

Self-reported prevalence and risk factors of asthma among Korean adolescents: 5-year follow-up study, 1995–2000

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Summary

Objectives The International Study of Asthma and Allergies in Childhood (ISAAC) questionnaires have shown that the prevalence of childhood asthma is increasing worldwide. Although Asian countries used to have lower prevalence rates of allergic disease than Western countries, this prevalence is increasing in several Asian countries. To determine whether the prevalence of childhood asthma is changing in Korean adolescents, we compared findings from nationwide cross-sectional surveys in 1995 and 2000 on populations of middle-school children using the Korean version of the ISAAC questionnaire.

Methods We developed Korean versions of the ISAAC written (WQ) and video (AVQ) questionnaires for allergic diseases. In 1995, the enrolled population consisted of 15481 children, ages 12–15, and encompassing all three grades in middle school, selected from 34 schools across the nation; the response rate was 97.3%. In 2000, 15894 children were selected from 31 of the same schools, and the response rate was 96.4%. The SAS system version 8.0 was utilized for all statistical analyses.

Results The WQ showed that the lifetime and 12-month prevalence of wheeze did not change from 1995 to 2000. While the 12-month prevalence rates of sleep disturbed by wheezing and night cough increased, the rates of severe attack of wheezing and exercise-induced wheeze did not change, over this period of time. The lifetime prevalence of asthma diagnosis, however, increased significantly, from 2.7% in 1995 to 5.3% in 2000, as did the 12-month prevalence of asthma treatment, from 1.0% in 1995 to 1.9% in 2000. The AVQ also showed increases in the lifetime and 12-month prevalence rates of wheeze at rest, exercise-induced wheeze, nocturnal wheeze, nocturnal cough, and severe wheeze over this period of time. These were especially because of significant increases in the Provincial cities of Korea. Interestingly, the 12-month prevalence of wheeze was consistently high in Cheju with low air pollution indices, whereas this rate was low in Ulsan and Ansan with very high air pollution indices. Risk factor analysis showed that body mass index (BMI), passive smoking, and living with a dog or cat, but not air pollution, were associated with higher risk of wheeze.

Conclusions In the 5-year period from 1995 to 2000, the prevalence of asthma symptoms has increased in Korean adolescents, much of it because of increases in Provincial Centers. BMI, passive smoking, and living with a dog or cat are important risk factors. Environmental factors other than air pollution may be associated with increases in asthma, especially in Provincial Centers.

Keywords adolescent, asthma, middle-school children, prevalence, risk factor

Submitted 12 November 2003; revised 31 May 2004; accepted 23 June 2004

Introduction

Asthma is a chronic inflammatory disorder of the airways characterized by episodes of recurrent wheezing, shortness of breath, chest tightness, and cough. Because of its increased prevalence, as well as the increased morbidity and mortality from this disease, asthma has come to be recognized as a

major worldwide public health issue [1–5]. Asthma is also an economically costly disease. On the basis of 1985 estimates adjusted to 1994 dollars, total health-care costs because of asthma increased by 54.1%, and direct medical expenditures caused by this disease increased by 20.4%, during this 10-year period [6].

Asthma is one of the most common disorders in children. The prevalence of childhood asthma has been on the rise over the last decades [7, 8]. While some studies suggest that this trend is still ongoing [9, 10], others suggest that the burden from childhood asthma may have levelled off [11]. In the US,

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the greatest increases have been seen among children and young adults living in the inner cities [5, 12].

The International Study of Asthma and Allergies in Childhood (ISAAC) investigated the worldwide prevalence of asthma using simple standardized methods. The worldwide prevalence of asthma in 13- to 14-year-old schoolchildren has been found to vary widely, with 20- to 60-fold differences observed among countries [13]. The highest 12-month prevalence of asthma symptoms was observed in the UK, Australia, New Zealand, and the Republic of Ireland, and the lowest prevalence was found in several Eastern European countries, as well as in Indonesia, Greece, China, Taiwan, Uzbekistan, India, and Ethiopia.

