

Do newly built homes affect rhinitis in children? The ISAAC phase III study in Korea

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Abstract

Background: As Korea has experienced rapid economic development, the lifestyles of Koreans have become more Westernized, in terms of urbanization and dietary habits. Also, the prevalences of allergic diseases, such as rhinitis, asthma, and dermatitis, have increased rapidly. This study aimed to identify the factors influencing the symptoms of rhinitis conditions, including rhinitis, allergic rhinitis, overlapped rhinitis, and overlapped allergic rhinitis, among Korean children aged 6–7 years.

Methods: The study subjects were drawn from participants in the International Study of Asthma and Allergies in Childhood (ISAAC) study in 2010 and were aged 6–7 years. We analysed data for a total of 3804 children.

Results: The prevalences of symptoms suggestive of rhinitis and allergic rhinitis in the previous 12 months were 43.4% and 22.1%, respectively. For overlapped rhinitis and overlapped allergic rhinitis, only 2.5% and 1.9% of the children had overlapping symptoms, having rhinitis with asthma and eczema simultaneously. Gender, a parental history of allergic disease, mould or dampness at home, and the risk factors for 'sick building syndrome' (SBS) were risk factors influencing rhinitis diseases. In particular, a history of moving to a newly built home in the child's infancy was strongly associated with symptoms of all the rhinitis diseases examined.

Conclusions: This study identified patterns of the prevalence of rhinitis conditions among Korean children that were similar to those reported in Western countries. We confirmed that a history of moving to a newly built home during infancy was associated with a considerable risk of rhinitis conditions.

The prevalence of rhinitis, including allergic rhinitis, has increased progressively over the last three decades; this has been seen in developed Westernized societies (1) and may be associated with a Western lifestyle and rapid changes in environmental and behavioural factors (2). A rapidly increasing pattern in the prevalence of rhinitis has now been identified in Middle-eastern and some Asian countries, where the prevalence is now higher than in Western countries (1). This may

be a consequence of improved living standards, with increased exposure to multiple sensitizing agents and risk factors, similar to those in the West, based on findings of studies using the International Study of Asthma and Allergies in Childhood (ISAAC) protocol (1, 2).

Given these rapid increases in allergic diseases, it is important to identify factors influencing them, so as to be able to change these patterns. Findings from many epidemiological

studies have been reported (2–11). Risk factors for rhinitis can be categorized into indoor environment factors, such as environmental tobacco smoke (ETS), indoor heating type, mould or dampness, genetic factors, such as a parental history of atopic disease, and sick building syndrome (SBS) related factors. SBS is likely associated with chemical substances because most of the affected individuals reside in newly built or renovated houses (12). A positive relationship between the concentration of chemicals in indoor air and SBS symptoms in localized areas has been reported (13).

As Korea's economic status has improved, the lifestyles of Koreans have changed, becoming more Westernized. Indeed, this new lifestyle has already had an impact on disease patterns in Koreans. For example, the prevalences of various cancers have become more similar to rates in the West: colon and breast cancer prevalences have increased, while stomach and cervical cancer prevalences have decreased (14).

During the 1990s, the Korean government provided 2 million homes through new city projects (15). Since then, the government has continued to provide new homes to sustain property prices and stimulate the domestic market. Thus, it is quite likely that recent Korean children will have moved to a newly built home during their infancy and it may be possible to assess the effects of this on allergic diseases. Additionally, the effects of newly built homes and urbanization, as predictors of rhinitis, can be considered in terms of the 'hygiene hypothesis'. However, the effects of many factors possibly related to allergic disease, such as house size, sharing bedrooms, nursery attendance at an early age, and exposure to a pet during childhood, remain controversial (16).

The purpose of this study was to identify factors influencing rhinitis and allergic rhinitis symptoms in Korean children aged 6–7 years. We focused on the effects of newly built homes on rhinitis in children, considering the Korean housing situation, with the provision of many new homes and the 'new towns' policy implemented since the 1980s.

Materials and methods

Study population

We used data from the Korean ISAAC study, conducted between October and November 2010. The ISAAC survey was administered to first-grade students at 45 elementary schools.

