

A population-based questionnaire survey on the prevalence of peanut, tree nut, and shellfish allergy in 2 Asian populations

Lynette Pei-Chi Shek, MRCP,^a Elizabeth Ann Cabrera-Morales, MD,^b Shu E. Soh, MSc,^a Irvin Gerez, MD,^a Pau Zhing Ng, MBBS,^a Fong Cheng Yi, PhD,^a Stefan Ma, PhD,^c and Bee Wah Lee, MD^a *Manila, Philippines, and Singapore*

Background: There has been a substantial increase in the prevalence of peanut and tree nut allergy in Western populations in the last 2 decades. However, there is an impression that peanut and tree nut allergy is relatively uncommon in Asia.

Objective: To evaluate the prevalence of peanut, tree nut, and shellfish allergy in schoolchildren in 2 Asian countries (Singapore and Philippines).

Methods: A structured written questionnaire was administered to local and expatriate Singapore (4-6 and 14-16 years old) and Philippine (14-16 years old) schoolchildren.

Results: A total of 25,692 schoolchildren responded to the survey (response rate, 74.2%). Of these, 23,425 responses fell within the study protocol's 4 to 6 and 14 to 16 year age groups and were included in the analysis. The prevalence of convincing peanut and tree nut allergy were similar in both local Singapore (4-6 years, 0.64%, 0.28%; 14-16 years, 0.47%, 0.3%, respectively) and Philippine (14-16, 0.43%, 0.33%, respectively) schoolchildren, but was higher in the Singapore expatriates (4-6 years, 1.29%, 1.12%; 14-16 years, both 1.21%, respectively; 4-6 years, expatriates vs local Singaporeans: peanut, $P = .019$; tree nut, $P = .0017$; 14-16 years, $P > .05$). Conversely, shellfish allergy was more common in the local Singapore (4-6 years, 1.19%; 14-16 years, 5.23%) and Philippine (14-16 years, 5.12%) schoolchildren compared with expatriate children (4-6 years, 0.55%; 14-16 years, 0.96%; $P < .001$). When data were pooled, respondents born in Western countries were at higher risk of peanut (adjusted odds ratios [95% CIs]: 4-6 years, 3.47 [1.35-8.93]; 14-16 years, 5.56 [1.74-17.76]) and tree nut allergy (adjusted odds ratios [95% CIs]: 4-6 years, 10.40 [1.61-67.36]; 14-16 years, 3.53 [1.00-12.43]) compared with those born in Asia.

Conclusion: This study substantiates the notion that peanut and tree nut allergy is relatively low in Asian children, and instead shellfish allergy predominates. Environmental factors that are yet to be defined are likely to contribute to these differences. (J Allergy Clin Immunol 2010;■■■■:■■■-■■■.)

Key words: Peanut allergy, tree nut allergy, shellfish allergy, food allergy, anaphylaxis, epinephrine autoinjectors, Singapore, Philippines, Asia

In recent decades, the prevalence of food allergy, in particular peanut allergy, has increased at alarming rates in the Western world, with increases of peanut allergy at rates of up to 2-fold, with prevalence rates of more than 1% of the population by the early 2000s.¹ The prevalence of sensitization in 3-year-olds in the United Kingdom increased from 1.3% to 3.2% between 1989 and 1995,² and in the United States, peanut allergy had increased in young children from 0.4% to 0.8% between 1997 and 2002.³ The estimated prevalence of peanut allergy in Canadian children is 1.34%.⁴ Similar increases have been observed in Australia.⁵

Based on data from food anaphylaxis registries, peanut is also the most common food trigger of fatal anaphylaxis in these communities.^{6,7} There is a suggestion that this increase in prevalence is also accompanied by more severe allergic reactions as reflected by increasing trends in hospitalization.⁸ In addition, the increasing importance of food allergy is reflected by the later age at which tolerance to early childhood food allergens such as milk is developed.⁹ Although the epidemiology of shellfish allergy is less well documented, it is another common cause of food allergy. A US population survey reported a 2% prevalence for shellfish allergy,¹⁰ which is also a common cause of food-induced anaphylaxis in the United States¹⁰ and Europe.¹¹

Despite the growing peanut allergy epidemic in Western populations, there is an impression that the prevalence of peanut allergy in Asia is relatively low. This notion, however, has not been well documented formally with population-based studies. In contrast with peanut allergy, shellfish has been found to be one of the most common causes of food-induced anaphylaxis in several Asian populations,¹²⁻¹⁵ indicating that the pattern of food allergy may vary between populations. This study set out to evaluate on a population basis the prevalence of peanut, tree nut, and seafood allergy among schoolchildren in 2 Asian populations. This survey involved the use of a structured questionnaire that has established criteria for convincing allergy¹⁶ to provide accurate information on convincing allergy in the Singapore and Philippine populations. This study would provide important insights to the

From ^athe National University Health System, Singapore; ^bthe Asian Hospital and Medical Center, Manila; and ^cthe Epidemiology and Disease Control Division, Ministry of Health, Singapore.

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Reprint requests: Bee Wah Lee, MD, Department of Pediatrics, Yong Loo Lin School of Medicine, National University of Singapore, 5 Lower Kent Ridge Road, Singapore 119074. E-mail: paeleebw@nus.edu.sg.

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Abbreviation used

adjOR: Adjusted odds ratio

epidemiology of peanut allergy in Asia and therefore provide a global perspective on this common and potent food allergen.

METHODS

Survey methods

This was a cross-sectional study involving schoolchildren in 2 age groups, 4 to 6 years and 14 to 16 years, conducted in Singapore and Metro Manila, the Philippines (August 2007 to February 2008). The selection of schools was based on cluster sampling. Schools were sampled randomly from a list of preschools (Singapore only) and secondary schools in Singapore and Manila, Philippines. Preschoolers were not surveyed in the Philippines because of difficulty in accessing the subjects. For these study populations, 2 age groups of students were targeted: the children 4 to 6 years old (preschoolers) and 14 to 16 years old (high school). The age difference of about 10 years between the age groups was chosen to provide a means to evaluate the prevalence of food allergy in young and adolescent children.

In addition, 3 large expatriate/international schools out of the 13 schools in Singapore were invited to participate in this survey with the aim to provide some data on children born outside Asia. Children from the age groups 4 to 6 and 14 to 16 years were selected for evaluation and comparison with the local Singapore and Philippine schoolchildren. This study was approved by the National University of Singapore's ethics committee, the Department of Education, Philippines, and the Ministry of Education, Singapore.

Questionnaire

The survey was conducted by using a structured questionnaire that has been used in the US population.³ The questionnaire was conducted in 2 parts (Appendix 1, Online Repository). All students in the respective age groups from the selected schools responded to part 1 of the survey, in which data on demography, country of birth, and physician diagnosis of allergic disorders (asthma, eczema, and allergic rhinitis) were obtained. Questions pertaining to peanut, tree nut (almond, Brazil, cashew, hazelnut, macadamia, pecan, pine, pistachio, walnut), crustacean shellfish (prawns, crab, lobster, crayfish), and mollusk (squid, scallops, clams, oysters, mussels, snails) allergy were asked in separate questions. Part 1 of the survey was completed by the parents for children 4 to 6 years old and by the students 14 to 16 years old.