In Korea, several epidemiologic studies have been conducted to determine the prevalence of asthma in children. Although these studies showed increased prevalence of asthma among Korean children (from 3.4% in 1964 to 10.1% in 1989), these findings were based on data from small numbers of subjects [14–16]. In 1995, the first Nationwide Study of Asthma and Allergies in Korean Children was conducted. This study, which utilized the methods formulated by ISAAC, compared the prevalence of asthma and allergy in Korea with that in other countries [13, 17]. This survey showed that, in Korea, 8.7% of 6–7-year olds, and 8.2% of 13–14-year olds, had asthma, prevalence rates lower than those observed in children in Western countries [17].

A second Nationwide Study of Asthma and Allergies in Korean Children was conducted in 2000. Here, we report the prevalence and severity of asthma in Korean adolescents, and show the changes that occurred over this 5-year period. We also describe the risk factors for development of this disease in Korean adolescents.

Materials and methods

Questionnaires

We developed the Korean version of the ISAAC questionnaire for asthma utilizing guidelines similar to those of ISAAC [13, 17]. The written questionnaire (WQ) included questions on demography (age and sex), body mass index (BMI), monthly electricity bill (as a socio-economic indicator), passive smoking, potential allergens (e.g. exposure to carpets, presence of a dog or cat in the home), and living environment (rural/industrial/urban). The survey also included the occurrence of symptoms of asthma, both during the preceding 12 months and over the course of the subject's lifetime.

A video questionnaire (AVQ) was also administered to all of these middle-school students.

Selection of subjects

To obtain a representative population, the survey was conducted in populations drawn from two different geographical locations. The first was Metropolitan Seoul, an area with a large population (over 10 million), polluted air, and high standards of living compared with other regions in Korea. The second, denoted the Provincial Centers, included eight Provincial cities, Suwon, Chungju, Chunju, Changwon, Chunchon, Cheju, Ulsan, and Ansan, one from each of eight

provinces of Korea. These Provincial Centers represented relatively rural areas with smaller populations (about half to 1 million), less pollution (except for Ulsan and Ansan, which are industrial cities), and lower standards of living than Seoul.

The enrolled schools were identical to those used for the 1995 survey [17]. Although ISAAC proposed the selection of only 13- and 14-year olds, we targeted all middle-school students between the ages of 12 and 15. In the 1995 survey, the total study population of 15481 children was selected from 34 schools across the nation, with a response rate of 97.3%. In 2000, three schools did not want to participate; thus, this survey involved a total of 15894 children selected from 31 schools, with a response rate of 96.4%. This study was approved by the ethics committee of the Korean Academy of Pediatric Allergy and Respiratory Disease and written consent was obtained from all parents after they were fully informed of the details of the study.

Data collection

The Korean version of the ISAAC WQ was administered to the students in school during September and October 2000, i.e. the same months of the year as the 1995 survey were administered [17]. Response rates for each school were monitored during the study to ensure that these rates were over 90%.

Statistical analysis

All data were entered into a computer using a specialized entry programme for this particular study. We excluded subjects who still had erroneous values after recheck. Also excluded were subjects who omitted answers on all questions about symptoms, as well as subjects not aged 12–15. The final numbers of subjects included in the analyses were 14946 and 15214 in 1995 and 2000, respectively.

Lifetime and previous 12-month prevalence rates of asthma symptoms were calculated by dividing positive responses to each question by the number of completed questionnaires. Ninety-five percent confidence intervals (CIs) of these prevalence rates were also calculated.

Twelve-month prevalence rates of symptoms by sex, age, and centre were calculated and compared using the χ^2 test and 95% CIs. CIs were calculated using the normal approximation of the binomial distribution. Logistic regression was used to analyse the effect of several risk factors on 12-month prevalence of symptoms. Adjusted odds ratio (aOR) and its 95% CI were also estimated using age, sex, centre, BMI, monthly electricity bill, passive smoking, living with a dog or cat, and living environments as covariates. The SAS system for Windows, version 8.0, was used for all statistical analyses.

