RESEARCH ARTICLE

Prevalence of food-allergen and aeroallergen sensitization among people in Sichuan, Western China: An 8-year observational study

Zhuochun Huang¹ | Weihua Feng¹ | Wei Wei² | Bin Yang¹ | Lanlan Wang¹

¹Department of Lab Medicine, West China Hospital, Sichuan University, Chengdu, China

²West China Medical School, Sichuan University, Chengdu, China

Correspondence

Bin Yang and Lanlan Wang, Department of Lab Medicine, West China Hospital, Sichuan University, Chengdu, China.
Emails: yangbinhx@scu.edu.cn;
wanglanlanhx@163.com

Funding information

National Natural Science Foundation of China (Grant number: No. 81772258, 81501816, 81601830). Foundation of Science and Technology bureau of Sichuan Province (2017FZ0070, 2017SZ0150, 2018FZ0106).

Background: Identifying the distribution of allergens is invaluable to effective diagnosis and treatment of allergic disease. The present study aims to analyze the epidemiology of allergens in Sichuan, Western China.

Methods: A total of 14 030 participants including 8031 men and 5999 women were enrolled in this study during 2007–2014 in West China Hospital. An assay testing for the presence of allergen-specific IgE was used to identify highly immunogenic allergens.

Results: Of the 14 030 total participants, 3470 (24.72%) were sensitive to at least one of tested allergens. The most immunogenic allergens were mite mix (1876, 13.38%), crab (876, 6.24%), sea-fish mix (865, 6.16%), house dust (355, 2.54%), and cockroach (292, 2.08%). The differences between population of participants who were sensitive to food allergens and aeroallergens were statistically significant in 0 to 10, 11 to 20, 21 to 30, 41 to 50, and 51 to 60 year-old age-groups (all $P < 0.05$). Distributions of three food allergens and two aeroallergens were significantly different between male and female participants. There was also an increase in sensitization to cow's milk, mutton, sea-fish, and mould that was observed in the 71 to 90 year-old group.

Conclusion: The most common allergens presented in Sichuan were observed to be mites, crab, sea-fish, and house dust. There was an observable difference in sensitivity to five allergens between males and females. Additionally, aeroallergens appeared to have a greater immunogenic effect in younger populations while the elderly presented with increased sensitization to specific allergens, suggesting that specific allergens' immunogenicity was age-dependent.

KEYWORDS

aeroallergen, age, food allergen, gender, prevalence, sensitization

1 | INTRODUCTION

The incidence of allergic diseases has been continuously increasing in recent decades.^{1,2} Allergic diseases are caused by pathological hyperresponsiveness by host immune systems to foreign antigens.¹ Aeroallergens (eg, mites, cockroach, and house dust) and

food allergens (eg, fish, crab, and shrimp) are the most common allergens.^{3,4} Even though some components of the pathophysiology behind allergic responses continue to elude researchers, it is universally accepted that debilitating pathologies such as asthma,⁵ allergic rhinitis,⁶ and eczema⁷ are, in large part, the direct result of the reaction mounted by a sensitized host immune system to a specific

allergen. In the most extreme cases, these reactions can even result in death.^{8,9} Therefore, it is undeniable that further exploration into the factors that contribute to allergic responses is critical for improving public health. Identifying allergen distributions is key to understanding these diseases because knowing common allergens can help to detect culprit allergens of allergic patients more exactly.^{10,11} It has been shown that allergens vary widely from region to region, depending on geographic location, climates, and lifestyles.^{3,12-14} Moreover, people of different ages have different sensitive allergens.^{15,16} Hence, local data of distribution of allergens are important and needed to be investigated. However, data elucidating the distribution of common allergens in Sichuan, Western China, are lacking.

Immunoglobulin E (IgE) is a critical molecule in type 1 allergic reaction.^{17,18} Specific IgE test is based on the combination of antigen and serum antigen-specific IgE antibody of participants. The great advantage of specific IgE test is that it does not cause skin rashes or other allergies while skin prick test and food challenge test may cause.

This study aims to use an IgE-specific test to investigate the distribution of common allergens in Sichuan, a basin located in Western China with a humid climate, to provide reference for allergen finding under allergic disease circumstance in such or similar geographic and climate area.