All respondents with a positive response to the presence of any of the specified food allergies proceeded to answer part 2 of the questionnaire, which was completed with the help of their parents. This section of the survey obtained information on specific symptoms of the food allergy to ascertain the presence of convincing immediate food allergy as previously developed by Sicherer et al.^{3,10} Reactions were considered convincing if the organ systems affected and symptoms were typical of those involved in allergic reactions (skin: hives and angioedema; respiratory system: trouble breathing, wheezing, and throat tightness; gastrointestinal system: vomiting and diarrhea) and occurred within 2 hours of ingestion. Although skin prick testing and food challenge are the ideal instruments for evaluating food allergy, this study involving a large number of subjects relied on this standardized questionnaire to indicate IgE-mediated food allergy.

The questionnaire was translated into the Chinese and Malay languages for parents who were not literate in English. No translation was required for the Philippines survey. The English questionnaire was used for all the students because this is the medium of teaching in Singapore and the Philippines.

Statistical power of study

We sought to accrue 12,000 children each from Singapore and the Philippines to enable us to estimate the prevalence of food allergy to within at least $\pm 0.06\%$ with a 95% CI, allowing for a low prevalence estimated at 0.1% or less for peanut allergy. These estimates were made after taking into

account cluster sampling with a design effect of 1.14 as determined from the International Study of Allergies and Asthma survey conducted in Singapore.¹⁷

Statistical analysis

SUDAAN V10.0.1 (Research Triangle Institute, Research Triangle Park, NC) was applied for statistical analyses. Weighted prevalence rates, 95% CIs and comparisons between age groups and populations were calculated by using SUDAAN to account for the cluster sampling survey design and to adjust for selection probability and nonresponse. Weights were calculated on the basis of the selection probability of schools in the 2 regions, Singapore and the Philippines, and the response probabilities (estimated using response rate at school level). A sampling design without replacement was chosen in estimation of prevalence.

For studying associated risk factors with food allergy conditions, weighted multiple logistic regression models were applied with adjustment for potential confounding factors: sex, ethnic group, country of birth, and comorbid conditions (asthma, allergic rhinitis, eczema, anaphylaxis and hives). A *P* value $< .05$ was considered statistically significant for all analyses.

RESULTS

Participation rate and demographic characteristics

The survey was sent to 34,628 subjects, and 25,692 responded (response rate, 74.2%). Of these, 23,425 responses fell within the study protocol's age groups of 4 to 6 and 14 to 16 years and were included in the analysis. The details of the number of subjects surveyed and the demographics of each age group and country are summarized in Fig 1 and Table I.

Reported prevalence rates of peanut, tree nut, and shellfish allergy

Table II summarizes the prevalence of peanut, tree nut, and shellfish allergy in the 2 age groups (4–6 years, 14–16 years) of the 3 categories (Singapore schools, Singapore expatriate schools, Philippine schools) of students surveyed. In all groups, the prevalence of self-reported allergy for all groups was higher than that of convincing allergy symptoms.

The prevalence of convincing peanut allergy and tree nuts was very similar for Singapore (peanut 0.47%; tree nuts 0.30%) and the Philippines (peanut 0.43%; tree nuts 0.33%) in the children 14 to 16 years old, and only slightly higher for peanut allergy in Singapore children 4 to 6 years old (peanut 0.64%; tree nuts 0.28%). In contrast, the prevalence of convincing shellfish allergy was higher than peanut and tree nut allergy, and remarkably similar in both Singapore (5.2%) and Philippine (5.1%) children 14 to 16 years old ($P = .850$), but lower in the Singapore children 4 to 6 years old (1.2%) compared with Singapore children 14 to 16 years old ($P < .001$). The types of shellfish reported to cause allergic symptoms, in decreasing order of frequency, were shrimp, crab, squid, mussels, lobster, clams, oysters, snails, scallops, and crayfish. For tree nuts, they were cashew, hazel, almond, walnuts, macadamia, pistachio, pecan, pine, and Brazil nuts, also in decreasing order of frequency.

On the contrary, the Singapore expatriate population showed a reverse pattern compared with that seen in the Asian schoolchildren in that the prevalence of convincing peanut (4–6 years, 1.29%; 14–16 years, 1.21%) and tree nut allergy (4–6 years, 1.12%; 14–16 years, 1.21%) was higher than that of shellfish in the children 4 to 6 years old (0.55%; $P = .096$) and 14 to 16 years old (0.96%; $P = .316$), although these differences were not statistically significant.

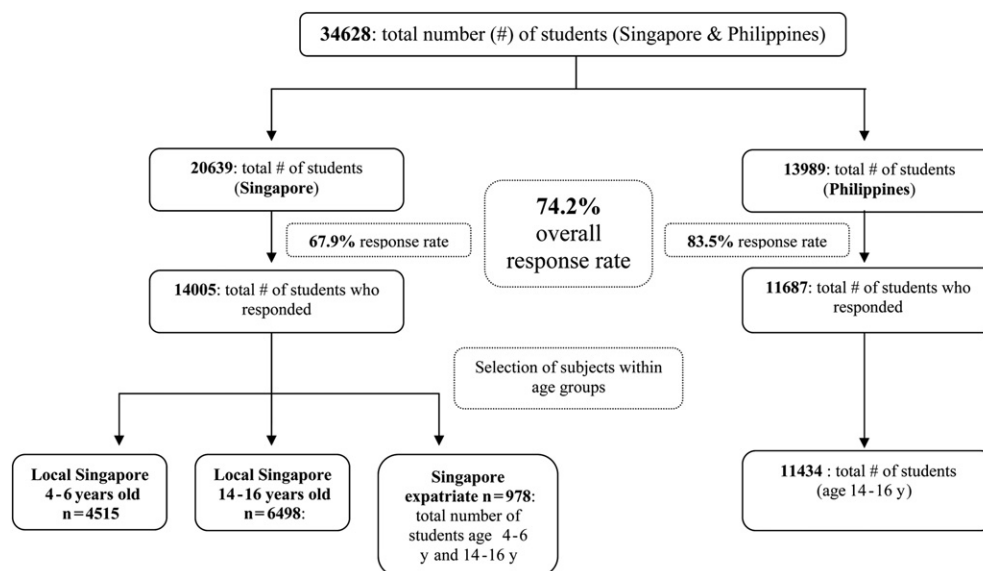


FIG 1. Flow chart shows the number of subjects surveyed and response rates from each population (Singapore, expatriate Singapore, Philippines) and age groups (4-6 years, 14-16 years) studied.

