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ORIGINAL ARTICLE

Age-related Prevalence of Allergic Diseases in Tokyo Schoolchildren

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ABSTRACT

Background: The International Study of Asthma and Allergies in Childhood (ISAAC) has reported the prevalence of asthma and allergic diseases in many countries.

Methods: We used the ISAAC core written questionnaire to examine the prevalence of asthma and allergic diseases in 6- to 14-year old schoolchildren in Tokyo. In 2005, we conducted a cross-sectional survey of all schoolchildren in all public schools located in the Setagaya area of Tokyo.

Results: Data were collected from 27,196 children in 95 schools. Prevalence ranged from 10.5% to 18.2% for asthma symptoms and from 10.9% to 19.6% for atopic dermatitis, with both conditions tending to decrease with age. As has been previously reported for all age groups, significantly higher rates of current asthma are observed in boys than in girls. The prevalence of allergic rhinoconjunctivitis exhibited a different pattern from that of asthma and atopic dermatitis, peaking at the age of 10 (34.8%). Prevalence of allergic rhinoconjunctivitis was 1.5 to 2-fold higher than the previous ISAAC studies that were performed in Tochigi and Fukuoka. In all age groups, symptoms of allergic conjunctivitis were more frequent from February to May, which coincides with the Japanese cedar pollen season, and were less frequent between June to September.

Conclusions: The prevalence of asthma and atopic dermatitis was higher in younger schoolchildren. Tokyo schoolchildren appear to have extremely high prevalence rates of seasonal allergic rhinoconjunctivitis.

KEY WORDS

asthma, atopic dermatitis, ISAAC, prevalence, rhinitis

INTRODUCTION

Asthma and allergic diseases are common in children. Urbanization has led to an increase in allergic diseases, and thus, this has become an important health problem in today's society.

Many countries have conducted large prevalence surveys of asthma and allergic diseases. In 1991, the International Study of Asthma and Allergic diseases in Childhood (ISAAC) established a standardized methodology to compare the prevalence and severity of asthma and atopic diseases in children.[1] Since starting the study in 1993, the ISAAC Phase One study group has examined the prevalence rates of asthma in children around the world and found that over a 12-month period, the highest rates were for children living in the UK, Australia, and New Zealand, while the lowest were in children residing in Eastern Europe, the Asia-Pacific, and Africa.[2] In contrast, the highest prevalence rates of symptoms related to allergic rhinoconjunctivitis occurred in countries that were scattered across the world. Moreover, the prevalence of allergic rhinoconjunctivitis in children aged 13-14 years was higher than those aged 6-7 years in all of the countries studied around the world. Interestingly, this pattern was not seen for asthma.

The Japanese Ministry of Education, Culture, Sports, Science and Technology has announced that the prevalence of doctor-diagnosed asthma in children has doubled from 1994 to 2004. They also reported that schoolchildren are more likely than other age groups to develop asthma.[3]

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In Japan, ISAAC surveys have been conducted in Fukuoka, the eighth largest city in Japan, and in Tochigi, which is an average-sized city. In Tochigi in 1995, the prevalence of allergic rhinoconjunctivitis in children aged 13-14 was 21.5%.[4] In Fukuoka, the 12-month prevalence of allergic rhinoconjunctivitis among children aged 6-7 increased from 7.8% in 1994 to 10.6% in 2002, while over the same period of time in children aged 13-14, it increased from 14.9% to 17.6%.[5] Similar trends were also seen in many other Asia-Pacific countries and in India. In contrast, the prevalence of asthma, however, did not notably increase in any of these countries or in Japan.

Children born in urban areas are expected to have higher prevalences of allergic diseases than those born in rural areas.[6] Although Tokyo is the largest city in Japan, and thereby, would be expected to have the highest prevalence of allergic diseases, previous ISAAC surveys have never been done in this city. Thus, there were two aims of the present study. First, the ISAAC protocol was used to determine whether age-related differences are responsible for the prevalence of allergic symptoms observed among Tokyo schoolchildren. Based on these findings, the second part of the study was designed to compare these results with the findings of previous ISAAC studies in Japan and determine if there were differences between large urban areas and other areas that were less populated/more rural in nature.