2 | MATERIALS AND METHODS

2.1 | Subjects

This study was approved by the Institutional Review Board of Sichuan University which included an Ethics Committee. Adult participants provided their written informed consents, and infant participants' informed consents were written by their guardians to participate in this study. A total of 14 030 participants who received specific IgE tests in West China Hospital between January 2007 and November 2014 were enrolled in this study. All participants were people who received routine medical examinations. Those participants included 8031 men (57.24%) and 5999 women (42.76%). The mean age of participants was 41.93 ± 14.49 years (old range 1 month to 90 years old). For investigating the difference of different allergens in different ages, participants were divided into eight age-groups (range 1 month to 90 years old): 0-10 years old (645, 4.60%), 11-20 years old (541, 3.86%), 21-30 years old (1292, 9.21%), 31-40 years old (3052, 21.75%), 41-50 years old (5242, 37.36%), 51-60 years old (2213, 15.77%), 61-70 years old (753, 5.37%), and 71-90 years old (292, 2.08%).

2.2 | Blood samples

We took blood samples (3 mL) from participants with a BD Vacutainer tube containing sodium heparin. All blood samples were stored at 2-8°C until testing. Before testing, all samples were incubated at room temperature (18-25°C) for 30 minutes.

2.3 | Serum specific IgE analysis

Serum specific IgE was tested by EUROBlotMaster (EUROIMMUN, Luebeck, Germany) with method Euro11 Allerg EL60 and EUROLINE Atopy China (IgE) kit (EUROIMMUN). Specific IgE to 10 food allergens (egg white, peanut, soybean, cow's milk, beef, mutton, crab, shrimp, sea-fish mix [cod, lobster, and scallop], and freshwater fish mix [salmon, weever, and carp]) and 10 aeroallergens (cat hair, dog dander, cockroach, *Humulus japonicus*, *Ambrosia artemisifolia*, *Artemisia vulgaris*, tree mix 2 [willow, poplar, and elm], mite mix 1 [*Dermatophagoides farinae* and *Dermatophagoides pteronyssinus*], house dust, and mould mix 1 [*Penicillium notatum*, *Cladosporium herbarum*, *Aspergillus fumigatus*, and *Alternaria alternata*]) were tested in this study. Positive bands, indicating the presence of allergen-specific IgE antibodies, were confirmed by two independent, experienced technicians.

2.4 | Statistical analysis

Descriptive analyses, chi-square tests, and odds ratios (OR) were performed by SPSS software (version 19.0; SPSS; Chicago, IL, USA). The chi-square tests were used to analyze differences of the distributions of allergens between different groups. The Bonferroni method was used to correct the significant levels, and the $P < 0.0025$ for single allergen and $P < 0.012$ for food allergens, aeroallergens, or whole allergens were considered statistically significant for difference between male and female participants. The $P < 0.05$ was considered statistically significant of difference between food allergens and aeroallergens in different age-groups.

3 | RESULTS

3.1 | Distribution of allergens in participants

Of 14 030 total participants, 3470 (24.72%) were sensitive to at least one of the tested allergens. A total of 2119 (15.10%) were sensitive to at least one food allergen, 2344 (16.72%) were sensitive to at least one aeroallergen, and 5264 (37.5%) were sensitive to both food allergens and aeroallergens. The allergens with the highest incidence of sensitivity among study participants were mite mix (1876, 13.38%, aeroallergen), crab (876, 6.24%, food allergen), sea-fish mix (865, 6.16%, food allergen), house dust (355, 2.54%, aeroallergen), and cockroach (292, 2.08%, aeroallergen; Figure 1).

3.2 | Distribution of allergens in different age-groups

The differences between population of participants who were sensitive to food allergens and aeroallergens were statistically significant in 0 to 10, 11 to 20, 21 to 30, 41 to 50, and 51 to 60 year-old age-groups (all $P < 0.05$). Analytical data showed a heightened sensitivity to aeroallergens across all age-groups except for the 51 to 60 year-old age-group, which presented with increased sensitivity

FIGURE 1 Distribution of allergens in participants

to food-borne allergens (Figure 2). Overall, sensitivity to allergens trended negatively with increasing age, up to around 50 years old. The trend then seemed to reverse in older age-groups (>50 years old) in both food allergens and aeroallergens (Figure 2). Interestingly, Figures S1 and S2 (supplementary data) show people older than 70 had significantly increased sensitization against cow's milk, mutton, sea-fish mix, and mould mix.