TABLE I. Demographic features of schoolchildren surveyed in Singapore and Philippines (n = 23,425)

	4-6 Years		14-16 Years		Philippines
	Expats*	Singapore	Expats*	Singapore	
n	641	4515	337	6498	11434
Sex, n (%)					
Male	320 (49.9)	2,249 (49.8)	145 (43.0)	3,183 (49.0)	4,756 (41.6)
Female	306 (47.7)	2,203 (48.8)	185 (54.9)	3,207 (49.4)	6,651 (58.2)
Ethnicity, n (%)					
Chinese	42 (6.6)	3,159 (70.0)	43 (12.8)	5,061 (77.9)	147 (1.3)
Malay	1 (0.2)	837 (18.5)	4 (1.2)	884 (13.6)	0 (0.0)
Indian	48 (7.5)	255 (5.6)	51 (15.1)	374 (5.8)	0 (0.0)
White	403 (62.9)	8 (0.2)	154 (45.7)	3 (0.05)	2 (0.02)
Eurasian	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	16 (0.14)
Filipino	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	10,534 (92.1)
Others	133 (20.7)	160 (3.5)	80 (23.7)	168 (2.6)	91 (0.8)

*Expats: Schoolchildren studying in international schools in Singapore.

Influence of demographic factors on prevalence of peanut, tree nut, and shellfish allergy

To evaluate the influence of demographic factors, country of birth, and a history of other allergic disease, the data were pooled and analyzed by using weighted multiple logistic regression models. The data are summarized in Table III. The results showed that compared with ethnic Chinese in the children 14 to 16 years old, the Malays had higher prevalence of convincing peanut (adjOR, 3.57) and shellfish allergy (adjOR, 1.83), whereas the Indians a higher prevalence of tree nut allergy (adjOR, 4.39).

When the data from all populations were pooled, it was found that for both age groups, respondents born in Western countries (United Kingdom, North America, Australia, New Zealand, and Western Europe) were at higher risk of having peanut (adjOR, 4-6 years, 3.47; 14-16 years, 5.56) and tree nut allergy (adjOR, 4-6 years, 10.40; 14-16 years, 3.53) compared with those born in Asia. This observation was not seen for shellfish allergy. To substantiate these findings, data from the pooled population were also analyzed by combining the variable ethnicity with country/

place of birth into 4 groups: Asians (Chinese, Malay, Indian, Filipino) born in Asia, Asians born in the West, white subjects born in Asia, and white subjects born in the West (Table IV). The results further corroborate the impression that the risk of peanut (adjOR, Asian-born Asian vs Western-born Asian, 8.26) and tree nut (adjOR, Asian-born Asian vs Western-born Asian, 5.09) allergy is increased for those born in the West compared with those born in Asia. In contrast, however, the results also showed that the risk of shellfish allergy is reduced in white subjects (adjOR, Asian-born white subject, 0.13; Western-born white subject, 0.08) and is unrelated to the place of birth. When analyzed by using weighted multiple logistic regression models to adjust for sex and allergic comorbidities, these associations remained statistically significant (data not shown).

Not unexpectedly, these food allergies were associated with coexisting allergic diseases (asthma, rhinitis, and eczema) in the respondents for most of the age categories. The strongest association was seen with eczema, with adjusted ORs of up to 15.23 for tree nut allergy in the age group 4 to 6 years (Table III).

TABLE II. Prevalence (%) of food allergies in schoolchildren in Singapore and Philippines

	4-6 Years		14-16 Years		
	Expats*	Singapore	Expats*	Singapore	Philippines
Any nut allergy					
Self-reported	4.29 (27/630)	4.37 (209/4,416)	2.41 (8/332)	1.50 (97/6,465)	1.72 (196/11,390)
Convincing history (95% CI)	2.06 (1.22-3.48)† (13/630)	0.70 (0.45-1.10)† (31/4,416)	1.20 (0.21-6.59) (4/332)	0.54 (0.45-0.65) (35/6,465)	0.67 (0.52-0.86) (76/11,390)
Peanut allergy					
Self-reported	3.22 (20/622)	3.60 (158/4,390)	2.42 (8/331)	1.18 (76/6,450)	1.29 (146/11,322)
Convincing history (95% CI)	1.29 (0.54-3.06) (8/622)	0.64 (0.41-1.00) (28/4,390)	1.21 (0.21-6.60) (4/331)	0.47 (0.36-0.59) (30/6,450)	0.43 (0.31-0.60) (49/11,322)
Tree nut allergy					
Self-reported	2.72 (17/626)	3.41 (148/4,339)	2.11 (7/331)	0.81 (52/6,436)	0.72 (80/11,071)
Convincing history (95% CI)	1.12 (0.69-1.80)‡ (7/626)	0.28 (0.14-0.53)‡ (12/4,339)	1.21 (0.21-6.60) (4/331)	0.30 (0.20-0.44) (19/6,436)	0.33 (0.21-0.53) (37/11,071)
Shellfish allergy					
Self-reported	2.55 (14/550)	7.22 (297/4,115)	3.22 (10/311)	11.56 (733/6,342)	8.68 (968/11,158)
Convincing history (95% CI)	0.55 (0.18-1.62) (3/550)	1.19 (0.87-1.63)§ (49/4,115)	0.96 (0.53-1.74) ¶ (3/311)	5.23 (4.46-6.14)§¶ (332/6,342)	5.12 (4.30-6.08) (571/11,158)

*Expats: Schoolchildren studying in international schools in Singapore.

†Any nut allergy, Local Singapore 4-6 years vs expatriate Singapore 4-6 years; $P = .0131$.

‡Tree nut allergy: Local Singapore 4-6 years vs expatriate Singapore 4-6 years; $P = .0017$.

§Shellfish allergy: Local Singapore 4-6 years vs local Singapore 14-16 years; $P < .001$.

||Shellfish allergy: Expatriate Singapore 14-16 years vs Philippines 14-16 years; $P < .001$.

¶Shellfish allergy: Expatriate Singapore 14-16 years vs local Singapore 14-16 years; $P < .001$.

Clinical characteristics of peanut, tree nut, and shellfish allergy

The data from all the populations were combined for evaluation of symptom characteristics. On the basis of the categories of age of onset of food allergy as shown in Fig 2, their distribution shows that the age of onset of peanut allergy (peak frequency, 1-5 years) occurred earlier than shellfish allergy (peak frequency, 6-10 years; Mann-Whitney U test, $P < .001$). This difference was also observed between tree nuts and shellfish even though their peak age range frequencies were similar at 6 to 10 years ($P < .001$). Allergic symptoms were more severe (as assessed by the presence of respiratory symptoms and/or those of hypotension) in those with peanut and tree nut allergy than those with shellfish allergy ($P < .0001$; Fig 3). This difference in severity may be a result of the higher prevalence of concomitant asthma in those with peanut and tree nut allergy (Table III). However, self-injectable epinephrine (Epipen, Dey Pharma LP, Calif) was seldom prescribed to those with peanut or tree nut allergy in the local Singapore population (7.5%) and in the Philippines (1.2%). In contrast, self-injectable epinephrine was more often prescribed to the children with peanut or tree nut allergy in the expatriate population in Singapore (60.8%).

