

(Research Article)

Allergic Sensitization to Ragweed and Orchard Grass Pollens among Chinese Schoolchildren: An Epidemiological Study in Jiangsu Province

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Allergic diseases including pollinosis have become a global issue of public health. However, little is known about the prevalence of pollen-related allergy in the Chinese population. During 1996 to 1999, we performed an epidemiological study on nasal allergy among schoolchildren (911 males and 750 females) aged 6 to 16 years in Lili Town, Wujiang City, Jiangsu Province, China. The cross-sectional observation between 1996 and 1998 showed that the prevalence of allergic sensitization (positive allergen skin reactions) to ragweed and orchard grass pollen was 6.3% and 3.9%, respectively, and the overall rate of sensitization to at least one kind of these two pollens was 8.7%. The positive rate of skin reactivity was significantly higher among 15 to 16-year-old students than that among 6 to 7-year-old students (13.6% vs. 7.4%; OR = 1.99, 95% CI 1.26~3.12). In addition, we observed a remarkable increase in the prevalence of sensitization to ragweed and/or orchard pollens from 2.8% in 1996 to 14.0% in 1998 among all participating subjects (OR = 5.76, 95% CI 3.25~10.22). This increasing trend was more significant in the prevalence of sensitization to ragweed pollen (OR = 9.24, 95% CI 4.23~20.19). Subsequent vertical-sectional observation showed that 5.8% of children with initially negative skin reactivity to ragweed and/or orchard grass pollens in 1996 had become positive three years later. Data from cross-sectional study carried out in 1996~1998 showed that the prevalence of pollinosis due to ragweed and/or orchard grass pollens was 1.1% among all of the participants. Further longitudinal observation is needed to find out time trends in pollinosis among those schoolchildren with positive allergen skin reactions. In this paper, we also discussed the methods of epidemiological study for pollinosis.

Key Words: ragweed pollen, orchard grass pollen, hypersensitivity, pollinosis, epidemiological study, schoolchildren, Chinese

Introduction

Pollen allergy is an immediate, IgE-mediated hypersensitivity reaction of the nasal mucosa to specific pollen allergens. Ragweed (*Ambrosia*) and orchard grass (*Dactylis glomerata*), which originally grow in North America and Europe respectively, have been expanding worldwide for the last several decades⁽¹⁻⁷⁾. Ragweed and orchard grass pollens are known as two of the major causes of pollinosis. The former one, which was recorded only in a few regions of China based on the national survey of airborne and allergenic pollens in late 1980s⁽⁸⁾, has rapidly spread over some new areas⁽⁹⁾. Orchard grass is a representative allergenic species of Gramineae family. The Gramineae pollens were detected in many regions of China, according to the national pollen survey⁽⁸⁾. However, little is known about the prevalence of ragweed and orchard grass pollen-related allergy in the Chinese population.

Since 1995, epidemiological studies among schoolchildren and medical college students have been carried out in China by our collaborative research group⁽¹⁰⁻¹²⁾. We have previously reported our findings focused on cedar (*Cryptomeria*) pollen and cedar pollinosis⁽¹³⁻¹⁶⁾. In this paper, we present the data from the study regarding allergic sensitization to ragweed and orchard grass pollens among schoolchildren aged 6 to 16 years in Jiangsu Province.

Materials and Methods

1. Study area and subjects

The study base included children from primary, middle and high schools in Lili Town, Wujiang City, Jiangsu Province (Fig. 1). Lili Town is located in the south of Jiangsu, and approximately 80 km west of Shanghai. It is a semi-rural area with approximately 38,000 inhabitants. Most of children in the town attended those participating schools in this study.

