

EPIDEMIOLOGY

Prevalence, severity and risk factors of asthma, rhinitis and eczema in a large group of Chinese schoolchildrenNing Song, MD^{1*}, Shamssain Mohammed, PhD^{2*}, Jin Zhang, MS³, Jianling Wu, MS¹, Chunling Fu, MS¹, Shuting Hao, BS¹, Jitao Guan, MS¹, Xixin Yan, MD¹¹Department of Respiratory Medicine, the Second Hospital of Hebei Medical University, Shijiazhuang, Hebei, P.R. China, ²College of Pharmacy and Health Sciences, Ajman University of Science and Technology, Ajman, UAE, and ³Department of Respiratory Medicine, the Second Hospital of Shijiazhuang, Shijiazhuang, Hebei, P.R. China.**ABSTRACT**

Background: There is a lack of information on the prevalence, severity and risk factors of asthma, rhinitis and eczema in Chinese children. **Objective:** To establish baseline data for a major longitudinal study of factors affecting asthma, rhinitis and eczema in a large group of children from the industrialized city of Shijiazhuang, China. **Methods:** We used the International Study of Asthma and Allergies in Childhood questionnaire and studied 10 338 children, ages 6–18, from Shijiazhuang. **Results:** The prevalence of childhood asthma, rhinitis and eczema is 1.2%, 13.5% and 11.8%, respectively. Boys had higher prevalence of these conditions than girls and younger children had higher prevalence of asthma and eczema but lower prevalence of rhinitis than older children. Breastfed children had lower prevalence of asthma and rhinitis, but not eczema, than non-breastfed children. Overweight children had higher prevalence of asthma and rhinitis than those who were not overweight. Children exposed to paternal smoking had higher prevalence of rhinitis and eczema than those not exposed; children exposed to pets had higher prevalence of asthma and rhinitis than those not exposed. **Conclusions:** The prevalence of asthma in this study group is low, but the prevalence of rhinitis is high, and could be considered a major public health problem. The prevalence of asthma, rhinitis and eczema is generally higher in boys and younger children generally have higher prevalence of asthma and eczema but lower prevalence of rhinitis. Exposure to pets is a risk factor for rhinitis, being overweight is a risk factor for asthma and rhinitis, and exposure to parental smoking is a risk factor for asthma, rhinitis and eczema in these children.

Keywords

Asthma, Chinese schoolchildren, eczema, ISAAC, rhinitis

History

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Introduction

Asthma continues to be a major cause of morbidity in childhood [1], with studies showing its prevalence on the rise [2–4]. There has been a significant increase in the rates of asthma-related hospital admissions among children in Canada [5–7], the USA [8] and other countries [9]. Rates of death from asthma among young adults have also increased since the mid-1970s in Canada [5,6,10] as well as many other countries [11].

Overall, the prevalence of asthma, rhinitis and eczema is growing in industrialized and developing countries [12,13], but rates vary by country. Although asthma symptoms tend to be more prevalent in more affluent countries, they appear to be more severe in less affluent countries [14]. In the Netherlands [2,3,15,16], Italy [17,18] and Australia [17,18], researchers have reported decrease in wheezing and asthma among pre-pubertal children, but research from Spain and the

UK [19–21] indicates a continuing increase in the prevalence in wheezing and asthma in children in those countries. Studies from Germany [22] and Norway [23] show the prevalence of wheezing and asthma in children has remained stable in those countries. Several additional studies in western populations report that this increase in these diseases seems to have slowed down or reached a plateau [24,25]. A study of Singapore children [26] shows that the change in the prevalence of current wheezing was age dependent, decreasing significantly in the 6–7 year age group but increasing to a small extent in the 12–15 year age group. The study also found that the 12-month prevalence of rhinitis did not change and there was an increase in current eczema symptoms in both age groups. These divergent trends in the prevalence of allergic diseases worldwide have led researchers to investigate the causes of these diseases further [27]. The International Study of Asthma and Allergies in Childhood (ISAAC) has established valid procedures to investigate the prevalence and severity of asthma, rhinitis and eczema worldwide [28].

Little research has been done on the prevalence, severity and associated risk factors of childhood allergies in mainland China [29]. Only a few studies using the ISAAC study

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protocol have been done in China [30]. The prevalence of childhood asthma is generally low in China. However, the findings from one large study of children from 27 different cities confirm an increase in the prevalence of childhood asthma from 1990 to 2000 [31]. A recent cross-sectional study by Zhao et al. [32] of Chinese children from Beijing, Chongqing and Guangzhou also reported a marked increase in the prevalence rates of asthma, rhinitis and eczema in children from these cities as compared to earlier results.

It has been hypothesized that environmental rather than genetic causes are responsible for the increase in the prevalence of childhood asthma, rhinitis and eczema. With increasing westernization and pollutants, less developed communities will follow this trend [33]. Poor outdoor air quality, exposure to indoor allergens and a stressful lifestyle have been connected with the prevalence of asthma and rhinoconjunctivitis [34]. An increasing trend in the prevalence of asthma and allergies is apparent in urban areas, by which children have been found to have more allergic reactions to outdoor and indoor allergens [35]. This may be due in part to the use of fossil fuels, as well as the high level of road traffic in cities [35,36]. Evidence supports a causal relationship between exposure to air pollution and exacerbation of asthma, mainly due to exposure to particulate matter and ozone [35].

The aims and objectives of this study are to investigate the prevalence, severity and risk factors of asthma, rhinitis and eczema in a large group of children ages 6–18 from the city of Shijiazhuang in Hebei province of China. Shijiazhuang is a city with rapid development, increasing westernization and a serious pollution problem [37]. The results of this study will be the baseline for a 10-year follow-up study looking at the prevalence and risk factors of asthma, rhinitis and eczema in children from Shijiazhuang. We will also compare the prevalence rates between these children and other children in China. Our hypothesis is that, due to differences in environmental factors, the prevalence and severity of asthma, rhinitis and eczema in children from Shijiazhuang will differ from that of children living in other Chinese cities. This long-term study will provide much-needed information about the prevalence and risk factors of allergic disease in China.