DISCUSSION

This population-based study in Asian schoolchildren substantiates the notion that the prevalence of peanut and tree nut allergy in this part of the world is relatively low. The survey was conducted by using a structured questionnaire that has established criteria for convincing allergy¹⁶ and has been used in surveys in the United States.^{3,10,18} The criteria used to estimate the prevalence of food

allergy (typical allergic symptoms occurring within 2 hours of ingestion) have been shown to be specific in that most subjects fulfilling these criteria had IgE antibody to the food implicated.¹⁶

Interestingly, the prevalences of peanut (0.4%) and tree nut (0.3%) allergy were very similar in the children 14 to 16 years old for both the Singapore and Philippines populations. In contrast, the Singapore expatriate population, albeit relatively small in numbers, showed a higher prevalence of 1.2% for peanut, tree nuts, and all nuts ($P < .02$). These figures are more akin to those of recent reports in the United States,³ United Kingdom,^{2,19,20} and Canada,⁴ where increasing trends have been observed and prevalence rates are more than 1% in adolescents and children.

The higher prevalence of peanut and tree nut allergy in the Western world is further substantiated by the finding in this study that those born in Western countries are at increased risk of peanut and tree nut allergy compared with those born in Asia (adjusted $P < .05$; Table III). These results are further substantiated by the finding that either Asians or white subjects born in the West were at higher risk of peanut and tree nut allergy (Table IV). Environmental factors are likely to be responsible for this observation. It has been reported that the prevalences of peanut and tree nut allergy in the United States are similar between ethnic groups,³ although the number of ethnic Asian subjects studied was too small to make any reliable comparisons. There have been growing concern and speculation that guidelines on strict avoidance of peanut and tree nuts during pregnancy, lactation, and young children until the age of 3 years²¹ may have in part contributed to the peanut allergy epidemic in the west. Although not fully substantiated but with intervention studies only currently under way,²² such strict avoidance of peanuts and tree nuts has not been implemented in Singapore and the Philippines. In fact, a previous study has

TABLE III. Weighted multiple logistic regression analysis of demographic factors influencing food allergies of pooled data from Singapore and the Philippines (n = 23,425)

Risk factor	Shellfish allergy		Peanut allergy		Tree nut allergy	
	4-6 y	14-16 y	4-6 y	14-16 y	4-6 y	14-16 y
	adjOR (95% CI)		adjOR (95% CI)		adjOR (95% CI)	
Sex						
Male	0.74 (0.35-1.54)	1.17 (0.94-1.47)	0.92 (0.35-2.44)	1.18 (0.69-2.03)	1.17 (0.24-5.75)	1.36 (0.74-2.18)
Female	1.00	1.00	1.00	1.00	1.00	1.00
Ethnic group‡						
Chinese	1.00	1.00	1.00	1.00	1.00	1.00
Malay	1.10 (0.58-2.07)	1.83 (1.31-2.56)	0.13 (0.01-2.64)	3.57 (1.35-9.42)	—	0.97 (0.15-6.32)
Indian	1.58 (0.47-5.29)	0.69 (0.40-1.19)	0.75 (0.10-5.83)	2.58 (0.77-8.63)	1.45 (0.09-23.08)	4.39 (1.31-14.72)
White	—	0.38 (0.03-5.13)	0.43 (0.14-1.36)	—	0.11 (0.01-1.44)	—
Eurasian	—	—	—	—	—	—
Filipino	—	0.81 (0.62-1.06)	—	1.09 (0.57-2.08)	—	1.50 (0.69-3.26)
Country of birth						
Western countries*	1.88 (0.52-6.78)	0.34 (0.08-1.47)	3.47 (1.35-8.93)	5.56 (1.74-17.76)	10.40 (1.61-67.36)	3.53 (1.00-12.43)
Asia	1.00	1.00	1.00	1.00	1.00	1.00
Comorbidities†						
Asthma	1.69 (0.83-3.43)	1.87 (1.53-2.27)	2.93 (1.04-8.28)	1.85 (0.92-3.71)	3.01 (0.94-9.62)	3.93 (1.84-8.38)
Allergic rhinitis	1.69 (0.82-3.49)	1.71 (1.41-2.08)	1.80 (0.63-5.14)	2.22 (1.14-4.33)	1.00 (0.36-2.80)	3.61 (1.62-8.03)
Eczema	3.15 (1.16-8.53)	1.70 (1.31-2.20)	3.33 (1.07-10.31)	4.03 (2.30-7.07)	15.22 (3.02-76.78)	2.31 (1.13-4.70)

Boldface formatting denotes statistical significance, $P < .05$.

*Western countries: Australia, New Zealand, United Kingdom, North America, and Western Europe.

†Reference groups for each comorbidity (asthma, allergic rhinitis, eczema) are subjects without the disorder.

‡Ethnic group tested simultaneously for each food allergy by age group (P value): for age group 4-6 years old, shellfish (.5132), peanut (.3676), tree nuts (.3580); for age group 14-16 years old, shellfish (<.001), peanut (.0312), tree nuts (.0002).

TABLE IV. Prevalence (%) and weighted univariate logistic regression analysis of peanut, tree nut, and shellfish allergy in schoolchildren in Singapore and Philippines analyzed according to place of birth and ethnicity

Outcome variable: shellfish allergy					
Place of birth/ethnicity	% (n)	Asia-born Asian*	Asia-born white	Western-born† Asian*	Western-born† white
		OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Asia-born Asian*	4.36 (881/20,222)	1.00	7.33 (1.02-52.62)	0.81 (0.36-1.85)	14.53 (1.57-134.43)
Asia-born white	0.62 (1/162)	0.14 (0.02-0.98)	1.00	0.11 (0.01-0.94)	1.98 (0.09-42.81)
Western-born† Asian*	5.31 (6/113)	1.23 (0.54- 2.80)	9.03 (1.06-76.77)	1.00	17.89 (1.60-199.94)
Western-born† white	0.31 (1/320)	0.07 (0.01-0.64)	0.50 (0.02-10.90)	0.06 (0.01-0.62)	1.00
Outcome variable: peanut allergy					
Place of birth/ethnicity	% (n)	OR (95% CI)	OR (95% CI)‡	OR (95% CI)	OR (95% CI)
Asia-born Asian*	0.47 (98/20,753)	1.00	—	0.02 (0.00-0.06)	0.02 (0.01-0.06)
Asia-born white	0.00 (0/174)	—	1.00	0.29 (0.07-1.11)	0.24 (0.07-0.74)
Western-born† Asian*	1.62 (2/123)	3.48 (0.90-13.44)	—	1.00	0.82 (0.14-4.94)
Western-born† white	1.98 (7/357)	4.25 (1.35-13.34)	—	1.22 (0.20-7.35)	1.00
Outcome variable: tree nuts allergy					
Place of birth/ethnicity	% (n)	OR (95% CI)	OR (95% CI)‡	OR (95% CI)	OR (95% CI)
Asia-born Asian*	0.30 (61/20,452)	1.00	—	0.02 (0.00-0.07)	0.01 (0.00-0.03)
Asia-born white	0.00 (0/177)	—	1.00	0.18 (0.04-0.78)	0.26 (0.09-0.74)
Western-born† Asian*	1.61 (2/124)	5.48 (1.28-23.46)	—	1.00	1.44 (0.29-7.22)
Western-born† white	1.12 (4/356)	3.80 (1.35-10.66)	—	0.69 (0.14-3.47)	1.00

Boldface denotes statistical significance, $P < .05$.

