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An increased prevalence of self-reported allergic rhinitis in major Chinese cities from 2005 to 2011

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Keywords
prevalence; increase over time; self-reported allergic rhinitis; rhinosinusitis; asthma.

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Abstract

Background: The prevalence of allergic rhinitis (AR) has increased worldwide in recent decades. This study was conducted to investigate the prevalence of self-reported AR and profiles of AR-related comorbidities in the adult population of China over time.

Methods: This study surveyed residents of 18 major cities in mainland China. Telephone interviews were conducted with study participants after sampling target telephone numbers by random digit dialing. The questions asked during telephone interviews were based on those included in validated questionnaires and focused on topics regarding AR, nonallergic rhinitis (NAR), acute/chronic rhinosinusitis (ARS/CRS), asthma, and atopic dermatitis (AD).

Results: During 2011, a total of 47 216 telephone interviews were conducted, and the overall response rate was 77.5%. When compared with the AR prevalence in 11 cities surveyed in 2005, there was a significant increase in self-reported adult AR in eight of those cities ($P < 0.01$). In 2011, the standardized prevalence of self-reported adult AR in the 18 cities was 17.6%. The concentration of SO_2 was positively correlated with the prevalence of AR ($r = 0.504$, $P = 0.033$). A multiple regression model showed that the absolute change in household yearly income was significantly associated with the change in the prevalence of AR ($R^2 = 0.68$), after adjusting for PM_{10}, SO_2, NO_2, temperature, and humidity. The overall prevalences of NAR, ARS, CRS, asthma, and AD in the general population were 16.4%, 5.4%, 2.1%, 5.8%, and 14%, respectively.

Conclusion: During a 6-year period, there was a significant increase in the prevalence of self-reported AR in the general Chinese adult population. The incidence of AR being accompanied by rhinosinusitis, asthma, or AD was significantly higher among individuals having self-reported AR compared with the general population.

Allergic rhinitis (AR) is one of the most common allergic disorders and affects 10% to 40% of the population worldwide (1). Its large prevalence produces a considerable burden on both rhinitis sufferers and society, and negatively impacts the quality of life for large numbers of individuals. The prevalence of AR in many countries has markedly increased during the past 30 years (1). Numerous studies have shown various associations between AR, asthma, and atopic dermatitis (AD). For example, the 'atopic march' refers to a typical progression of allergic diseases including pediatric food allergies, eczema, and asthma before a child reaches school age and later. AR is an important risk factor for asthma (1) and impairs the clinical management of asthma; however, adequate treatment of AR appears to alleviate the severity of asthma (2). Due to their associations, the prevalences of AR, asthma, and AD have often been surveyed together in epidemiological studies (3). While epidemiological surveys have extensively used telephone interviews to gather information in the past, the development of randomized sampling phone number techniques has made telephone-based surveys much easier and more economical to conduct than traditional face-to-face interviews (4, 5).

During the past decade, standardized questionnaires have been widely used to examine the prevalences of self-reported AR and asthma. For example, a Swedish survey reported a 28% prevalence of self-reported AR in Stockholm (6). In 2005, our group conducted the first multicenter survey of AR in China and found self-reported AR prevalences ranging from 8% to 21.4% in 11 Chinese central cities (4). Furthermore, when conducting a survey, a well-designed questionnaire can also be used to simultaneously gather information concerning clinical characteristics, comorbid diseases, and patient treatment histories, as well as disease prevalence.

China can be divided into seven geographic areas: Northeast, North, Northwest, Middle, East, South, and Southwest. These areas display considerable differences regarding their topography and climate, which influence the population's lifestyle and exposure to allergens. Eleven cities, mostly located in middle and eastern China, as well as some major cities in the North, Northwest, and Southwest were not included in our previous study in 2005 (4). The urban population of China has increased from 41.76% in 2004 to 49.95% in 2010, and the gross domestic product of China has risen from number seven in the world in 2004 to number two in 2010 (7). This transition in socioeconomic status may have influenced the prevalence and morbidity of diseases (8). Up to now, no study has examined changes in the prevalence of AR and AR-related multiple disorders over time in the Chinese population. Therefore, our current study was designed to investigate trends in the prevalence of AR among individuals who resided in mainland China between 2005 and 2011. Additionally, our survey investigated the profiles and prevalences of nonallergic rhinitis (NAR), rhinosinusitis, asthma, and AD in major cities representing the seven geographic regions of China.

Materials and methods

Selection of cities

Eighteen major cities in mainland China were selected in this study. These included 11 cities from the previous study conducted during 2004–2005 (4), plus seven additional new cities (Fig. 1). The smallest and largest cities were Haikou and Shanghai, with 2.0 million and 23 million people, respectively. The 18 major cities included two main municipalities (Beijing and Shanghai), 13 capital cities of major provinces throughout mainland China, and three capital cities of autonomous regions: Inner Mongolia (Hohhot), Ningxia (Yinchuan), and Xinjiang (Urumqi). The study was designed to include a random sample of the target population in each of the selected cities. The study protocol was reviewed and approved by the Ethics Review Committee of Beijing Institute of Otolaryngology.

