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Skin Prick Testing to Identify Food Allergens in 8393 Children and Adolescents with Asthma in Chongqing, Southwest China

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Background: The prevalence of food allergies in asthmatic children and adolescents has significantly increased over recent years. Nevertheless, the relevant clinical analyses are still lacking in China. Therefore, the present study aimed to determine common food allergens in pediatric patients with asthma in Chongqing, Southwest China.

Material/Methods: A total of 8393 asthmatic patients from Children's Hospital of Chongqing Medical University (CHCMU) were enrolled in this retrospective study between October 2014 and July 2017. All patients underwent skin prick test (SPT) with 10 food allergens and recorded history of clinical reactivity. The correlations among the positive rates, categories of allergens, gender, age, and living environment were analyzed.

Results: A total of 2544 patients (30.31%) had a positive SPT, while the prevalence of food allergy was 8%. Sea crab, peanut, and sea shrimp were the most common food allergens found in the studied population. The frequent food allergies were sea crab, peanuts, and sea shrimp.

Conclusions: Identifying allergens is important for the diagnosis and management of allergic disorders, and for performing immunotherapy.

MeSH Keywords: **Asthma • Child • Food Hypersensitivity**

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Background

Asthma is the most common chronic respiratory disease among children, with continuously rising prevalence in developing countries [1]. The third nationwide survey of childhood asthma conducted in urban areas of China in 2010 showed that the prevalence over the last 2-years was 2.32% while the total asthma incidence rate was 3.02%, which was 50.6% and 52.8% higher compared to year 2000, respectively. The prevalence in the last 2-years was 3.64%, and the total asthma incidence rate in Chongqing was 4.11% [2]. Numerous studies [3,4] have shown that asthmatic children have higher incidence of severe asthma with food allergy than children without food allergy. Food allergy can trigger asthma [5] and can seriously impact the life quality of children. Food allergy has been identified as an independent risk factor for life-threatening asthma with an adjusted OR of 5.89 (95% CI: 1.06–32.61) [6]. In addition, more severe atopic dermatitis has been reported to be associated with higher prevalence of food allergy [7].

Prescott et al. [8] suggested that the incidence of food allergies in children worldwide has increased from 2% to 8%, especially in infants and young children [9]. China has relatively few reports on the prevalence of food allergy. In Chongqing [10], food allergy increased more than 90% (from 3.5% to 7.7%) from 1999 to 2009. In agreement with elevated prevalence of self-reported food allergy was recently reported in Inner Mongolia (China) [11]. Although food allergies can be outgrown over time, studies have shown that food allergies in infancy may increase the incidence of other allergic diseases later in life [12]. However, a systematic review demonstrated that egg or peanut supplementation to the infant diet early could decrease the incidence related food allergy [13].

The best way to treat food allergies is strict avoidance of trigger foods, which require identifying the type of food allergen. The gold standard for diagnosing food allergies is the food challenge test, which is difficult to implement at our hospital due to culture, economic and lack of fellowship-trained allergists. Meanwhile, the skin prick test (SPT) is minimally invasive, inexpensive, the results are immediately available, and when carried out by trained health professionals, it is reproducible. Therefore, it is the most commonly used test to screen food allergens. Within the Global Asthma and Allergy European Network (GA(2) LEN) it was shown that, depending on the allergen, 40% and 87–89% of positive SPT reactions reflect self-reported clinical symptoms when administered the respective allergen [14]. In allergic rhinitis, the SPT is the most efficient diagnostic method, showing superiority to multiple allergen simultaneous test (MAST) [15]. However, SPT and specific IgE levels were shown not to be associated with reaction severity in food challenge for egg, milk, and multiple tree nut allergens [16].

In different regional population, climate, diet and so on can lead to different kinds of food allergies and different positive allergen rates in different regions, which is why it is very important to understand the distribution of primary food allergens and related factors in children with asthma. Indeed, Eastern and Western individuals show significant differences in food allergies, as well as populations within Asia, and associated environmental risk factors should be investigated [17]. Common food allergens in Chongqing include sea crab, sea shrimp, peanuts, eggs, milk, soybean, beef, and mango [18,19]. Mango and apple allergy are rare in European countries but are common in China and some other countries of East Asia. Data have shown that the mango allergy rate in Taiwan, China [20] is 18.5%, and 12.5% in Japan [21]. The incidence of apple allergies is lower compared to mango allergies, but anaphylactic shock is often reported [22].