*Asian: Chinese, Malay, Indian, Filipino.

†Western countries: Australia, New Zealand, United Kingdom, North America, Western Europe.

‡Analysis not done because the number for that reference group was 0.

shown that peanut sensitization among our atopic children is common (27%),²³ indicating exposure to the allergen. Despite this, our survey shows a low prevalence of clinical allergy.

Singapore has a multiethnic population consisting of Chinese (76.8% of the population), Malay (13.9%), Indian (7.9%), and

other races (1.4%; <http://www.singstat.gov.sg/pubn/popn/c2000sr1/t1-7.pdf>). Our data showed that instead of white subjects, Malays had a higher prevalence of peanut and shellfish allergy, and Indians of tree nut allergy. This observation may highlight the fact that within the Asian ethnic groups, a genetic

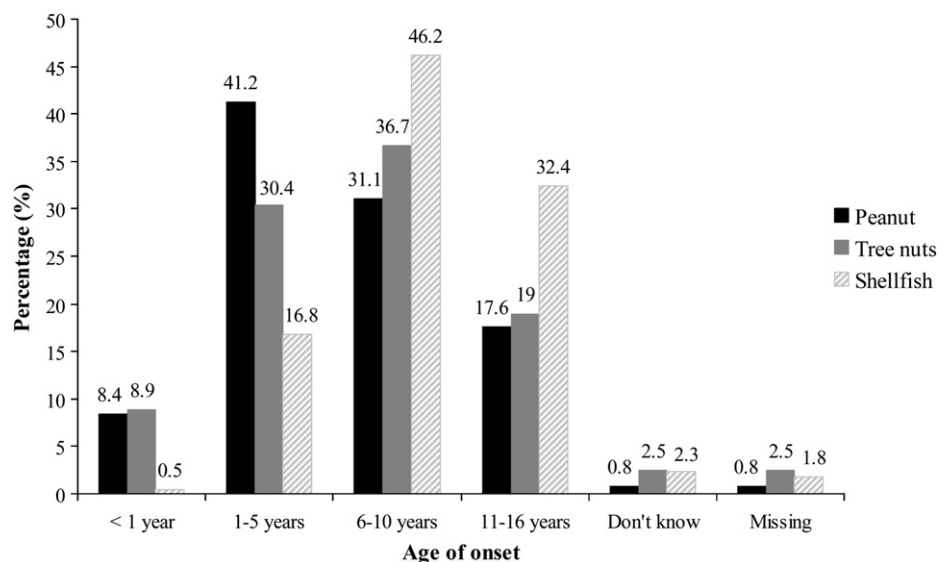
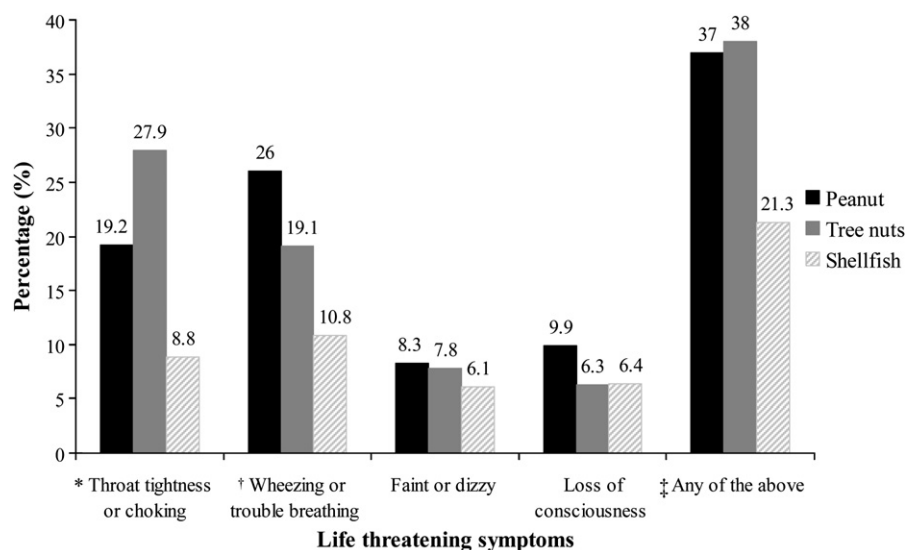


FIG 2. Age of onset of peanut ($n = 119$), tree nut ($n = 79$), and shellfish allergy ($n = 958$) among all populations (Singapore, expatriate in Singapore, Philippines) and age groups (4-6 years and 14-16 years) studied.



* Peanut vs Shellfish, $P < .001$
Tree Nuts vs Shellfish, $P < .001$

† Peanut vs Shellfish, $P < .001$
Tree Nuts vs Shellfish, $P < .05$

‡ Peanut vs Shellfish, $P < .001$
Tree Nuts vs Shellfish, $P < .005$

FIG 3. Life-threatening symptoms seen in peanut ($n = 119$), tree nut ($n = 79$), and shellfish allergy ($n = 958$) in all populations (Singapore, expatriate in Singapore, Philippines) and age groups (4-6 years, 14-16 years) studied.

predisposition to atopy and allergic diseases is observed among our Malays and Indians, who also have been shown to have a higher prevalence of asthma²⁴ and allergic rhinitis.²⁵

In contrast with peanut and tree nut allergy, the prevalence of shellfish allergy showed a strikingly different trend, with a higher

prevalence in Singapore and the Philippines compared with the West. Reactions to shrimp and crab were the most frequently reported, and this is likely related to the relatively higher frequency of consumption in these populations. Shellfish allergy and anaphylaxis are known to be common in the Asian

population.^{12,26} Because dust mites are highly prevalent in this region²⁷ with high rates of sensitization,²⁸ it has been suggested that in this region, a high prevalence of shellfish allergy is related to dust mite allergy,²⁹ and that the primary sensitizing agent of shellfish allergy is the tropomyosin (a panallergen and a major allergen of shellfish) of dust mites, akin to the oral allergy syndrome in pollenosis, in which the inhalant induces a food allergy reactions through cross-reacting allergens. The speculation that dust mite tropomyosin is the cross-reacting allergen in shellfish allergy in Asia arises from epidemiologic association. However, case reports have also substantiated this notion.³⁰⁻³³ The possibility of allergy to anisakis (a parasite known to contaminate seafood) contributing to the higher incidence of shellfish allergy in Asians in our study is unlikely, because anisakis-contaminated shellfish has not been detected in Singapore (personal communication, February 2010: K. Lim, Agri-Food and Veterinary Authority, Singapore).

