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Residential Environmental Risk Factors for Childhood Asthma Prevalence in Metropolitan and Semirural Cities in Korea

Gyu-Seok Hwang, MPH[1,2], Jae-Wook Choi, MD, PhD[1], Young Yoo, MD, PhD[1], Ji-Tae Choung, MD, PhD[1], and Chung-Sik Yoon, PhD[2]

Abstract

To identify the association between residential environmental risk factors and the prevalence of childhood asthma, the authors surveyed the prevalence of asthma, the residential environmental risk factors of 1819 elementary school students, and air pollution in metropolitan (Seongbuk), and semirural (Andong) areas. Although there was no significant difference in the prevalence of self-reported asthma (SA) between the 2 geographic areas (12.8% vs 13.6%), the prevalence of physician-diagnosed asthma (PDA) in Andong (15.0%) was significantly higher than that in Seongbuk (6.8%). After adjusting for confounding factors, logistic regression suggested that there were significant differences in size of the house (adjusted odds ratio [aOR] = 1.82), medical insurance (aOR = 2.59), and number of residents in the household (aOR = 1.54) between the SA and non-SA groups. There was a significant difference in the area of residence (aOR = 2.12) between the PDA and non-PDA groups. In conclusion, residential environmental risk factors and the area of residence affect the prevalence of childhood asthma.

Keywords

child, asthma, prevalence, risk factors, air pollution

Introduction

For the last several decades, the prevalence of asthma in Western countries has continued to increase, but the prevalence has recently reached an equilibrium or shown a decreasing trend.[1] These trends are also occurring in some Asian countries.[2] In Korea, the prevalence of childhood asthma was 5.6% in 1983, >10% in the late 1980s, and about 8% in the 2000s.[3] However, asthma

[1]Korea University, Seoul, Republic of Korea
[2]Seoul National University, Seoul, Republic of Korea

Corresponding Author:
Jaewook Choi, School of Preventive Medicine, Korea University, 126-1, 5Ga, Anam-Dong, Seongbuk-Gu, Seoul 136-705, Republic of Korea
Email: shine@korea.ac.kr

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affects all ages and is one of the major factors causing nonattendance and preventing regular physical activities for school-aged children. In particular, it has been suggested that children of low-income families have a higher prevalence of asthma and have longer hospitalizations and higher mortality rates from asthma.[4,5]

It has been suggested that the environment plays an important role in respiratory disease; the potential risk factors for respiratory disease include tobacco smoke, formaldehyde, VOCs, NO_2, and CO.[6] In addition, it has been reported that the risk of asthma in teenagers might be increased by air pollutants, such as total suspended particulates, NO_2, CO, O_3, and airborne dust. Research involving children in highly polluted metropolitan areas and other regions has concluded that there is a significant difference in respiratory syndrome based on environmental characteristics.[7] It has been reported that house dust mites and cockroach allergens are also related to childhood asthma.[8] Furthermore, it has been suggested that the prevalence of asthma is different and is based on parents' socioeconomic differences.[5]

Since the 1960s, the environmental degradation of Korea has been aggravated because of rapid population growth and urbanization. Studies on environmental factors and childhood asthma in Korea have mainly been performed on the correlation with specific factors, such as air pollution or allergens,[9,10] so studies on integrated factors, such as air pollution, residential environment, and living habits, have been inadequate. Therefore, the objectives of this study were to determine the prevalence of childhood asthma in a rapidly developing metropolitan area and a traditional semirural city and to identify relevant risk factors related to the air, residence, living habits, and socioeconomic status.