A cohort of 1,693 students aged 6 to 16 years from the first and the forth grade of primary school, the first grade of middle school and the first grade of high school were enrolled in a cross-sectional survey during 1996 to 1998. Furthermore, in 1999, a vertical-sectional survey was performed among the students of the forth grade of primary school, the first grade of middle school and the first grade of high school who underwent the survey in 1996 when they belonged to the first and the forth grade of primary school and the first grade of middle school,

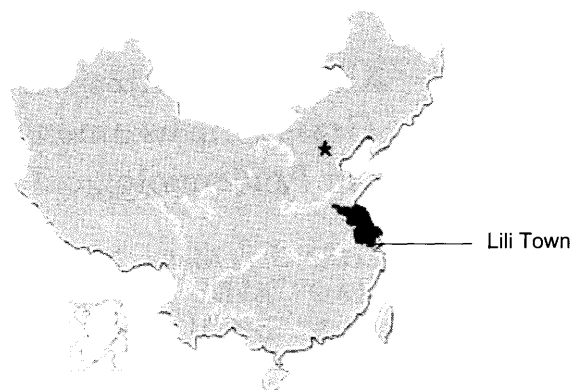


Fig. 1. The geographic location of Lili Town in Jiangsu Province, China.

respectively. The review board of local education committee and health department approved the study, and informed consent was obtained from the parents/guardians of all participants.

2. Skin scratch test

Five commercial extracts of inhaled allergens including house dust, mite (*Dermatophagoides farinae*), Japanese cedar (*Cryptomeria japonica*) pollen, ragweed pollen and orchard grass pollen (Torii Pharmaceutical Co. Ltd., Tokyo, Japan) were applied for skin scratch tests (Fig. 2) according to the manufacturer's instructions, with using allergen's solvent of 50% glycerin-saline as control. Scratch was conducted on the volar surface of the forearm of each participating subject. Skin reactions were evaluated 20 minutes after application of allergen extracts, and the perpendicular diameter to the scratch of wheal-and-flare was recorded. The reaction was considered positive if the wheal diameter was $\geq 5\text{mm}$ and/or if the flare diameter was $\geq 15\text{mm}$, and in addition the wheal-and-flare diameters should be more than twice of those response to the control liquid.

3. Questionnaire and doctor's inspection

A simple written questionnaire was delivered to the parent/guardian of each participant through the schools two weeks before the survey. The parent/guardian completed the questionnaire including nasal allergy symptoms (sneezing, runny and blocked nose), according to the core questionnaire for rhinitis (see Appendix) in the International Study of Asthma and Allergies in Childhood (ISAAC)⁽¹⁷⁾. Additional questions were used to ascertain the demographic data such as age and sex of the subject.



Fig. 2. Allergen skin scratch tests (left photo) and nasal inspection by ENT professional (right photo).

Intranasal inspection by an ENT professional (Fig. 2) was simultaneously performed with skin scratch tests in the participating schools to examine whether the subject had nasal allergy signs including the color of nasal mucosa, swelling of turbinates, and the quality and quantity of nasal secretions.

4. Data analysis

Data were analyzed for the entire participating subjects as well as separately by age and gender. Prevalence rates of allergic sensitization to pollens and pollinosis between different groups were calculated and compared by χ^2 test. *P*-value of less than 0.05 was considered statistically significant. Odds ratio (OR) and 95% confidence interval (CI) were estimated to describe the relationship between prevalence rates and participants' age, gender and study year variables.

Results

1. Number of subjects participated in the survey

A total of 1,661 students (911 males and 750 females) participated in the cross-sectional study during 1996 to 1998, and the response rate was 98.1%. The participants included 489 subjects (251 males and 238 females) aged 6 to 7 years from the first grade and 469 subjects (263 males and 206 females) aged 9 to 10 years from the forth grade of primary school, 336 subjects (164 males and 172 females) aged 12 to 13 years from the first grade of middle school and 367 subjects (233 male and 134 females) aged 15 to 16 years from the first grade of high school.

293 students (73.3%) who initially participated in the cross-sectional study in 1996 underwent the vertical-

sectional follow-up study three years later. The survey was performed among 138 subjects (75 males and 63 females) in the forth grade of primary school, 92 subjects (45 males and 47 females) in the first grade of middle school, and 63 subjects (26 male and 37 females) in the first grade of high school in 1999.