Materials and methods

Data collection

We obtained school lists from the Department of Education in Shijiazhuang city and prepared sampling frames of mixed sex schools with over 100 pupils in each school year. One school from each sampling frame was randomly selected to produce 10 schools for the study. Using the ISAAC written questionnaire for asthma, rhinitis and eczema, we sent 12 000 questionnaires to parents or guardians of 6–22-year-old schoolchildren during March to May in 2011. For the older children, the children themselves provided the answers to the questionnaire. The questionnaires were returned and the 6–18-year-old schoolchildren were selected for the analysis. We did not include 19–22-year-olds because this age group was not included in similar studies done in other Chinese cities [32], and we plan to compare our results with the results from these studies. Ten thousand and eight hundred and twenty four (10 824) questionnaires were returned with a final response rate

of 90%, yielding 10 338 children ages 6–18 to be included in the analysis. The cohort included 5095 boys and 5243 girls.

The ISAAC questionnaire includes questions on past and current wheezing episodes, wheezing frequency, sleep disturbance, speech limitation during attacks, exercise induced wheezing and persistent cough unrelated to respiratory infections. Other questions focus on the presence and severity of rhinitis and eczema. The exact questions as developed by ISAAC were presented to the subjects. For each of the symptoms of interest in this study, a 12-month period prevalence was calculated according to ISAAC protocol by dividing the number of positive responses to each question by the number of completed questionnaires.

According to the ISAAC protocol, asthma, rhinitis and eczema are defined as “doctor-diagnosed”, thus, reporting may be affected by mistakes in diagnosis or lack of diagnosis. In addition, reports of wheezing may not be accurate, particularly in obese children. Finally, answers to the ISAAC questionnaire do not include enough information to be able to quantify the severity of symptoms.

We added a question on any breastfeeding the children had in their life and the duration of breastfeeding. Body mass index (BMI) was calculated by dividing weight (in kg) by height squared (in meters).

Statistical analysis

Data were analyzed using SPSS for Windows, Version 17.0 (Chicago, IL, USA). The chi-square test was used to assess the association between categorical variables. Logistic regression was used for all outcomes. Estimates of the odds ratio (OR), standard errors, and 95% confidence intervals (95% CIs) were based on the asymptomatic likelihood theory. A p value <0.05 was considered to be significant.

Ethical considerations

Our study was approved by the Ethics Committee of the Second Hospital of Hebei Medical University in Shijiazhuang. A parent or legal guardian of each child gave written informed consent before completing a questionnaire.

Results

Our study group included 5095 boys and 5243 girls. Mean age was the same in boys and girls, but boys were significantly taller and heavier than girls ($p < 0.001$, Table 1). As shown in Table 2, the overall prevalence of ever having asthma (asthma) in children from Shijiazhuang is low, but the prevalence of ever having rhinitis (rhinitis) and ever having eczema (eczema) is relatively high. Boys had significantly higher prevalence rates of asthma, rhinitis and eczema than girls. There were no significant sex differences in cough and chronic rash.

Several studies have shown a strong association between asthma, rhinitis and eczema [32,38–40]. To determine whether these diseases are associated in our study group, we looked at prevalence of disease co-existence. As shown in Table 2, the presence of asthma, rhinitis and eczema together were reported in 0.3% of boys, 0.2% of girls and 0.2% of all children. Asthma and rhinitis were reported in 0.8% of boys, 0.4% of girls and 0.6% of all children and asthma and eczema

Table 1. Demographic data.

Variable	Male (n = 5095)			Female (n = 5243)			All (n = 10 338)		
	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Age (years)	6	17	10.1 ± 3.2	6	17	10.2 ± 3.3	6	17	10.2 ± 3.3
Height (cm)	80	190	141.5 ± 18.1	75	180	139.3 ± 16.4***	75	190	140.4 ± 17.3
Weight (kg)	14	105	37.5 ± 14.2	12.5	90	34.7 ± 12.0***	12.5	105	36.1 ± 13.2
BMI	8.3	48.0	18.2 ± 3.8	6.3	44.9	17.4 ± 3.5***	6.3	48.0	17.8 ± 3.7

****p* < 0.001 compared with male group.

Table 2. Prevalence and severity of self-reported asthma, rhinitis and eczema and related symptoms.

Symptom	All (%) n = 10 338	Male (%) n = 5095	Female (%) n = 5243	<i>p</i> ^a
Asthma				
Ever wheezed	5.8	6.6	5.0	0.000
Wheeze in the past year	1.9	2.3	1.4	0.088
Number of wheezing episodes				
1–3	1.6	1.9	1.2	0.008
4–12	0.1	0.2	0.1	0.097
>12	0.2	0.2	0.1	0.079
Woken by wheeze				
<1 each week	0.3	0.4	0.2	0.042
>1 each week	0.1	0.1	0.0	0.241
Limitation of speech during wheezing attack	0.2	0.3	0.1	0.189
Wheezing with exercise past year	3.3	3.4	3.1	0.546
Persistent cough past year	11.2	11.2	11.4	0.749
Ever had asthma	1.2	1.6	0.8	0.000
Rhinitis				
Ever had rhinitis	13.5	15.0	12.1	0.000
Rhinitis in the past year	9.5	10.8	8.8	0.196
Interference with daily activity				
Little	6.5	7.4	5.6	0.000
Moderate	0.7	0.9	0.5	0.014
Severe	0.1	0.1	0.1	0.190
Associated itchy eye in the past year	2.4	2.8	1.9	0.320
Ever had hay fever	4.2	4.8	3.7	0.008
Eczema				
Chronic rash ever	2.5	2.7	2.3	0.195
Chronic rash in the past year	1.5	1.6	1.4	0.455
Persistent rash without clearing	0.9	0.9	0.9	0.349
Kept awake by rash				
<1 each week	0.3	0.3	0.4	0.344
>1 each week	0.2	0.2	0.2	0.763
Chronic rash with typical distribution	1.0	1.0	1.0	0.248
Ever had eczema	11.8	12.7	10.9	0.004
Age at which itchy rash first occurred				
<2 years	3.3	3.6	3.0	0.062
2–4 years	1.4	1.4	1.5	0.514
>5 years	1.4	1.5	1.4	0.451
Coexistence				
Asthma and rhinitis	0.6	0.8	0.4	0.015
Asthma and eczema	0.4	0.6	0.3	0.012
Rhinitis and eczema	2.8	3.4	2.2	0.000
Asthma and rhinitis and eczema	0.2	0.3	0.2	0.195

^a*p* value = female group compared to male group.

were reported in 0.6% of boys, 0.3% of girls and 0.4% of all children. Rhinitis and eczema were present in 3.4% of boys, 2.2% of girls and 2.8% of all children. Of asthmatic children, 49.2% reported rhinitis, 36.1% reported eczema and 19% reported both rhinitis and eczema. Thus, as expected, we found a strong association among the three conditions.