The sampling method was a stratified two-stage cluster sampling design, based on a comprehensive national list of schools at the time. First, schools were stratified by geographical region and school location (metropolitan, urban, rural). For each stratum, sample schools were selected using a systematic 'probability proportional to size' (PPS) sampling procedure. Size was based on the number of classes in the school. In the second stage, three classes were selected randomly from the first grade of each sample school, and all students were asked to participate. The response rate among children aged 6–7 years was 92.1%. In total, 4003 children aged 6–7 years participated.

Subjects were identified from the ISAAC questionnaire and the skin prick test and were divided into children who had symptoms of rhinitis and allergic rhinitis (Fig. 1). Finally, we included 3804 children who completed the ISAAC questionnaire in 2010 and underwent a skin prick test (SPT). This study was approved by the Dankook University Institutional Review Board (IRB approved number: DKUH IRB 2010-09-0260). Written informed consent was obtained from the parents/guardians of all subjects.

Measures

Parents/guardians of participating children were asked to complete a validated questionnaire about asthma and allergies, based on the ISAAC phase III questionnaire. To evaluate allergic symptoms, children who completed the survey

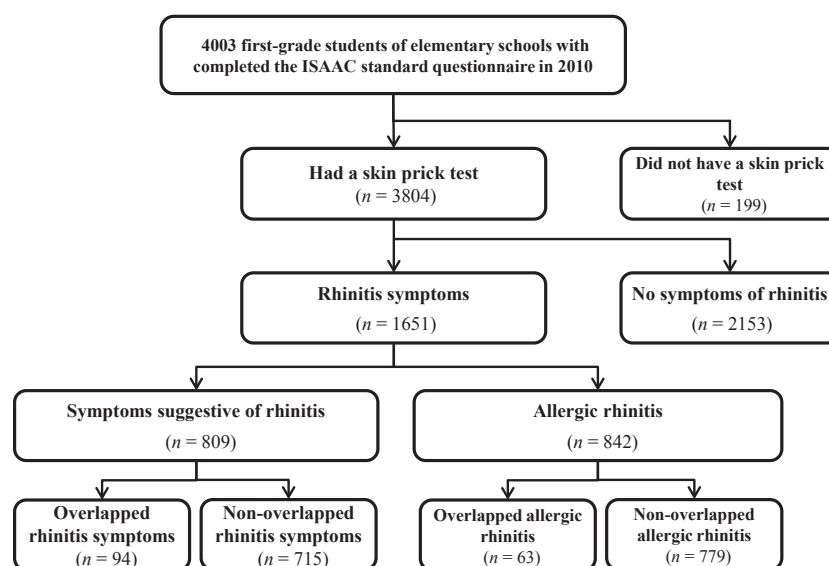


Figure 1 Flow chart of study subjects.

underwent a skin prick test. In total, 18 inhaled allergens were selected for the panel: *Der P*, *Der f*, *Tyrophagus putrescentiae* (*Tyr p*), cockroach, cat, dog, alder, birch, oak, Japanese cedar (Lofarma, Milan, Italy), orchard grass, Bermuda grass, timothy, mugwort, ragweed, Japanese hop, *Alternaria*, and *Aspergillus fumigatus*. Histamine was used as a positive control and normal saline as a negative control. Twenty subjects with negative reactions to the histamine control were excluded.

We defined symptoms suggestive of rhinitis and allergic rhinitis. To assess rhinitis, we used the following question: '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), according to the recommendations of the ISAAC phase III protocol (17). Allergic rhinitis was assessed as sensitization to at least 1 of the 18 inhaled allergens and reported experiencing symptoms in their responses to the rhinitis questionnaire.

We also assessed overlapped rhinitis and overlapped allergic rhinitis using questions about asthma and dermatitis. Asthma was assessed using the question 'Has your child had wheezing or whistling in the chest in the past 12 months?' (yes/no). A child with dermatitis was defined as one where the question 'Has your child had this itchy rash at any time in the past 12 months?' was answered 'yes'. We also asked 'Has your child ever had an itchy rash that came and went for at least 6 months?' Overlapped rhinitis was defined as symptoms of rhinitis with asthma or eczema simultaneously. Overlapped allergic rhinitis was defined as having overlapped rhinitis and exhibiting sensitization to more than one inhaled allergen in the SPT. Figure 2 illustrates the concepts of overlapped rhinitis and overlapped allergic rhinitis among asthma, dermatitis, and rhinitis.