Results

Demographic data

In 1995, 14964 adolescents were included in the final analysis, of whom 4396 (29.4%) were from Metropolitan Seoul and 10550 (70.6%) were from the Provincial Centers. In 2000, 15214 adolescents were included in the final analysis, of

Table 1. Response rate and age distribution of the subjects

Centre	Seoul		Provincial cities		Total	
Year	1995	2000	1995	2000	1995	2000
No. of schools	10	10	24	21	34	31
No. of subjects surveyed	4729	4617	10 752	11 277	15 481	15 894
No. of responses (%)	4439 (93.9)	4463 (96.7)	10 629 (98.9)	10 864 (96.3)	15 068 (97.3)	15 327 (96.4)
No. of subjects included in analysis	4396	4420	10 550	10 794	14 946	15 214
Male (%)	2763 (62.9)	2700 (61.1)	5457 (51.7)	5602 (51.9)	8220 (55.0)	8302 (54.6)
Age, years						
12 (%)	621 (14.1)	464 (10.5)	1484 (14.1)	1152 (10.7)	2105 (14.1)	1616 (10.6)
13 (%)	1425 (32.4)	1476 (33.4)	3663 (34.4)	3695 (34.2)	5058 (33.8)	5171 (34.0)
14 (%)	1519 (34.6)	1420 (32.1)	3549 (33.6)	3690 (34.2)	5068 (33.9)	5110 (33.6)
15 (%)	831 (18.9)	1060 (24.0)	1884 (17.9)	2257 (20.9)	2715 (18.2)	3317 (21.8)

Table 2. Comparison of prevalences of symptoms of asthma by written questionnaire among Korean adolescents

Centre	Seoul (95% CI)		Provincial cities (95% CI)		Total (95% CI)	
Year	1995	2000	1995	2000	1995	2000
Wheeze ever (%)	16.1 (14.97–17.19)	12.7 (11.68–13.77)*	12.9 (12.31–13.62)	12.8 (12.13–13.45)	13.9 (13.32–14.45)	12.8 (12.22–13.33)
Wheezing, last 12 months (%)	10.2 (9.26–11.10)	9.8 (8.89–10.70)	7.8 (7.26–8.31)	9.2 (8.59–9.71)†	8.5 (8.03–8.95)	9.3 (8.86–9.81)
Attacks of wheezing, (%)						
last 12 months						
1–3	7.7 (6.91–8.58)	7.1 (6.25–7.87)	6.1 (5.59–6.54)	6.8 (6.33–7.34)	6.6 (6.14–6.97)	6.9 (6.47–7.33)
4–12	1.8 (1.34–2.15)	2.2 (1.71–2.63)	1.2 (0.95–1.38)	1.8 (1.56–2.10)	1.4 (1.15–1.54)	1.9 (1.70–2.16)†
> 12	0.71 (0.45–0.97)	0.99 (0.68–1.31)	0.49 (0.35–0.63)	0.95 (0.76–1.15)†	0.56 (0.43–0.68)	0.96 (0.80–1.13)†
Sleep disturbed by wheezing, (%)	1.9 (1.45–2.3)	2.6 (2.08–3.04)	1.6 (1.32–1.81)	2.4 (2.09–2.68)†	1.7 (1.51–1.95)	2.4 (2.19–2.69)†
last 12 months						
Severe attack of wheezing, (%)	3.7 (3.14–4.32)	4.0 (3.36–4.55)	3.2 (2.82–3.53)	3.7 (3.31–4.04)	3.3 (3.03–3.64)	3.8 (3.44–4.06)
limiting speech, last 12 months						
Exercise-induced wheeze, (%)	16.2 (15.09–17.31)	14.2 (13.12–15.2)	12.5 (11.86–13.14)	14.7 (13.98–15.33)†	13.6 (13.03–14.14)	14.5 (13.94–15.08)
last 12 months						
Night cough, last 12 months (%)	10.4 (9.47–11.31)	13.9 (12.87–14.9)†	8.9 (8.3–9.41)	13.6 (12.96–14.28)†	9.3 (8.83–9.78)	13.7 (13.15–14.26)†
Diagnosis of asthma, ever (%)	3.4 (2.88–3.98)	5.3 (4.59–5.93)†	2.4 (2.13–2.72)	5.3 (4.83–5.69)†	2.7 (2.45–2.97)	5.3 (4.90–5.62)†
Treatment of asthma, (%)	1.0 (0.72–1.32)	1.9 (1.48–2.29)†	1.0 (0.83–1.22)	1.8 (1.52–2.02)†	1.0 (0.86–1.19)	1.8 (1.59–2.02)†
last 12 months						

* $P < 0.05$, the prevalence of 2000 is decreased significantly than that of 1995.