The prevalence data from our study can be directly compared to data from a similar study done on children from the Chinese cities of Beijing, Chongqing and Guangzhou [32] (Figure 1). Overall, children in Shijiazhuang showed lower

prevalence rates of asthma than children in Beijing, Chongqing and Guangzhou (1.1% vs. 3.2%, 7.5% and 2.6%). Similar to what we found in Shijiazhuang, prevalence rates for asthma were higher in boys than in girls in Beijing and Chongqing. Regarding specific symptoms of asthma, Shijiazhuang children had lower prevalence rates of wheezing in the past year (1.9% vs. 5.5%, 3.5% and 3.9%) and exercise-induced wheezing (3.3% vs. 6.8%, 7.1% and 8.5%). However, the prevalence of cough was higher in children from Shijiazhuang (11.2% vs. 8.7%, 8.7%, and 8.8%). The

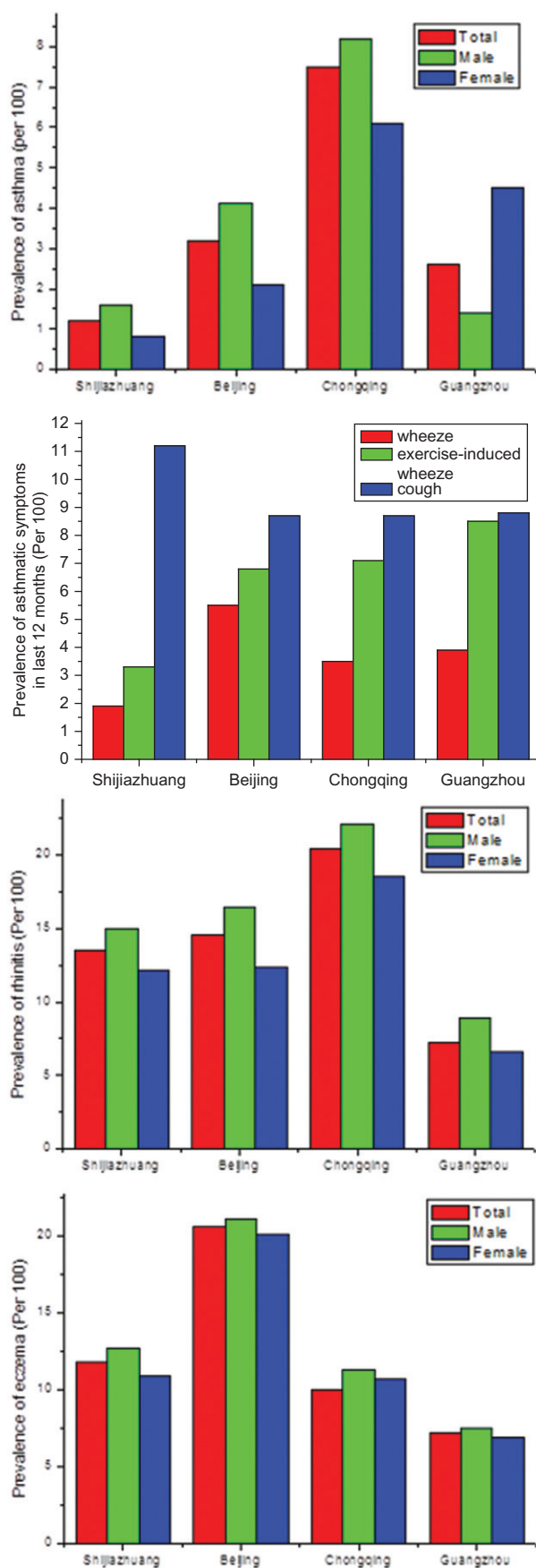


Figure 1. Prevalence of asthma, asthmatic symptoms in last 12 months, rhinitis and eczema across Chinese cities. Data for Shijiazhuang is from the current study. Data for Beijing, Chongqing and Guangzhou are from the study by Zhao et al. [32], which was done according to the ISAAC protocol with children ages birth to 14.

prevalence of rhinitis in boys and girls in this study was similar to Beijing children (13.5% vs. 14.7%), higher than Guangzhou children (13.5% vs. 7.2%) and lower than Chongqing children (13.5% vs. 20.4%). The prevalence of eczema in children in our study was similar to children in Chongqing (11.8% vs. 10.0%), lower than Beijing children (11.8% vs. 20.6%) and higher than Guangzhou (11.8% vs. 7.2%). The variations in prevalence of these diseases in different locations of China could be due to differences in diet, exposure to allergens, level of health care services, and/or availability of education/awareness programs.

We also considered the impact of age on allergic disease prevalence (Table 3). We stratified children into three age groups: 6–8 years; 8–13 years and 13–18 years. Asthma symptoms decreased with age from the 6–8 year age group to the 13–18 year age group (ever having wheezed from 7.1% to 3.7%, current wheeze from 2.2% to 1.4%, cough from 11.6% to 10.5% and asthma from 1.3% to 0.4%, respectively). Rhinitis symptoms increased with age from the 6–8 year age group to the 13–18 year age group (rhinitis from 11.2% to 16.6%, current rhinitis from 8.2% to 11.5%, rhinoconjunctivitis from 2.0% to 3.7% and hay fever from 3.3% to 4.7%, respectively). By comparison, rash and eczema symptoms decreased with age from the 6–8 year age group to the 13–18 year age group (ever having rash from 2.7% to 2.2%, current rash from 1.8% to 1.1% and eczema from 15.4% to 6.9%, respectively). Thus, symptoms of asthma and eczema decreased with age in this study group, whereas symptoms of rhinitis increased.