The earlier ages of onset of peanut and tree nut allergy compared with shellfish allergy (Fig 2) are similar to those observed in other populations.^{5,10} Of interest is the lower frequency of severe reactions (cardiorespiratory symptoms) in shellfish compared with peanut and tree nut allergy (Fig 3). These food allergies are known to be associated with severe reactions, and several reports in Asia indicate that shellfish is the most common food causing food allergy in Asia.¹²⁻¹⁵ Although the severity of the food allergy reaction may be more related to the presence of comorbidities such as asthma, another plausible reason for the lower frequency of severe reactions in shellfish allergy compared with peanut and tree nut allergy is the dilution by milder cases. This notion further supports our impression that those with shellfish allergy resulting from cross-reacting dust mite allergy in the tropics would contribute to the mild cases.

Subjects who had outgrown their allergies were included in our study because our aim was to analyze the prevalence of these allergies regardless of whether it had been outgrown. From our analysis, the percentages that had outgrown peanut, tree nut, and shellfish allergies were 13.4%, 10.1%, and 9.8%, respectively. This is comparable to the rates of 20% for peanut and 10% for tree nuts that have been shown in other studies.³⁴ The natural history of shellfish allergy has not been systematically studied, although it is thought to be persistent because shrimp-specific IgE levels stayed constant in subjects with shrimp allergy over a 24-month period in a separate follow-up study.³⁵

A prerequisite for emergency preparedness for emergency treatment of anaphylaxis in the community is the availability of self-injectable epinephrine.³⁶ Our data showing a low frequency of prescription of Epipen in our schoolchildren with peanut and tree nut allergy support an earlier Singapore study.³⁷ In the Philippines, self-injectable epinephrine in the form of autoinjectors is not available, possibly because of cost constraints, and this is a cause for concern. These data indicate that anaphylaxis induced by food allergy is not optimally managed in these Asian countries and contrast with the high frequency of prescribed epinephrine autoinjectors in Canada³⁸ and Australia.³⁹

In conclusion, this survey on peanut, tree nut, and shellfish allergy in 2 Asian populations substantiates the notion that the prevalence of peanut and tree nut allergy is relatively low in Asian children, and instead shellfish allergy is more predominant. This pattern contrasts with the pattern of food allergy in other populations and supports the findings of a recent meta-analysis that there is marked heterogeneity in the prevalence of food allergy between populations.⁴⁰

Clinical implications: There is heterogeneity in the prevalence of peanut and tree nut allergy between populations, with lower frequency in the Asian populations studied. In contrast, shellfish allergy is more common in Asians.

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STUDENT'S PARTICULARS

Race: Chinese/Malay/Indian/Others: _____ **Sex:** M/F
Date of birth: _____ (dd/mm/yy)

School: _____ **Class:** _____

Nationality: ☐ Singapore ☐ Others, please specify: _____

Where you born in Singapore?

☐ No. Please state the country where you were born: _____

And the number of years you have been living in Singapore: _____

☐ Yes. Have you spent more than 1 year in another country? ☐ Yes ☐ No ☐ Not Sure

If yes, how were you when you spent the 1 year outside of Singapore?

☐ < 2 years old ☐ 2 to 5 years old

☐ ≥ 5 years old

Please state the country and the period that you were there: _____

PART 1: SURVEY QUESTIONS

1. Has your doctor ever told you that you have any of the following?

• Asthma	Yes ☐	No ☐	Don't know ☐
• Allergic rhinitis or Sensitive nose or Hay fever	Yes ☐	No ☐	Don't know ☐
• Anaphylaxis	Yes ☐	No ☐	Don't know ☐

(very severe allergic reaction in which the throat swells up and closes the airway, or the child may lose consciousness)

• Eczema/Atopic dermatitis	Yes ☐	No ☐	Don't know ☐
• Hives/Urticaria	Yes ☐	No ☐	Don't know ☐

2. Have you ever had peanut allergy?

☐ Yes ☐ No ☐ Never eaten ☐ Not sure, please explain _____

3. Have you ever had allergy to nuts other than peanuts?

☐ Yes ☐ No ☐ Never eaten ☐ Not sure, please explain _____

4. Have you ever had allergy to fish?

☐ Yes ☐ No ☐ Never eaten ☐ Not sure, please explain _____

5. Have you ever had allergy to shellfish (e.g. prawn, crab, lobster, squid, scallops, clams, oysters, mussels, crayfish)?

☐ Yes ☐ No ☐ Never eaten ☐ Not sure, please explain _____

6. Other Food Allergy

☐ Yes please specify type of food: _____

☐ No ☐ Don't know

PART 2: QUESTIONNAIRE SURVEY**Section A: peanut allergy**

If you have ever had peanut allergy, please answer the following questions.

1. About how old were you when you first ate peanut? _____ years old
 1a. If you are not sure, can you give us an estimate?
 < 1 year old ☐
 1 – 5 years old ☐
 6 – 10 years old ☐
 11 – 16 years old ☐
 Don't know ☐
 Never eaten ☐
2. Did you react to peanut the FIRST time you ate them? Yes ☐
 No ☐
 Not sure ☐
 Found out by allergy test, no first reaction ☐
- IF YOU ANSWERED “**FOUND OUT BY ALLERGY TEST**,”
 PLEASE SKIP TO **QUESTION 8**
3. How old were you when you FIRST had a reaction to peanuts? _____ years old
 3a. If you are not sure, can you give us an estimate?
 < 1 year old ☐
 1 – 5 years old ☐
 6 – 10 years old ☐
 11 – 16 years old ☐
 Don't know ☐