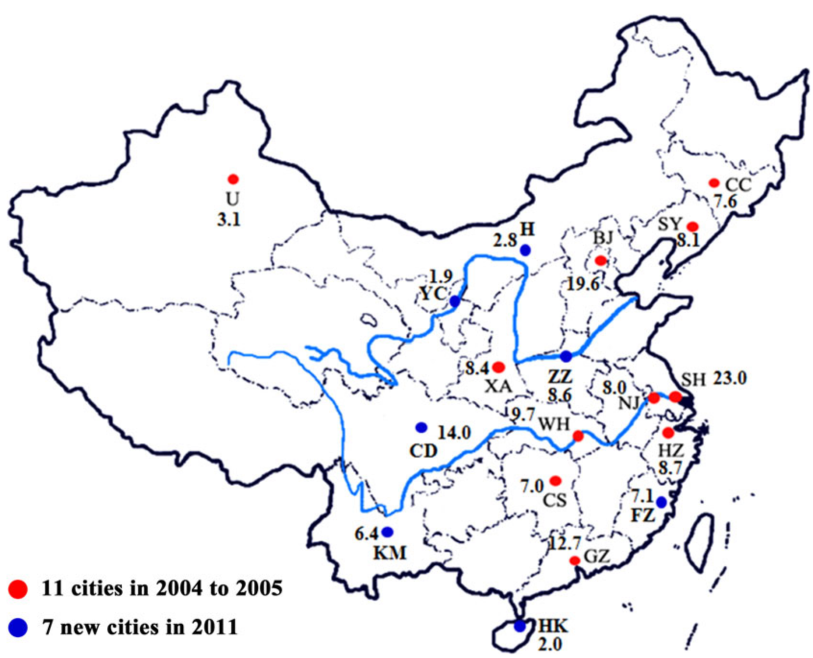

Figure 1 Locations of the 18 major cities in mainland China selected for inclusion in the present study. The number given for each city represents its population (millions of inhabitants) in 2010. Abbreviations: BJ, Beijing; CC, Changchun; CD, Chengdu; CS, Changsha; FZ, Fuzhou; GZ, Guangzhou; HK, Haikou; HZ, Hangzhou; H, Hohhot; KM, Kunming; NJ, Nanjing; SH, Shanghai; SY, Shenyang; U, Urumqi; WH, Wuhan; XA, Xi'An; YC, Yinchuan; ZZ, Zhengzhou.

Questionnaire

The questionnaire used in the current study was similar to that used in our previous study (4). The questions were derived from well-validated questionnaires used in the International Study of Asthma and Allergies in Childhood (ISAAC) (4, 9) and the European Community Respiratory Health Survey (ECRHS) (10); however, modifications were made to include additional questions regarding NAR, rhinosinusitis, asthma, and AD. The questionnaire consisted of two parts. The first part was a screening questionnaire used to gather information regarding the age, occupation, monthly income of the interviewee, and their histories of AR, NAR, rhinosinusitis, asthma, and AD. During the survey, each interviewee was asked the following question: 'In the past 12 months, have you or your family members ever had a problem with sneezing, or a runny, blocked or itchy nose, when you were exposed to allergens such as seasonal pollens, dust mites, etc., and did not have a cold or the flu?' If the answer was 'yes', the interviewee was asked 14 specific questions in the second part designed to gather specific information regarding the duration and severity of nasal symptoms, length of past AR history, ocular symptoms, self-reported allergens, treatments for AR, and response to treatments. The criteria used to diagnose AR were consistent with the ARIA guidelines (1) and AR severity and duration were classified accordingly as mild, moderate/severe, intermittent or persistent.

Similarly, NAR was diagnosed by asking the question: 'In the past 12 months, have you or your family members ever had a problem with sneezing, or a runny, blocked or itchy nose, when exposed to cold or dry air, temperature changes, airborne irritants, foods (especially hot and spicy foods), alcoholic beverages, or exercise?' (11); and chronic rhinosinusitis (symptoms for > 12 weeks) or acute rhinosinusitis (symptoms for < 12 weeks) if two or more symptoms (one of which was nasal blockage or discharge) were reported was diagnosed by asking the question: 'Has your nose been blocked; have you had nasal discharge or mucus in the throat; have you had a pain or facial pressure; or has your sense of smell been reduced or absent for less than 12 weeks or more than 12 weeks during the last 12 months?' (12, 13).

Asthma was defined as reporting 'having ever had asthma', plus at least one of the following symptoms during the previous 12 months: (i) Wheezing or whistling in the chest; (ii) Waking up with tightness in the chest, shortness of breath, or an attack of coughing (14). AD was diagnosed by a positive response to the following question 'Have you had an itchy rash at any time in the past 12 months?' (15).