The aim of the current study was to determine common food allergens and common food allergies in pediatric patients with asthma in Chongqing, Southwest China. SPT was performed and history of clinical reactivity after eating was collected in asthmatic children and adolescents. The findings could thus be used to provide evidence for the prevention and treatment of childhood asthma.

Material and Methods

Participants

In this retrospective study, 11 824 patients diagnosed with asthma who met the inclusion criteria and underwent SPT between October 2014 and July 2017. None of the patients had been tested for food allergy before. Among these patients, 2598 patients from the area outside Chongqing were excluded, 5 patients less than 0.5 years old were excluded, 659 patients had acute onset of asthma and were excluded, 30 patients who had local skin with severe dermatitis were excluded, 25 patients were excluded because of cachexia, 74 patients were excluded because of loss of data, resulting in 8393 patients (5150 male children and 3243 female children) that were finally included in the study. The mean age was 5.04 years (ranged 0.5 to 18 years). The diagnostic criteria for asthma were based on the Global Initiative for Asthma, scheme 2017 (GINA) [23] which defines asthma as: "heterogeneous disease, usually characterized by chronic airway inflammation and by the history of respiratory symptoms such as wheeze, shortness of breath, chest tightness, and cough that vary over time in intensity, together with variable expiratory airflow limitation".

This study was approved by the Institutional Review Board of CHCMU (Application Receipt Number: (2018) NO.14).

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The patients and/or their guardians were asked about the family history of allergic diseases, concurrent atopic dermatitis, concurrent allergic rhinitis, and history of clinical reactivity. Based on age, the patients were divided into 4 of the following groups: 1762 infants (21%) who were <3 years old, 4917 preschool children (58.58%) who were 3 years ≤ age <7 years, 1115 school-aged children (13.28%) who were 7 years ≤ age <12 years, and 599 adolescents (7.14%) who were 12 years ≤ age ≤18 years). There were 6373 patients (75.93%) from main urban areas, while 2020 patients (24.07%) were from rural areas.

Inclusion and exclusion criteria

The inclusion criteria were as follows: 1) the diagnostic criteria for asthma were done in accordance with 2017 GINA scheme [23]; 2) patients between 0.5 to 18 years old; 3) patients with residence in Chongqing city; 4) patients who were not prescribed antihistamines and systemic glucocorticoids 3 days before the skin test.

Exclusion criteria were as follows: 1) acute onset of asthma; 2) local skin had severe dermatitis preventing execution and interpretation of skin prick tests; 3) cachexia (such as autoimmune disease, immune deficiency and cancer) causing serious adverse reactions in children; 4) loss of data on age or other basic information.

Allergen

Ten standard allergen extracts (Beijing Macro-Union Pharmaceutical Limited Corporation, Beijing, China) were used including peanuts, milk, eggs, mango, apple, soybean, hair-tail, beef, sea shrimp, and sea crab, according to Chongqing children's diet characteristics and Chongqing Medical University Children Hospital breathing center expert consensus. Allergens were all water-soluble and administered at the following doses: soybean, hairtail, shrimp, and sea crab at ≥0.50 mg/mL; peanut and eggs at ≥5.00 mg/mL; mango at ≥0.01 mg/mL; milk at ≥1.00 mg/mL; apple at ≥0.005 mg/mL; and beef at ≥1.50 mg/mL.