METHODS

SUBJECTS

The survey was conducted from May to June, 2005, in accordance with the ISAAC protocol.[7] The present survey was part of an investigation by the Japanese Asthma Survey Group (JASG), and was aimed at surveying the prevalence of allergic diseases in all age groups at various places throughout Japan.

Setagaya was chosen as the research zone for this study, as it is located in the center of Tokyo. During the study period, this was the biggest geographical region within the Greater Tokyo Area. Setagaya has a population density that is close to the Tokyo average, with 830,000 inhabitants living in about 58 km^2 (22 square miles).

In Japan, compulsory education consists of nine grades (years). In April of each year, children who have reached the age of 6 enroll in an elementary school that has six grades. After graduating from elementary school, students enter junior high school, which has three grades. The current survey covered all of the schoolchildren in these nine grades. During the study period, Setagaya had 64 public elementary schools and 31 public junior high schools, with approximately 80% of the children attending these public schools. With the help of the Setagaya City Board of Education, we were able to investigate all public elementary and junior high school students.

QUESTIONNAIRE

We used the ISAAC written questionnaire for 6-7 year olds for the elementary school children and the questionnaire for 13-14 year olds for the junior high school children. Our group previously translated the ISAAC written questionnaire from English into Japanese and then back into English to confirm its accuracy. An explanatory note for eczema and rash was added, as the Japanese language does not normally differentiate between the two. The questionnaire was distributed at all of the schools, with the children then taking it home to be filled out. Prior to filling out the questionnaire, all participants in the study provided informed consent. For the younger age group, the children's parents completed the questionnaire, while the children in the older age group completed it on their own. After completing the form, the questionnaires were taken back to the schools for collection.

Based on the questionnaire answers, we evaluated the 12-month point prevalences of asthma, allergic rhinoconjunctivitis, and atopic dermatitis.[7] To define current asthma and examine wheezing during the previous 12 months, we asked the following question, "Have you (has your child) had wheezing or whistling in the chest in the last 12 months?". If current asthma was present, the questionnaire further assessed the frequency and severity of the episodes. Questions pertaining to allergic rhinoconjunctivitis included those regarding sneezing or a running or blocked nose (in the absence of flu) that was associated with itchy-watery eyes over the last 12 months. The monthly frequency among children who had symptoms of allergic rhinoconjunctivitis was evaluated by asking, "In which of the past 12 months did this nose problem occur? (please tick any which apply)." Atopic dermatitis was considered to be present when there was an itchy, relapsing skin rash that affected the flexural areas during the preceding 12 months.

ETHICAL CONSIDERATIONS

The ethics committee of the National Center for Child Health and Development approved the study protocol. The older children directly provided informed consent. However, since parents completed the questionnaire for the younger children, parental informed consent was obtained in this group.

STATISTICAL ANALYSIS

Analyses focused on changes in the 12-month prevalence of the symptoms, which included asthma, rhinitis and dermatitis. Data were analyzed using SPSS 15.0J (SPSS Inc., Chicago, IL, USA), with a p-value of <0.05 defined as being statistically significant. Proportions between the two groups were compared using chi-squared tests. The interrelationship between age and the 12-month point prevalence was evaluated by Pearson's correlation.