Analysis of distribution of food allergens and aeroallergens in different age-groups indicated mite mix, sea-fish mix, and crab were the most common allergens of all ages. Nevertheless, some allergens seemed to show age-specific. Egg sensitization was mostly observed in children under 10 years old. Sensitive to house dust was more frequent before age 20. Cat hair led to allergy predisposing mainly before age 30 (Figure S3 in supplementary data).

For the 0-10 age-group, the first three allergens were mite mix, house dust, and sea-fish mix. For the age-group 11-20, the first three allergens were mite mix, house dust, and crab. From 21 to 50 year-old people, mite mix, crab, and sea-fish mix were primary allergens. To people age above 50, major allergens were mite mix, sea-fish mix, and crab (Figure S4 in supplementary data).

3.3 | Difference of distribution of allergens between male and female participants

Analysis in Table 1 showed sensitization against at least one food allergen was more common in men than in women, especially for

allergens crab, shrimp, and sea-fish mix. As to aeroallergens, heightened sensitivity to cat hair was more common in women, while sensitization against cockroach was more frequent in men. Other distributions of allergens listed in Table 1 were not significantly different between male and female participants (all $P > 0.0025$).

4 | DISCUSSION

In this study, 3470 (24.72%) of total 14 030 participants were sensitive to at least one allergen. Our study showed that the most common allergens of allergic participants in Sichuan, China, were mite mix (1876, 13.38%), crab (876, 6.24%), sea-fish mix (865, 6.16%), house dust (355, 2.54%), and cockroach (292, 2.08%) among 20 testing allergens. Our result was consistent with the epidemiological survey that mites, fish, and crab were the most common allergens in China,¹⁹⁻²¹ while the distributions of cat hair (125, 0.89%), dog dander (103, 0.73%), and tree pollen (95, 0.68%) were less common than those in American and European.^{22,23} That might depend on different geographic locations, environment, and lifestyles as less families kept pets in China and difference of vegetation distribution. However, with some alteration of Chinese lifestyles and environment, changes in the distributions of allergens were predictable and needed to be continuously monitored to improve population health.

In different age-groups, food allergens and aeroallergens showed different distributions. In groups of 0- 10, 11 - 20, 21 - 30, and

FIGURE 2 Distribution of food allergens and aeroallergens in different age-groups. The dashed lines stand for the variation trend.

* $P < 0.05$

41-50 years old, distribution of aeroallergens was more common than food allergens. Food allergens showed more common distribution in the 51 to 60 year-old group, and in other groups, the distributions of two kinds of allergens were similar. The data of groups of 0-10 years old and 11-20 years old were consistent with a study done in Iran that aeroallergens were more common than food allergens in young participants with allergic symptoms.²⁴ In Iran study, percentage of participants who sensitive to allergens were much higher than that of ours (most >30% for food allergens and >70% for aeroallergens), which showed that people with allergic symptoms were more sensitive.

First, we noticed that the group of 0-10 years old showed high sensitization to most food allergens than other groups, while sensitization to aeroallergens did not show this phenomenon. Recent studies revealed that the intestinal microbiology of infants in 0-5 years old was not established as well as that of adults and the intestinal microbe could affect the immune function of gut and in turn affect the allergy to food,^{25,26} which could explain our finding. We found egg had the most common distribution in group of 0 to 10 year-old group than any other age-group (8.37% in 0-10 years old group and <1% in other groups), and the difference was huge, which conformed to the allergic data in Asia.²⁷ That indicated parents should be careful when they feed their children with egg. Cow's milk distributed most commonly in groups of 0-10 years old and 71-90 years old (2.95% and 1.03%, respectively). The distribution of 0 to 10 year-old group was expected,²⁸ while the result of the 71 to 90 year-old group showed a new opinion. Milk protein allergy became a worldwide medical concern while most

study paid attention to infants and young children but not old people. Old people in 71-90 years old had higher morbidity of many diseases such as cancer and Alzheimer's disease, and their health conditions were usually not good.^{29,30} Allergic diseases could do harm to the old as badly as to children. Our result suggested that old people should be more careful about cow's milk. Moreover, the sensitization to egg, mutton, and sea-fish rose up again in the 71 to 90 year-old group. Meanwhile, all other allergens showed peaks of sensitization in the young age-groups and sensitization got lower with older age. We attributed those phenomena to younger people had more active immune system while older people had less active one, and the chaotic inner environment of old people might contribute to those phenomena as well.^{31,32} Phenomena discussed above suggested that the complexity of allergies of old people should be studied in the future.