Telephone number sampling and telephone interviews

A computerized random digit dialing method was used to sample targeted telephone numbers as described previously (4, 16). Specific details of telephone number sampling used in this study are shown in the Online Repository.

The telephone interviews were conducted between August and October of 2011 by trained interviewers from a company with interviewers located in each major city in China. The interviews were conducted using the computer-assisted telephone interviews technique between 16:30 and 21:00 on weekdays and 10:00 and 21:00 on weekends and holidays. In the telephone screening interview, the interviewee was first asked to state their age, and only subjects aged between 16 and 65 years were eligible to answer the subsequent questions concerning their histories of AR, NAR, rhinosinusitis, asthma, and AD, as well as the core interview. If the subject did not satisfy the age criteria, an eligible family member whose self-reported age was between 16 and 65 years was contacted to answer the questions and allowed to complete the telephone interview.

Collection of data concerning socioeconomic status, meteorology, and air pollution

To generally assess the association between the standardized self-reported prevalence of AR and certain factors such as air pollution, meteorological conditions, and socioeconomic status in 2011, we considered the following factors: (1) indicators of air pollution, including the annual mean atmospheric content of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter with an aerodynamic diameter ≤ 10 μm (PM_{10}); (2) indicators of meteorological conditions including the annual average relative humidity and annual average temperature; (3) individual yearly household income as an indicator of socioeconomic status. All data were obtained from the National Bureau of Statistics of China (7).

Data analysis

All data were entered into the study database twice by two independent investigators. The data were categorized and analyzed using SPSS Statistics, Version 17.0. The age-standardized prevalences of AR in the 18 cities investigated were calculated based on data from the 2012 Statistical Yearbook (7). Potential differences among the self-reported prevalences of AR, NAR, rhinosinusitis, asthma, and AD in the 18 cities were assessed using the chi-square test. A bivariable correlation analysis was performed to assess the relationship between the standardized prevalence of AR and various external factors, including socioeconomic status, air pollution, and meteorological conditions. Moreover, differences were calculated between two time points (2011 − 2005) to reflect the change both in standardized prevalence of AR and the various external factors mentioned above. A multiple linear regression (forward method) was adapted to evaluate the correlation between the differences for the standardized prevalence of AR and differences for the external factors in 11 cities from 2005 to 2011. A P-value <0.05 was considered statistically significant.

Results

Telephone number sampling

A total 100 635 telephone numbers were dialed. Overall, 47 216 of these numbers (46.9%) contacted an individual who was eligible to complete the survey, of whom 36 577 subjects (77.5%) completed the interview.

Prevalence of self-reported AR and a comparison with 2005 results

Among the 36 577 surveyed respondents, 6483 subjects (17.7%) reported having AR. The prevalence of self-reported AR was <15% in Chengdu, Fuzhou, and Zhengzhou, and >20% in Beijing, Urumqi, Shenyang, Hangzhou, Kunming, and Shanghai. The highest and lowest prevalences of self-reported AR were 23% (Shanghai) in eastern China and 9.8% (Chengdu) in southwestern China, respectively. After adjustment for age distribution of each city's population, the standardized prevalence of self-reported AR ranged from 9.6% (Chengdu) to 23.9% (Shanghai). In contrast, in 2005, only 4 of the 11 cities surveyed (Shenyang, Wuhan, Changsha, and Urumqi) had a standardized AR prevalence >15%, while 3 cities (Beijing, Hangzhou, and Xi'an) had a standardized AR prevalence <10%. Comparison of age-adjusted prevalence of self-reported AR between 2005 and 2011 indicated that the standardized prevalence of AR had significantly increased in eight of 11 cities ($P < 0.01$ for Guangzhou and $P < 0.001$ for Beijing and Changchun, etc.), decreased in one city (Urumqi, $P < 0.01$), and not significantly altered in two cities (Wuhan and Changsha) (Table 1 and Fig. 2).

The most commonly reported symptoms of AR were sneezing (81.8%), rhinorrhea (60.2%), blocked nose (54.9%), nasal itching (49.6%), ocular itching (42.9%), pharyngolaryngeal symptoms (35.1%), watery eyes (34.5%), ocular swelling (19.1%), and ocular ache (17.6%).

When differentiated by severity, AR was described as mild in >50% of cases in 14 cities, but moderate/severe in ≥50% of cases in Zhengzhou, Fuzhou, and Changchun (Fig. S1 – Online Repository).

Assessment of intermittent and persistent AR reported by respondents in the 18 cities investigated indicated that a majority (57%) of respondents reported persistent AR in only one city (Zhengzhou), whereas a majority of respondents in each of the other 17 cities surveyed reported having intermittent AR (Fig. S2 – Online Repository). Indeed, in 12 of these cities, intermittent AR was reported by >80% of the respondents. The self-reported allergens indicated that house dust was the most frequently mentioned allergen (range = 31.5% of respondents in Haikou to 61.4% of respondents in Hangzhou), followed by pollen (range = 14.8% in Urumqi to 59.6% in Wuhan), weeds (range = 4.5% in Yinchuan to 51.2% in Changchun), fungi (range = 3.0% in Yinchuan to 36.2% in Zhengzhou), mites (range = 2.0% in Yinchuan and Urumqi to 31.6% in Beijing), and animal dander (range = 2.5% in Yinchuan to 30.6% in Beijing) (Table S1 – Online Repository).