Materials and Methods

Study Design

Elementary schools have been the focus in the assessment of the prevalence of asthma in a number of studies, and elementary schools are a convenient venue in which to collect study participants. This study was conducted between 6 April and 29 May in 2009 in an elementary school in a metropolitan area (Seonguk, Seoul) and 2 elementary schools in a semirural area (Andong, Kyoengbuk). These elementary schools were chosen in 2 cities with air monitoring systems. The participants were of both genders and represented all the elementary school grades. The age range was 6 to ~13 years. We surveyed the prevalence of asthma using a standardized questionnaire, as proposed by the ISAAC Steering Committee. We also surveyed the relevant residential environment, living habits, socioeconomic status, and family history of asthma. The questionnaires were distributed by school teachers to the students and answered by the students' parents. The students were classified into a self-reported asthma (SA) group, a physician-diagnosed asthma (PDA) group, and a control group, on the basis of the results of the survey. We analyzed the environmental and socioeconomic risk factors.

Questionnaire

The questionnaire for this study consisted of 4 parts. The first part was organized to elicit the birth date, sex, height, weight, and phone number as anthropometric information. In the second part, the students were asked if they had asthma symptoms, and if yes, what the symptoms were and if they had been diagnosed as asthma by the physician. This part was adopted from the criteria of the American Thoracic Society and previous studies.[11,12] In the third part, living habits were queried. Specifically, the type of ventilation in the house, use of a dehumidifier, use of an air conditioner,

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ventilation, pet breeding, and house repairs were surveyed. In the fourth part, the survey was performed on the residential environment. Specifically, this part investigated matters, such as current address, length of residence, the child's room and number of family members living in the household, type of housing, size of the house, amount of sunlight, humidity, distance from the nearest road, academic background, annual income of the parents, family history of asthma, and passive smoking. The questions that concerned living habits and residential environment in the third and fourth parts were prepared based on the existing domestic and foreign studies.[13,14] The questionnaires were distributed to the students through health and class teachers and collected by the health and class teachers after being completed by the parents.

Air Pollution Monitoring Data

The air pollution data were obtained from an air pollution monitoring network, which is operated by the Korea Ministry of Environment and consists of 225 automatic monitoring stations nationally; this system measures SO_2, O_3, NO_2, CO, and PM_{10} every 5 minutes. The monthly average air pollution concentrations of both areas were compared. For this comparison, data from June 2005 to May 2009 were used.

For the air pollution data of Seoul, the automatic monitoring data from Seongbuk, Seoul (operated by the Seoul Research Institute of Public Health and Environment), were used, and for the air pollution data of Andong, the automatic monitoring data from Andong (operated by Kyeonegbuk Research Institute of Public Health and Environment) were used.

Statistical Analysis

The air pollution concentrations of the 2 areas were compared using the Student's t test after a normal distribution test. The prevalence of asthma in the 2 areas and the relationship of asthma to living habits, residential environments, and socioeconomic indexes were assessed using a χ^2 test. The crude odds ratio (OR) with a 95% confidence interval (CI) was reported. Logistic regression analysis was used to correlate residential environmental factors and asthma, after adjusting for potential confounding variables, such as gender, family history, and age. The statistical software package SPSS 12.0 (SPSS Inc, Chicago, IL) was used for all analyses.

Results

Demographic Characteristics and Prevalence of Asthma

The total number of respondents was 1819 of 2050 (88.7%). Of 1163 students in Seongbuk, 1005 students (86.4%) responded. Of 887 students in the Andong area, 814 students (91.8%) responded. The percentage of boys was 50.2% (913) and that of girls was 49.8% (906). The average height was 138.7 cm in boys and 139.0 cm in girls. The average body weight of boys was 35.6 kg, and it was 33.5 kg for girls. The age range was 8 to 13 years (Table 1).

The results of the SA and PDA surveys were studied. The overall prevalence of SA symptoms was 13.2% (12.8% in Seongbuk and 13.6% in Andong; there was no significant difference). The overall prevalence of PDA was 10.4% (6.8% in Seongbuk and 15.0% in Andong, $P < .001$; Table 2).

The concentrations of SO_2 and O_3 were significantly higher in Andong ($P < .05$), and the concentration of NO_2 was significantly higher in Seongbuk ($P < .05$). There was no significant difference in concentrations of PM_{10} and CO (Table 2).