SPT

Three allergy nurses were responsible for performing SPT. In the skin prick test, a drop of antigen was placed on the volar forearm part, pricking the central part of the skin that contains the antigen at right angles and piercing into the epidermis. SPT acupuncture depth was achieved with a disposable sterile skin test sensitive point needle provided by Suzhou Shile Medical Equipment Co., Ltd., China. The distance between the allergen extract was 2 cm. Histamine and saline were used as positive and negative controls, respectively. In order to avoid false-positive results, a normal saline negative control was performed at 3 cm above the extract and histamine positive control was performed 3 cm below the extract. Skin tests were graded after 20 minutes. The longest diameter and the longest diameter in the perpendicular plane of each complete reaction were measured with a ruler manufactured by New Beijing Xinhualian Xiehe Pharmaceutical Co., Ltd., China; the wheal diameter was summed and then divided by 2 (mean diameter). Using histamine as a positive contrast solution, we compared the average value of the wheal diameter with the positive contrast solution. Average values 0% were judged as negative; values 1% to 50% were judged as 1+; values 51% to 100% were judged as 2+; values 101% to 200% were judged as 3+; and values above 200% were judged as 4+. Results that were equal or over 1+ were considered as positive responses.

Statistical analysis

SPSS22.0 statistical software (from IBM, Armonk, New York, USA) was used for data analysis. All data were expressed as a mean and standard deviation, while the classification variables were expressed in frequency and percentage. The statistical comparison of the differences was performed using the chi-square test. $P<0.05$ was considered statistically significant.

Results

The distribution of the positive rates of various food allergens

Among the 8393 cases, 2544 children had a positive reaction (30.31%), and 672 children had an allergy (8%). As shown in Table 1, 1567 patients showed positive responses to 1 allergen (18.67%), 693 patients to 2allergens (8.26%), 198 to 3 allergens (2.34%), 60 patients to 4 allergens (0.71%), 19 patients to 5 allergens (0.23%), and 7 patients showed positive responses to 6 allergens (0.08%) (Figure 1). Regarding the family history of disease in patients with a positive SPT, 29% of patients had a parent with allergic diseases, 28.18% of patients had a history of atopic dermatitis, and 17.73% of patients had a history of allergic rhinitis.

Differences between SPT positive rate and different gender, age, and living environment

After stratification by gender and age, the suburb SPT rate was higher compared to the urban area in adolescent females, while no significant difference was found in other groups (Table 2). In addition, higher SPT rate was found in preschool female children compared to preschool male children, while no significant difference was observed in other groups (Table 3).

Furthermore, various food allergens were analyzed between different age groups. Briefly, the highest positive rate was found

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Table 1. The prevalence of food allergen and food allergy with 8393 asthma patients.

Allergen	SPT positive N (%)	Food allergy N (%)
Sea crab	1066 (12.7)	203 (2.42)
Peanuts	945 (11.26)	159 (1.89)
Sea shrimp	590 (7.03)	158 (1.88)
Eggs	400 (4.77)	132 (1.57)
Milk	233 (2.78)	63 (0.75)
Beef	176 (2.1)	33 (0.39)
Mango	106 (1.26)	24 (0.29)
Soybean	236 (2.81)	14 (0.17)
Hair-tail	104 (1.24)	12 (0.14)
Apple	39 (0.46)	8 (0.1)

SPT – skin prick test.

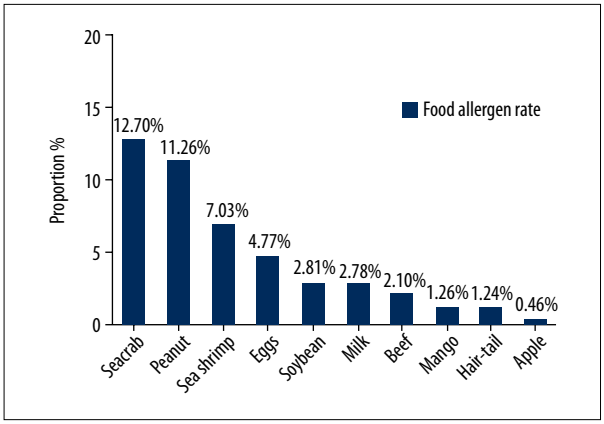

Figure 1. Positive responses towards one or more allergens in asthmatic children.

Table 2. Comparation between SPT positive rate and the living environment.