† $P < 0.05$, the prevalence of 2000 is increased significantly than that of 1995.
95% CI, 95% confidence interval.

whom 4420 (29.1%) were from Metropolitan Seoul and 10 794 (70.9%) were from the Provincial Centers. The age and sex distributions of the study groups are shown in Table 1. The proportion of boys was 55.0% in 1995 and 54.6% in 2000.

Prevalence of symptoms of asthma in written questionnaire

The overall lifetime prevalence of wheeze was 13.9% (95% CI, 13.3–14.5%) in 1995 and 12.8% (95% CI, 12.2–13.3%) in 2000, while the overall 12-month prevalence of wheeze was 8.5% (95% CI, 8.0–9.0%) in 1995 and 9.3% (95% CI, 8.9–9.8%) in 2000. In 1995, Metropolitan Seoul had a higher 12-month prevalence rate of wheeze (10.2%) than the Provincial Centers (7.8%), but there was no difference between the two centres in 2000 (9.8% vs. 9.2%), whereas a significant increase was observed in the Provincial Centers from 7.8% to 9.2% over the 5-year period. In addition, the 12-month prevalence

of '12 or more attacks of wheezing' and 'sleep disturbed by wheezing' in 2000 was significantly higher than in 1995; this increase was especially significant in the Provincial Centers.

The overall 12-month prevalence of exercise-induced wheeze was also not changed significantly, increasing from 13.6% in 1995 to 14.5% in 2000. When broken down by geographical area, a significant increase was observed in the Provincial Centers (from 12.5% to 14.7%), while there was a decrease in Seoul (from 16.2% to 14.2%). The overall 12-month prevalence of night cough increased significantly, from 9.3% to 13.7%, and also showed significant increases in Seoul (from 10.4% to 13.9%) and the Provincial Centers (from 8.9% to 13.6%).

The lifetime prevalence of asthma diagnosis increased significantly from 1995 (2.7%; 95% CI, 2.5–3.0%) to 2000 (5.3%; 95% CI, 4.9–5.6%). This change was found to be significant in both geographical locations. The 12-month prevalence of asthma treatment also increased significantly

from 1995 (1.0%; 95% CI, 0.9–1.2%) to 2000 (1.8%; 95% CI, 1.6–2.0%), and this increase was significant in both geographical areas also.

Prevalence of symptoms of asthma in video questionnaire

According to the AVQ, the lifetime prevalence of wheeze at rest rose from 6.7% (95% CI, 6.3–7.1%) in 1995 to 8.7% (95% CI, 8.2–9.1%) in 2000, while the 12-month prevalence of wheeze at rest increased from 3.9% (95% CI, 3.6–4.2%) in 1995 to 5.5% (95% CI, 5.1–5.8%) in 2000 (Table 3). This was especially notable in the Provincial Centers over this 5-year period. In Seoul, however, the lifetime and 12-month prevalence of wheeze at rest decreased significantly.

The overall lifetime prevalence of exercise-induced wheeze rose from 10.0% (95% CI, 9.5–10.5%) in 1995 to 16.8% (95% CI, 16.2–17.4%) in 2000. Again, this was especially notable in the Provincial Centers, where this prevalence rate increased from 8.4% to 17.3% over the 5-year period, but this prevalence in Seoul did not change. The overall 12-month prevalence of exercise-induced wheeze also rose significantly, from 6.6% in 1995 to 11.7% in 2000. While this rate was not altered in Seoul, it increased significantly in the Provincial Centers, from 5.3% to 12.2%.