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Table 1. Demographic Characteristics in Respondents

Characteristics	Seongbuk	Andong	Total
Respondents (%)	1005 (55.3)	814 (44.7)	1819
Boys	517 (51.4)	396 (48.6)	913 (50.2)
Girls	488 (48.6)	418 (51.4)	906 (49.8)
Average height (cm, mean ± SD)	136.5 ± 11.5	141.7 ± 10.0	138.8 ± 11.2
Boys	137.0 ± 11.3	140.5 ± 11.8	138.7 ± 10.8
Girls	135.8 ± 12.8	142.7 ± 10.7	139.0 ± 11.5
Average weight (kg, mean ± SD)	33.2 ± 9.6	36.3 ± 9.0	34.6 ± 9.5
Boys	34.6 ± 10.5	36.9 ± 9.6	35.6 ± 10.1
Girls	31.6 ± 8.5	36.0 ± 9.8	33.5 ± 8.69
Age range (years)	8 to ~13	8 to ~13	8 to ~13

Abbreviations: SD, standard deviation.

Table 2. Prevalence of Asthma and Air Pollution Levels in Metropolitan and Semirural Areas

Category		Metropolitan (Seongbuk)	Semirural (Andong)	Total	*P*
Prevalence, n (%)	SA	129 (12.8)	111 (13.6)	240 (13.2)	.616
	PDA	68 (6.8)	122 (15.0)	190 (10.4)	<.001
Air pollution, mean (SD)	SO_2 (ppm)	0.005 (0.003)	0.007 (0.004)	0.006 (0.004)	.001
	O_3 (ppm)	0.018 (0.008)	0.021 (0.009)	0.020 (0.009)	<.001
	PM_{10} ($\mu g/m^3$)	52.6 (15.5)	55.6 (18.0)	54.1 (16.7)	.101
	NO_2 (ppm)	0.036 (0.007)	0.019 (0.008)	0.027 (0.011)	<.001
	CO (ppm)	0.657 (0.186)	0.577 (0.370)	0.617 (0.292)	.196

Abbreviations: SA, self-reported asthma; PDA, physician-diagnosed asthma; SD, standard deviation.

Socioeconomic Factors

Table 3 shows the relationship between socioeconomic factors and SA and PDA. It was suggested that SA was significantly associated with gender, size of the house, home ownership, parents' income, medical insurance, and family history of asthma ($P < .05$). Among these factors, it was found that the unadjusted OR of a family history of asthma was strongly associated with SA (3.87; 95% CI = 2.64-5.67). PDA was significantly associated with the area of residence, gender, size of the house, home ownership, parents' income, and a family history of asthma ($P < .05$). Among these factors, the unadjusted OR of the family history of asthma had a strong association with PDA (5.87; 95% CI = 3.98-8.64; Table 3).

Residential Environmental Risk Factors

Table 4 shows the association of residential environmental factors with SA and PDA. It was suggested that SA had a significant association with the year of construction, amount of sunlight in the home, distance of the bus from the house, outdoor chemical odors, nearby harmful facilities, and number of family members in the household ($P < .05$). Among these factors, it was found that the unadjusted OR of nearby harmful facilities had a strong association with SA (2.15; 95% CI = 1.11-4.17). The prevalence of PDA had a significant association with the amount of sunlight

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Table 3. Socioeconomic Factors, Family History of Asthma, and the Prevalence of Asthma[a]

