

House dust mite sensitization is the main risk factor for the increase in prevalence of wheeze in 13- to 14-year-old schoolchildren in Guangzhou city, China

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Summary

Background Little is known about time trend of prevalence of asthma and the association between the changing prevalence and allergen sensitization in Chinese children.

Objective To determine the changes in prevalence of asthma and allergen sensitization in schoolchildren over a period of 15 years.

Methods A total of 6928 schoolchildren aged 13–14 years in 2009 were recruited for the study using the Phase III Protocol of the International Study of Asthma and Allergic disease in Childhood (ISAAC) and 2531 of them underwent skin prick test for seven common aeroallergens. The results were compared with those obtained in the Phase I (1994/95) and III (2001/02) ISAAC studies.

Results The prevalence of asthma ever and current wheeze increased from 3.9% and 3.4% in 1994, to 4.6% and 4.8% in 2001 ($P < 0.001$), and to 6.9% and 6.1% in 2009 ($P \leq 0.008$). The prevalence of higher degree of skin response to house dust mites (HDMs) and cat, and atopic index increased significantly in all children in 2010 when compared with those in 2002 ($P < 0.001$). Prevalence of wheeze remained unchanged in subjects without sensitization to any tested allergen including HDMs ($P > 0.05$). Sensitization to HDMs, especially *Dermatophagoides Pteronyssinus* was associated with increase in prevalence of wheeze.

Conclusion The prevalence of wheeze and sensitization to common aeroallergens in secondary schoolchildren in Guangzhou China has increased significantly since 1994. Sensitization to HDMs is an important risk factor associated with the increase in prevalence of wheeze in this group of population in Guangzhou city.

Keywords aeroallergens, asthma, prevalence, risk factor, skin prick test, wheeze

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Introduction

The prevalence of asthma and allergic diseases has increased in different parts of the world including China over the past few decades [1, 2]. Such an increase poses a considerable burden on individuals, the health-care systems, and society [3–5]. We have previously conducted two cross-sectional studies using the identical and validated core questionnaires of the International Study of Asthma and Allergic disease in Childhood (ISAAC) protocol in 1995 (Phase I) and 2001 (Phase III). We found that the prevalence rates of wheeze in the past 12 months in 13- to 14-year-old

secondary schoolchildren in Guangzhou had increase from 3.4% in 1995 to 4.8% in 2001 [6]. Rapid economic development and urbanization in the past 2 decades may be associated with further increase in the prevalence of asthma.

Among all potential risk factors, allergen sensitization, as measured by skin prick test (SPT), has one of the strongest and most consistent relationships with the development of asthma [7–10]. However, many children with allergic diseases are sensitized to more than one allergen, with the number of different sensitizations increasing over time [11, 12]. In our previous study [11], we found that multiple sensitizations were

common, and house dust mites (HDMs) were the most prevalent allergens in patients with asthma and/or rhinitis in China. We hypothesize that rapid environmental changes, such as rapid urbanization and increase in the temperature and humidity in many regions of China within this decade may facilitate the growth of HDMs in the environments. This change could be associated with increase in HDM sensitization in Chinese school-children and may contribute to further increase in the prevalence of asthma. We, therefore, conducted a follow-up cross-sectional study on the prevalence of asthma and skin sensitization in secondary schoolchildren aged 13–14 years from the same schools of Guangzhou using the ISAAC Phase III protocol in 2009–2010. The results were compared with those in Phase I and III surveys which used the same ISAAC core questionnaires conducted in 1995 and 2001.

Methods

Study population

For ISAAC Phase I, Phase III and the present surveys, cluster randomized samples of the same 10 secondary schools of four central districts in Guangzhou city were recruited for studies following the ISAAC protocols [1, 13]. All children of the first and second year of secondary school with the highest proportion of children aged 13–14 years in participating schools were invited to participate in the surveys. Between November 1994 and March 1995 (ISAAC Phase I), a total of 3868 students were invited with a response rate of 99.6%, whereas 3675 children were invited with the response rate of 96% for Phase III conducted between November and December 2001. The most recent survey was conducted between November and December in 2009. A total of 7165 students were invited with a response rate of 96.7% (Table 1). Informed consent was obtained from children's parents or guardians. All three surveys were approved by the Ethics Review Board of Guangzhou

Educational Department and the First Affiliated Hospital of Guangzhou Medical College.