It has been debated for many years whether low rates of breastfeeding are associated with asthma, wheezing and other manifestations of allergy [41–43]. To determine whether breast feeding affects the prevalence of asthma, rhinitis and eczema in children in Shijiazhuang, we added a question to the ISAAC questionnaire asking if the child had been breast fed at all, and, if so, for how long. In our study, 84.1% of children were breastfed and a very high proportion of them (almost 7000 of the 8693 breastfed children) were breastfed for more than 12 months. When determining the effect of breastfeeding on prevalence rates, we considered all lengths of breast feeding time equally, and did not distinguish between exclusive breast feeding and mixed breast/bottle feeding. As shown in Table 4, children in this study who had been breastfed had significantly lower prevalence rates of exercise-induced wheezing and rhinitis than those who had not been breastfed (3.0% vs. 4.3%, $p < 0.01$; 13.1% vs. 15.8%, $p < 0.01$, respectively). There was a similar trend for asthma (1.1% vs. 1.6%, $p = 0.058$). However, breastfed children had higher prevalence rates of eczema than those who were not breastfed (12.0% vs. 10.5%, $p = 0.071$).

High BMI has been shown to be associated with asthma, but the pattern of this association is still unclear and may differ by gender or stage of puberty [44]. We first considered prevalence of allergic disease in children having high BMI (BMI > P65th), overweight children (BMI > P85th) and obese children (BMI > P95th), comparing each group to all children with lower BMI (Table 5). BMI categories were derived from published standardized procedure [45]. Children with high BMI and overweight children had significantly higher prevalence of asthma and rhinitis, as well as hay fever, than those

Table 3. Prevalence of asthma, rhinitis and eczema and related symptoms in children of different ages.

Symptom	Elementary (%) (6–8 years) <i>n</i> = 2482	Adolescent (%) (8–13 years) <i>n</i> = 5242	Teen (13–18 years) <i>n</i> = 2614	χ^2	<i>p</i> ^a
Asthma					
Ever wheezed	7.1	6.2	3.7	30.498	0.000
Wheeze in the past year	2.2	1.9	1.4	1.401	0.496
Wheezing with exercise past year	2.3	3.0	4.7	25.022	0.000
Persistent cough past year	11.6	11.5	10.5	2.297	0.317
Ever had asthma	1.3	1.5	0.4	19.894	0.000
Rhinitis					
Ever had rhinitis	11.2	13.0	16.6	32.855	0.000
Rhinitis in the past year	8.2	9.2	11.5	1.404	0.496
Associated itchy eye in the past year	2.0	1.9	3.7	13.838	0.001
Ever had hay fever	3.3	4.4	4.7	7.300	0.026
Eczema					
Chronic rash ever	2.7	2.7	2.2	1.880	0.391
Chronic rash in the past year	1.8	1.8	1.1	8.851	0.012
Ever had eczema	15.4	12.5	6.9	92.538	0.000

^aElementary, adolescent and teen groups were compared to determine the *p* value.

with lower BMI. Children with high BMI, overweight children and obese children all had significantly higher prevalence of exercise-induced wheezing. Obese children also had significantly higher prevalence of sleep disturbances due to wheezing in the last 12 months compared with non-obese children (38.5% vs. 15.6%, $p < 0.05$).

To further investigate the effect of BMI on allergic disease in our study group, we stratified the children in our group into five groups based on BMI: underweight (BMI $\leq$ P5th), normal weight (BMI P6th–P65th), high BMI (BMI P66th–P84th), overweight (BMI P85th–P94th) and obese (BMI $>$ P95th) (Table 6). Using this approach we found that underweight children had significantly higher prevalence of ever having wheezed than the reference group ($p < 0.05$), and a trend of higher prevalence of exercise-induced wheezing and asthma ($p = 0.075$ and $p = 0.07$, respectively). This approach also showed that the prevalence of several symptoms of allergic disease was significantly higher in the high BMI, overweight and obese groups compared to the reference normal group.

As the incidence of allergic symptoms in children is associated with exposure to allergens in in-door environments with poor air quality [46], including, among other things, exposure to pets [47], we investigated the effect of exposure to pets (cats and/or dogs) on the prevalence of asthma, rhinitis and eczema in our study group. As shown in Table 7, the prevalence rates of exercise-induced wheezing and rhinitis were significantly higher in pet-exposed children compared to non-exposed children (exercise-induced wheezing 4.6% vs. 3.0%; rhinitis 18.4% vs. 12.4%). Other symptoms trended toward higher prevalence (wheeze ever 6.1% vs. 5.7%; current wheeze 2.2% vs. 1.8%; cough 12.5% vs. 11.0%; current rhinitis 12.8% vs. 8.8%; rhinoconjunctivitis 3.2% vs. 2.2%; hay fever 4.8% vs. 4.1%, respectively). Surprisingly, there was a trend for higher prevalence of eczema in children not exposed to cats and dogs compared with exposed children (12.1% vs. 10.5%).

Another allergen that can trigger asthma attacks and make asthma symptoms more severe is environmental tobacco smoke [48]. We considered the effect of parental smoking on the prevalence of asthma, rhinitis and eczema in our study

group. Of the fathers of the children in our study group, approximately 43% smoked, of the mothers less than 2% of the mothers smoked. Therefore we focused on the effect of paternal smoking. The prevalence rates of several of the allergic diseases and symptoms were significantly higher in children exposed to paternal smoking compared with those not exposed (ever having wheezed 6.6% vs. 4.8%; exercise-induced wheezing 3.9% vs. 2.5%; cough 13.2% vs. 8.8%; rhinitis 15.1% vs. 11.5%; hay fever 4.6% vs. 3.7%; ever having chronic rash 3.0% vs. 1.9%; eczema 13.1% vs. 10.1%, respectively) (Table 8).