		Self Reported			Physician Diagnosed		
Variables		n (%)	OR	95% CI	n (%)	OR	95% CI
Area of residence	Semirural	111 (13.6)	1.07	0.82-1.41	122 (15.0)	2.43***	1.78-3.32
	Metropolitan	129 (12.8)			68 (6.8)		
Gender	Male	151 (16.5)	1.82***	1.37-2.41	109 (11.9)	1.38**	1.02-1.87
	Female	89 (9.8)			81 (8.9)		
Age (years)	8-10	139 (14.4)	1.25	0.95-1.65	106 (11.0)	1.13	0.84-1.53
	11-13	101 (11.8)			84 (9.8)		
Size of the house	Small	59 (19.5)	1.83***	1.32-2.54	44 (14.5)	1.57**	1.09-2.27
	Larger than average	164 (11.7)			137 (9.7)		
Home ownership	Rented	91 (16.8)	1.58**	1.18-2.12	74 (13.6)	1.60**	1.16-2.20
	Own	127 (11.3)			101 (9.0)		
Parents' income (million KRW)	≤20	43 (16.8)	1.44**	1.00-2.08	38 (14.8)	1.64*	1.11-2.42
	>20	165 (12.3)			129 (9.6)		
Parents' education	High school	61 (13.4)	1.03	0.75-1.42	52 (11.4)	1.11	0.79-1.57
	College	157 (13.1)			125 (10.4)		
Medical insurance	Yes	209 (13.7)	2.44**	1.12-5.32	164 (10.7)	0.94	0.52-1.72
	No	7 (6.1)			13 (11.3)		
Family history of asthma	Yes	47 (32.2)	3.87***	2.64-5.67	50 (34.2)	5.87***	3.98-8.64
	No	169 (10.9)			126 (8.2)		

Abbreviations: OR, odds ratio; CI, confidence interval; KRW, South Korean won.
[a]*$P < .05$; **$P < .01$; ***$P < .001$.

in the house and passive smoking ($P < .05$). Among these factors, the unadjusted OR of the amount of sunlight in the house had a strong association with PDA (1.59; 95% CI = 1.00-2.53; Table 4).

Table 5 includes the results of logistic regression on the prevalence of asthma. There was an association between residential risk factors and the prevalence of asthma. After adjusting for income, a family history of asthma, gender, and age, it was suggested that there was a significant difference in size of the house (adjusted OR [aOR] = 1.82) and number of residents in the household (aOR = 1.54) between the SA and non-SA group. The prevalence of childhood SA when living in a small house was 1.82 times higher than the prevalence of childhood SA when living in a large house (95% CI = 1.14-2.89), and the prevalence of childhood SA in households with few family members was 1.54 times higher than the prevalence of childhood SA in households with a large number of family members (95% CI = 1.03-2.33).

There was a significant difference in the area of residence (aOR = 2.12) between the PDA and non-PDA groups. The prevalence of childhood PDA in the semirural area (Andong) was 2.12 times higher than the prevalence of childhood PDA in the metropolitan area (Seongbuk; 95% CI = 1.35-3.34; Table 5).

Discussion

In the current study, the prevalence of childhood asthma symptoms among all the participants was 13.2%, and the prevalence of PDA was 10.4%. These results were similar to the ISAAC study conducted in Korea. In the ISAAC study, the prevalence of asthma symptoms in Korean

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Table 4. Residential Environmental Risk Factors[a]

