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Prevalence of Self-Reported Food Allergy in Six Regions of Inner Mongolia, Northern China: A Population-Based Survey

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Background: The aim of this study was to determine the prevalence of self-reported food allergy in 6 regions of Inner Mongolia, northern China.





Material/Methods: A random cluster sampling population study using a field questionnaire was distributed to 4714 individuals in 6 regions within Inner Mongolia, northern China; the study included ethnic Mongol minorities and Chinese Han populations. The questionnaire obtained data on ethnicity, age, sex, level of education, income, socioeconomic status, rural versus urban location, medical and family history, and food allergy.

Results: There were 4441 (73.5%) completed questionnaires. The prevalence of self-reported food allergy was 18.0% (15.2% men; 20.6% women) and was age-related, being significantly greater in children compared with adults (38.7% vs. 11.9%) ($P < 0.001$). There was a significant difference in self-reported food allergy between rural and urban populations (14.6% vs. 21.4%) ($P < 0.001$) and between Mongolian and Han populations (20.8% vs. 15.8%) ($P < 0.001$). Socioeconomic status, higher education level, and increased family income were significantly correlated with the prevalence of food allergy ($P < 0.001$). Participants with allergic diseases and atopic family history were at increased risk ($OR > 1$, $P < 0.001$). There were no significant associations between the prevalence of food allergy and birth history, infant feeding, and duration of breastfeeding.

Conclusions: An increase in the prevalence of self-reported food allergy was found in the Inner Mongolia region of northern China, which was greater in urban areas compared with rural areas.

MeSH Keywords: **Food Hypersensitivity • Prevalence • Risk Factors • Self Report • Socioeconomic Factors**

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Background

Food allergy is defined as an immune-mediated reaction to certain foods or components of foods [1,2]. Adverse reactions to food were first reported in the 16th century and included reactions to dietary fish and egg, but food allergy is now known to be prevalent worldwide and has recently been shown to be increasing [3]. Epidemiological studies in developed countries have shown that between 1.4% and 33% of the population reported adverse reactions to food [4–8]. Food allergy has been associated with a negative psychosocial impact, anxiety, impaired quality of life, and is also a cause of cases of anaphylaxis in patients who present to hospital emergency departments [6,9,10].

Food allergy is associated with a broad array of signs and symptoms that may involve the skin, gastrointestinal tract, respiratory tract, and cardiovascular system [11]. The common risk factors for food allergy include childhood age, female gender, comorbidity with atopic diseases, industrialized lifestyle, and overuse of antibiotics [12,13]. The diagnosis of food allergy requires a detailed and reliable patient history and the results of allergen testing, including the skin prick test, the allergen-specific IgE (sIgE) antibody test and, if indicated, oral food challenges. In population-based studies, allergen testing has been unavailable in most cases, and so self-reported prevalence is frequently used in these studies [4,6,7,14]. Due to reporter bias, self-reported prevalence of food allergy may be exaggerated, however, the consensus is that when auxiliary tests are not available, then self-reported prevalence of food allergy could be an appropriate tool to evaluate the prevalence in a population-based study [1,15].

The prevalence of food allergy is well documented in developed countries and appears to be increasing, but the prevalence remains unknown in most emerging countries [11,16]. Currently, there is limited population-based information on the prevalence of self-reported food allergy in China. Therefore, the aim of this study was to determine the prevalence of self-reported food allergy in 6 regions of Inner Mongolia, northern China.

Material and Methods

Study population

A cross-sectional epidemiological survey was conducted in Inner Mongolia, northern China, between May 2015 to August 2015, in 6 regions that included Erenhot, Xilinhot, Duolun, Tongliao, Kailu, and Jarud regions. Study participants were enrolled to participate in the survey using random cluster sampling. The local population distribution was considered and adjusted before cluster sampling based on data obtained from

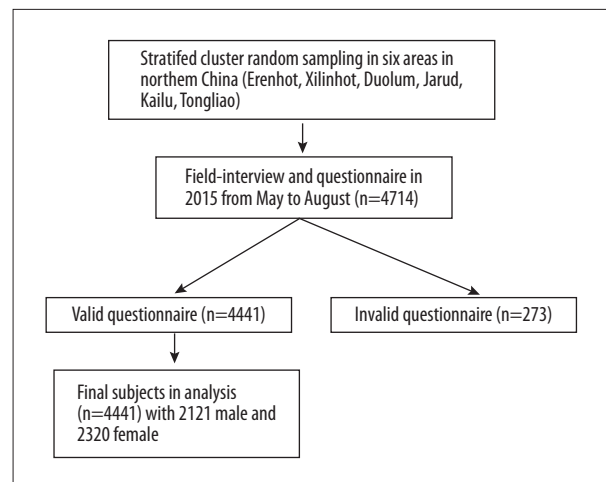


Figure 1. Flowchart of the study design of a population-based survey of 6 regions of Inner Mongolia, northern China, from May 2015 to August 2015.

the 2010 national population census. Figure 1 illustrates the study design using a flowchart.