Sex	Age	Living environment	Cases	SPT positive rate [n (%)]	χ^2 value	P value
Boy	Infancy	Urban	842	271 (32.19%)	0.842	0.447
		Suburb	314	103 (32.8%)		
	Preschool	Urban	2208	641 (29.03%)	0.712	0.373
		Suburb	682	203 (29.77%)		
	School-Age	Urban	546	135 (24.73%)	0.809	0.448
		Suburb	168	40 (23.81%)		
	Adolescence	Urban	300	91 (30.33%)	0.590	0.338
		Suburb	90	30 (33.33%)		
Girl	Infancy	Urban	462	154 (33.33%)	0.276	0.162
		Suburb	144	41 (28.47%)		
	Preschool	Urban	1560	507 (32.5%)	0.678	0.361
		Suburb	467	147 (31.48%)		
	School-Age	Urban	309	72 (23.3%)	0.583	0.337
		Suburb	92	24 (26.09%)		
	Adolescence	Urban	146	48 (32.88%)	0.044	0.032
		Suburb	63	30 (47.62%)		

SPT – skin prick test.

among infants; highest positive response to peanuts was found during infancy and preschool; highest positive response to sea crab was found during school-age and adolescence. In the 4 age groups, the lowest positive response was to apples, while no differences were found in response to milk, eggs, apple, soybean, hail-tail, and beef ($P>0.05$). In addition, significant differences in the positive response to peanuts, mango, sea shrimp, and sea crab were observed ($P<0.05$). The highest positive rate to peanuts was found during infancy, while the lowest was found in school-age; for mango, the highest positive

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Table 3. Comparation between SPT positive rate and sex.

Age group	Sex	Cases	SPT positive rate n (%)	χ^2 value	P value
Infancy	Boy	1156	374 (32.35%)	0.941	0.492
	Girl	606	195 (32.18%)		
Preschool	Boy	2890	844 (29.2%)	0.022	0.012
	Girl	2027	654 (32.26%)		
School-Age	Boy	714	175 (24.51%)	0.832	0.446
	Girl	401	96 (23.94%)		
Adolescence	Boy	390	121 (31.03%)	0.119	0.071
	Girl	209	78 (37.32%)		

SPT – skin prick test.

Table 4. Comparing food allergen test results in different age groups.

	Infancy	Preschool	School-age	Adolescence	χ^2 value	P value
N	1762	4917	1115	599		
Peanuts	299 (16.97%)	607 (12.34%)	81 (7.26%)	58 (9.68%)	106.435	0.001
Milk	55 (3.12%)	136 (2.77%)	25 (2.24%)	17 (2.84%)	1.967	0.579
Eggs	94 (5.33%)	236 (4.8%)	45 (4.04%)	25 (4.17%)	3.041	0.385
Mango	16 (0.91%)	66 (1.34%)	10 (0.9%)	14 (2.34%)	8.770	0.033*
Apple	13 (0.74%)	16 (0.33%)	7 (0.63%)	3 (0.5%)	5.562	0.135
Soybean	41 (2.33%)	139 (2.83%)	43 (3.86%)	13 (2.17%)	6.875	0.076
Hairtail	26 (1.48%)	56 (1.14%)	15 (1.35%)	7 (1.17%)	1.336	0.721
Beef	26 (1.48%)	110 (2.24%)	25 (2.24%)	15 (2.5%)	4.383	0.223
Sea shrimp	170 (9.65%)	287 (5.84%)	79 (7.09%)	54 (9%)	32.807	0.001
Sea crab	272 (15.44%)	579 (11.77%)	116 (10.4%)	93 (15.53%)	25.397	0.001

rate was found in adolescence and the lowest during school-age period; for sea shrimp, the highest positive rate was found in infancy and the lowest in school-age; for sea crab, the highest positive rate was found in adolescence and the lowest in school-age period (Table 4).

Discussion

Food allergy manifests as an adverse immune reaction to food allergens. The prevalence of food allergy and asthma have increased worldwide over the past 3 decades. They are seen in 2~8% of children, mostly in infants and small children [24]. Our study found food allergy in 8% of the studied population. Higher rates (9.3%) have been reported in Honduras [25]. In the present study, the sensitization to at least one food allergen was found in 30.31% of patients, which was less compared to rate of 40% reported in Iran [26]. Nonetheless, lower sensitization rates of 23% have been found in Spain [25]. The present findings corroborate previous findings indicating an increasing trend of food allergy in Chongqing. Indeed, Hu et al. conducted a study of Chinese infants in Chongqing comparing food allergy prevalence in 2009 versus 1999, and found an increase from 3.5% to 7.7%, which was in agreement with the rates of a positive skin-prick-test response (9.9% and 18% in 1999 and 2009, respectively; P=0.002) [10].