Variables		Self Reported			Physician Diagnosed		
		n (%)	OR	95% CI	n (%)	OR	95% CI
Type of house	Single family	36 (13.2)	1.04	0.71-1.52	32 (11.7)	1.15	0.77-1.72
	Multifamily	184 (12.8)			149 (10.4)		
Construction within 1 year	Yes	14 (22.6)	2.03*	1.10-3.74	11 (17.7)	1.89	0.96-3.69
	No	206 (12.6)			168 (10.3)		
Amount of house sunlight	Little	34 (19.0)	1.61*	1.06-2.45	27 (15.1)	1.59*	1.00-2.53
	Much	119 (12.7)			94 (10.0)		
Humidity of house	Much	16 (17.8)	1.44	0.80-2.59	10 (11.1)	1.14	0.56-2.30
	Little	91 (13.0)			69 (9.9)		
Distance from bus within 100 m	Yes	131 (14.5)	1.35*	1.01-1.81	100 (11.1)	1.13	0.83-1.55
	No	89 (11.2)			79 (9.9)		
Amount of traffic	Little	29 (10.9)	0.83	0.53-1.30	28 (10.5)	0.96	0.61-1.53
	Much	83 (12.9)			70 (10.9)		
House repair during last 12 months	Yes	44 (10.4)	0.71	0.50-1.01	46 (10.9)	1.06	0.75-1.51
	No	196 (14.0)			144 (10.3)		
Outdoor chemical odors	Yes	57 (17.9)	1.62**	1.17-2.26	40 (12.6)	1.29	0.89-1.87
	No	164 (11.9)			139 (10.1)		
Nearby harmful facility	Yes	12 (23.5)	2.15*	1.11-4.17	11 (21.6)	2.45	1.23-4.87
	No	205 (12.5)			165 (10.1)		
Use of air cleaner	Yes	42 (12.1)	0.89	0.62-1.28	40 (11.6)	1.11	0.76-1.61
	No	168 (13.5)			132 (10.6)		
Use of air conditioner	Yes	136 (13.6)	1.10	0.82-1.47	111 (11.1)	1.09	0.79-1.50
	No	84 (12.5)			69 (10.3)		
Cleaning cycle	≤7/week	164 (12.5)	0.71	0.44-1.15	131 (10.0)	0.66	0.39-1.10
	>7/week	22 (16.8)			19 (14.5)		
New furniture	Yes	63 (15.1)	1.27	0.93-1.75	48 (11.5)	1.14	0.80-1.63
	No	154 (12.3)			128 (10.2)		
Laundry cycle	≤4 weeks	175 (12.2)	0.67	0.45-1.01	146 (10.2)	0.75	0.48-1.18
	>4 weeks	34 (17.2)			26 (13.1)		
Indoor pet	Yes	18 (14.3)	1.13	0.67-1.90	7 (5.6)	0.48	0.22-1.05
	No	183 (12.9)			154 (10.9)		
Number of residents in the household	≤4	178 (14.1)	1.57*	1.09-2.25	140 (11.1)	1.23	0.84-1.78
	≥5	40 (9.5)			39 (9.2)		
Household with smokers	Yes	130 (14.3)	1.22	0.93-1.60	108 (11.9)	1.36*	1.01-1.85
	No	110 (12.1)			82 (9.0)		

Abbreviations: OR, odds ratio; CI, confidence interval.
[a]*$P < .05$; **$P < .01$; ***$P < .001$.

children was 17.5% in 1995 and 13.0% in 2000, and the prevalence of PDA was 7.7% in 1995, 9.1% in 2000, and 7.8% in 2006.[15]

The prevalence of respiratory disease (in particular, asthma) in childhood was associated with heavy air pollution. The results of a study in Morocco showed that air pollution, such as SO_2 and total suspended particulates, was not the only factor causing childhood asthma, but it was

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Table 5. Logistic Regression Analysis for Childhood Asthma[a]

Variables		B	aOR	95% CI	*P*
SA	Size of the house	0.60	1.82	1.14-2.89	.012
	Home ownership	0.15	1.16	0.78-1.71	.459
	Construction within 1 year	0.69	2.00	0.92-4.34	.080
	Distance from bus within 100 m	0.21	1.23	0.88-1.71	.223
	Outdoor chemical odors	0.25	1.28	0.86-1.92	.229
	Nearby harmful facilities	0.78	2.19	0.93-5.14	.071
	Number of residents in the household	0.43	1.54	1.03-2.33	.037
PDA	Size of the house	–0.01	0.99	0.53-1.86	.979
	Home ownership	0.35	1.42	0.87-2.33	.159
	Area of residence	0.75	2.12	1.35-3.34	.001
	Amount of house sunlight	0.49	1.63	0.96-2.75	.069
	Passive smoking	0.22	1.25	0.81-1.93	.320
	Construction within 1 year	–0.05	0.95	0.34-2.68	.927

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; SA, self-reported asthma; PDA, physician-diagnosed asthma.