Field interview study

In each area, different districts were selected as sampling units. The interviewers consisted of allergists and investigational staff who were trained before the study commenced. The standard procedure flowchart (Figure 1) was applied for each investigational site. The selected participants were notified by telephone or face-to-face meeting and were attended at the investigational site. The questionnaire was completed by the participants or by the parents, if the participants were <18 years of age.

Approval to conduct this study was granted by the institutional review boards of Beijing Shijitan Hospital, The Affiliated Hospital of the Beijing Capital Medical University, and of all 6 participating municipalities. All participants signed a written informed consent before the interview.

Study questionnaires

The participants were required to complete a specially designed questionnaire during the field interview by themselves, or by their parents if they were <18 years of age. Data on demographic information, family history, past medical disease history, allergic disease history (including allergic rhinitis, allergic conjunctivitis, asthma, drug allergy, eczema, and urticaria), smoking habit, cooking and heating mode, pets and livestock, infant breastfeeding history, and dietary details were collected using the same questionnaire for all participants. Also, the height (barefoot) and body weight for all study participants were measured.

Definition of the components of the self-reported food allergy questionnaire

In this study, the presence of self-reported food allergy was defined by asking all participants whether they had experienced a reaction to food during the past year, in the absence of supporting confirmatory tests and clinical diagnosis. Multiple food allergies were defined as ≥ 3 self-reported food allergens.

Ethnicity was determined from the study participant's identity (ID) card, as Mongolian or Han. The body mass index (BMI) was defined according to the World Health Organization (WHO) criteria, with a BMI < 25 kg/m² (lean or healthy); a BMI between 25–29 kg/m² (overweight), and a BMI ≥ 30 kg/m² (obese). Education status was categorized as low (primary education only, or no education), medium (completion of secondary school or high school) and high (graduated from college or university).

Statistical analysis

Categorical data were described as numbers and percentages. Continuous data were presented as the median and interquartile range (IQR). Between group differences in participant characteristics were tested using a Wilcoxon rank sum test for continuous variables, and the chi-squared and Fisher's exact test for categorical variables. Multivariate logistic regression analysis was performed to analyze the risk factors related to self-reported food allergy and to estimate the odds ratio (OR). All tests were 2-sided with a significance level of $P < 0.05$. Statistical analysis of data was performed using SAS software version 9.4 (SAS Institute Inc., NC, USA).

Results

Demographic characteristics of self-reported food allergy: sex, age, and ethnicity

Among the 4714 participants who were recruited to complete the survey, 4441 individuals responded (73.5%), which included 2121 men and 2320 women respondents. Table 1 summarizes the characteristics of the study participants and compares variables between the food allergy and non-food allergy participants

Of the 4441 individuals included in the study, 800 (18.0%) reported at least 1 food allergy. The prevalence of self-reported food allergy was significantly greater in women compared with men (20.6% vs. 15.2%) ($P < 0.001$). The prevalence of food allergy was 11.9% (410 out of 3433) in adults, which was significantly lower than in children which was 38.7% (390 out of 1008) ($P < 0.001$). A female gender preponderance was found

in the adult group but not the child group ($P < 0.001$, $P = 0.335$, respectively). As shown in Figure 2A, the self-reported prevalence of food allergy decreased significantly with age ($P < 0.01$). The highest prevalence of self-reported food allergy was found in the age group between 1 and 10 years, with a prevalence of 40.0%, followed by the age group of between 11 and 20 years, with a prevalence of 29.0%. The lowest self-reported prevalence of food allergy was present in the > 60 years old group (6.7%). The median (IQR) age of the participants with self-reported food allergy was significantly lower than the participants without self-reported food allergy ($P < 0.001$) (Table 1). Among 6 studied regions, the prevalence was highest in Xilinhot but lowest in Jarud, which was in consistent with age distribution and family income ($P < 0.001$).

The Mongolian participants in this survey had a greater prevalence of food allergy when compared with Han participants (20.8% vs. 15.8%) ($P < 0.001$). Participants who lived in urban areas had a higher prevalence of self-reported food allergy when compared with participants living in rural areas (21.4% vs. 14.6%) ($P < 0.001$).

