjects were sensitized to two food allergens (1 to both peanut and wheat; 1 to both shrimp and wheat). However, only 1.3% ($n = 15$) of the sample with food

sensitization actually perceived adverse food reactions to the same allergen. Thus, the community prevalence of probable IgE-mediated food allergy was found to be <0.27% for wheat, 0.09% (95% confidence intervals = 0.0 to 0.49%) each for cow's milk and egg, 0.53% (0.21 to 1.09%) for shrimp, and 0.61% (0.25 to 1.26%) for peanut (Table 5).

Nine of the 11 subjects who did not have SPTs performed to a particular allergen because of reported previous anaphylactic reaction to that allergen did report perceived adverse food reactions to the same allergen (shrimp, $n = 4$; peanut, $n = 4$; egg, $n = 1$). It should be noted, however, that 4 of these 9 subjects also perceived adverse reactions to other food substances.

Relationship between Probable IgE-Mediated Food Allergy and Atopic Diseases

Table 6 summarizes the relationships among those with probable IgE-mediated allergy and asthma, eczema, and nasal allergies. All subjects with probable IgE-mediated food allergy were also atopic to at least one aeroallergen. However, because of the small numbers of subjects with probable IgE-mediated food allergy, only basic analyses were conducted for probable IgE-mediated cow's milk, wheat, and egg allergies.

Nonetheless, there seem to be some positive associations between probable IgE-mediated peanut allergy and current asthma ($P = 0.003$), doctor-diagnosed asthma ($P = 0.03$), wheeze in the past 12 months ($P = 0.01$), and history of eczema ($P = 0.02$). However, no associations were found for asthma ($P = 0.08$), nasal allergies ($P = 0.12$), or current eczema ($P = 0.64$).

Further, those with probable IgE-mediated shrimp allergy were also more likely to have current asthma ($P = 0.009$), nasal allergies ($P = 0.03$), and doctor-diagnosed asthma ($P = 0.02$). No associations were found for asthma ($P = 0.34$), wheeze in the past 12 months ($P = 0.20$), history of eczema ($P = 0.36$), or current eczema ($P = 1.0$).

Table 3. Types of Foods and Most Common Symptoms Reported by Those Who Perceived Adverse Food Reactions (n = 187)

Item	N	% positive cases	Most common symptom (% of cases)
Dairy products	38	20.3	Rash/itchy skin (50%)
Fruits, fresh/frozen/canned	36	19.3	Rash/itchy skin (67%)
Alcohol	25	13.3	Breathlessness/wheeze (100%)
Seafood/shellfish/fish	18	9.6	Diarrhea/vomiting (72%)
MSG	18	9.6	Breathlessness/wheeze (56%)
Nuts (incl. peanut butter, coconut)	15	8.0	Breathlessness/wheeze (73%), Rash/itchy skin (73%)
Vegetables, fresh/frozen/canned	11	5.9	Rash/itchy skin (73%)
Herbs/spices/condiments (incl. garlic)	11	5.9	Diarrhea/vomiting (55%)
Spicy foods	11	5.9	Diarrhea/vomiting (82%)
Chocolate	10	5.4	Severe headache (60%)
Fruits, dried	9	4.8	Breathlessness/wheeze (89%)
Eggs	7	2.5	Rash/itchy skin (100%)
Preservatives, incl. sulphites	7	3.7	Breathlessness/wheeze (129%)
Vegetables, pickled	6	3.2	Breathlessness/wheeze (150%)
Wheat products, bread/plain cereals	6	3.2	Breathlessness/wheeze (67%), Diarrhea/vomiting (67%), Lethargy/mood/sleep changes (67%)
Other (20 different items)	47	25.1	

Responses exceed 100% as subjects listed up to three different adverse food reactions.

Table 4. Prevalences (and 95% Confidence Intervals) of Positive SPT Sensitization to Food Allergens among Young Adults (n = 1,141)

Food allergen	N	Prevalence (95% CI)
Cow's milk	4	0.35% (0.10–0.90%)
Peanut	43	3.77% (2.74–5.04%)
Shrimp	29	2.54% (1.74–3.58%)
Wheat	11	0.96% (0.48–1.72%)
Egg	4	0.35% (0.10–0.90%)

DISCUSSION

This study has found that probable IgE-mediated food reactions are rare in young adults. Only 1.3% of the sample with food sensitization also reported adverse food reactions to the same food. Perceived adverse food reactions were more likely to be reported by subjects with current asthma, but there was no association with other allergic disorders or alternative definitions of asthma. The allergens of greatest importance were peanut, shrimp, wheat, egg, and cow's milk in that order, but the prevalence was <1% for all of them.