In the present study, main food allergens in the asthmatic children from Chongqing included sea crab (12.7%), peanuts (11.26%), sea shrimp (7.03%), and eggs (4.77%). In the Hu et al. study, eggs and cow milk remained the most common food allergens in most pediatric patients [10]. However, our data were in line with other similar studies performed on asthmatic children in China; for example, Yinghui et al. [27] concluded

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that the main food allergens in 189 asthmatic children from Nanyang, Henan, are milk, eggs and shrimp. Zhengzhou et al. analyzed 1299 children from Henan province who were tested for food allergens, and identified eggs, milk, and cod as the main allergens [28]. In a Mexico study conducted in the year 2013–2014, the highest frequency of suspected allergic reactions was related to milk (44.5%), fruit (25.4%), eggs (21.8%), cereals (19.6%), and seafood (13.6%) [29]. Furthermore, James et al. [3] examined 300 city students from the United States and identified peanuts and nuts as the major food allergens. Data from the United States and Eastern Europe [24] suggest that the most common food allergies in children are milk (2% to 3.5%), eggs (1.3% to 3.2%), and peanuts (0.6% to 1.3%). Children from Japan [30] appear to be the most allergic to eggs, milk, and wheat, which accounted for 60% of all allergens. Compared with previous studies conducted in other cities and regions of China, Chongqing has a higher incidence of seafood sensitization. This might be explained by the location, which is inland from Chongqing, and thus is less exposed to sea crabs and other seafood.

The prevalence of shellfish allergy in Asian populations is likely to be more common than in the western world. Shellfish has been demonstrated to be one of the top-ranking causes of food allergy in children in the Asian Pacific region [31], which might be related to the fact that Asian Pacific region has the highest seafood consumption in the world [31]. Sea shrimp and sea crab, as a kind of shellfish, had higher food sensitization and food allergy rates in our study. Myosin was the primary sensitized substance; about 65% of prawn allergens caused the same symptoms as crab, while 20% of the clinical patients had a cross-reaction. These patients demonstrated a 7.03% and 12.7% sensitization to sea shrimp and sea crab allergens, respectively. Similar sensitization rates have been found in northwest China [32]. Sea shrimp and sea crab allergy was confirmed in 1.88% and 2.42% of the patients in our study, which is similar to rates reported by a study conducted in Singapore where a prevalence of 5.23% was found for shellfish [33].

Hair-tail is an uncommon food allergen; its sensitization is 1.24%. Higher sensitization for this allergen was found in Chongzhou, China with a prevalence of 10.6% [34]. Hair-tail allergy prevalence confirmed via history of clinical reactivity in our study was 0.14%.

Peanuts and soybeans are common foods in the Asian food culture. In the present study, sensitization to peanuts (11.26%) was the second most frequent allergen, and peanut allergy was 1.89%. This rate was higher compared to a study of Honduran children where 4.9% to 9.4% reacted to this food allergen [25]. Peanut allergy in Honduras was reported to be 0.8% [25] and in Singapore it was reported to be 0.64% [34]. Peanuts contain 44% to 56% fat and 22% to 30% protein [35]. There are 12 peanuts allergens [36], among which Ara h 2 is the most important one and is also a predictor of clinical response to peanuts. Peanuts and nuts have cross-allergic reactions. A previous study [37] showed that 60% of people that are allergic to peanuts are also allergic to 1 or more nuts, while the most common allergic response (49%) was to hazelnuts. Soybeans are one major vegetable protein. Another study reported a 1.3% positive SPT reaction in Iran [38]; the prevalence in our study was 2.81%. Soybean allergy in the present study was 0.17%, which was a lower rate than rates in a Honduras study of 0.5% [25] and rates in European countries of 0.7% [39].