To identify risk factors influencing rhinitis, we selected factors from previous reports (2–6, 11, 18). A measure of total current ETS exposure was calculated by summing the number of cigarettes smoked daily by each smoker living in the child's home. Exposures were measured as the sum of the

number of cigarettes smoked daily by each smoker. The questionnaire also included questions about age, gender, income, father's education level, parents' history of allergic disease, housing type, living floor, and age of the building where the child lived, dampness or mould at home, remodeling of the home in which the child resided at present, and history of moving to a newly built home during infancy (within 12 months after birth). We defined a parental history of allergic disease as positive when one or both parents had experienced asthma, rhinitis, or dermatitis in the past.

Statistical analyses

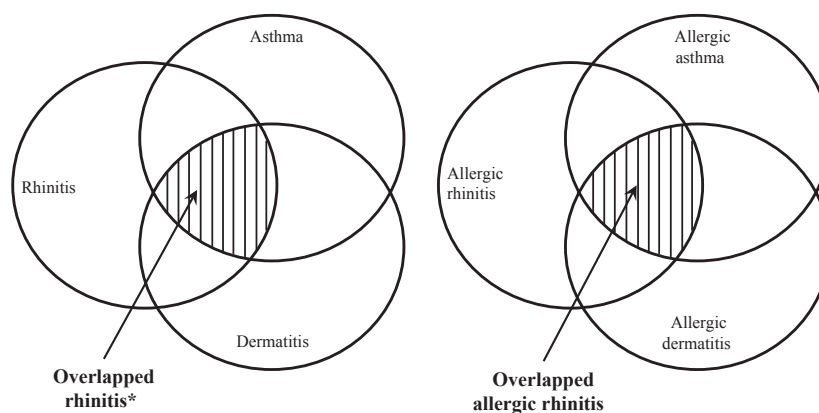
Comparisons of the prevalence of rhinitis among children were made in terms of the socioeconomic status of the parents, environmental factors, parents' history, and indoor environmental factors, using the chi-squared test. Some variables were included in the final logistic model because they were considered important even if they did not differ significantly according to the prevalence of rhinitis.

Univariate logistic regression models were used to identify individual associations between selected independent variables and rhinitis. Multivariate logistic regression models were used to determine the effects of newly built homes on the prevalences of the various types of rhinitis, after controlling for independent variables. Statistical analyses were performed using the SAS software (version 9.1; SAS Institute, Cary, NC, USA).

Results

Point prevalence of rhinitis and allergic rhinitis in children aged 6–7 years

The prevalences of symptoms suggestive of rhinitis or allergic rhinitis were 43.4% and 22.1%, respectively (Table 1). Children who had moved to a new home when they were infants were more likely to have symptoms of rhinitis than were



* Overlapped rhinitis was defined from the ISAAC questionnaire which measured suggestive symptoms of rhinitis, asthma, and dermatitis among children.

Figure 2 Venn diagrams illustrating the concept of overlapping asthma, dermatitis, and rhinitis.

Table 1 Prevalence of the four rhinitis diseases in elementary school students (aged 6–7 years) according to socio-demographic and indoor environmental factors