QUESTIONS 4 to 7 DEAL WITH YOUR MOST SEVERE REACTION TO PEANUTS

4. During the MOST SEVERE allergic reaction to peanuts, did you have the following symptoms?
- | | | | |
|---|------------------------------|-----------------------------|-------------------------------------|
| ● Hives (urticaria, itchy rash like mosquito bites) | Yes ☐ | No ☐ | Don't know ☐ |
| ● Swelling of eyes (eyelids) | Yes ☐ | No ☐ | Don't know ☐ |
| ● Swelling of lips or face | Yes ☐ | No ☐ | Don't know ☐ |
| ● Vomiting | Yes ☐ | No ☐ | Don't know ☐ |
| ● Diarrhea | Yes ☐ | No ☐ | Don't know ☐ |
| ● Abdominal pain | Yes ☐ | No ☐ | Don't know ☐ |
| ● Congested or running nose | Yes ☐ | No ☐ | Don't know ☐ |
| ● Itchy throat or mouth | Yes ☐ | No ☐ | Don't know ☐ |
| ● Throat tightness or choking | Yes ☐ | No ☐ | Don't know ☐ |
| ● Coughing | Yes ☐ | No ☐ | Don't know ☐ |
| ● Wheezing or trouble breathing | Yes ☐ | No ☐ | Don't know ☐ |
| ● Faint or dizzy | Yes ☐ | No ☐ | Don't know ☐ |
| ● Loss of consciousness | Yes ☐ | No ☐ | Don't know ☐ |
| ● Redness of skin | Yes ☐ | No ☐ | Don't know ☐ |
| ● Other symptoms, please specify _____ | | | |
5. During this MOST SEVERE episode, about how long did it take for the allergic reaction to occur?
 In less than 10 minutes ☐
 In 10 minutes to 1 hour ☐
 In 1 to 2 hours ☐
 In 2 to 12 hours ☐
 After more than 12 hours ☐
 Don't know ☐
6. Did you need/use any of the following in that MOST SEVERE reaction?
- | | | | |
|---|------------------------------|-----------------------------|-------------------------------------|
| ● Treatment at emergency department or hospitalization | Yes ☐ | No ☐ | Don't know ☐ |
| ● Antihistamine (e.g. Piriton, Benadryl, Atarax, Zyrtec, etc) | Yes ☐ | No ☐ | Don't know ☐ |
| ● Epinephrine/Adrenaline (Epipen) | Yes ☐ | No ☐ | Don't know ☐ |
| ● Steroids/Prednisolone | Yes ☐ | No ☐ | Don't know ☐ |
| ● Asthma medicines (e.g. inhalers) | Yes ☐ | No ☐ | Don't know ☐ |
7. Have you had an allergy test to confirm the allergy to peanuts? Yes ☐
 No ☐
 Don't know ☐
8. Have you ever seen a doctor for your allergy to peanuts? Yes ☐
 IF YOU ANSWERED “**NO**” or “**DON'T KNOW**”
 PLEASE SKIP TO **QUESTION 12**
 Don't know ☐
9. Has a doctor ever prescribed injectable epinephrine (Epipen) for you? Yes ☐
 IF YOU ANSWERED “**NO**” or “**DON'T KNOW**”
 PLEASE SKIP TO **QUESTION 12**
 Don't know ☐
10. Do you have injectable epinephrine with you at all times? Yes ☐
 IF YOU ANSWERED “**NO**” or “**DON'T KNOW**”
 PLEASE SKIP TO **QUESTION 12**
 Don't know ☐

(Continued)

PART 2. *(Continued)*

11. Why do you NOT carry injectable epinephrine with you at all times?

Not necessary ☐Avoid peanuts anyway ☐Never been prescribed ☐Not available ☐Others, pls specify: ☐ _____

12. Are you now able to eat peanuts without any reactions?

Still have reactions ☐Eat now with no reaction ☐Haven't eaten again ☐Only react sometimes ☐Don't know ☐

Section B: tree nut allergy

If you have ever had **tree nut (other than peanut) allergy**, please answer the following questions.

1. Which nut are you allergic to? (can tick more than 1)
- | | |
|--|------------------------------------|
| | Almond ☐ |
| | Brazil ☐ |
| | Cashew ☐ |
| | Hazelnut ☐ |
| | Macadamia ☐ |
| | Pecan ☐ |
| | Pine ☐ |
| | Pistachio ☐ |
| | Walnut ☐ |

Others, pls specify _____

- 1a. If you are allergic to more than one nut, indicate which nut gave the most severe reaction (leave blank if not sure).

Name of Nut: _____

QUESTIONS 2 to 13 DEAL WITH YOUR MOST SEVERE REACTION TO NUTS

2. About how old were you when you first ate this nut? _____ years old
- 2a. If you are not sure, can you give us an estimate?
- | | |
|--|--|
| | < 1 year old ☐ |
| | 1 – 5 years old ☐ |
| | 6 – 10 years old ☐ |
| | 11 – 16 years old ☐ |
| | Don't know ☐ |
| | Never eaten ☐ |

3. Did you have an allergic reaction to this nut the FIRST time you ate it?
- | | |
|--|-----------------------------------|
| | Yes ☐ |
| | No ☐ |
| | Not sure ☐ |

IF YOU ANSWERED “**FOUND OUT BY ALLERGY TEST**,”
PLEASE SKIP TO **QUESTION 9**

Found out by allergy test,
no first reaction ☐

4. How old were you when you FIRST had a reaction to this nut? _____ years old
- 4a. If you are not sure, can you give us an estimate?
- | | |
|--|--|
| | < 1 year old ☐ |
| | 1 – 5 years old ☐ |
| | 6 – 10 years old ☐ |
| | 11 – 16 years old ☐ |
| | Don't know ☐ |

5. During the **MOST SEVERE** allergic reaction to this nut, did you have the following symptoms?
- | | | | |
|---|------------------------------|-----------------------------|-------------------------------------|
| ● Hives (urticaria, itchy rash like mosquito bites) | Yes ☐ | No ☐ | Don't know ☐ |
| ● Swelling of eyes (eyelids) | Yes ☐ | No ☐ | Don't know ☐ |
| ● Swelling of lips or face | Yes ☐ | No ☐ | Don't know ☐ |
| ● Vomiting | Yes ☐ | No ☐ | Don't know ☐ |
| ● Diarrhea | Yes ☐ | No ☐ | Don't know ☐ |
| ● Abdominal pain | Yes ☐ | No ☐ | Don't know ☐ |
| ● Congested or running nose | Yes ☐ | No ☐ | Don't know ☐ |
| ● Itchy throat or mouth | Yes ☐ | No ☐ | Don't know ☐ |
| ● Throat tightness or choking | Yes ☐ | No ☐ | Don't know ☐ |
| ● Coughing | Yes ☐ | No ☐ | Don't know ☐ |
| ● Wheezing or trouble breathing | Yes ☐ | No ☐ | Don't know ☐ |
| ● Faint or dizzy | Yes ☐ | No ☐ | Don't know ☐ |
| ● Loss of consciousness | Yes ☐ | No ☐ | Don't know ☐ |
| ● Redness of skin | Yes ☐ | No ☐ | Don't know ☐ |
| ● Redness of skin | Yes ☐ | No ☐ | Don't know ☐ |
| ● Redness of skin | Yes ☐ | No ☐ | Don't know ☐ |
| ● Other symptoms, please specify _____ | | | |

6. During this **MOST SEVERE** episode, after you ate this nut, about how long did it take for the allergic reaction to occur?
- | | |
|--|---|
| | In less than 10 minutes ☐ |
| | In 10 minutes to 1 hour ☐ |
| | In 1 to 2 hours ☐ |
| | In 2 to 12 hours ☐ |
| | After more than 12 hours ☐ |
| | Don't know ☐ |