Eggs and milk are universal food allergens worldwide. The present study demonstrated a 4.77% prevalence in sensitization rate for eggs. A previous study showed that this rate was higher (6.16%) in northwest China [32]. Worldwide records estimate a 0% to 18% egg allergy in children of all ages [40], while the prevalence in our present study was 1.57%. Milk sensitization was found in 2.78% of the patients in our study. Higher rates have been reported in Honduras at 9% [25], Brazil at 9.1% [41], and 5.6% in Australia [42]. Milk allergy was found in 0.75% of participants in this study, which was similar to findings reported in Singapore 0.5% [34]. IN the United States the rate was reported to be (19.9%) [43].

Fruit allergy is a rare phenomenon in western countries, while it is very common in Korea (fruit allergy in Korea is estimated to be 6.7% [44]), Japan, China and other Asian countries. A study in northwest China reported a 3.18% sensitivity rate to mango, and 2.02% to apple [32]. Another study in Xinjiang China showed apple sensitization. Data our present study revealed sensitivity prevalence of 1.26% to mango, and 0.46% to apple. The clinically relevant prevalence of mango allergy was 0.29%. This prevalence was lower compared to Shaoguan, China (1.4%) [45], Taiwan, China (18.5%) [20], and Japan (12.5%) [21]. Apple allergy in our study was confirmed in 0.1% of the patients. A study in Germany revealed the highest prevalence estimates that were calculated for apple at 1.7% [46].

The reports about beef allergy are very rare even though beef is a main source of protein in some countries. Data in the present work showed sensitivity prevalence of 2.1% to beef, which was lower compared to a study in Tangshan, China where sensitization rates were 4.35% [47]. In the present study, the beef allergy was confirmed in 0.39% of the children. The data found in this study were lower than those reported in Vietnam (0.8% to 3%) [48].

In our study, the food sensitization rate detected by SPT was significantly higher than food allergy rate. The reason for such high discrepancy (false positivity) is not known and might be possibly be explained by cross-reactivity. For example, cross-reactivity

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of red meat with gelatin [49]; lipid transfer protein comprises a highly homologous amino acid sequence with that in peach, rice, tomato, spinach, apple, pollens, and soybean [50]; several studies have reported high rates (up to 90%) of IgE cross-reactivity between the crustaceans and the Mollusca group based on skin prick testing [31]; dust mite and cockroach sensitized individuals also displayed sensitization to shellfish suggesting cross reactivity between tropomyosins [31]. In addition, atopic inflammation skin testing (for example: atopic dermatitis) gives more false positive results. In our study, 28.18% of patients had atopic dermatitis, which could potentially lead to false positive results. Meanwhile, food protein-induced enterocolitis (FPIES) represents a non-IgE cell- mediated food allergy that can be severe and lead to shock [51]. Some other factors, such as smaller skin area and strain limits prick testing in small children could also have altered our study results.

People with 2 or more food allergies are more likely to have serious reactions compared to those with only 1 food allergy. Our study showed that among asthmatic children, 1567 (61.6%) were positive to 1 allergen (18.67%), while 977 (38.4%) were positive to 2 or more allergens. Contrary, James et al. [5] examined 300 children diagnosed with asthma and found food allergy in 73 cases (24.3%) where 37 patients (50.7%) were positive to 1 allergen and 36 patients (49.3%) to 2 or more allergens. Furthermore, this study has shown that the incidence of daytime symptoms and lifetime hospitalization in children with food allergies are almost twice as common compared to those without food allergies [52]. In children with 2 or more food allergies, the risk of daytime symptoms is increased by 3 times; the risk of lifetime hospitalization is increased by 5 times; the risk of hospitalization is increased by 4 times per 12 months; the hospitalization risk associated with asthma is increased by 3.5 times; the use of asthma control drugs also tripled. In our study, grade 2 was the highest positive rate and grade 4 was the lowest positive rate in food allergens. Friedlander et al. [4] reported that the higher variety among food allergies implies allergies of heavier degree, increased daytime symptoms and hospitalization as well as risk factors such as decreased lung function. This suggests that the more variety among foods allergens translates into more severe allergies, with symptoms that are more difficult to control.