Demographic characteristics of self-reported food allergy: socioeconomic factors

Participants who had a higher level of education had a higher prevalence of self-reported food allergy ($P < 0.01$), as shown in Table 1. The findings of this study also showed a significant correlation between family income and the prevalence of self-reported food allergy. The median (IQR) family income of participants with food allergy was higher than in the non-food allergy group ($P < 0.001$). With a higher family income, there was a greater prevalence of self-reported food allergy ($P < 0.001$) (Figure 2B). Noteworthy is a significant correlation between education status and family income ($r = 0.305$, $P < 0.001$). The household family number was associated with an increased prevalence of self-reported food allergy but had no significant difference while adjusted for age ($P = 0.286$, OR = 0.73, 95% CI 0.41–1.29).

Concomitant diseases and food allergy

The concomitant diseases with food allergy were analyzed in the adult group. As shown in Table 2, the prevalence of hypertension in individuals with self-reported food allergy was significantly lower compared with the non-food allergy participants ($P = 0.002$). There was no difference in the rate of cardiovascular disease, diabetes, or stroke between the 2 groups. Participants with self-reported food allergy had a significantly increased rate of other allergic diseases, as shown in Table 3. The OR = 1.57 (95% CI, 1.347–1.840) for allergic rhinitis; OR = 1.59 (95% CI, 1.355–1.860) for allergic conjunctivitis; OR = 3.55 (95% CI, 2.790–4.524) for asthma; OR = 3.31 (95% CI, 2.506–4.345)

Table 1. Demographic characteristic of the study population.

Characteristic	FA (n=800)	Non-FA (n=3641)	P value	Total (n=4441)
Age, median (IQR)	19.24 (34.10)	39.28 (28.17)	<0.001	36.64 (30.59)
Gender, N (%)				
Male	322 (15.2)	1799 (84.8)	<0.001	2121
Female	478 (20.6)	1842 (79.4)		2320
Age group, n (%)				
<18y	390 (38.7)	618 (61.3)	<0.001	1008
≥18y	410 (11.9)	3023 (88.1)		3433
Ethnicity, n (%)				
Han	392 (15.8)	2083 (84.2)	<0.001	2475
Mongolian	371 (20.8)	1416 (79.2)		1787
Other	37 (20.7)	142 (79.3)		179
Residence, n (%)				
Rural	479 (21.4)	1755 (78.6)	<0.001	2234
Urban	321 (14.6)	1883 (85.4)		2204
Region, n (%)				
Erenhot	180 (21.2)	670 (78.8)	<0.001	850
Xilinhot	136 (22.3)	475 (77.7)		611
Duolun	114 (17.5)	539 (82.5)		653
Jarud	116 (12.8)	788 (87.2)		904
Kailu	112 (16.0)	586 (84.0)		698
Tongliao	142 (19.6)	583 (80.4)		725
Education level, n (%)*				
Low	44 (6.1)	675 (93.9)	<0.001	719
Medium	166 (11.5)	1274 (88.5)		1440
High	200 (15.8)	1069 (84.2)		1269
Marriage status				
Unmarried	66 (14.2)	399 (85.8)	0.233	465
Married	334 (11.6)	2539 (88.4)		2873
Divorced/widowed	4 (4.6)	62 (95.4)		87
Family number				
1	15 (13.8)	94 (86.2)	<0.001	109
2	76 (11.2)	601 (88.8)		677
≥3	709 (19.4)	2944 (80.6)		3653
Family income, median (IQR)**	5.0 (6.9)	5.0 (4.8)	<0.001	5.0(5.0)
BMI, n (%)***				
Lean or healthy	600 (21.4)	2210 (78.6)	<0.001	2810
Overweight	147 (12.9)	994 (87.1)		1141
Obesity	52 (10.7)	435 (89.3)		487

* Education was categorized as low (received only primary education or no education), medium (finished secondary school or high school) and high (graduated from college or university) and was only calculated in adult group. ** Family income was calculated as 10,000RMB/year. *** BMI was categorized according to the World Health Organization criteria, with BMI <25 kg/m² defined as lean or healthy, BMI between 25 and 29 kg/m² defined as overweight, and BMI ≥30 kg/m² defined as obese.