Influence of air pollution, meteorological conditions, and socioeconomic status on the standardized prevalence of AR in the 18 cities

Table 2 shows data for air pollution, meteorological conditions, and the socioeconomic status of interviewees in 18 cities during 2011, 11 cities during 2005, and the ratios of change for above external factors and the standardized prevalence of AR. Firstly, we sought to evaluate the association between these external factors and the standardized prevalence of AR in 2011 (Table 1). No correlation was found between the prevalence of AR and either individual household yearly income ($r = 0.389$, $P = 0.11$), average temperature ($r = -0.233$, $P = 0.375$), or relative humidity ($r = -0.192$, $P = 0.445$). However, the standardized prevalence of AR was positively correlated with the concentration of atmospheric SO_2 ($r = 0.504$, $P = 0.033$). Moreover, there was no correlation between the prevalence of AR and other air pollutants such as PM_{10} and NO_2 ($r = 0.009$, $P = 0.973$ and $r = 0.504$, $P = 0.033$, respectively).

Secondly, we assessed the association between the differences for the standardized prevalence of AR and those for the various external factors in 11 cities from 2005 to 2011 by multiple regression analysis (Table 2). A significant multiple regression equation could be established ($F = 19.123$, $P = 0.002$), and the model demonstrated that the change of standardized prevalence of AR was associated with the absolute change in household yearly income ($R^2 = 0.68$, standardized coefficient $\beta = 0.825$, $P = 0.002$), but not with the absolute change in PM_{10} ($\beta = 0.079$, $P = 0.737$), SO_2 ($\beta = 0.283$, $P = 0.142$), NO_2 ($\beta = 0.330$, $P = 0.274$), average temperature ($\beta = 0.214$, $P = 0.284$), or relative humidity ($\beta = -0.111$, $P = 0.597$).

Self-reported NAR, rhinosinusitis, asthma, and AD

The prevalences of self-reported NAR, rhinosinusitis, asthma, and AD in each city are shown in Table 3. The overall self-reported prevalences of NAR, ARS, CRS, asthma, and AD were 16.4%, 5.4%, 2.1%, 5.8%, and 14%, respectively. After adjusting for the age distributions of the populations, the standardized prevalences of NAR, ARS, CRS, asthma, and AD were 14.9%, 5.9%, 2.2%, 5.2%, and 13.2%, respectively.

Comorbidity of rhinitis, rhinosinusitis, asthma, and AD

To evaluate possible comorbidities among rhinitis, rhinosinusitis, asthma, and AD, we compared the self-reported prevalences of AR, NAR, ARS, CRS, asthma, and AD in the total population as well as the AR, NAR, and asthma subpopulations. The prevalences of asthma, ARS, CRS, and AD in the AR and NAR subpopulations were significantly higher than in the total population. Furthermore, the prevalences of asthma and CRS in the AR subpopulation were significantly higher than in the NAR subpopulation (Fig. 3). Similarly, the prevalences of AR, NAR, rhinosinusitis, and AD in the asthma subpopulation were also higher than in the total population (Fig. 4).

Discussion

We conducted telephone interviews to assess trends in the prevalence of self-reported AR in 18 major cities in mainland China during an interval of 6 years (2005–2011). To the best of our knowledge, this is the first and most comprehensive multicenter collaborative, large-scale epidemiological survey

Table 1 Prevalence of self-reported AR in 2011 and a comparison with 2005

Geographic area	City	2011 Completed screening questionnaire	2011 Self-reported AR	2011 Prevalence of AR (%)	2011 Standardized (age) prevalence of AR (%)	2005 Completed screening questionnaire	2005 Self-reported AR	2005 Prevalence of AR (%)	2005 Standardized (age and sex) prevalence of AR (%)	*P*-value*
North	Beijing	2501	505	20.2	20.2	9688	940	9.7	8.7	<0.001
	Hohhot	1515	285	18.8	19.1					
Northeast	Changchun	2004	322	16.1	16.8	2347	211	9.0	11.2	<0.001
	Shenyang	2000	419	21.0	20.6	2252	317	14.1	15.7	<0.001
East	Shanghai	2500	576	23.0	23.9	4051	441	10.9	13.6	<0.001
	Nanjing	1999	364	18.2	19.6	2797	322	11.5	13.3	<0.001
	Hangzhou	2000	420	21.0	19.7	3403	346	10.2	8.9	<0.001
	Fuzhou	2001	276	13.8	13.5					
Middle	Zhengzhou	2500	369	14.8	16.7					
	Wuhan	2001	344	17.2	18.1	2064	335	16.2	19.3	0.330
	Changsha	1999	367	18.4	17.3	2.632	315	12.0	16.1	0.278
South	Guangzhou	2001	349	17.4	16.9	3346	440	13.2	14.1	0.006
	Haikou	1501	249	16.6	16.4					
Southwest	Chengdu	3043	299	9.8	9.6					
	Kunming	2001	437	21.8	22.4					
Northwest	Xi'An	2000	314	15.7	16.5	4602	368	8.0	9.1	<0.001
	Yinchuan	1500	273	18.2	17.2					
	Urumqi	1511	315	20.8	19.6	1021	218	21.4	24.1	0.007
Total		36577	6483	17.7	17.6	38 203	4253	11.1		

*Comparisons of the standardized prevalences of self-reported AR in 11 major cities between 2011 and 2005.