7. Did you need/use any of the following in that **MOST SEVERE** reaction?
- | | | | |
|---|------------------------------|-----------------------------|-------------------------------------|
| ● Treatment at emergency department or hospitalization | Yes ☐ | No ☐ | Don't know ☐ |
| ● Antihistamine (e.g. Piriton, Benadryl, Atarax, Zyrtec, etc) | Yes ☐ | No ☐ | Don't know ☐ |
| ● Epinephrine/Adrenaline (Epipen) | Yes ☐ | No ☐ | Don't know ☐ |
| ● Steroids/Prednisolone | Yes ☐ | No ☐ | Don't know ☐ |
| ● Asthma medicines (e.g. inhalers) | Yes ☐ | No ☐ | Don't know ☐ |

8. Have you had an allergy test to confirm the allergy to this nut?
- | | |
|--|-------------------------------------|
| | Yes ☐ |
| | No ☐ |
| | Don't know ☐ |

(Continued)

SECTION B. (Continued)

-
9. Have you ever seen a doctor for your allergy to this nut? Yes ☐
IF YOU ANSWERED “**NO**” or “**DON’T KNOW**” No ☐
PLEASE SKIP TO **QUESTION 13** Don’t know ☐
10. Has a doctor ever prescribed injectable epinephrine (Epipen) for you? Yes ☐
IF YOU ANSWERED “**NO**” or “**DON’T KNOW**” No ☐
PLEASE SKIP TO **QUESTION 13** Don’t know ☐
11. Do you have injectable epinephrine with you at all times? Yes ☐
IF YOU ANSWERED “**NO**” or “**DON’T KNOW**” No ☐
PLEASE SKIP TO **QUESTION 13** Don’t know ☐
12. Why do you NOT carry injectable epinephrine with you at all times? Not necessary ☐
Avoid the nuts anyway ☐
Never been prescribed ☐
Not available ☐
Others, pls specify: ☐ _____
13. Are you now able to eat this nut without any reactions? Still have reactions ☐
Eat now with no reaction ☐
Haven’t eaten again ☐
Only react sometimes ☐
Don’t know ☐
-

Section C: shellfish allergy

If you have ever had shellfish allergy, please answer the following questions.

1. Which shellfish are you allergic to? (can tick more than 1)	Prawn/Shrimp ☐ Crab ☐ Lobster ☐ Squid ☐ Scallops ☐ Clams ☐ Oysters ☐ Mussels ☐ Crayfish ☐ Snails ☐ Not sure which shellfish ☐ Others, pls specify: _____ Name of shellfish: _____
1a. If you are allergic to more than one shellfish, indicate which shellfish gave the most severe reaction (leave blank if not sure).	

QUESTIONS 2 to 13 DEAL WITH YOUR MOST SEVERE REACTION TO SHELLFISH

2. About how old were you when you first ate this shellfish?	_____ years old
2a. If you are not sure, can you give us an estimate?	< 1 year old ☐ 1 – 5 years old ☐ 6 – 10 years old ☐ 11 – 16 years old ☐ Don't know ☐ Never eaten ☐
3. Did you have an allergic reaction to this shellfish the FIRST time you ate it?	Yes ☐ No ☐ Not sure ☐

IF YOU ANSWERED “**FOUND OUT BY ALLERGY TEST**,”
PLEASE SKIP TO **QUESTION 9**.

Found out by allergy test,
no first reaction ☐

4. How old were you when you FIRST had a reaction to this shellfish?	_____ years old
4a. If you are not sure, can you give us an estimate?	< 1 year old ☐ 1 – 5 years old ☐ 6 – 10 years old ☐ 11 – 16 years old ☐ Don't know ☐

5. During the MOST SEVERE allergic reaction to shellfish, did you have the following symptoms?	
● Hives (urticaria, itchy rash like mosquito bites)	Yes ☐ No ☐ Don't know ☐
● Swelling of eyes (eyelids)	Yes ☐ No ☐ Don't know ☐
● Swelling of lips or face	Yes ☐ No ☐ Don't know ☐
● Vomiting	Yes ☐ No ☐ Don't know ☐
● Diarrhea	Yes ☐ No ☐ Don't know ☐
● Abdominal pain	Yes ☐ No ☐ Don't know ☐
● Congested or running nose	Yes ☐ No ☐ Don't know ☐
● Itchy throat or mouth	Yes ☐ No ☐ Don't know ☐
● Throat tightness or choking	Yes ☐ No ☐ Don't know ☐
● Coughing	Yes ☐ No ☐ Don't know ☐
● Wheezing or trouble breathing	Yes ☐ No ☐ Don't know ☐
● Faint or dizzy	Yes ☐ No ☐ Don't know ☐
● Loss of consciousness	Yes ☐ No ☐ Don't know ☐
● Redness of skin	Yes ☐ No ☐ Don't know ☐
● Other symptoms, please specify _____	

6. During this <u>MOST SEVERE</u> episode, after you ate this shellfish, about how long did it take for the allergic reaction to occur?	In less than 10 minutes ☐ In 10 minutes to 1 hour ☐ In 1 to 2 hours ☐ In 2 to 12 hours ☐ After more than 12 hours ☐ Don't know ☐
---	---

7. Did you use any of the following in that <u>MOST SEVERE</u> reaction?	
● Treatment at emergency department or hospitalization	Yes ☐ No ☐ Don't know ☐
● Antihistamine (e.g. Piriton, Benadryl, Atarax, Zyrtec, etc)	Yes ☐ No ☐ Don't know ☐
● Epinephrine/Adrenaline (Epipen)	Yes ☐ No ☐ Don't know ☐
● Steroids/Prednisolone	Yes ☐ No ☐ Don't know ☐
● Asthma medicines (e.g. inhalers)	Yes ☐ No ☐ Don't know ☐

(Continued)

SECTION C. (Continued)

-
8. Have you had an allergy test to confirm the allergy to shellfish? Yes ☐
No ☐
Don't know ☐
9. Have you ever seen a doctor for your allergy to shellfish? Yes ☐
IF YOU ANSWERED **"NO"** or **"DON'T KNOW"** No ☐
PLEASE SKIP TO **QUESTION 13** Don't know ☐
10. Has a doctor ever prescribed injectable epinephrine (Epipen) for you? Yes ☐
IF YOU ANSWERED **"NO"** or **"DON'T KNOW"** No ☐
PLEASE SKIP TO **QUESTION 13** Don't know ☐
11. Do you have injectable epinephrine with you at all times? Yes ☐
IF YOU ANSWERED **"YES"** or **"DON'T KNOW"** No ☐
PLEASE SKIP TO **QUESTION 13** Don't know ☐
12. Why do you NOT carry injectable epinephrine with you at all times? Not necessary ☐
Avoid the shellfish anyway ☐
Never been prescribed ☐
Not available ☐
Others, pls specify: ☐ _____
13. Are you now able to eat shellfish without any reactions? Still have reactions ☐
Eat now with no reaction ☐
Haven't eaten again ☐
Only react sometimes ☐
Don't know ☐
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