In the present study, five allergens' distributions were showing significant differences between male and female participants: crab, shrimp, sea-fish mix, cat hair, and cockroach. Crab, shrimp, and sea-fish mix showed higher allergic risk in men. That may depend on the different dietary habits. Women were more sensitive to cat hair than men. This finding was similar to the study of Bertelsen R. J and could be explained as different lifestyles causing different possibilities of contact.³³ While an epidemiological survey that enrolled 7047 participants in Guangzhou Province, which is located in southern China, showed no significant difference in the distributions of allergens between men and women,³⁴ we attributed the inconformity to the different geographic areas and our larger study samples. Moreover,

TABLE 1 Difference of distribution of allergens between male and female participants

Allergens	Men, n (%) n = 8031	Women, n (%) n = 5999	P	OR (95% CI)
Food allergens [*]				
Egg [*]	49 (0.61)	51 (0.85)	0.095	0.716 (0.483-1.061)
Peanut [*]	141 (1.76)	139 (2.32)	0.019	0.754 (0.595-0.955)
Soybean [*]	102 (1.27)	110 (1.83)	0.007	0.689 (0.525-0.904)
Cow's milk [*]	31 (0.39)	19 (0.32)	0.495	1.220 (0.688-2.162)
Beef [*]	7 (0.09)	9 (0.15)	0.275	0.581 (0.216-1.560)
Mutton [*]	5 (0.06)	3 (0.05)	0.763	1.245 (0.298-5.213)
Crab [*]	571 (7.11)	305 (5.08)	9.11E-07	1.429 (1.239-1.649)
Shrimp [*]	215 (2.68)	77 (1.28)	1.05E-08	2.116 (1.628-2.751)
Sea-fish mix 1 [*]	539 (6.71)	326 (5.43)	0.002	1.252 (1.087-1.443)
Freshwater fish mix 1 [*]	107 (1.33)	80 (1.33)	0.996	0.999 (0.747-1.338)
At least one food allergen ^{**}	1276 (15.88)	843 (14.05)	0.003	1.156 (1.052-1.279)
Aeroallergens [*]				
Cat hair [*]	53 (0.66)	72 (1.20)	0.001	0.547 (0.383-0.781)
Dog dander [*]	48 (0.60)	55 (0.92)	0.029	0.650 (0.441-0.959)
Cockroach [*]	194 (2.42)	98 (1.63)	0.001	1.491 (1.167-1.905)
<i>Humulus japonicus</i> [*]	19 (0.24)	27 (0.45)	0.029	0.525 (0.291-0.944)
<i>Ambrosia artemisifolia</i> [*]	63 (0.78)	40 (0.67)	0.418	1.178 (0.792-1.754)
<i>Artemisia vulgaris</i> [*]	123 (1.53)	129 (2.15)	0.006	0.708 (0.552-0.908)
Tree mix 2 [*]	58 (0.72)	37 (0.62)	0.451	1.173 (0.775-1.773)
Mite mix 1 [*]	1063 (13.25)	813 (13.56)	0.585	0.973 (0.882-1.073)
House dust [*]	191 (2.39)	164 (2.73)	0.202	0.872 (0.706-1.077)
Mould mix 1 [*]	65 (0.81)	52 (0.87)	0.712	0.933 (0.647-1.346)
At least one aeroallergen ^{**}	1320 (16.44)	1024 (17.08)	0.032	0.956 (0.874-1.045)
At least one allergen ^{**}	2012 (25.03)	1458 (24.29)	0.313	1.041 (0.963-1.125)

OR, odds ratio.

^{*}P < 0.0025 was considered statistically significant.^{**}P < 0.012 was considered statistically significant.

the survey in Guangzhou and our study both showed more men than women participants had allergic symptoms.