The overall lifetime prevalence of nocturnal wheeze also increased, from 1.9% in 1995 to 2.9% in 2000, as did the 12-month prevalence of nocturnal wheeze, from 0.6% to 1.4%. The lifetime prevalence of nocturnal cough also rose, from 6.9% in 1995 to 12.5% in 2000, as did the 12-month prevalence of nocturnal cough, which increased from 3.9% to 7.1% over the same period of time. The overall lifetime prevalence of severe wheeze was also increased, from 3.4% in 1995 to 4.6% in 2000, as was the 12-month prevalence of severe wheeze, which rose from 2.0% in 1995 to 2.6% in 2000. These increases were primarily because of significant changes in the Provincial Centers.

Effect of region

When individual cities were compared, wide rates of variation in the prevalence of asthma symptoms were noted (Table 4). In 1995, Seoul had higher prevalence rates than the Provincial Centers (aOR 1.343, 95% CI, 1.186–1.520), but these differences were not observed in 2000 (Table 5). In 2000, some of the Provincial cities, including Cheju, Changwon, Chungju, and Chunchon, had higher prevalence rates than Seoul. Interestingly, the 12-month prevalence of wheeze was consistently high in Cheju, a southern island city with low air pollution indices, whereas this rate was low in Ulsan and

Table 3. Comparison of lifetime and 12-month prevalences of symptoms of asthma by video questionnaire among Korean adolescents

Centre	Seoul (95% CI)		Provincial cities (95% CI)		Total (95% CI)	
Year	1995	2000	1995	2000	1995	2000
Wheeze (%)						
Ever	9.9 (9.0–10.8)	7.9 (7.1–8.7)*	5.4 (4.9–5.8)	9.0 (8.4–9.5)†	6.7 (6.3–7.1)	8.7 (8.2–9.1)†
Last 12 months	6.3 (5.6–7.1)	4.8 (4.2–5.5)*	2.9 (2.6–3.2)	5.7 (5.3–6.2)†	3.9 (3.6–4.2)	5.5 (5.1–5.8)†
Exercise-induced wheeze (%)						
Ever	13.9 (12.9–15.0)	15.6 (14.5–16.6)	8.4 (7.9–9.0)	17.3 (16.6–18.1)†	10.0 (9.5–10.5)	16.8 (16.2–17.4)†
Last 12 months	9.8 (8.9–10.7)	10.3 (9.4–11.2)	5.3 (4.9–5.7)	12.2 (11.6–12.8)†	6.6 (6.3–7.1)	11.7 (11.1–12.2)†
Nocturnal wheeze (%)						
Ever	2.5 (2.0–3.0)	2.7 (2.2–3.1)	1.7 (1.4–1.9)	2.9 (2.6–3.3)†	1.9 (1.7–2.1)	2.9 (2.6–3.1)†
Last 12 months	1.0 (0.7–1.2)	1.2 (0.9–1.5)	0.4 (0.3–0.6)	1.4 (1.2–1.6)†	0.6 (0.5–0.7)	1.4 (1.2–1.5)†
Nocturnal cough (%)						
Ever	9.9 (9.0–10.8)	11.6 (10.6–12.5)	5.7 (5.2–6.1)	12.9 (12.3–13.6)†	6.9 (6.5–7.3)	12.5 (11.0–13.1)†
Last 12 months	6.0 (5.3–6.7)	6.7 (6.0–7.5)	3.0 (2.7–3.4)	7.3 (6.8–7.8)†	3.9 (3.6–4.2)	7.1 (6.7–7.5)†
Severe wheeze (%)						
Ever	4.8 (4.1–5.4)	4.2 (3.6–4.8)	2.8 (2.5–3.1)	4.8 (4.4–5.2)†	3.4 (3.1–3.6)	4.6 (4.3–5.0)†
Last 12 months	3.1 (2.6–3.6)	2.4 (2.0–2.9)	1.6 (1.3–1.8)	2.7 (2.4–3.0)†	2.0 (1.8–2.2)	2.6 (2.4–2.9)†

* $P < 0.05$, the prevalence of 2000 is decreased significantly than that of 1995.

† $P < 0.05$, the prevalence of 2000 is increased significantly than that of 1995.

95% CI, 95% confidence interval.