We also found some evidence to suggest that probable IgE-mediated

peanut and shrimp allergies were associated with current asthma and doctor-diagnosed asthma. Those with probable IgE shrimp allergy were also more likely to have nasal allergies, whereas those with probable IgE peanut allergy were also more likely to have a past history of eczema and to have wheezed in the past 12 months. Unfortunately, because of the small number of subjects in this study with probable IgE-mediated cow's milk, wheat, and egg allergy, we were unable to determine whether any other relationships existed between probable IgE-mediated food allergy and allergic disorders.

Indeed, posthoc calculations revealed that this study had <50% statistical power to find any significant associations between probable IgE-mediated food allergy and the atopic diseases of interest. However, we did find that adverse food reactions were more likely to be reported by subjects with current asthma, but there was no association with other allergic disorders or alternative definitions of asthma. We also found that all of those who had probable IgE-mediated food

allergy were atopic to at least one aeroallergen. It is therefore possible that aeroallergen atopy, rather than food allergy, may have driven some of the significant associations seen with probable IgE peanut and shrimp allergy. Indeed, Levy et al¹⁸ recently found that concomitant pollen allergy is an important risk factor for determining which plant-derived foods sensitize latex-allergic adults. In light of these findings, either a study with much larger numbers is required to definitively answer this question or, alternatively, a different study design, such as a case-control study, should be performed.

Our results need to be interpreted with caution, as a positive skin prick test merely indicates sensitization. However, correlation between a positive skin prick test and a positive clinical history strongly suggests that the reported food reaction is a true food allergy attributable to an IgE-mediated mechanism. Our results are also consistent with the relative frequencies of adults who are known to have true food allergy, with peanut and shrimp allergy being the most commonly reported allergens in adults.¹⁹ Nevertheless, to determine the prevalence of true food allergy in the community, double-blind, placebo-controlled food challenge studies need to be performed on all of those individuals who had probable IgE-mediated food allergy. It is known that only approximately 50% of those with positive SPT reaction to food allergens are deemed to have food allergy when they undergo this gold standard for food allergy testing.^{20,21} It is known that SPT has a poor positive predictive value (many false positives), but a good negative predictive value.²¹ In addition, 9 of the 11 subjects who we have classified as having probable IgE-mediated food allergy did not in fact have SPT performed to the allergen in question because of a history of having experienced an anaphylactic-type reaction to that allergen. In the future, we plan to perform SPT on all subjects to eliminate this problem, unless we have accurate medical records diagnostic of a previous anaphylactic reaction. This would indicate

Table 5. Positive Skin Prick Tests among Those with Perceived Adverse Food Reactions

Food allergen	N	Type of food reported (n)	Type of reaction reported (n)†	% sample with positive SPT to food and reported adverse food reaction to the SAME allergen (95% CI)
Cow's milk	2	Dairy* (n = 1), preservatives (1), MSG* (1)	Severe headache (1), breathlessness (1), other (3)	0.09% (n = 1) (0.00–0.49%)
Peanut	13	Nuts (7), fresh vegetables (3), fresh fruits (2), dairy (1), sauces (1), yeast (1), alcohol (1), seafood (1), MSG (1)	Rash (5), diarrhea (4), runny nose (5), headache (2), breathlessness (10), other (12)	0.61% (n = 7) (0.25–1.26%)
Shrimp	8	Seafood (6), fresh fruits (1), dairy (2), alcohol (1)	Rash (6), diarrhea (2), runny nose (2), breathlessness (4), other (3)	0.53% (n = 6) (0.25–1.26%)
Wheat	4	Fresh fruit (2), fruit juice (1), dairy (1), seafood (1), eggs (1), acidic foods (1)	Rash (1), diarrhea (3), runny nose (2), breathlessness (1), other (6)	0% (0.00–0.26%)*
Egg	1	Eggs (1)	Rash, diarrhea, breathlessness, other	0.09% (n = 1) (0.00–0.49%)

* = same person.

† Subjects were able to report multiple types of reaction to each perceived adverse food reaction.

Table 6. Relationship between Those with Probable IgE-Mediated Food Allergy and Atopic Diseases

	n	Gender	Current asthma	Asthma	Dr.-diagnosed asthma	Wheeze	Nasal allergies	History of eczema	Current eczema	Current asthma, nasal allergies, & current eczema
Cow's milk	1	Male	0	0	0	0	1	1	0	0
Peanut*	7	4 male	4†	2	5†	6†	6	5†	3	2
Shrimp*	6	3 male	3†	1	5†	4	6†	3	2	0
Wheat	0	0	0	0	0	0	0	0	0	0
Egg*	1	Male	1	0	1	1	0	1	1	0

* Four of the seven subjects with probable IgE-mediated food allergy to peanut did not undergo SPT as they had previously experienced an anaphylactic type reaction to peanut. Similarly, 4 of the 6 subjects with probable IgE-mediated food allergy to shrimp and the subject with probable IgE-mediated food allergy to egg did not undergo SPT as they had previously experienced an anaphylactic type reaction to shrimp and egg, respectively.