Questionnaires

Each subject was given an ISAAC written questionnaire to complete, followed by the video questionnaire at the same session at school [13]. Both questionnaires were translated into Chinese following the ISAAC protocol as described previously [14]. All the participating students completed the questionnaire in their classrooms independently. Symptoms of asthma referred to 'wheezing' at any time especially after exercise and at night. 'Cough' at night was also defined as one of the symptoms of asthma when the subject did not have an upper respiratory tract infection. 'Current' symptoms referred to symptoms in the past 12 months; 'Asthma ever' was defined as having been diagnosed to have asthma by a physician in the subject's lifetime. The ISAAC video questionnaire consisted of five scenes displaying young persons of different races with wheezing at rest, wheeze after exercise, night waking with wheeze, night waking with cough and severe asthma attack.

Skin prick test

During April and May of 2002, a random subgroup of 1543 students from the Phase III was invited to have SPT and 1187 (77%) students agreed to participate. Between March and June of 2010, with the same method, a random subgroup of 3086 students was recruited for SPT, and 2531 (82%) students agreed to participate. The seven common aeroallergens tested by SPT were *Dermatophagoides pteronyssinus* (Der-p), *Dermatophagoides farina* (Der-f), cat, *Blatella germanica* (Bla-g), *Alternaria alternata*, mixed grass pollen and mixed tree pollen. Allergen extracts and control solutions were obtained from ALK (Horsholm, Denmark). Histamine (10 mg/mL) and diluent were used as positive and negative controls. A positive skin reaction was

Table 1. Demographic data of recruited subjects in questionnaire surveys in 1994, 2001 and 2009, and allergy skin prick tests in 2002 and 2010

	Questionnaire surveys			Skin prick tests	
	1994	2001	2009	2002	2010
<i>n</i>	3868	3675	7165	1543	3086
Response rate (%)	99.6	96.0	96.7	77.0	82.1
Sex, <i>n</i> (%)					
Boys	1891 (49.1)	1699 (48.3)	3504 (50.6)	613 (51.6)	1386 (54.8)
Girls	1964 (50.9)	1817 (51.7)	3424 (49.4)	574 (48.4)	1145 (45.2)
Average age (years, mean $\pm$ SD)	13.40 $\pm$ 0.64	13.30 $\pm$ 0.69	13.30 $\pm$ 0.64	13.13 $\pm$ 0.71	13.60 $\pm$ 0.65
Age group, <i>n</i> (%)					
≤ 12 years	305 (8.0)	411 (11.7)	823 (11.9)	156 (13.1)	278 (11.0)
13–14 years	3374 (87.5)	3067 (87.2)	6062 (87.5)	1019 (85.8)	2142 (84.6)
≥ 15 years	176 (4.5)	38 (1.1)	43 (0.6)	12 (1.0)	111 (4.4)

defined as a weal size ≥ 3 mm, after subtraction of the negative control. Skin index (SI) [15] and atopic index (AI) [16] were then calculated. Skin index was calculated by the ratio of weal diameter of each allergen to that induced by histamine, and graded by following criteria: 0: SI = 0; 1: $0 < \text{SI} < 0.5$; 2: $0.5 \leq \text{SI} < 1.0$; 3: $1.0 \leq \text{SI} < 2.0$; 4: $\text{SI} \geq 2.0$. The degree of atopy was graded by AI which was the sum of the number of the allergens that give a positive response plus the largest skin weal size ($1 \leq 4$ mm, $2 \geq 4$ mm). AI 0 was considered as normal, 2 and 3 as mild, 4 and 5 as moderate, ≥ 6 as severe.

Statistical analysis

The prevalence of various symptoms and positive skin tests to allergens was calculated as crude rates with 95% confidence intervals (CIs). The differences in the prevalence of the trend and between years were compared by chi-square tests. Logistic regression analyses were performed to test the associations between various degree of SI of each allergen, AI, the prevalence of wheeze (asthma ever, wheeze ever and current wheeze) and adjusted by sex and age. The results are given with adjusted odds ratios (OR with 95% CI). All data were categorized and analysed using the Statistical Package for the Social Sciences (SPSS Inc. Chicago, IL, USA) for Windows Release 13.0. A *P*-value of ≤ 0.05 was considered significant.