Table 4. Twelve-month prevalences of wheeze by cities among Korean adolescents

	Seoul	Suwon	Ansan	Ulsan	Chunju	Cheju	Changwon	Chungju	Chunchon
Written questionnaire									
1995 (%)	10.18	10.03	8.99	6.40	6.34	9.56	8.54	6.86	5.19
2000 (%)	9.80	8.43	7.34	6.98	8.76	11.16	9.87	10.01*	10.94*
Video questionnaire									
1995 (%)	6.34	3.75	2.76	2.68	2.41	3.33	3.24	2.30	2.48
2000 (%)	4.81†	4.74	4.47	3.82	5.34*	8.05*	5.89*	5.42*	9.16*

* $P < 0.05$, the prevalences in 1995 were increased than the prevalences in 2000.

† $P < 0.05$, the prevalences in 1995 were decreased than the prevalences in 2000.

Table 5. Odds ratio (OR) and its 95% confidence interval (CI) of potential risk factors for 12-month prevalence of wheeze by written questionnaire among Korean adolescents

	1995		2000	
	uOR (95% CI)	aOR (95% CI)	uOR (95% CI)	aOR (95% CI)
Age	1.000 (0.940–1.605)	1.004 (0.939–1.073)	1.087 (1.023–1.155)*	1.050 (0.972–1.134)
Sex				
Male	1.00	1.00	1.00	1.00
Female	1.110 (0.978–1.239)	1.106 (0.973–1.256)	1.016 (0.907–1.137)	1.038 (0.899–1.199)
Center				
Provincial	1.00	1.00	1.00	1.00
Seoul	1.343 (1.186–1.520)*	1.341 (1.173–1.532)*	1.078 (0.954–1.219)	1.067 (0.912–1.250)
Body mass index	1.017 (0.998–1.038)	1.019 (0.997–1.041)	1.037 (1.018–1.057)*	1.040 (1.015–1.066)*
Height	1.007 (1.000–1.014)	—†	1.008 (1.001–1.015)*	—
Weight	1.007 (1.001–1.013)*	—	1.011 (1.006–1.017)*	—
Electricity (Won/month) bill				
<30 000	1.00	—	1.00	—
30 000–60 000	1.085 (0.928–1.270)	—	1.161 (1.005–1.342)*	—
≥60 000	1.121 (0.842–1.493)	—	1.057 (0.830–1.346)	—
Passive smoking+	1.021 (0.903–1.156)	0.994 (0.875–1.130)	1.540 (1.309–1.812)*	1.466 (1.182–1.817)*
Living with dog or cat	1.076 (0.906–1.277)	1.087 (0.910–1.300)	1.248 (1.107–1.407)*	1.220 (1.047–1.422)*
Living environment				
Rural	1.00	—	1.00	—
Industrial area	1.381 (0.801–2.378)	—	0.707 (0.308–1.306)	—
Urban	1.247 (0.926–1.680)	—	0.817 (0.576–1.158)	—

* $P < 0.05$.

†Not included in multivariate models, +passive smoking associated with care giver in 2000, passive smoking associated with family in 1995.

uOR, univariate odds ratio; aOR, adjusted odds ratio.

Ansan, two industrialized cities with very high air pollution indices. During the 5-year period of this study, the Provincial cities Chungju and Chunchon showed significant increases in 12-month prevalence of wheeze by WQ, whereas there were no significant changes in Seoul. Also, the trend was the same in the AVQ.

Analysis of risk factors

When we performed univariate and multivariate logistic regression, we found that increased body weight was associated with a higher risk for 12-month prevalence of wheeze, both in 1995 (aOR, 1.01) and 2000 (aOR, 1.01). Increased BMI was also associated with a higher risk of wheeze in 2000 (aOR, 1.04, 95% CI, 1.02–1.06), but not in 1995. These findings suggest that overweight is an important risk factor for recent wheeze. In contrast, in both 1995 and 2000, monthly electricity bill was not associated with increased prevalence of wheeze, suggesting that economic status is not associated with risk of wheeze in Korea.