† $P < 0.05$ (Fisher's exact test).

that the true prevalence of food allergy in adults is likely to be <1.3% of the general population.

Several studies have shown that in both adults and children a limited number of foods cause most allergic reactions. According to Sampson,^{19,22,23} six foods (egg, peanut, milk, shellfish, soy, and wheat) account for nearly 90% of positive reactions by blinded food challenge. Foods frequently implicated, such as various fruits and chocolate, have not been found to elicit positive responses by blinded challenge. Hence, although there may be some subjects with true IgE-mediated allergy to a food not tested in the panel, the number is likely to be small. It is therefore unlikely that our results significantly underestimate the prevalence of food allergy in young adults.

Nonresponse bias was unlikely to be a major problem in this study as participants were initially randomly selected from the electoral rolls and a good response rate was achieved. Thus, our results are likely to be generalizable to the wider community.

The prevalence of adverse food reactions and food allergy as reported in this study is similar to that found in previous studies. Young et al¹ found that approximately 20% of a two-stage UK community study perceived that they had adverse food reactions. However, when these subjects underwent double-blind, placebo-controlled food challenges to eight common foods, only 1.4 to 1.8% were confirmed to have a true adverse food reaction. The distinction between food intolerance

and food allergy was not determined in that study. Similarly, Bjornsson et al⁴ found that 25% of a random Swedish community sample of 1,397 subjects reported symptoms of adverse food reactions, whereas only 6% had specific IgE antibodies to 1 of the 5 food allergens that were tested.

In a previous Australian study,⁸ using a similar study design, we found that 22% of adults perceived that they had adverse food reactions, whereas only 1.5% of adults had probable IgE-mediated food allergy. We also found that there was little agreement between the perception of adverse food reactions and positive skin prick tests to common food allergens in adults. This suggests that most perceived reactions are not attributable to IgE-mediated

food allergy. The current study confirms this conclusion as well as extends the observations.

Many adults reported clinical symptoms after cow's milk ingestion but were not sensitized to cow's milk on SPT. It is possible that some of this discrepancy may be because of lactose intolerance rather than IgE-mediated food allergy. Indeed, 50% of those who reported clinical symptoms after ingestion of cow's milk did report symptoms (nausea, vomiting, diarrhea, and/or lower gastrointestinal tract symptoms) that could be consistent with lactose intolerance (data not shown). However, it is unlikely that lactose intolerance accounts for all of this difference, as the prevalence of lactose intolerance in the Australian adult population is estimated to be 4 to 20%.²⁴ This result suggests that adults continue to perceive that cow's milk allergy is common despite the lack of scientific support for this perception.²⁵⁻²⁸

Similarly, a relatively large number of subjects reported perceived adverse food reactions to fruits and vegetables. It is indeed possible that some of these subjects may have oral allergy syndrome. The syndrome is mainly caused by cross-sensitization to fresh fruits and vegetables in subjects with pollen sensitization.²⁹ However, we did not collect adequate clinical data, nor did we perform skin prick tests to either the food(s) in question or the pollens most commonly associated with oral allergy syndrome to be able to accurately evaluate this form of IgE-mediated allergy.

It was interesting that we did not find any probable IgE-mediated food allergy to wheat, despite several people reporting clinical symptoms to wheat. Some of this discrepancy may be attributable to the presence of celiac disease. Unfortunately, we do not have any medical information on these subjects which could be used to verify whether this was indeed the case. Even so, our results do seem to reflect an extremely low prevalence rate of true wheat allergy in adults.

CONCLUSION

We have found that the prevalences of probable IgE-mediated food reactions are indeed rare in young adults. The allergens of greatest importance were peanut, shrimp, wheat, egg, and cow's milk. Those with probable IgE-mediated peanut allergy were more likely to have current asthma, doctor-diagnosed asthma, wheeze, and a history of eczema, whereas those with probable IgE-mediated shrimp allergy were also more likely to have current asthma, doctor-diagnosed asthma, and nasal allergies. We were unable to determine any such relationships between those with probable IgE cow's milk, wheat, and egg allergy and allergic diseases because of the small numbers of subjects with these types of food allergies. Further research, with larger numbers of subjects demonstrating IgE-mediated food allergy, is required to confirm these results.

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