The study sample of our study was larger than other epidemiologic survey in China, but all participants were people who received routine medical examinations and the kit we used only included 20 allergens; thus, some sensitive allergens might be missed, which might cause selection bias. And based on the principle of medical confidentiality, our data did not include the allergic events of participants; hence, we could not analyze the relationship between allergens and diseases. Studies with clinical data and comprehensive samples were needed to perform in the future.

In summary, our study indicated that the most common allergens in Sichuan, Western China, were mite, sea-fish, crab, and

house dust. We found the distribution of crab, shrimp, sea-fish, cat hair, and cockroach showed significant differences between male and female participants. Sensitizations of all allergens had peaks in participants with young age and old people's sensitization to cow's milk, mutton, sea-fish, and mould rose again in the 71 to 90 year-old group. Further research on the allergic response in elderly populations is needed.

ACKNOWLEDGMENTS

We are grateful to the participating allergic participants and their families. We also thank Michal Jandzinski and Yun Liao (Cleveland clinic) for language editing.

ORCID

Lanlan Wang <http://orcid.org/0000-0002-0601-1275>

REFERENCES

- Linneberg A. The increase in allergy and extended challenges. *Allergy*. 2011;66(Suppl 95):1-3.
- McGowan EC, Keet CA. Prevalence of self-reported food allergy in the National Health and Nutrition Examination Survey (NHANES) 2007-2010. *J Allergy Clin Immunol*. 2013;132(5):1216-1219.e5.
- Boulet L-P, Turcotte H, Laprise C, et al. Comparative degree and type of sensitization to common indoor and outdoor allergens in subjects with allergic rhinitis and/or asthma. *Clin Exp Allergy*. 1997;27(1):52-59.
- Gendel SM, Khan N, Yajnik M. A survey of food allergen control practices in the U.S. food industry. *J Food Prot*. 2013;76(2):302-306.
- Ridolo E, Albertini R, Giordano D, Soliani L, Usberti I, Dall'Aglio PP. Airborne pollen concentrations and the incidence of allergic asthma and rhinoconjunctivitis in Northern Italy from 1992 to 2003. *Int Arch Allergy Immunol*. 2007;142(2):151-157.
- Patil VK, Kurukulaaratchy RJ, Venter C, et al. Changing prevalence of wheeze, rhinitis and allergic sensitisation in late childhood: findings from 2 Isle of Wight birth cohorts' 12-years apart. *Clin Exp allergy*. 2015;45(9):1430-1438.
- Bhattarai S, Agrawal S, Rijal A. Clinical and contact allergological observations on hand eczema: a descriptive study. *Nepal Med Coll J*. 2014;16(1):37-41.
- Xu YS, Kastner M, Harada L, Xu A, Salter J, Wasserman S. Anaphylaxis-related deaths in Ontario: a retrospective review of cases from 1986 to 2011. *Allergy Asthma Clin Immunol*. 2014;10(1):38.
- Cantisani C, Visconti B, Paolino G, et al. Unusual food allergy: alioidea allergic reactions overview. *Recent Pat Inflamm Allergy Drug Discov*. 2014;8(3):178-184.
- Park HJ, Lim HS, Park KH, Lee JH, Park JW, Hong CS. Changes in allergen sensitization over the last 30 years in Korea respiratory allergic patients: a single-center. *Allergy Asthma Immunol Res*. 2014;6(5):434-443.
- Farrokhi S, Gheybi MK, Movahed A, et al. Common aeroallergens in patients with asthma and allergic rhinitis living in southwestern part of iran: based on skin prick test reactivity. *Iran J Allergy Asthma Immunol*. 2015;14(2):133-138.
- Lumia M, Luukkainen P, Kaila M, et al. Maternal dietary fat and fatty acid intake during lactation and the risk of asthma in the offspring. *Acta Paediatr*. 2012;101(8):e337-e343.
- Black PN, Sharpe S. Dietary fat and asthma: is there a connection? *Eur Respir J*. 1997;10(1):6-12.
- D'Amato G, Liccardi G, D'Amato M. Environmental risk factors (outdoor air pollution and climatic changes) and increased trend of respiratory allergy. *J Investig Allergol Clin Immunol*. 2000;10(3):123-128.