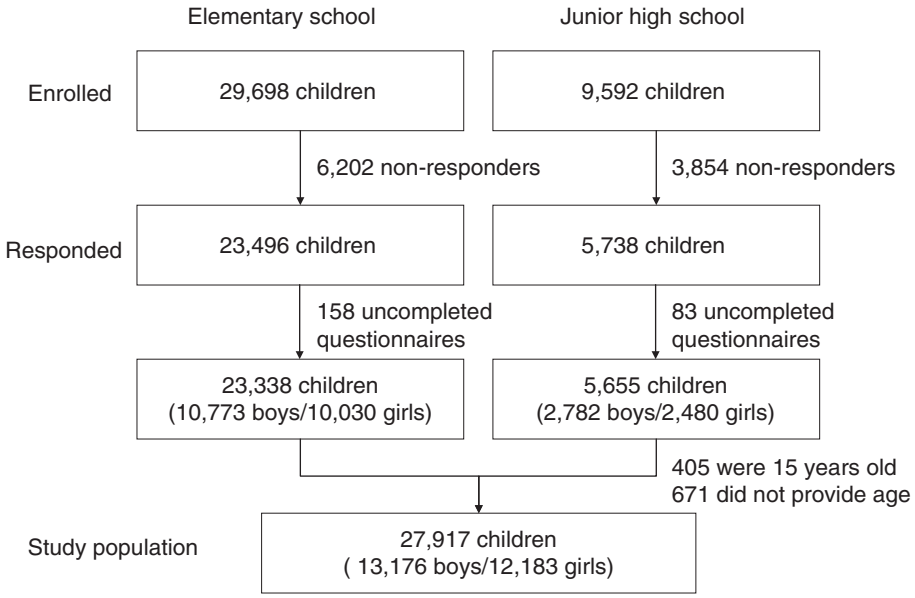

Fig. 1 Study subjects and the study protocol. All students in all public schools in Setagaya from May through June of 2005 were enrolled in the study, with more than 70% of all children aged 6-14 years at these schools included in the analyses.

RESULTS

Of the 95 schools approached, all agreed to participate, which resulted in a target population of 39,290 children (Fig. 1). Out of this population, a total of 23,338 elementary school children (78.6%), aged 6 to 12 years, and 5,655 junior high school children (59.0%), aged 12 to 15 years, completed questionnaires. For the 15-year-old children, numbers were quite small and thus, we excluded this group from the analyses. Of the 27,917 children aged 6 to 14 that we were able to analyze, 13,176 (47.2%) were boys, and 12,183 (43.7%) were girls. In 2,558 children, we were not able to determine the gender.

Current asthma prevalence ranged from 10.5% to 18.2% among all age groups (Table 1), with the highest found in the younger children. There was a strong inverse correlation between the age and prevalence (r = -0.956, P < .001). When boys were compared to girls in all of the age groups, boys had significantly higher rates of current asthma (P < .001 for ages 6 to 12, P < .05 for ages 13 and 14). While frequent wheezing and sleep disturbance were more common in younger children and in boys, exercise-induced wheezing during the last 12 months was more common in older children of both sexes and in younger boys.

In contrast to the asthma findings, the prevalence of allergic rhinoconjunctivitis tended to be higher in older children (Table 2), increasing rapidly from age 6 to 10. By the age of 10, the prevalence of allergic rhinoconjunctivitis was 34.8%. In all age groups, symptoms of allergic rhinoconjunctivitis were more frequent from February to May, and less frequent from June to September (Fig. 2). On a day-to-day basis, moderate or severe interference due to rhinoconjunctivitis was more common in older children of both sexes and in boys.

Similar to the asthma findings, the prevalence of atopic dermatitis was highest in younger children, with analyses showing a significant inverse correlation with age (r = -0.983, P < .001) (Table 2). However, severe symptoms of atopic dermatitis were more often observed in older children. There were no gender differences noted for the prevalence or severity of atopic dermatitis.

Among the 27,389 children aged 6 to 14 years who completed questionnaires about their current asthma, allergic rhinoconjunctivitis and atopic dermatitis symptoms, 14.0% had current asthma. Of these children, 41.6% and 31.3% had the symptoms of allergic rhinoconjunctivitis and atopic dermatitis, respectively. While 43.1% of the children in this study had ≥1 of the symptoms during the past 12 months, only 2.2% had all three symptoms (Fig. 3). Table 3 shows the overlap of the current symptoms for three diseases based on age among the 27,389 children.