Results

Characteristics of study population

The study population comprised of 3855 children (1891 boys and 1964 girls) in Phase I, 3516 (1699 boys and 1817 girls) in Phase III and 6928 (3504 boys and 3424 girls) in 2009. Percentage of children aged 13–14 years was 87.5%, 87.2% and 87.5% respectively. With regard to the allergen skin prick tests, 1187 children (613 boys and 574 girls) from Phase III participated in 2002, 2531 (1386 boys and 1145 girls) from the present survey participated in 2010 (Table 1).

Prevalence of asthma symptoms

The prevalence of asthma ever, wheeze ever and current wheeze increased from 3.9%, 6.2% and 3.4% in 1994, to 4.6%, 8.6% and 4.8% in 2001, and to 6.9%, 14.6% and 6.1% in 2009 ($P < 0.001$ for trend). With the exception of 'current wheeze at night', all responses obtained from the video questionnaire on asthma symptoms were significantly increased in 2009 when compared with those in 1994 and 2001. The prevalence of 'wheeze at rest ever', 'current wheeze at rest', 'wheeze

after exercise ever', 'current wheeze after exercise', 'cough at night ever', 'current cough at night' and 'severe wheeze attack ever' had all increased significantly ($P < 0.001$; Table 2).

Prevalence of allergen sensitization

Allergen skin prick tests were performed in random subsample of students from surveys of 2001 and 2009 in the subsequent years. Children from 2010 had significantly higher AI than those in 2002 ($P < 0.001$). The prevalence of sensitization against Der-p, Der-f, cat and mixed grass pollen increased significantly in 2010 (55.0%, 55%, 17.1% and 3.7% respectively) when compared with those in 2002 (41.7%, 42.7%, 4.7% and 0.5% respectively) ($P < 0.001$). Prevalence of sensitization to Bla-g decreased significantly from 16.0% in 2002 to 7.6% in 2010 ($P < 0.001$), especially for those with degree = 2 (12.2%, 3.0% respectively, $P < 0.001$; Table 3).

Wheeze in subjects with and without sensitization

Prevalence of wheeze increased significantly from 2001–2002 to 2009–2010 in all subjects (9.4% to 16.0% for Wheeze+/All) and those with sensitization to any tested allergen (14.4 to 29.3% for Wheeze+/SPT+), Der-p (15.3% to 33.1% for Wheeze+/Der-p+), Der-f (14.8% to 30.9% for Wheeze+/Der-f+), Bla-g (15.3% to 28.0% for Wheeze+/Bla-g+) and cat (21.4% to 44.6% for Wheeze+/Cat+) ($P < 0.05$). There was also a significant increase in prevalence of wheeze in subjects without sensitization to Bla-g (8.2% to 20.7% for Wheeze+/Bla-g-) and cat (8.8% to 16.5% for Wheeze+/Cat-) ($P < 0.0001$) whereas prevalence with wheeze remains unchanged between 2001–2002 and 2009–2010 in those without sensitization to any tested allergen (Wheeze+/SPT-) and Der-p (Wheeze+/Der-p-) ($P > 0.05$, Fig. 1).

Allergen sensitization in subjects with and without wheeze

Prevalence of allergen sensitization was 4- to 5-fold higher than prevalence of wheeze in our subjects. Prevalence of sensitization to any tested allergen, Der-p, Der-f and cat increased significantly from 2001–2002 to 2009–2010 in all subjects and both with and without wheeze ($P < 0.05$). However, Bla-g sensitization decreases significantly in subjects both with and without wheeze from 2001–2002 to 2009–2010 ($P \leq 0.008$, Fig. 2).

Association between allergen sensitization and asthma

Table 4 shows that the degrees 4–6 of AI, 2 and 3–4 of skin reactivity to Der-p, 3–4 to Der-f, 1–4 to cat and mixed grass pollen were all independent predictors of

Table 2. Comparison of prevalence of asthma and related symptoms in responses to written and video questionnaires of surveys in 1994, 2001 and 2009