	Total	Rhinitis		Allergic rhinitis		Overlapped rhinitis*		Overlapped allergic rhinitis†	
		<i>n</i> (%)	<i>P</i> value	<i>n</i> (%)	<i>P</i> value	<i>n</i> (%)	<i>P</i> value	<i>n</i> (%)	<i>P</i> value
Gender									
Female	1881	724 (38.5)	<0.0001	319 (17.0)	<0.0001	35 (1.9)	0.003	20 (1.1)	0.0009
Male	1923	927 (48.2)		523 (27.2)		59 (3.1)		43 (2.2)	
Total	3804	1651 (43.4)		842 (22.1)		94 (2.5)		63 (1.7)	
Father's education (years)									
≤9	66	29 (43.9)	0.0009	12 (18.18)	<0.0001	1 (1.5)	0.212	1 (1.5)	0.2193
>9, ≤12	1277	504 (39.5)		235 (18.4)		26 (2.0)		16 (1.3)	
>12	2377	1091 (45.9)		582 (24.5)		64 (2.7)		44 (1.9)	
Total	3720	1624 (43.7)		829 (22.3)		91 (2.5)		61 (1.6)	
Household income (US\$/month)									
<2000	523	216 (41.3)	0.1307	90 (17.2)	0.0041	14 (2.7)	0.1939	10 (1.9)	0.3155
>2000, ≤4000	1849	793 (42.9)		403 (21.8)		42 (2.3)		27 (1.5)	
>4000, ≤6000	938	436 (46.5)		41 (25.7)		30 (3.2)		21 (2.2)	
>6000	385	158 (41.0)		82 (21.3)		6 (1.6)		5 (1.3)	
Total	3695	1603 (43.4)		816 (22.1)		92 (2.5)		63 (1.7)	
Residential area									
Metropolitan	1758	721 (41.0)	0.0099	371 (21.1)	0.0007	31 (1.8)	0.0082	19 (1.1)	0.0247
Urban	1403	651 (46.4)		355 (25.3)		37 (2.6)		28 (2.0)	
Rural	643	279 (43.4)		116 (18.0)		26 (4.1)		16 (2.5)	
Total	3804	1651 (43.4)		842 (22.1)		94 (2.5)		63 (1.7)	
Total number of cigarettes‡									
No	1532	644 (42.0)	0.2468	337 (22.0)	0.4873	32 (2.1)	0.2239	24 (1.6)	0.4589
1–20	1815	792 (43.6)		392 (21.6)		49 (2.7)		31 (1.7)	
≥21	251	119 (47.4)		61 (24.3)		8 (3.2)		6 (2.4)	
Total	3598	1555 (43.2)		790 (22)		89 (2.5)		61 (1.7)	
Parents' history of atopic disease									
No	1721	536 (31.1)	<0.0001	233 (13.5)	<0.0001	23 (1.3)	<0.0001	11 (0.64)	<0.0001
Yes	2083	1115 (53.5)		609 (29.2)		71 (3.4)		52 (2.5)	
Total	3804	1651 (43.4)		842 (22.1)		94 (2.5)		63 (1.66)	
Breast feeding									
No	948	398 (42.0)	0.2583	217 (22.9)	0.9385	25 (2.6)	0.9756	17 (1.5)	0.9052
Yes	2808	1238 (44.1)		615 (21.9)		68 (2.4)		45 (1.6)	
Total	3756	1636 (43.6)		832 (22.2)		93 (2.5)		62 (1.7)	
Dampness or mould at home									
No	2757	1155 (41.9)	0.0032	600 (21.8)	0.0801	64 (2.3)	0.1009	47 (1.7)	0.7577
Yes	1009	477 (47.3)		234 (23.8)		29 (2.9)		16 (1.6)	
Total	3766	1632 (43.3)		834 (22.1)		93 (2.5)		63 (1.7)	
Carpet use at home									
No	3195	1397 (43.7)	0.3825	718 (22.5)	0.2215	80 (2.5)	0.3727	57 (1.78)	0.1554
Yes	523	218 (41.7)		105 (20.1)		10 (1.9)		5 (1.0)	
Total	3718	1615 (43.4)		823 (22.1)		90 (2.4)		62 (1.7)	
Home type									
Detached house	413	164 (39.7)	0.0679	86 (20.8)	0.0098	9 (2.2)	0.953	6 (1.5)	0.6094
Town house	756	305 (40.3)		137 (18.1)		19 (2.5)		10 (1.3)	
Apartment	2501	1120 (44.8)		592 (23.7)		62 (2.5)		46 (1.8)	
Other	111	49 (44.1)		22 (19.82)		3 (2.7)		1 (0.9)	
Total	3781	1638 (43.3)		837 (22.1)		93 (2.5)		63 (1.7)	
Floor of home									
Above 1st floor	3666	1587 (43.3)	0.3034	814 (22.2)	0.9953	88 (2.4)	0.0244	61 (1.7)	0.4866
Basement or semi-basement	99	48 (48.5)		20 (20.2)		5 (5.1)		2 (2.0)	
Total	3765	1635 (43.4)		834 (22.2)		93 (2.5)		63 (1.7)	

Table 1 (Continued)