Table 9 shows a binary regression analysis of the multiple factors associated with allergic disease symptoms in our study group. Our results show that boys are more likely to suffer from asthma, rhinitis and eczema than girls (OR = 2.0, 95% CI 1.4–2.9, $p < 0.001$; OR = 1.3, 95% CI 1.2–1.5, $p < 0.0001$; OR = 1.2, 95% CI 1.1–1.3, $p < 0.01$, respectively). Young children are more likely to suffer from asthma and eczema but not easy to suffer from rhinitis than older children (OR = 1.6, 95% CI 1.2–2.0, $p < 0.01$; OR = 1.5, 95% CI 1.4–1.7, $p < 0.001$; OR = 0.8, 95% CI 0.8–0.9, $p < 0.0001$). Overweight children are more likely to suffer from asthma and rhinitis than non-overweight children (OR = 1.6, 95% CI 1.0–2.5, $p < 0.05$; OR = 1.5, 95% CI 1.3–1.7, $p < 0.0001$). Children exposed to cats and/or dogs are more likely to suffer from rhinitis than non-exposed children (OR = 1.4, 95% CI 1.3–1.7, $p < 0.0001$), and children exposed to paternal smoking are more likely to suffer from rhinitis and eczema (OR = 1.4, 95% CI 1.2–1.6, $p < 0.001$; OR = 1.3, 95% CI 1.2–1.5, $p < 0.0001$; OR = 1.3, 95% CI 1.2–1.5, $p < 0.0001$).

Discussion

We carried out this study to address the need for more information about the prevalence, severity and risk factors of asthma, rhinitis and eczema in Chinese children. We used the ISAAC protocol to gather data on 10 338 children ages 6–18 living in the rapidly developing city of Shijiazhuang. The data from this study will be the baseline for a 10-year follow-up study. The current study shows that the prevalence of asthma is relatively low in this group of children, but within the group

Table 4. Effect of breastfeeding on reported allergic disease and related symptoms.

Symptom	Breastfeeding (%) n = 8693	Non-breastfeeding (%) n = 1642	χ ²	p	OR	95% CI
Asthma						
Ever wheezed	5.8	6.0	0.195	0.659	1.0	0.8–1.2
Wheeze in the past year	1.8	2.1	0.479	0.489	0.9	0.5–1.3
Wheezing with exercise past year	3.0	4.3	7.135	0.008	0.7	0.5–0.9
Persistent cough past year	11.2	12.0	0.971	0.324	0.9	0.8–1.1
Ever had asthma	1.1	1.6	3.601	0.058	0.7	0.4–1.0
Rhinitis						
Ever had rhinitis	13.1	15.8	9.036	0.003	0.8	0.7–0.9
Rhinitis in the past year	9.2	11.3	0.085	0.770	1.0	0.7–1.3
Associated itchy eye in the past year	2.2	3.0	0.495	0.482	0.9	0.6–1.3
Ever had hay fever	4.2	4.4	0.208	0.649	0.9	0.7–1.2
Eczema						
Chronic rash ever	2.5	2.6	0.043	0.836	1.0	0.7–1.3
Chronic rash in the past year	1.5	1.2	3.072	0.080	1.8	0.9–3.5
Ever had eczema	12.0	10.5	3.269	0.071	1.2	1.0–1.4

Table 5. Effect of higher BMI on the prevalence of allergic disease and related symptoms.

Symptom	High BMI ^a (%) n = 3475	Normal or low BMI ^b (%) n = 6863	p	Overweight ^c (%) n = 1549	Non-overweight ^d (%) n = 8789	p	Obese ^e (%) n = 508	Non-obese ^f (%) n = 9830	p
Asthma									
Ever wheezed	6.6	5.4	0.014	6.7	5.6	0.093	6.9	5.7	0.278
Wheeze in the past year	2.3	1.6	0.286	2.5	1.7	0.190	2.6	1.8	0.506
Wheezing with exercise past year	3.9	2.9	0.014	4.2	3.1	0.023	4.9	3.2	0.029
Persistent cough past year	11.9	11.0	0.173	11.9	11.2	0.377	11.8	11.3	0.703
Ever had asthma	1.5	1.0	0.021	1.7	1.1	0.026	1.6	1.2	0.398
Rhinitis									
Ever had rhinitis	15.6	12.4	0.000	17.7	12.8	0.000	15.6	13.4	0.166
Rhinitis in the past year	11.0	8.8	0.934	12.9	8.9	0.296	10.8	9.5	0.875
Associated itchy eye in the past year	2.4	2.3	0.082	3.1	2.2	0.715	3.5	2.3	0.166
Ever had hay fever	5.0	3.9	0.010	5.2	4.1	0.035	5.7	4.2	0.091
Eczema									
Chronic rash ever	2.9	2.4	0.125	3.1	2.4	0.133	2.4	2.6	0.790
Chronic rash in the past year	1.7	1.4	0.790	1.9	1.4	0.674	1.2	1.5	0.538
Ever had eczema	12.1	11.6	0.508	12.6	11.7	0.291	10.2	11.9	0.265

^aBMI > P65th.
^bBMI ≤ P65th.
^cBMI > P85th.
^dBMI ≤ P85th.
^eBMI > P95th.
^fBMI ≤ P95th.

the prevalence of asthma is higher for boys and younger children, and is affected by BMI, exposure to pets and exposure to smoking. The prevalence of rhinitis was found to be relatively high, and could be considered a public health problem.

One of our goals is to be able to compare prevalence rates of asthma, rhinitis and eczema in Shijiazhuang with prevalence rates of these conditions in other areas in China. Studies using the ISAAC protocol with the same question have been done in five mainland Chinese cities: Beijing, Chongqing, Guangzhou, Urumqi and Lhasa [32,49–55]. We chose to compare the Shijiazhuang results to results from the study done by Zhao et al. in Beijing, Chongqing and Guangzhou [32] since the residents of these four cities come mainly from the same background, the Han Chinese. We used the same questionnaire as Zhao et al., but we focused on children aged 6–18, whereas they focused on children ages birth to 14. We found that the prevalence of asthma is lower in Shijiazhuang

than in the three other cities studied, the prevalence of rhinitis is similar in Shijiazhuang and Beijing, and the prevalence of eczema is similar in Shijiazhuang and Chongqing.