	1994 <i>n</i> = 3855 % (95% CI)	2001 <i>n</i> = 3516 % (95% CI)	2009 <i>n</i> = 6928 % (95% CI)	<i>P</i> for trend
Written questionnaire				
Asthma ever	3.9 (3.2–4.5)	4.6 (3.9–5.3)	6.9 (6.5–7.2)	< 0.001
Wheeze ever	6.2 (5.4–7.0)	8.6 (7.6–9.5)	14.6 (14.1–15.0)	< 0.001
Current wheeze	3.4 (2.8–3.9)	4.8 (4.1–5.5)	6.1 (5.8–6.4)	< 0.001
Current sleep-disturbing wheeze	1.1 (0.8–1.4)	1.7 (1.3–2.1)	1.4 (1.3–1.5)	0.097
Current speech-limiting wheeze	0.5 (0.3–0.8)	0.8 (0.5–1.1)	1.2 (1.1–1.3)	0.01
Current exercise-induced wheeze	17.4 (16.2–18.6)	23.4 (22.0–24.8)	27.5 (26.9–28)	< 0.001
Current night waking with cough	18.9 (17.7–20.1)	19.2 (17.9–20.5)	21.0 (20.5–21.4)	0.017
Video questionnaire				
Wheeze at rest ever	3.2 (2.6–3.8)	5.9 (5.1–6.7)	7.9 (7.6–8.2)	< 0.001
Current wheeze at rest	2.0 (1.6–2.4)	3.8 (3.2–4.4)	4.9 (4.6–5.2)	< 0.001
Wheeze after exercise ever	9.2 (8.3–10.1)	14.1 (13.0–15.3)	18.4 (17.9–18.8)	< 0.001
Current wheeze after exercise	6.9 (6.1–7.7)	11.3 (10.3–12.3)	13.7 (13.3–14.1)	< 0.001
Wheeze at night ever	1.5 (1.1–1.9)	1.9 (1.4–2.4)	2.4 (2.2–2.6)	0.006
Current wheeze at night	0.7 (0.4–1.0)	0.8 (0.5–1.1)	1.0 (0.9–1.2)	0.220
Cough at night ever	11.7 (10.7–12.7)	10.2 (9.2–11.2)	15.5 (15.1–15.9)	< 0.001
Current cough at night	5.4 (4.7–6.1)	5.3 (4.6–6.0)	9.0 (8.6–9.3)	< 0.001
Severe wheeze attack ever	2.2 (1.7–2.7)	2.7 (2.2–3.3)	5.3 (4.6–5.9)	< 0.001
Current severe wheeze attack	1.1 (0.8–1.4)	1.6 (1.2–2.0)	3.0 (2.8–3.2)	< 0.001

physician-diagnosed asthma in our study population in both surveys with univariate logistic analysis ($P < 0.05$). In a multivariate analysis, degrees 3–4 of skin sensitization to Der-p in both surveys ($P < 0.01$) and degrees 4–6 of AI in 2009–2010 ($P = 0.016$) were associated with physician-diagnosed asthma.

Discussion

This is the first epidemiology study of asthma prevalence in adolescents in China since mid-2000s, a time when studies of asthma prevalence showed different trends in other regions of the world. For the first time, in this series of three cross-sectional studies from 1994 to 2010 examining a defined population of secondary schoolchildren, we found a continuing increase in prevalence of physician-diagnosed asthma and wheeze by both ISAAC written and video questionnaires. There is a parallel increase in the prevalence of sensitization against common aeroallergens, Der-p, Der-f, cat in the last two surveys. Furthermore, we found the prevalence of wheeze increased mainly in children with sensitization. In particular, the increase was found in those sensitized to house dust mites, but not in those without sensitization.

Our results showed significant increases in the prevalence of physician-diagnosed asthma and lifetime wheeze in Guangzhou secondary schoolchildren from 1994 to 2009. The prevalence of physician-diagnosed asthma from the three surveys showed a 1.17-fold