	Total	Rhinitis		Allergic rhinitis		Overlapped rhinitis*		Overlapped allergic rhinitis†	
		<i>n</i> (%)	<i>P</i> value	<i>n</i> (%)	<i>P</i> value	<i>n</i> (%)	<i>P</i> value	<i>n</i> (%)	<i>P</i> value
Building age									
>2 years	3613	1566 (43.3)	0.8859	804 (22.3)	0.5977	91 (2.5)	0.1308	61 (1.7)	0.299
≤2 years	159	68 (42.8)		32 (20.1)		1 (0.6)		1 (0.6)	
Total	3772	1634 (43.3)		836 (22.2)		92 (2.4)		62 (1.6)	
Pet at home during pregnancy or infancy									
Yes	223	95 (42.6)	0.8044	43 (19.3)	0.3806	9 (4.0)	0.1261	6 (2.7)	0.237
No	3503	1522 (43.5)		780 (22.3)		81 (2.3)		56 (1.6)	
Total	3726	1617 (43.4)		823 (22.1)		90 (2.4)		62 (1.7)	
Pet at home									
Yes	328	140 (42.7)	0.7591	78 (23.8)	0.6742	8 (2.4)	0.9671	6 (1.8)	0.8484
No	3363	1465 (43.6)		742 (22.1)		81 (2.4)		55 (1.6)	
Total	3691	1605 (43.5)		820 (22.2)		89 (2.4)		61 (1.7)	
Remodelling within the last 12 months									
No	3089	1324 (42.9)	0.0676	664 (21.5)	0.0207	67 (2.2)	0.0013	48 (1.6)	0.0608
Yes	588	276 (46.9)		151 (25.7)		24 (4.1)		14 (2.4)	
Total	3677	1600 (43.5)		815 (22.2)		91 (2.5)		62 (1.7)	
New furniture within the last 12 months									
No	2614	1113 (42.6)	0.1324	573 (21.9)	0.3327	65 (2.5)	0.8364	44 (1.7)	0.857
Yes	1150	520 (45.2)		262 (22.8)		28 (2.4)		19 (1.7)	
Total	3764	1633 (43.4)		835 (22.2)		93 (2.5)		63 (1.7)	
Moving to new home when an infant									
No	3094	1289 (41.7)	<0.0001	661 (21.4)	0.0003	63 (2.0)	<0.0001	42 (1.4)	<0.0001
Yes	675	348 (51.6)		175 (25.9)		30 (4.4)		21 (3.1)	
Total	3769	1637 (43.4)		836 (22.2)		93 (2.5)		63 (1.7)	

*Overlapped rhinitis: having asthma and eczema, based on a questionnaire for people having a rhinitis symptom.

†Overlapped allergic rhinitis: having asthma and eczema, based on a questionnaire for people having an atopic rhinitis symptom.

‡Total number of cigarettes: sum of number of cigarettes smoked daily by each smoker living in a child's home.

those who did not (51.6% vs 41.7% for rhinitis, 25.9% vs 21.4% for allergic rhinitis). For overlapped rhinitis, only 2.5% of the children had overlapping symptoms.

Factors associated with rhinitis and allergic rhinitis in univariate and multivariate logistic regression analyses

We suggested independent variables for the logistic model based on previous studies of rhinitis or allergic rhinitis and the results of the chi-squared test. Table 2 shows that children having parents with a history of an allergic disease were more likely to have rhinitis or allergic rhinitis than children whose parents had no history of allergic disease (OR = 2.55, 95% CI = 2.23–2.91; OR = 3.20, 95% CI = 2.69–3.81) in univariate logistic regression analyses. Additionally, children living in a home with mould or dampness were more likely to have rhinitis than children living in a home with no mould or dampness (OR = 1.24, 95% CI = 1.08–1.44). Regarding moving to a newly built home, subjects who had done so were 1.49 times (95% CI = 1.26–1.76) and 1.46 times (95% CI = 1.19–1.79) more likely to have symptoms of rhinitis or allergic rhinitis, respectively, than children who had not. Risk factors identified for overlapped rhinitis and overlapped allergic rhinitis were identical to those for rhinitis and allergic rhinitis, with the exception of fungus or dampness at home.

Table 3 lists the adjusted associations between potential risk factors and symptoms of rhinitis and allergic rhinitis. Regarding genetic risk factors, children with a parental history of allergic diseases were more likely to experience rhinitis or allergic rhinitis (OR = 2.55, 95% CI = 2.20–2.95; OR = 3.25, 95% CI = 2.68–3.95). A history of moving to a newly built home was a major risk factor associated with both rhinitis and allergic rhinitis in the multivariate logistic regression (OR = 1.42, 95% CI = 1.18–1.71 and OR = 1.42, 95% CI = 1.13–1.79, respectively).