DISCUSSION

In 2005 we examined the prevalence of asthma, allergic rhinoconjunctivitis and atopic dermatitis in a large sample of schoolchildren who resided in the Tokyo metropolitan area of Setagaya. The prevalence of current asthma and atopic dermatitis was inversely correlated with age, whereas that of allergic rhinoconjunctivitis showed an age-dependent increase until

Table 1 Prevalence (%) and severity of asthma symptoms in 6 to 14 year old children

Symptoms	Age (years)								
	6	7	8	9	10	11	12	13	14
Current wheeze									
Total	18.2	15.7	15.6	13.3	14.5	11.9	12.0	10.3	10.5
Boys	***21.4	***17.8	***17.8	***16.0	***17.4	***14.7	***14.9	*12.0	*12.0
Girls	14.5	13.5	12.9	10.9	10.9	9.3	9.3	8.6	8.8
Wheezing attacks ≥ 4 /12 months									
Total	5.1	3.7	4.4	3.7	4.0	3.3	3.1	3.3	3.1
Boys	*6.0	**4.6	**5.5	*4.4	*4.6	*4.2	*4.0	4.1	3.1
Girls	4.3	2.8	3.2	2.9	3.0	2.7	2.3	2.7	3.0
Awakened by wheezing ≥ 1 /wk									
Total	2.4	2.3	2.0	2.0	1.6	1.3	1.2	0.6	1.2
Boys	3.0	2.4	2.2	2.1	1.8	*1.6	1.7	0.6	*2.0
Girls	2.0	2.2	1.7	1.9	1.2	0.8	0.9	0.7	0.5
Speech limitation									
Total	2.4	1.7	1.5	1.8	1.2	1.2	1.4	0.9	1.8
Boys	**3.3	2.0	1.8	2.2	*1.7	***1.8	***2.0	1.2	1.9
Girls	1.6	1.6	1.1	1.5	0.8	0.5	1.0	0.7	2.0
Exercised-induced wheezing									
Total	5.8	6.0	6.2	6.7	7.6	7.1	11.7	13.2	14.4
Boys	***7.6	***7.3	6.6	**7.9	7.8	7.9	12.0	13.6	*14.3
Girls	4.1	4.6	5.7	5.3	6.8	6.4	12.1	13.1	15.0

Comparisons were performed between boys and girls for each symptom and age. *P < .05, **P < .01, ***P < .001.

Table 2 Prevalence (%) and severity of allergic rhinoconjunctivitis and atopic dermatitis symptoms in 6 to 14 year old children

Symptoms	Age (years)								
	6	7	8	9	10	11	12	13	14
Allergic rhinoconjunctivitis									
Total	19.7	22.5	25.1	26.9	34.8	32.5	33.8	27.8	29.1
Boys	*21.2	23.1	26.3	27.1	35.6	33.0	35.2	29.3	27.0
Girls	17.7	22.3	23.9	25.4	34.5	31.9	32.3	27.1	30.1
Moderate to severe interference by rhinitis									
Total	10.2	11.9	14.1	14.6	21.4	19.9	21.5	18.1	20.6
Boys	11.2	*13.1	**16.1	15.1	*23.4	*21.1	*23.8	18.9	20.6
Girls	9.5	10.7	12.3	13.3	20.6	18.1	19.4	15.9	19.8
Atopic dermatitis									
Total	19.6	17.4	16.9	16.6	15.3	15.0	13.6	11.9	10.9
Boys	19.9	17.0	17.3	17.7	15.6	14.8	13.3	10.7	10.3
Girls	19.7	18.5	16.2	15.6	14.8	15.0	14.1	12.8	11.4
Kept awake by rash ≥1/wk									
Total	1.6	1.7	1.7	1.5	1.5	1.3	1.9	2.5	2.5
Boys	1.5	1.8	1.9	1.6	1.2	1.2	2.1	2.0	2.7
Girls	1.8	1.6	1.4	1.5	1.4	1.5	1.6	2.9	2.2