increase from 1994 to 2001 with an average increase in 0.10% per year, and 1.50-fold increase from 2001 to 2009 corresponding to an average increase in 0.29% per year (Table 2). Lifetime prevalence of wheeze also showed a 1.39- (from 1994 to 2002) to 1.70-fold (from 2001 to 2009) corresponding to an average increase in 0.34% and 0.75% per year respectively. The increase in the prevalence was also confirmed by the video questionnaire. Similar increases in prevalence have been reported all around the world. In studies using the ISAAC questionnaire, an increase in 12-month prevalence of symptoms suggestive of asthma was reported in adolescents in Korea (from 2.7% in 1995 to 5.3% in 2000) [17] and Singapore (from 9.9% in 1994 to 11.9% in 2001 [18]. However, a small decrease in prevalence of asthma symptoms was reported in Hong Kong (from 11.2% in 1994/1995 to 10.2% in 2002) [19]. One other cross-sectional study in Hong Kong reported no change in asthma symptoms between 1993 and 2001 [20]. Anandan *et al.* [21] undertook a systematic review recently which revealed no overall signs of a declining trend in asthma prevalence. On the contrary, asthma prevalence is still increasing in many parts of the world. The reasons for the different trends in some parts of the world are not clear. As genetic alternations would not change significantly in such short period of time, environmental factors are likely to play an important role in affecting the changing trends [22].

In comparison with the increase in prevalence of wheeze, the change prevalence of allergen sensitization

Table 3. Prevalence of degree of atopy and allergen sensitivity in children of the surveys in 2002 and 2010

	Degree*	2002	2010	P
		n = 1187 % (95% CI)	n = 2531 % (95% CI)	
Atopy index [†]	0	53.7 (52.4–55.1)	37.7 (36.3–39)	< 0.001
	2–3	31.0 (29.7–32.3)	11.2 (8.3–15.1)	< 0.001
	4–5	14.7 (13.7–15.6)	29.8 (28.5–31.1)	< 0.001
	6	0.6 (0.4–0.8)	21.3 (20.1–22.4)	< 0.001
<i>Dermatophagoides pteronyssinus</i>	0	58.2 (55.4–61)	45.0 (43.6–46.4)	< 0.001
	1	2.7 (2.2–3.1)	3.0 (2.6–3.5)	0.321
	2	17.9 (16.9–19)	12.2 (9.1–16.1)	< 0.01
	3	17.0 (16–18.1)	25.5 (24.3–26.7)	< 0.001
	4	4.1 (3.6–4.7)	14.3 (13.3–15.3)	< 0.001
<i>Dermatophagoides farinae</i>	0	57.2 (54.5–60.1)	45.0 (39.7–50.4)	< 0.01
	1	2.5 (2.1–3.0)	3.3 (2.8–3.8)	0.091
	2	18.3 (17.2–19.4)	10.9 (10.1–11.8)	< 0.01
	3	17.6 (16.5–18.7)	23.4 (22.2–24.6) [‡]	< 0.05
	4	4.3 (3.7–4.9)	17.3 (16.3–18.4)	< 0.001
<i>Blatella germanica</i>	0	84.0 (81.8–86)	92.4 (91.7–93.1)	< 0.001
	1	2.1 (1.7–2.5)	4.0 (3.4–4.5)	0.209
	2	12.2 (11.3–13.1)	3.0 (2.6–3.5)	< 0.001
	3–4	1.7 (1.3–2.0)	0.6 (0.4–0.8)	0.114
Cat	0	95.2 (94.6–95.8)	83.0 (81.9–84)	< 0.001
	1	0.8 (0.5–1.0)	7.3 (6.6–8.0)	< 0.001
	2	2.4 (2.0–2.9)	4.3 (3.7–4.8)	< 0.001
	3–4	1.5 (1.2–1.9)	5.5 (4.8–6.1)	< 0.001
<i>Alternaria alternata</i>	0	98.8 (97.9–99.6)	98.5 (97.9–99.0)	0.672
	1–4	1.2 (0.4–2.1)	1.5 (1.0–2.1)	0.278
Mixed grass pollen [‡]	0	99.5 (98.3–99.9)	96.3 (95.1–97.7)	0.116
	1–4	0.5 (0.1–1.3)	3.7 (2.3–4.9)	< 0.001
Mixed tree pollen [§]	0	99.8 (99.6–99.9)	98.8 (98.1–99.3)	0.671
	1–4	0.2 (0.1–0.4)	1.2 (0.7–1.9)	0.106

*Degree of allergen sensitivity is defined by skin index, which was calculated by the ratio of weal diameter of each allergen to diameter of weal induced by histamine, and graded by following criteria: 0: SI = 0; 1: 0 < SI < 0.5; 2: 0.5 ≤ SI < 1.0; 3: 1.0 ≤ SI < 2.0; 4: SI ≥ 2.0.