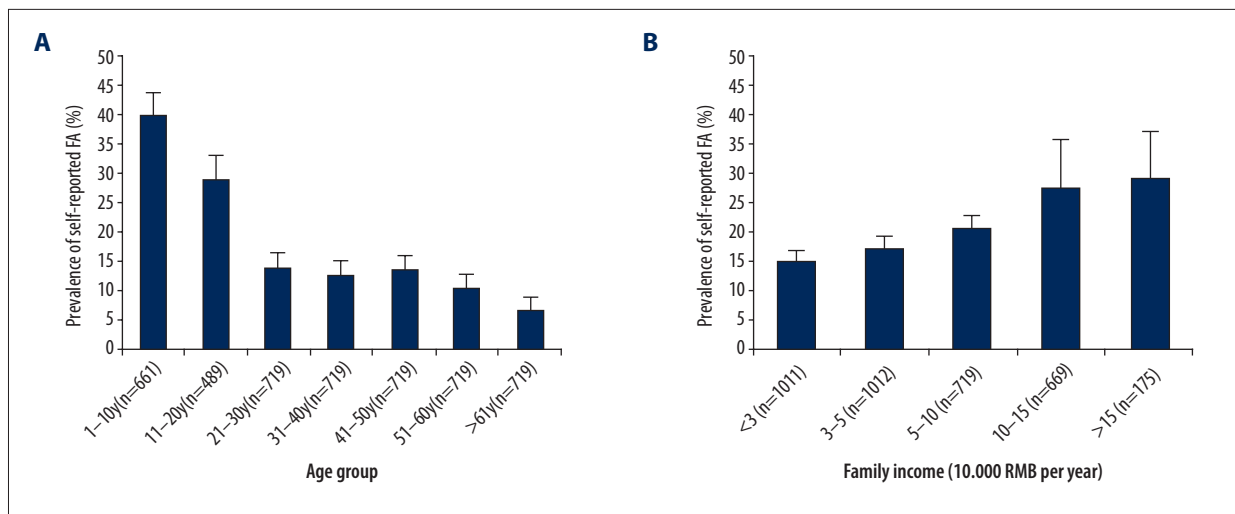


Figure 2. Prevalence of self-reported food allergy with age, family income, and social status. **(A)** The age difference of the prevalence of self-reported food allergy, which shows that the decline in prevalence was significantly associated with increasing age ($P<0.001$). **(B)** The prevalence of self-reported food allergy is shown to increase significantly with family income and economic status ($P<0.001$).

Table 2. Concomitant metabolic disease with food allergy only performed in adult group.

Metabolic disease	FA	Non-FA	P value	Total
Hypertension	81 (29.3)	675 (39.2)	0.002	756
Cardiovascular disease	87 (31.5)	569 (33.1)	0.609	656
Diabetes	20 (7.2)	156 (9.1)	0.321	176
Stroke	8 (2.9)	28 (1.6)	0.141	36

for eczema. The prevalence of food allergy in common allergic patients was higher in the child group than in the adult group: in allergic rhinitis, allergic conjunctivitis, asthma, urticaria ($P<0.001$) and in drug allergy ($P=0.022$).

Common risk factors for food allergy

Commonly assumed risk factors for self-reported food allergy were analyzed by multivariate regression analysis, and included a family history of atopy, keeping a pet, smoking, the mode of heating, patterns of infant feeding and breastfeeding time. The associations between these factors and the self-reported food allergy and the non-food allergy participants are shown in Table 4.

Study participants who had a positive family history of atopy had a higher risk of developing food allergy (OR=2.24, 95% CI, 1.917–2.626). The use of central heating resulted in a greater risk of developing food allergy compared with wood heating (OR=1.58, 95% CI, 1.222–2.051). Other risk factors including smoking habit, pet keeping, overuse of antibiotics, feeding pattern, infant delivery mode, and duration of breastfeeding

were not associated with a significantly increased risk of developing food allergy.

The self-reported allergic food allergens and multiple food allergy

The most common self-reported food allergens in the child group were shrimp and crab (20.4%), egg (11.2%), mango (10.0%), peach (10.0%), and milk (9.6%) while in the adult group, they were shrimp and crab (31.6%), peach (6.3%), fish (6.3%), mutton (4.9%), and wheat (3.6%). Multiple food allergy was defined as ≥ 3 self-reported food allergens. Multiple food allergy was 29.9% in the child group while 12.9% in the adult group ($P<0.001$).

Discussion

This population-based survey was undertaken to determine the prevalence of self-reported food allergy in 6 regions of Inner Mongolia, northern China, showing a high prevalence of food allergy (18.0%). This finding was greater than the prevalence

Table 3. Prevalence of food allergy in allergic group.