[a]Adjusted for income, family history of asthma, gender, age, and all other respective factors in table. Although area variable was inserted into SA, there was no change in significant items, and the area was not significant.

a crucial factor.[16] According to some epidemiological studies, there was a report that during episodes of smog, SO_2, respiratory disease, and the related mortality increased.[15] The presence of SO_2 in the air is associated with increased respiratory symptoms.[17] In a study on the effect of indoor air pollution, it was reported that NO_2 and suspended particulate matter were related to asthma symptoms.[18] According to the study on the association between air pollution and asthma crises in Korea, it was found that PM_{10}, CO, SO_2, NO_2, and O_3 had significant hazardous effects at a similar level.[19]

Although the total prevalence of asthma in Korea has shown a declining tendency, it seems that the prevalence of asthma differs according to the area and the socioeconomic level. In a study performed in Ilsan, Korea, in 2005, the results showed that the prevalence of asthma in the downtown area was 11.7%, and it was 15.2% in the rural area studied.[20]

The prevalence of SA and PDA by gender was 1.82 and 1.38 times higher in boys than in girls, respectively. These results are consistent with other conventional results.[13,14] It was found that there were significant differences in the prevalence of asthma according to socioeconomic factors, such as size of the house, home ownership, and annual income. This was consistent with the results of the study by Weitzman et al[21] in the United States, in which the prevalence of childhood asthma was found to be higher in students residing in smaller houses and in those with a lower economic status. In addition, the SA and PDA prevalence was 1.44 and 1.64 times higher in students whose parents had an income <20 million KRW (South Korean won). These results are consistent with the results by Lin et al,[14] who showed that the prevalence of asthma was 1.22 times higher in students at the poverty level. The high entrance rate into the college (82.8%) may be attributed to mandatory high school attendance in Korea. There seemed to be no significant

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difference in the prevalence of asthma between children of parents with high and low levels of education.[22]

The SA and PDA prevalence for a family history of asthma was 3.87 and 5.87 times higher, respectively. In a study on environmental risk factors, Lin et al[14] reported that the prevalence of childhood asthma was 3.17 times higher in those with a family history of asthma. Jenkins et al[23] reported that the OR was 3.47 in those with a brother or sister with asthma, and the OR was 3.13 in those with a mother with asthma.[23] A number of studies have reported that the prevalence of asthma is higher in those with a family history of asthma, which was consistent with the results of this study.[24] Additionally, it was suggested that there was a difference in the prevalence of asthma according to various residential environmental factors. It was found that the SA and PDA prevalence was 1.61 and 1.59 times higher, respectively, in those who responded that the amount of sunlight in the house was too little. With adequate sunlight in the house, it may be easy to control humidity and reduce the viability of allergens, such as house dust mites, thus reducing exposure to allergens. There have been some reports that the amount of allergens were reduced through bedding control, such as boiling or sterilization of bedclothes or use of impermeable covers.[25,26]

In a number of studies, the association between traffic or the concentration of pollutants, such as PM or NO_X, and the prevalence of childhood asthma was analyzed, and it was found that there was a significant association.[27] In this study, there was no significant difference in the prevalence of asthma in terms of the distance between the main road and the house, and the traffic on the road. Because the cities in Korea are very dense, there was no significant difference in the distance between each house and the road, and the traffic and residence area were relatively the same.