Previous studies have shown a close association between asthma, rhinitis and eczema [56]. We investigated the co-existence of these allergic disorders in Shijiazhuang and compared our results to data from other regions in China. Of asthmatic children in Shijiazhuang, 49.2% reported rhinitis, 36.1% reported eczema and 19% reported both rhinitis and eczema. In the study by Zhao et al. [32], 49.54%, 50.14% and 34.83% of asthmatic children from Beijing, Chongqing and Guangzhou, respectively, suffered from rhinitis, 45.23%, 32.29%, 19.10% suffered from eczema, and 23.08%, 21.25%, 10.11% suffered from both rhinitis and eczema. A recent study in Hefei, China [38] showed that allergic rhinitis and infantile eczema were risk factors for asthma in children, with ORs of 7.56 and 4.58, respectively. A study in Taiwan on 308 849 children [39] found the “atopic march” pattern of

Table 6. Effect of low or high BMI on the prevalence of allergic disease and related symptoms.

Symptom	Low BMI ^a (%) n = 499	Normal BMI ^b (%) n = 6364	High BMI ^c (%) n = 1974	Overweight ^d (%) n = 993	Obese ^e (%) n = 508	χ^2	p
Asthma							
Ever wheezed	7.6 [▲]	5.2	6.7 [▲]	6.2	6.9	11.285	0.024
Wheeze in the past year	2.2	1.6	2.3	2.3	2.6	2.109	0.716
Wheezing with exercise past year	4.2	2.8	3.9 [▲]	3.5	4.9 ^{**}	12.320	0.015
Persistent cough past year	10.4	11.1	11.6	12.2	11.8	1.785	0.775
Ever had asthma	1.8	1.0	1.4	1.6 [▲]	1.6	8.027	0.091
Rhinitis							
Ever had rhinitis	13.2	12.2	14.2 [▲]	19.3 ^{***}	15.6 [▲]	40.595	0.000
Rhinitis in the past year	9.2	8.6	9.7	14.5	10.8	2.722	0.605
Associated itchy eye in the past year	2.2	2.2	2.3	3	3.5	3.647	0.456
Ever had hay fever	4.2	3.7	5.0 [▲]	5.1 [▲]	5.7 [▲]	11.515	0.021
Eczema							
Chronic rash ever	3.2	2.2	2.9	3.4 [▲]	2.4	7.553	0.109
Chronic rash in the past year	1.8	1.3	1.6	2.3	1.2	1.385	0.847
Ever had eczema	13.0	11.6	11.6	13.8 [▲]	10.2	6.134	0.189

^{**} $p < 0.001$, ^{***} $p < 0.0001$, [▲] $p < 0.05$ compared with BMI 16–65th (%) group.

^aBMI $\leq$ P5th.

^bBMI P6th–P65th.

^cBMI P66th–P84th.

^dBMI P85th–P94th.

^eBMI $>$ P94th.

Table 7. Effect of pets ownership on reported allergic disease and related symptoms.

Symptom	Pets (%) n = 1877	No pets (%) n = 8461	χ^2	p	OR	95% CI	Pets		Pets	
							Cats (%) n = 779	Dogs (%) n = 855	Cats or dogs (%) n = 1634	Cats and dogs (%) n = 161
Asthma										
Ever wheezed	6.1	5.7	0.328	0.567	1.1	0.9–1.3	5.1	7.0	6.1	5.0
Wheeze in the past year	2.2	1.8	0.989	0.320	1.2	0.8–1.9	2.1	2.2	2.1	2.5
Wheezing with exercise past year	4.6	3.0	12.919	0.000	1.6	1.2–2.0	5.1 [*]	4.3 [▲]	4.7 ^{***}	4.3
Persistent cough past year	12.5	11.0	3.179	0.075	1.1	1.0–1.3	12.1	12.6	12.4	15.5
Ever had asthma	1.2	1.2	0.040	0.841	1.0	0.7–1.7	0.8	1.5	1.2	1.9
Rhinitis										
Ever had rhinitis	18.4	12.4	46.671	0.000	1.6	1.4–1.8	17.3 ^{***}	19.1 ^{***}	18.3 ^{***}	19.2 [▲]
Rhinitis in the past year	12.8	8.8	0.202	0.653	0.9	0.7–1.2	12.6	13.5	13.0	13.0
Associated itchy eye in the past year	3.2	2.2	0.019	0.890	1.0	0.7–1.4	3.6	3.2	3.4	2.5
Ever had hay fever	4.8	4.1	1.761	0.185	1.2	0.9–1.5	4.5	5.3	4.9	4.3
Eczema										
Chronic rash ever	2.7	2.5	0.277	0.599	1.1	0.8–1.5	1.5	3.5 [□]	2.6	3.1
Chronic rash in the past year	1.8	1.4	0.986	0.321	1.4	0.7–2.6	0.9	2.0	1.5	3.1
Ever had eczema	10.5	12.1	3.405	0.065	0.9	0.7–1.0	9.4 [▲]	10.6	10.0 [▲]	14.3

[▲] $p < 0.05$, ^{*} $p < 0.01$, ^{***} $p < 0.0001$ vs. non-pets group. [□] $p < 0.05$ vs. cats group.

allergic diseases based on their age prevalence. In these children, early eczema was associated with asthma and allergic rhinitis at the age of 7 years. Those with eczema symptoms persisting after 36 months of age had a higher risk than those with transient eczema. Another study in Guangzhou [40] also found that age, history of eczema and asthma were related to the pathogenesis and development of allergic rhinitis in childhood. Our observations confirm other Chinese studies [32, 38–40] indicating strong association between allergic diseases.

It is generally acknowledged that boys have a significantly higher prevalence of asthma, rhinitis, eczema and related symptoms than girls. This gender difference has been reported in several international studies [32, 57]. However, some

findings are inconsistent with this view. A study on children in Sweden [56] showed that more preadolescent girls than boys had eczema. Our results show that boys in Shijiazhuang are more likely to suffer from asthma, rhinitis and eczema than girls. One explanation for this gender difference could be that girls tend to underestimate the severity of the disease. Higher prevalence of asthma in boys could also be a result of their smaller airways relative to lung size as compared to girls [58]. In addition, boys have higher BMI than girls, which may increase the likelihood that they will develop these allergic conditions. Differences in the age of onset of asthma between boys and girls may also affect the prevalence rate of ever having asthma. Although asthma affects males mainly in early childhood, before age 5, it is a disease primarily of females

Table 8. Effect of parental smoking on reported allergic disease and related symptoms.