2. Cross-sectional study of sensitization to ragweed and orchard grass pollens

The total positive rate of allergic skin reactivity against ragweed and orchard grass pollen was 6.3% and 3.9%, respectively, and the overall prevalence rate of sensitization to ragweed and/or orchard grass pollens was 8.7% (Table 1). Positive rate of ragweed pollen among the subjects aged 15 to 16 years (11.4%) was significantly higher than that among the subjects aged 6 to 7 years (3.9%; OR = 3.20, 95%CI 1.83~5.60; *P* < 0.001). Moreover, positive rate of skin reactivity against ragweed and/or orchard grass pollens was also found to be higher in 15 to 16-year-old group (13.6%) compared with 6 to 7-year-old group (7.4%; OR = 1.99, 95% CI 1.26~3.12; *P* = 0.003). But for orchard grass pollen alone, no significant difference in the positive rates of allergic skin reactivity was found between these two age groups (4.9% vs. 3.9%; OR = 1.28, 95% CI 0.66~2.47; *P* > 0.05). In addition, there was no statistically significant difference in the positive rates of skin reactivity against at least one kind of two pollens between 6 to 7-year-old and 9 to 10-year-old groups, as well as 6 to 7-year-old and 12 to 13-year-old groups (*P* > 0.05).

As shown in Table 1, there was a significant difference in the prevalence of allergic sensitization to ragweed pollen (*P* < 0.001, *df* = 3), but not to orchard grass pollen (*P* > 0.05, *df* = 3), among the subjects in

Table 1. Prevalence of allergic sensitization to two pollens in different age groups

Age (yrs)	n	RW*		OG**		RW and/or OG***	
		%	OR (95% CI)	%	OR (95% CI)	%	OR (95% CI)
6~7	489	3.9	1.00	3.9	1.00	7.4	1.00
9~10	469	6.2	1.63 (0.90-2.95)	3.2	0.82 (0.41-1.63)	7.9	1.08 (0.67-1.74)
12~13	336	4.5	1.16 (0.58-2.31)	3.9	1.00 (0.49-2.04)	6.3	0.84 (0.48-1.46)
15~16	367	11.4	3.20 (1.83-5.60)	4.9	1.28 (0.66-2.47)	13.6	1.99 (1.26-3.12)
Total	1661	6.3		3.9		8.7	

* $P < 0.001$, ** $P > 0.05$, *** $P = 0.002$ compared by χ^2 test among four groups ($df = 3$).

Reference group (aged 6 to 7 years) designated with an OR of 1.00.

RW, ragweed pollen; OG, orchard grass pollen; OR, odds ratio; CI, confidence interval; df, degrees of freedom.

Table 2. Prevalence of allergic sensitization to two pollens in different gender groups

Age (yrs)	Sex	n	RW*		OG*		RW and/or OG*	
			%	OR (95% CI)	%	OR (95% CI)	%	OR (95% CI)
6~7	M	251	4.0	1.00	5.2	1.00	8.4	1.00
	F	238	3.8	0.95 (0.38-2.37)	2.5	0.47 (0.18-1.27)	6.3	0.74 (0.37-1.47)
9~10	M	264	7.2	1.00	2.7	1.00	8.0	1.00
	F	205	4.9	0.66 (0.30-1.46)	3.9	1.49 (0.53-4.18)	7.8	0.98 (0.50-1.93)
12~13	M	164	4.3	1.00	3.7	1.00	6.1	1.00
	F	172	4.7	1.09 (0.39-3.09)	4.1	1.12 (0.37-3.40)	6.4	1.05 (0.44-2.55)
15~16	M	233	12.0	1.00	4.7	1.00	14.2	1.00
	F	134	10.4	0.85 (0.43-1.69)	5.2	1.11 (0.42-2.94)	12.7	0.88 (0.47-1.65)
Total	M	912	7.0	1.00	4.1	1.00	9.3	1.00
	F	749	5.5	0.77 (0.51-1.15)	3.7	0.92 (0.56-1.52)	7.9	0.83 (0.59-1.18)

* $P > 0.05$ compared by χ^2 test between male and female subjects ($df = 1$).

Reference group (male) designated with an OR of 1.00.

RW, ragweed pollen; OG, orchard grass pollen; M, male; F, female; OR, odds ratio; CI, confidence interval; df, degrees of freedom.

four groups separated by age. Significant difference was also found in the prevalence of sensitization to at least one kind of these two pollens among four groups ($P = 0.002$, $df = 3$).

We then compared the positive rates of skin reactivity to ragweed and orchard grass pollens in different gender groups (Table 2), and found no significant differences between the male and female children either in the groups separated by age or in the combined group aged 6 to 16 years ($P > 0.05$).