Comparisons were performed between boys and girls for each symptom and age. *P < .05, **P < .01, ***P < .001.

reaching the age of 10. These correlations also showed an overlap of the prevalences for the three diseases in accordance with age. These findings suggest that the peak prevalence of asthma and atopic dermatitis may occur at or before the age of 5, similar to that previously reported. In an Australian study, the frequency of atopic dermatitis increased and reached a maximum prevalence by the age of 1, after which it decreased in an age-dependent manner in a group of preschool-age children.[8] For asthma, the

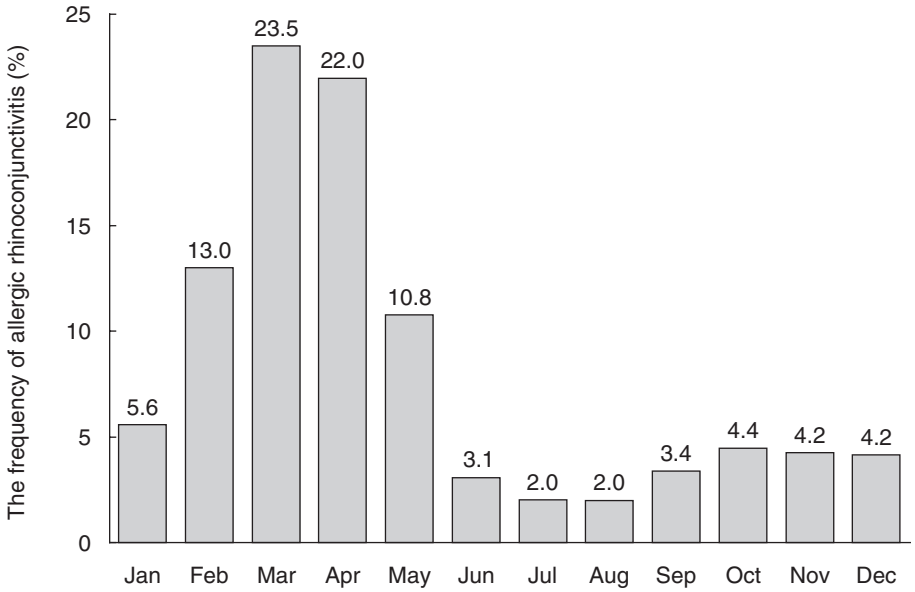

Fig. 2 Monthly frequency of allergic rhinoconjunctivitis in all subject age groups.

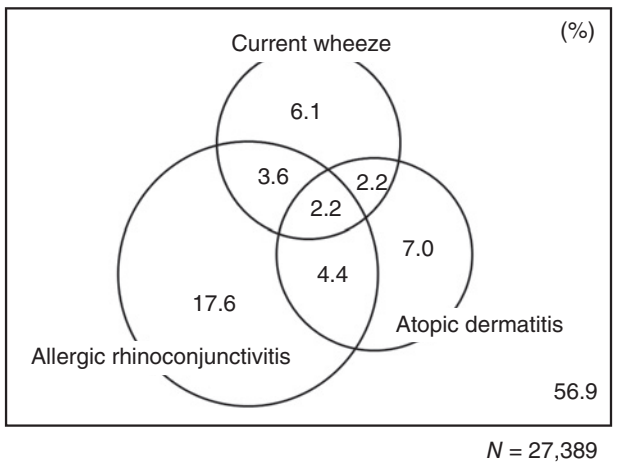

Fig. 3 Venn diagram showing overlap of the current asthma, allergic rhinoconjunctivitis and/or atopic dermatitis symptoms among children aged 6 to 14 who completed questionnaires that gathered symptom prevalence data over a 12-month period.

prevalence in boys was higher than that in girls in each age group of the present study. This supports the findings of previous ISAAC studies, including one that was performed in Fukuoka. This study demonstrated that 6-7 year olds had higher prevalences of asthma and atopic dermatitis and a lower prevalence of allergic rhinoconjunctivitis when compared to 13-14 year olds. The study also showed that the prevalence of asthma was higher in boys.[2]