Allergic diseases	<18y				≥18y				Total			
	FA	Non-FA	P	OR (95%CI)	FA	Non-FA	P	OR (95%CI)	FA	non-FA	P	OR (95%CI)
Allergic rhinitis	150 (38.5)	176 (28.5)	0.001	1.57 (1.200–2.053)	198 (48.3)	1020 (33.7)	<0.001	1.83 (1.490–2.258)	348 (43.5)	1196 (32.9)	<.001	1.57 (1.347–1.840)
Allergic conjunctivitis	114 (29.2)	118 (19.1)	<0.001	1.75 (1.301–2.354)	205 (50.0)	955 (31.6)	<0.001	2.17 (1.758–2.667)	319 (39.9)	1073 (29.5)	<0.001	1.59 (1.355–1.860)
Asthma	67 (17.2)	37 (5.9)	<0.001	3.26 (2.132–4.977)	59 (14.4)	145 (4.8)	<.0001	3.34 (2.417–4.605)	126 (15.8)	182 (5.0)	<0.001	3.55 (2.790–4.524)
Eczema*	NA	NA	NA	NA	85 (20.7)	222 (7.3)	<0.001	3.31 (2.506–4.345)	85 (20.7)	222 (7.3)	<0.001	3.31 (2.506–4.345)
Urticaria	118 (30.3)	131 (21.2)	0.001	1.61 (1.207–2.155)	166 (40.5)	575 (19.0)	<0.001	2.89 (2.331–3.599)	284 (35.5)	706 (19.4)	<0.001	2.29 (1.937–2.703)
Drug allergy	85 (23.2)	176 (30.2)	0.019	0.70 (0.518–0.944)	154 (39.4)	475 (16.0)	<0.001	3.42 (2.731–4.286)	239 (31.6)	651 (18.3)	<0.001	2.06 (1.73–2.456)
Vaccine allergy	13 (3.5)	30 (5.1)	0.245	0.68 (0.348–1.312)	5 (1.3)	11 (0.47)	0.015	3.44 (1.190–9.957)	18 (2.3)	41 (1.2)	0.010	2.05 (1.172–3.591)

* Only performed in adult group. NA – not available. The prevalence of food allergy in atopy group was higher in child than in adult except vaccine allergy.

of food allergy reported in a recent systematic review that reported that food allergy affected between 2%–10% of the American population and was also greater than the self-reported overall prevalence of food allergy in Canada, of 6.6% [13,17–19]. Nwaru et al. reported a lifetime prevalence of self-reported food allergy of 6% [13]. A meta-analysis, published in 2007, reported a range of estimated prevalence for self-reported food allergy from 3–35% [20,21]. A study performed in Canada in 2009 showed a prevalence of self-reported food allergy of 8.1% [22]. Our findings demonstrated a higher prevalence of self-reported food allergy in northern China.

There is published evidence of a sharp increase in the prevalence of food allergy at an estimated rate of 1.2% per decade [23]. Jackson et al. reported an increase of food allergy from 3.4% in 1997–1997 to 5.1% in 2009–2011 in the USA [8]. However, in some Asian countries, the reported prevalence of food allergy has been much lower. A study in India found that 1.2% of individuals had food allergy [13]. In a cross-sectional survey, 11% of Ghanaian schoolchildren reported adverse reactions associated with food [24]. In southwest China, the prevalence of food allergy increased from 3.5% to 7.7% in children between 1999–2009 [25]. Therefore, self-reported food allergy can vary between different regions and countries, and

local dietary habits should be considered in epidemiological studies of food allergy prevalence.

In the present study, a key finding was that the prevalence of self-reported food allergy declined with increasing age. This finding is consistent with the natural history of food allergy, which mostly occurs in childhood as the immune system (IgE) responds to specific food proteins and goes into remission in adulthood despite some food allergy that could occur in adulthood. In the present study, the prevalence of food allergy in children was significantly greater than in adults, which was in accordance with previous studies from Canada and the USA [12,22,23]. Many food allergies, particularly allergies to milk, egg, soy, and wheat, are usually outgrown within the first 10 years of life. In contrast, allergies to peanut, tree nuts, fish, and shellfish can be lifelong, although 20% of individuals may also outgrow peanut allergy [23,26]. In our study, the main self-reported allergy food for child were shrimp and crab, egg, mango, peach, and milk while in adult, they were shrimp and crab, peach, fish, mutton, and wheat. This finding was consistent with previous studies and outgrowing child allergies [26,27]. The multiple food-allergic pattern was more common in children than in adults according to our data. Recently, a research by Andorf et al. [28] analyzed the mutual components and gave us a clue to explore the mechanism of multiple allergy.

Table 4. Common risk factors among subjects with food allergy(FA) by multivariate logistic regression models.

Variable	FA, n (%)				P	OR (95%CI)*
	Yes n=800		No n=3641			
Family history						
No	383	(13.7)	2422	(86.3)		1
Yes	397	(26.2)	1119	(73.8)	<0.001	2.24 (1.917–2.626)
Pet keeping						
No	611	(18.4)	2712	(81.6)		1
Yes	169	(17.0)	825	(83.0)	0.320	0.91 (0.754–1.907)
Smoking habit						
Never smoking	330	(13.4)	2130	(86.6)		1
Now smoking	52	(7.3)	658	(92.7)	0.118	1.32 (0.931–1.878)
Heating mode						
Wood heating	75	(13.0)	503	(87.0)		1
Coal heating	94	(17.0)	460	(83.0)	0.06	1.37 (0.987–1.904)
Central heating	582	(19.1)	2466	(80.9)	0.001	1.58 (1.222–2.051)
Antibiotics use (>3 times/year)						
No	579	(17.5)	2732	(82.5)		1
Yes	202	(19.6)	827	(80.4)	0.118	1.86 (0.739–4.661)
Feeding pattern**						
Breast feeding	301	(38.4)	482	(61.6)		1
Mixed feeding	88	(39.3)	136	(60.7)	0.983	1.03 (0.754–1.334)
Delivery mode**						
Cesarean section	153	(38.7)	242	(61.3)		1
Natural	237	(38.7)	376	(61.3)	0.982	0.99 (0.769–1.293)
Full-term birth**						
No	19	(36.5)	33	(64.5)		1
Yes	371	(38.8)	585	(61.2)	0.745	1.11 (0.598–2.052)
Breast feeding time**						
<6-month	63	(38.2)	102	(61.8)		1
>6-month	301	(38.2)	487	(61.8)	0.997	1.00 (0.708–1.413)