Risk factors identified for overlapped rhinitis and overlapped allergic rhinitis were the same as those for rhinitis and allergic rhinitis, except for mould or dampness at home. Regarding SBS, children who had moved to a newly built home were 2.92 times (95% CI = 1.76–4.84) and 3.09 times (95% CI = 1.71–5.57) more likely to have overlapped rhinitis or overlapped allergic rhinitis, respectively.

Discussion

We sought to identify factors influencing rhinitis and allergic rhinitis, based on the first nationwide, population-based study of Korean school children aged 6–7 years according to the ISAAC protocol (phase III). The prevalences of symptoms of rhinitis and allergic rhinitis in the previous

Table 2 Results of univariate logistic regression for identification of factors influencing rhinitis diseases in the last 12 months

	Rhinitis			Allergic rhinitis			Overlapped rhinitis*			Overlapped allergic rhinitis†		
	Odds Ratio	95% CI		Odds Ratio	95% CI		Odds Ratio	95% CI		Odds Ratio	95% CI	
Gender												
Female	1.00			1.00			1.00			1.00		
Male	1.49	1.31	1.69	1.90	1.62	2.24	1.90	1.24	2.91	2.42	1.41	4.14
Father's education (years)												
≤9 (middle school or less)	1.00			1.00			1.00			1.00		
>9, ≤12 (high school)	0.83	0.51	1.37	0.94	0.48	1.83	1.25	0.17	9.55	0.77	0.10	6.01
>12 (post-high school)	1.08	0.66	1.77	1.40	0.72	2.70	1.87	0.25	13.93	1.29	0.17	9.64
Household income (US\$/month)												
<2000	1.00			1.00			1.00			1.00		
>2000 ≤ 4000	1.07	0.88	1.30	1.30	1.00	1.69	0.86	0.46	1.60	0.78	0.37	1.62
>4000 ≤ 6000	1.23	0.99	1.53	1.64	1.24	2.17	1.31	0.68	2.52	1.29	0.60	2.78
≤6000	0.99	0.76	1.29	1.23	0.87	1.74	0.58	0.22	1.55	0.68	0.23	2.03
Parental history of atopic diseases												
No	1.00			1.00			1.00			1.00		
Yes	2.55	2.23	2.91	3.20	2.69	3.81	4.13	2.56	6.67	6.32	3.28	12.21
Residential area												
Metropolitan	1.00			1.00			1.00			1.00		
Urban	1.25	1.08	1.43	1.32	1.11	1.57	1.59	0.97	2.59	1.96	1.08	3.54
Rural	1.10	0.92	1.32	0.89	0.70	1.13	2.29	1.34	3.92	2.30	1.17	4.53
Total number of cigarettes‡												
No smoking	1.00			1.00			1.00			1.00		
1–20	1.07	0.93	1.23	1.01	0.85	1.20	1.39	0.88	2.20	1.17	0.68	2.02
≥21	1.24	0.95	1.63	1.22	0.88	1.69	1.77	0.80	3.96	1.77	0.71	4.44
Mould/dampness												
No	1.00			1.00			1.00			1.00		
Yes	1.24	1.08	1.44	1.17	0.98	1.41	1.46	0.93	2.29	1.10	0.61	1.95
Carpets												
No	1.00			1.00			1.00			1.00		
Yes	0.92	0.76	1.11	0.86	0.68	1.09	0.74	0.38	1.44	0.52	0.21	1.31
Remodelling												
No	1.00			1.00			1.00			1.00		
Yes	1.18	0.99	1.41	1.29	1.04	1.59	2.19	1.35	3.56	1.78	0.97	3.28
New furniture												
No	1.00			1.00			1.00			1.00		
Yes	1.11	0.97	1.28	1.09	0.92	1.30	1.05	0.67	1.65	1.05	0.61	1.82
Moving to new home when an infant												
No	1.00			1.00			1.00			1.00		
Yes	1.49	1.26	1.76	1.46	1.19	1.79	2.90	1.84	4.58	3.05	1.77	5.24

*Overlapped rhinitis: having asthma and eczema, based on a questionnaire for people having a rhinitis symptom.

†Overlapped allergic rhinitis: having asthma and eczema, based on a questionnaire for people having an atopic rhinitis symptom.

‡Total number of cigarettes: sum of number of cigarettes smoked daily by each smoker living in a child's home.

12 months were 43.4% and 22.1%, respectively. This pattern was also identified in a report showing that the prevalence of allergic rhinitis had increased progressively over the last three decades (1). For overlapped rhinitis, the prevalences of overlapped rhinitis and overlapped allergic rhinitis in the previous 12 months were 2.5% and 1.7%, respectively. These rates were similar to those reported in other developed countries (18–20).