Fig. 3 showed the time trends in allergic sensitization to ragweed and orchard grass pollens in the subjects who underwent the survey during 1996 to 1998. A significant increase in the positive rate of skin reactivity either to ragweed ($P < 0.001$, $df = 2$) or to orchard grass ($P = 0.007$, $df = 2$) pollen was observed among the subjects from 1996 to 1998. The increasing trend was

also found when comparing the positive rate of skin reactivity against at least one kind of these two pollens among the subjects during 1996 to 1998 ($P < 0.001$, $df = 2$).

As shown in Table 3, the positive rate of allergic skin reactivity to ragweed pollen in the subjects was significantly higher in 1998 (11.4%; OR = 9.24, 95% CI 4.23~20.19; $P < 0.001$), as well as in 1997 (4.1%; OR = 3.07, 95% CI 1.28~7.37; $P = 0.008$) compared with that in 1996 (1.4%). However, the positive rate of skin reactivity against orchard grass pollen was only found to be significantly higher in 1998 (5.5%; OR = 2.90, 95% CI 1.43~5.87; $P = 0.002$), but not in 1997 (3.7%; OR = 1.90, 95% CI 0.86~4.20; $P > 0.05$) compared with the data of 1996 (2.0%). Finally, for at least one kind of these two pollens, we found that the positive rate of skin reactivity in the subjects was remarkably higher both in

Table 3. Prevalence of allergic sensitization to two pollens in different study years

Year	n	RW*		OG**		RW and/or OG*	
		%	OR (95% CI)	%	OR (95% CI)	%	OR (95% CI)
1996	508	1.4	1.00	2.0	1.00	2.8	1.00
1997	462	4.1	3.07 (1.28–7.37)	3.7	1.90 (0.86–4.20)	7.1	2.71 (1.43–5.14)
1998	691	11.4	9.24 (4.23–20.19)	5.5	2.90 (1.43–5.87)	14.0	5.76 (3.25–10.22)
Total	1661	6.3		3.9		8.7	

* $P < 0.001$, ** $P = 0.007$ compared by χ^2 test among three groups ($df = 2$).

Reference group (study year of 1996) designated with an OR of 1.00.

RW, ragweed pollen; OG, orchard grass pollen; OR, odds ratio; CI, confidence interval; df, degrees of freedom.

Table 4. Vertical-sectional observation of sensitization to two pollens in 1996 and 1999

Age (yrs)		n	RW (%)*		OG (%)*		RW and/or OG (%)*	
in 1996	in 1999		N→P	Unchanged	N→P	Unchanged	N→P	Unchanged
6~7	9~10	138	4.3	95.7	2.2	97.8	6.5	93.5
9~10	12~13	92	2.2	97.8	5.4	94.6	5.4	94.6
12~13	15~16	63	1.6	98.4	3.2	96.8	4.8	95.2
Total		293	3.1	96.9	3.4	96.6	5.8	94.2

$P > 0.05$ compared by χ^2 test among three study groups ($df = 2$).

RW, ragweed pollen; OG, orchard grass pollen; N, negative skin test; P, positive skin test; df, degrees of freedom.

1997 (7.1%; OR = 2.71, 95% CI 1.43~5.14; $P = 0.001$) and in 1998 (14.0%; OR = 5.76, 95% CI 3.25~10.22; $P < 0.001$) than that in 1996 (2.8%).

3. Vertical-sectional study of sensitization to ragweed and orchard grass pollens

3.1% and 3.4% of participating subjects who were of initially negative skin reactivity to ragweed and orchard grass pollen respectively in the survey of 1996 became positive three years later, and there were a total of 5.8% subjects who allergic to ragweed and/or orchard grass pollens in the follow-up study performed in 1999 (Table 4). There was no significant difference in the change of skin reactions among three study groups ($P > 0.05$, $df = 2$).