The SA prevalence was 1.62 and 2.15 times higher in cases with outdoor bad odors and harmful facilities, respectively. These results are consistent with the results of existing studies on various causative factors of childhood asthma, such as chemical vapors and indoor chemical odors.[13,14] According to the worldwide European Community Respiratory Health Survey conducted in Europe, the indoor concentrations of VOC and formaldehyde have a significant relationship with respiratory symptoms.[28]

Specifically, the prevalence of SA in children who resided with fewer than 4 family members was 1.57 times higher than in those living with more than 5 family members. When the child has older siblings or attends a day care program, the risk of infection is greater. A study showed that there was a protective effect against developing asthma if the family included older children.[29]

The PDA prevalence was 1.36 times higher if there was a smoker among the family members in the household. These results are consistent with the results of a study in the United States, which reported that household smoking had a connection with a high risk of childhood asthma, excluding the effect of air pollution or socioeconomic factors.[30]

This study has several limitations. Because it was conducted in 1 elementary school in Seongbuk and 2 elementary schools in Andong, all the elementary schools in Korea were not represented. However, because the study intended to identify the causes of childhood asthma based on objective living habits and the residential environment, it was reasoned that the study was meaningful. Second, it is possible that asthma may change the behavior of the patient's parents. We showed that parents with asthmatic children paid more attention to the household environment because of their child's asthma. Third, the reliability of the questionnaire was a limitation because the survey on asthma was performed via a questionnaire. The questionnaire used in this study referred to criteria of the American Thoracic Society and was developed based on existing studies.[11,12] Fourth, we used a questionnaire asking about indoor air pollutants, amount of traffic, and house dust mite allergens. The automatic monitoring network data of air pollution were collected and analyzed, thus, reflecting the corresponding factors through related questions. Nevertheless,

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more precise studies on children's exposure to indoor and outdoor pollutants are needed in the future.

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References

1. Eder W, Ege MJ, von Mutius E. The asthma epidemic. *N Engl J Med.* 2006;355:2226-2235.
2. Lee HB, Shin SA, Oh JW. New patterns of childhood asthma prevalence in six Asian countries: comparison of ISAAC phases I and III. *Pediatr Allergy Respir Dis.* 2008;18:70-77.
3. Cho SH, Park HW, Rosenberg DM. The current status of asthma in Korea. *J Korean Med Sci*. 2006;21:181-187.
4. Taylor WR, Newacheck PW. Impact of childhood asthma on health. *Pediatrics.* 1992;90:657-662.
5. Crain EF, Weiss KB, Bijur PE, Hersh M, Westbrook L, Stein RE. An estimate of the prevalence of asthma and wheezing among inner-city children. *Pediatrics.* 1994;94:356-362.
6. Wieslander G, Norback D, Bjornsson E, Janson C, Boman G. Asthma and the indoor environment: the significance of emission of formaldehyde and volatile organic compounds from newly painted indoor surfaces. *Int Arch Occup Environ Health.* 1997;69:115-124.
7. Wang TN, Ko YC, Chao YY, Huang CC, Lin RS. Association between indoor and outdoor air pollution and adolescent asthma from 1995 to 1996 in Taiwan. *Environ Res.* 1999;81:239-247.
8. Platts-Mills TA, Thomas WR, Aalberse RC, Vervloet D, Champman MD. Dust mite allergens and asthma: report of a second international workshop. *J Allergy Clin Immunol.* 1992;89:1046-1060.
9. Kim HH, Lim YW, Kim CS, et al. Characterization of asthmatic children in indoor and outdoor environmental exposure. *J Korean Soc Indoor Environ.* 2008;5:106-121.
10. Song DJ, Kim HJ, Park SH, Choung JT. Effects of paternal tobacco smoking on children's pulmonary function and prevalence of asthma and lifetime wheezing episode. *Pediatr Allergy Respir Dis.* 2007;17:206-215.
11. Ferris BG. Epidemiology standardization project: children's questionnaire. *Am Rev Respir Dis.* 1978;118:36-53.
12. Clark NM, Brown R, Joseph CL, et al. Issues in identifying asthma and estimating prevalence in an urban school population. *J Clin Epidemiol.* 2002;55:870-881.
13. Tsai HJ, Tsai AC, Nriagu J, Ghosh D, Gong M, Sandretto A. Risk factors for respiratory symptoms and asthma in the residential environment of 5th grade schoolchildren in Taipei, Taiwan. *J Asthma.* 2006;43:355-361.
14. Lin S, Gomez MI, Hwang SA, Munsie JP, Fitzgerald EF. Self-reported home environmental risk factors for childhood asthma: A cross-sectional study of children in Buffalo, New York. *J Asthma* 2008; 45:325-332.
15. Jee HM, Kim KW, Kim CS, Sohn MH, Shin DC, Kim KE. Prevalence of asthma, rhinitis and eczema in Korean children using the international study of asthma and allergies in childhood (ISAAC) questionnaires. *Pediatr Allergy Respir Dis.* 2009;19:165-172.