[†]The degree of atopy was graded by atopic index (AI) which was the sum of the number positive SPT plus the largest skin weal size (1 ≤ 4 mm, 2 ≥ 4 mm). AI 0 was considered as normal, 2 and 3 as mild, 4 and 5 as moderate, ≥ 6 as severe.

[‡]Mixed grass pollen included *Dactylis glomerata*, *Festuca pratensis*, *Lolium perenne*, *Phleum pratense* and *Poa pratensis*.

[§]Mixed tree pollen included *Ulmus americana*, *Platanus acerifolia*, *Salix caprea* and *Populus deltoids*.

was even greater and it showed a 4- to 5-fold increase between the two surveys. We also documented a significant increase in prevalence of sensitization to common allergens in our schoolchildren from 2002 to 2010. The intensity of sensitization to these allergens was also increased significantly (Table 3). The magnitude of increase for the prevalence of allergen sensitizations was similar in both wheeze and non-wheeze children (Fig. 2). This finding suggests that prevalence of allergen sensitization increased in this group of population from Guangzhou city regardless whether they have previous history or current symptoms of asthma. When we subdivided our children into sensitized and non-sensitized groups, we found a higher increase in prevalence of wheeze in subjects with positive SPT and the main allergen was house dust mite sensitization. Although temperature and climatic factors were not analysed in

this study, these factors may be of relevance to the increase in house dust mite allergy. In China, house dust mite sensitization is generally more prevalent nowadays when the winters are becoming warmer and the climate more humid than in the past [11]. Guangzhou is one of the fastest developing areas in China and located in much warmer and humid tropical zone of the country. Indoor HDM level has been found to be higher from beds [23] and in most of the families with installation of air-conditioners. The filters of these air-conditioners have been found to contain a high concentration of HDM [24]. Thus, exposure to mite in household dust or from air-conditioner filters and beds may be an important risk factor for the development of sensitizations and allergic airway diseases in Guangzhou.

In this study, we also found that the prevalence of sensitization against cat has increased by 3.54-fold.

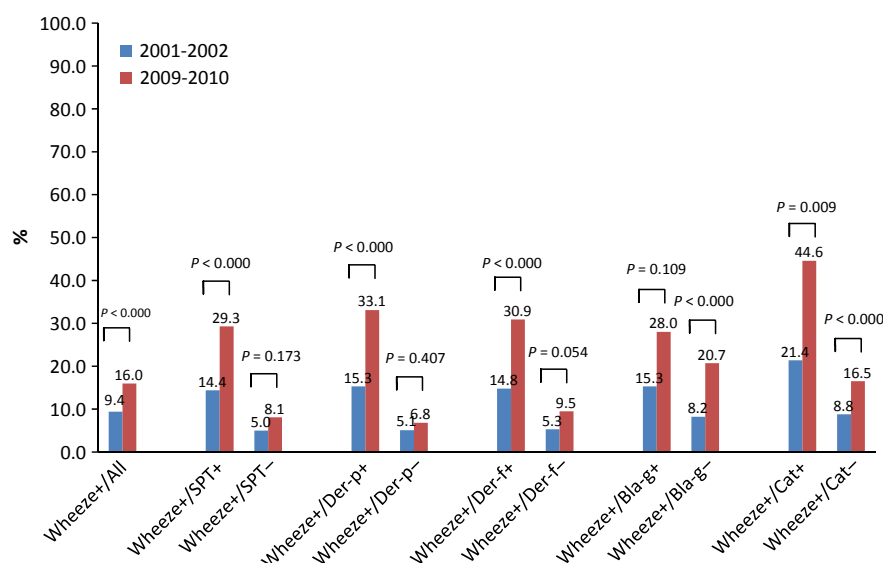


Fig. 1. Prevalence of wheeze (any positive response to asthma ever, wheeze ever or wheeze in recent 12 months) in all subjects who had received allergen skin prick test (Wheeze+/All) and those with or without positive reaction to any tested allergen, *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, *Blatella germanica* or cat (Wheeze+/SPT+ or Wheeze+/SPT-, Wheeze+/Der-p+ or Wheeze+/Der-p-, Wheeze+/Der-f+ or Wheeze+/Der-f-, Wheeze+/Bla-g+ or Wheeze+/Bla-g-, Wheeze+/Cat+ or Wheeze+/Cat- respectively) during surveys in 2001–2002 and 2009–2010.