4. Pollinosis due to ragweed and orchard grass pollens

18 (1.1%) of 1,661 students were diagnosed as pollinosis due to ragweed and/or orchard grass pollens, based on the analysis of the results of questionnaire, doctor's inspection and allergen skin tests. Of 11 (0.7%) subjects with pollinosis were induced by sensitization to ragweed pollen, and 10 (0.6%) to orchard grass pollen. As shown in Fig. 4, significant difference was found in the prevalence of pollinosis due to at least on kind of

two pollens between 6 to 7-year-old and 15 to 16-year-old groups (0.2% vs. 2.2%, $P = 0.01$). Significant difference was also found in the prevalence of ragweed pollinosis (0.0% vs. 1.4%, $P = 0.03$), but not of orchard grass pollinosis (0.2% vs. 1.1%, $P > 0.05$), between these two different age groups. There were no significant differences in the pollinosis prevalence between different groups separated by gender, as well as by study year ($P > 0.05$).

Discussion

Charles Blackley, in 1873, firstly performed a systematic study to evaluate causative agents of hay fever stressing the importance of pollen, and opened the door to the study of pollen-related allergy. Nowadays, allergic diseases have become a global health problem⁽¹⁸⁾. ISAAC carried out in 56 countries/regions has shown that allergic rhinoconjunctivitis (i.e., hay fever, or pollinosis) among children is truly worldwide, with considerable international variation in the prevalence and the predilection for Western developed countries^(19, 20). China is a vast country with multifarious vegetation belts which can result in a wide spread of various airborne plant pollens in atmosphere⁽⁸⁾. There has been, however, few

epidemiological studies on pollen hypersensitivity and pollinosis epidemic from the mainland China⁽¹²⁾.

Aiming to reveal the status of sensitization to common inhaled allergens and the prevalence of nasal allergy in the population of China, a collaborative study among Chinese schoolchildren and medical college students started by our research group in 1995⁽¹⁰⁻¹²⁾. In this paper, we presented data focused on allergic sensitization to ragweed and orchard grass pollens among schoolchildren aged 6 to 16 years in Lili Town, Jiangsu Province. The cross-sectional survey performed during 1996 to 1998 showed that the population prevalence of sensitization to ragweed and/or orchard grass pollens was 8.7%, with a prevalence rate of 6.3% and 3.9% for ragweed and orchard grass pollen, respectively. The prevalence of ragweed and/or orchard grass pollinosis, which was diagnosed on the basis of the presence of nasal symptoms, signs and positive allergen skin reac-

tions, was 1.1% in all of the participants, with a prevalence rate of 0.7% and 0.6% for ragweed and orchard grass pollinosis, respectively. There was no gender difference in allergic sensitization as well as pollinosis prevalence.

Environmental factors are known to affect the onset and development of allergic diseases among high-risk individuals^(21, 22). In the present study, we found that the prevalence of sensitization to ragweed and/or orchard grass pollens was significantly higher among 15 to 16-year-old students than that among 6 to 7-year-old students (13.6% vs. 7.4%; OR = 1.99, 95% CI 1.26~3.12). Subsequent vertical-sectional observation showed that 5.8% of children with initially negative skin reactivity to ragweed and/or orchard grass pollens in 1996 became positive three years later. These results were concordant with our previous reports focused on sensitization to house dust mite and cedar pollen among

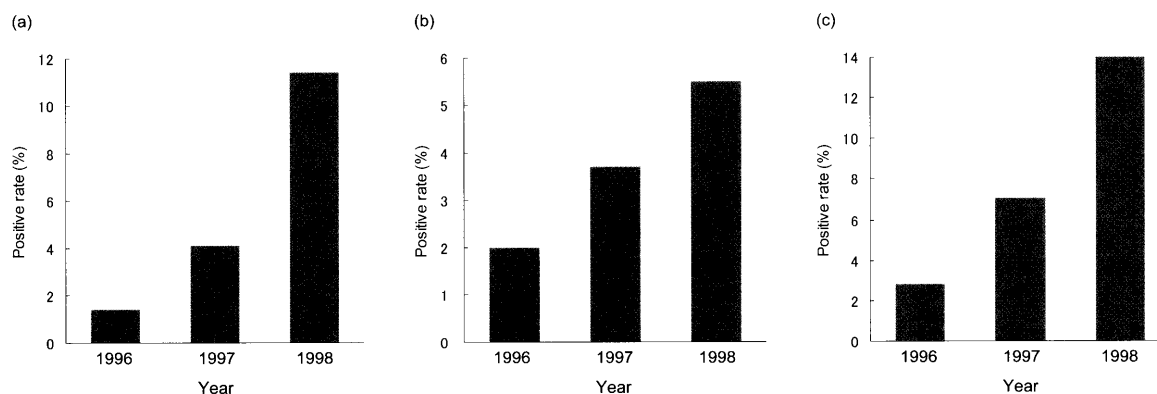


Fig. 3. Prevalence of allergic sensitization to two pollens in each of study years.