Symptoms	One parent smokes (%) n = 5892	No parent smokes (%) n = 4446	Both parents smokes (%) n = 101	p	Maternal smoking (%) n = 142	Maternal non-smoking (%) n = 10196	Paternal smoking (%) n = 5851	Paternal non-smoking (%) n = 4487	Maternal smoking		Paternal smoking	
									OR	95% CI	OR	95% CI
Asthma												
Ever wheezed	6.6	4.7	10.9	0.000	9.9	5.8 [▲]	6.6	4.8 ^{***}	1.8	1.0–3.1	1.4	1.2–1.7
Wheeze in the past year	2.1	1.5	1.0	0.256	2.1	1.9	2.1	1.6	0.6	0.2–2.1	1.0	0.7–1.4
Wheezing with exercise past year	3.9	2.4	5.0	0.000	4.9	3.2	3.9	2.5 ^{***}	1.6	0.7–3.4	1.6	1.3–2.0
Persistent cough past year	13.2	8.8	15.8	0.000	13.4	11.3	13.2	8.8 ^{***}	1.2	0.7–2.0	1.6	1.4–1.8
Ever had asthma	1.2	1.1	3.0	0.235	2.8	1.1	1.2	1.1	2.5	0.9–6.8	1.1	0.7–1.5
Rhinitis												
Ever had rhinitis	15.1	11.4	13.9	0.000	13.4	13.5	15.1	11.5 ^{***}	1.0	0.6–1.6	1.4	1.2–1.5
Rhinitis in the past year	10.7	8.0	10.9	0.747	10.6	9.5	10.7	8.0	1.6	0.5–4.8	1.0	0.8–1.3
Associated itchy eye in the past year	2.5	2.1	3.0	0.543	4.2	2.3	2.5	2.2	2.0	0.7–5.8	0.8	0.6–1.1
Ever had hay fever	4.6	3.7	4.0	0.083	4.2	4.2	4.6	3.7 [▲]	1.0	0.4–2.3	1.2	1.0–1.5
Eczema												
Chronic rash ever	3.0	1.9	5.0	0.001	5.6	2.5 [▲]	3.0	1.9 ^{**}	2.3	1.1–4.8	1.6	1.2–2.0
Chronic rash in the past year	1.8	1.0	1.0	0.144	1.4	1.5	1.8	1.0	0.2	0.0–1.1	1.3	0.8–2.1
Ever had eczema	13.1	10.1	11.8	0.000	12.7	11.8	13.1	10.1 ^{***}	1.1	0.7–1.8	1.3	1.2–1.5

** $p < 0.001$, *** $p < 0.0001$, [▲] $p < 0.05$ compared with smoking group.

beginning with adolescence. In contrast to males, airway responsiveness persists in females during maturation, sex specific risk factors associated with this persistence have been identified [59].

Age is another potential risk factor for asthma, rhinitis and eczema. In our study, the prevalence rates of asthma, rhinitis and eczema decreased with age. However, the prevalence rates of exercise-induced wheezing, ever having rhinitis, current rhinitis and hay fever increased with age. The study by Zhao et al. [32] of children from Beijing, Chongqing and Guangzhou showed that the prevalence of asthma, rhinitis and eczema varied with age and that asthma was relatively less common in children under 2 years of age and in those age 9 years or more. The prevalence of rhinitis was also lower in children younger than 2 years, and the prevalence of eczema fell with age. A study on children from Beijing [60] confirms that allergic rhinitis is a common disease in Asian preschool children, with an increasing trend as children get older.

One of the objectives of this study was to investigate whether there is any association between breastfeeding and asthma, rhinitis and eczema in Chinese schoolchildren. Exclusive breastfeeding for at least 4 months has been recommended by many governments and allergy organizations to prevent allergic disease and the World Health Organization recommends that babies be exclusively breastfed for 6 months [61]. Breastfeeding is essential for protection against infections in babies living under poor hygienic conditions in developing countries [62,63]. Breast milk has been reported to contain a high concentration of long-chain polyunsaturated fatty acids such as arachidonic acid and bioactive immune factors such as T-regulatory cytokine that might lead to decreased respiratory infections and delay allergic sensitization. There is conflicting evidence concerning the relationship between breastfeeding and asthma, wheezing illness and other disorders. Some studies link exclusive breastfeeding to a reduction in asthma and other conditions [64,65]. Other studies show no association between any or exclusive breastfeeding and wheezing illness and a lack of evidence for a protective effect of prolonged breastfeeding on childhood eczema [66].

Results from our study show that in children from Shijiazhuang, those who had been breastfed for any length of time had lower prevalence of exercise-induced wheezing and rhinitis and a trend toward lower prevalence of asthma. However, breastfed children had higher prevalence of eczema. Binary regression analysis of the multiple factors associated with allergic disease symptoms suggest that breastfeeding reduces the prevalence rates of exercise-induced wheezing, asthma and rhinitis, but there is no significant effect of breastfeeding on eczema. Thus, breastfeeding might have a protective effect on asthma and rhinitis, but not on eczema. Our results are similar to that of a recent study in Hefei, China [38], which showed that lack of breast feeding is a risk factor for asthma in children, with ORs of 2.16.

A close association between high BMI and asthma has been observed in several studies. Asthma is not only more frequently observed in obese subjects but also it is more difficult to control [67]. There are many possible explanations for this finding. Obese asthmatic patients have lower lung function and more comorbidities compared with normal

Table 9. Binary regression analysis of the multiple factors associated with allergic disease and related symptoms.