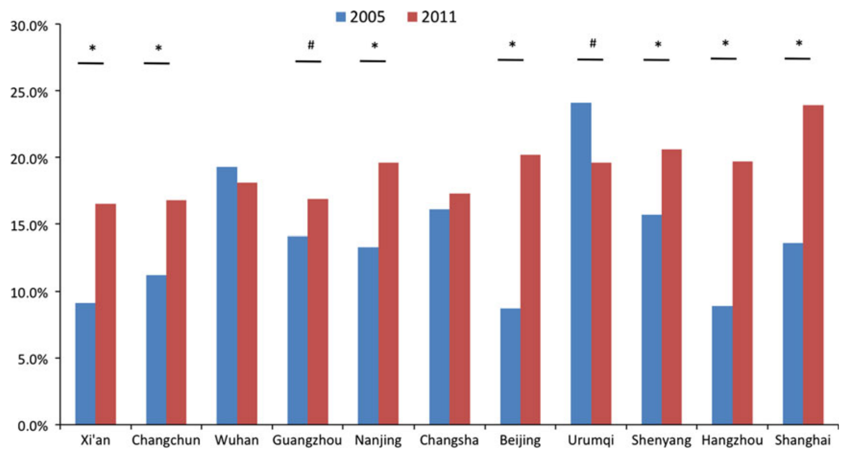

Figure 2 Comparisons of the standardized prevalences of self-reported allergic rhinitis (AR) in 11 major cities between 2005 and 2011. (*$P < 0.001$, # $P < 0.01$; Table 1 shows the P-values for comparisons between 2005 and 2011.)

of multiple atopic disorders (AR, NAR, rhinosinusitis, asthma, and AD) ever conducted in mainland China. Compared with the survey in 2005, seven new cities were added for this survey. This allowed us to expand our nationwide epidemiological map to better represent the prevalence and comorbidities of AR in various geographic regions of China. Our results revealed an overall increase in the prevalence of self-reported AR in most cities from 2005 to 2011, suggesting that the prevalence of AR in mainland China has not yet reached a plateau.

The prevalences and trend of AR shown in our studies are not consistent with the worldwide pattern of AR prevalence. The ECRHS examined geographic variations in the prevalence of nasal allergies in 15 394 adults who visited 35 medical centers in 15 countries and found AR prevalences ranged from 11.8% in Oviedo (Spain) to 46.0% in Melbourne (Australia) (17). Furthermore, the ISAAC found a slight worldwide increase in the prevalence of AR among children aged 13-14 years (0.18% per year) and 6-7 years (0.17% per year), as well as a > 20-fold variation in the prevalence of self-reported AR among countries in the same region and between centers in the same country (3). As our data pertain to the most populous developing country in the world, the etiology underlying the rapid increase in self-reported AR in various regions of China needs to be explored. It is well known that AR results from interactions between atopic individuals and their ambient environment. The typical Chinese diet is characterized by the high consumption of vegetables and a relatively low consumption of animal fat. This type of diet can lead to a relatively low intake of n-6 fatty acids, and a reduced risk for allergic respiratory diseases (18). Therefore, it is speculated that the characteristic prevalence of AR in China could be attributed to environmental factors.

It is widely recognized that China's socioeconomic growth has resulted in a deteriorated quality of air, as the demand for fossil fuels has greatly increased (19, 20). Statistical yearbooks show that China's coal and oil consumption increased from 2318.5 and 325.4 million tons, respectively, in 2005 to 3429.5 and 453.8 million tons, respectively, in 2011 (7). Several epidemiological studies have confirmed that outdoor air pollution created by increased fossil fuel combustion contributes to both the initiation and exacerbation of allergic diseases (21). SO_2, the pollutant often related to combustion of fossil fuels, can increase the permeability of airway mucosa, and thus enhance the penetration of allergens and development of allergic reactions. In our 2011 survey, SO_2 concentrations were positively associated with AR prevalence, which is consistent with our findings in 2005 (4). Moreover, higher concentrations of atmospheric CO_2 can induce an increase in the production of pollen. This effect is particularly significant in China, where 75% of total CO_2 emissions result from the burning of fossil fuels (22). To make matters worse, the number of automobiles in China has tripled from 31 million in 2005 to 93 million in 2011 (7). These vehicles discharge large amounts of particulate matter and thus may contribute to an overproduction of IgE and the increased permeability of nasal mucosa in susceptible individuals (23, 24). In this survey, multiple regression analysis showed that the increase in prevalence of AR was associated with the increased household yearly income. It is reported that the rapid increase in the wealth of Chinese households has been accompanied by sales of houses increasing from 554 million m^2 in 2005 to 1 billion m^2 in 2011 (7). These factors likely lead to increasing amounts of volatile organic compounds associated with high rates of AR and respiratory conditions (25–27). Increasing numbers of individuals who came from small families and had only limited exposure to respiratory infections when they were children, have now grown into adults, and constitute a high percentage of the general adult population. This change may contribute to the prevalence of AR in Chinese adults to the same extent as the hygiene hypothesis (28).