(a): $P < 0.001$ for ragweed pollen; (b): $P = 0.007$ for orchard grass pollen; (c): $P < 0.001$ for ragweed and/or orchard grass pollens compared among groups (χ^2 test, $df = 2$).

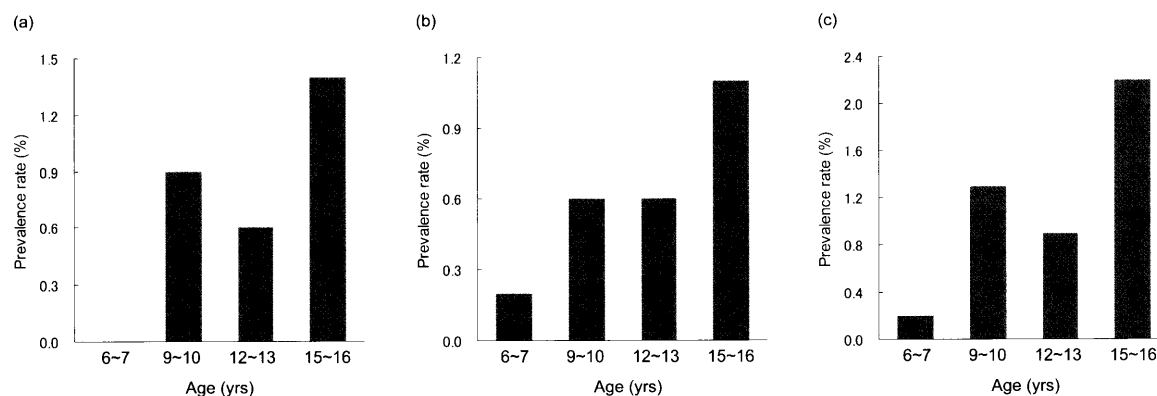


Fig. 4. Prevalence of ragweed and orchard grass pollinosis in each of age groups.

(a): $P = 0.03$ for ragweed pollinosis; (b): $P > 0.05$ for orchard grass pollinosis; (c): $P = 0.01$ for ragweed and/or orchard grass pollinosis in 15 to 16-year-old group compared with 6 to 7-year-old group (χ^2 test, $df = 1$).

Japanese schoolchildren⁽²³⁻²⁵⁾, indicating that the degree of allergen exposure in early life is an important environmental factor for atopic sensitization.

Lack of standardized methods to determine allergic prevalence on general population makes it particularly problematical in comparisons among studies. The comparison of rates between different groups is unreliable if these rates are themselves affected by the method used to collect them. For this reason much effort has been made to develop repeatable methods for international collaborative study of the prevalence of allergic diseases⁽¹⁷⁾. Self-evaluated questionnaire for the symptoms of pollinosis would be useful in the population-based survey^(17, 19, 20, 26, 27), but the validation of such a questionnaire also raises a number of problems including the definition of disease, and for this reason, questions that might predict nasal allergy but not common cold or rhinosinusitis have been looked for. There may be a limit to the information that questionnaires only can elicit. Thus, while recognition of pollinosis is based usually and mainly on the association of symptoms of rhinoconjunctivitis with well-defined seasons and environments, our study used core questionnaire of ISAAC combined with intranasal inspection by ENT professional as well as allergen skin tests to know the prevalence of a specific pollinosis for definitive. Not surprisingly, according to this criterion the prevalence rate might be lower than that obtained through questionnaire only, but it will present exactly the status of pollinosis epidemic among the study populations.