Symptom	Male		6–8 years old		Breastfeeding		Overweight		Pets		Maternal smoking		Paternal smoking	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Asthma														
Ever wheezed	1.4**	1.1–1.6	1.4***	1.2–1.6	0.9	0.7–1.2	1.2	0.9–1.5	1.2	1.0–1.5	1.7	0.9–2.9	1.4**	1.2–1.6
Wheezed in the past year	1.4	1.0–2.0	0.9	0.7–1.2	0.8	0.5–1.3	1.3	0.9–2.1	1.2	0.8–2.9	0.5	0.1–2.0	1.0	0.7–2.4
Wheezing with exercise past year	1.1	0.9–1.3	0.7***	0.6–0.8	0.7**	0.5–0.9	1.4 [▲]	1.0–1.8	1.3 [▲]	1.0–1.7	1.5	0.7–3.2	1.6**	1.2–2.0
Persistent cough past year	1.0	0.9–1.1	1.1	1.0–1.2	0.9	0.8–1.1	1.1	0.9–1.3	1.1	1.0–1.3	1.1	0.7–1.8	1.6***	1.4–1.8
Ever had asthma	2.0**	1.4–2.9	1.6*	1.2–2.0	0.6 [▲]	0.4–1.0	1.6 [▲]	1.0–2.5	1.3	0.8–2.0	2.3	0.8–6.4	1.0	0.7–1.5
Rhinitis														
Ever had rhinitis	1.3***	1.2–1.5	0.8***	0.8–0.9	0.8**	0.7–0.9	1.5***	1.3–1.7	1.4***	1.3–1.7	0.9	0.6–1.5	1.3***	1.2–1.5
Rhinitis in the past year	1.2	0.9–1.5	1.1	0.9–1.3	1.0	0.7–1.3	1.2	0.9–1.6	1.0	0.7–1.3	1.5	0.5–4.7	1.0	0.8–1.3
Associated itchy eye in the past year	1.2	0.9–1.6	0.8 [▲]	0.6–0.9	0.9	0.6–1.3	1.0	0.7–1.4	0.9	0.7–1.3	2.3	0.8–6.7	0.8	0.6–1.1
Ever had hay fever	1.3*	1.1–1.6	0.8 [▲]	0.7–1.0	0.9	0.7–1.2	1.3 [▲]	1.0–1.7	1.1	0.8–1.4	1.0	0.4–2.2	1.2 [▲]	1.0–1.5
Eczema														
Chronic rash ever	1.2	0.9–1.5	1.1	0.9–1.3	1.0	0.7–1.3	1.3	0.9–1.7	1.1	0.8–1.5	2.2 [▲]	1.0–4.5	1.5*	1.2–2.0
Chronic rash in the past year	0.8	0.4–1.3	1.1	0.8–1.6	2.0	1.0–3.9	1.2	0.6–2.2	1.5	0.8–3.0	0.2	0.0–1.0	1.2	0.7–2.1
Ever had eczema	1.2*	1.1–1.3	1.5***	1.4–1.7	1.1	1.0–1.4	1.1	0.9–1.3	1.0	0.8–1.2	1.0	0.6–1.7	1.3***	1.2–1.5

* $p < 0.01$, ** $p < 0.001$, *** $p < 0.0001$, [▲] $p < 0.05$.

weight asthmatics. Obesity could influence airway function due to its effect on lung mechanics or development of a pro-inflammatory state, as well as other genetic, developmental, hormonal or neurogenic influences.

In this study, there were significantly higher prevalence rates of exercise-induced wheezing ($p < 0.05$) in obese children (BMI > P95th) compared to non-obese children. Overweight children (BMI > P85th) or those with higher BMI (BMI > P65th) had significantly higher prevalence rates of current wheezing, exercise-induced wheezing, rhinitis, rhinoconjunctivitis and hay fever compared with children who were not overweight or had a lower BMI (BMI < P65th). Underweight children (BMI ≤ P5th) had significantly higher prevalence of ever having wheezed than the reference group ($p < 0.05$), and a trend of higher prevalence of exercise-induced wheezing and asthma. Binary regression analysis shows that being overweight is a risk factor of asthma and rhinitis. The study provides evidence for an association between high BMI or obesity and atopy, particularly asthma and rhinitis, and suggests that being overweight might increase the likelihood of asthma and the other conditions. Being underweight may also increase the likelihood of asthma and some of its symptoms.

The association between pet ownership in childhood and asthma, rhinitis and eczema is very controversial. A recent study looked at the role of pets in the development of atopy in children [68] and indicated that the effect of pets depends on the type of pets, the time and duration of exposure, and the genetic background of the individual. Another study in Guangzhou [40] showed that the main inhaled allergen sensitivities in children with allergic rhinitis tested by skin prick test were mites, dog hair and cat hair. Our objective was to determine the effects of exposure to cats and/or dogs on the incidence of asthma, rhinitis and eczema. In this study, the prevalence rates of asthma and rhinitis symptoms were significantly higher in children exposed to cats or dogs compared with children not exposed. However, there was a trend for higher prevalence of eczema in children not exposed to cats and dogs compared with exposed children. It seems that pet ownership has a protective effect on eczema. Children exposed to dogs had higher prevalence rates of most of the three conditions compared with children exposed to cats. Binary regression analysis shows that pet ownership is a risk factor for exercise-induced wheezing and rhinitis, but there was no significant association between pet ownership and eczema. Thus, this study confirms an association between pet ownership and symptoms of asthma and rhinitis.

Tobacco smoking, passive smoking and exposure during pregnancy facilitate allergic sensitization and the appearance of asthma symptoms [69]. In asthmatic individuals environmental tobacco smoke can trigger asthma attacks and make asthma symptoms more severe [48]. Our study shows that children exposed to parental smoking have higher prevalence rates of ever having wheezed, exercise-induced wheezing, cough, rhinitis, hay fever, chronic rash and eczema compared to those not exposed. Binary regression analysis shows that paternal smoking is a risk factor for asthma, rhinitis and eczema. The study shows a strong association between parental smoking and symptoms of asthma, rhinitis and eczema. Our results are similar to those of the recent study in

Hefei, China [47], which showed that exposure to smoking was a risk factor for asthma in children, with ORs of 1.55.

Conclusions/key findings

This study shows that the prevalence of asthma is relatively low in this group of children from Shijiazhuang, but within the group the prevalence of asthma is higher for boys and for younger children. The prevalence of rhinitis in this group was found to be relatively high. Implementation of intervention strategies to control rhinitis in this population is encouraged. We considered several potential risk factors for allergic disease and found that being overweight is a risk factor for asthma and rhinitis, exposure to cats and/or dogs is a risk factor for rhinitis and exposure to paternal smoking is a risk factor for asthma, rhinitis and eczema. The results from this study should aid in early identification and intervention for these allergic diseases.

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Declaration of interest

The authors declare that they have no competing interests.

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