- Leonardi A, Piliago F, Castegnaro A, et al. Allergic conjunctivitis: a cross-sectional study. *Clin Exp Allergy*. 2015;45(6):1118-1125.
- Dupont C, Hol J, Nieuwenhuis EE, Cow's Milk Allergy Modified by Elimination and Lactobacilli Study Group. An extensively hydrolysed casein-based formula for infants with cows' milk protein allergy: tolerance/hypo-allergenecity and growth catch-up. *Br J Nutr*. 2015;113(07):1102-1112.
- Frew AJ. The immunology of respiratory allergies. *Toxicol Lett*. 1996;86(2-3):65-72.
- Valenta R, Kraft D. Type 1 allergic reactions to plant-derived food: a consequence of primary sensitization to pollen allergens. *J Allergy Clin Immunol*. 1996;97(4):893-895.
- Kim JS, Ouyang F, Pongracic JA, et al. Dissociation between the prevalence of atopy and allergic disease in rural China among children and adults. *J Allergy Clin Immunol*. 2008;122(5):929-935.e924.
- Hill DJ, Hosking CS, Zhie CY, et al. The frequency of food allergy in Australia and Asia. *Environ Toxicol Pharmacol*. 1997;4(1-2):101-110.
- Smit DV, Cameron PA, Rainer TH. Anaphylaxis presentations to an emergency department in Hong Kong: incidence and predictors of biphasic reactions. *J Emerg Med*. 2005;28(4):381-388.
- Ogershok PR, Warner DJ, Hogan MB, Wilson NW. Prevalence of pollen sensitization in younger children who have asthma. *Allergy Asthma Proc*. 2007;28(6):654-658.
- Dales RE, Cakmak S, Judek S, Coates F. Tree pollen and hospitalization for asthma in urban Canada. *Int Arch Allergy Immunol*. 2008;146(3):241-247.
- Hosseini S, Shoormasti RS, Akramian R, et al. Skin prick test reactivity to common aero and food allergens among children with allergy. *Iran J Med Sci*. 2014;39(1):29-35.
- Russell SL, Finlay BB. The impact of gut microbes in allergic diseases. *Curr Opin Gastroenterol*. 2012;28(6):563-569.
- Wopereis H, Oozeer R, Knipping K, Belzer C, Knol J. The first thousand days - intestinal microbiology of early life: establishing a symbiosis. *Pediatr Allergy Immunol*. 2014;25(5):428-438.
- Lee AJ, Thalayasingam M, Lee BW. Food allergy in Asia: how does it compare? *Asia Pac Allergy*. 2013;3(1):3-14.
- Kim J, Kim HY, Park MR, et al. Diagnostic decision points of specific IgE concentrations in Korean children with egg and cow's milk allergies. *Allergy Asthma Immunol Res*. 2015;7(4):332.
- Polidori MC, Ruggiero C, Croce MF, et al. Association of increased carotid intima-media thickness and lower plasma levels of vitamin C and vitamin E in old age subjects: implications for Alzheimer's disease. *J Neural Transm (Vienna)*. 2015;122(4):523-530.
- Kluthcovsky AC, Urbanetz AA. Fatigue and quality of life in breast cancer survivors: a comparative study. *Rev Bras Ginecol Obstet*. 2015;37(3):119-126.
- Rozsa L, Apari P, Muller V. The microbiome mutiny hypothesis: can our microbiome turn against us when we are old or seriously ill? *Biol Direct*. 2015;10:3.
- Atsmon J, Caraco Y, Ziv-Sefer S, et al. Priming by a novel universal influenza vaccine (Multimeric-001)-a gateway for improving immune response in the elderly population. *Vaccine*. 2014;32(44):5816-5823.
- Bertelsen RJ, Instanes C, Granum B, et al. Gender differences in indoor allergen exposure and association with current rhinitis. *Clin Exp Allergy*. 2010;40(9):1388-1397.
- Sun BQ, Zheng PY, Zhang XW, Huang HM, Chen DH, Zeng GQ. Prevalence of allergen sensitization among patients with allergic diseases in Guangzhou, Southern China: a four-year observational study. *Multidiscip Respir Med*. 2014;9(1):2.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

How to cite this article: Huang Z, Feng W, Wei W, Yang B, Wang L. Prevalence of food-allergen and aeroallergen sensitization among people in Sichuan, Western China: An 8-year observational study. *J Clin Lab Anal*. 2019;33:e22723. <https://doi.org/10.1002/jcla.22723>