In our study, SPT positive rate was higher in adolescents from suburban areas compared to adolescents from urban areas. There was no significant difference between female population in other age groups, or in any age group of male population. Logistic regression analysis also showed that there was no statistically significant difference between urban and suburban areas. The absence of significant difference between food allergens in the same area may be associated with dietary changes and adjustments in adolescent girls from urban areas. The logistic regression analysis revealed a significant difference in SPT positive rate between genders, which was in line with Ruchi's analysis [53] of food allergies among children in Chicago public schools and was contrary to the analysis of gender differences in asthma allergens in the Songjiang region of Shanghai [53]. The latter could be explained by inhalation of food allergens, which was a study requirement. Specific to each age group, preschool girls showed significantly higher rates than boys. The fact that there was no difference between the genders in other age groups could be explained with the fact that parents feed preschool children with different types and kinds of food.

This study compared the various food allergens in different age groups; the main identified allergens in infancy and preschool children were peanuts, sea crabs, and sea shrimp. The main allergens in school-age and adolescence were sea crab, peanuts, and sea shrimp. The positive rates to sea crab, sea shrimp, and peanuts were high in all age groups. The difference between mango and shrimp varied greatly from age to age, and this difference was statistically significant. There was no statistically significant difference in rates among remaining food allergens. Analysis of food allergens in Shijiazhuang tested in 217 children [37] showed that: in children aged 5 months to 3 years old major food allergens were shrimp, meat, sea crab, and soybean; in children 3 to 5 years old the major food allergens were sea shrimp, sea crab, eggs, fish, and soybean; in children 5 to 14 years old the major food allergens were soybean, sea shrimp, milk, and sea crab. Although all positive rates to food increased with age, rates to milk were the only ones that were statistically significant. In Japan [30], in infants aged <1-year, hen's eggs, cow's milk, and wheat were the 3 major causative food allergens that represented approximately 90% of the total causative foods. The allergic reactions to hen's eggs and cow's milk sharply decreased in 12 months old children. In contrast, in school-age children, the probability of crustacean and fruit allergies increased while that for hen's eggs and cow's milk allergies decreased. Therefore, the positive reaction to wheat remained high in all age groups. Compared with Shijiazhuang, Chongqing had higher allergen rates for peanuts and lower soybean allergen rates. These differences might be associated with greater exposure to soybeans, which is the main economic crop in Chongqing, and with lower exposure to peanuts. Due to differences in diet and geographical environment, there were big differences between Chongqing and Japanese food allergies and relative change across different life stages.

The most common food allergens in the present study were sea crab, peanuts, and sea shrimp. These data might contribute to a better understanding of the distribution of food allergens in children and adolescents with asthma in Chongqing. It is an important step for the appropriate diagnosis and management of food allergies and asthma in children and adolescents.

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A study [54] suggested that an asthma attack or aggravation of asthma is associated with food allergies. It is very important to improve the management of food allergies in children and adolescents with asthma and to reduce or prevent asthma attacks or aggravation in clinical practice.

The strengths of the present study are the very large number of patients (age from 0.5 to 18 years) included in the study as well as the fact that the current study was a unique report from a selected population in China that thus far has been underrepresented in the published literature.

This study had a few limitations. First, a positive skin prick test indicates sensitization but not necessarily clinical allergy and testing with food allergens might not reflect atopy to aero-antigens associated with asthma. In addition, the selection of skin test devices might affect the size of the mean wheal diameter. Furthermore, the sample was limited to Chongqing area and not compared with other regions. Finally, oral food challenge was not performed in this study because it is unethical and impractical.

Conclusions

To the best of our knowledge this is the first study that examined food allergens and food allergy in asthmatic population aged 0.5 to 18 years in Chongqing district. Somewhat contrary to other districts, the main allergens for asthmatic children and adolescents were sea crab, peanuts, and sea shrimp. Among 8393 patients, 2544 patients (30.31%) had food sensitization, 672 patients (8%) had food allergy; the maximum number of food sensitization per 1 patient was 6. Infants had the highest levels of food sensitization and food allergy. Our results showed that the food sensitization and food allergy in children and adolescents with asthma in Chongqing had their own characteristics. It is imperative to work toward an accurate food allergy management and treatment programs where patients with asthma and food allergy can get access to proper and timely management of their condition.

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Conflict of interests

None.

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