Passive smoking increased the risk of wheeze (aOR, 1.54, 95% CI, 1.31–1.81) in 2000, but not in 1995. Direct comparison of this factor over time may be difficult, however, since the questions regarding smoking differed in the two questionnaires. For example, the 2000 questionnaire asked about passive smoking associated with care givers, whereas the 1995 questionnaire asked about passive smoking associated with family members. The result of the 2000 questionnaire, however, suggests that passive smoking associated with care givers may be an important risk factor for developing wheeze. Similarly, living with a dog or cat, which was not a risk factor for wheeze in 1995, was

significantly associated with increased symptoms in 2000 (aOR, 1.25, 95% CI, 1.11–1.41). There was no association between living environment (i.e. rural, industrial, or urban area) and risk of wheeze in Korean adolescents.

Discussion

This is the second nationwide epidemiologic study on asthma in Korean adolescents, performed in conjunction with ISAAC. Using self-reported WQ and AVQs, performed at 5-year intervals, and at the same time of the year, we have found that the prevalence of symptoms of asthma increased significantly in the Provincial Centers from 1995 to 2000. This was particularly notable when assessing the prevalence of sleep disturbed by wheezing and night cough. In addition, the occurrence of diagnosis of asthma and treatment of asthma also increased significantly during this 5-year interval. The awareness of asthma by doctors and/or patients and their parents may have increased over this period of time, explaining, at least in part, the increased prevalence of asthma in Korea. This may have been a result of the nationwide asthma awareness campaign that took place in Korea over the past several years. Other explanations for the increased prevalence of asthma in the Provincial Centers may include environmental changes caused by rapid westernization, or increased air pollution in Korean cities.

Utilizing standardized methods in the same community at different times over the past 40 years, the prevalence of asthma has been found to increase [18]. Interpretation of these studies is limited, however, by the lack of objective

markers of asthma, and these findings may in part be attributed to greater patient awareness of asthma symptoms or greater physician awareness of diagnostic criteria. Nonetheless, the few studies that have examined changes in the prevalence of bronchial hyper-responsiveness (BHR) in children have demonstrated increases over this period [19].

Using our AVQ, we found that the lifetime and 12-month prevalence of all symptoms of asthma, including wheeze, exercised-induced wheeze, nocturnal wheeze, nocturnal cough, and severe wheeze, increased significantly from 1995 to 2000. The ISAAC studies revealed similar patterns in the overall international prevalence of asthma symptoms and were well correlated with our findings [20]. Neither our questionnaire nor the standard ISAAC questionnaire was better than the other in predicting BHR in a group of Korean schoolchildren [21]. Results from the ISAAC study have suggested that the AVQ may be more objective than the WQ, regardless of translation or interpretation problems [22], suggesting that our findings using the AVQ may be true indicators of the prevalence of asthma in Korean adolescents.

Because the diagnosis of asthma is made on the basis of clinical history, physical findings, and pulmonary function tests, the determination of the prevalence of asthma is based on a simple comparison of symptoms in large numbers of people [23]. When we compared the results based on our WQ and AVQs, we found that the prevalence of asthma symptoms was generally higher using the WQ. The trends toward increasing prevalence over time of these symptoms were the same, regardless of the questionnaire used. These results allow us to conclude that the prevalence of asthma symptoms has increased in Korean adolescents.

Our study also showed significant increases in the percentage of Korean adolescents diagnosed with, and treated for, asthma from 1995 to 2000, both in Seoul and the Provincial Centers. The percentage of Korean adolescents diagnosed with asthma doubled over this 5-year period, from 2.7% to 5.3%. Despite this increase, however, the prevalence of asthma diagnosis in Korea remained lower than in Western countries. The percentage of Korean adolescents treated for asthma also doubled over this 5-year period, from 1.0% to 1.8%. Taken together, these findings suggest that the childhood asthma campaign, held in conjunction with the first nationwide asthma prevalence survey in 1995, was successful and has led to increased awareness of this disease by doctors, patients, and their parents.