In both 2005 and 2011, the majority of surveyed individuals in almost all of the cities studied suffered from intermittent AR, which is in accordance with a finding of 71% subjects with intermittent AR and 29% persistent AR, in a

Table 2 Data for socioeconomic status, air pollution, and meteorological conditions in the 18 cities (2011) and 11 cities (2005) in China

	Standardized prevalence of AR (%)	Individual household yearly income (yuan)			PM_{10} (mg/m^3)			SO_2 (mg/m^3)			NO_2 (mg/m^3)			Average temperature (°)			Average relative humidity (%)		
	2011–2005	2011	2005	2011–2005	2011	2005	2011–2005	2011	2005	2011–2005	2011	2005	2011–2005	2011	2005	2011–2005	2011	2005	2011–2005
Beijing	11.5	32 903	17 653	15 250	0.113	0.141	−0.028	0.028	0.05	−0.022	0.056	0.066	−0.01	13.4	13.2	0.2	49	49	0
Hohhot		20 407			0.076			0.054			0.039			7.9			42		
Changchun	5.6	17 796	8691	9105	0.091	0.099	−0.008	0.026	0.026	0	0.043	0.035	0.008	5.9	5.6	0.3	61	61	0
Shenyang	4.9	20 466	9108	11 358	0.096	0.118	−0.022	0.059	0.054	0.005	0.033	0.036	−0.003	7.7	8.0	−0.3	68	64	4
Shanghai	10.3	32 630	18 645	13 985	0.080	0.088	−0.008	0.029	0.061	−0.032	0.051	0.061	−0.01	16.9	17.1	−0.2	69	70	−1
Nanjing	6.3	26 340	12 318	14 022	0.097	0.11	−0.013	0.034	0.052	−0.018	0.049	0.054	−0.005	16.1	16.3	−0.2	68	66	2
Hangzhou	10.8	30 970	16 293	14 677	0.093	0.112	−0.019	0.039	0.06	−0.021	0.058	0.058	0	17.2	17.5	−0.3	69	69	0
Fuzhou		24 907			0.069			0.009			0.032			20.2			70		
Zhengzhou		18 194			0.103			0.051			0.047			15.1			56		
Wuhan	−1.2	18 373	8786	9587	0.10	0.119	−0.019	0.039	0.054	−0.015	0.056	0.05	0.006	16.3	17.8	−1.5	77	69	8
Changsha	1.2	18 844	9524	9320	0.083	0.112	−0.029	0.040	0.081	−0.041	0.047	0.036	0.011	17.9	17.7	0.2	72	73	−1
Guangzhou	2.8	26 897	14 770	12 127	0.069	0.088	−0.019	0.028	0.053	−0.025	0.049	0.068	−0.019	21.4	22.8	−1.4	74	71	3
Haikou		18 368			0.041			0.008			0.016			23.3			81		
Chengdu		17 899			0.10			0.009			0.051			15.9			74		
Kunming		18 575			0.065			0.037			0.044			15.5			71		
Xi'an	7.4	18 245	8272	9973	0.118	0.114	0.004	0.042	0.044	−0.002	0.041	0.032	0.009	14.1	15.0	−0.9	65	60	5
Yinchuan		17 578			0.095			0.038			0.030			9.9			53		
Urumqi	−4.5	15 513	7990	7523	0.132	0.114	0.018	0.079	0.116	−0.037	0.068	0.056	0.012	7.3	7.5	−0.2	56	56	0