Despite such problems of study methods and disease definitions, most comparative studies have tended to show an increase in the prevalence of allergic rhinitis over time^(26, 29). In this survey, we did not find the same trends in ragweed and/or orchard grass pollinosis possibly owing to a short period of the study and a lower prevalence in the participating schoolchildren, but we found a remarkable increase in the prevalence of allergic sensitization to ragweed and/or orchard pollens from 2.8% to 14.0% amongst whole subjects during 1996 to 1998 (OR = 5.76, 95% CI 3.25~10.22). This increasing trend was more significant in the prevalence of sensitization to ragweed pollen (OR = 9.24, 95% CI 4.23~20.19). There is evidence that exposure to high concentrations of atmospheric ragweed pollen in early life is an increased risk factor of developing allergic sensitization to ragweed and later to develop pollinosis, even lead to asthma⁽³⁰⁾. Therefore, further longitudinal study is certainly needed to find out the time trends in

pollinosis among those schoolchildren with positive allergen skin reactions.

Some recent studies have suggested that there is a positive association between prevalence of pollinosis symptoms and person's socioeconomic class^(31, 32). The remarkable social and economical changes have been under way in our study area, southern Jiangsu Province, since 1990s. Hence, further observation on the relationship of changes in socioeconomic status and lifestyle with pollinosis epidemic in China would clarify the association of allergic diseases and various environmental factors. This may provide the principal information from which to determine the environmental causes of pollinosis and other allergic disorders.

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要 約

中国江蘇省の小、中、高校生におけるブタクサ・カモガヤ花粉への感作に関する疫学研究

花粉症などのアレルギー疾患は世界諸国に増加しつつあり、公衆衛生学上の問題となっている。しかし、中国において花粉症に関する実態調査は、これまでほとんど行われてこなかった。我々のグループは、1996年から1999年にかけて、中国江蘇省呉江市黎里鎮の小、中、高校生（6～16歳；男性911例、女性750例）を対象に、鼻アレルギーの疫学調査を行った。1996～1998年にわたる横断調査の結果、全生徒のブタクサ・カモガヤ花粉に対するスクラッチテスト陽性率はそれぞれ6.3%と3.9%で、これら2種の花粉のいずれかに対する総感作率は8.7%であった。15～16歳の生徒は、6～7歳の生徒に比べ、陽性率が有意に高かった（13.6% vs. 7.4%；オッズ比1.99, 95%信頼区間1.26～3.12）。全生徒において、ブタクサ・カモガヤ花粉のいずれかに対する総感作率は1996年の2.8%

から1998年には14.0%へと有意に増加した（オッズ比5.76, 95%信頼区間3.25~10.22）。この頻度の増加はブタクサ花粉においてより著明であった（オッズ比9.24, 95%信頼区間4.23~20.19）。一方、同一生徒を対象とした縦断調査の結果、5.8%の生徒はブタクサ・カモガヤ花粉のいずれかに対する皮膚試験が1996年の陰性から1999年に陽性化した。なお、1996~1998年にわたる横断調査では、全生徒におけるブタクサ・カモガヤ花粉症の有病率は1.1%であった。感作の成立した生徒においては、いつ花粉症が発症するかを経時的観察が必要であると考えている。本論文は花粉症に関する疫学調査の方法についても考察を加えた。

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Appendix: ISAAC core questionnaire for rhinitis

Questionnaire for 6 and 7 year olds

1. Has your child ever had a problem with sneezing, or a runny, or blocked nose when he/she DID NOT have a cold or the flu?

☐Yes ☐No

IF YOU ANSWERED 'NO' PLEASE SKIP TO QUESTION 6

2. In the past 12 months, has your child had a problem with sneezing, or a runny, or blocked nose when he/she DID NOT have a cold or the flu?

☐Yes ☐No

IF YOU ANSWERED 'NO' PLEASE SKIP TO QUESTION 6

3. In the past 12 months, was this nose problem been accompanied by itchy-watery eyes?

☐Yes ☐No

4. In which of the past 12 months did this nose problem occur? (please tick any which apply)

☐Jan ☐Feb ☐Mar ☐Apr ☐May ☐Jun

☐Jul ☐Aug ☐Sep ☐Oct ☐Nov ☐Dec

5. In the past 12 months, how much did this nose problem interfere with your child's daily activities?

☐Not at all ☐A little ☐A moderate amount ☐A lot

6. Has your child ever had hayfever?

☐Yes ☐No