* Adjusted odds ratio including gender, age, region, education level. ** Only performed in child group.

Most of the ethnic differences in the prevalence of food allergy have been studied in African Americans, individuals of East Asian ethnicity, and Caucasians, and found a higher risk of food allergy in African Americans and in individuals with parents of East Asian ethnicity who were 3-times more likely to have a food allergy compared with individuals with parents

of Caucasian ethnicity [29]. In New Zealand, Pacific Islanders have been shown to have an increased risk of food-associated anaphylaxis compared with other ethnic groups [30]. In the USA, African American children have a higher risk of food allergy compared with Caucasian children; the increased rate of food allergy per decade in African Americans was 2.1 times

greater than for Caucasians, and the increased rate of food allergy per decade for white Hispanics was 1.2 times greater than for Caucasians [23].

One study conducted in 2016 found a higher prevalence of hypertension in a Mongolian group [31]. However, differences between self-reported food allergy in the Han and Mongolian population in northern China, which are the 2 main populations in Inner Mongolia, have not been previously studied. In the present study, the Mongolian population had a higher prevalence of self-reported food allergy than the Han population which was presumed to be due to either different genetic background or different dietary habits between the 2 populations, most likely due to genetic factors.

There have been several proposed risk factors for food allergy, including gender, ethnicity, genetics (family history), co-existing atopic diseases, the influence of the microbiome, vitamin D deficiency, obesity, the timing and route of exposure to foods, feeding patterns in infancy, which several of them have been addressed in this study. Food allergy is more common in developed countries, which indicates that socioeconomic status may be involved in the development of food allergy [32]. The present study showed that participants who had a higher education status or higher economic income were more likely to report food allergy, which is consistent with findings of previous studies [22,33]. Soller et al. reported that individuals residing in households that had a higher level of education or were born in Canada were more likely to report food allergy [22]. Pawlinska-Chmara et al. reported an increased prevalence of food allergy in families with highly educated parents living in favorable economic conditions [33]. The positive correlation between high socioeconomic status and prevalence of food allergy may be attributed to a variety of factors that include the fact that individuals in this socioeconomic group tend to be aware of their health and seek for medical diagnosis, and their clean-living conditions may under stimulate the immune system, leading to reduced immune tolerance to food allergens.

Participants with atopic (allergic) disorders tend to have a higher prevalence of food allergy. In the present study, the risks of developing a food allergy in atopic participants were high (OR >1), especially in individuals with asthma (OR >3). The development of food allergy was closely associated with asthma, which was in accordance with the findings of Liu et al. [12]. Therefore, food allergy might be a marker for a generalized phenotype for atopy and suggests that atopic diseases coexist and may share the susceptibility genes, especially asthma and eczema, as suggested by the findings of this study.

As in other chronic diseases, food allergy is also influenced by genes and environmental factors, which result in epigenetic

effects [12]. Several recent clinical guidelines on atopic disease suggest a family history of atopic diseases could be a risk factor for developing food allergy [16,34]. In this study, a positive family history could increase the risk of food allergy of 2.24 times. Environmental antigen exposure in early life may play an important role in the development of food allergy. Factors associated with an urbanized lifestyle such as microbial exposure, antibiotic use, and dietary habits, were hypothetical to be relevant as food allergy according to previous studies [15,32]. Higher economic status of participants living in urban regions could result in improved living conditions and enhanced urbanized lifestyle, resulting in a higher prevalence of food allergy.

In the present study, no correlation was found between infant feeding patterns or the time of introduction of solid food, or the food delivery mode, and the prevalence of self-reported food allergy. This is supported by the findings of the Enquiring About Tolerance (EAT) trial, which attempted to introduce allergenic food to infants at 4 months of age and found no preventive effects [35]. Bleach et al. introduced hen eggs to infants and found no preventive effects [36]. However, Netsuke et al. performed a similar study in children with eczema and showed a reduced risk of food allergy [37]. The Learning Early About Peanut Allergy (LEAP) study revealed that early consumption of peanuts in infants at high risk of peanut allergy could prevent the development of peanut allergy [38]. Currently, there is consensus for recommendations for the early introduction of allergenic food (peanut) to atopic infants released by several national allergy associations in 2015 [39]. However, a more recent result also from LEAP demonstrated that early introduction of peanuts could only protect peanut allergy but not other allergic diseases [40]. There is also insufficient evidence that breastfeeding and its duration results in protection from food allergy [34].