Table 3 Prevalences of self-reported NAR, ARS, CRS, asthma, and AD in 2011

City	NAR			ARS			CRS			Asthma			AD		
	Screened/ Positivity	Self-reported prevalence (%)	Standardized prevalence (%)	Screened/ Positivity	Self-reported prevalence (%)	Standardized prevalence (%)	Screened/ positivity	Self-reported prevalence (%)	Standardized prevalence (%)	Screened/ positivity	Self-reported prevalence (%)	Standardized prevalence (%)	Screened/ positivity	Self-reported prevalence (%)	Standardized prevalence (%)
Beijing	2344/458	19.5	18.5	2318/239	10.3	10.6	2318/40	1.7	2.0	2286/244	10.7	11.5	2298/369	16.1	14.8
Hohhot	1332/102	7.7	8.0	1322/19	1.4	2.4	1322/11	0.8	0.9	1323/25	1.9	1.0	1322/40	3.0	3.6
Changchun	1758/110	6.3	6.8	1756/14	0.7	1.1	1756/50	2.8	3.6	1760/35	2.0	2.4	1762/124	7.0	6.8
Shenyang	1867/397	21.3	20.5	1846/154	8.3	9.3	1846/91	5.0	6.6	1804/177	9.8	10.7	1863/402	21.6	21.9
Shanghai	2381/554	23.3	22.4	2278/205	9.0	9.6	2278/38	1.7	1.5	2254/198	8.8	8.7	2351/452	19.2	17.7
Nanjing	1861/406	21.8	18.6	1789/109	6.1	6.4	1789/28	1.6	2.2	1785/116	6.5	6.4	1860/358	19.2	17.4
Hangzhou	1860/314	16.9	15.4	1827/142	7.8	8.9	1827/17	0.9	1.3	1807/132	7.3	8.2	1850/228	12.3	12.4
Fuzhou	1763/82	4.7	5.1	1756/30	1.7	1.9	1756/10	0.6	0.6	1756/20	1.1	1.1	1762/59	3.3	3.7
Zhengzhou	2304/442	19.2	17.3	2293/67	2.9	3.3	2293/196	8.5	6.7	2257/165	7.3	7.7	2358/506	21.5	17.7
Wuhan	1933/651	33.7	22.9	1843/182	9.9	8.5	1843/36	2.0	1.7	1819/166	9.1	6.4	1853/345	18.6	15.1
Changsha	1805/253	14	13.2	1800/124	6.9	9.0	1800/9	0.5	0.5	1777/96	5.4	6.6	1871/354	18.9	18.8
Guangzhou	1874/433	23.1	20.7	1806/137	7.6	6.9	1806/25	1.4	1.2	1795/144	8.	7.5	1797/198	11.0	10.4
Haikou	1314/119	9.1	9.1	1309/19	1.5	2.0	1309/32	2.4	4.2	1307/25	1.9	1.9	1307/76	5.8	7.8
Chengdu	2876/486	16.9	15.3	2795/128	4.6	4.8	2795/29	1.0	1.1	2789/150	5.4	5.3	2862/416	14.5	13.8
Kunming	1790/100	5.6	6.3	1765/40	2.3	2.4	1765/27	1.5	1.6	1764/26	1.5	1.6	1786/80	4.5	4.8
Xi'an	1877/428	22.8	22.8	1800/123	6.8	6.8	1800/16	0.9	1.0	1786/123	6.9	7.9	1876/521	27.8	26.2
Yinchuan	1321/110	8.3	8.1	1315/27	2.1	2.7	1315/32	2.4	2.9	1308/51	3.9	4.6	1310/119	9.1	9.8
Urumqi	1319/51	3.9	4.0	1313/17	1.3	1.5	1313/11	0.8	1.4	1316/17	1.3	1.4	1318/37	2.8	2.9
Total	33 579/5496	16.4	14.9	32 931/1776	5.4	5.9	32 931/698	2.1	2.2	32 693/1910	5.8	5.2	33 406/4684	14.0	13.2

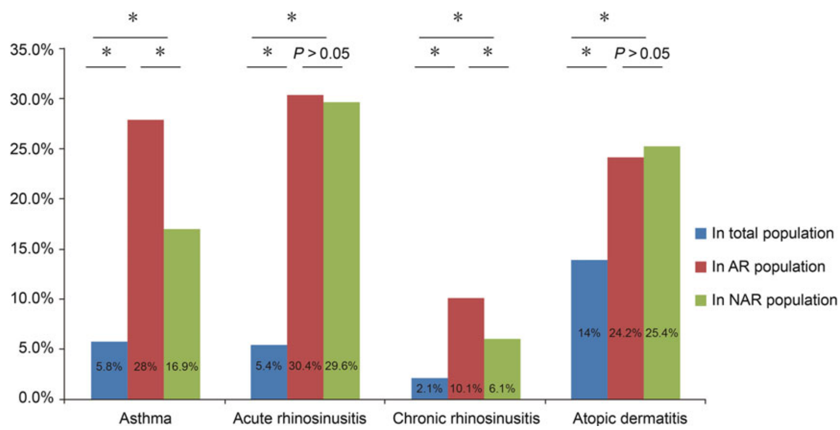

Figure 3 Comorbidity of self-reported asthma, acute rhinosinusitis, chronic rhinosinusitis, and atopic dermatitis in the total population, and allergic rhinitis (AR) and non-AR subpopulations (*$P < 0.001$).