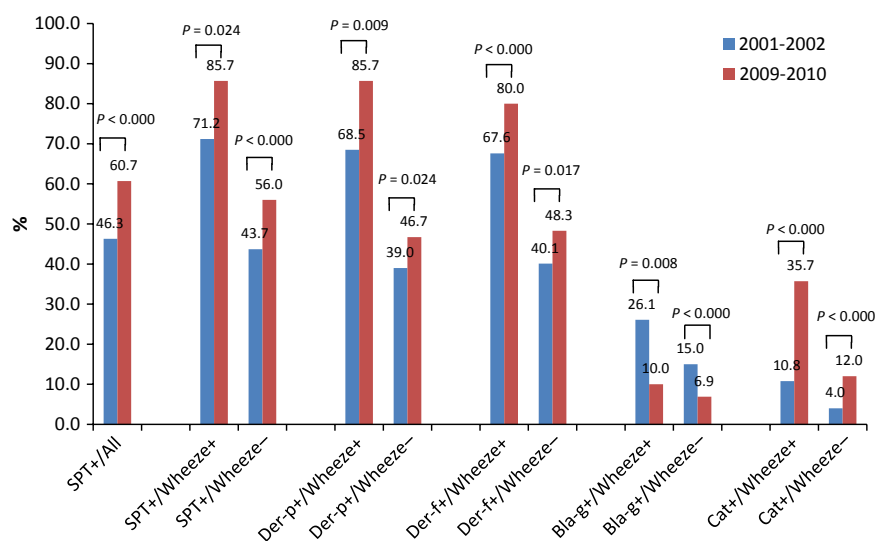


Fig. 2. Prevalence of positive skin reaction to any tested allergen in all subjects who had received allergen skin prick test (SPT+/All) and prevalence of positive skin reaction to any tested allergen, *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, *Blatella germanica* or cat in subjects with or without any positive response to asthma ever, wheeze ever or wheeze in recent 12 months (SPT+/Wheeze+ or SPT+/Wheeze-, Der-p+/Wheeze+ or Der-p+/Wheeze-, Der-f+/Wheeze+ or Der-f+/Wheeze-, Bla-g+/Wheeze+ or Bla-g+/Wheeze-, Cat+/Wheeze+ or Cat+/Wheeze- respectively) during surveys in 2001–2002 and 2009–2010.

This may be related to an increasing popularity of pet ownership in China over the last decade [25]. According to the data from our previous study [11], sensitizations to dog and cat were twice as high in subjects who had either dog or cat at home when compared with those who didn't. Although we did not include pet ownership in our questionnaire, we also realized a relatively large number of children who might not have any pet, but

still had positive skin reactions to cat. This finding may be explained by the fact that animal danders can be brought into homes from other places. Many of our children might also have developed cat allergy in the past, but the current symptoms were due to other concomitant allergens, particularly house dust mite. The marked decrease in prevalence of sensitization to Bla-g could be related to improvement in the hygiene

Table 4. Logistic regression analysis between the degree of atopy index and allergen sensitizations and doctor-diagnosed asthma in surveys in 2001–2002 and 2009–2010