This study has several limitations. Because it was undertaken using subjective self-reporting questionnaires, the overall prevalence of food allergy could have been over-reported. However, characterizing all the adverse reactions to foods and determining which reaction could be IgE-mediated would have made the questionnaire longer and could have resulted in a lower compliance rate in the completion of the questionnaires. The second main study limitation was that over-representation of higher family income individuals in this study could have resulted in an overestimate of the prevalence of food allergy in the general population. Therefore, in future studies, attention to the design of the self-reporting questionnaire and the relationship between family income and the prevalence of food allergy requires further study.

Conclusions

The findings of this study have shown an increase in the prevalence of self-reported food allergy in the Inner Mongolia region of northern China, which was greater in urban areas compared with rural areas. These findings may inform public health officials on the disease burden of food allergy and may lead to recommendations for prevention and reduction of the effects of food allergy.

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Conflicts of interest

None.

References:

- Sicherer SH: Epidemiology of food allergy. *J Allergy Clin Immunol*, 2011; 127(3): 594-602
- Bartuzi Z, Kaczmarek M, Czerwionka-Szaflarska M. et al: Position Paper of Food Allergy Section the Polish Society of Allergology on the diagnosis and management of food allergies. *Alergologia Polska – Polish Journal of Allergology*, 2017; 4(3): 109-22
- Verrill L, Bruns R, Luccioli S: Prevalence of self reported food allergy in US adults: 2001, 2006, and 2010. *Allergy Asthma Proc*, 2015; 36(6): 458-67
- Ali F: A survey of self-reported food allergy and food-related anaphylaxis among young adult students at Kuwait University, Kuwait. *Med Princ Pract*, 2017; 26(3): 229-34
- Bergmann MM, Eigenmann PA: Food allergy in childhood (infancy to school age). *Chem Immunol Allergy*, 2015; 101: 38-50
- Ho MH, Lee SL, Wong WH et al: Prevalence of self-reported food allergy in Hong Kong children and teens – a population survey. *Asian Pac J Allergy Immunol*, 2012; 30(4): 275-84
- Irani C, Maalouly G: Prevalence of self-reported food allergy in Lebanon: A Middle-Eastern taste. *International Scholarly Research Notices*, 2015; 2015(3): 1-5
- Jackson KD, Howie LD, Akinbami LJ: Trends in allergic conditions among children: United States, 1997-2011. *NCHS Data Brief*, 2013; 121(121): 1-8
- Gupta RS, Walkner MM, Greenhawt M et al: Food allergy sensitization and presentation in siblings of food allergic children. *J Allergy Clin Immunol Pract*, 2016; 4(5): 956-62
- DunnGalvin A, Koman E, Raver E et al: An examination of the food allergy quality of life questionnaire performance in a countrywide American sample of children: Cross-cultural differences in age and impact in the United States and Europe. *J Allergy Clin Immunol Pract*, 2017; 5(2): 363-68.e2
- Venter C, Arshad SH: Epidemiology of food allergy. *Pediatric Clinics of North America*, 2011; 58(2): 327-49
- Liu AH, Jaramillo R, Sicherer SH et al: National prevalence and risk factors for food allergy and relationship to asthma: Results from the National Health and nutrition examination survey 2005-2006. *J Allergy Clin Immunol*, 2010; 126(4): 798-806.e14
- Nwaru BI, Hickstein L, Panesar SS et al: Prevalence of common food allergies in Europe: A systematic review and meta-analysis. *Allergy*, 2014; 69(8): 992-1007
- Kalogeromitros D, Makris MP, Chliva C et al: An internet survey on self-reported food allergy in Greece: clinical aspects and lack of appropriate medical consultation. *J Eur Acad Dermatol Venereol*, 2013; 27(5): 558-64
- Sicherer SH, Sampson HA: Food allergy: Epidemiology, pathogenesis, diagnosis, and treatment. *J Allergy Clin Immunol*, 2014; 133(2): 291-307; quiz 308
- Ebisawa M, Ito K, Fujisawa T: Japanese guidelines for food allergy 2017. *Allergol Int*, 2017; 66(2): 248-64
- Ben-Shoshan M, Harrington DW, Soller L et al: A population-based study on peanut, tree nut, fish, shellfish, and sesame allergy prevalence in Canada. *J Allergy Clin Immunol*, 2010; 125(6): 1327-35
- Chafen JJ, Newberry SJ, Riedl MA et al: Diagnosing and managing common food allergies: A systematic review. *JAMA*, 2010; 303(18): 1848-56
- Gupta RS, Springston EE, Warrier MR et al: The prevalence, severity, and distribution of childhood food allergy in the United States. *Pediatrics*, 2011; 128(1): e9-17
- Vierk KA, Koehler KM, Fein SB, Street DA et al: Prevalence of self-reported food allergy in American adults and use of food labels. *J Allergy Clin Immunol*, 2007; 119(6): 1504-10
- Rona RJ, Keil T, Summers C et al: The prevalence of food allergy: A meta-analysis. *J Allergy Clin Immunol*, 2007; 120(3): 638-46
- Soller L, Ben-Shoshan M, Harrington DW et al: Overall prevalence of self-reported food allergy in Canada. *J Allergy Clin Immunol*, 2012; 130(4): 986-88
- Keet CA, Savage JH, Seopaul S et al: Temporal trends and racial/ethnic disparity in self-reported pediatric food allergy in the United States. *Ann Allergy Asthma Immunol*, 2014; 112(3): 222-29.e3
- Obeng BB, Amoah AS, Larbi IA et al: Food allergy in Ghanaian schoolchildren: Data on sensitization and reported food allergy. *Int Arch Allergy Immunol*, 2011; 155(1): 63-73
- Hu Y, Chen J, Li H: Comparison of food allergy prevalence among Chinese infants in Chongqing, 2009 versus 1999. *Pediatr Int*, 2010; 52(5): 820-24
- Lomidze N, Gotua M: Prevalence of self-reported food allergy in different age groups of georgian population. *Georgian Med News*, 2015; (241): 40-44
- Peters RL, Koplin JJ, Gurrin LC et al: The prevalence of food allergy and other allergic diseases in early childhood in a population-based study: HealthNuts age 4-year follow-up. *J Allergy Clin Immunol*, 2017; 140(1): 145-53.e8
- Andorf S, Borres MP, Block W et al: Association of clinical reactivity with sensitization to allergen components in multifood-allergic children. *J Allergy Clin Immunol Pract*, 2017; 5(5): 1325-34.e4
- Koplin JJ, Peters RL, Ponsonby AL et al: Increased risk of peanut allergy in infants of Asian-born parents compared to those of Australian-born parents. *Allergy*, 2014; 69(12): 1639-47
- Kool B, Chandra D, Fitzharris P: Adult food-induced anaphylaxis hospital presentations in New Zealand. *Postgrad Med J*, 2016; 92(1093): 640-44
- Li G, Wang H, Wang K et al: Prevalence, awareness, treatment, control and risk factors related to hypertension among urban adults in Inner Mongolia 2014: differences between Mongolian and Han populations. *BMC Public Health*, 2016; 16: 294
- Sicherer SH, Sampson HA: Food allergy: A review and update on epidemiology, pathogenesis, diagnosis, prevention and management. *J Allergy Clin Immunol*, 2018; 141(1): 41-58
- Pawlinska-Chmara R, Wronka I, Muc M: Prevalence and correlates of allergic diseases among children. *J Physiol Pharmacol*, 2008; 56(4): 549-56