In the present study, the prevalence of atopic dermatitis also decreased with increasing age. On the other hand, older children were more likely to have severe symptoms. This suggests that even though mild dermatitis appears to have been completely resolved, severe dermatitis actually became exacerbated with increased age. While results of previous ISAAC studies have been mixed with regard to these findings, most Asian studies have shown a similar pattern. Therefore, atopic dermatitis rates in Setagaya, as in other Asian cities, might be influenced by exposure to irritant gases such as car exhaust fumes or by high concentrations of house dust mites.[9]

The prevalence rates of allergic rhinoconjunctivitis in children aged 6-7 and 13-14 in the present study were extremely high as compared to those in the 2002 Fukuoka study, even though the asthma rates were similar. It should also be noted that the prevalence of allergic rhinoconjunctivitis in Tokyo children aged 6-7 was one of the highest that has been documented among all of the ISAAC Phase Three populations.[6] Tokyo has the highest per-capita income in Japan, and thus, our findings are consistent with previous reports that have shown that the prevalence of allergic rhinoconjunctivitis is higher in high-income versus low-income countries.[10]

We compared the present results from Tokyo with those obtained using the same questionnaire several years previously in Fukuoka and Tochigi. These ISAAC Phase Three surveys revealed that the prevalence of allergic diseases in Fukuoka and other Asian areas did not change markedly from Phase One.[11] This suggests that the prevalence of allergic disease in Tokyo is also likely to have remained relatively constant during this period, hence comparisons between the present and previous studies can provide meaningful information.

Table 3 Overlap prevalence (%) of asthma, allergic rhinoconjunctivitis and/or atopic dermatitis symptoms in children 6 to 14 years of age

Symptoms	Age (years)								
	6	7	8	9	10	11	12	13	14
BA (+), ARC (+), AD (+)	2.6	2.1	2.9	2.6	2.2	1.9	1.7	1.6	1.6
BA (+), ARC (+), AD (-)	3.2	3.9	3.4	3.4	4.9	3.4	4.2	2.4	2.5
BA (+), ARC (-), AD (+)	3.5	2.9	2.5	2.1	1.7	1.6	1.3	1.5	1.2
BA (-), ARC (+), AD (+)	3.8	4.0	4.1	4.5	5.5	5.5	5.1	2.7	2.6
BA (+), ARC (-), AD (-)	8.9	6.7	6.8	5.3	5.8	5.0	5.0	4.6	5.1
BA (-), ARC (+), AD (-)	10.0	12.5	14.7	16.4	22.3	21.7	22.9	20.9	22.5
BA (-), ARC (-), AD (+)	9.6	8.4	7.4	7.3	5.9	6.0	5.5	6.1	5.4
BA (-), ARC (-), AD (-)	58.4	59.4	58.1	58.4	51.8	54.8	54.4	60.2	59.1

BA, current wheeze; ARC, allergic rhinoconjunctivitis; AD, atopic dermatitis.

Asthma is more prevalent in urbanized areas, as air pollution is one of environmental factors that can exacerbate asthma. It is well known that components of diesel exhaust particles worsen respiratory symptoms through a variety of mechanisms.[12] In Tokyo, the number of diesel-powered automobiles is heavily regulated by prefectural ordinances that were put in place in 2003 in order to control the severe air pollution. Pollution concentration differences might explain why the prevalence of current wheezing in the present study was higher in Tokyo than in Tochigi, which is a less populated area.