	Degree	2001–2002					2009–2010				
		%*	Univariate		Multivariate		%*	Univariate		Multivariate	
			OR [†] (95% CI)	P	OR [†] (95% CI)	P		OR [†] (95% CI)	P	OR [†] (95% CI)	P
Atopy index	0	5.0	1.00		1.00		5.6	1.00		1.00	
	2–3	11.3	2.42 (1.50–3.90)	0.000	2.07 (0.91–4.03)	0.125	8.1	1.48 (0.36–6.01)	0.251	1.26 (0.24–3.77)	0.290
	4–6	20.8	4.97 (3.00–8.25)	0.000	2.16 (0.94–4.64)	0.103	25.5	5.75 (2.49–13.29)	0.000	2.96 (1.33–5.22)	0.016
<i>Dermatophagoides pteronyssinus</i>	0	5.1	1.00		1.00		4.7	1.00		1.00	
	1	9.4	1.94 (0.56–6.67)	0.295	1.12 (0.44–1.96)	0.565	10.0	0.57 (0.07–4.6)	0.598	0.86 (0.11–3.24)	0.603
	2	8.9	1.83 (1.03–3.28)	0.041	1.34 (0.83–2.04)	0.302	15.0	1.91 (1.36–2.29)	0.039	0.99 (0.81–1.67)	0.241
	3–4	21.5	5.13 (3.26–8.08)	0.000	2.87 (1.68–5.09)	0.002	29.8	5.57 (2.88–10.78)	0.000	3.44 (1.75–6.41)	0.001
<i>Dermatophagoides farinae</i>	0	5.3	1.00		1.00		7.5	1.00		1.00	
	1	10.0	1.99 (0.58–6.86)	0.277	1.20 (0.49–2.06)	0.529	9.1	0.51 (0.06–4.07)	0.525	0.62 (0.08–3.20)	0.492
	2	7.8	1.52 (0.84–2.77)	0.170	1.33 (0.52–1.73)	0.591	8.3	0.44 (0.13–1.49)	0.187	0.46 (0.08–1.17)	0.273
	3–4	21.2	4.80 (3.07–7.52)	0.000	1.95 (0.89–3.04)	0.291	28.4	4.72 (2.47–9.02)	0.000	1.99 (0.91–4.38)	0.116
<i>Blatella germanica</i>	0	8.2	1.00		1.00		15.1	1.00		1.00	
	1–4	15.3	2.01 (1.28–3.17)	0.003	0.71 (0.30–1.64)	0.563	28.0	2.18 (0.86–5.52)	0.099	1.37 (0.95–1.98)	0.262
Cat	0	8.8	1.00		1.00		11.7	1.00		1.00	
	1–4	21.4	2.84 (1.45–5.56)	0.002	1.32 (0.91–2.65)	0.208	37.5	4.48 (2.33–8.63)	0.000	1.48 (0.85–2.42)	0.365
<i>Alternaria alternata</i>	0	9.0	1.00		1.00		16.4	1.00		–	
	1–4	35.7	5.59 (1.84–16.99)	0.001	1.13 (0.55–2.34)	0.332	0.0 [‡]	–	–	–	
Mixed grass pollen	0	9.1	1.00		1.00		14.5	1.00		1.00	
	1–4	50.0	9.93 (1.98–49.83)	0.003	1.27 (0.75–2.19)	0.602	58.3	8.43 (2.56–27.72)	0.000	2.03 (0.91–5.06)	0.154
Mixed tree pollen	0	9.2	1.00		–		16.0	1.00		–	
	1–4	100.0 [‡]	–	–	–		25.0 [‡]	–	–	–	

*Percentage of the subjects with doctor-diagnosed asthma in the respective degree of the allergen sensitivity.

[†]Odds ratio adjusted for sex and age in a logistic regression model.[‡]Analysis could not be performed because of small number of the subjects.

conditions of the living environment of Guangzhou city over the past 10 years.

In addition, degree 2 and 3–4 of skin sensitization to Der-p in both surveys and degree 4–6 of AI in 2009–2010 were associated with physician-diagnosed asthma. Our results are consistent with many other previous studies in Chinese schoolchildren. One study [26] recruited Chinese schoolchildren aged 12–18 years from Hong Kong, Malaysia and Sam Bu, China, where the investigators found positive skin prick response to house dust mite was a significant factor associated with asthma. Another study [27] in Chinese children also confirmed that sensitization to Der-p, Der-f and cat was significantly associated with current wheeze and bronchial hyperresponsiveness. AI, defined as the sum of the

number of the allergens with positive response plus the largest skin weal size was also associated with the size of skin response against Der-p or Der-f (data not shown), which suggests that higher degree of AI was mainly due to higher intensity of sensitization to house dust mite. Similar to previous studies [27, 28], we also confirmed that asthma symptoms have a strong relationship with sensitization to several aeroallergens including Der-p, but not with the non-specific positive response to any allergen.

Conclusion

Over 15-year period, we found strong evidence of a substantial increase in the prevalence of asthma symp-

toms and sensitization to common aeroallergens in secondary schoolchildren aged 13–14 years from Guangzhou, China. HDM sensitization is an important risk factor associated with the increase in prevalence of asthma in schoolchildren from Guangzhou city. Despite the high prevalence of allergic sensitization, the prevalence of wheeze and asthma is still relatively low. Factors other than those related to allergic sensitization must also play important roles in the development of asthma in children.

Conflicts of interest

All the authors have no conflict of interest to declare.

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