One of the striking results of this study is that, in the Provincial Centers, there were significant increases in the prevalence of all symptoms of asthma between 1995 and 2000. This may be because of the rapid economic development and westernization of Korea that took place during this time, especially in the Provincial cities. While the prevalence of asthma symptoms in 1995 was lower in the Provincial Centers than in Seoul, they were comparable in 2000. Seoul, which is one of the largest cities in the world, is a fully developed urban area. In contrast, the Provincial cities of Korea, whose population is half million to one million, are still developing and changing lifestyles. Thus, our findings suggest that there may be little difference in westernization between Seoul and the Provincial cities. These findings are similar to those of childhood asthma prevalence studies in Africa, which have confirmed urban-rural differences, but

have shown that this gap is rapidly narrowing, perhaps due in part to exposure to a more westernized lifestyle [24].

Although Seoul had a higher 12-month prevalence rate of wheeze than the Provincial Centers in 1995, most cities in the latter, especially Cheju, Changwon, Chungju, and Chunchon, had rates similar to Seoul in 2000. This was not solely because of air pollution, as Ansan and Ulsan are among the most industrialized cities in Korea, with the highest rates of air pollution; yet, we observed the lowest 12-month prevalence rates of wheeze in these two cities. In addition, Chunchon, a more rural area and known as one of the least polluted cities in Korea, had a higher 12-month prevalence of wheeze than Seoul. Thus, environmental risk factors other than air pollution are implicated as causing asthma in Korea. Whereas genetic predisposition may be important in determining whether asthma develops in an individual, environmental factors in their broadest sense are the major determinants of asthma within a community. Our results support the importance of environmental factors as causative agents of asthma in Korean adolescents.

A worldwide trend has shown increases in the prevalence of asthma [9–12]. In some areas, however, this trend has been halted [13]. Numerous hypotheses relating to socio-economic status, family size, early childhood infections and hygiene, allergen exposure, diet and obesity, perinatal risk factors, and pollution may be involved.

BMI was found to increase the risk of asthma in 2000, but not in 1995. The 12-month prevalence of wheeze also tended to increase with weight in both years, suggesting that this symptom may be associated with obesity. In fact, several studies have shown positive associations of obesity or BMI with respiratory symptoms, asthma, and airway hyper-responsiveness [25–28]. A strong inverse relation between having been breastfed and BMI has recently been found in children starting school [29]. Thus, BMI may be an important risk factor for asthma in Korea adolescents.

Passive smoking is one of the most important factors affecting children's health. Smoking is a major public health problem in Korea, as reflected by both the high rate of smoking among adult males (60%) and the high prevalence of passive smoking among children in this study (42.18% in 1995 and 10.64% in 2000). The results of the 2000 survey showed that passive smoking is an important risk factor for the symptoms of asthma. Part of this was undoubtedly because of the rephrasing of the questions involving passive smoking. While the 1995 survey asked about passive smoking associated with family members, the 2000 survey asked about passive smoking associated with care givers. Previous studies have shown that smoking by a child's mother during pregnancy plus smoking by any member of the household after the child is born increases the child's risk of developing asthma and wheeze [30, 31]. Our findings are also in agreement with a recent report showing that exposure of inner city children to moderate-to-heavy environmental tobacco smoke is associated with an increased frequency of nocturnal symptoms of asthma, including coughing, wheezing, and shortness of breath [32].

Although the 1995 survey did not show that living with a dog or cat was a risk factor for the development of asthma, it was found to be a risk factor in the 2000 survey. While early exposure to cats may decrease rather than increase a child's

risk for developing asthma [33], cat allergens may exacerbate asthma symptoms and increase the frequency of emergency room visits.

In conclusion, the prevalence of symptoms of asthma increased in Korean adolescents from 1995 to 2000. Much of this increase is because of increases in the Provincial Centers. Among the risk factors identified are BMI, passive smoking, and living with a dog or cat. Environmental factors other than air pollution may enhance the risk of asthma in Korean children.

Acknowledgements

The authors thank the Seoul School Health Center and its paediatric allergists, all of whom are members of the Korean Academy of Pediatric Allergy and Respiratory Disease (KAPARD), and all of whom participated in this survey, for their invaluable devotion and assistance. This study was supported by a 2000-Grant from the Korean Academy of Medical Sciences, KMA.

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