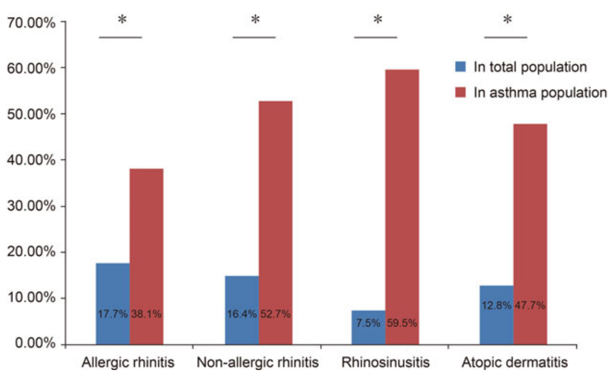

Figure 4 Comorbidity of self-reported allergic rhinitis, nonallergic rhinitis, acute rhinosinusitis, chronic rhinosinusitis, and atopic dermatitis in the total population and asthma population (*$P < 0.001$).

study involving six European countries (29), but in contrast to a finding of 19% subjects with intermittent AR and 81% persistent AR in an Italian survey (30). Additionally, with respect to severity, 65% of individuals in our study reported mild AR and 35% moderate/severe AR. These findings, however, are in contrast to findings from two European studies, in which the participants reported a higher proportion of moderate/severe AR (30, 31). Further studies need to investigate whether in future years AR severity might also increase in China. On the other hand, one study using skin prick tests (SPTs) reported that house dust mites were the most common aeroallergen; with ~40% of patients who suffered from asthma and/or rhinitis in northern China and nearly 70% of patients in southern China being sensitized to dust mites (32). In contrast, <5% of adult patients in most regions of China were sensitized to grass or tree pollen (32). A SPTs study of adult AR patients in Beijing by our group found that >60% of the participants were sensitized to dust mites and 10–20% were sensitized to grass and tree pollens (33). However, <20% of participants in the present study reported mites as an allergen, while >40% of the participants in most cities reported house dust as an allergen. Moreover, 20% of participants in >50% of the cities reported pollen and weeds as allergens. It is likely that the differences between the findings in the present study and the other studies mentioned above may have resulted from differences in study design and the population selected, as well as suboptimal understanding of allergen in the general population.

In the present 2011 study, the overall prevalence of NAR was found to be 16.4%, which was similar to the 17.7% prevalence of AR in the Chinese adult population. However, this finding is not in accordance with other surveys (34). Both monocenter and multicenter studies have found NAR and AR prevalences ranging from 17% to 36% and 64% to 83%, respectively, with the distribution ratio of NAR and AR in Western countries being 1 : 3 (2, 35, 36). This skewing toward a lower proportion of NAR in Western countries suggests that more studies were performed among patients seeking treatment at allergy clinics than among the general population (34). Furthermore, in the current study, the prevalences of ARS, CRS, asthma, and AD in the general population of China were 5.4%, 2.1%, 5.8%, and 14%, respectively, and wide variations were found across different regions of the country. In Sweden, Finland, and Korea, the prevalence of doctor-diagnosed CRS ranged from 3% to 5% (13). The GA^{2}LEN study found asthma prevalences to be 7.1%, 6.4%, 7.6%, and 6.3% in Sweden, Netherlands, Belgium, and Germany, respectively (37). With regard to comorbidities, both our study and previous studies have identified a strong association between AR and asthma (5, 38). In the present study, asthma was significantly more prevalent in the AR population (28%) *vs* the NAR population (16.9%). Furthermore, AR and NAR were reported more frequently in the asthma population (38.1% and 52%, respectively), compared with the total population (17.7% and 16.4%, respectively). Similarly, CRS was more prevalent among AR subjects (10.1%) than in NAR subjects (6.1%) and the total population (2.1%). These findings are consistent with those in most studies (39–41). Shi and colleagues (42) have recently conducted a face-to-face survey in seven Chinese cities and also demonstrated a higher prevalence of CRS among AR subjects than normal subjects (42).

In summary, this is the first report of a rapid increase in the prevalence of self-reported AR across various geographic regions of China. Furthermore, the study establishes a nationwide map showing the prevalences of AR, NAR, rhinosinusitis, asthma, and AD in China. Epidemiological cross-sectional surveys and continuous monitoring of the dynamics are fundamental for assessing changes in AR and its comorbidities, identifying risk factors influencing such trends and providing a basis for defining new health policies. The trends in AR prevalence and the various features of its comorbidities identified in this study suggest that China's authorities should act to halt this increasing challenge to public health.

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Author contributions

Xiangdong Wang, Ming Zheng, Nan Zhang, Luo Zhang, and Claus Bachert designed and organized the survey, monitored the data, and prepared the manuscript. Hongfei Lou, Chengshuo Wang, Yuan Zhang, Mingyu Bo, and Siqi Ge analyzed the data and conceptualized the Results section of the manuscript.

Conflict of interest

None of the authors have any conflict of interest to declare.

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Figure S1. Severity of allergic rhinitis in 18 cities in China.

Figure S2. Prevalences of intermittent and persistent allergic rhinitis in 18 cities in China.

Table S1. Self-reported allergens in the 18 cities (%).

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