34. de Silva D, Geromi M, Halken S et al: Primary prevention of food allergy in children and adults: systematic review. *Allergy*, 2014; 69(5): 581–89
35. Perkin MR, Logan K, Tseng A et al: Randomized trial of introduction of allergenic foods in breast-fed infants. *N Engl J Med*, 2016; 374(18): 1733–43
36. Bellach J, Schwarz V, Ahrens B et al: Randomized placebo-controlled trial of hen's egg consumption for primary prevention in infants. *J Allergy Clin Immunol*, 2017; 139(5): 1591–99.e2
37. Natsume O, Kabashima S, Nakazato J et al: Two-step egg introduction for prevention of egg allergy in high-risk infants with eczema (PETIT): A randomised, double-blind, placebo-controlled trial. *Lancet*, 2017; 389(10066): 276–86
38. Du Toit G, Roberts G, Sayre PH et al: Randomized trial of peanut consumption in infants at risk for peanut allergy. *N Engl J Med*, 2015; 372(9): 803–13
39. Fleischer DM, Sicherer S, Greenhawt M et al: Consensus communication on early peanut introduction and the prevention of peanut allergy in high-risk infants. *Ann Allergy Asthma Immunol*, 2015; 115(2): 87–90
40. du Toit G, Sayre PH, Roberts G et al: Allergen specificity of early peanut consumption and effect on development of allergic disease in the Learning Early About Peanut Allergy study cohort. *J Allergy Clin Immunol*, 2017 [Epub ahead of print]