The multivariate logistic regression model for rhinitis and overlapped rhinitis suggested that male gender, a parental

history of allergies, mould or dampness at home, and moving to a newly built home during infancy were risk factors. Specifically, the results of this study indicated that the occurrence of current allergic rhinitis in Korean children aged 6–7 years was strongly associated with living in a newly built home during infancy. Also, the effect of a newly built home increased as the symptoms of rhinitis increased: the effect was much greater for overlapped allergic rhinitis than for rhinitis (overlapped allergic rhinitis OR = 3.09, 95% CI = 1.71–5.57; rhinitis OR = 1.42, 95% CI = 1.18–1.71).

Table 3 Results of multiple logistic regression for identification of factors influencing rhinitis disease in the last 12 months

	Rhinitis			Atopic rhinitis			Overlapped rhinitis*			Overlapped allergic rhinitis†		
	Odds Ratio	95% CI		Odds Ratio	95% CI		Odds Ratio	95% CI		Odds Ratio	95% CI	
Gender												
Female	1.00			1.00			1.00			1.00		
Male	1.51	1.31	1.74	1.99	1.65	2.39	2.22	1.36	3.62	2.86	1.56	5.23
Father's education (years)												
≤9 (middle school or less)	1.00			1.00			1.00			1.00		
>9, ≤12 (high school)	0.71	0.40	1.28	0.61	0.29	1.31	1.05	0.12	9.32	0.66	0.07	6.67
>12 (post-high school)	0.92	0.51	1.66	0.90	0.42	1.93	1.67	0.19	15.11	1.26	0.12	13.05
Household income (US\$/month)												
<2000	1.00			1.00			1.00			1.00		
>2000, ≤4000	0.91	0.72	1.14	1.08	0.80	1.47	0.78	0.37	1.64	0.72	0.30	1.74
>4000, ≤6000	1.00	0.77	1.30	1.28	0.91	1.79	1.00	0.44	2.26	0.87	0.33	2.29
>6000	0.88	0.64	1.21	1.00	0.66	1.50	0.47	0.15	1.48	0.48	0.13	1.79
Parental history of atopic diseases												
No	1.00			1.00			1.00			1.00		
Yes	2.55	2.20	2.95	3.25	2.68	3.95	4.02	2.36	6.84	6.87	3.29	14.34
Residential area												
Metropolitan	1.00			1.00			1.00			1.00		
Urban	1.21	1.04	1.42	1.35	1.10	1.64	1.86	1.07	3.23	2.24	1.16	4.35
Rural	1.18	0.96	1.45	1.05	0.80	1.37	2.62	1.42	4.85	2.88	1.36	6.10
Total number of cigarettes‡												
No smoking	1.00			1.00			1.00			1.00		
1–20	1.12	0.97	1.30	1.09	0.90	1.31	1.65	1.00	2.72	1.40	0.78	2.50
≥21	1.30	0.97	1.74	1.30	0.90	1.87	1.73	0.69	4.34	1.64	0.56	4.83
Mould/dampness												
No	1.00			1.00			1.00			1.00		
Yes	1.27	1.08	1.49	1.31	1.07	1.61	1.39	0.83	2.35	1.23	0.65	2.34
Carpets												
No	1.00			1.00			1.00			1.00		
Yes	0.94	0.76	1.16	0.92	0.71	1.21	0.81	0.39	1.69	0.47	0.16	1.36
Remodelling												
No	1.00			1.00			1.00			1.00		
Yes	1.07	0.87	1.30	1.15	0.90	1.48	1.81	1.00	3.27	1.55	0.74	3.25
New furniture												
No	1.00			1.00			1.00			1.00		
Yes	1.07	0.91	1.25	1.04	0.85	1.27	0.86	0.51	1.46	0.90	0.48	1.68
Moving to new home when an infant												
No	1.00			1.00			1.00			1.00		
Yes	1.42	1.18	1.71	1.42	1.13	1.79	2.92	1.76	4.84	3.09	1.71	5.57

*Overlapped rhinitis: having asthma and eczema, based on a questionnaire for people having a rhinitis symptom.

†Overlapped allergic rhinitis: having asthma and eczema, based on a questionnaire for people having an atopic rhinitis symptom.