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16. Houssaini AS, Messaouri H, Nasri I, Roth MP, Nejjari C, Benchekroun MN. Air pollution as a determinant of asthma among schoolchildren in Mohammedia, Morocco. *Int J Environ Health Res.* 2007;17:243-257.
17. Kumar KS, Prasad CE, Balakrishna N, Rao KV, Reddy PUM. Respiratory symptoms and spirometric observations in relation to atmospheric pollutants in a sample of urban population. *Asia Pac J Public Health.* 2000;12:58-64.
18. Kumar R, Nagar JK, Kumar H, et al. Indoor air pollution and respiratory function of children in Ashok Vihar, Delhi: an exposure-response study. *Asia Pac J Public Health.* 2008;20:36-48.
19. Kim SY, Kim H, Kim JY. Effects of air pollution on asthma in Seoul: comparisons across subject characteristics. *J Prev Med Public Health.* 2006;39:309-316.
20. Son KY, Park KS, Hwang HH, et al. Prevalence of allergic diseases among primary school children in Ilsan, Gyeonggi and changes of symptoms after environmental control in 2005. *Pediatr Allergy Respir Dis.* 2007;17:384-393.
21. Weitzman M, Gortmaker S, Sobol A. Racial, social, and environmental risks for childhood asthma. *Am J Dis Child*. 1990;144:1189-1194.
22. Korea National Statistical Office. *Social Index of Korea*. Seoul, Republic of Korea: Korea National Statistical Office; 2007
23. Jenkins MA, Hopper JL, Giles GG. Regressive logistic modeling of familial aggregation for asthma in 7,394 population-based nuclear families. *Genet Epidemiol.* 1997;14:317-332.
24. Whu R, Cirilo G, Wong J, Finkel ML, Mendez HA, Leggiadro RJ. Risk factors for pediatric asthma in the South Bronx. *J Asthma.* 2007;44:855-859.
25. Bemt LV, Knapen LV, Vries MP, Jansen M, Cloosterman S, Schayck CP. Clinical effectiveness of a mite allergen-impermeable bed-covering system in asthmatic mite-sensitive patients. *J Allergy Clin Immunol.* 2004;114:858-862.
26. Lee IS. Effect of bedding control on amount of house dust mite allergens, asthma symptoms, and peak expiratory flow rate. *Yonsei Med J.* 2003;44:313-322.
27. Jerrett M, Shankardass K, Berhane K, et al. Traffic-related air pollution and asthma onset in children: a prospective cohort study with individual exposure measurement. *Environ Health Perspect.* 2008;116:1433-1438.
28. Norback D, Bjornsson E, Janson C, Widstrom J, Boman G. Asthmatic symptoms and volatile organic compounds, formaldehyde, and carbon dioxide in dwellings. *Occup Environ Med.* 1995;52:388-395.
29. Ball TM, Castro-Rodriguez JA, Griffith KA, Holberg CJ, Martinez FD, Wright AL. Siblings, day-care attendance, and the risk of asthma and wheezing during childhood. *N Engl J Med.* 2000;343:538-543.
30. Goodwin RD, Cowles RA. Household smoking and childhood asthma in the United States: a state-level analysis. *J Asthma.* 2008;45:607-610.

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