Compared to Fukuoka, Tokyo has higher pollen levels. Thus, the higher exposure to pollen in Tokyo might contribute to the higher prevalence of allergic diseases that are seen as compared to Fukuoka. However, it is unclear as to why Tochigi, which has higher recorded pollen counts would have a lower prevalence of allergic diseases as compared to Tokyo.[13] Braun-Fahrländer suggested that there may be factors associated with occupations related to agriculture, and thus parents who farm, may pass on a reduced risk to their children for producing specific IgE antibodies to aeroallergens, thereby preventing the development of clinical symptoms of allergic rhinitis.[14] Therefore, we speculate that Tochigi's higher farming population might account for this discrepancy.

The prevalence of allergic rhinoconjunctivitis was higher in older children, and there were no clear gender differences noted. In all age groups, the peak prevalences were observed during March and April, a period that coincides with the release of Japanese cedar pollen, which is one of the most common spring pollen antigens in Japan. Therefore, it is highly likely that the main pediatric seasonal pollen allergy that is seen in Tokyo is due to the Japanese cedar tree. When the monthly prevalence of allergic rhinoconjunctivitis was examined, it was found to be similar to the high prevalence that is seen in older children (data not shown). As seasonal rhinoconjunctivitis is a strong indicator of IgE-mediated allergy in children, our study results suggest that older children have a higher prevalence of IgE-mediated allergy than younger children.

Interestingly, the highest pollen counts during the past two decades were recorded in Tokyo during the same time when the present 10-year-old children were in their first year of life. A Swedish study that examined sensitization found that children born during a year of exceptionally high birch pollen counts had a higher prevalence of birch pollen sensitivity at ages 4 to 5.[15] In contrast, Burr showed an inverse association between grass pollen counts and the prevalence of allergic rhinitis symptoms.[16] However, they analyzed grass pollen counts in European countries, Australia, and Kuwait, and thus, their results might not be applicable to the present study in Japan.

In the current study, parents of elementary schoolchildren under the age of 11 along with a few elementary schoolchildren who were 12 years old completed the questionnaires. All of the junior high school children completed the questionnaires by themselves, which included some 12-year-old junior high school students. When reporting symptoms, answers provided by the parents and the children often differed, with the children appearing to be more valid reporters than their parents. However, the respondent differences could be ignored in the present study, as the age differences over the 12-month examination period for the three diseases did not significantly change for those who were 12 years old. Nevertheless the prevalence of exercise-induced wheezing and sleep disturbance caused by eczema more increased after the age of 11. While it is feasible that the differences were mainly because of the respondents, these differences might actually mean that some parents incorrectly judged the symptoms present in their children. Therefore, the actual prevalence of exercise-induced wheezing and sleep disturbance caused by eczema in the younger age groups could be higher than what was actually reported in the current re-

sults.

In addition to the point discussed above, other limitations of this study might include the time period that was covered by the survey. The study period covered the time between May and June, which corresponded to the time immediately after the peak months of exposure to Japanese cedar pollens. The ISAAC protocols recommend that studies on allergic rhinoconjunctivitis should not use surveys in which 50% of the surveyed population is studied in the months that precede the allergy season. However, it was unclear in our study as to whether or not Japanese cedar pollen was the main allergen that causes allergic problems in Tokyo schoolchildren. In Japanese adults, in addition to Japanese cedar pollen, the major allergens associated with allergic rhinoconjunctivitis include grass and ragweed pollens, which are released at the beginning of the summer and continue to be released until autumn. In addition, it should also be noted that when conducting these types of surveys in public schools, the seasons when the surveys can be conducted are dictated by when schools are in session, and thus, they cannot be done year round.

In conclusion, the present study demonstrated the prevalence of asthma, allergic rhinoconjunctivitis, and atopic dermatitis in school-age children. Our findings indicate that the prevalence of asthma and atopic dermatitis was higher in younger children, while the prevalence of allergic rhinoconjunctivitis was much higher than that which has been reported in previous surveys of other Asian cities. To prevent onset and exacerbation of symptoms along with improving the quality of life of schoolchildren affected by asthma and allergic diseases, additional studies that investigate allergic disease prevalence in preschool children will need to be undertaken in the future.

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CONFLICT OF INTEREST

No potential conflict of interest was disclosed.

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