‡Total number of cigarettes: sum of number of cigarettes smoked daily by each smoker living in a child's home.

While previous studies have investigated how SBS affected asthma or allergic diseases, including rhinitis, to our knowledge no previous study has focused on how the new building effect is related to allergic disease (21–24). Kwon and colleagues, using data from students in one region of Seoul, Korea, suggested that moving to a newly built home was not a risk factor for asthma (3). Indoor air in newly built apartments typically contains much higher concentrations of volatile organic compounds (VOCs) than are found in older homes (25). It has been assumed that VOCs might be

associated with atopy and asthmatic conditions (26). Thus, we considered the possibility that exposure to VOCs during infancy might cause symptoms of rhinitis in 6- to 7-year-old children. Additionally, since the 1980s, Korea has experienced a continuous supply of new homes to manage the housing shortage caused by industrialization and urbanization and to stimulate the domestic market (15). These events may have increased the probability of moving to a newly built home during infancy and adolescence, increasing the risk of exposure to chemicals, such as VOCs, which may

affect allergic diseases. Therefore, improved ventilation systems should be introduced in newly built houses to reduce the nasal effects of VOCs (12).

This study confirmed that mould or dampness at home was associated with rhinitis and atopic rhinitis (rhinitis OR = 1.27, 95% CI = 1.08–1.49; allergic rhinitis OR = 1.31, 95% CI = 1.07–1.61), similar to previous studies (4, 7, 22–24). Specifically, when sensitization to *A. fumigatus* or *Alternaria* was added to the original multiple logistic model, it was significantly associated with four types of rhinitis symptoms (data not shown in the table). Previous studies about SBS suggested that mould or dampness at home could influence rhinitis and allergic rhinitis in children. Dampness and mould in the indoor environment should be controlled to prevent allergic diseases in children. However, in the cases of overlapped rhinitis and overlapped allergic rhinitis, we found no association with mould or dampness at home. Sample size must be considered if a significant association between mould and overlapped rhinitis and overlapped allergic rhinitis is to be confirmed. Because there were minor differences in the odds ratios among the four types of rhinitis symptom, mould or dampness might affect general rhinitis symptoms.

We examined the effects of factors related to the hygiene hypothesis, such as breast feeding, the presence of a pet in the home during pregnancy or infancy, a pet in the home, and residential area, on the prevalence of rhinitis. However, we found no differences in prevalence according to such factors. Although evidence supporting associations between hygiene hypothesis factors and allergic diseases has been reported (16), our data do not support an association.

Some limitations should be considered when interpreting these results. First, recall bias has to be considered. Questionnaires were completed by parents or guardians of the children, and information about environmental exposure was obtained retrospectively, which may have resulted in recall bias. Second, it is important to consider that the prevalence of rhinitis was measured based on a questionnaire. Thus, the rates reported here may have been over- or underestimated. However, recognition of the symptoms of asthma, rhinitis, and eczema for the children in the study was based on validated symptom-based written questionnaires from the ISAAC protocol (27, 28).

In conclusion, we identified patterns in the prevalences of rhinitis conditions among Korean children similar to those

reported in Western countries. We confirmed that a history of moving to a newly built home during infancy was associated with a high risk of rhinitis conditions. Also, this association was stronger when allergic factors were considered.

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Author contributions

Myung-Il Hahm, Jihyun Kim, Yoomi Chae and Ho-Jang Kwon contributed to conception, design, data collection, analysis, interpretation, and writing; Kangmo Ahn contributed to conception, data collection, and interpretation; Wo-Kyung Kim, So-Yeon Lee, Yong Mean Park and Man Yon Han contributed to design and data collection; Kee-Jae Lee and Hoo-Yeon Lee contributed to design, data collection, and analysis; Insoon Min contributed to conception and writing.

Conflicts of interest

This manuscript has not been published previously in print or electronic format and is not under consideration by another publication or electronic medium. Copies of related or possibly duplicative materials (i.e. those containing substantially similar content or using the same or similar data) have not been previously published or are not under consideration elsewhere. There are no potential conflicts of interest, financial or otherwise, related to the content of the manuscript. All authors of this work do not have any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work. All authors of this work have not received a financial contribution from a company or organization that might benefit (or lose) financially from the results, conclusions, or discussion presented in this manuscript. All authors of this work do not have any other competing financial interests to disclose.

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